Genetic architecture of grain yield and its components in pearl millet

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SUMMARY

Combining ability was studied in a line x tester fashion for grain yield and 13 component traits using four male sterile lines and 12 restorers in pearl millet. The predictability ratio of gca and sca revealed the preponderance of non-additive gene action in the inheritance of all the traits *viz*., grain yield per plant, days to flowering, length of protogyny, number of nodes per plant, plant height, ear head girth, ear head length, number of effective tillers per plant, ear heads weight per plant, days to maturity, 1000-grain weight, harvest index, threshing index and fodder yield per plant. Female parent JMSA-20073 and male parents J-2290, J-2498 and H-77/833-2 were identified as the best general combiners for grain yield per plant along with many other component traits. Majority of their crosses had depicted significant and desirable sca effects, coupled with high *per se* performance for grain yield. Among the 48 crosses, 19 displayed significant and positive sca effects for grain yield. Of these, three hybrids *viz*., ICMA-95444 x J-2405, JMSA-20073 x J-2474 and ICMA-98444 x J-2498 were the most promising having good specific combining ability effects in addition to high *per se* performance and heterobeltiosis for grain yield. These cross combinations also registered significant sca effects in desired direction for many of the yield attributing characters. Heterotic hybrids were more frequently observed in crosses involving at least one of the good combiner parents.

Key words : Combining ability, Pearl millet, Line x Tester, Grain yield

The choice of right type of parents for hybridization in achieving a good cross combination with the aim of improving yield potential is very important. The *per se* performance of a parent may not necessarily reveal it to be a good or poor combiner. Combining ability studies are 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 action in the inheritance of grain yield and its components, which will decide the breeding programme to be followed in segregating generations. Therefore, identification and assessment of the parental combinations with respect to their general and specific combining abilities and gene actions involved in the inheritance of grain yield and various component characters are of utmost importance for a successful hybridization programme. The selection of suitable outstanding parents with favourable alleles, which upon crossing would give heterotic hybrids. Accordingly, the present investigation was undertaken to have an idea on the nature of gene action involved in the inheritance of quantitative traits and to select the parents with good gca and crosses with good sca effects through line x tester analysis in pearl millet.

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MATERIALS AND METHODS

In the present investigation, four male sterile lines and 12 diverse restorer lines (Table 2) were crossed in a line x tester mating design during summer-2009. The resulting 48 hybrids along with fertile counter part of four male sterile lines and 12 male parents were sown on 13th July during *Kharif* 2009 in a randomized block design replicated thrice at Pearl millet Research Station, Junagadh Agricultural University, Jamnagar (Gujarat), India. Each entry was grown in a single row of 5.0 m length each with inter and intra row spacing of 60 x 15 cm. The recommended agronomic practices and plant protection measures whenever necessary were adopted for raising the good crop. Observations were recorded on ten randomly selected competitive plants for each entry, in each replication for 14 characters (Table 1). Mean values were analyzed using the line x tester model suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance for combining ability (Table 1) revealed that the mean square due to females was significant for plant height and ear head length; and mean square due to males was significant for plant height; while, the remaining traits exhibited non-significant indicating there is very little contribution of females and males towards general combining ability (gca) variance

Table 1 : Analysis of variance and variance estimates for combining ability for various characters in pearl millet

Source	d. f.	Mean squares													
		Days to 50 % flowering	Length of protogyny	Number of nodes per plant	Plant height (cm)	Ear head girth (cm)	Ear head length (cm)	Number of effective tillers per plant	Ear heads Weight per Plant (g)	Days to maturity	1000 grain weight (g)	Harvest index (%)	Threshing index (%)	Fodder yield per plant (g)	Grain yield per plant (g)
Females	3	51.04	0.19	1.17	2791.2**	0.52	99.18*	0.06	136.54	94.01	7.21	107.52	19.74	540.9	45.74
Males	11	35.03	0.60	1.48	897.06*	1.30	10.60	4.11	419.11	40.61	3.53	35.46	39.14	210.2	154.16
F x M	33	46.50**	0.55	1.58**	374.4**	0.99**	23.0**	2.40**	268.4**	48.4**	5.59**	104.5**	21.6**	267.9**	118**
Error	94	6.08	0.45	0.70	31.67	0.17	1.20	0.37	10.71	6.19	1.35	3.23	9.82	7.59	1.69
σ^2f		1.24	-0.007	0.01	76.65	0.01	2.72	-0.009	3.49	2.44	0.16	2.89	0.27	14.8	1.22
σ^2m		2.41	0.013	0.06	72.11	0.09	0.78	0.31	34.03	2.86	0.18	2.68	2.44	16.9	12.7
σ^2gca		1.54	-0.002	0.02	75.51	0.03	2.23	0.07	11.13	2.54	0.16	2.84	0.81	15.33	4.09
σ^2sca		13.47	0.034	0.29	114.24	0.27	7.27	0.67	85.88	14.07	1.41	33.74	3.92	86.77	38.91
σ^2gca/ σ^2sca		0.11	-0.06	0.08	0.66	0.11	0.30	0.10	0.13	0.18	0.11	0.08	0.20	0.17	0.10

* and ** indicate significance of values at P=0.05 and 0.01, respectively

components for these traits (Table 1). Females x males interaction mean square depicted significant differences for all the characters except length of protogyny. This revealed the significant contribution of hybrids for specific combining ability (sca) variance components for all the characters except length of protogyny. Further, the variance due to males was higher than that of females for all the characters except for plant height, ear head length and harvest index. This might be due to the wide diversity among the male parents. The reverse was true for remaining characters, where the contribution of females towards the genetic variance was greater than the males. The ó^{2}gca/ó^{2}sca ratio was less than unity for all the characters studied, indicating the preponderance of non-additive gene action in expression of the traits. Similar results were also reported earlier by Sheoran *et al*. (2000), Dangaria *et al*. (2004), Singh *et al*. (2004), Shanmuganathan and Gopalan (2006), Bhanderi *et al*. (2007), Davda *et al*. (2007) and Vaghasiya *et al*. (2008).

The parents with significant negative gca effects for days to 50 per cent flowering, length of protogyny and days to maturity are desirable. Therefore, the parents with significant negative gca effects for days to 50 per cent flowering, length of protogyny, days to maturity and with significant positive gca effects for the rest of the characters are considered as good general combiners. The estimates of gca effects for parents (Table 2) revealed that none of the parents was found to be a good general combiner simultaneously for all the characters but good combining ability for multiple characters could be noticed in some parents. Present result is conformed by the findings of Bhanderi *et al*. (2007), Davda *et al*. (2007) and Vaghasiya *et al*. (2008). From all females, JMSA-20073 was the best general combiner for grain yield per plant as well as for increasing number of nodes per plant, ear head girth, ear head length, ear heads weight per plant and dry fodder yield per plant. Similarly, female ICMA-95444 turned to be a very good general combiner for grain yield per plant and other four yield contributing traits *viz*., length of protogyny, number of nodes per plant, ear heads weight per plant and fodder yield per plant. Besides, ICMA-98444 and JMSA-20072 had significant desirable gca effects for six and three yield contributing characters, respectively. Out of 16 parents, J-2290 ranked first in respect to good general combining ability for grain yield per plant. This male parent was also found to be good general combiner for five yield attributing characters *viz*., days to 50 % flowering, ear head girth, ear heads weight per plant, days to maturity and fodder yield per plant. Similarly, male parent J-2454 was good general combiner for grain yield per plant, days to 50 % flowering, length

of protogyny, days to maturity and fodder yield per plant. J-2467 was found to be good source of genes for increasing grain yield per plant. They also registered good general combining ability effects for other five components *viz*., days to 50 % flowering, ear head girth, number of effective tillers per plant, days to maturity and harvest index. Besides, J-2495 had significant desirable gca effect only for grain yield and length of protogyny. J-2498 had good source of gene for increasing ear head weight per plant, fodder yield per plant and grain yield. H-77/833-2 had significant and desirable gca effect for grain yield as well as days to 50 % flowering, days to maturity and number of nodes per plant. Thus, the parents which were good general combiners for grain yield possessed significant gca effects in desired direction for many yield components. This finding has also been reported earlier by Karale *et al*. (1998), Dangaria *et al*. (2004), Singh *et al*. (2004), Dhuppe *et al*. (2006), Davda *et al*. (2007) and Vaghasiya *et al*. (2008). Other male parents J-2340, J-2405, J-2433, J-2474 and J-2483 were good general combiners for at least three different component traits. J-2479 was good general combiner only for ear head length.

Over all JMSA-20073 female and J-2290, J-2498 and H-77/833-2 male parents were good general combiners for grain yield per plant as well as for majority of yield contributing characters including days to 50 % flowering, number of nodes per plant. ear head girth, ear head length, ear heads weight per plant, days to maturity and dry fodder yield per plant, indicating the importance of these characters towards grain yield. Further, the hybrids showing high *per se* performance for grain yield per plant involved either JMSA-20073 as female parent and/or J-2290 or J-2498 or H-77/833-2 as the male parent. Therefore, these parents can be helpful in further pearl millet breeding programme to improve yield potentiality.

Estimates of sca effects revealed that none of the cross combinations was found to be consistently good for all the characters. Among 48 crosses, 19 hybrids depicted significant sca effects in desired direction for grain yield per plant. Of these, seven hybrids (Table 3) exhibited significant and high positive sca effects, coupled with high *per se* performance and heterobeltiosis for grain yield per plant. These seven hybrids also displayed significant and desirable sca effects for three or more yield attributing characters. Out of seven hybrids, six cross combinations involved one good and one poor combiners for grain yield. The present results are in accordance with the findings of Karale *et al*. (1998), Sheoran *et al*. (2000), Dangaria *et al*. (2004), Singh *et al*. (2004), Davda *et al*. (2007) and Vaghasiya *et al*. (2008).

The highest positive sca effect for grain yield was depicted by the cross ICMA-95444 x J-2405 (10.81) followed by ICMA-98444 x J-2340 (9.96), JMSA-20073 x J-2474 (8.39) and ICMA-98444 x J-2498 (7.66). A perusal of Table 3 revealed that there was some degree of correspondence between sca effect, mean performance and heterobeltiosis. But there was no linearity found between sca effects, heterobeltiosis and mean performance that means a cross showing the highest sca effect may not show the highest heterobeltiosis or mean performance. Although heterobeltiosis, *per se* performance and sca effects expressed an association to some extent, so far selecting the promising cross combination all the three criterions to be considered. The highest positive sca effect was observed in cross ICMA-95444 x J-2405 that involved good x poor general combining parents and had high *per se* performance as well as better parental heterosis for grain yield. This hybrid also registered useful and significant sca effect for component traits *viz*., ear head length, ear heads weight per plant, harvest index and threshing index. Likewise,

Table 3: Best specific combinations for grain yield in pearl millet

Sr. No.	Crosses	Grain yield/ plant (g)	sca	gca				Useful and significant sca effects for other traits	Heterobeltiosis
				Female		Male			
1.	ICMA-95444 x J-2405	43.47	10.81**	0.34**	G	-3.49**	P	EW, EL, HI, TI	34.02**
2.	ICMA-98444 x J-2340	30.60	9.96**	-1.44**	P	-2.58**	P	NN, EW, DM, HI	71.04**
3.	JMSA-20073 x J-2474	44.50	8.39**	1.25**	G	-0.95**	P	DF,PH, EL, EW, DM, HI	31.79**
4.	ICMA-98444 x J-2498	45.67	7.66**	-1.44**	P	3.64**	G	PH, EL, EW, FY	105.71**
5.	ICMA-95444 x J-2340	29.27	7.10**	0.34**	G	-2.58**	P	DF, PH, EL, EW, DM	66.67**
6.	JMSA-20072 x J-2467	43.60	6.30**	-0.15**	P	1.64**	G	ET, EW, HI	42.64**
7.	JMSA-20072 x J-2454	42.47	6.10**	-0.15**	P	0.71*	G	PH, EL, EW, DM, TW	105.15**

* and ** indicate significance of values at P=0.05 and 0.01, respectively. P=Poor, G=Good, DF= Days to 50 % flowering, PH = Plant height, NN = Number of nodes per plant, EL = Ear head length, ET = Number of effective tillers per plant, DM = Days to maturity, EW = Ear heads weight per plant, TW = 1000 grain weight, HI = Harvest index, TI = Threshing index, FY = Fodder yield/plant

ICMA-98444 x J-2498 occupied first rank in heterobeltiosis, third position in *per se* performance, stood fourth in sca effect and involvement of poor x good general combiner parents for grain yield. They also recorded significant and desired sca effects for four component traits *viz*., plant height, ear head length, ear head weight and dry fodder yield per plant. The cross combination JMSA-20073 x J-2474 involving good x poor parents and had third and fourth ranking in sca effect and mean performance, respectively, along with high heterobeltiosis for grain yield. This hybrid also depicted significant sca effect in desired direction for six yield attributing characters *viz*., days to 50 % flowering, plant height, ear head length, ear heads weight, days to maturity and harvest index. Therefore, in the present study, ICMA-95444 x J-2405, JMSA-20073 x J-2474 and ICMA-98444 x J-2498 were the most promising having good specific combining ability (sca) effects, coupled with high *per se* performance and heterobeltiosis for grain yield and yield components. Thus, these three hybrids evaluated under multiplication trials along with the standard hybrid for their direct released as a high yielding hybrids is suggested.

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