SELECTION CRITERION BASED ON TRAIT LINKAGES IN AFRICAN AND ASIAN PEARL MILLET [Pennisetum glaucum (L.) R. Br.] POPULATIONS TO ENHANCE PRODUCTIVITY

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SELECTION CRITERION BASED ON TRAIT LINKAGES IN AFRICAN AND ASIAN PEARL MILLET [*Pennisetum glaucum* (L.) R. Br.] POPULATIONS TO ENHANCE PRODUCTIVITY

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Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is commonly grown in the arid and semi-arid regions of Africa and Asia. It serves as staple food for the people living in relatively dry tracts of the India and Sub-Sahelian Africa and an important source of fodder/ feed for livestock and poultry. It can be cultivated even in the poor infertile soils and drought prone environments, where no other cereal crop can survive. In India, currently pearl milletis cultivated on ~7.5 m ha area with grain production of 9.7 Mt with an average productivity of 1,305 kg ha^{-1}(www.indiastat.com). The ultimate aim in most plant breeding programs is the improvement in the productivity of grains as measured in terms of the yield per unit area. The possibilities of achieving this goal through genetic improvement have been elucidated by evolving high yielding hybrids and varieties of pearl millet in Asia and West Africa.

Pearl millet germplasm such as landraces, open pollinated varieties (OPVs) and populations exhibits a wide range of valuable genetic variability for agronomic traits, tolerance to biotic and abiotic stresses and are often well adapted to varying climatic condition. These landraces and OPVs are majorly cultivated in African countries where as Indian pearl millet cultivation is dominated by hybrids and an area of about 2 m ha is under OPVs and landraces. The existing wide variability in the pearl millet germplasm is less utilized in the breeding program (Yadav *et al.* 2009). Therefore, assessing the extent of variability for the economically important traits and identification of promising germplasm is essential to generate knowledge useful for efficient breeding programs. Recently, few studies have been carried out to assess variability among pearl millet germplasms of Asia (Yadav *et al.,* 2004; Yadav *et al.,* 2009; Jyothi Kumari *et al.,* 2016) and Africa (Bashir *et al*., 2014; Pucher *et al*., 2015; Sattler *et al*., 2017). They reported existence of wide variability among the germplasm for various yield-contributing traits. Nevertheless, until now, there is no increase in productivity (or in improvement in yield of OPVs) even though there is substantial increase in area and production in Africa (ICRISAT and ICARDA, 2012). This necessitates utilization of germplasms in current breeding programs by studying the relationship and effects of various yield-contributing traits on grain yield to derive proper selection criteria for enhancing productivity in pearl millet crop.

Correlation analyses relationship among the characters has great value in the evaluation of the most effective procedures for selection of superior genotypes. Positive association between major yield contributing characters would be desirable and it eases the selection process in breeding program. Correlation analyses provides relationship at phenotypic, genotypic and environment level. The genotypic correlation is the heritable association among the traits, and the environmental correlation is environmental deviations together with non-additive genetic deviations (Allard, 1960; Falconer and Mackay, 1996). However, Correlation measures only mutual association between traits and does not say anything about the cause and effect relationship (Roy, 2000). Hence, Path coefficient analysis is an important statistical tool that indicates which variables (causes) exert influence on other variables (effects). It measures the direct influence of one variable upon another and permits the separation of correlation coefficient into components of direct and indirect effects as well as specifies the relative importance of the characters (Dewey and Lu, 1959). In any breeding

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program where target trait is grain yield improvement for which direct selection is not effective, it becomes essential to measure the contribution of each of the component variables towards higher grain yield and to partition the correlation into components of direct and indirect effect. Therefore, the present study was conducted to determine trait association and direct and indirect effects of yield contributing traits on grain yield of pearl millet populations.

Forty-five pearl millet populations of Asian and African genetic backgrounds were evaluated in this study. The experiment was conducted during rainy season of 2015 at two locations, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru (18°N, 78°E) and Regional Agricultural Research station (RARS), Palem (17°N, 78°E), Professor Jayashankar Telangana State Agricultural University (PJTSAU).

The experimental trial involving 45 populations (10 Asian origin and bred in Asia, 7 African origin and bred in Africa, and 28 African origin and bred in Asia) laid out in alpha-lattice design with three replications. In each replication, the size of the plot consisted of 6 rows with a length of 4 meters. The spacing between the rows and within the plants was maintained at 75 cm and 12-15 cm, respectively. A basal dose of 100 kg of di-ammonium phosphate (18% N and 46% P) was applied at the time of field preparation and 100 kg of urea (46% N) was applied as top dressing in two-split dose at the stage of three weeks and five weeks after sowing. Trials were regularly irrigated to avoid any moisture stress. All the recommended agronomic practices were followed for raising good crop.

Data collection was done for the grain yield and six yield component characters. The observations were taken on 20 random plants from each population for the traits like plant height (cm), number of productive tillers/plant, panicle length (cm), and panicle girth (cm). Other traits such as days to 50% flowering, 1000-grain weight (g) and grain yield (g) data were recorded on plot basis. Further, data of grain yield was converted to kg ha^{-1}.

Phenotypic and genotypic linear correlation coefficients were calculated for all the possible comparisons using the formula suggested by Falconer and Mackay (1996). The correlation coefficients were partitioned into direct and indirect effects using the path coefficient analysis according to Dewey and Lu (1959). Data analysis was carried out using SAS v 9.4 software (SAS, Inc., 2017).

The genotypic and phenotypic correlation coefficients between all possible combinations of traits and the direct and indirect effects are presented in Tables 1 and 2.

Table 1. Analysis of genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients for grain yield and yield component traits in pearl millet across locations

Trait	DFF	PHT	NPT	PL	PG	TGW	GY
DFF		0.86**	-0.57**	0.63**	0.19*	-0.29*	0.33**
PHT	0.72**		-0.61**	0.72**	0.22**	0.02	0.50**
NPT	-0.35**	-0.45**		-0.47**	-0.70**	-0.42**	-0.41**
PL	0.54**	0.68**	-0.30*		-0.05	0.00	0.23*
PG	0.13	0.18*	-0.45**	-0.05		0.65**	0.59**
TGW	-0.24*	-0.03	-0.16	0.00	0.43**		0.28*
GY	0.19*	0.38**	-0.22*	0.02	0.39**	0.18*	

*, **, Significance at 0.05, 0.01 levels of probability, respectively

DFF: Days to 50% flowering, PHT: Plant height (cm), NPT: Number of productive tillers/plant, PL: Panicle length (cm), PG: Panicle girth (cm), TGW: 1000-grain weight(g), GY-Grain yield (kg ha^{-1})

Table 2. Path coefficient analysis of grain yield [direct effects (diagonal) and indirect effects] with other yield component traits in pearl millet, across locations

Trait	DFF	PHT	NPT	PL	PG	TGW	GY
DFF	**-1.27**	1.28	-0.17	0.02	0.23	0.24	0.33**
PHT	-1.09	**1.49**	-0.19	0.03	0.28	-0.02	0.50**
NPT	0.72	-0.91	**0.31**	0.01	-0.88	0.34	-0.41**
PL	-0.80	1.07	-0.14	**0.16**	-0.06	0.00	0.23*
PG	-0.24	0.33	-0.22	-0.01	**1.25**	-0.53	0.59**
TGW	0.37	0.03	-0.13	0.01	0.81	**-0.81**	0.28*

*, **, Significance at 0.05, 0.01 levels of probability, respectively

DFF: Days to 50% flowering, PHT: Plant height (cm), NPT: Number of productive tillers/plant, PL: Panicle length (cm), PG: Panicle girth (cm), TGW: 1000-grain weight (g), GY-Grain yield (kg ha^{-1})

Phenotypic and genotypic correlation between grain yield and all of the component traits was significant and positive for all the traits except for number of productive tiller per plant for both phenotypic and genotypic level (Table 1). Highest significant positive correlation for grain yield was found with panicle girth (r = 0.59, P d” 0.01) followed by plant height (r = 0.50, P d” 0.01), days to 50% flowering (r = 0.33, P d” 0.01), 1000-grain weight (r = 0.27, P d” 0.01) and panicle length (r = 0.23, P d” 0.01). Whereas, number of productive tillers per plant had negative correlation with grain yield. However, high tillering and asynchrony of tillering is attributed to adaptation to drought stress during the vegetative growth phase rather than its positive association with grain yield under optimum environmental condition (Yadav and Rai, 2013). This indicated that grain yield increases with increase in panicle girth, plant height, bold seed size and late flowering. Previous studies by Kulkarni *et al*., (2000) Borkhataria *et al.,* (2005) and Yahaya *et al.,* (2015) also reported the strong correlation between grain yield with plant height, panicle girth, panicle length and 1000-grain weight. The correlation coefficient for most of the pairs of characters revealed the presence of strong positive genotypic association between yield and its component traits. In addition, genotypic correlation coefficients were higher than their respective phenotypic correlation coefficients for all the characters under study. This indicated strong inherent association between the different characters studied but the phenotypic values was lessened by the significant interaction of environment on the traits under study. Previous studies in pearl millet also reported high genotypic correlation than phenotypic correlation (Chaudry *et al.,* 2003, Atif *et al.,* 2012, Yahaya *et al.,* 2015 and Dehinwal *et al.,* 2017).

Days to 50% flowering had significant positive correlation with most of the traits except number of productive tillers per plant and 1000-grain weight. The plant height had high positive genotypic and phenotypic correlation with all yield component traits except with number of productive tillers/plant (Table1). It indicated that selection for plant height will be rewarding to improve the grain yield. The number of productive tillers/plant had highly significant negative genotypic and phenotypic correlations with all the component traits (Table 1). Panicle length exhibited highly significant positive correlation with days to 50% flowering (r = 0.63, P d” 0.01) and plant height (r = 0.72, P d” 0.01) while it had negative

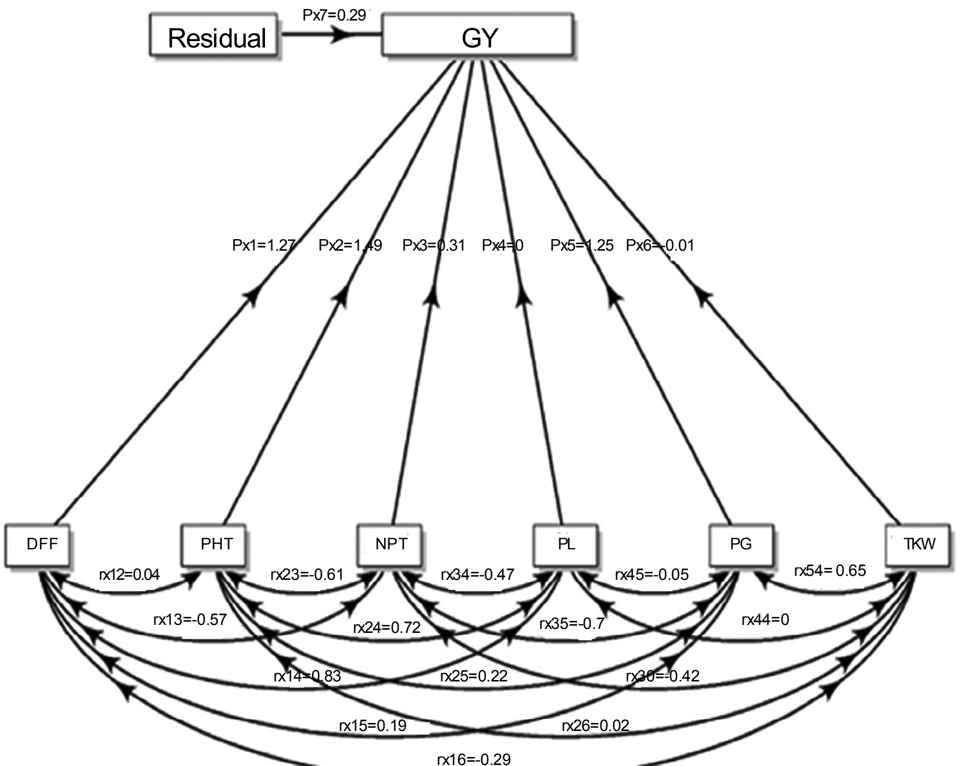

Fig.1: Path diagram for grain yield (kg ha^{-1}) and its component traits for pearl millet

[DFF: Days to50% flowering, PHT: Plant height (cm), NPT: Number of productive tillers/plant, PL: Panicle length (cm), PG: Panicle girth (cm), TGW: 1000-grain weight (g), GY-Grain yield (kg ha^{-1})]

correlation with rest of the traits. Panicle girth had significant but low positive correlation with days to 50% flowering and plant height. Thousand-grain weight has significant positive correlation with panicle girth (r = 0.65, P < 0.01) and it had no correlation with plant height and panicle length (Table 1).

Path coefficient used to study the cause and effect relationship, delineates the correlation coefficient into direct and indirect effect. Direct and indirect effects of all the characters are presented in Table 2 and Fig.1. Plant height had strong positive direct effect (1.49) on grain yield, followed by panicle girth (1.25) whereas number of productive tillers per plant (0.31) and panicle length (0.16) had low direct effects. On the other hand, grain yield had direct negative effect by days to 50% flowering (-1.27) and 1000-seed weight (-0.81). Residual effect was low (0.29) indicated that most of the yield contributing traits in pearl millet were considered in the present study. The high positive direct effects of plant height and panicle girth were in agreement with previous reports of Kumar *et al.,* (2014), Ezeaku *et al.,* (2015), Talwar *et al.,* (2017) and Dehinwal *et al.,* (2017).The relatively high positive indirect effects on grain yield was caused by days to 50% flowering via plant height (1.28) followed by panicle length via plant height (1.07) and1000-grain weight via panicle girth (0.81).This indicated that selection for days to 50% flowering and panicle length traits would contribute to high grain yield via plant height. Talwar *et al.,* (2017) and Unnikrishnan *et al.,*(2004) reported high positive indirect effect of these traits on grain yield. The highest negative indirect effects on grain yield was caused by plant height via days to 50% flowering (-1.09) followed by number of productive tillers/plant via plant height (-0.91).

The results indicated that days to 50% flowering, plant height, and panicle girth had high positive significant correlation and these traits had high direct effects with grain yield. In addition, plant height and panicle girth have high positive indirect effect each other on grain yield. This shows that selection based on plant height and panicle girth are more effective to improve grain yield. Panicle length also an important trait to be considered since it had positive direct effect and high indirect effect on grain yield via plant height. However, number of productive tillers had high direct effects it cannot be considered for selection since it had negative indirect effects via plant height and panicle girth as well as negative correlation with yield and its component traits. Hence, selection should be carried out based on plant height, panicle girth and days to 50% flowering to develop superior breeding material.

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