



Studies on Variability, Character Association and Genetic Diversity in Maintainer Lines of Pearl Millet [*Pennisetum glaucum* (L.) R. Br.]

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Abstract: Variability, character association and genetic diversity were studied with 150 maintainer lines of pearl millet. Analysis of variance indicated significant variances among genotypes for all 12 quantitative traits studied. Characters like biological yield per plant, flag leaf width, tillers per plant and seed yield per plant showed high PCV along with high genetic advance as per cent of mean. Moderate heritability and GCV indicates the possibility of improving these characters through phenotypic selection. Seed yield had significant and positive correlation with biological yield, tillers per plant, plant height and flag leaf width. The direct and indirect effects of component characters like biological yield per plant, leaves per plant, flag leaf length, flag leaf width, panicle length, panicle diameter, plant height and tillers per plant were found positive on seed yield. Therefore, selection based on these component characters would results in improvement of seed yield also. Based on the D² analysis all genotypes were grouped into 18 clusters. The contribution of seed yield (27.58%) was found highest towards total divergence followed by biological yield (23.84%), days to maturity (21.20%) and days to flowering (7.36%), respectively. Nineteen genotypes were found superior for seed yield and other related traits in early and medium maturity group of genotypes. Three genotypes namely B-1116, B-1133 and B-1003 were substantially better in both seed yield and biological yield besides other related attributes. Therefore, these genotypes may be used in the breeding program for developing the dual purpose hybrids for arid zone.

Key words: Correlation, diversity, maintainer lines, pearl millet, quantitative traits, variability.

Pearl millet commonly known as '*Bajra*', is a coarse cereal that belongs to family Poaceae. This is the most important food grain crop mainly cultivated under rainfed situation in arid zone. The C₄ pathway of pearl millet enhances photosynthetic efficiency and ability to produce higher biomass under hot and dry environment. Pearl millet is well adapted to the production system characterized by low and erratic rainfall, frequent drought, high temperature and poor soil conditions. It is widely cultivated as sole crop as well as mixed crop with legumes. It is also cultivated exclusively for green fodder during summer and kharif season (Sharma, 2013). Its grains have high protein content (11.5%) with balanced amino acid profile and high level of iron, zinc and insoluble dietary fiber. These adaptive and nutritional features combined with high yield potential make pearl millet an important cereal crop that can effectively address the emerging

challenges of global warming, water shortages, land degradation and food related health issues (Khairwal *et al.*, 2007).

Utilization of different kinds of germplasm and breeding material is very critical in the diversification of cultivars. Hybrid parental lines are developed with considerable morphological diversity. In the development of A-lines, African germplasm has largely been used whereas locally adapted material has been utilized in R-line breeding programs in India to achieve adequate adaptation of hybrids to different agro-ecologies (Yadav *et al.*, 2012). In the breeding of seed parents, high grain yield potential of A-lines, both as lines *per se* as well as in hybrids is the most important consideration. Thus, high yield potential is the first target trait for which selection is targeted. High yield, however, is achieved in combination with other agronomic and farmers' preferred traits. Most of these agronomic traits have high heritability for which visual selection during generation advance is fairly effective.

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The present experiment has been conducted to determine the magnitude of genetic variability, character association and genetic diversity among maintainer lines of pearl millet. So that, promising inbred lines could be identified for the development of superior hybrids of pearl millet in arid zone.

Materials and Methods

A field study was conducted during kharif 2016 at experimental farm, College of Agriculture, SKRAU, Bikaner. The site is situated at 28.01°N latitude and 73.22°E longitude at an altitude of 234.70 meters and has a tropical arid climate with mean annual rainfall of 263 mm. The soil of the experimental field was loamy sand in texture and slightly alkaline in reaction, poor in organic carbon, low in available nitrogen and medium in phosphorus but high in available potassium.

A total of 150 maintainer lines of pearl millet procured from ICRISAT, Patancheru were evaluated in a randomized block design with two replications. Sowing was done on 5th July, 2016 accommodating 4 m long 2 rows per plot at 50 cm row distance as per standard seed rate of 4.0 kg ha⁻¹. Plant to plant distance was maintained 15 cm. A fertilizer dose of 60 kg N and 30 kg P ha⁻¹ was provided to the crop. A half dose of N and full dose of P were applied at the time of sowing, in the form of urea and DAP. The remaining half dose of the N was top dressed in the form of urea at 25 days after sowing. Additional foliar spray of 1% soluble NPK (18:18:18) was also applied to the crop at 40 and 55 days after sowing. Total 5 sprinkler irrigations were applied according to requirement of the crop. Two hand weedings were carried out at 18-20 and 32-35 days after sowing to have crop free from weeds.

Observations recorded for 12 characters viz. days to 50% flowering, days to maturity, plant height, number of tillers per plant, number of leaves per plant, flag leaf length, flag leaf width, panicle length, panicle width, biological yield per plant, seed yield per plant and harvest index were analyzed to study the variability, character association and genetic diversity in maintainer lines of pearl millet.

Results and Discussion

Analysis of variance revealed significant differences among maintainer lines of pearl

millet for all 12 characters indicating that the material has adequate genetic variability to support the breeding program for improving seed and biological yield of pearl millet (Table 1). In early and medium maturity groups of parental lines, nineteen genotypes were found superior for seed yield and other related traits. Out of them, three genotypes namely B-1116, B-1133 and B-1003 were found substantially better for both seed and biological yield along with other attributes (Table 2). These three genotypes were also found early in flowering and maturity, which is the fundamental requirement of rainfed situation in arid zone. Therefore, these genotypes may be used in the breeding program for developing the dual purpose hybrids in arid zone. High and significant variability for seed and biological yield in pearl millet has been reported by Unnikrishnan *et al.* (2004), Nagar *et al.* (2006), Shanmuganathan *et al.* (2006), Bhoite *et al.* (2008), Yadav (2008) and Maya (2008).

Estimates of genetic variability parameters for different characters in B-lines of pearl millet revealed that characters like biological yield per plant, flag leaf width, tillers per plant and seed yield showed high PCV along with high genetic advance as per cent of mean and moderate heritability and GCV, which indicates that these characters were under the control of additive gene action (Table 3). This suggests that the selection based on these characters would facilitate isolation of desirable genotypes.

Seed yield had significant and positive correlation with biological yield, tillers per plant, plant height and flag leaf width at phenotypic level (Table 4). Therefore, emphasis should be given to these characters while selecting parental lines of pearl millet for breeding program. The direct and indirect effects of component characters like biological yield per plant, leaves per plant, flag leaf length, flag leaf width, panicle length, panicle diameter, plant height and tillers per plant were found positive on seed yield (Table 5). Therefore, selection based on these component characters would result in improvement of seed yield also. The magnitude of residual effect was medium which indicated that major portion of contribution towards seed yield may be explained on the basis of characters included in the study. Similar findings in pearl millet have been reported by Chaudhry *et al.* (2003) and Yadav *et al.* (2004).

Table 1. Analysis of variance for different characters in maintainer lines of pearl millet

Source of variation	D.F.	Days to 50% flowering	Days to maturity	Plant height	Tillers/ plant	Leaves/ plant	Flag leaf length	Flag leaf width	Panicle length	Panicle diameter	Biological yield/ plant	Seed yield/ plant
Replication	1	10.08	0.27	4.17	0.50	28.85	40.55	3.20	6.84	0.03	241.80	1.33
Genotypes	149	75.05**	59.25**	759.36**	0.40**	1.94*	41.72**	0.46**	19.36**	0.29**	1454.85**	452.74**
Error	149	5.46	2.35	205.30	0.14	1.44	10.16	0.12	4.06	0.10	96.61	28.78

*Significant at P = 0.05; ** Significant at P = 0.01.

Table 2. Yield and related traits in superior maintainer lines of pearl millet

Genotypes	Days to 50% flowering	Days to maturity	Plant height (cm)	Tillers/ plant	Leaves/ plant	Flag leaf length (cm)	Flag leaf width (cm)	Panicle length (cm)	Panicle diameter (cm)	Biological yield (g)	Seed yield/ plant (g)	Harvest Index (%)
B-1003	51.00	77.00	151.50	1.33	10.50	34.00	3.09	20.50	2.75	175.50	62.50	35.59
B-1008	54.00	80.00	90.00	3.17	9.00	35.50	3.10	15.25	2.87	123.50	52.50	42.55
B-1033	55.50	79.00	145.00	1.00	11.00	29.50	3.00	20.00	2.73	139.50	49.50	35.46
B-1038	53.50	78.00	120.50	1.17	12.00	27.50	2.38	15.58	2.02	103.50	51.50	49.78
B-1039	53.00	78.50	117.33	1.17	11.50	30.00	2.70	18.00	2.48	133.17	62.50	46.93
B-1049	55.00	82.00	111.33	1.17	10.50	33.00	2.77	18.50	2.55	145.17	52.50	36.22
B-1057	51.50	76.50	92.00	1.17	11.33	28.00	3.00	23.33	2.53	129.50	63.00	48.69
B-1062	58.00	81.00	146.50	2.67	10.00	28.50	3.28	21.50	3.13	143.50	68.50	47.76
B-1064	56.50	78.00	138.00	2.67	11.33	22.13	2.88	15.62	2.74	123.50	61.50	49.71
B-1069	54.50	81.00	109.00	1.33	10.17	27.50	2.48	16.67	2.33	138.33	67.00	48.41
B-1074	52.00	79.00	160.00	1.33	9.83	34.33	3.30	24.50	2.22	114.50	53.50	46.69
B-1078	54.50	81.00	110.33	1.50	10.00	26.50	2.57	18.67	2.37	124.00	58.50	47.17
B-1079	55.00	78.50	105.00	1.33	10.50	32.67	2.50	19.17	2.81	138.17	63.00	45.62
B-1088	56.50	79.50	122.00	1.00	8.50	31.75	4.30	26.58	3.57	136.50	65.50	48.03
B-1099	56.50	80.00	129.50	1.50	9.83	26.00	3.93	22.50	1.63	143.17	58.00	40.27
B-1116	45.00	69.00	180.50	2.00	7.17	25.67	2.90	15.68	1.81	140.00	49.00	35.00
B-1132	57.50	81.00	84.50	2.33	10.50	30.00	2.71	24.50	3.17	168.00	71.00	42.27
B-1133	49.50	75.50	126.50	1.33	9.00	25.50	2.48	21.23	2.48	156.50	71.50	45.72
B-1141	58.50	79.00	155.50	1.33	10.00	24.00	2.68	21.50	3.07	140.00	54.50	38.95

Table 3. Estimates of genetic variability parameters for different characters in maintainer lines of pearl millet

Characters	Range	Mean	GCV	PCV	Heritability (%)	Genetic advance	GA as % of mean
Days to 50% flowering	45.00 - 75.50	63.58	9.28	9.98	86.00	11.29	17.77
Days to maturity	69.00 - 97.00	86.89	6.14	6.39	92.00	10.56	12.15
Plant height (cm)	66.20 - 180.50	119.16	13.97	18.43	57.00	25.99	21.81
Tillers/plant	1.00 - 3.30	1.45	24.75	35.59	48.00	0.52	35.46
Leaves/plant	7.20 - 12.70	10.29	4.89	12.63	15.00	0.40	3.90
Flag leaf length (cm)	17.50 - 39.50	27.98	14.19	18.20	60.80	6.38	22.81
Flag leaf width (cm)	1.51 - 4.30	2.91	14.08	18.50	57.90	0.64	22.06
Panicle length (cm)	13.50 - 39.50	19.51	14.18	17.54	65.40	4.61	23.62
Panicle diameter (cm)	1.60 - 3.60	2.60	11.77	16.92	48.00	0.44	16.86
Biological yield/plant (g)	54.50 - 197.70	117.86	22.11	23.63	87.00	50.23	42.62
Seed yield/plant (g)	17.50 - 73.50	43.47	33.49	35.69	88.00	28.14	64.75

Table 4. Phenotypic (P) and genotypic (G) correlation coefficient for maintainer lines in pearl millet

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Table 5. Phenotypic (P) and genotypic (G) path coefficient of various characters on seed yield in maintainer lines of pearl millet

Characters		Days to 50% flowering	Days to maturity	Plant height	Tillers plant ⁻¹	Leaves plant ⁻¹	Flag leaf length	Flag leaf width	Panicle length	Panicle diameter	Bio-logical yield	Seed yield/plant
Days to 50% flowering	P	-0.427	-0.116	0.019	-0.007	0.003	0.005	-0.008	0.000	0.001	-0.162	-0.692**
	G	-0.770	0.125	-0.016	-0.013	0.048	0.022	-0.034	0.002	0.013	-0.166	-0.790
Days to maturity	P	-0.400	-0.124	0.020	-0.006	0.003	0.005	-0.008	0.000	0.001	-0.162	0.671**
	G	-0.733	0.131	-0.018	-0.015	0.052	0.020	-0.044	0.003	0.016	-0.161	-0.750
Plant height	P	0.121	0.037	-0.068	-0.002	0.005	-0.006	0.009	0.001	-0.001	0.105	0.200**
	G	0.199	-0.040	0.060	-0.019	-0.019	-0.032	0.034	-0.013	-0.018	0.117	0.270
Tillers/plant	P	0.015	0.004	0.001	0.198	-0.005	-0.004	0.003	-0.002	-0.001	0.145	0.355**
	G	0.048	-0.010	-0.006	0.204	-0.056	-0.024	0.002	0.017	-0.015	0.131	0.292
Leaves/plant	P	-0.039	-0.011	-0.009	-0.025	0.035	-0.001	-0.008	0.002	0.001	-0.013	-0.068
	G	-0.127	0.024	-0.004	-0.039	0.290	-0.029	-0.189	-0.014	-0.002	-0.072	-0.163
Flag leaf length	P	0.048	0.013	-0.010	0.016	0.001	-0.044	0.024	0.002	0.000	0.061	0.110
	G	0.087	-0.014	0.010	0.025	0.043	-0.196	0.109	-0.019	0.007	0.071	0.124
Flag leaf width	P	0.047	0.015	-0.009	0.009	-0.004	-0.015	0.068	0.002	0.000	0.053	0.166**
	G	0.082	-0.018	0.006	0.001	-0.170	-0.066	0.323	-0.018	-0.001	0.068	0.207
Panicle length	P	-0.018	-0.002	-0.006	-0.034	0.005	-0.010	0.013	0.010	0.000	0.071	0.029
	G	0.015	-0.004	0.010	-0.047	0.056	-0.050	0.080	-0.074	0.008	0.085	0.079
Panicle diameter	P	-0.037	-0.013	0.006	-0.019	0.007	-0.001	0.000	0.000	0.006	-0.008	-0.059
	G	-0.110	0.022	-0.011	-0.033	-0.007	-0.015	-0.005	-0.006	0.094	-0.028	-0.099
Biological yield	P	0.161	0.047	-0.016	0.067	-0.001	-0.006	0.008	0.002	-0.001	0.429	0.690**
	G	0.343	-0.056	0.019	0.072	-0.056	-0.037	0.058	-0.017	-0.007	0.374	0.692

Based on D² statistic, 150 maintainer lines were grouped into 18 clusters. The cluster I was the largest and consists of 80 genotypes followed by cluster II with 54 genotypes, and rest of clusters had solitary genotype (Table 6). This grouping indicated considerable diversity among pearl millet genotypes. The maximum intra cluster distance was recorded for cluster I followed by cluster II and the highest inter cluster distance was observed between cluster XVI and cluster XVII (Table 7). Thus, genotypes of outstanding mean performance from these clusters may be utilized in hybridization program for development of superior hybrids in pearl millet. The contribution of seed yield (27.58%) was found highest towards total divergence followed by biological yield (23.84%), days to maturity (21.20%) and days to flowering (7.36%), respectively; however,

least contribution was recorded for leaves per plant (Table 8).

It is therefore inferred from the study that parental lines have adequate genetic variability to support the breeding program of pearl millet in arid zone and characters like biological yield, flag leaf width, tillers per plant and seed yield were positively correlated and controlled by additive gene action. Therefore, these component traits may be taken into consideration for pearl millet improvement program.

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Table 6. Composition of D^2 clusters in maintainer lines of pearl millet

Cluster numbers	No. of genotypes	Composition of clusters
	80	B-1039, B-1056, B-1078, B-1069, B-1079, B-1119, B-11041, B-1126, B-1052, B-1096, B-1087, B-1067, B-1043, B-1019, B-1010, B-1051, B-1065, B-1014, B-1071, B-1032, B-1013, B-1076, B-1011, B-1086, B-1098, B-1050, B-1012, B-1127, B-1100, B-1101, B-1020, B-1006, B-1048, B-1124, B-1143, B-1034, B-1044, B-1137, B-1061, B-1018, B-1121, B-1104, B-1054, B-1024, B-1055, B-1150, B-1033, B-1030, B-1005, B-1063, B-1089, B-1108, B-1074, B-1136, B-1015, B-1111, B-1123, B-1049, B-1002, B-1062, B-1023, B-1095, B-1112, B-1107, B-1135, B-1118, B-1004, B-1145, B-1146, B-1038, B-1103, B-1122, B-1141, B-1099, B-1009, B-1053, B-1148, B-1125, B-1140, B-1022
	54	B-1036, B-1059, B-1082, B-1084, B-1134, B-1029, B-1042, B-1083, B-1046, B-1085, B-1094, B-1097, B-1128, B-1092, B-1081, B-1027, B-1115, B-1025, B-1139, B-1131, B-1144, B-1129, B-1045, B-1080, B-1073, B-1070, B-1058, B-1142, B-1147, B-1077, B-1068, B-1066, B-1091, B-1138, B-1090, B-1017, B-1130, B-1114, B-1106, B-1075, B-1102, B-1149, B-1113, B-1035, B-1031, B-1021, B-1093, B-1037, B-1047, B-1060, B-1007, B-1028, B-1072, B-1105
	1	B-1016
	1	B-1003
	1	B-1110
	1	B-1040
	1	B-1057
VIII	1	B-1117
IX	1	B-1064
X	1	B-1133
XI	1	B-1109
XII	1	B-1001
XIII	1	B-1132
XIV	1	B-1088
XV	1	B-1008
XVI	1	B-1026
XVII	1	B-1116
XVIII	1	B-1120

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Table 8. Contribution of different characters towards total divergence in maintainer lines of pearl millet

Characters	Per cent contribution
Days to 50% flowering	7.36
Days to maturity	21.20
Plant height	4.68
Tellers/plant	2.81
Leaves/plant	0.43
Flag leaf length	3.32
Flag leaf width	3.45
Panicle length	3.73
Panicle diameter	1.60
Biological yield	23.84
Seed yield	27.58

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