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Research Note

Genetic diversity in pearl millet inbred restorers for agro-morphological and grain quality traits

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Abstract
Genetic diversity was assessed in 60 pearl millet inbred restorers for 10 agro-morphological and six seed quality traits. High range of variation was observed and trait contribution to genetic diversity depicted that panicle length contributed the maximum (19.04 %) followed by panicle girth (18.76 %). Based on the clustering pattern, a total of 09 clusters were obtained of which Cluster II was the largest and comprised of 39 inbreds followed by cluster III with 10. Cluster mean depicted that cluster I, III and IX comprised of potential lines having a desirable mean performance for the traits studied. Cluster distance was also high among these aforesaid clusters thus suggesting their use in hybrid development as well as in recombination breeding for generating better inbreds in pearl millet.

Keywords
Pearl millet, inbred restorers, agro-morphological, seed quality, genetic diversity

Pearl millet is the third most important crop of India and the sixth most important crop globally. The inherent potential of pearl millet to grow under marginal and poor agro conditions makes it most preferred crop for cultivations in hot arid and semi-arid ecologies of the world (Tara *et al.,* 2017). In India, it is cultivated in and around 8.16 m ha area, with major acreage of about 56 % i.e., 4.62 m ha in western arid and semi-arid regions of Rajasthan. Indian national productivity is about 11.47 q/ha whereas of Rajasthan State it is 8.70 q/ha (Solanki *et al*., 2018) depicting a significant gap to be addressed. Development of hybrids in the past three decades, has led to the dramatic increase in the productivity levels at regional and national level both, an average yield increase of 20 kg/ha/year has been observed since the year 1990, but in harsh arid ecologies the productivity is low accounting 6.88 q/ha) (Solanki *et al*, 2018). The hybrid development programme strongly depends upon the recombination of diverse parents, therefore the selection of diverse seed parent and pollen parent is very important in developing high yielding hybrids. Hence it becomes imperative to study the extent of genetic diversity within the seed parent and pollen parent. There is a need to emphasis on quality traits also along with grain and stover yield. High nutritive value of millets made them classified as Nutri-cereals from coarse grains from the year 2018, studies have shown that high genetic variation exits in pearl millet for Fe (30 to 140 mg/kg) and Zn (20-90 mg/kg) content in grains (Govindaraj, 2019). Looking to the importance of both agro-morphological and seed quality traits, in the present investigation 60 pearl millet pollen parents i.e., inbred restorers were studied for genetic diversity in 10 agro-morphological traits and six seed quality traits.

Genetic diversity was assessed in 60 pearl millet inbred restorers for 10 agro-morphological and six seed quality traits. The experiment was conducted at RARI (Rajasthan Agricultural Research Institute), Jaipur (India) during *Kharif* 2017, the site is at 450 meters above mean sea level on latitude 26.49º and longitude 75.48º having semi-arid climate with an average annual rainfall of about 400 mm. The experiment was laid in RBD (Randomized Block Design) of 03 replications, each inbred was planted in 2 rows of 4 m length, row to row and plant to plant distance was 45 cm and 10-15 cm respectively. Recommended package of practices was followed: the crop was raised in rainfed conditions, during the cropping season 362.8 mm rainfall was received. Observation was recorded on 10 randomly selected plants on 10 agro-morphological traits *viz.,* DF: Days to 50 per cent flowering; DM: Days to maturity; PH: Plant height (cm); PTP: the no. of productive tillers/plant; PL: Panicle length (cm); PGM; Panicle girth (maximum point; cm): TW: 000-grain weight (g): GYP: Grain yield per plot (kg): DFY: Dry fodder yield per plot (kg): HI: Harvest index (%) and six seed quality traits viz., ZnC: Zinc content (ppm); FeC: Iron content (ppm); CC: Calcium content (ppm); PC: Phosphorus content (ppm); PRC: Protein content (%): MgC: Magnesium content (ppm). In the grain samples, iron and zinc were estimated by using Atomic Absorption Spectrophotometer (Jackson, 1973); whereas calcium, phosphorous and magnesium content was estimated following sulfuric acid-selenium (Se) digestion method (Sahrawat *et al.,* 2002). Mean values were analyzed using Indostat software for calculating the genetic distance using Mahalanobis D^2 Statistics (Rao, 1952), a further grouping of inbreds was done by Tocher method (Rao, 1952).

To understand the extent of genetic diversity for agro-morphological and seed quality traits; mean and range was estimated for each trait, potential inbred restorers showing the minimum and maximum performance was also identified (**Table 1)**. Out of sixty inbred lines, only four lines had minimum or maximum value for more than one trait *viz.,* RIB-15147 was earliest in flowering and maturity (43.33 days; 83.15 days), RIB-15177 was late in flowering and maturity (59.33 days; 92.0 days), RIB-11006 had minimum values for Zn content (23.78 ppm), Fe content (26.79 ppm) and protein content (8.69 %), RIB-16316 had the highest values for P content (4799.1 ppm) and Mg content (1695.3 ppm). High variation was observed for grain yield (0.07 to 0.5 kg/plot), dry fodder yield (0.43 to 2.98 kg/plot), iron content (26.79 to 108.48 ppm), Calcium content (164.34 to 436.31 ppm). The extent of genetic variation depicted a high level of genetic diversity in the set of inbreds. The character contribution to genetic diversity depicted that panicle length contributed maximum (19.04 %) followed by panicle girth (18.76 %), whereas important traits like grain yield, fodder yield, days to flowering contributed less than 5 %. Zn and Fe content contribution to diversity was 9.72 and 9.44 % respectively (**Table 1**).

Table 1. Mean, range and per cent contribution to diversity for 16 traits in pearl millet inbreds

Traits	Trait Mean	Minimum Value	Minimum Inbred Identified	Maximum Value	Maximum Inbred Identified	Contribution to Diversity (%)
Agro-morphological traits						
DF	52.31	43.33	RIB 15147	59.3	RIB-15177	2.94
DM	83.15	72.67	RIB-15147	92.0	RIB-15177	6.38
PH	130.31	98.67	RIB-16332	179.0	RIB-12341	8.87
PTP	1.40	1.00	RIB-16296	2.50	RIB-9185	3.56
PL	18.76	13.33	RIB-12306	28.33	RIB-12271	19.04
PGM	2.19	1.25	RIB-15148	3.50	J-2290	18.76
TW	10.00	7.40	RIB-12256	13.27	RIB-16 S/109	1.30
GYP	0.21	0.07	RIB-15175	0.50	RIB-12306	4.63
DFY	1.10	0.43	RIB-16308	2.98	RIB-15137	6.44
HI	14.93	4.58	RIB-15131	25.53	RIB-16328	0.28
Seed Quality Traits						
ZnC	45.62	23.78	RIB-11006	73.28	RIB-16320	9.72
FeC	49.72	26.79	RIB-11006	108.48	RIB-15177	9.44
CC	289.07	164.34	RIB-15147	436.31	RIB-494	1.69
PC	3920.96	3093.09	RIB16324	4799.1	RIB-16316	1.13
PRC	10.61	8.69	RIB-11006	13.74	RIB-11133	2.27
MgC	1398.51	904.16	RIB-16324	1695.3	RIB-16316	3.05

Based on Mahalanobis D^2 statistic and Tocher method, the 60 restorer lines of pearl millet were grouped into 9 clusters depicting a high degree of divergence in the material (**Table 2**). Cluster II was the largest and comprised of 39 genotypes followed by cluster III with 10 genotypes, cluster IV with 4 genotypes and cluster I with 2 genotypes. The remaining clusters *viz.,* cluster V, VI, VIII and IX were mono genotypic. Intra-cluster distance was highest in cluster IV (32.45) followed by cluster III (27.45), cluster II (24.51) and cluster I (3.24). The highest inter-cluster distance was exhibited between cluster III and IX (112.34) indicating wider genetic divergence among the clusters. Hence, crossing between inbreds grouped in diverse clusters may deliver variable inbreds for the desired heterotic response to develop hybrids in pearl millet. The lowest inter-cluster distance was observed between clusters V and VI, indicating that these clusters were genetically close.

Table 2. Clustering pattern and composition of pearl millet inbred restorers

Clusters	No of Inbreds	Composition of clusters
I	2	RIB lines:15177, 11133
II	39	RIB lines: 11506, 11577, 9205, 11086, 16296, 8079, 10011, 7056, 6031, 8127, 9215, 15076, 3135-18, 494, 16 S/S110, 16 S/111, 335 /74, 12256, 11006, 57, 16308, 15147, 9184, 16300, 11483, 12256, 13S071, 15148, 11591, 12171, 12141, 11487, 11096, 192, 16316 and G-73-107, J-2340, HBL-11, H-77/833-2
III	10	RIB lines 8089, 9178, 16324, 16328, 16 S/109, 15176, 15175, 16320, 9185 and 20K86
IV	4	RIB lines 5137, 15131, 8016 and J-2290
V	1	RIB-16332
VI	1	RIB-12271
VII	1	RIB-10181
VIII	1	RIB-12306
IX	1	RIB-12341

RIB stands for Rajasthan Inbred Bajra

Mean performance of the cluster was assessed to identify potential clusters for target traits. Looking to the desirable traits; cluster III (of 10 inbreds) contained early maturing lines (80.50 days) which also had the highest mean value of panicle girth (2.77 cm), 1000 seed weight (11.14 g) and high harvest index (17.62 %). Cluster I (of 02 inbreds) depicted late maturity based on mean performance (91.33 days) but had shown highest mean value for quality traits viz., Zn content (58.30 ppm), Fe Content (107.55 ppm) and protein content (13.15 %). However, mono genotype cluster IX (RIB 12341) had maximum mean values for plant height (179 cm), productive tillers (2.20), grain yield (0.25 kg/plot) and calcium content (407.19 ppm). These three clusters viz., I, III and IX can be used in developing suitable hybrids and inbred lines by recombination and the inter-cluster distance (D values) was also high *ie*., I to III (44.87), I to IX (112.34) and III to IX (123.34). Intra cluster distance was least in cluster I (3.24) and high in cluster III (27.45) suggesting a selection of inbreds from cluster III based on target traits for genetic improvement and hybrid development. Similarly, a high degree of diversity in pearl millet is also reported by Shanmuganathan *et al.* (2006), Vidyadhar and Devi (2007), Lakshmana *et al.* (2009) Pawar *et al.* (2010), Sumathi *et al.* (2016).

Table 3. Mean Values of Pearl Millet Inbred Restorers in different clusters for 16 Traits

Clusters	Agro-morphological Traits										Seed quality traits					
	DF	DM	PH	PTP	PL	PGM	TW	GYP	DFY	HI	ZnC	FeC	CC	PC	PRC	MgC
I	59.3	91.3	109.8	1.1	18.6	2.2	9.5	0.1	1.1	6.8	58.3	107.6	307.9	3689.8	13.2	1433.0
II	51.4	82.2	131.4	1.4	18.8	2.1	9.8	0.2	1.0	15.7	42.1	42.8	292.7	3983.6	10.3	1426.6
III	50.1	80.5	125.0	1.4	16.6	2.8	11.1	0.2	1.0	17.6	51.2	63.0	266.1	3642.6	10.5	1251.9
IV	58.5	90.3	147.8	1.4	18.7	2.6	10.0	0.2	2.2	7.0	53.1	56.7	335.8	4056.1	12.5	1403.5
V	57.7	88.7	98.7	1.4	24.7	2.1	10.7	0.2	0.8	17.6	40.0	38.6	173.9	4169.8	10.5	1428.9
Vi	58.7	90.0	110.3	1.2	28.3	1.9	9.3	0.2	1.4	10.6	53.1	50.1	237.1	3786.9	12.1	1515.5
VII	57.0	87.7	101.7	1.0	21.0	1.5	9.0	0.1	0.5	9.7	70.8	66.0	287.2	4364.5	12.5	1498.5
VIII	52.3	83.3	145.3	1.2	13.3	2.1	10.8	0.5	2.1	18.0	46.9	45.0	202.5	3686.5	9.3	1328.9
IX	54.0	85.3	179.0	2.2	26.0	1.7	8.0	0.3	1.7	11.3	41.5	42.2	407.2	3858.1	11.1	1502.8

The level of genetic diversity among the inbreds was very high, inbreds of cluster I, III and IX has shown desirable performance based on mean values, hence inbreds of these clusters can be used to develop hybrids or maybe recombined to generate new inbred lines. Panicle length and girth contributed the maximum to diversity depicting the extent of variation available in the set for utilization as it's the most significant trait contributing to seed yield. Quality traits are of high importance, inbreds with high Fe, Zn and protein available in cluster I offer an opportunity for breeders to use them in hybrid development programmes.

Table 4. Average Intra (in bold) and inter-cluster distance based on corresponding D^2 values

Cluster	I	II	III	IV	V	VI	VII	VIII	IX
I	**10.50 (3.24)**	2656.37 (51.54)	2013.32 (44.87)	2240.13 (47.33)	4842.77 (69.59)	4773.43 (69.09)	1449.33 (38.07)	4455.56 (66.75)	12620.28 (112.34)
II		**600.74 (24.51)**	1600.00 (40.00)	2248.66 (47.42)	1389.05 (37.27)	2432.46 (49.32)	1037.48 (32.21)	1422.04 (37.71)	4340.17 (65.88)
III			**753.50 (27.45)**	3695.42 (60.79)	4192.56 (64.75)	7383.96 (85.93)	2264.81 (47.59)	2520.04 (50.20)	15212.76 (123.34)
IV				**1053.01 (32.45)**	3972.78 (63.03)	3280.99 (57.28)	2892.29 (53.78)	2775.18 (52.68)	4563.01 (67.55)
V					**0.00 (00.00)**	213.74 (14.62)	693.80 (26.34)	4277.16 (65.40)	5096.53 (71.39)
Vi						**0.00 (00.00)**	724.69 (26.92)	6449.70 (80.31)	2224.07 (47.16)
VII							**0.00 (00.00)**	3031.60 (55.06)	6622.71 (81.38)
VIII								**0.00 (00.00)**	6655.30 (81.58)
IX									**0.00 (00.00)**

Note: The values in parenthesis represent the D-values i.e. "D^2

REFERENCES

Govindaraj M, Rai K. N., Cherian C., Pfeier W. H. Kanatti A. and Shivade H. (2019). Breeding Biofortified Pearl Millet Varieties and Hybrids to Enhance Millet Markets for Human Nutrition. Agriculture, **9** (106): 2-11.

Jackson, M.L. 1973. Soil and plant analysis. Prentice Hall of India Private Ltd, New Delhi

Lakshmana, D., Biradar, B.D. and Jolli, R.B. 2009. Genetic variability studies for quantitative traits in a pool of restorers and maintainers lines of pearl millet [*Pennisetum glaucum* (L.) R. Br.]. *Karnataka Journal of Agricultural Sciences*. **22**(4): 881-882.

Pawar, S., Dhoran, G.D. and Jagtap, E.K. 2010. Genetic diversity for morpho-physiological traits in inbreds, maintainers, restorers and male sterile lines of pearl millet. *International Journal of Plant Sciences*. **5**(1): 56-59.

Rao, C.R. 1952. Advanced statistical methods in biometrical research. John Wiley and Sons, New York.

Sahrawat, K.L., Kumar, R.G and Murthy, K.V.S. 2002. Sulfuric acid–selenium digestion for multi-element analysis in a single plant digest. Communications in soil science and plant analysis. **33**(19 and 20): 3757–3765.

Shanmuganathan, M., Gopalan, A. and Mohanraj, K. 2006. Genetic variability and multivariate analysis in pearl millet. *Journal of Agricultural Sciences-Sri Lanka*, **2**(1): 73-80.

Solanki, R. K., Mahla, H. R., Kakani, R. K., Choudhary, K. B. and Sharma, R. 2018. Stress tolerant crop varieties of major arid zone crops to promote resilience to climatic stresses. *Indian Farming*. **68** (9): 41-45.

Sumathi, P., Lalithkannan, R. and Revathi, S. (2016). Genetic analysis and diversity studies in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. *Electronic Journal of Plant Breeding*, **7**(4): 1014-1019.

Tara Satyavathi, C., Praveen Shelly, Mazumdar Saikat, Chugh, L.K. and Kawatra Asha (2017), Enhancing demand of pearl millet as super grain current status and way forward. ICAR - AICRP on Pearl millet, Jodhpur, Rajasthan, India. 20 Pp.

Vidyadhar, B. and Devi, I.S. (2007), Evolution of germplasm for genetic diversity in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. *The Journal of Research*, ANGRAU, **35**(1): 119-123.