

Heterosis for Yield and Yield Components in Maize (*Zea mays* L.)

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Abstract

In view of recently adopted strategy in maize breeding program to develop single cross hybrids for maximum exploitation of heterosis the present investigation was carried out in line \times tester mating design involving ten lines and four testers to analyze the extent of heterosis and to identify superior single cross hybrids for yield and yield components in maize. About 30—50% of all the hybrids manifested significant and positive heterobeltiosis, relative heterosis and standard heterosis for grain yield in the range of -27.64 to 148.88, -11.52 to 264.17 and -8.24 to 189.69% respectively. Most of the higher yielding hybrids manifested positive heterosis for yield and yield contributing characters. The crosses $L_{10} \times T_4$ (Pant 7421 + S_3 -93-1) \times Jogia local + S_3 -72-1-39, $L_1 \times T_4$ (M_9 + S_4 -2-1 \times Jogia Local + S_3 -72-1-39), $L_{10} \times T_3$ (Pant 7421 + S_3 -93-1 \times Jogia local + S_3 -12-1-15) and $L_6 \times T_4$ (Pant 7421 + S_3 -107-1 \times Jogia local + S_3 -72-1-39) were outstanding as they yielded more than standard commercial check hybrids. These hybrids also showed improvement in ear length, ear diameter and ears per plot. These single cross hybrids provide opportunity for commercial exploitation. The present study indicated that these higher yielding single cross hybrids must be screened for the stability in yield over season in maize breeding program.

Key words : *Zea mays* L. Heterosis, Yield, Standard heterosis, Heterobeltiosis.

A major break through in corn has been obtained by utilizing the phenomenon of heterosis resulting from crosses of genetically diverse parents. High percentage of heterosis among the crosses of parents of sufficient genetic diversity in maize has been reported in the past (Hayes and Olson 1919, Richey 1946, Dhawan and Singh 1961). The single cross hybrids have theoretically higher yield potential and are more uniform than double cross. A recently adopted strategy in maize breeding program is to develop single cross hybrid for maximum exploitation of heterosis. Assessment of heterosis of single crosses is important in maize breeding program in India. The present investigation was carried out to analyze the extent of heterosis over mid better and check parent, in crosses and to identify the best heterotic combination for yield and yield components in maize.

Methods

The experimental material consisted of 40 crosses of maize produced by crossing ten female parents (lines) with four pollen parents (testers) in a line \times tester mating design (Kempthorne, 1957). The pedi-

gree of the female parents, designated as L_1 to L_{10} were M_9 + S_4 -2-1 (L_1), M_9 S_4 -36-1 (L_2), M_9 + S_4 -37-1 (L_3), M_9 + S_4 -37-2 (L_4) and M_9 + S_4 -37-3 (L_5), Pant 7421 + S_3 + 107-1 (L_6), Pant 7421 + S_3 + 16-1 (L_7), Pant 7421 + S_3 + 22-1 (L_8), Pant 7421 + S_3 + 76-1 (L_9), Pant 7421 + S_3 + 93-1 (L_{10}) and Jogia local + S_3 -4-2-8 (T_1), Jogia local + S_3 -10-2-13 (T_2), Jogia local + S_3 -12-1-15 (T_3) and Jogia local + S_3 -72-1-39 (T_4), respectively and were used as testers. The 40 crosses along with 14 parents and standard check (CM 300 \times CM 400) single cross were evaluated at the research farm of Tirhut College of Agriculture, Dholi, Rajendra Agricultural University, Pusa, Bihar during the *kharif* of 1994 in a randomized block design with three replications. Each entry was provided a two-row plots of 5 m length. Inter row and inter plant distances were kept at 75 cm and 25 cm, respectively. All the recommended cultural practices were followed to obtain normal growth of the crop. Observations were recorded on five randomly selected competitive plants in each plot of all the treatments. The observations were recorded on plant height (cm), ear height (cm), days to 50% tassel, days to 50% silk, days to maturity, ear diameter (cm), ear length (cm), number of ears per plot, 1,000-kernel

Table 1. Analysis of variance for ten quantitative characters in maize. * and **, Significant at $P = 0.05$ and 0.01 respectively.

Source	df	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Ears/plot	1,000-grain weight (g)	Grain yield (kg/ha)
Treatment	53	732.99**	247.87**	11.09**	0.42**	72.38**	0.0056*	0.87**
Crosses	39	402.86*	140.30	8.78**	0.16**	50.50**	0.0047**	0.51**
Parents	13	583.56**	145.86	11.00**	0.50**	84.67**	0.0046**	0.70**
Parents vs crosses	1	15550.50**	5769.43**	102.32**	9.51**	765.97**	0.0535**	17.11**
Error	106	258.01	103.92	4.00	0.05	15.42	0.0034	0.18

weight (g) and grain yield (kg/ha). Data were analyzed statistically according to the analysis of variance technique. Heterosis was calculated as percentage increase in F_1 generation over the mid parent, (MP), better parent (BP) and check parent (CK), respectively.

Results and Discussion

The analysis of variance indicated significant differences among genotypes for grain yield and other

characters, showed the existence of variability among the genotypes (Table 1). The crosses/hybrid progenies also showed significant differences for all the characters except ear height. The mean squares due to parents vs crosses were significant for all the characters, which indicated the presence of heterotic response for all the characters studied.

Estimates of better parent, mid-parent and standard heterosis for yield and various yield components are presented in Table 2. For grain yield nine out of 40 hybrids evaluated, gave higher yield than the respec-

Table 2. Estimates of percent heterosis over better parent (BP), mid-parent (MP) and standard for grain yield and other agronomic characters. * and **, Significant at $P = 0.05$ and 0.01 respectively.

Cross	Plant height (cm)			Ear height (cm)			Ear length (cm)			Ear diameter (cm)		
	BP	MP	CK	BP	MP	CK	BP	MP	CK	BP	MP	CK
$L_1 \times T_1$	18.65**	21.48**	29.37**	26.08*	26.78**	39.75**	12.49	14.18	52.31**	9.81	12.57*	3.40
$L_1 \times T_2$	15.59**	29.76**	23.16**	19.56	34.15	32.52**	2.57	-9.85	38.88**	10.69	7.64*	2.18
$L_1 \times T_3$	11.41	12.01	15.81	26.03*	28.08	45.77**	13.65	13.98	54.57**	-4.75	2.67	5.50
$L_1 \times T_4$	8.70	21.60**	12.99	9.78	19.52	21.68	10.75	22.59*	49.95**	17.09*	20.79**	11.00
$L_2 \times T_1$	0.00	9.34	9.03	7.70	18.18	21.68	7.96	22.33*	41.84**	10.12	19.26**	9.78
$L_2 \times T_2$	30.00**	30.95**	17.51*	29.99*	36.85**	25.29*	24.72*	34.00**	46.46**	10.37	18.18**	9.73
$L_2 \times T_3$	8.78	15.78*	11.86	7.70	11.37	18.07	-13.26	-0.25	17.95	-1.65	11.93**	9.17
$L_2 \times T_4$	33.12	39.67**	20.33*	26.24*	28.66**	21.68	25.05*	30.85**	36.61*	24.05**	27.36**	9.61
$L_3 \times T_1$	-6.12	-1.65	2.15	1.10	5.14	10.84	16.39	-6.97	9.85	12.88*	19.48**	12.53*
$L_3 \times T_2$	0.55	9.54	1.69	9.52	17.95	10.84	-6.97	-4.10	9.24	3.45	8.22	0.61
$L_3 \times T_3$	-2.202	-2.14	0.56	-1.16	2.22	10.84	1.73	15.34	38.36**	6.28	3.62	3.36
$L_3 \times T_4$	8.84	20.35*	11.30	10.71	13.52	12.04	23.46	26.80*	34.87*	30.04**	30.68**	15.90**
$L_4 \times T_1$	3.42	6.47	19.20*	5.78	10.87	27.69*	-4.44	3.84	25.54	5.33**	31.23**	14.98*
$L_4 \times T_2$	0.00	14.60	15.25	5.78	23.10*	27.69*	16.77	20.35	37.14**	10.69	24.62**	7.64
$L_4 \times T_3$	3.92	9.86	19.77*	13.77	16.20	37.34**	14.10	25.92**	55.18**	-2.20	16.39**	8.56
$L_4 \times T_4$	9.80	28.37	26.55*	7.78	21.89*	30.11*	31.01*	17.43	44.72**	29.55**	40.14**	15.29*
$L_5 \times T_1$	-4.66	0.00	3.95	4.40	9.75	14.45	-20.83	-12.27	4.01	6.44	19.86**	6.11
$L_5 \times T_2$	24.57**	33.33**	23.10	34.92**	44.50**	34.92**	-3.48	1.56	13.33	11.32	23.91**	8.25
$L_5 \times T_3$	4.94	7.00	7.91	-1.03	6.74	14.45	-3.84	8.68	30.77*	11.01*	4.87	-1.22
$L_5 \times T_4$	25.71**	37.52**	24.29**	33.72**	38.79**	33.72**	1.11	2.75	10.46	19.93**	28.30**	6.72
$L_6 \times T_1$	9.84	10.70	19.77*	19.56	20.22*	32.52**	-7.10	-2.09	22.05	7.24	12.40*	17.73**
$L_6 \times T_2$	11.58	21.68**	17.51*	2.16	14.63	13.24	17.73	18.00	38.8**	7.24	13.79*	17.73**
$L_6 \times T_3$	8.94	10.24	16.94	1.03	1.02	14.45	6.29	24.83	31.76*	0.36	0.36	0.74
$L_6 \times T_4$	13.68	29.37**	22.03*	7.28	21.88**	24.88**	36.10*	50.98**	31.76*	1.83	2.02	2.21
$L_7 \times T_1$	9.84	13.51	19.77*	12.09	13.97	22.88	20.34	73.02**	22.23	-0.35	0.00	1.84

Table 2. Continued.

Cross	Plant height (cm)			Ear height (cm)			Ear length (cm)			Ear diameter (cm)		
	BP	MP	CK	BP	MP	CK	BP	MP	CK	BP	MP	CK
L ₇ × T ₂	12.98	22.29**	14.69	20.45	32.49	27.69*	-5.85	20.88	-15.85	-1.44	-1.20	0.74
L ₇ × T ₃	9.88	10.25	12.99	10.46	16.37	28.91*	-13.87	27.86	-1.57	-1.46	-0.54	0.70
L ₇ × T ₄	20.00**	33.23**	20.03*	11.37	22.50*	17.34	20.45	59.32**	-6.33	-2.88	-1.81	0.73
L ₈ × T ₁	5.18	9.93	14.69	17.59	26.68**	28.91**	-3.09	44.24**	-1.57	-1.09	-0.54	0.37
L ₈ × T ₂	6.70	16.50	7.91	29.49*	34.67**	21.68	3.58	48.69*	-7.95	-2.17	-1.45	-0.36
L ₈ × T ₃	-0.55	0.27	2.98	4.78	15.62	20.47	-18.29	25.54	-6.33	-0.36	0.36	0.74
L ₈ × T ₄	24.57**	37.60	25.98**	35.89**	36.76**	27.69*	40.81*	94.42**	9.52	0.10	1.29	1.48
L ₉ × T ₁	-5.69	3.41	2.82	4.00	8.59	14.45	-15.61	-14.95	-14.28	0.35	1.88	1.84
L ₉ × T ₂	21.53*	24.11**	9.02	4.75	12.80	6.01	14.28	-29.41*	-33.33**	-1.09	0.36	1.00
L ₉ × T ₃	6.03	13.19	9.03	8.33	15.56	25.29*	-1.37	5.20	12.71	-3.30	3.69*	3.69*
L ₉ × T ₄	21.38*	26.98**	9.03	17.61	22.92*	19.02	-12.71	-1.76	-12.71	-0.36	-0.18	-0.36
L ₁₀ × T ₁	1.03	2.36	10.66	11.34	14.89	30.11	3.04	3.86	6.33	-3.04	-3.64*	-2.21
L ₁₀ × T ₂	11.16	22.99**	18.08*	5.15	20.71*	22.88	21.50*	28.98	25.38	-1.44	-1.26	0.37
L ₁₀ × T ₃	21.80**	23.77**	29.37**	28.87**	29.54**	50.57**	2.79	8.03	17.47	-0.73	-0.18	0.74
L ₁₀ × T ₄	9.57	23.78**	16.38	11.34	24.13*	30.11**	1.52	15.78	4.76	-2.18	-1.46	-0.73
SE (±)	13.05	11.30	13.05	8.32	7.20	8.32	3.19	2.76	3.19	1.63	1.41	1.63

Table 2. Continued.

Cross	Ears per plot			1000-grain weight			Grain yield (kg/ha)		
	BP	MP	CK	BP	MP	CK	BP	MP	CK
L ₁ × T ₁	-28.12	17.13	-27.00	10.71	12.72	0.00	56.81	85.65**	113.40**
L ₁ × T ₂	-23.24	-16.54	-31.76*	0.00	3.57	-6.45	14.15	26.47	32.98
L ₁ × T ₃	-16.66	12.13	-4.76	0.00	1.81	-9.67	34.14	54.20	70.10
L ₁ × T ₄	12.24	14.56	-12.71	11.11	0.052	-3.72	58.25**	169.61**	151.54**
L ₂ × T ₁	10.72	5.55	-9.52	-3.57	10.20	-12.90	25.00	87.50*	70.10
L ₂ × T ₂	26.78	41.99*	12.71	3.44	20.00	-3.22	76.99**	156.41**	106.18**
L ₂ × T ₃	15.29	5.17	-3.19	3.57	18.66	-6.45	1.62	49.70	28.86
L ₂ × T ₄	92.93**	104.32**	50.80**	34.61	48.93**	12.90	148.88**	264.17	130.92**
L ₃ × T ₁	-10.92	18.75	-9.52	-5.7	10.20	-12.90	6.06	54.69	44.32
L ₃ × T ₂	-19.65	2.24	-28.57	-6.89	8.00	-12.90	11.50	48.14	40.20
L ₃ × T ₃	-18.04	13.48	-6.33	17.85	34.69*	6.45	8.94	55.81	38.14
L ₃ × T ₄	32.70	60.57**	3.19	19.23	31.77	0.00	142.22**	213.66**	124.70**
L ₄ × T ₁	34.41*	63.82**	36.52*	10.71	29.16	0.00	40.15	113.87	90.72*
L ₄ × T ₂	-4.28	19.57	-11.95	10.34	30.61	3.22	62.83	138.96**	89.69*
L ₄ × T ₃	0.00	27.52	14.28	-17.85	-4.16	-25.80	30.39	96.34**	64.94
L ₄ × T ₄	61.23**	75.33**	25.38	19.23	34.78	0.00	75.55	79.87**	62.88
L ₅ × T ₁	-7.78	20.45	-6.33	3.57	16.00	-6.45	29.54	95.42**	76.28**
L ₅ × T ₂	19.88	2.20	-27.00	3.44	17.64	-3.22	39.82	102.56**	62.88
L ₅ × T ₃	-26.37*	0.00	-15.85	-17.85	-8.00	-25.80	-27.64	7.22	-8.24
L ₅ × T ₄	20.45	42.82**	-6.33	15.38	25.00	-3.22	60.00	116.54**	48.54
L ₆ × T ₁	0.00	2.40	1.57	-9.37	-3.33	-6.45	12.13	27.21	100.00*
L ₆ × T ₂	8.27	12.82	4.76	12.50	18.08	16.12	0.57	21.61	79.38*
L ₆ × T ₃	-7.69	-1.13	25.54	6.25	13.33	9.67	23.69	44.59*	120.61**
L ₆ × T ₄	9.90	14.14	29.64*	18.75	31.03*	22.58	26.01	65.77*	124.70**
L ₇ × T ₁	-6.63	6.83	22.66	10.71	24.00	0.00	23.48	65.46*	68.04
L ₇ × T ₂	4.45	13.14	22.66	-24.13	-13.72	-29.03	14.15	44.94	32.98
L ₇ × T ₃	0.83	17.08	37.14**	10.71	24.00	0.00	-2.43	27.66	23.71
L ₇ × T ₄	18.11	24.36*	29.03*	-11.53	-4.16	25.80	56.56	81.93*	45.36
L ₈ × T ₁	4.84	18.42	37.75**	17.08	29.41	6.45	15.90	48.54	57.73
L ₈ × T ₂	17.81	26.60**	38.36**	3.44	15.38	-3.22	37.16	65.97*	59.79
L ₈ × T ₃	11.98	28.48**	52.31**	17.85	29.41	6.45	21.95	52.28	54.63
L ₈ × T ₄	31.44*	36.31**	43.51**	26.92	34.69*	6.45	123.33**	145.12**	107.21**

Table 2. Continued.

Cross	Ears per plot			1000-grain weight			Grain yield (kg/ha)		
	BP	MP	CK	BP	MP	CK	BP	MP	CK
$L_9 \times T_1$	-4.78	-3.56	28.42*	-7.14	13.20	-3.02	-6.06	20.38	23.71
$L_9 \times T_2$	-12.54	-6.49	17.95	-31.03	-25.92	-35.48*	0.88	21.92	17.52
$L_9 \times T_3$	-3.01	-2.68	31.90*	10.71	16.98	0.00	-21.13	-11.52	0.00
$L_9 \times T_4$	-0.92	9.50	33.65*	-23.07	25.49	3.22	116.66**	137.80**	101.03**
$L_{10} \times T_1$	-10.82	-4.18	34.26*	-25.80	-22.03	-25.80	-8.24	9.20	83.50*
$L_{10} \times T_2$	-16.21	-5.85	6.15	-16.12	-13.33	-16.12	-20.61	0.32	58.76
$L_{10} \times T_3$	15.40	21.26*	73.75**	17.47	6.89	0.00	12.88	38.17*	125.77**
$L_{10} \times T_4$	3.47	19.93*	55.79**	4.76	14.88	3.22	44.81**	97.85**	189.69**
SE (\pm)	1.63	1.41	1.63	0.07	0.41	0.47	0.34	0.30	0.34

tive better parent and 21 crosses gave higher relative heterosis while 17 were better than standard check, yielding 1,293.33 kg/ha under protected condition. About 30—50% of all the F_1 hybrids manifested significant and positive heterobeltiosis, relative heterosis and standard heterosis in the range of -27.64 to 148.88%, -11.52 to 264.17% and -8.24 to 189.69%, respectively. The top ranking hybrid $L_{10} \times T_4$ out yielded than check CM 300 \times CM 400, the most popular commercial single cross. The other high yielding hybrids/crosses were $L_1 \times T_4$, $L_2 \times T_4$, $L_{10} \times T_3$, $L_6 \times T_4$, $L_3 \times T_4$ and $L_6 \times T_3$ with per cent heterosis of 151.54, 130.92, 125.77, 124.74, 124.70 and 120.61, respectively. The heterotic response of the crosses over better parent for plant height ranged from -6.21 to 33.12%. Eleven crosses had significantly higher heterosis. The cross $L_2 \times T_4$ had given the highest heterosis of 33.12% followed by $L_2 \times T_2$, $L_3 \times T_4$ and $L_{10} \times T_3$. Twenty crosses showed significantly higher relative heterosis for plant height. The cross $L_2 \times T_4$ had the highest relative heterosis of 39.67% followed by $L_8 \times T_4$, $L_5 \times T_2$ and $L_7 \times T_4$. Standard heterosis ranged from 0.56 to 29.37% and 16 crosses exhibited significantly higher heterosis. The cross $L_1 \times T_1$ had the highest standard heterosis followed by $L_{10} \times T_3$ and $L_5 \times T_4$.

The range of standard heterosis for ear height ranged from 6.01 to 50.57%. Twenty crosses had significantly higher heterosis, the crosses $L_{10} \times T_3$ had the highest standard heterosis followed by $L_1 \times T_3$, $L_1 \times T_{11}$, $L_4 \times T_3$ and $L_5 \times T_2$. The 19 crosses exhibited significantly higher, relative heterosis while nine crosses showed significantly higher heterobeltiosis. The cross $L_5 \times T_2$ gave relative heterotic response of 44.50% followed by $L_2 \times T_2$, $L_8 \times T_2$ and $L_8 \times T_4$ while maximum heterobeltiosis was recorded by $L_5 \times T_4$.

The range of standard heterosis for ear length and ear diameter was 4.01 to 73.75 and -20.48 to 22.01% respectively. The cross $L_{10} \times T_3$, showed highest standard heterosis for ear length while $L_6 \times T_3$ for ear diameter. The heterobeltiosis response for ear length ranged from -20.32 to 31.44 while -19.00 to 30.04% for ear diameter. The crosses significantly differing were four for ear length and 12 for ear diameter. The highest heterotic response was recorded by the cross $L_8 \times T_4$ for ear length and $L_3 \times T_4$ for ear diameter, respectively. The relative heterosis ranged from -12.27 to 36.31% and 12 crosses showed significantly higher heterosis for ear length while 32 crosses had significantly higher heterotic response for ear diameter. For yield contributing character, ears per plot, standard heterosis ranged from -33.39 to 50.80%, nine crosses exhibited significantly higher heterosis. The cross $L_2 \times T_4$ had the highest standard heterosis followed by $L_4 \times T_1$, $L_6 \times T_3$ and $L_6 \times T_4$. The cross $L_2 \times T_4$ showed the highest heterosis over better parent (92.93%) and mid-parent (104.32%), respectively. It was observed that none of the crosses exhibited significantly higher heterobeltiosis and standard heterosis for 1,00-grain weight. The range of heterosis over better parent, mid-parent and check parent ranged from -31.03 to 34.61, -25.92 to 48.93 and -35.48 to 22.58%, respectively. The cross $L_2 \times T_4$ had the highest relative heterosis followed by $L_3 \times T_3$, $L_8 \times T_4$ and $L_6 \times T_4$. Estimates of heterosis for various yield components of heterotic hybrids indicated that significant yield increase was largely attributed to increase ear length, ear height, ear diameter and ears per plot. Similar results have also been reported by other workers (Ahmad and Al-younis 1968, Kovacs 1970, Svanovic 1979). Ahmad and Al-younis (1968) have reported

Table 3. Promising heterotic combinations for different yield contributing characters in maize.

Characters	Cross combinations
Plant height (cm)	$L_1 \times T_1 (M_9 + S_4 -2-1 \times \text{Jogia local} + S_3-4-2-8)$
	$L_{10} \times T_3 (\text{Pant } 7421 + S_3-93-1 \times \text{Jogia local} + S_3-12-1-15)$
	$L_5 \times T_4 (M_9 + S_4 -37-3 \times \text{Jogia local} + S_3 -72-1-39)$
Ear height (cm)	$L_1 \times T_2 (M_9 + S_4 -2-1 \times \text{Jogia local} + S_3-10-2-13)$
	$L_1 \times T_1 (M_9 + S_4 -2-1 \times \text{Jogia local} + S_3-4-2-8)$
	$L_4 \times T_3 (M_9 + S_4 -37-2 \times \text{Jogia local} + S_3-12-1-15)$
Ear length (cm)	$L_{10} \times T_3 (\text{Pant } 7421 + S_3-93-1 \times \text{Jogia local} + S_3-12-1-15)$
	$L_1 \times T_3 (M_9 + S_4 -2-1 \times \text{Jogia local} + S_3-12-1-15)$
	$L_4 \times T_3 (M_9 + S_4 -37-2 \times \text{Jogia local} + S_3-12-1-15)$
Ear diameter (cm)	$L_6 \times T_3 (\text{Pant } 7421 + S_3-107-1 \times \text{Jogia local} + S_3 -12-1-15)$
	$L_6 \times T_1 (\text{Pant } 7421 + S_3-107-1 \times \text{Jogia local} + S_3-4-2-8)$
	$L_6 \times T_2 (\text{Pant } 7421 + S_3-107-1 \times \text{Jogia local} + S_3-10-2-13)$
	$L_3 \times T_4 (M_9 + S_4 -37-1 \times \text{Jogia local} + S_3 -72-1-39)$
Ears per plot	$L_2 \times T_4 (M_9 + S_4 -36-1 \times \text{Jogia local} + S_3 -72-139)$
	$L_4 \times T_1 (M_9 + S_4 -37-2 \times \text{Jogia local} + S_3-4-2-8)$
	$L_6 \times T_3 (\text{Pant } 7421 + S_3-107-1 \times \text{Jogia local} + S_3 -12-1-15)$
	$L_6 \times T_4 (\text{Pant } 7421 + S_3-107-1 \times \text{Jogia local} + S_3 -72-1-39)$
Grain yield (kg/ha)	$L_{10} \times T_4 (\text{Pant } 7421 + S_3-93-1 \times \text{Jogia local} + S_3-72-1-39)$
	$L_1 \times T_4 (M_9 + S_4 -2-1 \times \text{Jogia local} + S_3-72-1-39)$
	$L_{10} \times T_3 (\text{Pant } 7421 + S_3-93-1 \times \text{Jogia local} + S_3 -12-1-15)$
	$L_6 \times T_4 (\text{Pant } 7421 + S_3-107-1 \times \text{Jogia local} + S_3-72-1-39)$
	$L_6 \times T_3 (\text{Pant } 7421 + S_3-107-1 \times \text{Jogia local} + S_3-12-1-15)$

beterosis for yield along with ear length and kernel weight. Kovacs (1970) reported greatest heterosis for kernel per row, kernel length, 1,000-grain weight and ear length Svanovic (1979) also reported heterosis for yield, ear length and plant height. Lin and Chen (1986) reported heterosis for grain yield and eight agronomic traits. Some of the promising hybrids selected

Table 4. Range of heterosis over mid and better parent with number of crosses with significant heterosis in maize.

Characters	Range		No. of crosses with significant heterosis	
	BP	MP	BP	MP
Plant height (cm)	-6.21 to 33.12	-2.14 to 39.67	11	20
Ear height (cm)	-1.16 to 53.72	1.02 to 44.50	9	19
Ear length (cm)	-20.83 to 31.44	-12.27 to 36.31	4	12
Ear diameter (cm)	-19.00 to 30.04	-16.39 to 40.14	12	32
Ears per plot 1000-grain weight (g)	-28.12 to 92.98	-29.41 to 104.32	7	13
Grain yield (kg/ha)	-31.03 to 34.61	-25.92 to 48.93	9	4
	-27.64 to 148.88	-11.52 to 264.17	8	22

on the basis of highly significant values of standard heterosis for individual yield contributing characters are given in Table 3.

The lines and testers selected in the present investigation are genetically diverse origin. The diverse genetical origin of the lines and testers is responsible for heterotic responses. These findings are in accordance with the results of Dhawan and Singh (1961), Moll et al. (1962) and Ahmad and Al-younis (1968).

The range of heterobeltiosis, relative heterosis and number of significant crosses are presented in Table 4. The range of heterosis was found to be high and more wider for mid-parent than better parent for six yield contributing characters except ear height. The results suggested that the heterosis of the crosses to be governed by partial dominance genes. Similar results were reported by Robinson and Cokerham (1961), Paterniani and Lonnquist (1963), Troyer et al. (1968), Akhtar and Singh (1981) and Lin and Chen (1986). Khristova (1978) reported predominantly over dominance effect in genetic control of yield. Svanovic (1979) has suggested that grain yield, ear length and plant height are governed mainly through dominance.

In the present investigation promising single cross combinations identified for grain yield were $L_{10} \times T_4$, $L_1 \times T_4$, $L_{10} \times T_3$ and $L_6 \times T_4$. The cross $L_2 \times T_4$ was mediocre in yield, had higher heterobeltiosis and relative heterosis. It was also found to possess signifi-

cant heterosis for different yield contributing characters. The present study indicated four single cross hybrids each giving significant positive standard heterosis, showing the possibility of achieving economically higher yield in maize. It is suggested that the higher yielding single cross hybrids must be screened for their stability in yield over season in maize breeding program.

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