Research Article

Genetic Divergence, Character Association and Path Coefficient Analysis for Yield Attributing Traits in Pearl Millet [*Pennisetum Glaucum* (L.) R. Br] Inbreds

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Abstract

Efforts were made on augmentation of 49 pearl millet inbred lines to estimate the genotypic and phenotypic variability, heritability, genetic advance, correlation and path coefficient for yield and its contributing quantitative characters. The study revealed wide variation for all the quantitative characters indicating sufficient genetic variability to be exploited in breeding programme. Correlation analysis revealed that grain yield potential had positive and highly significant associations with time of spike emergence, productive tillers, 1000-grain weight, plant height, dry fodder yield and green fodder yield potential. Path coefficients analysis revealed that plant height (0.438) followed by 1000 grain weight (0.309), spike length (0.239) and number of productive tillers (0.180) had high direct contribution towards grain yield per plant, whereas, indirect effects of independent traits indicated that plant height and 1000 grain weight exhibited high contribution towards grain yield potential. Hence, it would be rewarding to lay stress on these characters in selection programme for increasing yield.

Keywords: Pearl millet, inbred, genetic advance, heritability, correlation, path coefficient

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Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br] is the staple food grain and as a source of feed, fodder, fuel and construction material for hundreds of millions of the world's poorest [1-3]. Pearl millet is one of the major cereals grown, primarily for grain production, occupying more than 29 mha in the arid and semi-arid tropical regions of Africa and Asia [1]. India is the largest producer of pearl millet in Asia and occupied an area of 7.95 mha with production of 8.79 mt and productivity 1106 kg/ha [4]. Pearl millet in India is mainly grown in *kharif* season and resistant to drought in comparison to other cereals. Pearl millet is 'high energy' coarse cereal with high starch (70%) in dry grain, protein (10-12%) and 5-7% fat. It is also rich in Calcium and Iron having low contents of fibre. Besides its importance as food and feed crop, pearl millet is an ideal plant species for genetic studies because of its small diploid genome with large chromosome, abundant phenotypic variation with protogynous flowering nature.

Progress in any crop improvement programme depends on the magnitude of genetic variability and heritability present in the source material.The extent of variability is measured by GCV and PCV which provides information about relative amount of variation present in different characters. Genetic variability studies provide information about the genetic properties of the population. Grain yield character is quantitative in nature and polygenetically inherited. Simple correlation does not take into account the extremely complex inter relationship between various characters that are related to dependent variable. A more realistic study is desirable through path coefficient analysis by partitioning the correlation coefficients for understanding direct and indirect contribution of various traits towards grain yield.The present investigation was conducted with the objectives to characterize 49 inbreds using morphological and agronomical characters, provide information on inter-relationship of yield with other important yield components and to partition the genotypic correlation coefficients into their direct and indirect effects.

Material and Methods

The experimental materials for the present study comprised offorty nine (**Table 1**) stay green inbreds (HSGR01 to HSGR44, H77/ 833 -2-202, H77/ 833 -2, H77/ 29 -2, HBL-11, ICMR 01004) of pearl millet (*Pennisetum glaucum*). These inbreds were grown in a randomized block design (RBD) with three replications in a single row of 3 m length for each inbred, with spacing of 40 cm and 5 cm between rows and plants, respectively during kharif season, 2014 at experimental research area of Department of Genetics & Plant breeding, CCS Haryana Agricultural University, Hisar. All the recommended package of practices was followed. The observations were recorded on five randomly selected plants from each replication and genotypes, for the characters namely, days to 50% flowering, leaf sheath length, leaf blade length, leaf blade width, number of nodes/ plant, spike length, spike girth at maximum point, number of productive tillers/plant, plant height, 1000 grain weight, dry fodder yield/plant, green fodder yield /plant, grain yield/ plants. Statistical analysis was carried out for estimating analysis of variance as suggested [5]. Phenotypic coefficient of variation and genotypic coefficient of variation were calculated as described [6]. Heritability in broad sense [7] and expected genetic advance [8] were also calculated. The genotypic and phenotypic correlation between yield and its component traits and among themselves was calculated as per the methods suggested [9]. The correlation coefficients were partitioned into direct and indirect effects, using the path coefficient analysis [10].

Table 1 List of pearl millet stay green inbred lines used for experiment

S. No.	Name of inbred line	Pedigree	S. No.	Name of inbred line	Pedigree
1.	HSGR-01	SPF 2 98-2	**26.**	HSGR-26	DMRC - 09 / 11-81 -2
2.	HSGR-02	H 90/4-5 X 77/ 29-2	**27.**	HSGR-27	High Fe JBT / 12 -122
3.	HSGR-03	HTP 92/5	**28.**	HSGR-28	TPRT / 12- 119
4.	HSGR-04	(ICMB 92333 X EEBC CI-I)-5-B-B	**29.**	HSGR-29	TCPTA / 12 – 128
5.	HSGR-05	K-560-2 X(J 834-7 X 700544 -7-2-1)	**30.**	HSGR-30	110041
6.	HSGR-06	HTP 3/14	**31.**	HSGR-31	HPT - 2 - 12 -7
7.	HSGR-07	VCF 6862/ 98-1	**32.**	HSGR-32	99 HS – 22
8.	HSGR-08	AC-04 /6	**33.**	HSGR-33	2305
9.	HSGR-09	1210/1	**34.**	HSGR-34	MIR 97041
10.	HSGR-10	H 94 / 61-2	**35.**	HSGR-35	G 73 - 107 - 05 K -1
11.	HSGR-11	JBV 3 S1 - 44-3 -B -4 –B	**36.**	HSGR-36	AC-04 /13
12.	HSGR-12	HTP - 07-26	**37.**	HSGR-37	99 HS – 23
13.	HSGR-13	HTP 07-44	**38.**	HSGR-38	99HS -145
14.	HSGR-14	96 AC – 99	**39.**	HSGR-39	98 Raj 4
15.	HSGR-15	HMP - 0810 (ICMA 01222 X ICMP 451)	**40.**	HSGR-40	99 ABL – 5
16.	HSGR-16	SPF 2 98-2	**41.**	HSGR-41	{ICMB 91777 X (91777B X HHVBC)} - 6 -B
17.	HSGR-17	VCF 4 1864	**42.**	HSGR-42	HBL – 34
18.	HSGR-18	HTP 92 / 110	**43.**	HSGR-43	1660(M.T.)
19.	HSGR-19	SGP -10 – 110	**44.**	HSGR-44	HF IT - 1 -129
20.	HSGR-20	HTP -10 -137	**45.**	H 77 / 833 -2-202	
21.	HSGR-21	PT - 1-10 -1038	**46.**	H 77 / 833 -2	
22.	HSGR-22	PT-1-10 – 1043	**47.**	H77 / 29 -2	
23.	HSGR-23	TCF 3-10 -3 -2	**48.**	HBL - 11	
24.	HSGR-24	TCF 3 -10 - 28 -5	**49.**	ICMR 01004	
25.	HSGR-25	PT -1 - 10 – 1099			

Results and Disscussion

Genotypic and phenotypic variability, heritability and genetic advance

Genetic variability play a vital role in the improvement of crops since it offers scope for natural and artificial selection to tailor genotypes suitable for diverse agro-ecological conditions. Thus, more the genetic variability in the base material more is the chance of improvement. The analysis of variance revealed that the significant differences among inbreds for all characters in this study, which indicated presence of variability among the lines being evaluated and ample scope of improvement by selection in breeding programmes. Large variation among inbreds were found for the traits like, days to 50% flowering (40.33-58.33 days), leaf blade length (33.53-72.13 cm), spike length (13.60-24.60 cm),number of productive tillers/plant (1.60-9.57), plant height (115.60-160.87 cm), 1000 grain weight (4.35-14.80), dry fodder yield/plant (57.74-284.37 g), green fodder yield/plant (192.34-517.53 g) and grain yield/plant (21.20-48.47 g) in the present study, offer scope of selection for development and evaluation of desirable inbreds that can further be used as a parental lines for developing hybrids in pearl millet. These significant differences could also be attributed to the genetic composition of the population, which was made up of diverse genetic composition of genes. Results of present study (**Table 2**) revealed that days to 50% flowering exhibited lowest GCV and PCV (7.77 and 8.32) values implying the difficulty of improving these traits through simple selection procedure. However, similar results were reported [11, 12] and contradicting results were obtained [13] in pearl millet. The difference between estimates of PCV and GCV was also indicative of heritability, since the characters with low difference between PCV and GCV like plant height, days to 50% flowering, leaf sheath length, spike length exhibiting high heritability estimates would be useful, although these characters were having low values of GCV and PCV. It was observed that PCV and GCV were higher for number of productive tillers, 1000 grain weight, green fodder yield, dry fodder yield and seed yield indicating the possibilities of improving these characters through phenotypic selection for the development of dual purpose hybridsi.e.for grain and fodder purposes. High amount of GCV and PCV suggested greater scope of selection of superior genotypes for these traits. The magnitude of PCV was higher than GCV for all the characters suggesting the influences of the environmental forces on the expression of these characters.

Table 2 Estimation of grand mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability, genetic advance and genetic advance as percent of mean for quantitative characters in pearl millet inbreds

Characters	**Mean ±S.E(m)**	**Range**	**PCV (%)**	**GCV (%)**	**Heritability (h^2) (%)**	**Genetic advance**	**Genetic advance as % of mean**
1. Days to 50% flowering (days)	46.02± 0.79	40.33-58.33	8.32	7.77	87.03	6.87	14.92
2. Leaf sheath length (cm)	14.79±0.39	12.67-17.20	8.80	7.50	72.59	1.95	13.16
3. leaf blade length (cm)	50.88 ± 0.69	33.53-72.13	19.64	19.50	98.55	20.29	39.88
4. Leaf blade width (cm)	2.68± 0.29	1.14-4.53	31.29	25.02	63.97	1.11	41.22
5. Number of nodes/ plant	7.51± 0.31	5.20-10.93	16.40	14.75	80.93	2.05	27.34
6. Spike length (cm)	19.48 ± 0.46	13.60-24.60	12.29	11.57	88.61	4.37	22.44
7.Spike girth at maximum point (cm)	2.31 ± 0.06	1.22-3.81	21.89	21.36	95.15	0.99	42.91
8. Number of productive tillers/ plant	4.29 ± 0.20	1.60-9.57	36.01	35.11	95.05	3.03	70.52
9. Plant height (cm)	135.35 ± 2.41	115.60-160.87	8.69	8.12	87.34	21.15	15.63
10. 1000 grain weight (g)	8.72 ± 0.17	4.35-14.80	23.43	23.18	97.82	4.12	47.22
11. Dry fodder yield/plant(g)	160.61 ± 2.18	57.74-284.37	28.93	28.83	99.34	95.07	59.19
12. Green fodder yield/ plant (g)	341.09± 4.03	192.34-517.53	26.08	26.00	99.38	182.14	53.40
13. Grain yield/ plant(g)	32.24 ± 1.25	21.20-48.47	25.62	24.72	93.12	15.85	49.15

The GCV along with heritability estimates provides a better picture of the amount of expected genetic advance by phenotypic selection by breeders. The heritability of charactersdetermine how much the phenotype of a plant is a guideline to the genotype and thus, help the breeder to base his selection on the phenotypic performance of the plant. High heritability coupled with high genetic advance for number of productive tillers per plant, 1000 grain weight, dry fodder yield, green fodder yield and grain yield indicated the scope of improvement through direct phenotypic selection. High heritability coupled with high genetic advance for these traits may be because of additive gene effect, which were in conformity with previous works High heritability with moderate to low genetic advance in days to 50% flowering, Number of nodes/ plant, leaf blade length, Spike girth at maximum point, Spike length and Plant height may be due to dominant and epistatic gene action and simple selection may not be futile. Improvement of these traits could be made through hybridization, which were in conformity with previous works [14]. Low heritability estimates along with low genetic advance as a percent of mean for Leaf sheath length and Leaf blade width indicated contribution of non-additive gene effect and adequate progeny testing could be done for improvement.

Correlation and path coefficient analysis

Correlation studies were carried out to reveal the nature and extent of association between growths, flower and spike related traits. From correlation matrix (**Table 3**), it was observed that grain yield/plant had positive and significant association with characters like number of productive tillers, plant height, days to 50% flowering, 1000 grain weight, dry fodder and green fodder yield which is in agreement to the previous works [15-17]. Significant and positive association between fodder yield and grain yield potential is in close confirmation with the earlier findings [15, 17]. Positive and significant correlation of fodder yield with grain yield potential was found encouraging for the development of hybrids for dual purpose. Spike length was also important yield determinant characters because of their positive and highly significant levels of correlations with grain yield potential. Number of productive tillers and spike length had highly significant positive correlation with plant height, which revealed that tall plants could contribute to fodder types coupled with grain yield types, which is in agreement with previous works [18]. The positive correlation of grain yield with these characters implies that improving one or more of these traits could results in higher grain yield for pearl millet. The genotypic correlation coefficient value for most of the characters were higher in magnitude than the corresponding phenotypic values showing the existence of inherent association among the traits.

Table 3 Genotypic (below diagonal) and Phenotypic (above diagonal) correlation coefficients among pearl millet inbreds

	Days to 50% Flowering (days)	**Leaf sheath length (cm)**	**Leaf blade length (cm)**	**Leaf blade width (cm)**	**Number of nodes/ plant**	**Spike length (cm)**	**Spike girth at maximum point(cm)**
Days to 50% flowering (days)	1	0.182*	-0.032	-0.065	0.247**	0.358**	0.001
Leaf sheath length (cm)	0.185*	1	0.135	-0.063	0.018	0.094	-0.092
Leaf blade length (cm)	0.036	0.151	1	0.329**	0.270**	0.503**	0.527**
Leaf: blade width (cm)	-0.083	-0.142	0.404**	1	0.022	0.242**	0.453**
Number of nodes/plant	0.290**	0.063	0.309**	0.029	1	0.342**	0.079
Spike length (cm)	0.388**	0.100	0.534**	0.300**	0.392**	1	0.284**
Spike girth at maximum point (cm)	0.001	-0.127	0.544**	0.591**	0.095	0.311**	1
Number of productive tillers/plant	0.505**	0.094	0.056	0.039	0.334**	0.391**	0.128
Plant height (cm)	0.528**	0.071	0.179*	0.246**	0.468**	0.514**	0.099
1000 grain weight (g)	0.570**	0.112	0.192*	0.268**	0.222**	0.502**	0.306**
Dry fodder yield per plant (g)	0.365**	0.062	-0.109	-0.133	0.032	0.217**	-0.198*
Green fodder yield per plant (g)	0.509**	0.158	0.230**	0.125	0.194*	0.459**	0.113
Grain yield /plant (g)	0.564**	0.018	0.165*	0.217**	0.327**	0.626**	0.149

	Number of productive tillers/plant	**Plant height (cm)**	**1000 grain weight (g)**	**Dry fodder yield/plant (g)**	**Green fodder yield/plant (g)**	**Grain yield /plant (g)**
Days to 50% flowering (days)	0.459**	0.459**	0.526**	0.340**	0.473**	0.494**
Leaf sheath length (cm)	0.076	0.061	0.089	0.054	0.139	0.002
Leaf blade length (cm)	0.052	0.166*	0.190*	-0.108	0.229**	0.158
Leaf: blade width (cm)	0.040	0.225**	0.212**	-0.106	0.106	0.177*
Number of nodes/plant	0.299**	0.392**	0.207*	0.027	0.175*	0.298**
Spike length (cm)	0.359**	0.455**	0.469**	0.205*	0.432**	0.558**
Spike girth at maximum point (cm)	0.126	0.095	0.290**	-0.194*	0.110	0.142
Number of productive tillers/plant	1	0.594**	0.540**	0.366**	0.447**	0.674**
Plant height (cm)	0.659**	1	0.625**	0.426**	0.548**	0.772**
1000 grain weight (g)	0.559**	0.683**	1	0.289**	0.476**	0.761**
Dry fodder yield per plant (g)	0.375**	0.461**	0.291**	1	0.398**	0.437**
Green fodder yield per plant (g)	0.459**	0.586**	0.482**	0.401**	1	0.608**
Grain yield /plant (g)	0.715**	0.866**	0.792**	0.454**	0.630**	1

* Significant at p= 0.05, ** Significant at p= 0.01

Selection of genotypes based only on correlation may be misleading because it measures only the mutual association between two variables, whereas, path coefficient analysis specifies and measures the importance of different components. In the present investigation the path coefficient analysis was performed to estimate the direct and indirect contribution of various plant characters to grain yield potential (**Table 4**). The magnitude of direct effects revealed that plant height, 1000 grain weight and spike length had high and positive direct effects on grain yield. It is suggested that these characters can be considered as main components for selection in a breeding programme for higher grain yield. Indirect effects of independent traits indicated that plant height and 1000 seed weight had indirect effects on grain yield per plant. Days to 50% flowering had negative phenotypic and genotypic direct effect on grain yield per plant. Similar results were found [19]. Number of productive tillers and green fodder yield were another important traits indirectly contributing to grain yield *via* plant height and thousand seed weight (Table 4). Low value of residual effects (0.105) indicated that contribution of independent characters included in this study explained about 90 %of variation for grain yield. Based on the ongoing discussion, the traits viz. plant height, 1000 grain weight and spike length may be given due attention in pearl millet breeding.

Table 4 Path coefficient analysis of grain yield per plant with its component characters in pearl millet inbreds

	Days to 50% flowering (days)	**Leaf sheath length (cm)**	**Leaf blade length (cm)**	**Leaf blade width (cm)**	**No. of Nodes per plant**	**Spike length (cm)**	**Spike girth at maximum point (cm)**	**Number of productive tillers per plant**	**Plant height (cm)**	**1000 grain weight (g)**	**Dry fodder Yield per plant (g)**	**Green fodder Yield per plant (g)**
Days to 50% flowering (days)	**-0.046**	-0.009	0.002	0.004	-0.013	-0.018	0.000	-0.023	-0.024	-0.026	-0.017	-0.024
Leaf sheath length (cm)	-0.017	**-0.094**	-0.014	0.013	-0.006	-0.009	0.012	-0.009	-0.007	-0.011	-0.006	-0.015
Leaf blade length (cm)	0.002	-0.009	**-0.056**	-0.023	-0.017	-0.030	-0.031	-0.003	-0.010	-0.011	0.006	-0.013
Leaf blade width (cm)	0.002	0.003	-0.009	**-0.023**	-0.001	-0.007	-0.013	-0.001	-0.006	-0.006	0.003	-0.003
Number of nodes/plant	-0.023	-0.005	-0.024	-0.002	**-0.078**	-0.030	-0.007	-0.026	-0.036	-0.017	-0.002	-0.015
Spike length (cm)	0.093	0.024	0.128	0.072	0.094	**0.239**	0.074	0.093	0.123	0.120	0.052	0.110
Spike girth at maximum point (cm)	0.000	0.007	-0.031	-0.034	-0.005	-0.018	**-0.058**	-0.007	-0.006	-0.018	0.011	-0.007
Number of productive tillers/plant	0.091	0.017	0.010	0.007	0.060	0.070	0.023	**0.180**	0.119	0.101	0.068	0.083
Plant height (cm)	0.231	0.031	0.078	0.108	0.205	0.225	0.043	0.288	**0.438**	0.299	0.202	0.257
1000 grain weight (g)	0.176	0.034	0.059	0.083	0.069	0.155	0.094	0.173	0.211	**0.309**	0.090	0.149
Dry fodder yield/plant(g)	0.002	0.000	-0.001	-0.001	0.000	0.001	-0.001	0.002	0.002	0.002	**0.005**	0.002
Green fodder yield/plant (g)	0.054	0.017	0.024	0.013	0.021	0.048	0.012	0.048	0.062	0.051	0.042	**0.106**
Genotypic Correlation coefficient	0.564**	0.018	0.165*	0.217**	0.327**	0.626**	0.149	0.715**	0.866**	0.792**	0.454**	0.630**
Residual effect- 0.105												

Conclusion

The present study illustrated the existence of wide range of variations for most of the characters among the pearl millet inbreds and opportunities of genetic gain through selection and hybridization. Correlation studies concluded that number of productive tillers, plant height, days to 50% flowering, 1000 grain weight and spike length appeared to be the most prominent characters when selecting for total grain yield in pearl millet, because of their highly significant genotypic and phenotypic correlations with grain yield. The studies on path analysis indicated that plant height, 1000 grain weight and spike length had highest direct effect on grain yield/plant and high indirect effects through most of the other traits, suggesting the possibility of improvement in grain yield by direct selection of these important traits.

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