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Genetic variability, heritability and association of grain yield characters in pearl millet (*Pennisetum glaucum* L)

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Abstract
The extent of genetic variability and correlation for grain yield and its attributing characters in forty nine parental lines of pearl millet were evaluated at Indian Institute of Millet Research, Hyderabad during 2017 rainy season. Wide genetic variability coupled with high heritability and genetic advance as percent mean was reported for grain yield per plant and 1000 seed weight indicating the association of additive gene action in expression of these traits and hence selection for these traits would be effective. Grain yield showed a significant positive correlation with plant height and ear length, while path analysis revealed that selection for characters *viz.* days to maturity, seed diameter, ear width and plant height will have positive influence on grain yield per plant. Selection of traits plant height, days to maturity, ear length and ear width will help in yield improvement in pearl millet.

Keywords: Pearl millet, variability, heritability, genetic advance, correlation

Introduction
Pearl millet a high nutritive value crop grown in arid and semi arid tropics of the world and has capability to produce grain even under hot and low moisture conditions where other cereal crops fail. In India it is cultivated in an area of 7.5 m ha with a production of 9.8 million tons and productivity of 1311 kg per ha. Nutritionally it is rich source of proteins (6-15%), fat (5-6%), fiber (1-1.8%), minerals like iron, calcium, zinc and essential amino acids when compared to other cereals (Fleck, 1981) [7].
The low production of pearl millet in India urges the need to develop stable, high yielding varieties and hybrids with wider adaptability. It is always desirable to study the genetic variability of traits associated with grain yield in the genetic material utilized in the breeding program. Heritability estimates along with genetic advance are helpful in prediction of gain under selection (Johansen *et al*, 1955) [9]. Association among yield components can be better understood by correlation studies which can be further utilized by plant breeders in the selection process. Path coefficient analysis helps in determining the characters associated with yield and their direct and indirect effects on yield which further helps in selection for genetic improvement in yield. The current investigation was carried out to study the genetic variability among the parental lines and to estimate heritability, genetic advance and correlation coefficient among the characters of seed yield of pearl millet and identify suitable promising parental lines which can be further utilized in the hybridization programme of pearl millet.

Materials and Methods
The experimental material constituted 49 parental lines of pearl millet. The lines were sown in a paired row plot of two meter length keeping row to row spacing of 45 cm and plant to plant spacing of 15 cm in two replications at Indian Institute of Millet Research, Hyderabad during 2017 rainy season in Randomised Block Design. The recommended dose of N, P and K were applied @ 80: 40: 30 kg ha $^{-1}$. The entire P and K and half the dose of Nitrogen were applied as basal, while remaining Nitrogen is applied at 30 days after sowing. Intercultural operations and irrigation schedules were followed as and when necessary. Need based plant protection measures were adopted to raise a healthy crop.
The observations for plant height, effective tillers per plant, ear length, ear width and grain yield per plant were recorded on five randomly selected competitive plants of each genotype in each replication and the mean of five plants was taken for statistical analysis, while days to 50% flowering and days to maturity was recorded on plot basis. For 1000 seed heaviness, a random sample of 200 seeds of each entry was recorded for weight and multiplied by a factor

of 5 to estimate 1000-seed weight in grams, while for seed diameter five seeds at random were selected and diameter was measured with the help of screw guage and expressed in millimeters and the mean of five seeds is used for statistical analysis.

The analysis of variance for the RBD was carried out for each character according to the model given by Panse and Sukhatme (1967). Phenotypic and genotypic variance were estimated as per the procedure given by Lush (1949) [11] and Choudhary and Prasad (1968) [4], while Phenotypic and genotypic coefficient of variance were determined as suggested by Burton (1952) [3]. The estimates of heritability and genetic advance as percent mean was estimated as per the procedure of Hanson *et al*. (1956) [8], Lush (1949) [11] and Johnson *et al*. (1955) [9]. The correlation coefficient was portioned into direct and indirect effects according to Dewey and Lu (1959) [5] and Turner and Stevens (1959) [14].

Results and Discussion

All the traits showed a wide range of variation as shown in Analysis of Variance (Table: 1) depicting existence of variability among the characters under study. The mean sum of squares due to genotypes is high for all the characters except days to 50% flowering, days to maturity, effective tillers per plant and grain yield per plant.

Table 1: Analysis of variance for Grain Yield, Rancidity and other traits in Pearl millet

Character	Mean Sum of Squares	
	Treatments (d.f = 48)	Error (d.f = 48)
Days to 50% Flowering	73.485	9.625
Plant Height (cm)	1231.335*	258.047
Days to maturity	82.563	63.979
Effective Tillers per plant	1.451	1.461
Ear Length (cm)	33.674**	1.791
Ear Width (cm)	0.567**	0.034
Seed Diameter (mm)	0.104*	0.016
1000 seed weight (g)	8.812**	0.350
Grain yield per plant (g)	23.13	6.72

*significant at 0.05 level of probability, ** significant at 0.01 level of probability

The mean, range, Phenotypic coefficient of variation (PCV), Genotypic coefficient of variation (GCV), heritability and genetic advance as percent mean are presented in Table: 2. The PCV was higher than GCV for all the parameters indicating the influence of environment on expression of all the characters. The highest GCV was reported for grain yield per plant followed by 1000 seed weight and ear width. Yadav (2008) [15] also reported high GCV and PCV for grain yield, effective tillers per plant, ear length and days to maturity. The high PCV and GCV were reported in pearl millet by Kumar *et al.* (2014) [11] for productive tillers per plant, grain yield per plant and panicle length traits, similarly by Bhuri *et al.* (2014) [1] for grain yield per plant. Effective tillers per plant followed by grain yield per plant showed highest ECV indicating influence of environment on expression of all these traits. The difference between PCV and GCV was small for days to 50% flowering, ear length, ear width, 1000 seed weight and seed diameter indicating that influence genetic factors is more than environment factors in expression of these characters hence rapid progress can be made from selection for these traits.

Table 2: Estimates of genetic variability, heritability and genetic advance as percent mean for yield and yield contributing characters in Pearl millet

Genetic Parameter	Range	General Mean	PCV (%)	GCV (%)	ECV(%)	h2bs (%)	GAPM
Days to 50% Flowering	52 - 61.5	55.61	11.591	10.161	5.578	76.84	18.348
Plant Height (cm)	95 – 200	153.44	17.785	14.377	10.469	65.35	23.942
Days to maturity	78 – 91	85.79	9.978	3.553	9.324	12.68	2.606
Effective Tillers per plant	2 - 6.17	3.038	40.797	5.964	40.760	2.14	1.814
Ear Length (cm)	13.5 – 29.5	21.918	19.212	18.216	6.106	89.90	35.581
Ear Width (cm)	1.5 – 4	2.566	21.349	20.111	7.165	88.74	39.033
Seed Diameter (mm)	1.44 – 2.6	1.975	12.396	10.667	6.304	74.04	18.901
1000 seed weight (g)	4.64 – 13.01	9.584	22.333	21.462	6.177	92.35	42.487
Grain yield per plant (g)	2.17 – 15.19	7.16	71.88	62.10	36.20	55.70	16.02

High heritability coupled with high genetic advance was reported for grain yield per plant and 1000 seed weight, plant height, ear length and ear width demonstrating the influence of additive genes in expression of these traits and this was in accordance with findings of Ezeaku *et al.* (2014) [7] who also reported that high heritability for ear length followed by grain yield per plant. Hence effective selection helps in improvement of these traits. High heritability with low genetic advance was reported for days to 50% flowering suggesting the role of additive gene action for expression of these traits which are in agreement with the findings of Yadav (2008) [15] who also reported high heritability and low genetic advance for days to 50% flowering.

The genotypic and phenotypic correlations for yield and yield components are presented in Table 3. The genotypic correlation and phenotypic correlation coefficient were generally higher than phenotypic correlation coefficient indicating a strong inherent association between various traits. Grain yield per plant showed a significant and positive correlation with plant height and ear length, while a negative correlation was reported with days to maturity. Bunty Sharma *et al.* (2018) also reported grain yield per plant was highly significant and positively associated with ear length and ear girth. For other agronomic traits *viz* days to 50% flowering had significant and positive correlation with plant height, days to maturity, ear length and negative correlation with effective tillers per plant, while plant height had significant positive

association with days to maturity, ear length and negative association with effective tillers per plant. The effective tillers per plant had significant negative association with ear length and ear width and positive association with seed diameter and 1000 seed weight while ear width and seed diameter had positive association with 1000 seed weight.

Table 3: Genotypic and phenotypic correlation coefficient for yield and yield contributing characters in Pearl millet

Characters		Days to 50% Flowering	Plant Height (cm)	Days to maturity	Effective Tillers per plant	Ear Length (cm)	Ear Width (cm)	Seed Diameter (mm)	1000 seed weight (g)	Grain yield per plant (g)
Days to 50% Flowering	r_p	1.00	0.402**	1.280**	-1.032**	0.530**	0.027	-0.003	-0.127	0.160
	r_g	1.00	0.301**	0.474**	-0.178	0.321**	0.025	-0.045	-0.085	0.045
Plant Height (cm)	r_p		1.00	0.836**	-0.527**	0.376**	-0.052	-0.023	0.004	0.529**
	r_g		1.00	0.289**	-0.201*	0.284**	-0.08	-0.028	-0.039	0.286**
Days to maturity	r_p			1.00	-0.786**	0.990**	-0.362**	0.031	-0.075	-0.459**
	r_g			1.00	-0.236*	0.228*	-0.083	0.086	-0.110	0.015
Effective Tillers per plant	r_p				1.00	-0.545**	-0.636**	1.266**	0.869**	0.125
	r_g				1.00	-0.057	-0.054	0.111	0.070	0.027
Ear Length (cm)	r_p					1.00	-0.013	-0.113	-0.092	0.230*
	r_g					1.00	-0.018	-0.079	-0.057	0.179
Ear Width (cm)	r_p						1.00	0.118	0.304**	0.062
	r_g						1.00	0.109	0.266**	0.042
Seed Diameter (mm)	r_p							1.00	0.884**	0.009
	r_g							1.00	0.724**	-0.019
1000 seed weight (g)	r_p								1.00	0.035
	r_g								1.00	-0.01

*significant at 0.05 level of probability, ** significant at 0.01 level of probability

Path analysis depicts the association of various characters and further helps in understanding the direct and indirect contribution of various agronomic characters towards yield. Maximum direct effect on yield was exhibited by days to maturity (0.765) followed by seed diameter (0.548), ear width (0.485) and plant height (0.373), while ear length and ear width showed negative direct effect on grain yield. Ezeaku *et al* (2014) [7] also found a positive direct effect on grain yield with plant height and negative direct effect with ear length and ear width. The days to maturity had direct effect with yield and had relatively high correlation with plant height (0.312), effective tillers per plant (0.037), seed diameter (0.017) and 1000 seed weight (0.048). The seed diameter also showed a positive direct effect on grain yield per plant via days to 50% flowering (0.003), days to maturity (0.024), ear length (0.015), ear width (0.057). The ear width had next direct effect on grain yield per plant. This trait had highest indirect effect via effective tillers per plant (0.03), ear length (0.002) and seed diameter (0.065). Finally plant height also reported a positive direct effect on grain yield per plant via days to maturity (0.639) and effective tillers per plant (0.025).

Table 4: Path coefficient analysis for yield and yield contributing characters in Pearl millet

Characters		Days to 50% Flowering	Plant Height (cm)	Days to maturity	Effective Tillers per plant	Ear Length (cm)	Ear Width (cm)	Seed Diameter (mm)	1000 seed weight (g)	Grain yield per plant (g)
Days to 50% Flowering	G	-1.040	-0.150	0.980	0.049	0.071	-0.013	0.002	-0.082	0.160
	P	-0.050	0.091	-0.027	-0.014	0.040	0.002	-0.0003	0.003	0.045
Plant Height (cm)	G	-0.417	0.373	0.639	0.025	-0.050	-0.025	-0.012	-0.003	0.529**
	P	-0.015	0.303	-0.017	-0.016	0.036	-0.006	-0.0002	0.001	0.286**
Days to maturity	G	-1.33	0.312	0.765	0.037	-0.133	-0.175	0.017	0.048	-0.459**
	P	-0.023	0.088	-0.058	-0.018	0.029	-0.006	0.0006	0.004	0.015
Effective Tillers per plant	G	1.073	-0.197	-0.602	-0.048	0.073	-0.308	0.693	-0.559	0.125
	P	0.009	-0.061	0.014	0.078	-0.007	-0.004	0.001	-0.002	0.027
Ear Length (cm)	G	-0.551	0.140	0.757	0.026	-0.134	-0.006	-0.062	0.059	0.230*
	P	-0.016	0.086	-0.013	-0.004	0.126	-0.001	-0.0005	0.002	0.179
Ear Width (cm)	G	-0.027	-0.019	-0.277	0.030	0.002	0.485	0.065	-0.196	0.062
	P	-0.001	-0.024	0.005	-0.004	-0.002	0.077	0.001	-0.009	0.042
Seed Diameter (mm)	G	0.003	-0.008	0.024	-0.060	0.015	0.057	0.548	-0.569	0.009
	P	0.002	-0.008	-0.005	0.009	-0.01	0.010	0.007	-0.023	-0.019
1000 seed weight (g)	G	0.132	0.001	-0.057	-0.041	0.012	0.147	0.484	-0.644	0.035
	P	0.004	-0.012	0.006	0.005	-0.007	0.021	0.005	-0.032	-0.01

*significant at 0.05 level of probability, ** significant at 0.01 level of probability, the bold values forming diagonal represent direct effects. Residual effect=1.34.

The current study clearly indicates that grain yield of pearl millet can be improved by selecting parental lines with high performance for plant height and ear length, hence selecting tall plants with long ear length can be ideal for developing high yielding pearl millet hybrids for locations in Telangana. Path analysis suggests late maturing, taller plants with higher ear width would serve as effective selection attributes in the breeding programme for pearl millet yield improvement.

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