ASSOCIATION AND CAUSAL EFFECTS IN PEARL MILLET GERMPLASM LINES FOR YIELD AND ITS CONTRIBUTING TRAITS

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(Received : 07 March 2023: Accepted : 27 March 2023)

SUMMARY

An investigation was carried out for eight morphological parameters to assess the character association in forty pearl millet germplasm lines. Correlation coefficient analysis revealed that 1000 grain weight (g), dry fodder yield per plant (g), plant height (cm), panicle length (cm) and productive tillers (no.). Path coefficients analysis revealed that dry fodder yield per plant (g), productive tillers (no.), panicle length (cm) and 1000 grain weight (g) had high direct contribution towards grain yield per plant, whereas indirect effects of independent traits indicated that plant height (cm), productive tillers (no.), panicle length (cm) and panicle diameter (cm) exhibited high contribution towards grain yield. Hence, it would be rewarding to lay stress on these characters in selection programme for increasing yield.

Key word : Pearl millet, phenotypic correlation, genotypic correlation, path analysis

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is staple food crop for people living in dry regions of arid and semi-arid tropics (Arya and Yadav, 2009). It is well-adapted to nutrient-depleted soil and low rainfall conditions, yet it is capable of grow quickly and vigorously in the right conditions (Yadav *et al*., 2013& 2014). Pearl millet, an annual diploid, is a highly cross pollinated C_4 monocot species of the family *Poaceae*. It serves as an important forage and food crop in arid and semi-arid Indian and African regions covering more than 26 million ha area. In India, during the year 2020-21, pearl millet was grown in an area of 7.65 million ha with production and productivity of 10.86 million tons and 1420 kg/ha, respectively. In Haryana, area covered by crop was 5.69 lakh ha with production and productivity of 13.5 lakh tons and 2372 kg/ha, respectively (Anonymous, 2021). It contains starch, fat, protein, calcium, iron, and zinc content and serves as the staple food for poor families (Arya *et al*., 2008 & 2013). Pearl millet is a requisite source of fodder in many regions of the world. Green fodder from pearl millet is a cherished feed for livestock. Being gluten free, it is famed among the people suffering from gluten allergy. It is a rich source of energy (361 Kcal/100g) which is more than sorghum and just about equivalent to that of brown rice, because of the lipid content which is generally higher *i.e*., 3 to 6%. It contains antioxidants which can prove to be beneficial for the overall health and wellbeing. (Nambiar *et al*., 2011). Pearl millet is a crop normally grown in an area with low and erratic rainfall (200-600 mm), high temperature, high salinity or low pH and impoverished infertile soils. It is tolerant to harsh growing conditions (Arya et al., 2014) and hence it can be grown in areas where other cereal crops, such as wheat, maize or rice would not survive.

Before starting any breeding or hybridization programme it is important to learn about the yield and its contributing traits. Grain yield and minerals contents are complex attributes that are influenced by the nearby environment and are governed by multiple genes (Owere *et al.*, 2015). Correlation is helpful in revealing the magnitude as well as the direction of the relationship between grain yield and its contributing traits (Dewey and Lu, 1959). It provides better understanding of yield component which helps the plant breeder during selection. Path coefficient calculates the direct and indirect effect on dependent variable exerted by independent variable (Dewey and Lu, 1959) and helps to understand the cause of association between two variables. The information obtained by path coefficient analysis helps in indirect selection for genetic improvement of yield, as the direct selection is not effective for low heritable traits like yield. Therefore, the correlation studies along with the path analysis provide an unblemished understanding of the association of different characters with grain yield. The purpose of this study, therefore, was to estimate correlation between grain yield and its attributing traits as well as the direct and indirect effects of these component traits over grain yield. The information so derived could be exploited in framing further breeding strategies and the selection procedures to develop new varieties of the crop with high yielding potential along with a significantly good quality in terms of nutrition.

MATERIALS AND METHODS

The field experiment was conducted in research area of Bajra Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. It is situated in semi-arid sub-tropical region at global geographical position between 29.09°N and 75.43°E with elevation of 215.52 meter above mean sea level with sandy-loam soil. Forty pearl millet germplasm lines were taken as experimental material, collected from CCS HAU, Hisar. The present investigation was carried out by taking 40 genotypes (elite inbred lines) of pearl millet including some checks namely HMS 81B, ICMB 843-22, H77/833-2-202 and HBL 11. The material was evaluated in randomized block design with three replications during *Kharif 2015*. Each plot comprised of two rows of 4 m length with row-to-row distance 45 cm and plant to plant distance of 10-12 cm. All recommended package of practices were adopted to raise a good crop. The observation was recorded on five randomly chosen plants from every genotype in each replication for 8 quantitative characters namely, days to 50 per cent flowering (DTF), plant height (PH), number of productive tillers per plant (PT), panicle length (PL), panicle girth (PG), 1000 grain weight (TW), grain yield per plant (GY), dry fodder yield per plant (DFY).

TABLE 1

List of elite inbred lines of pearl millet used for experiment.

S. No.	Inbred line	S. No.	Inbred line
1.	TCP-10-110	21.	TPC-1
2.	H 78/711	22.	*ICMB 843-22
3.	SGP 10-120	23.	*H 77/ 833-2-202
4.	HPT-1-12-84	24.	*HBL -11
5.	HPT-1-12-44	25.	HPT -2/12-06
6.	HTP-92/80	26.	PT-1-10-1002
7.	PT 1-10-1021	27.	HPT-10-129
8.	S97/120	28.	RAJ - 3
9.	SGP10-111	29.	PT- 2- 10-173
10.	HTP 03/13-901-78-3	30.	AC -04/13
11.	HPT-2-12-62	31.	LPRLT- 14/104
12.	H 12/009	32.	LPRLT-14/109
13.	IH 8	33.	A5RLT-14/106
14.	H 12/011	34.	SGRLT-14/ 106
15.	ISK 51	35.	HPT-10-144
16.	99HS-139	36.	TCH-26-1
17.	HFe PPT-2/12-141	37.	PT-1-10-1047
18.	HFe PPT-2/12-152	38.	HFeT-3-11-125
19.	G 73/107	39.	EMRLT-14-116
20.	HTP 93/109-1	40.	*HMS 81B

(*Check entries).

The correlation coefficient between characters was determined as per the method given by Al-Jibouri *et al.* (1958). Path coefficient analysis was carried out using phenotypic correlation values of yield components on yield as illustrated by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The aim of studying correlation is primarily to know the fitness of various characters for indirect selection of yield because selection for any particular trait brings about undesirable changes in various other associated traits. Further, any direct selection done for yield is not effective as it is a complex quantitative character which is generally influenced by environment. Therefore, the correlation between yield, its component traits and among themselves is of substantial importance in any selection programmes. The phenotypic and genotypic correlation coefficients between yield and other related component characters and among themselves were estimated. The same has been tabulated and presented in Table 2. The magnitude of correlation coefficients at genotypic level were almost higher than the corresponding correlation coefficients at the phenotypic level and revealed a strong inherent association between different attributes and less influence of environment.

The selection of superior genotypes based on grain yield as such may not be effective being end product of many component traits (Whitehouse *et al.* 1958). Generally, correlation among different characters is due to the presence of linkage and pleiotropic effect between different genes. In some cases, environment affects both the traits simultaneously in same direction or some time in opposite directions and thus environment plays an important role in the development of phenotypic correlation (Ali *et al.*, 2009). The results of correlation coefficient analysis revealed that 1000 grain weight (g), dry fodder yield per plant (g), plant height (cm),

TABLE 2

Genotypic (below diagonal) and Phenotypic (above diagonal) Correlation coefficient among grain yield per plant and its component traits

Characters	Days to 50% flowering	1000-grain weight (g)	Grain yield/ plant (g)	Dry fodder yield/plant (g)	Plant height (cm)	Panicle length (cm)	Panicle diameter (cm)	Productive tillers (Number/ plant)
Days to 50% flowering		0.182*	-0.028	0.178	-0.092	-0.011	0.493**	-0.077
1000 grain weight (g)	0.201*		0.309**	0.304**	-0.053	-0.034	0.581**	-0.018
Grain yield/ plant (g)	-0.047	0.328**		0.799**	0.365**	0.389**	0.185*	0.626**
Dry fodder yield/ plant (g)	0.191*	0.320**	0.846**		0.421**	0.305**	0.302**	0.469**
Plant height (cm)	-0.095	-0.069	0.395**	0.436**		0.268**	-0.099	0.387**
Panicle length (cm)	0.008	-0.055	0.440**	0.364**	0.290**		-0.143	0.069
Panicle diameter (cm)	0.570**	0.668**	0.201*	0.348**	-0.117	-0.234		0.014
Productive tillers (Number per plant)	-0.098	-0.038	0.717**	0.516**	0.425**	0.129	0.013	

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

panicle length (cm) and productive tillers (no.) were significantly and positively correlated with grain yield per plant (Table 2). Kumari *et al.* (2018) found positive association of plant height, panicle length, panicle diameter and tillers per plant with grain yield/plant. Similar results were also reported by Saini *et al.* (2022); Govindaraj *et al.* (2009); Dapke *et al.* (2014); Ezeaku *et al.* (2015). The correlation coefficient helps the breeder in determining the direction and number of characters to be considered for improving the grain yield. Significant and positive correlation of grain yield with effective tillers agrees to the works of Balakrishnan and Das (1995). Positive association of plant height with grain yield was in close agreement to the previous findings in pearl millet by Poongodi and Palannisamy (1995); Harrer and Karad (1998) and Bikash et al. (2013). Positive correlation of 1000 grain weight with grain yield was also reported by Kulkarni *et al.* (2000), Arya *et al.* (2009). Similar results for all the traits were reported by Bhasker *et al.* (2017). Sabiel *et al.* (2014) revealed that plant height and 1000-seed weight was found positively associated with grain yield/ plant in pearl millet genotypes. Significant and positive association between fodder yield and grain yield was reported by Harrer and Karad (1998), Kulkarni *et al.* (2000) and Arya *et al.* (2009). Positive and significant correlation of fodder yield with grain yield was found encouraging for the development of dual-purpose hybrids (Bikash et al., 2009). These findings are contradictory to most of the results of Abuali *et al.* (2012), Dapke *et al.* (2014), Sabiel *et al.* (2014). Panicle length was also important yield determinant

TABLE 3

Path coefficient analysis of grain yield per plant with its component characters in Pearl millet germplasm lines

Characters	Days to 50% flowering	1000-grain weight (g)	Dry fodder yield/plant (g)	Plant height (cm)	Panicle length (cm)	Panicle diameter (cm)	Productive tillers (Number/ plant)	Genotypic correlation coefficient (g)
Days to 50% flowering	-0.162	0.042	0.103	0.009	0.002	0.002	-0.043	-0.047
1000 grain weight (g)	-0.033	0.207	0.173	0.007	-0.012	0.002	-0.017	0.328**
Dry fodder yield per plant (g)	-0.031	0.066	0.540	-0.041	0.083	0.001	0.227	0.846**
Plant height (cm)	0.015	-0.014	0.235	-0.094	0.066	0.000	0.188	0.395**
Panicle length (cm)	-0.001	-0.011	0.197	-0.027	0.227	-0.001	0.057	0.440**
Panicle diameter (cm)	-0.092	0.139	0.188	0.011	-0.053	0.004	0.006	0.201*
Productive tillers (Number/plant)	0.016	-0.008	0.279	-0.040	0.029	0.000	0.441	0.717**

Residual effect- 0.0883.

character because of the positive and highly significant levels of correlations with yield. Govindaraj *et al.* (2009) found a positive association of grain yield with zinc content also. The positive correlation of grain yield with these attributing characters implies that improving one or more of these traits, could result in higher grain yields for pearl millet. The study revealed substantial genetic variability among the germplasm lines and a scope for improvement through selection. The selection procedure may be formulated in such a way that the genetic improvement in one component is not jeopardized by the deterioration effect of the other. Therefore, results of correlation study revealed that the characters *viz.* plant height, panicle diameter and dry fodder yield per plant were the important component traits of grain yield and during development of populations and inbred lines, these traits may get due attention of the breeders in pearl millet breeding programmes.

Simple correlation coefficients provide measure of positive and negative association between variables, but it does not give casual basis of such association. Path analysis provides the information on direct and indirect effects of various independent components on the dependent character. As more variables are considered in the correlation studies, 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. This cause-and-effect approach facilitates the selection of component traits in breeding programme of a crop species for its genetic improvement in a desired direction. An apparent association of a trait to the yield might be appearing, due to balancing of positive and negative contribution. Therefore, path coefficient analysis could be more effective method for use in selection programme, based on component breeding.

Considering grain yield as effect and other characters as causes, genotypic correlation coefficients were partitioned by using method of path analysis to find out the direct and indirect effects (Table 1). The magnitude of direct effects revealed that 1000 grain weight and panicle length had high and positive direct effects on grain yield which is supported by the findings of Kumar *et al.* (2014, 2020) for 1000 grain weight and panicle length. Bhasker *et al.* (2017) reported that fodder yield/plot and panicle length had the greatest direct effect on grain production per plant. The results were also supported by Singh *et al.* (2015), Kaushik *et al.* (2018) and Kumar *et al.* (2020). 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, 1000 grain weight had indirect effects on grain yield per plant. Low value of residual effects (0.088) indicated that contribution of independent characters included in this study explained about 92 % of variation for grain yield. Based on the on-going discussion, the traits *viz.,* days to 50% flowering, number of productive tillers per plant, plant height, 1000 grain weight, dry fodder yield and panicle length may be given due attention in pearl millet breeding.

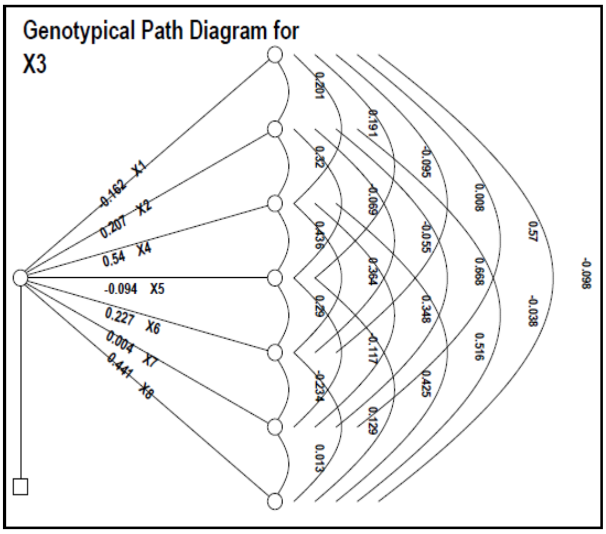

Fig. 1. Path diagram (genotypic) for the grain yield/ plant (dependent variable) X1-Days to 50% flowering, X2-1000 grain weight, X3-Grain yield per plant, X4-Dry fodder yield per plant, X5-Plant height, X6-Panicle length , X7-Panicle diameter, X8-productive tillers (no. per plant).

CONCLUSION

The correlation coefficients at genotypic level had higher magnitude than their corresponding correlation coefficients at phenotypic level, thereby, revealing a good amount of strong inherent association of 1000 grain weight, dry fodder yield per plant, plant height, panicle length and productive tillers. Path coefficients analysis revealed that dry fodder yield per plant, productive tillers, panicle length and 1000 grain weight had high direct contribution towards grain yield per plant, whereas indirect effects of independent traits indicated that plant height, productive tillers, panicle length and panicle diameter exhibited high contribution towards grain yield. Hence, it would be rewarding to lay stress on these characters in selection programme for increasing yield.

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