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Diallel analysis for yield and yield components in pearl millet

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Combining ability was studied in 8x8 diallel set, excluding reciprocals, for grain yield and its 12 attributes in pearl millet. Both GCA and SCA variances were highly significant for all characters. The predictability ratio of GCA and SCA revealed preponderance of additive genetic variance for plant height, ear head length, ear head girth and 1000 grain weight, whereas, non-additive genetic variance for days to 50 per cent flowering, days to maturity, number of effective tillers per plant, fodder yield per plant, harvest index and grain yield per plant, while, both were equally important for number of nodes, ear head weight and threshing index. The parents like J-2420, J-2441, J-2440 and J-2340 were identified as good general combiners for grain yield per plant and some other components. Majority of their crosses had also displayed significant and desirable SCA effects, coupled with high *per se* performance for grain yield per plant. The hybrids viz., J-2420 x J-2480, J-2340 x J-2440 and J-2440 x J-2420 were the most promising having good SCA, alongwith with high *per se* performance and heterobeltiosis for grain yield. Analyses of crosses revealed majority of the superior crosses were involved high x low; and few cases high x high or low x low general combiners.

Key words : Combining ability, Pearl millet, Diallel cross, Grain yield.

INTRODUCTION

Efforts to develop pearl millet inbreds have greatly increased since the discovery of cytoplasmic-nuclear male sterility (Burton, 1958) and the development of single cross forage and grain hybrids. With the production and extensive testing of single crosses with Tift $23A_1$, Indian breeders were able to announce the release of 'HB-1' first pearl millet hybrid in 1965 (Athwal, 1965). Restorer lines are used as pollinators to produce commercial hybrids. They should have good general combining ability (GCA), but also high specific combining ability (SCA), completely restorer male fertility in grain hybrid, confer stable fertility restoration, have similar or less days to flowering as A-line, produce large amounts of pollen, and confer desirable agronomic traits to the hybrid (Andrews, 1987). Combining ability studies regarded useful to select best combining parents, which upon crossing would produce more desirable segregates. Such studies also elucidate the nature and magnitude of gene actions involved in the inheritance of grain yield and its components, which will decide the breeding programme to be followed in segregating generations. Good combining ability of improved inbreds is essential because inbreds are usually used to produce hybrids and synthetics. Both GCA and SCA are important, depending on the use of the inbred and traits of interest (Kumar *et al.*, 1982; Gartan *et al.*, 1988). Accordingly, the present study was undertaken to have an idea on the nature of gene action involved in the inheritance of quantitative traits and to identify appropriate parents and crosses for development of new restorer lines in pearl millet.

MATERIALS AND METHODS

Eight genetically diverse inbreds of pearl millet viz., J-2340, J-2405, J-2440, J-2441, J-2444, J-2454, J-2420 and J-2480 were crossed in all possible combinations excluding reciprocals at the Main Millet Research Station, Junagadh Agricultural University, Jamnagar (Gujarat) during summer 2005 to generate a diallel set. Eight parents' alongwith their 28 F_1s were evaluated for grain yield and 12 yield components in a Randomized Block Design with three replications at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat), India, during *Kharif*-2005. Each entry was sown in single row of 4.0 m length having 60 x 15 cm crop geometry. All the recommended cultural practices were adopted to raise good crop of pearl millet. Observations were recorded on five randomly selected competitive plants for each entry, in each replication for 13 characters (Table 1). Days to 50 per cent flowering and days to maturity were noted on the basis of whole

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plot. The general combining ability (GCA) and specific combining ability (SCA) variances and effects were worked out according to Method II, Model 1 of Griffing (1956).

RESULTS AND DISCUSSION

The analysis of variance for combining ability (Table 1) showed that general combining ability and specific combining ability variances were highly significant for all the characters. The results suggested the importance of both additive and non additive genetic components in the inheritance of all the characters. However, GCA : SCA variance ratio indicated the predominance of additive genetic variance for plant height, ear head length, ear head girth and 1000 grain weight. Similar results were reported for plant height, ear head length and ear head girth by Ansodariya *et al.* (2006), Dhuppe *et al.* (2006), Chotaliya (2005), Rasal and Patil (2003) and Karale *et al.* (1998), and for 1000 grain weight by Ansodariya *et al.* (2006) and Pethani and Kapoor (1995). While, in case of days to 50 per cent flowering, days to maturity, number of effective tillers per plant, fodder yield per plant, harvest index and grain yield per plant, the predictability ratio of GCA and SCA variance revealed the preponderance of non-additive genetic variance in the expression of these characters. The results are in accordance with the reports of earlier workers for grain yield per plant and fodder yield per plant by Ansodariya *et al.* (2006), Shanmuganathan and Gopalan (2006), Chotaliya (2005) and Dangaria *et al.*, (2004), for days to 50 per cent flowering and days to maturity by Dangaria *et al.* (2004) and Pethani and Kapoor (1995), for number of effective tillers per plant by Singh *et a*l., (2004), Sheoran *et al*., (2000) and Karale *et al.* (1998), and for harvest index by Chotaliya (2005). The equal importance of both additive and non-additive gene effects was observed in the genetic control of number of nodes, ear head weight and threshing index. These findings are also in conformity with the reports of earlier workers for number of nodes by Chotaliya (2005), and for ear head weight by Yadav *et al.*, (2004).

A perusal of the general combining ability effects for parents (Table 2) revealed that none of the parents was good general combiners for all the characters, but good combining ability for multiple characters could be noticed in some parents. Out of eight parents, J-2420 ranked first in respect to good general combining ability for grain yield per plant. They also registered good general combining ability effects for other eight attributes viz., days to 50 per cent flowering, plant height, number of nodes, ear head girth, ear head weight, 1000 grain weight, fodder yield per plant and threshing index. Similarly, J-2340 was found to be good source of genes for increasing the grain yield per plant, number of effective tillers per plant and ear head weight. Whereas, early parent J-2441 recorded significant GCA effects in desired direction for grain yield per plant as well as for days to 50 per cent flowering, days to maturity, ear head

Table 1 : Analysis of variance for diallel Model-1, Method-II for grain yield and its component traits in pearl millet.

Source	d.f.	Grain yield/ plant (g)	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of effective tillers/ plant	No. of nodes	Ear head length (cm)	Ear head girth (cm)	ear head weight (g)	1000 grain weight (g)	Fodder yield/ plant (g)	Harvest index (%)	Threshing index (%)
GCA	7	35.08**	26.14**	25.04**	2240.68**	1.40**	3.48**	45.36**	1.21**	81.93**	7.11**	19.79**	23.30**	25.65**
SCA	28	10.30**	6.79**	11.23**	256.59**	1.64**	0.82**	4.69**	0.21**	18.04**	0.50**	7.20**	15.78**	6.13**
Error	70	0.36	0.42	0.47	21.02	0.01	0.07	0.48	0.02	0.65	0.04	0.60	2.37	0.81
Σ^2 gca : σ^2 sca	-	0.41	0.44	0.31	0.65	0.14	0.47	0.68	0.95	0.48	0.75	0.36	0.23	0.48

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

Table 2: Estimates of general combining ability effects of parents for grain yield and its component traits in pearl millet

Parent	Grain yield/ plant (g)	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of effective tillers/ plant	No. of nodes	Ear head length (cm)	Ear head girth (cm)	ear head weight (g)	1000 grain weight (g)	Fodder yield/ plant (g)	Harvest index (%)	Threshing index (%)
J-2340	0.93**	1.17**	0.08	0.78	0.31**	-0.63**	-3.19**	-0.58**	2.55**	-1.07**	0.17	-2.13**	0.24
J-2405	-2.74**	0.13	0.34	0.02	0.39**	-0.57**	-2.34**	0.05	-3.55**	-1.03**	-1.00**	-1.91**	-2.21**
J-2440	0.46**	2.33**	1.98**	-20.62**	-0.16	-0.50**	0.37	-0.23**	0.95**	0.14*	-0.85**	-0.47	0.69**
J-2441	0.59**	-1.43**	-0.86**	-21.72**	-0.72**	-0.07	2.78**	-0.08	0.78**	1.09**	0.79**	0.25	0.98**
J-2444	-1.37**	0.47*	1.08**	-2.32	0.15	0.30**	0.87**	0.27**	-2.53**	-0.70**	2.38**	1.11*	-2.18**
J-2454	-0.99**	-2.93**	-3.32**	11.45**	0.34**	0.03	-0.19	-0.24**	-2.45**	0.79**	-1.57**	2.44**	0.58*
J-2420	3.55**	-0.40**	-0.02	18.42**	-0.22**	0.30**	-0.88**	0.36**	4.89**	0.64**	1.83**	0.79	2.48**
J-2480	-0.43*	0.67**	0.74**	13.98**	-0.10**	1.13**	-2.59**	0.44**	-0.64**	0.16**	-0.17	-0.08	-0.58*
S.E. (gi) ±	0.178	0.191	0.204	1.356	0.035	0.079	0.204	0.042	0.239	0.059	0.228	0.456	0.266
S.E. (gi-gj) ±	0.269	0.290	0.972	6.484	0.053	0.120	0.309	0.063	0.362	0.087	0.345	0.689	0.402

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

length, ear head weight, 1000 grain weight, fodder yield per plant and threshing index. The inbred J-2440 was a good general combiner for grain yield per plant. This parent was also appeared to be good general combiner for ear head weight, 1000 grain weight and threshing index. The early restorer J-2454 turned out to be a very good general combiner for plant height, number of effective tillers per plant, 1000 grain weight, harvest index and threshing index. J-2444 had a good source of genes for increasing the number of nodes, ear head length, ear head girth, fodder yield per plant and harvest index. Besides, J-2480 identified as a good general combiner for plant height, number of nodes, ear head girth and 1000 grain weight. While, J-2405 depicted significant and positive GCA effects only for number of effective tillers per plant. These good combiner parents may be used in crop breeding programme aimed at improvement of the respective characters. Further, consideration of *per se* performance in combination with combining ability estimates was reported to provide a better criteria for the choice of superior parents in hybridization programmes Rao (1972). Results of the present study also revealed that a close relationship between *per se* performance and GCA effects for grain yield and some of its components. The inbred lines J-2420, J-2441, J-2440 and J-2340 exhibiting significant and desirable GCA effects for grain yield per plant had also recorded high *per se* performance for the trait. Majority of their crosses had also registered significant and positive SCA effects for grain yield per plant. Hence, these parents can be helpful in further pearl millet breeding programme to improve yield potentiality. It is observed that the parents were good general combiners for grain yield, possessed significant and desired GCA effects for many yield components. The results are akin with reports of Ansodariya *et al.* (2006), Dhuppe *et al.* (2006), Chotaliya (2005), Dangaria *et al.* (2004), Sheoran

Table 3 : Hybrids showing significant positive SCA alongwith their *per se* performance, GCA, heterobeltiosis for grain yield and their performance in other traits in pearl millet

S. No.	Cross	SCA effects	Grain yield/ plant (g)	GCA status of parents		Heterobeltiosis (%)	Traits showing useful and significant SCA effects
				P_1	P_2		
1	J-2420 x J-2480	9.41**	31.31	high	low	58.92**	PH, ET, EL, EW, TW, FY, HI, TI
2	J-2340 x J-2440	4.37**	24.53	high	high	51.75**	PH, EW, TI
3	J-2440 x J-2420	3.01**	25.79	high	high	30.91**	ET, EW
4	J-2340 x J-2454	2.29**	21.00	high	low	29.92**	DM, PH, ET, EW, FY, HI
5	J-2340 x J-2444	2.16**	20.49	high	low	26.72**	DF, ET, NS, EW, TI
6	J-2441 x J-2444	2.12**	20.11	high	low	35.57**	EL EG, EW, TW, HI, TI
7	J-2441 x J-2454	2.02**	20.39	high	low	37.46**	DF, DM, PH, EL, EW, TW, TI
8	J-2405 x J-2441	1.74**	18.35	low	high	23.73**	PH, EG, EW, FY
9	J-2441 x J-2480	1.66**	20.59	high	low	38.81**	DF, DM, PH, NS, EL, EW
10	J-2340 x J-2441	1.56**	21.84	high	high	35.13**	ET, EW, FY
11	J-2340 x J-2405	1.49**	18.44	high	low	14.08**	PH, ET, EW, TW
12	J-2405 x J-2454	1.37**	16.41	low	low	12.29**	DF, PH, EG, HI, TI

*, ** = Significant at 5% and 1% levels, respectively. DF = Days to 50 per cent flowering, DM = Days to maturity,

PH = Plant height, ET = Number of effective tillers per plant, NS = Number of nodes, EL = Ear head length, EW = Ear head weight, EG =Ear head girth, TW = 1000 grain weight, FY = Dry fodder yield per plant, HI = Harvest index, TI =Threshing index.

et al. (2000) and Karale *et al.* (1998).

It is apparent that none of the cross combinations was found to be consistently significant SCA effects in desired direction for all the characters. Among 28 crosses, 12 hybrids exhibited significant and positive SCA effects for grain yield per plant (Table 3). These twelve crosses also displayed significant and desirable SCA effects for yield components. The results were corroborating with findings of Dhuppe *et al.* (2006), Chotaliya (2005) and Karale *et al.* (1998). Out of 12 hybrids showing significant and positive SCA effects, eight crosses involved high x low combiners alongwith high *per se* performance, high estimates of heterobeltiosis, indicated involvement of predominantly both non-additive and additive gene effects in the expression of grain yield and its attributes. Such crosses can generate desirable transgressive segregants in further generations, if additive effect of one parent and complimentary epistatis effects of the other parent act in the same direction. Other three crosses viz., J-2340 x J-2440, J-2440 x J-2420 and J-2340 x J-2441 involved both good general combiner parents and also exhibited high SCA effects, high *per se* performance and high heterobeltiosis, which pinpointed the prominent prevalence of additive and additive x additive type of gene action ruling the inheritance of grain yield and its components. The high SCA status of these hybrids indicated that substantial role was also played by dominance and other epistatis interaction. Such crosses have potential to throw up desirable transegresants in the segregating material, which the breeder can handle through pedigree method. However for the exploitation of the full potential of these crosses, the convention methodology needs some modification for exploiting both additive as well as non-additive genetic effect governing the traits in the crosses.

Among the above hybrids, J-2420 x J-2480 recorded the highest *per se* performance, also possessed first rank in both SCA effects and heterobeltiosis and involved high x low combiners for grain yield. Similarly, hybrid J-2340 x J-2440 occupied second rank each in SCA and heterobeltiosis and third position in *per se* performance and involved high x high combiner parents for grain yield. The cross combination J-2440 x J-2420 had third rank in SCA effects, second rank in *per se* performance, seventh position in heterobeltiosis and involvement of both parents with high GCA effects for grain yield. Therefore, in the present study, J-2420 x J-2480, J-2340 x J-2440 and J-2440 x J-2420 were the promising ones on the basis of SCA effects, *per se* performance and heterobeltiosis, which could be exploited for improvement in grain yield and its components.

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