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Heterosis and combining ability for yield and its related traits in maize (*Zea mays*) in contrasting environments*

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Hybrids in maize (*Zea mays* L.) have a greater yield potential than open pollinated or synthetic varieties with the modern production practices and ensure food and nutritional security to poor. The single cross hybrids offer better advantage over the other types of hybrids or synthetics because of their uniformity, low cost of seed production and availability of superior and diverse inbred lines. The parent values in different crosses depend on their potential *per se* and their combining ability in different combinations. Commercial production of hybrid maize requires extensive assessment of inbred lines and the diallel cross method is widely used for such purposes where the genetic identity of genotypes, especially on dominant-recessive relations and some other genetic interactions can be easily determined in earlier generations. Heterosis only indicates the percentage gain of F_1 over their better and standard parents but it fails to identify the possible causes of superiority of hybrid. The concept of general and specific combining ability is useful to characterize inbreds for their nicking ability in hybrid breeding programme and also elucidate the nature and magnitude of gene actions involved in the trait of interest. Thus, the present investigation was carried out to estimate the heterosis and combining ability of diverse and productive maize inbred lines using diallel crosses.

Ten selected superior maize inbred lines available at BHU centre were used as experimental material. All possible crosses among these inbred lines were made in diallel crossing block without reciprocals. The 45 F_1's along with 10 parents and 3 standard checks were evaluated during rainy (*kharif*) 2006 and winter (*rabi*) 2006–07 at Crop Research Centre, BHU Varanasi in 3 replications in randomized block design. The row-to-row (60 cm) and plant-to-plant (25 cm) distance was maintained. Data were recorded on the 5 competitive plants for plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), kernels rows/ear, kernels/row, 100-kernel weight (g), grain yield/plant (g) and yield/plot (kg). The days to 50% tasseling and silking were calculated on population basis. Data were statistically analyzed using analysis of variance appropriate for design used. The combining ability was estimated according to the Model I, Method 2 of Griffing (1956a), while heterosis was according to Meredith and Bridge (1971).

The ANOVA for combining ability revealed highly significant variations due to general and specific combining ability for different characters. However, general combining ability (GCA) mean square was lower in magnitude for grain yield/plant signifying control of non-additive gene effect is in accordance with the findings of Moneam *et al.* (2009). None of the parental line was good general combiner for all the characters. The estimates of GCA effects revealed that inbred I_1, I_2 and I_{-6} were found as desirable general combiner for yield/plant over both environments. The manifestation of gca effect is due to additive and additive×additive gene interaction having linear quantitative effects (Muraya *et al.* 2006) which favoured the accumulation of desirable genes during selection and formed fixable component of genetic variation. Parents with good GCA effects and *per se* performance can be crossed to develop high-yielding synthetics that can be released as an open -pollinated variety or as a population for further breeding work. Therefore, it would be worthwhile to use above parental line in hybridization programme. The specific combining ability (sca) effects are the manifestation of non-additive components of genetic variation and are highly valuable for discrimination of crosses for their genetic worth as breeding material. The significance of sca effects elucidates the presence of genetic diversity among breeding material tested and illustrated the contribution of dominance and epistatic effects,

* Short note

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Table 1 Economic heterosis for kernel row/ear, kernel/row, 100-kernel weight, yield/plant and yield/plot for 7 best common hybrids over both the environments

Hybrid	Kernel row/ear		Kernels/row		100-kernels weight (g)		Yield/plant (g)		Yield/plot (kg)	
	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2
$I_9 \times I_5$	22.82**	–0.00	3.50*	16.03**	–20.25**	4.44**	9.76**	7.66**	0.71	7.50
$I_9 \times I_6$	–5.56**	2.56	–7.52**	25.26**	3.45**	2.11*	20.83**	24.72**	36.90*	2.50
$I_{10} \times I_6$	–20.89**	–12.82**	5.34**	14.49**	–17.47**	2.44**	12.64**	22.21**	30.95*	2.50
$I_9 \times I_7$	5.11**	–10.26**	–6.16**	5.26*	–17.13**	–16.56**	13.11**	12.17**	33.33*	7.50
$I_{10} \times I_7$	–11.56**	–10.47**	–34.34**	–23.21**	1.15	7.56**	12.24**	–8.91**	13.10**	6.67
$I_9 \times I_8$	5.11**	–15.38**	–6.16**	–4.74*	2.18*	–8.89**	9.76**	34.76**	15.48	27.50*
$I_{10} \times I_8$	2.44	–2.78	–10.95**	–1.67	3.91**	5.22**	3.12**	–2.64**	–5.95	6.67

*P= 0.05, **P= 0.01

which is non-fixable component of genetic variation related to heterosis. Among all 45 crosses, only 17 crosses exhibited desirable positive specific combining ability effects for yield/plant over both the environments. The study indicated that crosses having highly significant sca effects generally involved low, high and average general combiners suggesting the involvement of one general good combiner appears to be essential to get the better specific cross combination. Occurrence of low × low combination crosses with desirable specific combining ability effects revealed that the parents in such crosses lack additive gene effects as compared to high gca parents. The higher magnitude of sca effects may be relatively due to high magnitude of complementary genes.

Table 1 shows the top 7 hybrids with positive and desirable economic heterosis for yield/plant over both the environments. The top 8 to 9 best performing crosses in both the environment with their yield (tonnes/ha) is presented in Table 2. On the basis of *per se* performance, specific combining ability effects, standard heterosis some crosses were found common as in E_1, I_8´I_6 and I_8´I_1 for ear length, I_9´I_5 for number of kernels row/ear, I_8´I_5 and I_9´I_4 for number of kernel/row, I_8´I_1 for 100 kernel weight, I_9´I_6, I_{10}´I_6 and I_{10}´I_7 for yield/plant and I_9´I_6, I_9´I_7 and I_{10}´I_3 for yield/plot were common, whereas in E_2 cross, I_{10}´I_6 for ear length, I_2´I_1, I_9´I_3 and I_3´I_1 for ear height, I_8´I_2, I_7´I_6 and I_{10}´I_2 for number of kernel row/ear, I_2´I_1 and I_3´I_2 for number of kernel/row, I_7´ I_6 for 100 kernel weight, I_9´ I_8 and I_7 ´I_1 were found common for yield/plant. Most of the crosses had the parents with the combination of low and high general combining ability. Crosses with good specific combining ability and *per se* may be utilized to recover transgressive segregants.

Table 2 Best performing crosses in both environments and their yield

	Yield		
E_1	Tonnes/ha	E_2	Tonnes/ha
$I_9 \times I_6$	13.08	$I_9 \times I_8$	14.17
$I_9 \times I_7$	12.23	$I_9 \times I_6$	13.12
$I_{10} \times I_6$	12.19	$I_{10} \times I_6$	12.85
$I_{10} \times I_7$	12.15	$I_9 \times I_1$	12.39
$I_9 \times I_8$	11.88	$I_4 \times I_1$	12.12
$I_9 \times I_5$	11.88	$I_9 \times I_7$	11.80
$I_7 \times I_6$	11.48	$I_9 \times I_5$	11.32
$I_{10} \times I_8$	11.16	$I_{10} \times I_8$	10.24
$I_{10} \times I_4$	11.01		

SUMMARY

A 10 parent diallel cross of maize inbreds and their 45F_1's were assessed for the heterosis and combining ability for yield and its attributing traits during rainy (*kharif*) 2006 and winter (*rabi*) season 2006–07. General and specific combining ability mean squares significantly differ for the yield components with higher magnitude of general combining ability mean squares for most of characters except for ear diameter, 100-kernel weight and grain yield. Parent 'HUZM67' (I_{10}), (1.95) in E_1 and 'HUZM40' (I_8), (2.52) in E_2 recorded the highest general combining ability effect for grain yield/plant. In both the environments, hybrids 'HUZM53' (I_9) × 'HUZM49' (I_6), (20.83, 24.72) and 'HUZM53' (I_9) × 'HUZM49' (I_8) (9.76, 34.76) exhibited highly significant heterosis for grain yield/plant and may be further exploited for hybrid development over both the environments.

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