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SHORT COMMUNICATION

TRAIT ASSOCIATION IN DIVERSE PEARL MILLET [*PENNISETUM GLAUCUM* (L.) R. BR.] POPULATIONS UNDER IRRIGATED AND RAINFED CONDITIONS

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SUMMARY

Trait association among 21 diverse pearl millet populations was studied and the experiment was conducted in a randomized block design with three replications during **kharif** season of 2013 in two locations/environments viz., Bajra Section, Research Area, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar (E_1) in irrigated and Regional Research Station, Bawal (E_2) in rainfed conditions. The observations were recorded on each population for seven quantitative traits viz., days to 50 per cent flowering, plant height (cm), number of effective tillers per plant, panicle length (cm), panicle diameter (mm), dry fodder yield (q/ha) and grain yield (kg/ha). The mean performance and range in two environments for each character revealed that E_1 (Hisar) i. e. irrigated condition was the best environment for the expression of almost all the characters except days to 50 per cent flowering, whereas E_2 (Bawal) i. e. rainfed condition was found to be the best for days to 50 per cent flowering. The correlation study revealed that estimated genotypic correlations for most of the characters were greater than their corresponding phenotypic ones. Grain yield exhibited either positive (plant height and dry fodder yield) or negative (days to flowering) but significant association with all the traits in both the environments. Grain yield displayed significant but contrasting values of genotypic correlation with number of effective tillers (positive in E_1 but negative in E_2) and panicle diameter (negative in E_1 but positive in E_2). The results of path coefficient analysis revealed that plant height (0.558 and 24.379) exerted the highest positive direct effect on grain yield followed by panicle length (0.086 and 19.369) and panicle diameter (0.164 and 13.483) in both the environments. Days to 50 per cent flowering, effective tillers per plant and dry fodder yield exhibited the positive direct effect on grain yield in irrigated condition and negative direct effect on grain yield in rainfed condition. Whereas productive tillers per plant and dry fodder yield/plant were not reflecting any direct effect in rainfed condition. The study concludes that main emphasis should be given on days to 50 per cent flowering, plant height and dry fodder yield for grain yield improvement as they exhibited high correlation with grain yield in both the environments.

Key words : Correlation coefficients, path coefficients, pearl millet, grain yield

Grain yield is a complex character and a final product of several contributing traits having a positive or negative relation with it as well as amongst various characters. Direct selection for yield is not that easy. Therefore, any improvement in grain yield is made through improvement in contributing characters such as number of productive tillers/plant, panicle length, panicle girth, number of grains/panicle, 1000-grain weight, etc. along with yield (Arya *et al*., 2009). In order to have appropriate choice of characters for selection of desirable genotypes, the knowledge of nature and magnitude of variability, the association of component characters with yield and their exact contribution through direct and indirect effect are very important. The present study was, therefore, undertaken with the objective to estimate the genetic variability, correlation and path analysis in diverse pearl millet populations with a view to identify the populations with best potential for enhancing yield and its component characters.

The experiment was conducted to study the variability and character association among 21 populations of pearl millet developed by the Bajra Section,

Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar during **kharif** season of 2013 at two locations viz., Bajra Section Research Area, Hisar (E_1) and CCS HAU Regional Research Station, Bawal (E_2) in irrigated and rainfed conditions, respectively. The experiment was carried out in a randomized block design with three replications in a plot size consisting of 6 rows of 4 m, row to row spacing of 45 cm and plant to plant distance at 12 cm. Observations were recorded on five random but representative plants of each population for seven quantitative traits viz., days to 50 per cent flowering, plant height (cm), effective tillers per plant, panicle length (cm), panicle diameter (mm), dry fodder yield (q/ha) and grain yield (kg/ha) in each replication. Recommended package of practices were followed to raise a good crop. The mean value of each genotype was used for statistical analysis. Correlation and path coefficients were worked out as per method suggested by Al-Jibouri *et al.* (1958) and Dewey and Lu (1959), respectively.

A perusal of data presented in Table 1 on mean performance and range in two environments for each character revealed that in E_1 (Hisar) i. e. irrigated condition all the characters except days to 50 per cent flowering exhibited higher mean (52 days) and range (50-57) values as compared to environment E_2, in which the mean (44 days) as well as range (40-62 days) for days to 50 per cent flowering was lower indicating most of the entries flowered early in this environment. Overall, in the irrigated environment, the expression of most of the yield contributing traits was better than in the rainfed conditions. This could be due to the general observation that in favourable environment, enhanced tillering and speedy growth resulted in delayed flowering and more accumulation of biomass in pearl millet. Similar findings were also reported by Arya *et al.* (2010) and Bikash *et al.* (2013). If favourable condition prevails up to grain filling stage, it increases both grain as well as dry fodder yield. On the other hand, if unfavourable condition prevails, then there will be reduction in all yield contributing characters.

Correlation Coefficient and Path Coefficient Analysis

The understanding of association among different component traits and their direct effect on grain yield on their own or through another trait (indirect effect) is one of the pre-requistes for overall improvement of grain yield. The correlation coefficient helps the plant breeder in determining the direction and number of characters to be considered for improving the grain yield (Abuali *et al.*, 2012).

A perusal of Table 2 reveals that the estimated genotypic correlations for most of the characters were greater than their corresponding phenotypic ones. The results are in corroboration with the report of Abuali *et al.* (2012). At genotypic level, days to 50 per cent flowering had negative and highly significant correlation with plant height and grain yield both in irrigated (-0.323**, -0.343**) and rainfed condition (-0.552**, -0.639**), respectively. This is in agreement with the findings of Bikash *et al.* (2013). While negative and significant correlation of days to 50 per cent flowering was observed with effective tillers per plant (-0.369**) in irrigated condition but positive and highly significant correlation with effective tillers per plant (0.639**) in rain fed condition. At phenotypic level it had negative and high phenotypic correlation with plant height (-0.488**) and grain yield (-0.580**) only in rain fed condition. Similar findings were also reported by Kumari *et al.* (2013). At genotypic level, plant height had negative

TABLE 1
Mean performance and range for different characters in pearl millet populations

Character	E_1 (Irrigated)		E_2 (Rainfed)	
	Mean	Range	Mean	Range
Days to 50% flowering	52.0	50-57	44.0	40-62
Plant height (cm)	230.5	195.7-254.0	215.9	150-236.7
Effective tillers/plant	2.6	2.0-2.9	2.55	2.11-3.1
Panicle length (cm)	27. 5	23.1-37.3	25.2	21.67-36.9
Panicle diameter (mm)	31.1	25.1-36.5	30.4	26.17-34.6
Dry fodder yield (q/ha)	81.7	64.67-95.7	63.3	51.7-74.9
Grain yield (kg/ha)	2882.1	1987.33-3680.7	1060.6	410.3-1771.0

and highly significant correlation with effective tillers per plant (-0.340**) and panicle length (-0.444**) only in rain fed condition. The negative and highly significant correlation with panicle diameter (-0.509**) in irrigated (Hisar) condition and positively significant correlation (0.281*) in rain fed condition was observed. At phenotypic level, negative and high phenotypic correlation with panicle diameter (-0.353**) in irrigated condition was observed. This may be due to the difference in genetic materials and the environmental conditions. Number of effective tillers per plant had negative and highly significant genotypic correlation with days to 50 per cent flowering (-0.369**) in irrigated condition, while positive and significant correlation was observed (0.639**) in rainfed condition. Number of effective tillers per plant showed negative but significant correlation with panicle diameter (-0.296*) and positive significant correlation with panicle length (0.258*) and days to 50 per cent flowering (0.325*) in rainfed condition. Similar findings were also reported by Bikash *et al.* (2013). At genotypic level panicle length had negative and highly significant correlation with panicle diameter (-0.479**) in rainfed condition. At phenotypic level it was observed non-significant with all the characters in both the locations. This is in close agreement with that of Bikash *et al.* (2013). At genotypic level, panicle diameter had negative and highly significant correlation with days to 50 per cent flowering (-0.473**) and panicle length (-0.479**) only in rainfed condition. At phenotypic level, it was observed negative significant correlation with days to 50 per cent flowering (-0.301*) and panicle length (-0.275*) only in rainfed condition. Similar findings were also reported by Choudhary *et al.* (2012). At genotypic level, dry fodder yield had positive and highly significant correlation with plant height and grain yield both in irrigated (0.356**, 0.733**) and rainfed condition (0.572**, 0.353**) respectively, While positive and significant correlation was observed with panicle length (0.470**) in irrigated condition and also it was observed negative and highly significant correlation with panicle diameter (-0.399**) in irrigated condition. At phenotypic level, it also had high phenotypic correlation with grain yield at both the locations (0.551** and 0.357**) respectively, While positive and significant correlation was observed with panicle length (0.254*) in irrigated condition and also it was observed negative and highly significant correlation with panicle diameter (-0.250*) in irrigated condition. Positive and significant correlation of dry fodder yield with grain yield was found encouraging for the use of populations as dual purpose. Similar findings were also reported by Kulkarni *et al.* (2000), Arya *et al.* (2009), Bikash *et al.* (2013) and Kumar *et al.* (2014). At genotypic level, grain yield had positive and highly significant correlation with plant height

TABLE 2

Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among pearl millet traits in two environments during **kharif** 2013 season

Character	Environments	Days to 50% flowering	Plant height (cm)	Effective tillers/ plant	Panicle length (cm)	Panicle diameter (mm)	Dry fodder yield (q/ha)	Grain yield (kg/ha)
Days to 50% flowering	Irrigated	1	-0.323**	-0.369**	0.236^{NS}	-0.193^{NS}	-0.058^{NS}	-0.343**
	Rainfed	1	-0.552**	0.639**	0.050^{NS}	-0.473**	-0.044^{NS}	-0.639**
Plant height (cm)	Irrigated	-0.142^{NS}	1	0.084^{NS}	-0.208^{NS}	-0.509**	0.356**	0.667**
	Rainfed	-0.488**	1	-0.340**	-0.444**	0.281*	0.572**	0.408**
Effective tillers/plant	Irrigated	-0.201^{NS}	0.070^{NS}	1	-0.118^{NS}	0.006^{NS}	0.144^{NS}	0.437**
	Rainfed	0.325**	-0.070^{NS}	1	0.258*	-0.296*	0.056^{NS}	-0.372**
Panicle length (cm)	Irrigated	0.221^{NS}	-0.070^{NS}	-0.042^{NS}	1	-0.040^{NS}	0.470**	0.166^{NS}
	Rainfed	0.063^{NS}	-0.171^{NS}	0.125^{NS}	1	-0.479**	0.109^{NS}	-0.124^{NS}
Panicle diameter (mm)	Irrigated	-0.179^{NS}	-0.353**	0.020^{NS}	-0.094^{NS}	1	-0.399**	-0.326**
	Rainfed	-0.301*	0.129^{NS}	-0.055^{NS}	-0.275*	1	0.150^{NS}	0.246*
Dry fodder yield (q/ha)	Irrigated	-0.025^{NS}	0.028^{NS}	0.028^{NS}	0.254*	-0.250*	1	0.733**
	Rainfed	-0.037^{NS}	0.390**	0.082^{NS}	0.133^{NS}	0.127^{NS}	1	0.353**
Grain yield (kg/ha)	Irrigated	-0.226^{NS}	0.355**	0.097^{NS}	0.048^{NS}	-0.208^{NS}	0.551**	1
	Rainfed	-0.580**	0.369**	-0.103^{NS}	-0.055^{NS}	0.214^{NS}	0.357**	1

*,**Significant at P=0.05 and P=0.01 levels, respectively. NS–Not Significant.

both in irrigated condition (0.667**) and rain fed condition (0.408**), respectively. Similar findings were also reported by Kumar *et al.* (2002). While positive and significant correlation was observed with effective tillers per plant (0.437**) in irrigated condition, it is in agreement to the previous workers viz., Kumar *et al.* (2002) and Arya *et al.* (2009) and Bikash *et al.* (2013) who reported effective tillers as the principal component of grain yield in pearl millet. Negatively significant correlation was observed (-0.372**) in rainfed condition. It was observed negative and highly significant correlation with panicle diameter (-0.326**) in irrigated condition and positively significant correlation with panicle diameter (0.246*) in rain fed condition. This may be due to the difference in genetic constitution of populations and the environmental conditions. At phenotypic level grain yield had positive and highly significant correlation with plant height both in irrigated (0.355**) and rainfed condition (0.369**). Similar findings were also reported by Choudhary *et al.* (2012) and Kumar *et al.* (2014). Phenotypic selection may, sometimes, mislead the plant breeder as phenotype is a result of apparent expression of many characters which are correlated to each other in a positive or negative manner.

As more variables are considered in the correlation tables, the indirect association becomes more complex, less obvious and somewhat perplexing. Under such circumstances, the path coefficient analysis (Wright, 1921; Dewey and Lu, 1959) provides an effective means of separating direct and indirect causes of association and permits critical examination of the specific forces acting to produce a given correlation and measures the relative importance of each casual factor. The yield component characters develop invariably a positive or negative relationship among themselves. An apparent association of a trait to the yield might be appearing due to balancing of positive and negative contribution. Direct and indirect effects of these components determined on grain yield at genotypic level are presented in Table 3. The results of path coefficient analysis revealed that plant height (0.557 and 24.379) exerted the highest positive direct effect on grain yield followed by panicle length (0.085 and 19.369) and panicle diameter (0.164 and 13.482) at both the locations, respectively, which supports the findings of Kumar *et al*. (2014) and Kumar *et al*. (2014). Days to 50 per cent flowering, effective tillers per plant and dry fodder yield exhibited the positive direct effect on grain yield in irrigated condition i. e. (Hisar) and negative direct effect on grain yield in rain-fed condition at location i. e. (Bawal). Moreover, productive tillers per plant and dry fodder yield (q/ha) did not reflect any direct effect in rainfed condition.

From the foregoing discussion on correlation and path coefficient analysis, it could be concluded that for planning any selection criterion for improved grain

TABLE 3

Genotypic path coefficients showing direct (diagonal) and indirect effects of various characters on grain yield in pearl millet populations during **kharif** 2013 season

Character	Environments	Days to 50% flowering	Plant height (cm)	Effective tillers/ plant	Panicle length (cm)	Panicle diameter (mm)	Dry fodder yield (q/ha)	Grain yield (kg/ha)
Days to 50% flowering	Irrigated*	**-0.002**	-0.180	-0.120	0.020	-0.032	-0.030	-0.002
	Rainfed**	**21.132**	-13.462	-3.621	0.971	-6.383	0.724	21.132
Plant height (cm)	Irrigated	0.001	**0.558**	0.027	-0.018	-0.084	0.183	0.558
	Rainfed	-11.669	**24.379**	1.930	-8.601	3.785	-9.417	24.379
Effective tillers/plant	Irrigated	0.001	0.047	**0.325**	-0.010	0.001	0.074	0.325
	Rainfed	13.503	-8.301	**-5.667**	5.006	-3.997	-0.917	-5.667
Panicle length (cm)	Irrigated	0.000	-0.116	-0.038	**0.086**	-0.007	0.241	0.086
	Rainfed	1.059	-10.825	-1.465	**19.369**	-6.464	-1.798	19.369
Panicle diameter (mm)	Irrigated	0.000	-0.284	0.002	-0.003	**0.164**	-0.205	0.164
	Rainfed	-10.005	6.844	1.680	-9.287	**13.483**	-2.469	13.483
Dry fodder yield (q/ha)	Irrigated	0.000	0.199	0.047	0.040	-0.066	**0.513**	0.513
	Rainfed	-0.929	13.936	-0.315	2.114	2.021	**-16.474**	-16.474

*Residuals are 0.148, **Residuals are 7.371.

yield, main emphasis should be given on days to 50 per cent flowering, plant height, number of effective tillers per plant, panicle diameter and dry fodder yield which exhibited high correlation with grain yield in both the environments.

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