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Research of correlation and path coefficient analysis for grain yield and it's attributes in pearl millet (*Pennisetum glaucum* (L.) r. br.)

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Abstract
Total twenty six genotypes of pearl millet (*Pennisetum glaucum* (L.) R. Br.) were evaluated for fifteen quantitative characters with a view to study the correlation coefficient and path coefficient analysis using randomized block design (R.B.D.) with three replications at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *kharif* 2021-22. The results of correlation coefficients revealed that grain yield per plant (g) exhibited positive and significant correlation with its yield contributing characters like number of effective tiller per plant, panicle length (cm), panicle girth (mm), panicle weight (g), panicle harvest index (%), 1000 grain weight and harvest index (%) at genotypic as well as phenotypic levels which signifies these are the major yield attributing traits and improvement in these traits will leads to the improvement in grain yield. The results of path coefficient analysis depicted that panicle weight contributed the highest positive and direct effect on grain yield per plant (g) followed by panicle harvest index (%), harvest index (%), dry fodder yield per plant (g), plant height (cm), iron content (%), zinc content (%) and days to flowering indicated their appreciable contribution in improving the grain yield of pearl millet.

Keywords: Correlation coefficient, genotypes, grain yield per plant, path coefficient analysis

Introduction
Pearl millet [*Pennisetum glaucum* (L.) R.Br.], a diploid species (2n=2x=14) believed to be originated in West Africa and from there it was introduced to India. It is of great importance in the arid and semi-arid tropics, where it is a staple food for millions of people. It is commonly known as bulrush millet or cattail millet in English (Adam, 1996) [1] and in India it commonly known as 'bajra'. It is third most important cereal crop after rice and wheat in India. India is the largest pearl millet growing country. Pearl millet is mainly grown in Rajasthan, Uttar Pradesh, Gujarat, Maharashtra, Haryana, Karnataka, Tamil Nadu, Madhya Pradesh and Andhra Pradesh states of the country. In India pearl millet occupies an area of 6.93 million hectares with production of 8.61 million tonnes with productivity of 1243 Kg/ha (Anonymous, 2020) [2]. In Gujarat, *Kharif* season pearl millet occupies an area of 1.77 lakh hectares and production of 3.08 lakh tonnes with the productivity of 1740 kg/ha. Whereas, in *summer* season pearl millet occupies an area of 2.72 lakh hectares and production of 7.83 lakh tonnes with the productivity of 2879 kg/ha. (Anonymous, 2020) [2].
The grain yield is a complex character, so direct selection for grain yield is not so much effective and easy. Therefore, improvement in grain yield is made through improvement in its contributing characters. This study will determine the criteria for selection that could be effectively used with high yield potential. Hence, correlation must be worked out among grain yield and its contributing traits. The correlation coefficients were estimated among fifteen quantitative and qualitative characters to discover association between grain yield per plant and its components at genotypic (r_g) and phenotypic (r_p) levels. The characters that are positively correlated with grain yield are considerably important for desirable selection in upcoming future variety development programme.
Path coefficient analysis splits the correlation coefficient into measure of direct and indirect effects thus providing understanding of the direct and indirect contribution of each character towards grain yield. A line diagram is also constructed with the help of simple correlation coefficient among various characters included under study is referred to as a path diagram

(Figure No. 1). Hence, the present study was under taken to unravel the correlation and path coefficient of grain yield and its attributes in diverse germplasms of pearl millet.

Materials and Methods

A set experimental material comprised of 26 (twenty six) diverse genotypes were collected from breeding material maintained at the Centre for Crop Improvement, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. An investigation was conducted in a randomized block design with three replications at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *kharif* 2021-22. Each genotype was accommodated in a single row of 4 m length with a spacing of 45 cm between rows and 15 cm between plants. The recommended package of practices were followed to raise a healthy crop. Observation recorded on five random representative plants of each line for 15 different quantitative traits *viz*., days to flowering, days to maturity, plant height (cm), number of effective tiller per plant, panicle length (cm), panicle girth (mm), panicle weight per plant (g), grain yield per plant (g), panicle harvest index (%), dry fodder yield per plant (g), 1000 grain weight (g), harvest index (%), protein content (%), iron content (%) and zinc content (%). Genotypic and phenotypic correlation coefficients were calculated from the genotypic and phenotypic components of variance and covariance as described by Singh and Choudhary (1985) [12] and as per formula given by Johnson *et al*., (1955) [7]. Path analysis was carried out as per the procedure given by Dewey and Lu (1959) [6]. Correlation and path coefficient analysis were worked out by using statistical package developed by R studio analysis.

Results and Discussion

Genotypic correlation coefficients (r_g) and phenotypic correlation coefficients (r_p)

The genotypic and phenotypic correlation coefficient was worked out among the important grain yield and yield related traits (Table No. 1). Higher value of genotypic correlation than phenotypic correlation coefficients were also observed by most of the character pairs. This indicated high degree of association between two variables at genotypic levels and its phenotypic expression may deflated by the influence of environment. The grain yield per plant showed positive and significant correlation with number of effective tiller per plant (r_g = 0.930 and r_p = 0.786), panicle length (r_g = 0.904 and r_p = 0.839), panicle girth (r_g = 0.920 and r_p = 0.845), panicle weight per plant (r_g = 0.991 and r_p = 0.968), panicle harvest index (r_g = 0.805 and r_p = 0.615), 1000 grain weight (r_g = 0.814 and r_p = 0.760) and harvest index (r_g = 0.558 and r_p = 0.540) at both genotypic and phenotypic levels which signifies these are the major yield attributing traits and improvement in these traits will leads to the improvement in grain yield. The present findings were earlier found by Scientists *viz*., Singh *et al*., (2015) [13], Narasimhulu and Veeraraghavaiah (2020) [10], Anuradha *et al.*, (2018) [3], Manga (2013) [9], Dapke *et al*., (2014) [5] and Yadav *et al*., (2022) [16].

The relationship of number of effective tiller per plant, panicle length (cm), panicle girth (mm), panicle weight (g), panicle harvest index (%), 1000 grain weight (g) and harvest index (%) showed positive and significant correlation of high order both at genotypic as well as phenotypic levels of correlation. The characters which were highly correlated with grain yield per plant were closely related to each other as well in most of the cases.

Positive and significant association of grain yield attributing traits with each other lays the emphasis on higher the number effective tiller lead to greater number of panicle which ultimately leads to the higher grain yield per plant. Greater size of panicle length (cm) leads to the higher panicle weight per plant (g) and higher 1000 grain weight (g) which also lead to the higher grain yield per plant (g). Panicle length (cm) which is important grain yield contributing parameters which exhibited positive significant correlation with panicle girth (mm), panicle weight (g), panicle harvest index (%), 1000 grain weight (g) and harvest index (%) at both genotypic and phenotypic levels of correlation. Panicle girth (mm) depicted significant positive correlation with panicle weight (g), panicle harvest index (%), 1000 grain weight (g) and harvest index (%). Panicle weight (g) showed positive significant correlation with panicle harvest index (%), 1000 grain weight (g) and harvest index (%) at both the levels indicating their contribution towards expression of grain yield. Therefore, selection of these characters found desirable for improvement of grain yield in pearl millet.

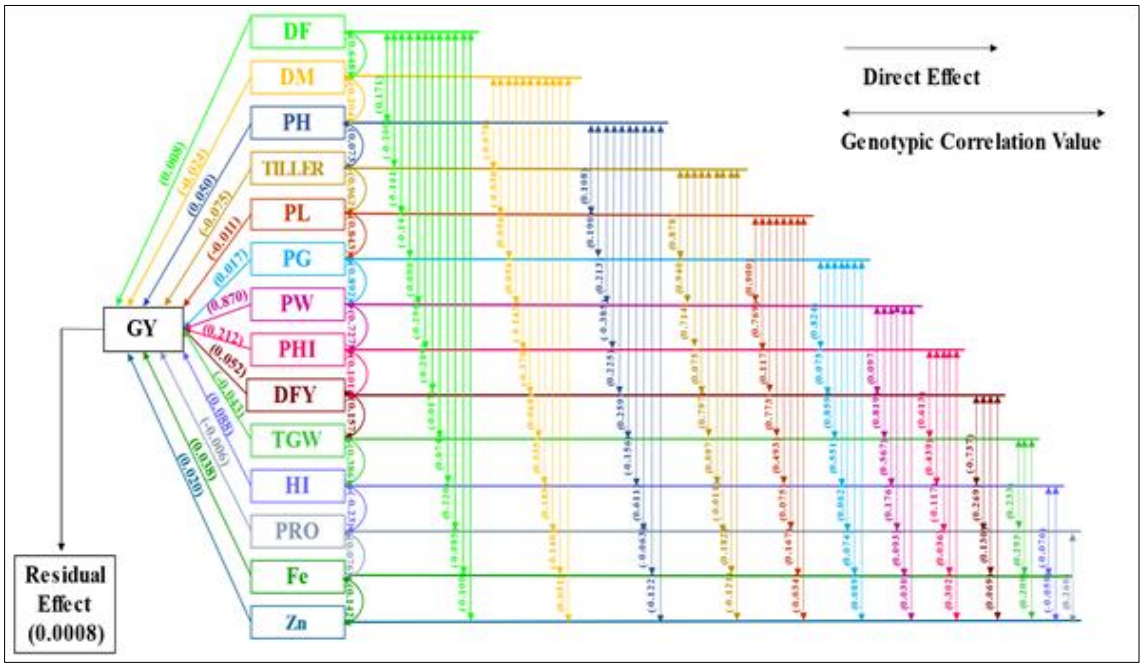
Days to flowering exhibited positive and significant genotypic and phenotypic correlation with days to maturity which leads to early maturity of genotypes. Number of effective tiller per plant recorded positive significant association with panicle length (cm), panicle girth (mm), panicle weight (g), panicle harvest index (%), 1000 grain weight (g) and harvest index (%) which is correspondence with results of Singh *et al*., (2015) [13] and Anuradha *et al*., (2018) [3]. Hence focus more on above parameters for improving grain yield in pearl millet. The association of grain yield with days to flowering and dry fodder yield per plant was negative and non-significant. While days to maturity, plant height (cm), protein content (%), iron content (%) and zinc content (%) was positive and non-significant at genotypic and phenotypic level of correlation with grain yield per plant.

Therefore, the directional improvement should be done in the traits like panicle length (cm), panicle girth (mm), number of effective tiller per plant, 1000 grain weight (g) and dry fodder yield per plant (g) for enhancing the yield potential in pearl millet using effective breeding strategies.

Path coefficient analysis

The results of path coefficient analysis revealed (Table No. 2) that panicle weight contributed the highest positive direct effect on grain yield per plant followed by panicle harvest index, harvest index, dry fodder yield per plant, plant height, iron content, zinc content and days to flowering indicated their appreciable contribution in improving the grain yield of pearl millet. Hence these characters considered as main components for selection in a breeding programme for higher grain yield. which supports the findings of Kumar *et al*., (2020) [8], Choudhary *et al*., (2012) [4], Dapke *et al*., (2014) [5], Nehra *et al*., (2017) [11], Sumathi *et al*., (2016) [15] and Subbulakshmi *et al*., (2018) [14]. Among these characters, high and positive indirect effect on grain yield per plant was observed through number of effective tiller per plant, panicle length, panicle girth, panicle harvest index, 1000 grain weight and harvest index. Negative and direct effect of days to maturity, number of effective tiller per plant, panicle length, 1000 grain weight and protein content on grain yield. The

residual effect in path coefficient was considerably low (0.0008) indicating the majority of yield attributes have been included in the study of path analysis. Therefore, breeding program done in effective manner based on these traits could be beneficial for improvement in grain yield.



(Residual effect = 0.0008)

DF = Days to flowering, DM = Days to maturity, PH = Plant height (cm), TILLER = Number of effective tiller per plant, PL = Panicle length (cm), PG = Panicle girth (mm), PW = Panicle weight per plant (g), GYP = Grain Yield per plant (g), PHI = Panicle harvest index (%), DFY = Dry fodder yield per plant (g), TGW = 1000 grain weight (g), HI = Harvest index (%), PRO = Protein content, (%), Fe = iron content (%), Zn = Zinc content (%)

Fig 1: Diagrammatic representation of factor influencing grain yield in pearl millet, single arrowed line depicting direct effect while double arrowed line depicting value of correlation coefficients

Table 1: Genotypic correlation (r_g) and phenotypic correlation (r_p) coefficients of grain yield and its different component traits in pearl millet

		DF	DM	PH	TILLER	PL	PG	PW	PHI	DFY	TGW	HI	PRO	Fe	Zn	GYP
DF	r_g	1	0.648**	0.171	-0.200	-0.161	-0.142	-0.090	-0.296	-0.013	-0.017	0.134	0.220	-0.085	-0.100	-0.136
	r_p	1	0.616**	0.106	-0.175	-0.157	-0.119	-0.094	-0.204	-0.013	-0.027	0.130	0.221	-0.073	-0.084	-0.136
DM	r_g		1	0.204	-0.078	-0.030	0.056	0.056	-0.143	0.106	0.068	0.068	0.185	-0.140	0.051	0.018
	r_p		1	0.082	-0.053	-0.042	0.053	0.056	-0.124	-0.116	0.060	0.077	0.180	-0.126	0.073	0.012
PH	r_g			1	0.073	0.108	0.190	0.213	-0.385	0.083	0.259	-0.070	0.611**	-0.063	-0.122	0.125
	r_p			1	0.029	0.088	0.148	0.175	-0.241 *	0.067	0.175	-0.045	0.451**	-0.083	-0.130	0.108
TILLER	r_g				1	0.962**	0.878**	0.940**	0.714**	-0.229	0.797**	0.877**	-0.011	0.182	-0.121	0.930**
	r_p				1	0.767**	0.701**	0.770**	0.475**	-0.126	0.681**	0.670**	-0.015	0.158	-0.087	0.786**
PL	r_g					1	0.843**	0.900**	0.769**	-0.160	0.773**	0.823*	0.075	0.167	-0.034	0.904**
	r_p					1	0.762**	0.824 **	0.527**	-0.159	0.737**	0.751**	0.062	0.158	-0.041	0.839**
PG	r_g						1	0.892**	0.824**	0.102	0.859**	0.746**	0.058	0.074	0.089	0.920**
	r_p						1	0.801**	0.585**	-0.107	0.778**	0.674**	0.062	0.070	0.088	0.845**
PW	r_g							1	0.727**	-0.124	0.819**	0.814**	0.176	0.093	0.030	0.991**
	r_p							1	0.411**	-0.092	0.743**	0.633**	0.160	0.091	0.014	0.968**
PHI	r_g								1	-0.097	0.613**	0.722**	-0.117	0.036	0.302	0.805**
	r_p								1	-0.090	0.449**	0.554**	-0.093	0.037	0.246*	0.615**
DFY	r_g									1	-0.048	-0.627**	0.142	-0.114	0.196	0.104
	r_p									1	-0.071	-0.647**	0.136	-0.098	0.147	0.100
TGW	r_g										1	0.639*	0.233	0.293	0.209	0.814**
	r_p										1	0.573**	0.226*	0.285*	0.186	0.760**
HI	r_g											1	-0.037	0.095	-0.068	0.558**
	r_p											1	-0.043	-0.085	-0.044	0.540**

*, ** significant at 5% and 1% level of significance, respectively.

DF = Days to flowering (N), DM = Days to maturity (N), PH = Plant height (cm), TILLER = Number of effective tiller per plant (N), PL = Panicle length (cm), PG = Panicle girth (mm), PW = Panicle weight per plant (g), GYP = Grain Yield per plant (g), PHI = Panicle harvest index (%), DFY = Dry fodder yield per plant (g), TGW = 1000 grain weight (g), HI = Harvest index (%), PR0 = Protein content (%), Fe = Iron content (%), Zn = Zinc content (%).

Table 2: Path coefficient analysis showing direct and indirect effects of different component traits on grain yield in pearl millet

Sr. No.	Characters	DF	DM	PH	Tiller	PL	PG	PW	PHI	DFY	TGW	HI	PRO	Fe	Zn	Genetic correlation with GYP
1	DF	0.0081	-0.0158	0.0086	0.0151	0.0018	-0.0025	-0.0787	-0.0630	-0.0110	0.0007	0.0067	-0.0015	-0.0033	-0.0021	-0.136
2	DM	0.0052	-0.0244	0.0103	0.0059	0.0004	0.0010	0.0491	-0.0304	-0.0198	-0.0030	0.0298	-0.0013	-0.0054	0.0011	0.018
3	PH	0.0014	-0.0050	0.0502	-0.0055	-0.0012	0.0034	0.1861	-0.0817	0.0118	-0.0113	-0.0139	-0.0041	-0.0024	-0.0025	0.125
4	TILLER	-0.0016	0.0019	0.0037	-0.0750	-0.0108	0.0154	0.8184	0.1517	0.0039	-0.0347	0.0531	0.0001	0.0070	-0.0025	0.930**
5	PL	-0.0013	0.0008	0.0054	-0.0722	-0.0113	0.0148	0.7837	0.1632	0.0061	-0.0337	0.0439	-0.0005	0.0064	-0.0007	0.904**
6	PG	-0.0012	-0.0014	0.0096	-0.0660	-0.0095	0.0176	0.7765	0.1750	0.0040	-0.0374	0.0490	-0.0004	0.0029	0.0018	0.920**
7	PW	-0.0007	-0.0014	0.0107	-0.0706	-0.0101	0.0157	0.8701	0.1544	0.0051	-0.0357	0.0505	-0.0012	0.0036	0.0006	0.991**
8	PHI	-0.0024	0.0035	-0.0193	-0.0537	-0.0087	0.0145	0.6330	0.2123	0.0053	-0.0267	0.0391	0.0008	0.0014	0.0062	0.805**
9	DFY	-0.0017	0.0092	0.0113	-0.0055	-0.0013	0.0013	0.0844	0.0215	0.0525	-0.0068	-0.0654	-0.0018	0.0050	0.0014	0.104
10	TGW	-0.0001	-0.0017	0.0130	-0.0599	-0.0087	0.0151	0.7132	0.1303	0.0083	-0.0435	0.0343	-0.0016	0.0113	0.0043	0.814**
11	HI	0.0006	-0.0082	-0.0079	-0.0448	-0.0056	0.0097	0.4939	0.0933	-0.0386	-0.0168	0.0889	0.0016	-0.0030	-0.0012	0.558**
12	PRO	0.0018	-0.0045	0.0307	0.0009	-0.0008	0.0011	0.1537	-0.0250	0.0142	-0.0102	-0.0213	-0.0068	0.0029	0.0054	0.142
13	Fe	-0.0007	0.0034	-0.0032	-0.0137	-0.0019	0.0013	0.0810	0.0078	0.0068	-0.0128	-0.0068	-0.0005	0.0385	0.0029	0.102
14	Zn	-0.0008	-0.0013	-0.0062	0.0091	0.0004	0.0016	0.0266	0.0642	0.0036	-0.0091	-0.0053	-0.0018	0.0055	0.0205	0.107

*, ** significant at 5% and 1% level of significance, respectively.

DF = Days to flowering, **DM** = Days to maturity, **PH** = Plant height (cm), **Tiller** = Number of effective tiller per plant, **PL** = Panicle length (cm), **PG** = Panicle girth (mm), **PW** = Panicle weight per plant (g), **GYP** = Grain Yield per plant (g), **PHI** = Panicle harvest index (%), **DFY** = Dry fodder yield per plant (g), **TGW** = 1000 grain weight (g), **HI** = Harvest index (%), **PRO** = Protein content, (%), **Fe** = iron content (%), **Zn** = Zinc content (%).

Conclusion

The findings of present experiment of genotypic correlation coefficients (r_g) and phenotypic correlation coefficients (r_p) as well as path coefficient analysis in pearl millet suggested that characters like number of effective tiller per plant, panicle length, panicle girth, panicle weight, panicle harvest index, 1000 grain weight and harvest index showed higher order positive and significant genotypic and phenotypic correlations with grain yield per plant. The characters which were highly correlated with grain yield per plant were highly related to each other as well in most of the cases.

Characters like Panicle weight, panicle harvest index, harvest index, dry fodder yield per plant, plant height, iron content, zinc content and days to flowering possess positive direct effect on grain yield per plant indicated that these are the major yield contributing characters. Hence, more weightages should be given to these characters for selection of genotypes in breeding programme for developing high yielding cultivars in pearl millet.

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