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Heterosis in Relation to Combining Ability in Maize*

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ABSTRACT

Eight diverse inbreds were crossed in a half diallel to estimate heterosis and combining ability. Involvement of both additive and non-additive gene actions were detected for all the characters with preponderance of latter except for plant height and days to maturity. The inbreds P_4, P_7 and P_6 were good general combiners for majority of the characters, which gave high **gca** effects for yield per plant with positive and significant **gca** effects for many of the yield characters. Taking into consideration the *per-se* performance, **gca** effect and heterosis, P_1xP_7 was the best hybrid, yielding 14.30 per cent more grain yield per plant followed by P_4xP_7 (13.07%) over the superior check viz: CM-400 x CM-300. Crosses between high x high and high x low **gca** parents exhibited greater heterosis. Heterosis for yield was generally accompanied by heterosis for yield components.

The recognition and use of heterotic groups have contributed to the efficiency and success of hybrid maize breeding programme. The present study is an attempt to see the combining ability and heterosis by crossing eight diverse inbreds in a half diallel.

MATERIALS AND METHODS

A set of 8 x 8 diallel crosses excluding reciprocals were made with eight maize inbreds (Table 1). The 28 F1 s, eight parents and four hybrids viz; CM-400 x CM-300, CM-202 x CM-211, Rajendra Hybrid-1 and Rajendra hybrid-2 served as checks were planted in RBD with three replications during *Rabi* 1994-95 at Dholi farm. Each entry was planted in a two-row plot of 5 m length with a spacing of 75 x 25 cm. Observations were recorded on randomly taken ten competitive plants from each entry in each replication for the days to 75 per cent tassel, days to 75 per cent silk, days to maturity, plant height, ear length, ear diameter, karnel rows per ear and yield per plant. Combining ability effects and variances were worked out by following Method-2, Model-1 of Griffing (1956).

RESULTS AND DISCUSSION

Combining ability analysis (Table 2) indicated that mean squares due to **gca** and **sca** were highly significant for all the characters indicating that both additive as well as non-additive gene actions were involved in the control of these characters.

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However, for these traits additive gene action was predominant. Similar results were reported by Sharma and Bhalla (1993).

Table 1 - Source of Inbred lines.

Parents	Pedigree
P_1	(Mg x CM 601) $S_{6-7-8-\otimes-\otimes}$
P_2	Across 831 $S_{5-3-3-\otimes-\otimes}$
P_3	AB (W) $S_{5-3-2-\otimes-\otimes}$
P_4	Mg - $S_{6-11-\otimes-\otimes}$
P_5	CM 400 x CM 300 - $S_{5-\otimes-\otimes}$
P_6	Jogia local - $S_{6-2-1-\otimes-\otimes}$
P_7	Pant 7421 - $S_{6-194-3-\otimes-}$[illegible]
P_8	CM 601 - $S_{5-8-7-\otimes-\otimes}$

Table 2- Analysis of variance of combining ability of eight quantitative characters in maize.

Source	d.f.	Mean squares							
		Days to 75 per cent tassel	Days to 75 per cent silk	Days to maturity	Plant height	Ear length	Ear diameter	Kernel rows per ear	Grain yield per plant
GCA	7	7.87**	7.94**	20.33**	214.09**	2.37**	0.35**	2.04**	135.29**
SCA	28	10.09**	12.33**	8.67**	126.45**	3.98**	0.42**	4.02**	301.88**
Error	10	0.73	1.08	0.80	10.89	0.70	0.02	0.25	7.64

** Significant at 1 percent level of probability.

Pronounced heterosis was observed in most of the characters. The expression and magnitude of heterosis however, varied for different characters in the same cross and even for the same characters among the crosses. The two hybrids namely, P_1 x P_7 and P_4 x P_7 were identified to be superior hybrids as these yielde 14.30 and 13.07 per cent more grain yield, respectively, over best check hybri (CM-400x CM-300). On the other hand, lowest heterosis over the best check wa observed in the cross P_1 x P_2 (-24.76). This may be attributed to presence of non additive gene effects for grain yield.

The **gca** effects with per-se performance of the parents for different characte under study are presented in Table 3. The parents P_7, P_6 and P_4 were judged a good general combiners for grain yield. Besides grain yield P_7 for earliness, pla height, ear diameter and kernel rows per ear, P_6 for earliness, plant height ar kernel rows per ear, P_4 for ear lenght and ear diameter displayed desirable ar significant gca effects. The parents having best *per-se* performance were also t best general combiners for days to 75 per cent tassel, days to maturity, ear lengt

■ rows per ear and yield per plant. However, this was not true for other ts,confirming the earlier views of Singh *et al.*, 1989.

Table 3 – Estimates of general combining ability effects and mean performance of the eight attributes in maize.

	Days to 75 per cent tassel GC	Days to 75 per cent silk GC	Days to maturity GC	Plant height GC
P_1	0.47	0.52	-0.03	-2.15**
	(132.67)	(135.33)	(185.67)	(150.25)
P_2	0.00	-0.08	-0.57*	-1.43
	(130.67)	(134.33)	(185.33)	(169.33)
P_3	-0.27	-0.08	0.47	0.80
	(131.67)	(135.67)	(186.00)	(159.51)
P_4	1.07**	1.06**	1.93**	-7.69**
	(134.33)	(137.33)	(191.00)	(137.82)
P_5	0.50*	0.19	0.27	1.33
	(132.33)	(134.00)	(184.33)	(158.47)
P_6	-1.40**	-1.21**	-2.37**	2.27*
	(128.00)	(131.67)	(182.00)	(159.32)
P_7	-1.13**	-1.34**	-1.30**	8.58**
	(132.00)	(135.33)	(184.33)	(157.82)
P_8	0.77**	0.92**	1.60**	-1.69
	(131.67)	(135.67)	(185.67)	(152.46)
SE (gi) ±	0.25	0.31	0.26	0.98
SE (gi-gj) ±	0.38	0.46	0.40	1.48

** Significant at 5 and 1 Per cent level of significance, respectively.

The seven most promising combinations selected separately on the basis of heterotic effect over best check viz; CM-400 x CM-300 and their **sca** effects are presented characterwise in Table 4. Most of these cross combinations were uniformly superior both from **sca** as well as heterosis point of view. The cross combinations $P_4 \times P_7$, $P_1 \times P_7$, $P_6 \times P_8$, $P_4 \times P_6$, $P_5 \times P_6$ and $P_5 \times P_8$ showed positive heterotic response over check hybrids for yield per plant. These crosses had high heterosis for yield components, in particular, kernal rows per ear, ear diameter and plant height. This indicates that heterosis for yield was through individual yield components. Similar observation on high heterosis for grain yield was reported by Velicnko *et al.* 1986).

A perusal of heterotic behaviour and magnitude of heterosis in the superior hybrids reveals that heterosis for grain yield may be because of the fact that atleast one of parent(s) involved in these crosses had desirable and significant **gca** effects along with high *per-se* performance, suggesting besides genetic diversity, per-se per-performance and **gca** effect should also taken into account for heterosis breeding.

Table 3 - Contd

	Ear length percent tassel	Ear diameter percent silk	Kernel rows/ear	Grain yield/plant
	GC	GC	GC	GC
P_1	-0.65**	-0.07*	-0.15	-2.57**
	(7.93)	(2.77)	(9.33)	(36.22)
P_2	-0.71**	-0.08*	-0.43**	-4.30**
	(9.07)	(2.60)	(8.77)	(31.50)
P_3	-0.09	-0.30**	-0.34*	-4.37**
	(9.13)	(2.89)	(9.33)	(31.08)
P_4	0.74**	0.19**	0.14	4.97**
	(12.44)	(3.71)	(9.46)	(48.58)
P_5	0.03	1.15**	0.07	-0.86
	(9.97)	(3.10)	(10.37)	(34.13)
P_6	0.34	-0.19**	0.35**	2.77**
	(10.00)	(2.74)	(9.28)	(33.05)
P_7	0.10	0.21**	0.85**	4.24**
	(8.73)	(3.10)	(10.80)	(41.00)
P_8	0.24	0.08*	-0.49	0.19
	(10.72)	(3.95)	(9.25)	(41.88)
SE (gi) ± 0.25		0.04	0.15	0.82
SE (gi-gi) ± 0.37		0.06	0.22	1.24

** Significant at 5 and 1 Percent level of significance, respectively.

The inbreds P_4, P_7 and P_6 were promising parents giving high heterosis fo most of the traits. Utilization of these inbreds in breeding programme may prov useful for improvement of yield and other component characters. The hybrids P_4 P_7 and P_1 x P_7 manifested high **sca** as well as heterotic effects for grain yield an other characters indicating such crosses could be more rewarding in hybr breeding programme of maize.

Table 4 – Top seven hybrids selected separately on the basis of heterosis over the best check and sca effects.

Characters	Cross	Heterosis (%) over CM 400 x CM 300	Cross	sca effect
Days to 75 per cent tassel	P_4 X P_6	-6.87**	P_4 X P_6	-8.41**
	P_1 X P_7	-4.29**	P_3 X P_5	4.97**
	P_3 X P_5	-3.78**	P_1 X P_7	4.74**
	P_6 X P_7	-3.28**	P_1 X P_5	2.04**
	P_7 X P_8	2.02*	P_2 X P_8	2.17**
	P_2 X P_3	1.76*	P_7 X P_8	2.04**
	P_2 X P_7	1.76*	P_4 X P_7	2.01**
Days to 75 per cent silk	P_4 X P_6	6.68**	P_4 X P_6	8.30**
	P_6 X P_7	4.95**	P1 X P7	4.97**
	P_1 X P_7	4.70**	P_3 X P_5	4.57**
	P_3 X P_5	3.71**	P_6 X P_7	3.57**
	P_2 X P_7	2.97**	P_2 X P_3	3.30**
	P_2 X P_8	2.97**	P_3 X P_4	3.10**
	P_6 X P_8	2.48*	P_7 X P_8	3.04**
Days to maturity	P_4 X P_8	3.96**	P_4 X P_6	5.94**
	P_4 X P_6	3.95**	P_1 X P_7	3.70**
	P_1 X P_7	3.23**	P_4 X P_7	3.67**
	P_2 X P_7	3.23**	P_7 X P_8	3.34**
	P_6 X P_7	3.23**	P_2 X P_7	3.17**
	P_5 X P_6	3.05**	P_5 X P_6	2.60**
	P_2 X P_6	2.51**	P_2 X P_3	1.66*
Plant height	P_4 X P_7	9.19**	P_4 X P_6	20.01**
	P_5 X P_7	7.45**	P_4 X P_7	17.53**
	P_6 X P_7	7.10**	P_2 X P_8	15.35**
	P_1 X P_7	6.96**	P_3 X P_6	10.79**
	P_4 X P_6	6.93**	P_1 X P_7	8.21**
	P_3 X P_7	6.84**	P_{15} X P_6	7.63**
	P_7 X P_8	6.66*	P_7 X P_8	7.24*

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Table 4 - Top seven hybrids selected separately on the basis of heterosis over the best check anc effects.

Characters	Cross	Heterosis (%) over CM 400 x CM 300	Cross	sc effe
Ear length	P_4 X P_3	19.96	P_1 X P_7	2.4
	P_4 X P_7	11.46	P_1 X P_6	1.7
	P_1 X P_7	10.49	P_5 X P_7	11.5
	P_6 X P_7	9.67	P_3 X P_6	1.5
	P_3 X P_6	9.59	P_2 X P_5	1.4
	P_3 X P_4	8.84	P_6 X P_7	1.3
	P_5 X P_7	8.99	P_4 X P_8	1.2
Ear diameter	P_4 X P_7	27.97**	P_{12} X P_5	0.9
	P_2 X P_5	25.64**	P_1 X P_5	0.8
	P_1 X P_5	25.38**	P_1 X P_7	0.7
	P_1 X P_7	24.35**	P_3 X P_7	0.7
	P_4 X P_5	19.68**	P_4 X P_7	0.6
	P_2 X P_7	18.65**	P_4 X P_6	0.6
	P_4 X P_6	17.09**	P_1 X P_8	0.61
Kernel rows per ear	P_4 X P_7	13.33**	P_1 X P_6	1.86
	P_1 X P_7	12.65*	P_2 X P_6	1.73
	P_1 X P_6	12.27*	P_2 X P_4	1.47
	P_6 X P_7	11.51*	P_1 X P_7	1.41
	P_3 X P_7	10.68*	P_3 X P_7	1.35
	P_5 X P_7	9.62	P_4 X P_5	1.35
	P_2 X P_7	9.62	P_4 X P_6	1.23
Yield per plant	P_4 X P_7	14.30**	P_1 X P_7	18.59*
	P_1 X P_7	13.07*	P_3 X P_6	17.15*
	P_6 X P_8	8.50	P_6 X P_8	13.87*
	P_4 X P_6	7.28**	P_5 X P_8	13.09*
	P_3 X P_6	6.79	P_4 X P_7	12.02*
	P_5 X P_6	4.58	P_3 X P_6	12.00*
	P_3 X P_8	2.61	P_2 X P_7	11.97*

*,** Significant at 5 and 1 per cent levels of significance, respectively.

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