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Studies on variability, character association and genetic diversity in r-lines of pearl millet

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Abstract

A field study conducted with 150 R-lines of pearl millet revealed significant differences in the germplasm 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 percent of mean and moderate heritability and GCV. 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. Genotypes were grouped into 8 diversified clusters. The contribution of seed yield (45.51%) was found highest towards total divergence followed by biological yield (27.53%) and days to maturity (9.23%), respectively.

Twenty genotypes in restorer lines were found reasonably superior in seed yield and other related traits in early maturity and medium maturity group of genotype. Out of them five genotypes namely R-1088, R-1008, R-1095, R-1124 and R-1094 substantially showed higher mean values for seed yield as well as biological yield per plant. Therefore, these genotypes may be used in the breeding programme for developing the dual purpose hybrids for arid zone.

Keywords: variability, character association, r-lines, pearl millet

Introduction

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) commonly known as “Bajra”, is a coarse cereal 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 or mixed crop with legumes and intercropped with woody perennials. It is also cultivated exclusively for green fodder during summer and *Kharif* season (Sharma, 2013a) [6]. 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) [3].

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 programmes in India to achieve adequate adaptation of hybrids to different agro-ecologies (Yadav *et al.*, 2012) [8]. 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 made. 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.

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

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Materials and Methods

A field study was conducted during *Kharif* 2016 at the 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 R-lines of pearl millet received 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. 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 weeding 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 percent 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 R-lines of pearl millet.

Results and Discussion

Analysis of variance revealed significant differences among R-lines of pearl millet for all 12 characters indicating that the material has adequate genetic variability to support the breeding programme for improving seed and biological yield of pearl millet (Table-1). In early and medium maturity group of parental lines, twenty genotypes were found superior for seed yield and other related traits. Out of them, three genotypes namely R-1088, R-1008, R-1095, R-1124 and R-1094 were found substantially better for both seed yield and biological yield along with other attributes (Table-2). These four 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 programme for developing the dual purpose hybrids in arid zone. High and significant variability for seed and biological yield in pearl millet has been reported Unnikrishnan *et al.* (2004) [7], Nagar *et al.* (2006) [4], Shanmuganathan *et al.* (2006) [5] and Bhoite *et al.* (2008) [11].

Estimates of genetic variability parameters for different characters in R-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 percent of mean and moderate heritability and GCV, which indicates that these characters were under the control of additive gene action (Table 3). Therefore, selection of the male sterile line based on these component traits could be utilized for crossing to exploit genetic potential of the genotype.

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 programme. 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) [2] and Yadav *et al.* (2004) [9].

D² analysis proved to be a very useful technique in isolating diverse genotypes from the material under study. On the basis of D² statistic, One hundred fifty restorer lines of pearl millet were grouped into 8 clusters indicating the presence of high degree of divergence in the material. Cluster I was the largest and comprised of 64 genotypes followed by cluster II with 39 genotypes, cluster III with 22 genotypes, cluster IV with 16 genotypes and cluster VII with 6 genotypes. The remaining clusters V, VI and VIII were mono genotypic. This grouping indicated considerable diversity among pearl millet genotypes. The maximum intra cluster distance was recorded for cluster VII followed by cluster IV, III, II and I and the highest inter cluster distance was observed between cluster III and cluster V (Table 7). Thus, the crossing between genotypes of these two clusters hold good promise as parents for obtaining potential hybrids and thereby of creating large variability for superior hybrids in pearl millet. The contribution of seed yield (45.51%) was found highest towards total divergence followed by biological yield (27.53%) and days to maturity (9.23%), 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 programme 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 programme.

Table 1: Analysis of variance for different characters in R-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	6.16	13.23	1731.21	1.34	22.21	5.51	0.14	3.13	1.07	2144.01	1972.89
Genotypes	149	64.98**	55.80**	595.50**	0.58**	1.23*	44.11**	.519**	21.09**	0.27**	2418.85**	364.49**
Error	149	14.28	4.03	207.64	0.17	0.92	9.02	0.10	3.59	0.06	84.15	7.42

*Significant at P = 0.05, ** Significant at P = 0.01

Table 2: Yield and related traits in superior B-lines of pearl millet

Genotype	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
R-1007	58.50	78.50	157.17	1.50	10.33	37.50	2.73	25.50	3.58	224.17	60.00	26.77
R-1008	51	71	153.00	2.50	10.67	30.50	2.03	19.50	2.10	171.50	66.00	38.67
R-1036	59.50	80.50	154.50	1.83	10.17	37.00	3.38	23.00	2.55	192.50	59.00	30.62
R-1045	59	80.50	165.83	2.50	11.33	32.83	2.33	20.00	2.28	158.50	52.50	33.13
R-1046	55	78.50	158.67	1.67	10.67	33.00	2.45	21.00	2.27	150.50	56.00	37.2
R-1061	52.50	74.50	149.17	2.33	8.17	31.83	3.33	20.10	2.22	168.50	53.50	31.78
R-1072	56	78	127.00	1.33	8.33	35.50	3.60	21.00	2.15	143.00	44.50	31.19
R-1073	55	79.50	167.50	1.67	9.00	29.92	2.62	23.50	2.70	173.50	64.00	36.89
R-1074	51.50	73	161.50	1.33	10.17	32.00	2.43	18.00	2.33	186.50	62.00	33.3
R-1088	46	72	183.67	1.50	11.17	33.55	4.15	23.67	2.98	249.50	72.00	28.86
R-1094	50	74.50	139.67	2.50	10.50	32.00	2.82	19.50	3.35	172.50	60.50	35.08
R-1095	49.50	77	133.00	1.83	11.00	21.50	2.03	17.25	1.98	148.50	57.00	38.39
R-1097	52	77	137.00	1.83	11.17	37.00	2.98	21.50	2.58	148.50	55.50	37.36
R-1122	55	78	146.50	2.33	9.50	33.33	2.98	22.17	3.00	199.50	55.50	27.85
R-1123	56.50	78.50	172.67	1.83	10.50	36.33	2.72	21.00	2.93	230.33	52.00	22.64
R-1124	50	75	155.67	1.67	10.17	32.00	2.18	26.33	1.97	246.00	59.00	24.02
R-1128	56.50	77.50	144.67	2.00	10.17	31.17	2.92	33.50	2.83	174.50	59.00	22.19
R-1143	54	80.50	151.00	3.00	10.67	34.83	3.78	27.50	2.95	239.00	68.50	29.59
R-1149	50.50	76	168.83	2.67	10.50	28.50	2.81	20.50	2.10	142.00	51.50	25.89
R-1150	51.50	77.50	144.50	2.17	10.00	35.50	3.28	21.00	2.30	148.50	53.50	36.27

Table 3: Estimates of genetic variability parameters for different characters in R-lines of pearl millet

S. No.	Characters	Range	Mean	GCV	PCV	Heritability (%)	Genetic Advance	GA as % of mean
1	Days to 50% flowering	46 – 73	61.48	8.19	10.24	64	8.29	13.49
2	Days to maturity	71 - 95.50	84.68	6.01	6.45	86	9.75	11.51
3	Plant height (cm)	108.50 – 200	146.48	9.51	13.68	48	19.94	13.61
4	Tillers/plant	1 - 3.83	1.75	25.91	35.04	54.70	0.69	39.45
5	Leaves/plant	8 - 12.33	10.23	3.83	10.15	14.30	0.31	2.98
6	Flag leaf length (cm)	20.45 - 44.67	31.48	13.31	16.38	66	7.01	22.28
7	Flag leaf width (cm)	1.72 - 4.15	2.77	16.48	20.16	66.80	0.77	27.76
8	Panicle length (cm)	14.33 - 33.5	21.22	13.95	16.56	70.90	5.13	24.19
9	Panicle diameter (cm)	1.71 - 3.58	2.51	12.86	16.23	62.80	0.53	20.99
10	Biological yield/plant (g)	77.50 - 249.50	149.86	22.79	23.61	93.30	67.98	45.36
11	Seed yield/plant (g)	13.50 – 72	38.69	34.53	35.24	96	26.97	69.69

Table 4: Phenotypic and genotypic Correlation coefficient for different characters for R-lines in pearl millet

Characters		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	seed yield/plant
Days to 50% flowering	P	1	0.8664**	-0.2603**	-0.1228*	0.0100	0.0169	0.0194	-0.1508**	0.0735	-0.3726**	-0.6820**
	G	1	0.9468	-0.2801	-0.1380	0.2297	-0.0309	-0.0129	-0.1743	0.0298	-0.4525	-0.8658
Days to maturity	P		1	-0.2400**	-0.1372*	0.0825	-0.0106	-0.0067	-0.1142*	0.0186	-0.3904**	-0.6859**
	G		1	-0.2832	-0.1527	0.2727	-0.0541	-0.0263	-0.1191	-0.0021	-0.4238	-0.7557
Plant height	P			1	0.1794**	0.1302*	0.0003	0.0712	0.2798**	0.1733**	0.3667**	0.3401**
	G			1	0.1896	0.5124	-0.0053	0.0398	0.3612	0.1216	0.5521	0.5078
Tillers/ plant	P				1	0.1192*	-0.0774	0.0044	0.0758	-0.0020	0.1899**	0.2703**
	G				1	0.2359	-0.1367	-0.0534	0.1479	0.0034	0.2814	0.3642
Leaves/ Plant	P					1	-0.0791	-0.0924	0.0163	-0.0389	0.0652	0.0479
	G					1	-0.1737	0.0293	0.3098	0.0558	0.0513	0.1062
Flag leaf length	P						1	0.4148**	0.2454**	0.2423**	0.0961	0.0493
	G						1	0.4498	0.3096	0.3442	0.1208	0.0523
Flag leaf width	P							1	0.2759**	0.3701**	0.2611**	0.1373*
	G							1	0.3247	0.4131	0.3282	0.1752
Panicle length	P								1	0.2254**	0.3554**	0.3329**
	G								1	0.2594	0.4669	0.4118
Panicle diameter	P									1	0.2212**	0.0609
	G									1	0.2889	0.0870
Biological yield	P										1	0.6354**
	G										1	0.6488
Seeds yield/ plant	P											1
	G											1

Table 5: Phenotypic (P) and genotypic (G) path coefficient of various characters on seed yield in R-line of pearl millet

Characters		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	Seed yield/plant
Days to 50% flowering	P	-0.2591	-0.2540	-0.0047	-0.0141	0.0004	-0.0001	0.0006	-0.0184	-0.0023	-0.1304	-0.6820**
	G	-1.3582	0.5813	-0.0355	0.0264	0.0270	-0.0002	-0.0015	-0.0083	0.0004	-0.0445	-0.8658
Days to maturity	P	-0.2245	-0.2931	-0.0043	0.0157	0.0029	0.0001	-0.0002	-0.0139	-0.0006	-0.1366	-0.6859**
	G	-1.2859	0.6140	-0.0359	0.0292	0.0321	-0.0003	-0.0031	-0.0057	0.0000	-0.0417	-0.7557
Plant height	P	0.0674	0.0703	0.0179	0.0206	0.0046	0.0000	0.0022	0.0341	-0.0053	0.1283	0.3401**
	G	0.3805	-0.1739	0.1267	0.0036	0.0603	0.0000	0.0047	0.0172	0.0017	0.0543	0.5078
Tillers/Plant	P	0.0318	0.0402	0.0032	0.1145	0.0042	0.0005	0.0001	0.0092	0.0001	0.0665	0.2703**
	G	0.1874	-0.0937	0.0240	0.1911	0.0278	0.0008	-0.0064	0.0070	0.0000	0.0277	0.3642
Leaves/Plant	P	-0.0026	-0.0242	0.0023	0.0136	0.0351	0.0005	-0.0029	0.0020	0.0012	0.0228	0.0479
	G	-0.3120	0.1674	0.0649	0.0451	0.1177	0.0010	0.0035	0.0147	0.0008	0.0050	0.1062
Flag leaf length	P	-0.0044	0.0031	0.0000	0.0089	-0.0028	-0.0067	0.0129	0.0299	-0.0075	0.0336	0.0493
	G	0.0420	-0.0332	-0.0007	0.0261	-0.0204	0.0057	0.0537	0.0147	0.0048	0.0119	0.0523
Flag leaf width	P	-0.0050	0.0020	0.0013	0.0005	-0.0032	-0.0028	0.0311	0.0336	-0.0114	0.0914	0.1373*
	G	0.0176	-0.0162	0.0050	0.0102	0.0034	0.0025	0.1194	0.0154	0.0058	0.0323	0.1752
Panicle length	P	0.0391	0.0335	0.0050	0.0087	0.0006	-0.0016	0.0086	0.1218	-0.0069	0.1244	0.3329**
	G	0.2368	-0.0731	0.0458	0.0263	0.0365	0.0018	0.0388	0.0476	0.0036	0.0459	0.4118
Panicle Diameter	P	-0.0191	-0.0055	0.0031	0.0002	-0.0014	-0.0016	0.0115	0.0274	-0.0308	0.0774	0.0609
	G	-0.0405	-0.0013	0.0154	0.0007	0.0066	0.0019	0.0493	0.0123	0.0140	0.0264	0.0870
Biological yield	P	0.0965	0.1144	0.0066	0.0218	0.0023	-0.0006	0.0081	0.0433	-0.0068	0.3499	0.6354**
	G	0.6147	-0.2602	0.0700	0.0538	0.0060	0.0007	0.0392	0.0222	0.0041	0.0984	0.6488

Table 6: Composition of clusters for R-lines of pearl millet

Clusters	Number of genotypes	Composition of clusters
I	64	R-1063, R-1104, R-1100, R-1052, R-1028, R-1067, R-1057, R-1071, R-1134, R-1101, R-1139, R-1070, R-1025, R-1076, R-1110, R-1077, R-1050, R-1069, R-1137, R-1083, R-1054, R-1089, R-1033, R-1031, R-1048, R-1116, R-1098, R-1087, R-1066, R-1096, R-1011, R-1075, R-1136, R-1015, R-1090, R-1108, R-1026, R-1030, R-1009, R-1027, R-1117, R-1115, R-1144, R-1044, R-1010, R-1042, R-1085, R-1118, R-1017, R-1024, R-1112, R-1014, R-1047, R-1121, R-1131, R-1084, R-1034, R-1126, 1020, R-1103, R-1138, R-1092, R-1120, R-1145.
II	39	R-1109, R-1114, R-1064, R-1001, R-1005, R-1036, R-1045, R-1046, R-1150 R-1073, R-1086, R-1097, R-1106, R-1149, R-1061, R-1039, R-1006, R-1038, R-1082, R-1072, R-1102, R-1058, R-1093, R-1111, R-1012, R-1095, R-1019, R-1142, R-1146, R-1049, R-1081, R-1122, R-1022, R-1018, R-1029, R-1043, R-1074, R-1013, R-1094.
III	22	R-1055, R-1062, R-1105, R-1040, R-1079, R-1037, R-1021, R-1060, R-1004, R-1133, R-1032, R-1065, R-1053, R-1080, R-1051, R-1113, R-1041, R-1125, R-1078, R-1132, R-1068, R-1056.
IV	16	R-1091, R-1107, R-1119, R-1135, R-1141, R-1147, R-1035, R-1003, R-1127, R-1099, R-1130, R-1148, R-1002, R-1140, R-1123, R-1016
V	1	R-1008
VI	1	R-1007.
VII	6	R-1059, R-1129, R-1128, R-1143, R-1124, R-1088
VIII	1	R-1023

Table 7: Average intra (in bold) and inter cluster D² value in R-lines of pearl millet

Clusters	I	II	III	IV	V	VI	VII	VIII
I	23.10	53.10	44.34	71.20	124.83	106.92	112.61	43.99
II	53.10	27.58	118.10	95.23	45.77	61.16	66.02	90.90
III	44.34	118.10	32.04	107.03	227.79	197.79	199.90	51.16
IV	71.20	95.23	107.03	45.18	166.75	81.02	97.71	113.05
V	124.83	45.77	227.79	166.75	0	64.94	73.16	190.03
VI	106.92	61.16	197.79	81.02	64.94	0	45.94	173.11
VII	112.61	66.02	199.90	97.71	73.16	45.94	56.73	163.09
VIII	43.99	90.90	51.16	113.05	190.03	173.11	163.09	0

Table 8: Mean values for seed yield and component characters in various clusters in R -lines of pearl millet

Clusters	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	Seed yield/plant
I	63.05	86.05	145.04	1.68	10.16	31.46	2.76	20.65	2.54	136.82	34.12
II	55.99	79.51	149.38	1.84	10.09	31.22	2.78	21.30	2.47	157.29	51.63
III	67.91	90.50	135.93	1.54	10.38	31.71	2.62	19.69	2.35	113.02	20.06
IV	63.50	86.56	151.21	1.98	10.54	31.53	3.02	22.66	2.70	209.06	39.78
V	51	71	153	2.50	10.67	30.50	2.03	19.50	2.10	171.50	66
VI	58.50	78.50	157.17	1.50	10.33	37.50	2.74	25.50	3.59	224	60
VII	54.25	79.17	170.72	2.03	10.55	31.96	2.89	28.19	2.48	207.17	61.25
VIII	59	94	119.50	1.17	10	29	1.98	20.17	2.25	118	35.50

Table 9: Contribution of different characters towards total divergence in parental lines of pearl millet

S. No.	Name of characters	Contribution of characters in R-lines
1.	Days to 50% flowering	0.38%
2.	Days to maturity	9.23%
3.	Plant height	1.23%
4.	Tellers/plant	1.96%
5.	Leaves/plant	0.28%
6.	Flag leaf length	3.96%
7.	Flag leaf width	2.99%
8.	Panicle length	3.96%
9.	Panicle diameter	2.95%
10.	Biological yield	27.53%
11.	Seed yield	45.51%

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