Plant Archives Vol. 25, No. 2, 2025 pp. 2005-2011 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.290

ASSESSMENT OF GENETIC DIVERSITY FOR YIELD, YIELD COMPONENTS AND NUTRITIONAL TRAITS IN INBRED LINES OF PEARL MILLET (*PENNISETUM GLAUCUM* L.)

N. Sabitha[1]*, P. L Jyothika[1], L. Madhavilatha[2] and G. Mohan Naidu[3]
[1]Dept.of Genetics & Plant Breeding, S.V. Agricultural College, Tirupati, ANGRAU, A.P, India.
[21]Dept.of Genetics & Plant Breeding, ARS, Ananthapuramu, A.P, India.
[3]Dept. of Statistics and Computer Application, S.V. Agricultural College, Tirupati, ANGRAU, A.P, India.
*Corresponding author E-mail: nsabitha84@gmail.com
(Date of Receiving : 17-07-2025; Date of Acceptance : 10-10-2025)

ABSTRACT

In the current study 97 inbred lines and three checks were studied for genetic diversity at ARS, Ananthapuram during *kharif*, 2024 in an alpha lattice design with two replications. Based on the D^2 analysis all the 100 genotypes were grouped into seven clusters. Maximum inter cluster distance was recorded between cluster I and V followed by cluster V and VI, cluster IV and V and cluster I and VII. Genotypes from these clusters can be utilized for development of hybrids as well as inbred lines. The traits *viz*., iron content followed by zinc content, protein content, thousand grain weight, harvest index and grain yield per plant contributed maximum towards divergence. The cross combinations *viz.*, API 2054 x API 1018, API 2054 x API 1039 and API 2052 x API 1012 (cluster I x cluster V) could be considered for obtaining a wide spectrum of variation among the segregants for high yield and nutritional traits.

***Keywords*:** Pearl millet, Genetic diversity, D^2 analysis, Cluster distance

Introduction

Pearl millet is a C_4 crop with good photosynthetic efficiency and biomass production capacity (Varshney *et al*., 2017). Its tolerance to drought and low inorganic fertilizer requirement makes it a preferred crop for growing in arid and semi-arid regions. The hermaphrodite flowers of pearl millet exhibit protogyny, which promotes a high degree of cross-pollination. Pearl millet is the fourth most important cereal crop in India after rice, wheat and maize. It is cultivated in an area of 6.835 Mha, with production and productivity of 9.490 Mt and 1388 Kg ha^{-1}, respectively, in 2024-25 (Indiastat, 2025). In Andhra Pradesh it occupies an area of 0.027 Mha with an average production of 0.059 Mt and productivity of 2199 Kg ha^{-1} in 2024-25 (Indiastat, 2025).

Pearl millet is also nutritionally superior and rich in micronutrients such as iron and zinc and can mitigate malnutrition and hidden hunger. Hundred grams of pearl millet grain contains (17 MJ/kg), carbohydrate (60-70%), quality-proteins (9.5 −14.41 g/100 g), lipids (4.8 – 7.1 g/100 g) and minerals (Calcium: 16 – 46; Iron: 4 - 11.2; Zinc: 2.95 - 7.1 mg/100 g) (Hassan *et al*., 2021). It is a dual-purpose crop and more palatable compared to sorghum.

The use of genetically diverse parents in hybridization leads to greater productivity of hybrids (Gupta *et al*., 2018). Multivariate analysis has been successfully adopted by researchers as a valuable tool for selecting parents in hybridization (Hazra *et al*., 1992; Nath *et al*., 2009). Genetic diversity estimated through D^2 statistics provides information on the diversity of any intraspecies population for various traits among the genotypes.

Materials and Methods

The experiment was carried out during *kharif*, 2024 at Agricultural Research Station, Ananthapuramu located at 14° 41'N latitude and 77° 40'E longitude from an altitude of 373 m above mean sea level, and situated in scarce rainfall zone of Andhra Pradesh. The

experimental material comprising 97 pearl millet inbred lines and three checks i.e., ABV04 (Composite variety), SBH 888 (Hybrid), Pittaganti (local variety) were evaluated in an Alpha lattice design with two replications. Each genotype was sown in single row of four meters length with a spacing of 45 cm between rows and 15 cm between the plants within the rows. All the recommended cultural and agronomic measures were followed in raising a healthy crop. Observations on plant height (cm), number of productive tillers per plant, panicle length (cm), panicle girth (cm), SPAD chlorophyll meter reading (SCMR) at 60 DAS, relative water content (%), thousand grain weight (g), harvest index (%) and grain yield per plant (g) were recorded on five randomly selected competitive plants in each genotype and each replication. Days to 50% flowering and days to maturity observations were recorded on whole plot basis. Iron content (ppm) and zinc content (ppm) in grain were estimated using AAS (Tandon, 1999) and protein content (%) in grain estimated by Kjeldahl method (AOAC 1990). Mean of five plants was taken for statistical analysis using WINDOSTAT. The data collected on different traits was analysed by using D^2 statistics suggested by Mahalanobis (1936) to determine genetic divergence. Grouping of genotypes into different clusters was done by using Tocher's method as described by Rao (1952).

Results and Discussion

Analysis of variance revealed significant differences among the genotypes for all the traits studied. All the 100 genotypes of pearl millet were grouped into seven distinct and non-overlapping clusters using Tocher's method (Rao, 1952) such that the genotypes belonging to same cluster had an average smaller D^2 values than those belonging to different clusters. The distribution of genotypes into various clusters was presented in Table 1 and Fig1.

Grouping of genotypes

Out of seven clusters, cluster I was the largest one comprising of 46 genotypes followed by cluster II with 34 genotypes, cluster III with eight genotypes, cluster VI contains six genotypes, cluster V with three genotypes and cluster VII with two genotypes while, cluster IV had only one genotype indicating high degree of heterogeneity among the genotypes. The genotype of the solitary clusters may be unique and very useful for breeding purpose.

Intra and inter cluster distances :

The average intra and inter cluster D^2 and D values among seven clusters were given in Table 2 and Fig 2. The average intra cluster distance ranged from 0.00 to 1491.47 cm.

Table 1 : Distribution of 100 Pearl millet genotypes in seven clusters based on Tocher's method

Cluster number	No. of Genotypes	Genotypes included
Cluster I	46	API 2019, API 2029, API 2040, API 2034, API 1036, API 2008, API 2021, API 2038, API 2030, API 2033, API 2037, API 2031, API 2027, API 1052, API 2023, API 2006, API 2004, API 1054, API 2017, ABV 04, API 1118, API 1071, API 2043, API 2056, API 2026, API 2005, API 1073, API 1046, API 1044, API 2010, API 1116, API 1117, API 2036, API 1049, API 1087, Pittaganti, API 2001, API 2007, API 2012, API 2054, API 1101, API 2035, API 2053, API 1114, API 1083 and SBS 888.
Cluster II	34	API 1010, API 1021, API 1112, API 1034, API 1016, API 1047, API 1109, API 2003, API 2020, API 1024, API 1084, API 1066, API 1074, API 1072, API 1014, API 1005, API 1033, API 1110, API 2024, API 2018, API 1107, API 1102, API 1075, API 1007, API 1098, API 1069, API1006, API 1067, API 1035, API 1076, API 1038, API 1026, API 1090 and API 1008
Cluster III	8	API 1030, API 1042, API 1032, API 1029, API 1111, API 1058, API 1041 and API 1057
Cluster IV	1	API 2042
Cluster V	3	API 1018, API 1039 and API 1012
Cluster VI	6	API 2045, API 2048, API 2052, API 1103, API 1045 and API 1106
Cluster VII	2	API 1011 and API 1105

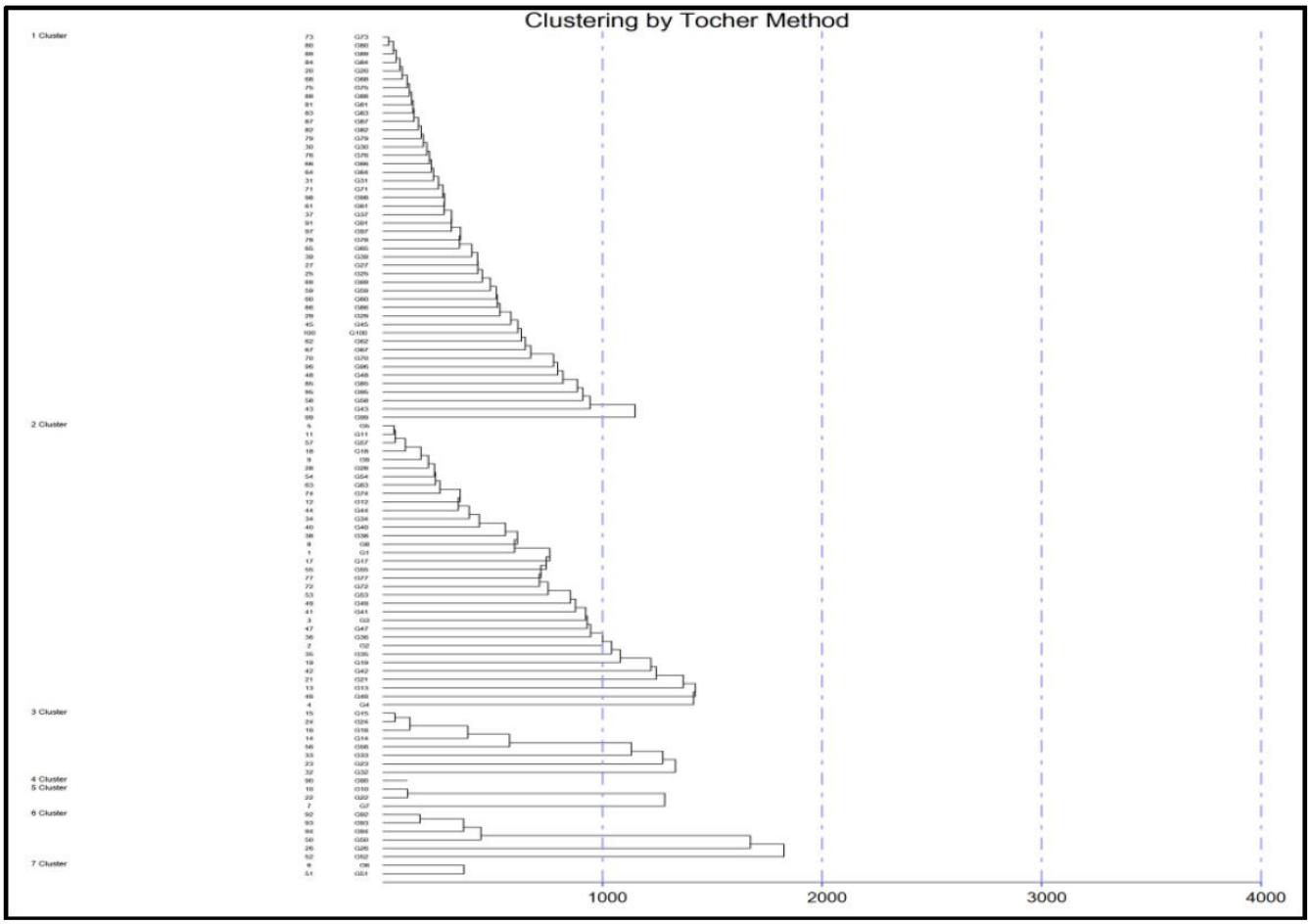

Fig. 1 : Dendrogram of 100 pearl millet genotypes obtained through Tocher's method

Maximum intra cluster distance was recorded in cluster VI (1491.47), followed by cluster V (1320.77), cluster III (1115.29), cluster II (950.86), cluster I (567.54) and cluster VII (369.58) suggesting that there is still some diversity among the genotypes within the same cluster, which could be utilized for enhancing yield through recombination breeding. The genetic diversity observed among the genotypes within the same cluster may due to heterogeneity, degree of general combining ability (GCA), and pedigree. Consequently, selection within these clusters could focus on the genotypes with the best average performance for traits of interest.

While, the inter-cluster D^2 values ranged from 824.64 to 18507.91, the maximum inter cluster distance (18507.91) was recorded between cluster I and V followed by cluster V and VI (12782.45), cluster IV and V (12550.22) cluster I and VII (10058.41), cluster II and V (9140.23), cluster IV and VII (8020.57) and cluster I and III (7641.58) whereas, minimum inter cluster distance of 824.64 was recorded between cluster IV and VI, followed by cluster I and IV (1226.17) and between cluster I and VI (1746.05) indicating that genotypes of these clusters were genetically close and had maximum number of gene complexes. High value of inter cluster distance and intra cluster distance in pearl millet was reported earlier by Ramya *et al.* (2017), Sharma *et al*. (2020) and Barathi and Reddy (2022) (Table 2 and Fig. 2).

The distances between clusters were greater than those within the clusters, suggesting significant diversity among the genotypes. The genotypes grouped in these clusters can serve as promising parents, and crossing among these genotypes is likely to lead to strong heterotic expression for yield and its components. Based on inter cluster distances the combination of clusters *viz.*, I × V, V × VI, IV × V, I × VII and II × V were found to be more divergent with high mean performance.

Table 2 : Intra (diagonal) and Inter cluster average of D^2 and D values (in parentheses) of seven clusters in pearl millet genotypes

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII
Cluster I	**567.54 (23.82)**	3590.05 (59.92)	7641.58 (87.42)	1226.17 (35.02)	18507.91 (136.04)	1746.05 (41.79)	10058.41 (100.30)
Cluster II		**950.86 (30.84)**	3170.30 (56.31)	2832.30 (53.22)	9140.23 (95.60)	2741.57 (52.36)	2625.6 (51.24)
Cluster III			**1115.29 (33.40)**	4104.80 (64.07)	3528.00 (59.40)	4461.93 (66.80)	3231.63 (56.85)
Cluster IV				**0.00 (0.00)**	12550.22 (112.03)	824.64 (28.72)	8020.57 (89.56)
Cluster V					**1320.77 (36.34)**	12782.45 (113.6)	5082.57 (71.30)
Cluster VI						**1491.47 (38.62)**	7310.25 (85.50)
Cluster VII							**369.58 (19.22)**

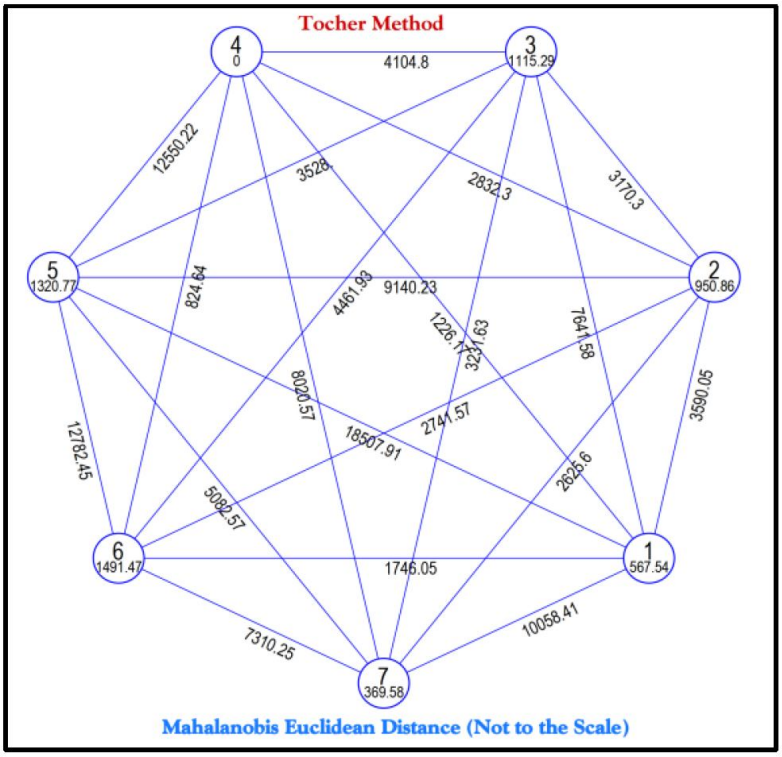

Fig. 2 : Intra cluster and Inter cluster (D^2) distances among seven clusters

Cluster means for traits

The cluster means for all the yield and yield attributing traits were compiled in the Table 3. Significant differences in the cluster means for all traits suggested the diverse nature of the clusters. Early flowering was registered in the genotypes of cluster V (43.17 days) while delayed flowering in the genotypes of cluster VI (49.83 days). Days to maturity ranged from 76.75 days in cluster VII to 82.42 days in cluster VI. The genotypes of cluster IV (61.05) displayed high SPAD chlorophyll meter reading at 60 DAS, while genotypes of cluster III (56.36) had low SPAD chlorophyll meter reading at 60 DAS. Relative water content was ranged from 73.68% in cluster VI to 81.43% in cluster VII. The genotypes of cluster IV were taller in plant height (161.90 cm), while that of cluster III were shorter in plant height (147.38cm)

Table 3 : Cluster means with respect to yield, yield components and overall trait wise score in 100 genotypes of pearl millet

Cluster	Character(s)														Productivity traits	
	DFF	DM	SCMR	RWC	PH	NPT	PL	PG	TGW	HI	IRON	ZINC	PC	GYP	Total score	Final Rank
Cluster I	47.74 (6)	80.98 (6)	59.34 (3)	75.29 (6)	153.42 (6)	2.19 (5)	25.72 (3)	2.86 (3)	11.52 (4)	39.77 (5)	47.90 (7)	19.65 (7)	9.21 (3)	29.89 (3)	67	6
Cluster II	46.09 (5)	79.37 (4)	58.94 (5)	76.99 (4)	153.48 (5)	2.12 (7)	25.03 (5)	2.85 (4)	11.28 (5)	39.56 (6)	115.83 (4)	23.07 (6)	8.76 (5)	28.84 (5)	70	7
Cluster III	45.38 (3)	78.63 (3)	56.36 (7)	76.98 (3)	147.38 (7)	2.13 (6)	25.27 (4)	2.81 (5)	11.80 (3)	42.33 (3)	137.39 (3)	55.21 (2)	8.74 (6)	28.41 (6)	61	5
Cluster IV	45.50 (4)	79.50 (5)	**61.05 (1)**	75.40 (5)	**161.90 (1)**	**2.90 (1)**	**27.70 (1)**	**3.25 (1)**	11.15 (6)	37.05 (7)	65.40 (6)	38.85 (3)	9.60 (2)	**34.85 (1)**	44	2
Cluster V	**43.17 (1)**	77.50 (2)	56.95 (6)	78.47 (2)	158.40 (2)	2.27 (4)	24.75 (7)	2.73 (7)	10.55 (7)	40.13 (4)	**196.20 (1)**	**72.88 (1)**	8.47 (7)	25.88 (7)	58	4
Cluster VI	49.83 (7)	82.42 (7)	59.06 (4)	73.68 (7)	154.30 (4)	2.63 (3)	26.03 (2)	2.93 (2)	**12.30 (1)**	43.40 (2)	75.30 (5)	34.25 (4)	**10.66 (1)**	34.42 (2)	51	3
Cluster VII	44.00 (2)	**76.75 (1)**	60.60 (2)	**81.43 (1)**	155.70 (3)	2.80 (2)	24.78 (6)	2.78 (6)	11.88 (2)	**49.48 (1)**	174.08 (2)	26.95 (5)	9.20 (4)	28.95 (4)	41	1

Note: Numbers in the parenthesis indicates the rank based on cluster mean. Total score is the summation of rank numbers for all characters, based on which final rank indicated. Bold numbers indicated highest mean values for each character.

DFF : Days to 50% Flowering
DM : Days to Maturity
SCMR : SPAD Chlorophyll Meter Reading
RWC : Relative Water Content (%)
PH : Plant Height (cm)
NPT : Number of Productive Tillers per plant
PL : Panicle Length (cm)
PG : Panicle Girth (cm)
TGW : Thousand Grain Weight (g)
HI :HarvestIndex
IRON : Iron Content (ppm)
ZINC : Zinc Content (ppm)
PC : Protein Content (%)
GYP : Grain Yield per plant(g)

Similarly, number of productive tillers per plant ranged from 2.12 in cluster II to 2.90 in cluster IV. Whereas, panicle length was highest in cluster IV (27.70 cm) and shortest in cluster V (24.75 cm). The panicle girth ranged from 2.73 cm in cluster V to 3.25 cm in cluster IV. The genotypes of cluster IV recorded high grain yield per plant (34.85 g), while genotypes of cluster V recorded low grain yield per plant (25.88 g). Thousand grain weight ranged from 10.55 g in cluster V to 12.30 g in cluster VI. Harvest index was maximum in cluster VII (49.48%) and was minimum in cluster IV (37.05%). The genotype in cluster V recorded high iron content (196.20 ppm), while genotypes in cluster I recorded low iron content (47.90 ppm). Zinc content was maximum in cluster V (72.88 ppm) and minimum in cluster I (19.65 ppm). Protein content was maximum in cluster VI (10.66%) and was minimum in cluster V (8.47%).

Cluster VII (API 1011 and API 1105) secured first rank with overall score of 41 among the seven clusters followed by cluster IV (API 2042) and cluster VI (API 2045, API 2048, API 2052, API 1103, API 1045 and API 1106) indicating the presence of most promising genotypes in them and can be extensively used for further crop improvement programme. The least ranking was recorded by cluster II followed by I, III and V.

Contribution of traits to diversity:

Among all the characters studied, maximum contribution towards genetic divergence is recorded by iron content (40.69%) by taking first rank in 2014 times out of 4950 combinations, followed by zinc content (18.32%), protein content (11.78%), thousand grain weight (6.42%), harvest index (6.16%), grain yield per plant (6.04%), number of productive tillers per plant (2.14%), plant height (1.88%), panicle girth (1.66%), panicle length (1.41%), days to 50% flowering (1.17%), relative water content (1.01%), days to maturity (0.79%) and SPAD chlorophyll meter reading (0.53%) contributed least towards genetic divergence. Fig. 3.

In the present study, by iron content, zinc content, protein content, thousand grain weight, harvest index and grain yield per plant were found the best discriminatory characters for better selection of diverse genotypes and contributing maximum towards divergence. Hence, these traits could be exploited maximum in order to get superior hybrids with higher yield.

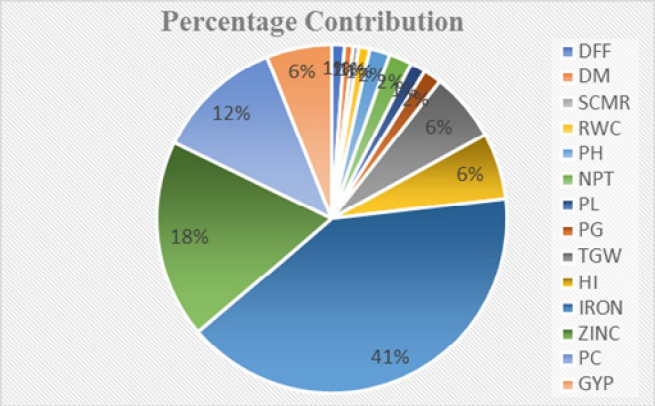

Fig. 3 : Relative contribution of different traits towards genetic divergence in pearl millet

Similar results were reported by Rachana *et al.* (2023) and Andhale *et al.* (2024) for iron content; Rachana *et al.* (2023) for zinc content; Kambel *et al.* (2022) and Rajpoot *et al.* (2023) for thousand grain weight; Rachana *et al*. (2023) and Rajpoot *et al.* (2023) for grain yield per plant; Saikumar *et al*. (2021) for number of productive tillers per plant and days to maturity; Barathi and Reddy (2022) for harvest index, plant height, panicle length and panicle girth; Kavitha *et al*. (2023) for days to 50% flowering; Gupta *et al* (2015) for relative water content; and Kumar *et al*. (2022) for SPAD chlorophyll meter reading.

Conclusion

Based on the divergence analysis, the cross combinations viz., API 2054 x API 1018, API 2054 x API 1039 and API 2052 x API 1012 (cluster I x cluster V) could be considered for obtaining a wide spectrum of variability among the segregants for high yield and nutritional traits. As cluster I had high yielding genotypes and cluster V with high iron and zinc content, along with high inter-cluster distance between cluster I and cluster V. Hybridization among the genotypes drawn from widely divergent clusters may exhibit high yield potential and also expected to generate greater heterotic effects as well as transgressive segregants.The distances between clusters were found to be greater than those within clusters, indicating a significant level of diversity among the parents. It also revealed the prevalence of high genetic diversity in pearl millet, which is very useful in defining heterotic groups for hybrid breeding, trait mapping, and holds promise for improving pearl millet for yield and nutritional quality.

References

Andhale, G.R., Shinde, C.S., Bhavsar, V.V and Barhate, K.K. (2024). Estimation of variability and genetic diversity in different genotypes of pearl millet (*Pennisetum glaucum* L.). *International Journal of Advanced Biochemistry Research*. **8**(9), 207-213

AOAC (1990) Official Methods of Analysis. Association of Official Analytical Chemists, Washington, D.C.

Barathi, M.B and Reddy, P.S. (2022). Genetic diversity analysis of indigenous collection of pearl millet [*Pennisetum glaucum* (L.) R. Br.] germplasm. *Electronic Journal of Plant Breeding*. **13**(4), 1220-1225.

Gupta, P.C., Agarwal, V.P., Narayan, S., Gupta, N.K and Singh, G. (2015). Studies on genetic associations, variability and diversity in pearl millet (*Pennisetum glaucum* (L.) R. Br.). *Indian Research Journal of Genetics and Biotechnology*. **7**(04), 405-414.

Gupta, S.K., Nepolean, T., Shaikh, C.G., Rai, K., Hash, C.T., Das, R.R and Rathore, A. (2018). Phenotypic and molecular diversity-based prediction of heterosis in pearl millet (*Pennisetum glaucum* L. (R.) Br.). *The Crop Journal*. **6**(3), 271-281.

Hassan, Z.M., Sebola, N.A and Mabelebele, M. (2021). The nutritional use of millet grain for food and feed: a review. *Agriculture & Food Security*, **10**, 1–14.

Hazra, P., Som, M.G and Das, P.K. (1992). Selection of parents for vegetable cowpea breeding by multivariate analysis. *Vegetable Science*, **19**, 166-173.

Indiastat (2025). *Area and Production of Bajra in India*. https://www.indiastat.com/.

Kamble, P.S., Barhate, K.K and Andhale, G.R. (2022). Genetic Diversity for Zinc, Iron and Yeild Contributing Characters in Pearl Millet (*Pennisetum glaucum* (L.) R.Br.) Genotypes. *International Journal of Multidisciplinary Research and Analysis*, **5**(06), 1194-1199.

Kavita, Yadav, D., Kumar, R., Chugh, L.K., Sheokand, R.N. and Singla, P. (2023). Genetic Divergence for Grain Quality and Agro-morphological Traits in Pearl Millet. *Annals of Arid Zone*. **63**(1), 87-98.

Kumar, I.P. (2022). DUS characterization and diversity analysis of inbred lines in pearl millet (*Pennisetum glaucum* (L.) R. Br.). *M.Sc. (Ag.) Thesis*. Acharya N.G. Ranga Agricultural University, Guntur.

Mahalanobis, P.C. (1936). A note on the statistical and biometric writings of Karl Pearson. *Sankhyā: The Indian Journal of Statistics*, **2**(4): 411-422.

Nath, V., Lal, H., Rai, M., Rai, N and Ram, D. (2009) Hierarchical Clustering and Character Association Studies in Cowpea [*Vigna unguiculata* (L.) Walp.]. *Indian Journal of Plant Genetic Resources*, **22**: 22-25.

Rachana, M., Athoni, B.K., Soregaon, C.D., Sajjanar, G and Biradar, A.H. (2023). Correlation and path coefficient studies in advanced breeding lines for yield and yield contributing traits along with grain micronutrients in pearl millet (*Pennisetum glaucum* (L.) R. Br.). *Cereal Research Communications*. **52**(2), 833-840.

Rajpoot, P., Tripathi, M.K., Solanki, R.S., Tiwari, S., Tripathi, N., Chauhan, S., Pandya, R.K and Khandelwal, V. (2023). Genetic variability and multivariate analysis in pearl millet (*Pennisetum glaucum* (L.) R. Br.) germplasm lines. *The Pharma Innovation Journal*. **12**(4), 216-26.

Ramya, A.R., Ahamed, M.L and Srivastava, R.K. (2017). Genetic diversity analysis among inbred lines of pearl millet [*Pennisetum glaucum* (L.) R. Br.] based on grain yield and yield component characters. *International*

Journal of Current Microbiology and Applied Sciences. **6**(6), 2240-2250.

Rao, C.R.V. (1952). *Advanced Statistical Methods in Biometrical Research*. John Wiley and Sons Inc. New York. 326-272.

Saikumar, P., Priya, M.S., Shanthi, P and Latha, P. (2021). Genetic divergence analysis in maintainer (B) and restorer (R) lines of pearl millet (*Pennisetum glaucum* (L.) R. Br.). *Electronic Journal of Plant Breeding*. **12**(4), 1120-1126.

Sharma, V., Sharma, L.D., Jakhar, M.L., Govindraj, M., Singh, R.V., Sharma, S.K., Parashar, N and Solanki, R.K. (2020). Genetic diversity in pearl millet inbred restorers for agro-morphological and grain quality traits. *Electronic Journal of Plant Breeding*. **11**(1), 310-313.

Tandon, H.L.S. (1999). *Methods of Analysis of Soils, Plants, Waters and Fertilizers*. Fertilizer Development and Consultation Organisation, New Delhi, India. 86-96.

Varshney, R.K., Shi, C., Thudi, M., Mariac, C., Wallace, J., Qi, P., Zhang, H., Zhao, Y., Wang, X., Rathore, A and Srivastava, R.K. (2017). Pearl millet genome sequence provides a resource to improve agronomic traits in arid environments. *Nature Biotechnology*. **35**(10), 969-976.