GRAIN YIELD AND BLAST DISEASE GENETIC ARCHITECTURE IN PEARL MILLET [*Pennisetum glaucum* (L.) R. BR.]

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ABSTRACT

The present investigation was undertaken on pearl millet [Pennisetum glaucum (L.) R. Br.] to carry out the combining ability analysis of yield and yield contributing characters. The experimental material comprised of 8 parents and resultant 28 hybrids developed through half daillel mating design were evaluated in a randomized block design with three replications. The observations were recorded on yield and its contributing traits and blast disease. Analysis of variance for the experimental design revealed significant differences among the genotypes for all the characters indicated the presence of wide genetic variability in the material used. The analysis of variance for combining ability revealed significant mean sum of squares due to gca and sca for all the traits, except mean sum of square due to gca for days to 50 per cent flowering. These results suggested the existence of additive and non-additive gene actions for various traits in the materials under study. The mean sum of squares due to gca were higher than corresponding sca for most of the characters except days to 50 per cent flowering, fodder yield per plant, grain yield per plant, which suggested that in the expression of all these traits both additive and non-additive components of variation played an important role. The estimates of σ^2SCA were greater than the corresponding σ^2GCA for all the characters. The parental line ICMB$_1$ 95444 gave desirable gca effect simultaneously for grain yield per plant with other characters. The cross ICMB$_5$ 01777 x ICMB$_1$ 04999 and ICMB 95444 x JMSB$_1$ 20102 expressed significant sca effect for in desirable direction for grain yield per plant.

KEY WORDS: Combining ability, gene action, pearl millet, yield

INTRODUCTION

Pearl millet is world's sixth most important crop. In India, it is fourth most important food grain crop after rice, wheat and Maize. Pearl millet [*Penisetum glaucum* (L.) R.Br.] belongs to family *Poaceae* and genus *Pennisetum*. It is a diploid (2n=14) in nature, highly cross pollinated and is commonly known as Bajra, Cat tail millet and Bulrush millet in different parts of the world, which is believed to be originated in Africa. As an arid and semi-arid crop, it is the component of dry land system and usually grown on the soil with depleted fertility, which receives rainfall of 150 to 750 mm per annum. Nutritionally, the pearl millet grains are rich source of protein (9-15%), fat (5%), carbohydrates (67%), mineral matters (2-7%), high energy value (>360 Kcal/100g), high Fe, Zn and Ca compared to other cereals. Thus, it is the cheapest source not only energy and protein, but also for micronutrients such as Fe and Zn. Moreover, it is gluten free and has also low glycine index. Apart from grain, dry fodder is an important secondary product in low resource agriculture for animal feed.

The performance of the parents may not always necessarily give an indication of the probable performance of the progeny. Thus, the choice of right type of parents to be incorporated in the hybridization programme is a crucial step for a breeder to achieve the desired genotype. The use of parents of known superior genetic potential ensures much better success. The foremost step in the development of hybrids is the identification and assessment of parental combinations with respect to their general and specific combining abilities and gene actions involved in the inheritance of yield, its component characters and quality parameters which are of utmost importance for a successful hybridization program.

Because of the climate change effect, the minor disease of blast in pearl millet slowly became major disease. Host resistance against blast not exploited to a large extent and breeder faces problems for developing the resistant cultivars against blast. Breeding for blast resistance appears to be the best approach to reduce this disease.

The choice of right type of parents to be incorporated in hybridization programme is a crucial step for the breeders, because the use of parents known superior genetic worth ensures much better success. With this view, the present investigation was, planned on half-diallel analysis because it has certain advantages over other mating design. This deign gives information about genetic architecture of a trait, parents and allelic frequency (Kearsey, 1956).

MATERIALS AND METHODS

The eight diverse maintainer lines were obtained from Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar and crossed in all possible combinations, excluding reciprocals, to make a diallel set. The complete set of 36 genotypes comprising 28 hybrids and 8 parents were evaluated in a randomized block design with three replications at the Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar during *Kharif* 2015. Each entry was accommodated in single row plot of 4 meter length, inter and intra row distance was kept 60 cm and 12 cm apart, respectively. All the recommended agronomical practices and plant protection measures were followed for raising a good crop.

Observations were recorded on five randomly selected competitive plants of each entry in each replication for the traits *viz*., days to 50 per cent flowering, days to maturity, plant height (cm), number of effective tillers per plant, ear head length (cm), ear head girth (cm), fodder yield per plant (g), 1000 grain weight (g), grain yield per plant (g), harvest index (%) and blast disease score. The mean values were used in statistical analysis. The combining ability analysis for diallel mating design was performed according to Model-I (fixed effect) Method-II (parents and one set of F_1's without reciprocals) proposed by Griffing (1956).

RESULTS AND DISCUSSION

Mean performance of parents and hybrids

The mean performance of parents and hybrids showed wide range of variation among the parents and also among the hybrids for all the characters. Similarity, remarkable mean differences were observed between mean values of parents and hybrids. This indicated the presence of considerable genetic diversity among selected parents and also revealed the presence of remarkable heterosis due to directional dominance for grain yield and its component traits.

Analysis of variance for experimental design

Analysis of variance depicting mean sum of squares for traits studied is presented in Table 1. The analysis of variance showed highly significant differences among the genotypes for all the traits. This indicated the presence of variability in the material selected for the present investigation for grain yield and important yield attributes. The genotypic variance was further partitioned into parents, hybrids and parent *vs.* hybrids. The differences among parents and hybrids were also found highly significant for all character under investigation. Differences due to parent *vs.* hybrids were also found highly significant for all the traits under study, which indicated the presence of high level of mean heterosis due to selection of female and male lines with diverse genetic origin.

Analysis of variance for combining ability

The mean squares for combining ability and estimated components of genetic variance for various characters are presented in Table 2. The analysis of variance for combining ability revealed significant mean sum of squares due to gca and sca for all the traits studied, except days to 50 per cent flowering. These results suggested the existence of additive and non-additive gene actions for various traits in the materials under study while for days to 50 per cent flowering preponderance of non additive gene action. Similar results were reported by Ansodariya (2004), Dangaria *et al.* (2004). Dhuppe *et al.* (2006) and Bhanderi *et al.* (2007).

Further, the magnitude of mean sum of squares due to gca were higher than sca for most of the characters *viz.*, days to maturity, plant height, number of effective tillers per plant, ear head length, ear head girth, 1000 grain weight, harvest index, downy mildew and blast score. Similarly the magnitude of mean sum of squares due to sca were higher than that of gca for some of the characters *viz.*, days to 50 per cent flowering, fodder yield per plant and grain yield per plant, which suggested that in the expression of all these traits, both additive and non-additive components of variation played an important role. The estimates of σ^2SCA were greater than the corresponding σ^2GCA for all the characters. This resulted in less than unity ratio of σ^2GCA/σ^2SCA for all the characters. Similar results were also obtained in pearl millet by Mungra, *et al.* (2015) for days to flowering and grain yield, Dangariya *et al.* (2004) for tillers per plant, Joshi *et al.* (2006) for maturity, Bhanderi *et al.* (2007) for 1000 grain weight, Chotaliya *et al.* (2010) for plant height, Chaudhary *et al.* (2012) and Singh and Sharma (2014) and for harvest index and Immanuel *et al.* (2011) for blast disease score.

General and specific combining ability effects

The parents were classified as good, average or poor general combiners on the basis of their gca effect. The parents showing desirable and significant gca effect were considered as good general combiners, while those with non-significant gca effect as average general combiners and parents with significant but, undesirable gca effect were considered as poor general combiners (Table 3). The analysis for the gca effect in the present investigation indicated that none of the parents was found good general combiner simultaneously for all the characters. This indicated that separate parents would have to be used for improvement of different traits. Similar results were reported by Ansodariya (2004), Dangaria *et al.* (2004) and Dhuppe *et al.* (2006).

However, the parental line $ICMB_1$ 95444 gave desirable gca effect simultaneously for five characters i.e., days to 50 per cent flowering, days to maturity, fodder yield per plant, grain yield per plant and harvest index followed by $ICMB_4$ 05333 for 1000 grain weight, ear head length, ear head girth and 1000 grain weight and $JMSB_1$ 20102 for ear head girth, 1000 grain weight and harvest index. These parents were identified as the best lines in the present study. The parents identifies as good general combiners simultaneously for more number of characters can be considered as the potential parents and should be preferred in breeding programme in order to combine more number of characters by involving fewer numbers of parents in a crossing programme. The high yielding segregants are expected to appear in the progenies of the crosses for their utilization in the improvement in component traits, which are related to grain yield in pearl millet.

The crosses showing high sca effect involved at least one parent with good gca effect thereby showing additive x dominance type of gene interaction. Some crosses showed poor sca effect even though they involved good x good general combiners. Such results are feasible due to lack of genetic diversity between the two parents involved. This further emphasizes the importance of combination breeding involving genetically diverse and high combining parents.

Estimates of SCA effects revealed that none of the cross combinations were found to be consistently significant SCA effects in desired direction for all the characters. The summarized information on the three best crosses on the basis of high sca effect for various characters is given in Table 4. A high sca effect denotes undoubtedly a high heterotic response, but this may be due to very poor performance of the parents in comparison with their hybrids. The cross $JMSB_1$ 20102 x $JMSB_1$ 20064 was found to have the highest sca effect for days to 50 per cent flowering and cross $ICMB_5$ 01777 x $ICMB_1$ 04999 was found to have the higher sca effect for days to maturity, $ICMB_1$ 94555 x $ICMB_4$ 10444 was found to have the highest sca effect for the plant height. The cross combination $JMSB_1$ 20064 x $ICMB_1$ 04999 was found to have the highest sca effect for number of effective tillers per plant. The cross combination $ICMB_1$ 95444 x $ICMB_4$ 10444 was found to have the highest sca effect for ear head length, $ICMB_4$ 10444 x $ICMB_4$ 05333 for ear head girth and $ICMB_1$ 94555 x $ICMB_4$ 10444 for fodder yield per plant. The cross combination $ICMB_5$ 01777 x $JMSB_1$ 20102 was found highest sca effect for 1000 grain weight. For grain yield $ICMB_5$ 01777 x $ICMB_1$ 04999 was found to have the highest sca effect. The cross $ICMB_4$ 10444 x $ICMB_4$ 05333 found with the highest sca effect for harvest index. The cross $ICMB_4$ 10444 x $ICMB_4$ 05333 was found to have the highest sca effect for the trait blast score could be exploited for practical breeding.

CONCLUSION

The following suggestions can be made with respect to breeding of pearl millet based on this study. The cross $ICMB_5$ 01777 x $ICMB_1$ 04999 and $ICMB_1$ 95444 x $JMSB_1$ 20102 expressed significant sca effect for in desirable direction for grain yield per plant and high *per se* performance for grain yields. Thus, these hybrids can be through transgressive segregants in advanced segregating generation and such segregant can be the potential 'B' lines and with the utilization of these lines breeder can develop the new CGMS pair with the traits of seed parent line along with resistance to blast diseases. Alternatively above F_1 hybrids had restored the fertility in F_1 generation so such hybrids can be commercially exploited through heterosis breeding programme after testing in multilocational trial to work out its stability in order to achieve hybrids with high grain yield in pearl millet.

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Table 1: Analysis of variance for experimental design for different characters in pearl millet

Source of Variation	DF	Days to 50 % Flowering	Days to Maturity	Plant Height (cm)	No. of Effective Tillers per Plant	Ear Head Length (cm)	Ear Head Girth (cm)	Fodder Yield per Plant (g)	1000 Grain Weight (g)	Grain Yield per Plant (g)	Harvest Index (%)	Blast Score
Replications	2	1.676	1.750	51.420	0.435	0.007	0.012	16.453**	0.285	4.825*	8.318	0.159
Genotypes	35	8.881**	10.086**	2446.679**	0.810**	53.073**	0.614**	918.596**	9.194**	544.042**	90.224**	0.247**
Parents	7	10.423**	12.000**	1056.313**	0.431**	22.316**	0.815**	318.011**	4.1681**	193.070**	49.954**	0.395**
Hybrids	27	8.026**	9.272**	2383.878**	0.877**	49.700**	0.547**	780.968**	10.389**	486.617**	85.087**	0.199**
P. vs. H.	1	21.191**	18.667**	13874.860**	1.647**	359.453**	1.017**	8838.671**	8.510**	4551.321**	510.820**	0.515**
Error	70	2.209	2.445	19.276	0.142	4.096	0.084	43.833	0.101	23.205	10.621	0.064

, ** Significant at 5% and 1% levels, respectively

Table 2: Analysis of variance for combining ability and variance components for different characters in pearl millet

Source of Variation	DF	Days to 50 % Flowering	Days to Maturity	Plant Height (cm)	No. of Effective Tillers per Plant	Ear Head Length (cm)	Ear Head Girth (cm)	Fodder Yield per Plant (g)	1000 Grain Weight (g)	Grain Yield per Plant (g)	Harvest Index (%)	Blast Score
GCA	7	1.39	3.43**	2047.95**	0.31**	33.06**	0.59**	154.97**	7.53**	136.05**	32.41**	0.24**
SCA	28	3.35**	3.34**	507.46**	0.26**	13.85**	0.11**	344.01**	1.95**	192.67**	29.49**	0.04**
Error	70	0.74	0.82	6.43	0.05	1.37	0.03	14.61	0.03	7.74	3.54	0.02
Variance Components												
σ^2GCA		0.07	0.26	204.15	0.03	3.17	0.06	14.04	0.75	12.83	2.89	0.02
σ^2SCA		2.62	2.53	501.04	0.21	12.48	0.08	329.40	1.92	184.94	25.95	0.02
σ^2GCA/ σ^2SCA		0.03	0.10	0.41	0.13	0.25	0.70	0.04	0.39	0.07	0.11	0.94

, ** Significant at 5% and 1% levels, respectively

Table 3: Classification of parents with respect to general combining ability effect for various characters in pearl millet

Parents	Days to 50 % Flowering	Days to Maturity	Plant Height (cm)	No. of Effective Tillers per Plant	Ear Head Length (cm)	Ear Head Girth (cm)	Fodder Yield per Plant (g)	1000 Grain Weight (g)	Grain Yield per Plant (g)	Harvest Index (%)	Blast Score
ICMB$_1$ 95444	G	G	P	A	P	P	G	A	G	G	P
ICMB$_1$ 94555	A	A	P	A	P	P	P	P	P	P	A
ICMB$_5$ 01777	A	A	G	A	G	G	A	G	A	A	G
JMSB$_1$ 20102	A	A	A	P	P	G	A	G	P	G	P
ICMB$_4$ 10444	A	G	A	A	A	G	A	G	A	A	A
JMSB$_1$ 20064	P	P	G	P	G	P	A	P	A	A	G
ICMB$_1$ 04999	A	P	P	G	A	P	P	P	P	A	G
ICMB$_4$ 05333	P	A	P	P	G	G	A	G	A	A	A

G = Good; A = Average and P = Poor

Table 4: Best crosses on the basis of sca effect for various characters in pearl millet

Days to 50 % Flowering	Days to Maturity	Plant Height (cm)	No. of Effective Tillers per Plant	Ear Head Length (cm)	Ear Head Girth (cm)	Fodder Yield per Plant (g)	1000 Grain Weight (g)	Grain Yield per Plant (g)	Harvest Index (%)	Blast Score
$JMSB_1$ 20102 x $JMSB_1$ 20064	$ICMB_1$ 94555 x $ICMB_4$ 05333	ICM B_1 94555 x $ICMB_4$ 10444	$JMSB_1$ 20064 x $ICMB_1$ 04999	$ICMB_1$ 95444 x $ICMB_4$ 10444	$ICMB_4$ 10444 x $ICMB_4$ 05333	$ICMB_1$ 94555 x $ICMB_4$ 10444	$ICMB_5$ 01777 x $JMSB_1$ 20102	$ICMB_5$ 01777 x $ICMB_1$ 04999	$ICMB_4$ 10444 x $ICMB_4$ 05333	$ICMB_4$ 10444 x $ICMB_4$ 05333
$JMSB_1$ 20064 x $ICMB_1$ 04999	$ICMB_5$ 01777 x $ICMB_1$ 04999	$ICMB_5$ 01777 x $JMSB_1$ 20102	$ICMB_1$ 94555 x $ICMB_4$ 10444	$ICMB_5$ 01777 x $JMSB_1$ 20064	$ICMB_1$ 95444 x $ICMB_4$ 10444	$ICMB_5$ 01777 x $ICMB_1$ 04999	$ICMB_1$ 94555 x $JMSB_1$ 20064	$ICMB_1$ 95444 x $JMSB_1$ 20102	$ICMB_1$ 95444 x $JMSB_1$ 20102	$ICMB_1$ 95444 x $ICMB_4$ 10444
$ICMB_1$ 94555 x $ICMB_4$ 05333	$ICMB_1$ 95444 x $ICMB_1$ 94555	$ICMB_5$ 01777 x $ICMB_4$ 05333	$ICMB_5$ 01777 x $JMSB_1$ 20064	ICMB4 10444 x $ICMB_1$ 04999	$JMSB_1$ 20102 x $JMSB_1$ 20064	$ICMB_1$ 95444 x $ICMB_4$ 05333	$ICMB_1$ 95444 x $ICMB_4$ 05333	$ICMB_1$ 94555 x $ICMB_4$ 10444	$JMSB_1$ 20102 x $JMSB_1$ 20064	$ICMB_1$ 94555 x $ICMB_5$ 01777

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