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HETEROSIS AND COMBINING ABILITY STUDIES IN PEARL MILLET

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ABSTRACT

This study was conducted to access the combining ability and heterosis by using a complete 5x5 diallel experiment for the measurement of grain yield and its components in Pearl millet (*Pennisetum glaucum*) .The effects for both general and specific combining ability were found to be highly significant for all the characters. This suggested the involvement of both additive and non-additive gene actions in the inheritance of days to 50% flowering, number of nodes, panicle girth, panicle length, plant height and grain yield. General combining ability (GCA) effects revealed that all the parents proved as superior general combiners for grain yield and plant height. Specific combining ability (SCA) estimates showed that crosses MGP-02 x MGP-31 and MGP-74 x MGP-84 were the best combinations for grain yield which involved good x good general combiners. MGP-74 x MGP-84, MGP-31 x MGP-318 and MGP-02 x MGP-318 were the best combinations for days to flowering. These crosses possessed genes for earliness. Our results showed that SCA variances were greater than GCA variances which clearly indicated that a major part of genetic variability in the traits under studied was contributed by non-additive genes.

Key words: Pearl millet, Diallel crosses, Combining ability, Hybrid vigour and Grain yield

INTRODUCTION

Pearl millet is an important kharif crop of rain fed areas of the world. Its multiple use increases its importance manifolds. It is used as food for humans, feed for poultry/pet birds and dry stalk for live stock. It is a drought tolerant crop and can grow at minimum moisture level where other cereal crops are unable to grow. Pearl millet is a highly cross-pollinated diploid (2x=14) plant species and a C_4 crop with protogynous flowering. Pearl millet is regarded as a suitable crop for the development of heterozygous populations, which can lead towards the production of hybrids with higher grain yield. Pearl millet is nutritionally superior and staple food for millions of people. Pearl millet grains contain good levels of high quality protein with a balanced amino acids composition, carbohydrates and fat. These dietary ingredients present in pearl millet are important for human health. Considering its nutritive value which is comparable to rice and wheat. This crop is under cultivated in the country for the purpose of green fodder for dairy cattle. The high quality of green fodder is marked by its palatability and absence of HCN content which make sorghum poisonous at early growth stage. Nutritionally it is very affluent, providing maximum calories than all other cereals, along with high protein, fiber and fat content (NIN, 2003). In Pakistan, area under bajra crop was 469 thousand hectares with total production of 305 thousand tons (GOP, 2017). Unfortunately, no serious attempts have been made to explore its genetic potential and hence yield.acre^{-1} is too low i.e. 650 kg.ha^{-1} (GOP, 2017) as compared to other countries of the world. Although, private seed companies have recently introduced some hybrids having better yield potential but farmers are reluctant to accept these hybrids as cultivated varieties because of more inputs need and short stature (low fodder yield).

Enhancement of yield in pearl millet is possible with Heterosis breeding (Ramamoorthi and Nadarajan, 2001). Heterosis breeding caused earliness in flowering (Karad and Harer, 2004). Negative heterosis of hybrids was considered desirable due to heterosis for early flowering, (Arulselvi *et al.*, 2006). Pethani *et al*. (2004) observed the existence of additive as well as non-additive effects for yield and related component traits in pearl millet. Non-additive genes appeared more important for the phenotypic expression of grain yield and related traits (Yadav*et al.*, 2002; Parmar *et al.*, 2013).

It is indeed the need of time to develop high yielding, medium statured, insects/pests resistant and drought tolerant varieties which can even be grown economically on marginal lands with low inputs. Millets Research Station Rawalpindi (Pakistan) have investigated the genetic potential of Pearl millet since 2011-12 to develop open pollinated varieties. This study was planned to ascertain the genetic behavior of grain yield and related quantitative characters of five diverse genotypes of Pearl millet through combining ability analyses aiming at to identify the good general combiners and desirable cross combinations.

MATERIALS AND METHODS

Five diverse Pearl millet genotypes viz. MGP-02, MGP-31, MGP-74, MGP-84 and MGP-318 were crossed in complete diallel fashion during Kharif, 2016. Twenty crosses and five parents were sown in mid July 2016 at Millets Research Station Rawalpindi using Randomized Complete Block Design replicated thrice, keeping row to row and plant to plant spacing of 75 cm and 20 cm, respectively. To attain the desirable crop stand all suitable cultural practices were adopted. Ten randomly selected plants from each entry were used to record the data for characters under study. The data were analyzed following Steel and Torrie (1980). Griffing's procedure, (Method –I, Model –II) (Griffing, 1956) was used to calculate general and specific combining ability of parents and their crosses, respectively.

RESULTS AND DISCUSSION

The results obtained after the analysis of variance (ANOVA) suggested highly significant differences for all the traits (Table 1). General combining ability (GCA) and Specific combining ability (SCA) effects were found highly significant for all the characters. Reciprocal effects were also highly significant for days to flowering, number of nodes, panicle girth, panicle length and plant height while these were non-significant for grain yield (Table 2). These findings suggested the existence of additive as well as non-additive gene actions and their involvement in the inheritance of all the studied parameters. Importantly, SCA variances in this study were found to be higher than GCA variances for the studied traits showing that non-additive type of gene action was more important in controlling these characters. Similar results have been reported by the experimental results of Bhanderi *et al.* (2007); Haq *et al.* (2016); Jeeterwal *et al.* (2017); Sheoran *et al.* (2000); Dangaria *et al*. (2004); Singh *et al*. (2004), Shanmuganathan and Gopalan (2006); Davda *et al*. (2007); Dhuppe *et al*. (2006) and Vaghasiya *et al*. (2008).

GCA/SCA ratio (Table 2) revealed prevalence of non additive gene effects for all the studied characters. Davda and Dangaria (2018) have reported similar findings except panicle girth for which additive components have been reported more prominent. It is not essential that both parents having good combining ability will give high SCA as also reported by Kumar and Sagar (2010). The present results are in harmony with findings of Rasal and Patil (2003).

GCA effects for parents (Table 3) indicated that MGP-31 and MG-318 produced good results for all the characters except panicle girth for which these were poor general combiners. All the five parents were found to be good general combiners (having high GCA) for pearl millet grain yield, plant height and panicle length except MGP-84 which was poor general combiner for panicle length. MGP-31 possessed genes for early flowering as it had highest significant negative GCA effect. It is also good general combiner for grain yield hence, it was the most suitable parent found for the development of early maturing varieties with improved grain yields. Similar results presented in the reports of Chotaliya *et al.* (2010), Vagadiya *et al*. (2010) and Jethva *et al.* (2011).

Table 1. Mean square values for grain yield and related traits in a 5x5 diallel cross in Pearl millet.

S.O.V	d. f	DTF	# of nodes	Panicle Girth	Panicle Length	Plant Height	Grain Yield
Replications	2	0.433	0.013	0.297	0.018	19.413	8.517
Treatments	24	13.586**	1.452**	1.968**	10.873**	708.892**	583.631**
Error	48	2.716	0.361	0.082	0.965	45.802	59.274

*and ** significant at 5% and 1% level of probability, respectively; DTF = days to 50% flowering

Table 2. Combing ability mean square values for grain yield and related traits in a 5x5 diallel cross in Pearl millet.

S.O.V	d. f	DTF	No. of nodes	Panicle Girth	Panicle Length	Plant Height	Grain Yield
GCA	4	8.387**	1.020**	0.186**	5.392**	551.456**	768.956**
SCA	10	4.240**	0.470**	0.991**	2.934**	241.945**	155.469**
Reciprocals	10	3.272**	0.283**	0.509**	3.607**	104.60**	3.851ns
Error	48	0.9053	0.120	0.027	0.322	15.267	19.758
$\sigma^2 gca$		0.748	0.090	0.016	0.507	53.619	74.920
$\sigma^2 sca$		3.335	0.350	0.964	2.613	226.678	135.711
$\sigma^2 gca$ / $\sigma^2 sca$ ratio		0.224	0.257	0.016	0.194	0.237	0.552

*and ** significant at 5% and 1% level of probability, respectively; General combining ability (GCA); Specific combining ability (SCA); DTF = days to 50% flowering

Table 3. General combing ability estimates for grain yield and related traits in a 5x5 diallel cross in Pearl millet.

Parents	DTF	No. of nodes	Panicle Girth	Panicle Length	Plant Height	Grain Yield
MGP-02	-0.345ns	0.087ns	0.118^{*}	-0.493^{**}	-5.460^{**}	9.191^{**}
MGP-31	-1.380^{**}	0.487^{**}	0.089ns	-0.746^{**}	4.607^{**}	-4.693^{**}
MGP-74	0.920^{**}	-0.080ns	0.067ns	1.101^{**}	6.673^{**}	-9.633^{**}
MGP-84	0.120ns	-0.113ns	-0.209^{**}	-0.191ns	4.440^{**}	9.464^{**}
MGP-318	0.687^{*}	-0.380^{**}	-0.066	0.329^{*}	-10.260^{**}	-4.329^{**}
SE	0.269	0.098	0.045	0.160	1.105	1.257

*and ** significant at 5% and 1% level of probability, respectively; DTF = days to 50% flowering

Table 4. Specific combing ability estimates for grain yield and related traits in a 5x5 diallel cross in Pearl millet.

Crosses	DTF	No. of nodes	Panicle Girth	Panicle Length	Plant Height	Grain Yield
MGP02XMGP31	-0.420ns	0.513^{*}	-0.089ns	-1.908^{**}	9.360^{**}	10.739^{**}
MGP02XMGP74	0.780ns	-0.253ns	-0.147ns	-0.353ns	-9.873^{**}	5.446^{*}
MGP02XMGP84	-0.587ns	0.113ns	-0.038ns	1.830^{**}	-9.973^{**}	0.033ns
MGP02XMGP318	-1.320^{*}	-0.120ns	0.104ns	0.496ns	-11.40^{**}	-0.074ns
MGP31XMGP74	2.313^{**}	0.680^{**}	0.170ns	1.827^{**}	-8.440^{**}	-5.437^{*}
MGP21XMGP84	0.447ns	0.380ns	1.153^{**}	-0.589ns	-5.707^{*}	3.156ns
MGP31XMGP318	-1.620^{**}	-0.520^{*}	0.326^{**}	-0.339ns	3.827ns	5.926^{*}
MGP74XMGP84	-2.020^{**}	-0.387ns	-0.388^{**}	-1.311^{**}	11.727^{**}	10.189^{**}
MGP74XMGP318	-0.420ns	-0.120ns	0.043ns	0.679*	-4.240ns	-2.867ns
MGP84XMGP318	1.547^{**}	0.413^{**}	0.653^{**}	0.114ns	12.660^{**}	3.353ns

*and ** significant at 5% and 1% level of probability, respectively; DTF = days to 50% flowering

Table 5. Reciprocal effects for grain yield and related traits in a 5x5 diallel cross in Pearl millet.

Crosses	DTF	No. of nodes	Panicle Girth	Panicle Length	Plant Height	Grain Yield
MGP-31xMGP-02	1.667^{*}	0.500^{*}	0.097ns	0.180ns	0.667ns	0.800ns
MGP-74xMGP-02	1.167ns	-0.167ns	-0.175ns	0.652ns	-11.167^{**}	-2.533ns
MGP-84xMGP-02	0.667ns	-0.167ns	0.025ns	0.280ns	-0.167ns	-0.417ns
MGP-318xMGP-02	-0.833ns	0.000ns	-0.160ns	-0.850^{*}	-4.167ns	0.550ns
MGP-74xMGP-31	2.333^{**}	-0.833^{**}	0.275^{*}	0.318ns	-15.000^{**}	0.367ns
MGP-84xMGP-31	-1.000ns	-0.500^{*}	0.515^{**}	-0.890^{*}	-2.500ns	0.583ns
MGP-318xMGP-31	1.500^{*}	0.000ns	0.522^{**}	0.715ns	-2.000ns	2.000ns
MGP-84xMGP-74	0.167ns	0.167ns	-0.335^{**}	-2.975^{**}	-11.667^{**}	1.550ns
MGP-318xMGP-74	0.333ns	-0.167ns	-0.135ns	-2.477^{**}	3.000ns	-1.833ns
MGP-318xMGP-84	1.500^{*}	-0.333ns	1.317^{**}	0.623ns	-0.333ns	-1.217ns

*and ** significant at 5% and 1% level of probability, respectively; DTF = days to 50% flowering

Table 6. Most heterotic crosses, their mean performance, GCA/ SCA effects for grain yield and related traits in a 5x5 diallel cross in Pearl millet.

Crosses	Grain Yield	% Heterosis over			SCA	GCA		Other traits showing heterosis	
		MP	BP	SH		P_1	P_2	Heterobeltosis	Standard Heterosis
MGP-31xMGP-318	67.5	37.69	25.95	51.84	5.93*	Good (- 4.69)	Good (-4.33)	DTF, PG,PH	DTF, PG, PH
MGP-02xMGP-74	85.8	22.99	22.65	95.48	0.03ns	Good (9.19)	Good (9.46)	PH	PH
MGP-02xMGP-31	84.6	46.83	19.50	90.40	10.74**	Good (9.19)	Good (-4.69)	DTF, NN, PL	DTF, NN, PL
MGP-74xMGP-84	80.1	42.63	13.83	80.35	10.19**	Good (-9.63)	Good (9.46)	PG, PL	PG, PH
MGP-31xMGP-74	49.2	13.81	10.65	10.65	-5.44*	Good (-4.69)	Good (-9.63)	NN, PL, PH	PL
MGP-31xMGP-84	77.4	34.86	9.99	79.27	3.16ns	Good (-4.69)	Good (9.46)	PG	PG
MGP-84XxMGP-318	75.8	22.34	7.72	70.67	3.35ns	Good (9.46)	Good (-4.33)	PG	-
MGP-02xMGP-74	71.0	25.98	0.33	59.86	5.45**	Good (9.19)	Good (-9.63)	PG,PH	PL, PH

*and ** significant at 5% and 1% level of probability, respectively.
DTF= Days to 50% flowering, NN= No. of nodes, PG= Panicle girth, PL=Panicle length and PH= Plant height.

Both GCA effects and average performance of parents can provide a better selection criteria for superior parents. Parents MGP-02, MGP-84 and MGP-318, having considerable average performance, showed highly significant *GCA* effects for grain yield per plant. This clearly indicated that while selecting proper parents for a successful hybridization programme, their *per se* performance may be considered along with GCA effects. Present findings are in agreement with Davda and Dangaria (2018); Mohan *et al.* (2002) and Manga and Dubey (2004), who have suggested that better parents can be selected on the basis of *per se* performance and *GCA* effects.

Specific combining ability analysis revealed that MGP-02 x MGP-31, MGP-74 x MGP-84, MGP-31 x MGP-318, MGP-02 x MGP-74 and MGP-31 x MGP-74 were best combinations regarding grain yield respectively (Table-4). These crosses involved good x good combining parents. These crosses also exhibited significantly positive heterobeltosis, and standard heterosis for the grain yield and the component traits indicating that both *GCA* and *SCA* have contributed in their outstanding performance. The genetic architecture of these crosses can be exploited by hybridization and reciprocal recurrent selection in the subsequent generations to improve yields in Pearl millet. Davda and Dangaria, 2018; Sheoran *et al*. (2000) and Madhusudhana and Govila (2001) have also reported similar findings.

The present investigation revealed that the traits under study were controlled by the both addictive and non-additive genes with larger proportion of later ones. Thus heterosis breeding is of much importance in exploiting non additive genetic system to boost yield potential in Pearl millet. Grain yield is a complex character which can be improved by additive genes pyramiding alongwith maintaining maximum heterozygosity for exploiting non additive gene action through reciprocal recurrent selection. Davda and Dangaria (2018) have suggested that reciprocal recurrent selection is effective in boosting grain yield in Pearl millet.

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