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GENETIC VARIABILITY AND CHARACTER ASSOCIATION OVER ENVIRONMENT IN PEARL MILLET [*PENNISETUM GLAUCUM* (L.) R. BR.] UNDER DRYLAND CONDITIONS OF GUJARAT

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ABSTRACT
To assess the genetic variability and character association among the twenty advanced hybrids, twelve R line and twelve B lines of pearl millet were studied for ten quantitative traits. All the genotypes showed considerable amount of variation in their mean performances with respect to the characters studied, indicates presence of sufficient variability and scope for further selection and breeding superior and desirable genotypes. GCV played a major role for the expression of the traits. Grain yield/plant (55.5) had high GCV per cent followed by grain yield/earhead (48.6) biological yield/plant (46.0), Plant height (26.3), earhead length (20.5) Flag leaf area (19.8) harvest index (15.7) and number of effective tillers (13.8) in pooled environment. Heritability in narrow sense ranged from 65.0 (harvest index) to 95.0 (grain yield/plant) in pooled environment. High GA% observed for grain yield (111.5) coupled with high heritability (95.0), indicating the preponderance of the additive gene action. Grain yield had genotypically significant positive correlation with most of the characters under study viz. grain yield/earhead (0.976), biological yield/plant (0.986), plant height (0.814), harvest index (0.666), earhead length (0.556) and number of effective tillers/plant (0.732) indicating any increase in these traits will increase the yield. The path analysis revealed high positive direct effect on grain yield per plant with respect to grain yield per earhead, biological yield per plant, number of effective tillers, days to 50 per cent flowering, earhead length and harvest index indicating importance of these characters, which can be strategically used to improve the yield of pearl millet.

INTRODUCTION

Pearl millet (*Pennisetum glaucum* (L.) R. Br.), the world's hardiest warm season cereal crop (Reddy *et al.,* 2012). Globally it ranks sixth after rice, wheat, maize, barley and sorghum in terms of area (Khairwal *et al.,* 2007) and share 42% of total world production (*Ramesh et al.,* 2006). Pearl millet is an indispensable arid and semi arid crop of India cultivated as dual purpose (food and feed) crop in over 8.3 m ha ranking fourth among total cereals (Yadav *et al*., 2011). The present scarcity situation pearl millet cultivation is the heart of dry land agriculture, being C4 plant it can utilize sunlight and water efficiently. It is unique to adapt to environmental extremes of a biotic and biotic stresses. It is well established fact that the progress in improvement of a crop depends on the degree of variability in the desired character in the base material. The study of relationships among quantitative traits is important for assessing the feasibility of joint selection of two or more traits and hence for evaluating the effect of selection for secondary traits on genetic gain for the primary trait under consideration. A positive genetic correlation between two desirable traits makes the job of the plant breeder easy for improving both traits simultaneously. Path coefficient analysis was performed to qualify the direct and indirect contributors of yield. Therefore the present investigation was undertaken to study the genetic variability, relationships among quantitative traits and Path coefficient analysis in selected genotypes of pearl millet during summer 2011.

MATERIALS AND METHODS

The experimental material for the present investigation comprised (Hybrids- GHB-907, GHB-909, GHB-927, GHB-538, GHB-915, GHB-744, GHB-757, GHB-905, GHB-906, GHB-892, GHB-933,GHB-558, GHB-891, GHB-902, GHB-911, GHB-900, GHB-904, GHB-935, GHB-908, GHB-732), (B lines J-2340, J-2467, J-2496, J-2523, J-2507, J-2511, J-2372, J-2433, J-2405, J-2517, J-2526, J-2500) (R lines ICMB-97111, ICMB-07999, ICMB-92777, IMSB-9904, ICMB-98444, ICMB-94555, ICMB-04999, ICMB-96222, ICMB-06777, IMSB-20064, ICMB-05222, IMSB-20071) of pearl millet developed at different centers were evaluated in a randomized block design with three replications and four different dates of sowing *i.e.* 15th February, 1st March, 15th March and 1st April at the Centre for Crop Improvement, S.D. Agricultural University, Sardarkrushinagar during summer season of 2011 with a

spacing 45 cm x 15 cm. Observations were recorded on five competitive plants in each genotype in each replication for days to 50% flowering, days to maturity, plant height (cm), number of effective tillers per plant, earhead length (cm), flag leaf area (cm^2), grain yield per earhead (g), grain yield per plant (g), biological yield per plant (g), harvest index and their mean values were subjected to statistical analysis. Phenotypic and genotypic variances were estimated according to the formula given by Lush (1940), Phenotypic coefficient of variation and genotypic coefficient of variation were computed based on the methods given by Burton (1952). The heritability estimates of >70% was considered very high; 50-70% high; 30-50% moderate and <30% low (Hallauer and Miranda, 1981).

The genotypic correlations between yield and its component traits and among themselves were worked out as per the methods suggested by Al-Jibouri *et al.* (1958). Path coefficient analysis was carried out as suggested by Dewey and Lu (1959). The simple correlation coefficients already estimated at genotypic level were utilized for this purpose. By keeping yield as dependent variable and other nine yield attributing characters as independent variables, various direct and indirect effects were estimated.

RESULTS AND DISCUSSION

The analysis of variance revealed that the significant differences among genotypes for all characters, in the all the environment (Table 1) which indicated presence of variability among the lines being evaluated and ample scope of improvement by selection. Vidyadhar *et al.* (2007) and Lakshmana *et al.* (2009).

The range of variation and the estimate of genetic parameters which include heritability in broad sense, coefficient of variation (GCV and PCV) and genetic advance are presented in Table 1. The PCV was higher than GCV for all the characters studied showing that all the traits were highly influenced by environment. However differences between them were not of high magnitude. High estimates of GCV and PCV were observed for grain yield/plant (55.5, 56.8), grain yield/earhead (48.6, 50.5) biological yield/plant (46.0, 47.6), Plant height (26.3, 27.2), earhead length (20.5, 22.05), Flag leaf area (19.8, 20.6) harvest index (15.7, 19.4) and number of effective tillers (13.8, 16.8). Low GCV and PCV was noticed for days to 50% flowering (9.5, 10.0), days to maturity (10.3, 10.7) in pooled environment. Similar results were observed by Arunkumar *et al.,* in sorghum (2013) Kumari and Nagarajan (2008) and Lakshmana et al. (2009). The effectiveness of selection for any character depends, not only the extent of genetic variability but also in the extent to which it will be transferred from one generation to the other generation. High heritability coupled with high genetic advance was observed for grain yield per plant (95.0,111.5), biological yield per plant (93.2, 96.4), grain yield per earhead (93.2, 96.4), plant height (94.0, 52.5), flag leaf area (92.4, 39.2) earhead length (86.0, 39.2), number of effective tillers (67.0, 23.2), and harvest index (65.0, 26.2) in

Table 1: Mean, range, variability parameters, heritability and genetic advance for ten characters in individual environment in pearl millet

Parameter	Days to 50 % flowering	Days to maturity	Plant Height (cm)	Earhead length (cm)	No. of effective tillers	Flag leaf area (cm^2)	Grain Yield/ Plant (g)	Grain yield / earhead(g)	Biological yield / plant (g)	Harvest index (%)
SOWING DATE-I (15/02/2011)										
Mean	51.4	79.0	131.4	22.5	2.8	77.0	42.0	14.4	100.2	40.7
Range	42. 7-61. 7	65.0-92.0	77.6-204.8	12.7-34.7	1.9-4.1	47.2-106.6	14.0-74.5	5.0-28.0	47.3-167.3	25.4-47.8
VXG	25.9	58.78	1103.2	21.4	0.2	201.2	410.9	33.8	1712.9	16.1
VXP	28.3	64.68	1212.2	23.7	0.3	232.8	434.2	36.9	1819.2	31.9
VXE	2.4	5.59	109.04	2.2	0.08	31.6	23.2	3.0	106.2	15.7
GCV%	9.9	9.70	25.2	20.5	16.2	18.4	48.2	40.1	41.2	9.8
PCV%	10.4	10.15	26.4	21.5	19.3	19.8	49.5	41.9	42.5	13.8
Heritability	91.4	91.30	91.0	90.6	70.4	86.4	94.6	91.6	94.2	50.6
GA (% mean)	19.5	19.08	49.6	40.2	28.0	35.2	96.5	79.0	82.5	14.4
SOWING DATE- II (01/03/2011)										
Mean	50.8	77.0	129.3	21.9	2.6	74.9	38.0	13.8	91.9	39.5
Range	42.7-61.0	64.0-92.3	74.9-201.3	12.3-32.6	1.9-3.3	46.9-105.6	7.5-71.1	3.1-26.1	39.0-154.6	16.9-47.8
VXG	24.2	64.9	1120.7	19.3	0.1	214.6	431.3	44.0	1758.5	31.8
VXP	26.2	69.0	1227.5	22.6	0.1	226.2	451.7	46.7	1864.2	48.3
VXE	2.0	4.0	106.7	3.3	0.06	11.5	20.3	2.7	105.7	16.4
GCV%	9.7	10.4	25.8	20.0	12.5	19.5	54.6	47.8	45.5	14.2
PCV%	10.1	10.7	27.0	21.7	15.8	20.0	55.9	49.3	46.9	17.5
Heritability	92.4	94.1	91.3	85.4	62.4	94.9	95.5	94.3	94.3	65.9
GA (%mean)	19.2	20.9	50.9	38.1	20.4	39.2	109.1	95.7	91.2	23.0
SOWING DATE- III (15/03/2011)										
Mean	49.8	74.4	126.9	21.0	2.59	73.8	33.5	12.6	82.9	38.0
Range	41.3-59.0	63.0-89.3	74.2-198.0	12.1-29.8	1.7-3.1	46.2-106.9	6.6-63.0	2.8-22.6	34.1-148.2	16.4-61.8
VXG	21.1	60.4	1111.2	17.1	0.1	235.0	385.8	43.8	1610.0	48.9
VXP	22.9	64.5	1212.9	22.0	0.1	260.7	405.0	46.5	1702.2	66.6
VXE	1.8	4.1	101.6	4.86	0.06	25.7	19.1	2.6	92.2	17.7
GCV%	9.2	10.4	26.2	19.7	11.7	20.7	58.6	52.5	46.8	18.3
PCV%	9.6	10.7	27.4	22.3	15.3	21.8	60.1	54.0	49.7	21.4
Heritability	91.9	93.7	91.6	77.9	58.6	90.1	95.2	94.3	94.5	73.4
GA (% mean)	18.2	20.8	51.1	35.8	18.4	40.5	117.2	105.3	96.0	32.4

Table 1: Cont.....

SOWING DATE- IV (01/04/2011)										
Mean	48.2	72.1	124.5	20.0	2.5	71.1	28.5	10.9	74.7	36.3
Range	41.6-58.0	62.0-87.3	69.7-195.4	11.9-29.1	1.6-3.3	45.3-104.7	5.1-66.1	2.1-21.1	28.3-144.8	14.2-63.3
VXG	19.7	59.8	1116.2	16.7	0.1	210.3	330.7	39.6	1438.4	60.2
VXP	21.8	67.8	1202.0	20.6	0.1	260.4	342.7	41.5	1553.1	78.9
VXE	2.1	8.01	85.7	3.9	0.05	50.0	12.0	1.8	114.8	18.7
GCV%	9.2	10.7	26.8	20.4	12.8	20.3	63.7	57.5	50.8	21.4
PCV%	9.6	11.3	27.8	22.6	15.8	22.6	64.9	58.8	52.8	24.5
Heritability	90.2	90.0	92.9	81.0	65.9	80.8	96.4	95.4	92.6	76.3
GA (% mean)	17.9	53.3	53.2	37.8	21.5	37.7	129.0	115.7	100.0	38.5
POOLED ENVIRONMENT										
Parameter	Days to 50% flowering	Days to maturity	Plant height (cm)	Earhead length (cm)	Number of effective tillers	Flag leaf area (cm^2)	Grain yield/plant (g)	Grain yield per earhead(g)	Biological yield / plant(g)	Harvest index(%)
Mean	50.1	75.6	128.0	21.4	2.6	74.5	35.5	13.0	87.4	38.6
Range	42.8-59.7	63.8-90.1	74.4-199.9	12.3-31.2	1.8-3.3	46.3-105.8	8.3-67.2	3.3- 23.4	37.8-151.0	18.3-53.3
VXG	22.8	61.1	1137.5	19.2	0.1	218.9	388.7	39.8	1619.2	36.9
VXP	24.9	66.2	1213.7	22.2	0.2	237.3	408.4	42.9	1735.4	56.4
VXE	2.0	5.0	76.1	3.0	0.1	18.3	19.6	3.1	116.2	19.6
GCV%	9.5	10.3	26.3	20.5	13.8	19.8	55.5	48.6	46.0	15.7
PCV%	10.0	10.7	27.2	22.05	16.8	20.6	56.8	50.5	47.6	19.4
Heritability	92.0	92.0	94.0	86.0	67.0	92.4	95.0	93.2	93.1	65.0
GA (% mean)	18.8	20.4	52.5	39.2	23.2	39.2	111.5	96.4	91.5	26.2

Note: VXG, VXP, and VXE are the genotypic, phenotypic and environmental variance, respectively; GCV % and PCV % are genotypic and phenotypic coefficient of variance, respectively; GA (% mean) is genetic advance as per cent of mean.

Table 2: Genotypic (r_g) and phenotypic (r_p)) correlation coefficients among ten quantitative characters in Pearl millet

Characters		DM	PH	EL	NET	FLA	GY	GYE	BY	HI
DF	r_g	0.903**	-0.164*	0.398**	-0.418**	0.422**	-0.211**	-0.139**	-0.225**	-0.042
	r_p	0.831**	-0.154*	0.367**	-0.326**	0.400**	-0.199**	-0.123*	-0.277**	-0.033
DM	r_g		-0.292**	0.294**	-0.433**	0.453**	-0.312**	-0.241**	-0.339**	-0.082
	r_p		-0.280**	0.266**	-0.339**	0.414**	-0.291**	-0.226**	-0.315**	-0.056
PH	r_g			0.564**	0.523**	0.119*	0.814**	0.824**	0.863**	0.427**
	r_p			0.508**	0.416**	0.111*	0.764**	0.764**	0.802**	0.332**
EL	r_g				0.160*	0.286**	0.556**	0.606**	0.539**	0.517**
	r_p				0.107*	0.254**	0.505**	0.545**	0.490**	0.370**
NET	r_g					-0.0924	0.732**	0.580**	0.739**	0.502**
	r_p					-0.0755	0.586**	0.382**	0.590**	0.322**
FLA	r_g						0.0088	0.0422	0.0474	-0.137*
	r_p						0.0066	0.0393	0.0464	-0.116*
GY	r_g							0.976**	0.986**	0.783**
	r_p							0.952**	0.963**	0.666**
GYE	r_g								0.959**	0.796**
	r_p								0.916**	0.671**
BY	r_g									0.686**
	r_p									0.505**

*$p < 0.05$, and **$p < 0.01$

Note: DF: Days to 50% flowering, DM: Days to maturity, PH: Plant height, EL: Earhead length, NET: Number of effective tillers, FLA: Flag leaf area, GY: Grain yield per plant, BY: Biological yield, HI: Harvest index

pooled environments revealing that the characters are governed by additive gene action and phenotypic selection for these characters will be effective. High heritability coupled with high genetic advance values were reported in pearl millet by Lakshmana *et al.* (2009) for Flag leaf area, plant height, productive tillers per plant, earhead length, grain yield per earhead and grain yield per plant., Singh *et al.* (2013) for Number of tillers per plant and fodder yield per plant in sorghum and Vidyadhar *et al.* (2007) for days to flowering and days to maturity.

Correlation coefficient is a statistical measure, which denotes the degree and magnitude of association between any two casually related variables. This association is due to pleiotropic gene action or linkage or more likely both. In plant breeding correlation coefficient analysis measures the mutual relationship between two characters and it determines character association for improvement yield and other economic characters. Since the association pattern among yield components help to select the superior genotypes from divergent population based on more than one interrelated characters. Thus information on the degree and magnitude of association between characters is of prime important for the

Table 3: Path coefficient analyses in pooled environment direct and indirect effect of nine causal variables on grain yield per plant

Parameter	Days to 50 % flowering	Days to maturity	Plant height	Earhead length	No. of effective tillers	Flag leaf area	Grain yield / earhead	Biological yield	Harvest index	Genotypic correlation of grain yield /plant
Days to flowering	0.041	-0.0449	0.0092	0.0116	-0.0806	0.0029	-0.0898	-0.0542	-0.0006	-0.211**
Days to maturity	0.0370	-0.050	0.0163	0.0086	-0.0836	-0.0031	-0.1550	-0.0814	-0.0011	-0.312**
Plant height	-0.0067	0.0146	-0.056	0.0164	0.1008	-0.0008	0.5320	0.2080	0.0056	0.814**
Earhead length	0.0163	-0.0147	-0.0315	0.029	0.0310	-0.0019	0.3913	0.1300	0.0068	0.556**
No. of effe. tillers	-0.0171	0.0216	-0.0292	0.0047	0.193	0.0006	0.3740	0.1780	0.0060	0.732**
Flag leaf area	0.0173	-0.0226	-0.0067	0.0083	-0.0178	-0.007	0.0273	0.0114	-0.0018	0.008
Grain yield/earhead	-0.0057	0.0120	-0.4600	0.0176	0.1119	-0.0003	0.645	0.2311	0.0105	0.976**
Biological yield	-0.0092	0.0168	-0.0481	0.0157	0.1424	-0.0003	0.6190	0.241	0.0090	0.986**
Harvest index	-0.0017	0.0041	-0.0238	0.0150	0.0968	0.0009	0.5140	0.1654	0.0131	0.783**

breeder to initiate any selection plan. In general the genotypic correlation was generally of higher magnitude than phenotypic correlation (Table 2), indicating that inherent association between various characters studied. In general the genotypic correlation was generally of higher magnitude than phenotypic correlation, indicating that inherent association between various characters studied. Grain yield per plant exhibited highly significant positive correlation with grain yield/earhead (0.976, 0.952), biological yield/plant (0.986, 0.963), plant height (0.814, 0.764), harvest index (0.666, 0.796), earhead length (0.556, 0.505) and number of effective tillers/plant (0.732, 0.586) whereas, days to maturity (-0.312, 0.291) and days to flowering (-0.211, -0.199) which showed highly significant negative correlation at both genotypic and phenotypic levels. The similar result obtained by Abuali *et al.* (2009) in pearl millet, Kumar *et al.* (2013) for plant height and number of effective tillers per plant in wheat.

Due to mutual cancellation of component traits, the estimation of correlation alone may be often misleading so it is necessary to study the path co-efficient analysis, which takes into account, the casual relationship in addition to the degree of relationship. Hence genotypic and phenotypic correlation was partitioned into direct and indirect effects to know the relative importance of the components (Table 4). Grain yield per earhead (0.646), biological yield/plant (0.241) and number of effective tillers per plant (0.193) had positive direct effect on grain yield/plant. While, Plant height (-0.056.), days to maturity (-0.050), and flag leaf area (-0.007) had direct negative effect on grain yield per plant. Similar results were revealed by Chaudhry *et al.*, (2003) for grain yield per earhead, biological yield per plant, number of effective tillers per plant and harvest index as well as negative direct effect for leaf area; Arulselvi *et al.* (2008) for plant height.

The present conclusion revealed substantial genetic variability in the pearl millet germplasm collection and a scope for improvement through selection. The studies on correlation coefficients and path analysis indicated that the characters viz. grain yield per earhead, biological yield per plant, number of effective tillers per plant and earhead length were the predominant yield contributing characters in pearl millet.

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