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HETEROSIS AND COMBINING ABILITY STUDIES IN PEARL MILLET

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ABSTRACT

Pearl millet (*pennisetum glaucum* l.) Considered a main warm-season cereal crop for grain and fodder in the arid and semi-arid tropical regions. The present research was carried out to assess combining ability and heterosis through a complete 5x5 diallel experiment for grain yield and related parameters in pearl millet. General combining ability (gca) effects were highly significant for days to 50% flowering, panicle length and plant height while non-significant for grain yield per plant, no. Of productive tillers and panicle girth. Specific combining ability (sca) effects were highly significant for grain yield and non- significant for rest of the characters. These studies suggested that non-additive gene action was more important regarding the inheritance of grain yield while additive gene action had major role in the inheritance of days to 50% flowering, no. Of productive tillers, panicle girth, panicle length and plant height. The parent mgp-84 was good general combiner for the parameters studied. 15rbs-01 was good general combiner for all the characters except days to flowering. The crosses, mgp-84 x 13rbs-09, mgp-304 x 15rbs-01, mgp-84 x 13rbs-10, 13rbs-10 x 15rbs-01, 13rbs-09 x 15rbs-01, mgp-84 x 15rbs-01 and mgp-84 x mgp-304 were the best combinations for grain yield which involved good x good and good x poor general combiners. Sca variance for grain yield was higher than gca variance indicating that non-additive gene action had major role in its inheritance. Gca variances for days to flowering, productive tillers, panicle girth, panicle length and plant height were higher than sca variances which suggested that additive gene action had played key role in the inheritance of these traits. The consistency in results of both the trials for all the parameters implies that the results could be of broader use to the genetic improvement of grain yield and growth parameters in pearl millet.

Key words: pearl millet, diallel crosses, combining ability, heterosis, grain yield

INTRODUCTION

Pearl millet (*pennisetum glaucum* l.) The world's 6th essential cereal crop in terms of area of cultivation and its production after wheat, rice, maize, barley and sorghum. It is considered as an allogamous crop consisting a well mechanized wind borne pollination process fulfilling a vital hybrid seed development requirement. Pearl millet is widely grown, both for grain and fodder purpose, in Pakistan. Its average area under cultivation is 350 thousand hectares with total production of 266 thousand tones. However, its average production is very low (304 kg/acre) (gop, 2021). High yielding pearl millet varieties are the dire need to make it more profitable crop for the farmers. Grain yield is the complex plant character. Hence, to boost it genetically plant breeders need comprehensive knowledge of plant's genetics. For a successful breeding programme, it is imperative to evaluate the available gene pool. Combining ability analysis (griffing, 1956) is one of the best techniques to identify desirable parents and choose an effective selection criterion in the segregating generations.

According to parthasarathy et al. (2006) in India the total intake contribution of fe and zn has been reported from pearl millet across rural areas. It was reported 19-63% and 16-56% cont-ributing of fe and zn intake respectively in three states of india including rajasthan, maharashtra and gujarat (parthasarathy et al., 2006). It is considered as a decidedly cross-pollinated crop as an option of two broad cultivar. According to the reports of rai et al. (2013) in India these hybrids considered dominant cultivars occupying more than 70% of area. A study reported about a difference of two-fold for iron and zinc densities among the hybrids of pearl millet and also reported that the iron and zinc density vary between 31 to 61 mg kg-1 and 32 to 54 mg kg-1 respectively.

It is a fact that considerably two high yielding lines may not combine well using hybridization process. Therefore, it is important to study the general combining ability (gca) as well as specific combining ability (sca) to evaluate the quantitative traits of both the lines. The gca may reflect the breeding values of the lines by estimating the mean performance of lines in the crosses. Moreover it may elucidate the magnitude of gene involved in the inheritance of components for grain yield. Gca and sca are essential to determine the use of inbred and their traits (Navale and Harinarayana, 1992).

Similar studies conducted and reported that the analysis of variance showed significant differences for every parameter between the hybrids. The average sum of squares was significant for all every parameter excluding the effect on effective tillers and the yield/plant. The inter-actions were significant for every study trait except yield and harvest index per plant (Saini et al., 2018).

The current study, aiming at to explore the genetic potential of five diverse genotypes of pearl millet through 5x5 diallel analysis carried out during kharif 2019 to evaluate the grain yield and growth parameters.

MATERIALS AND METHODS

Field experiment: Five diverse pearl millet genotypes viz. Mgp-84, mgp-304, 13rbs-09, 13 rbs-10 & 15rbs-01 were grown in randomized block design with five replications during kharif 2019 at millets research station, Rawalpindi, Pakistan. Plants were sown keeping inter row and inter plant spacing of 75cm and 20cm respectively. Two row of each line was sown in each replication. The recommended agronomic practices were performed to obtain a good crop stand. Ten randomly selected plants were used to collect observations of each entry for grain yield and its related components.

Data parameters: Twenty crosses, along with five parents, were sown. Ten randomly selected plants were used to collect observations of each entry for grain yield and its related components. On individual plant data was recorded on randomly selected plants for each entry for the parameters including number of productive tillers, panicle girth, panicle length and plant height while the parameters including days to 50% flo-wering was recorded on the basis of whole plot.

Statistical analysis: The mean values were analyzed using the procedure of Steel and Torrie (1980). The data was analyzed for general and specific combining ability using griffing's method-1, model-ii. For female × male hybrid, line × tester model was done for the estimation of general combining ability (gca) and specific combining ability (sca) for male and female par-ents as well as the effects for the hybrids (Kempthorne, 1957).

RESULTS AND DISCUSSION

Analysis of variance (table 1) showed highly significant differences for grain yield, days to 50 % flowering, number of productive tillers, panicle girth and plant height except panicle length which was non- significant. This pointed out that the parents had sufficient genetic variability for all the parameters studied apart from panicle length.

Table 1: mean square values for grain yield and its components in 5x5 diallel cross in pearl millet.

Source of variation	Df	Days to 50% flowering	No. of productive tillers/plant	Panicle girth(cm)	Panicle length(cm)	Plant height(cm)	Grain yield/plant (g)
Replications	2	0.17 ^{ns}	0.44^{ns}	0.06^{ns}	3.09^{ns}	14.92^{ns}	16.42^{ns}
Treatments	24	105.49**	0.76**	1.73**	23.45^{ns}	1186.40**	1591.43**
Error	48	2.01	0.10	0.24	8.71	43.67	19.79

* & ** significant at 5% & 1% level of probability respectively, ns = non-significant

General combining ability (gca) effects were highly significant for days to flowering, panicle length and plant height while non- significant for grain yield, productive tillers and panicle girth. Specific combining ability (sca) effects were highly significant for grain yield only and non-significant for rest of the characters. Reciprocal effects were non- significant for all the traits studied (table 2). The above results pro-posed that lines used in the current study were diverse as well as the significant difference subsists in these lines ultimately resulted in the formation of genetic variability among the crosses. Similar results in parents have been stated by Patel et al., (2014) and Rathore et al., (2004) that the mean squares were larger due to the testers excluding the plant height that indicated diversity even higher among the testers.

Table 2: combining ability mean square values for grain yield and its components in 5x5 diallel cross in pearl millet.

Sov	Df	Days to 50% flowering	No. Of productive tillers/ plant	Panicle girth(cm)	Panicle length(cm)	Plant height(cm)	Grain yield/plant (g)
Gca	4	148.66**	0.47ns	1.70 ns	31.93**	1941.20**	929.11 ns
Sca	10	20.53ns	0.38 ns	0.63 ns	4.67 ns	78.96 ns	897.66**
Reciprocals	10	4.24ns	0.06 ns	0.05 ns	1.32 ns	92.78 ns	4.14 ns
Error	48	32.11	1.59	3.85	139.31	698.73	316.63

Table 3 revealed that mgp-84 was found good general combiner for all the agronomic parameters studied. 15rbs-01 was proved good general combiner for no. Of productive tillers, panicle girth, panicle length and plant height. 13rbs-10 was the poorest general combiner for all the parameters except days to 50 % flowering.

The current study results and the findings of previous studies reported by Lakshmana et al., (2011) obviously showed that the grain yield was principally under the control of few non-additive actions of the genes. Similarly the results indicated that the negative gca effect of even one parent was observed but the performance percentage was observed maximum resulting the good yield hybrid as in a combination in the cross.

Table 3: general combining ability estimates for grain yield and its components in 5x5 diallel fashion Crosses in pearl millet.

Parents	days to 50% flowering	No.of prodcuctive tillers/plant	Panicle girth(cm)	Panicle length(cm)	Plant height(cm)	Grain yield/plant (gm)
Mgp-84	2.25**	0.32 ns	0.42 ns	2.38 ns	6.88**	8.25**
Mgp-304	0.50ns	-0.06 ns	0.08 ns	-0.10 ns	-10.96 **	-9.54**
13rbs-09	2.83**	-0.14 ns	-0.25 ns	-0.35 ns	-4.52 **	-5.60**
13rbs-10	1.12**	-0.23 ns	-0.57 ns	-2.56 ns	-12.32 **	-5.43**
15rbs-01	-6.70**	0.09 ns	0.33 ns	0.65 ns	20.90**	12.32**

Sca estimates (table 4) pointed out that the crosses mgp-84x13rbs-mgp-304x15rbs-01, mgp-84 x 13rbs-10, 13rbs-10x15rbs-01 and 13rbs-09x15 rbs-01 were the best combinations for grain yield. These crosses involved at-least one good general combiner. It means that genetic variability of parental genotypes can easily be exploited to boost grain yield by using good general combiners in the subsequent breeding programmes. The results of the current study was in accordance with the results reported by Latha and Shanmugasundaram (1998) and Rasal and Patil (2003)that the high sca effects or heterosis may not depend on the effect the parents of gca that may be due to the type of gene that can exploited during the generations to get preeminent combination of cross.

Table 4: Specific combining ability estimates for grain yield and its components in 5x5 diallel cross in pearl millet

Crosses	Days to 50% flowering	No. Of productive tillers/plant	Panicle Girt (cm)	Panicle length (cm)	Plant height (cm)	Grain yield /plant (g)
Mgp-84 x mgp-304	5.47**	0.21 ns	-0.08 ns	1.61 ns	-4.34*	0.47 ns
Mgp-84 x13rbs-09	0.69 ns	0.19 ns	0.45 ns	1.51 ns	12.72**	18.29**
Mgp-84 x13rbs-10	1.05 ns	-0.07 ns	0.32 ns	-0.53 ns	-1.83 ns	15.99**
Mgp-84 x 15rbs-01	-2.13**	0.61 ns	0.07 ns	1.21 ns	0.45 ns	10.84**
Mgp-304 x13rbs-09	-0.41 ns	0.07 ns	0.04 ns	-0.31 ns	-3.59*	-3.39**
Mgp-304 x13rbs-10	-2.00**	0.36 ns	0.61 ns	0.55 ns	2.21 ns	-2.92**
Mgp-304 x 15rbs-01	-0.18 ns	0.14 ns	0.21 ns	-0.21 ns	3.44 ns	16.81**
13rbs-09 x 13rbs-10	2.97**	0.09 ns	0.14 ns	-0.60 ns	-3.08 ns	-9.48**

13rbs-09 x15rbs-01	-3.71**	0.17 ns	0.49 ns	-0.06 ns	1.85 ns	12.03**
13rbs-10 x 15rbs-01	-0.50 ns	-0.04 ns	0.01 ns	1.70 ns	6.00**	15.92**

Keeping in view both gca & sca effects, 15rbs-01 was the most suitable parent found. It was good general combiner for all the traits except days to 50% flowering. This suggested that 15 rbs-01 can be used to evolve short duration varieties with improved grain yield.

Variance components (table 5) indicated that gca variances were more prominent for days to 50% flowering, no. Of productive tillers, panicle length, panicle girth and plant height suggesting that major part of genetic variability associated with these traits was controlled by additive genes. Sca variance was the most prominent for grain yield which suggested that major part of inheritance of grain yield was associated with non-additive type of gene action. Sca variances for the rest of the characters were least which indicated that additive genes had major contribution in the expression of these parameters.

Table 5: variances for grain yield and its components in 5x5 diallel cross in pearl millet.

Variances	Days to 50% flowering	No. Of productive tillers/ plant	Panicle girth(cm)	Panicle length(cm)	Plant height(cm)	Grain yield/ plant (gm)
Vg	3.88	-0.06	-0.11	-4.47	46.69	-9.70
Vs	-6.89	-0.72	-1.92	-80.14	-368.91	345.85
Vr	-13.94	-0.76	-1.90	-68.99	-302.98	-156.25
Ve	32.11	1.59	3.85	139.31	698.73	316.63

Similar findings reported by Haq et al., (2 020), Khanum et al., (2018), Santosh et al., (2018), Jeeterwal et al., (2017), Parmar and Jasrai (2014) and Yadav *et al*., (2012) have reported additive as well as non-additive gene actions along with the prevalence of later ones. Present findings regarding grain yield is in conformity with the conclusion of above researchers. The difference in the present findings for the rest of the characters might be due to environmental influences.

Table 6 revealed that best performing crosses also exhibited significant heterosis for grain yield and most of the components indicating that both gca and sca have contributed in their out-standing performance. Davda and Dangaria (2018), Madhusudhana and Govila (2001) and Sheoran et al., (2000) have also reported the similar findings.

Table 6: heterotic crosses, their mean performance, gca/sca effects for grain yield and its components in 5x5 diallel cross in pearl millet.

Crosses	Grain yield/ Plant (g)	% heterosis over		Sca	Gca		Other traits showing heterosis
		Mp	bp		P-i	P-ii	
Mgp-84 x 13rbs-09	96.0	115.7	114.8	18.29**	G (8.3)	P (-5.6)	Dtf, pt, pg, pl & ph
Mgp-304 x15rbs-01	95.5	122.9	120.6	16.81**	P (-9.5)	G (12.3)	Pt, pg & ph
Mgp-84 x13rbs-10	94.0	115.4	112.2	15.99**	G (8.3)	P (-5.4)	Dtf & pg
13rbs-10 x 15rbs-01	94.6	121.6	120.0	15.92**	P (-5.4)	G (12.3)	Pg, pl & ph
13rbs-09 x15rbs-01	92.7	112.9	107.4	12.05**	P (-5.6)	G (12.3)	Pt, pg & ph
Mgp-84 x15rbs-01	106.4	145.4	140.2	10.84**	G (8.3)	G (12.3)	Pt, pg, pl & ph
Mgp-84 x mgp-304	72.4	65.3	63.4	0.47ns	G (8.3)	P (-9.5)	Dtf, pt & pl

Mgp=millet gene pool, rbs=rawalpindi bajra selection, dtf=days to flowering, pt=productive tillers, pg= panicle girth, pl=panicle length , ph=plant height, mp=mid parent, bp=better parent, g=good and p= poor

The present study highlighted that grain yield is an intricate character. Although both types of gene actions were prominent for grain yield, however, non-additive gene action was more important. It can be improved by exploiting additive as well as non- additive gene action through reciprocal recu-rrent selection. Similar results have been reported by Davda and Dangaria (2018).

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