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RESEARCH ARTICLE

Heterobeltiosis in white seeded genotypes of maize (*Zea mays* L.)

P.P. SHARMA, MUKESH VYAS AND S.P. SHARMA

SUMMARY

The extent of heterosis depends generally on the magnitude of non-additive gene action and wide genetic diversity among parents. The investigation of heterosis of parent and their hybrids were studied for 14 traits involving of 45 hybrids along with 15 lines and 3 testers alongwith four checks *viz.*, Arawali Makka-1, Mahi Kanhan, Navjot and PEHM-2, a total of 67 entries was conducted in Randomised Block Design having three replications. The data were recorded on fourteen traits to study the heterosis over better parents heterobeltiosis (BP) to identify suitable single cross hybrids using line x tester designed. The analysis of variance showed presence of significant amount of variability among parents and parents v/s crosses for all the traits except for anthesis silking interval and 100 grain weight and due to crosses were significant for all the traits. The inbred line L_7 exhibited maximum mean value for grain yield per plant and biological yield per plant. Tester to exhibited highest mean value for grain yield per plant, ear girth, harvest index and starch content. Hybrid L_{14} x T_2 exhibited maximum mean value for grain yield per plant. Hybrid L_{13} x T_2 exhibited minimum value of days to 50 per cent tasseling and days to 50 per cent silking. Out of 45 Hybrids, 25 hybrids exhibited significant positive heterobeltiosis for grain yield per plant. The maximum estimate of significant positive heterobeltiosis for grain yield per plant exhibited by hybrid L_{11} x T_3 (60.00%) while the hybrid L_{13} x T_3 and L_1 x T_2 exhibited highest estimates of significant positive heterobeltiosis for protein (66.93%) and starch content (9.92%), respectively. Majority of the hybrids exhibited significant positive relative heterosis for yield and yield contributing traits as well as quality traits, thereby indicating that for these traits the genes with positive effects were dominant. On the other hand for maturity traits as well as plant type traits, majority of hybrids exhibited significant negative relative heterosis. Therefore, indicating that for these traits. The genes with negative effets were dominant.

Key Words : Maize, Single cross hybrid, Heterosis, Heterobeltiosis, Check heterosis

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The development and identification of vigorous and productive inbred lines with good seed quality and high per see performance, is the primary requirement of any breeding programme aiming at identification of superior single crosses by exploitation of heterosis and single cross hybrids are considered more desirable because of the convanience in breeding and seed production than the multi parent hybrid (Vasal,1988). As highly vigorous and productive inbred lines form the base of single cross hybrids.They are more uniform, higher yielder with good seed quality and better stability. In view of the above facts and in order to develop and identify productive, nutritionally superior and industrially important conventional single cross hybrids.As such we can adopt the option of developing single cross hybrid to achieve quantum jump in production and productivity of maize. The actual exploitation of single cross hybrids require development of vigorous and productive inbred lines. This can be achieved through the development of diverse broad based populations and heterotic gene pools with their subsequent improvement for hybrids. The integration of population improvement with inbrd line development is likely to provide new superior lines for single cross hybrid breeding and other options of hybrid development. The present study was, therefore, undertaken with a view to estimate the magnitude of heterobeltiosis over better parents.

MATERIAL AND METHODS

The present investigation was carried out to elicit the information on heterobeltiosis in white seeded genetypes of maize at the intructional farm of Plant Breeding and Geneties, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. 15 inbred lines *i.e.* L_1 (E1 552), L_2 (E1-553), L_3 (E1 554), L_4 (EI-555), L_5 (EI-556), L_6 (E1557), L_7 (E1 503), L_8 (E1 501), L_9 (E1 499), L_{10} (E1 460), L_{11} (E1 461), L_{12} (E1 423), L_{13} (E1 420), L_{14} (E1 558) and L_{15} (E1 559) were crossed with three tester *viz.*, T_1 (EI 457), T_2 (EI 494) and T_3 (CM 400) thus, developed 45 hybrids.

The 45 hybrids, with 18 parents alongwith four checks *viz.*, experimental material consisted of total 67 entries planted in Randomized Block Design comprising three replications with a single row plot of 5 meter length, maintaining a crop geometry of 60 x 25 cm. All recommended agronomical practices were followed to raise to healthy crop. Observation for fourteen different traits were recorded on ten randomly seleted comparative plants for each entry in each replication except for days to 50 per cent tasseling, days to 50 per cent silking and day to 50 per cent brown husk.

RESULTS AND DISCUSSION

The first success in the development of single cross hybrid was Paras followed by PEHM-1, PEHM-2, Prakash, PEHM-4 and Pratap Hybrid Maize-1 etc. in contrast to 90 per cent area of single cross hybrids in USA (Troyer, 1990). As the major area of maize is under rainfed situation *viz.*, Rajasthan, Gujarat, MP, UP and Bihar. There is a need of developing early and medium maturity hybrids. Identification of vigorous and productive inbred lines to be used as parents, is the primary requirement for developing nutritionally superior, high yielding and short duration single cross hybrids. Genetic parameters like heterosis form the

Table 1 : Mean and range of parents and their hybrids for different traits in white seeded genotypes of maize

Sr. No.	Name of characters	Overall G.M.	Parents			Hybrid		
				Range			Range	
			Mean	Min.	Max.	Mean	Min.	Max.
1.	Days to 50 % tasseling	45.57	45.96	41.67	50.67	45.38	41.33	47 67
2.	Days to 50% silking	47.95	48.25	44.33	52.67	47.80	44.00	49 67
3.	ASI	2.37	2.31	2.00	3.00	2.41	2.00	3.33
4.	Days to 50 % brown husk	74.96	74.22	70.33	79.00	75.15	70.33	82.00
5.	Plant height(cm)	214.75	205.61	170.00	245.33	217.07	182.00	263.00
6.	Ear height(cm)	98.77	94.96	67.00	117.00	99.37	85.33	123.67
7.	Ear length(cm)	14.07	12.89	10.30	14.77	14.50	12.83	16.07
8.	Ear girth	12.12	11.45	9.77	12.23	12.38	10.93	13.47
9.	100 grian weight	18.51	18.46	16.75	19.96	18.63	14.96	22.34
10.	Grain yield per plant	80.98	71.00	37.67	90.67	84.94	63.33	96.67
11.	Biological yield per plant	229.00	224.95	117.41	328.68	230.45	154.25	290.00
12.	Harvest index	35.59	31.90	27.58	35.99	37.09	31.52	42.45
13.	Protein content(%)	9.08	7.69	6.50	8.69	9.73	7.45	11.51
14.	Starch content (%)	62.29	61.75	54.79	65.21	62.52	56.42	67.38

Table 2: Analysis of variance for fourteen traits in white seeded genotypes of maize

Sourec of variation	d.f.	Days to 50 % Tasseling	Days to 50% silking	ASI	Days to 50 % brown husk	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear girth	100 grian weight	Grain yield per plant	Biologica l yield per plant	Harvest index	Protein content (%)	Starch content (%)
Replication	2	1.5124	0.9602	1.0348*	10.2687*	32.6567*	0.1841	0.9793	0.0277	1.4047	271.29**	488.25**	19.253**	0.1541	0.9434
Genotypes	66	7.8061**	6.9858**	0.4155**	26.262**	943.48**	275.35**	4.4773**	1.4083**	5.8050**	351.54**	3536.1**	35.259**	5.3531**	21.32**
Checks	3	2.0833*	2.2222**	0.0833	26.9722**	428.45**	353.89**	0.1467	0.3033	4.9738*	24.3056	1132.1**	11.7754*	1.285888	13.376**
Checks v/s parent	1	1.1523	0.1212	0.5261	34.0076**	5681.5**	1980.8**	23.2512**	5.3067**	11.8061**	1031.5**	362.689*	113.709**	0.9713	1.6437
Parents	17	14.110**	13.333**	0.3714	24.5098**	1085.1**	400.74**	4.4401**	0.984**	2.4355	478.63**	7089.4**	20.8822**	1.5487**	24.702**
Testers	2	1.4444	2.3333**	0.1111	21.00**	1079.1**	145.33**	1.8433*	3.7544**	1.6728	353.78**	2718.6**	18.747**	1.7617**	0.9708
Lines	14	10.069**	9.9047**	0.4032*	20.81**	1123.8**	455.69**	1.851**	0.4451	2.6823	194.04**	4009.4**	21.538**	1.400**	28.884**
	1	96.004**	83.333**	0.4482	83.333**	554.70**	142.28**	45.8803**	2.9873**	0.5052	4712.5**	58952**	15.9676*	3.2035**	13.628**
Parents v/s crosses	1	10.8196**	6.8762**	0.3857	33.0688**	5068.3**	749.26**	99.613**	33.60**	1.1274	7496.1**	1166.5**	1037.69**	159.86**	22.953**
Crosses	44	5.7364**	4.9758**	0.4418	26.963**	787.01**	185.685**	2.6873**	0.9468**	7.0209**	170.34**	2460.2**	20.412**	3.3773**	20.998**
Error	132	0.5679	0.4804	0.2217	2.3242	60.4193	6.2749	0.5368	0.2698	1.5456	26.8088	62.1409	3.0785	0.2945	0.5662

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

selection criteria for parent and hybrids to exploit the heterosis.

The analysis of variance for experimental design (Table 2) revealed significant amount of variability among parents and parents v/s crosses for all the traits except for anthesis, silking interval and 100 grain weight. Variability due to crosses was significant for all the traits. This suggested that the parental lines selected were quite variable, considerable amoung of variability existed among the hybrids of over all heterosis for most of the traits under study was present.

Similar trends for variance of its components were reported by Debnath and Sarkar (1987) for plant height, ear height, ear length, 100 grain weight, grain yield per plant, harvest index and starch content in maize. Hetrosis over mid parent and standard check was calculated as per usual procedure whereas, heteobeltiosis was calculated as per suggested by Fonesca and Patterson (1968).

Heterobeltiosis (BP) is important parameter as it provide information about the presnce of over dominance type of gene action in the expression of various traits. Positive direction was considered desirable for all traits except traits like days to 50 per cent tasseling, days to 50 per cent silking, anthesis silking intervals, days to 50 per cent brown husk, plant height and ear height whereas negtive direction was considerable desirable. Heterobeltiosis was calculated only in desirable direction.

The data on maturity related traits indicate that all the parents and their hybrids indicated better likely tolerance to drought stress. Four hybrids depicting significant negative heterobeltiosis for anthesis- silking interval and days to 50 per cent brown husk and thirteen hybrids for days to 50 per cent tasseling. Whereas, only one hybrid (L_8 x T_1) exhibited significant regative heterobeltiosis for ear height (Table 3).

Among the hybrids $L_{13}xT_3$ (HP (A)67-2-1-1xCM 400) exhibited maximum value for ear length (16.07 cm). Hybrid L_3xT_1 exhibited maximum ear girth (913.47). Another hybrid L_5xT_1 exhibited maximum 100 grain weight (22.34g/plant),silked in the 45.33 days having anthesis silking intervals of 2 days and matured in 71.00 day. This hybrid contains 66.78 per cent starch. Hybrid $L_{12}xT_1$ exhibited maximum biological yield per plant (290.00g/plant).Hybrid L_6xT_3 exhibited maximum protein content (11.51%) and hybrid $L_{11}xT_2$ exhibited maximum value for starch content (67.38%) acording to (Table 1) .

Table 3: Per cent heterobeltiosis for grain yield per plant and its contributing traits in white seeded genotypes of maize

	Days to 50% Tasseling	Days to 50% SE	Anthesis silking nterval Silking	SE	Day to 50% broson husk	SE	Plant height	SE
$L_1 x T_1$	-		-		-			
L_2 xT_1	-		-		-14.29	16.48	-	
L_3 xT_1	-0.70	1.29	-0.67	1.14	0.00		-	
L_4 xT_1	-		-0.68	1.15	-14.29	16.48	-	
L_5 xT_1	-		-		0.00		-	
L_6 xT_1	-		-		-		-1.80	1.68
L_7 xT_1	-3.57*	1.32	-2.04	1.15	-		-	
L_8 xT_1	-	1.35	-		-		-	
L_9 xT_1	-		-1.36	1.15	-14.29	16..48	-	
L_{10} xT_1	-2.84*	1.31	-3.38**	1.15	-14.29	16.48	-	
L_{11} xT_1	-1.46	1.35	-2.05	1.16	-		-1.35	1.68
L_{12} xT_1	-		-		-		-	
L_{13} xT_1	-		-		-		-	
L_{14} xT_1	-5.80*	1.34	-5.56**	1.18	0.00		-1.80	1.68
L_{15} xT_1	-3.62**	1.34	-2.08	1.18	-		-	
$L_1 x T_2$	-	-	-	-	0.00		0.00	
L_2 xT_2	-5.07**	1.34	-3.45**	1.17	-		-1.33	1.66
L_3 xT_2	-4.90**	1.29	-3.36**	1.14	-		-	
L_4 xT_2	-4.26**	1.31	-3.38**	1.15	-		-	
L_5 xT_2	-1.47	1.36	-	-	-		6.49**	1.62
L_6 xT_2	-	-	-	-	-		-1.32	1.64
L_7 xT_2	5.71**	1.32	-4.08**	1.15	-		-	
L_{8v} xT_2	-2.19	1.35	-2.07	1.17	-		-	
L_9 xT_2	-2.16	1.33	-1.36	1.15	-		-	
L_{10} xT_2	-2.13	1.31	-2.70*	1.15	0.00		-2.23	1.67
L_{11} xT_2	-2.92*	1.35	-4.11**	1.16	-		6.22**	1.66
L_{12} xT_2	-	-	-	-	0.00		-2.74	1.71
L_{13} xT_2	-0.80	1.48	0.75	1.28	-		-	
L_{14} xT_2	-5.80**	1.34	-5.56	1.18	0.00		8.97**	1.60
L_{15} xT_2	-1.45	1.34	-1.39	1.18	0.00		-2.63	1.64
$L_1 x T_3$	-	-	-	-	-	-	-	
L_2 xT_3	-.580**	1.34	-4.83**	1.17	-	-	-4.00*	1.66
L_3 xT_3	-2.80*	1.29	-1.34	1.14	-	-	-	
L_4 xT_3	-	-	-	-	0.00	-	-	
L_5 xT_3	-	-	-	-	0.00	-	0.00	
L_6 xT_3	-	-	-	-	-	-	-	
L_7 xT_3	-0.00	1.32	0.00	-	-	-	-	
L8 xT_3	-0.73	1.35	-0.69	1.17	-	-	-	
L_9 xT_3	-	-	-0.68	1.15	0.00	-	-	
$L_{10} x T_3$	-	-	-	-	0.00	-	-	
$L_{11} x T_3$	-2.92*	1.35	-3.42	1.16	-	-	-0.44	1.66
$L_{12} x T_3$	-	-	-	-	-	-	-	
$L_{13} x T_3$	-	-	-	-	-	-	-	
$L_{14} x T_3$		-	-	-	-	-	-	
$L_{15} x T_3$	-	-	-	-	0.00	-	-3.07	1.64

Table 3 : Contd…………..

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	Ear height	SE	Ear length	SE	Ear girth	SE	100 grain weight	SE	Grain yield/ plant	SE
L_1xT_1	-	-	11.64**	4.26	1.40	3.56	-	-	25.58**	5.90
L_2 xT_1	-	-	-	-	-	-	3.01	5.29	-	
									-	
L_3 xT_1	-	-	20.32**	4.80	11.29	3.51	2.74	5.32	25.54**	5.49
L_4 xT_1	-	-	15.98**	4.63	4.49	3.81	7.16	5.32	23.19**	6.13
L_5 xT_1	-	-	16.62**	4.89	4.05	3.68	17.03**	5.32	17.78**	5.64
L_6 xT_1	-	-	9.85*	4.53	9.97*	3.84	-	-	-	-
L_7 xT_1	-	-	3.99	4.21	6.57	3.64	2.62	5.32	-	-
L_8 xT_1	8.10**	2.16	-	-	-	-	-	-	6.82	5.76
L_9 xT_1	-	-	1.74	4.45	1.12	3.56	-	-	6.67	5.64
L_{10} xT_1	-	-	7.79	4.37	3.87	3.79	-	-	6.19	5.61
L_{11} xT_1	-	-	24.59**	4.85	3.54	3.47	-	-	53.71**	7.25
L_{12} xT_1	-	-	13.10	4.27	4.66	3.71	-	-	15.51**	5.18
L_{13} xT_1	-	-	17.11**	4.80	17.47**	3.83	-	-	21.43**	6.04
L_{14} xT_1	-	-	18.96**	4.66	4.39	3.72	-	-	42.50**	6.34
L_{15} xT_1	-	-	11.31*	4.61	17.70**	3.75	2.79	5.32	24.44**	5.64
L_1xT_2	-	-	6.41	4.26	4.72	3.53	-	-	20.93**	5.90
L_2 xT_2	-	-	-	-	0.56	3.53	2.95	5.29	2.83	5.13
L_3 xT_2	-	-	21.93**	4.80	1.65	3.51	-	-	10.39	5.49
L_4 xT_2	-	-	12.37**	4.63	4.72	3.53	1.19	5.64	30.43	6.13
L_5 xT_2	-	-	13.62**	4.89	2.78	3.53	7.93	5.61	13.33**	5.64
L_6 xT_2	-	-	-	-	-	-	3.57	5.09	-	-
L_7 xT_2	-	-	0.70	4.21	6.67	3.53	-	-	-	-
L_{8v} xT_2	-	-	3.61	4.05	0.00	-	2.40	5.15	20.45**	5.76
L_9 xT_2	-	-	5.71	4.45	3.89	3.53	4.63	5.59	8.89	5.64
L_{10} xT_2	-	-	11.92**	4.37	4.44	3.53	-	-	12.83**	5.61
L_{11} xT_2	-	-	13.78**	4.85	3.00	3.47	-	-	40.00**	7.25
L_{12} xT_2	-	-	11.19	4.27	-	-	-	-	-	-
L_{13} xT_2	-	-	12.30*	4.80	10.56**	3.53	-	-	21.43**	6.04
L_{14} xT_2	-	-	17.66**	4.66	4.17	3.53	7.59	5.64	47.50**	6.34
L_{15} xT_2	-	-	15.68**	4.61	8.33*	3.53	8.10	5.64	22.22**	5.64
L_1xT_3	-	-	6.18	4.26	-	-	-	-	11.63	5.90
L_2 xT_3	-	-	-	-	14.24**	3.70	2.71	5.29	3.24	5.13
L_3 xT_3	-	-	16.31**	4.80	5.51	3.51	5.02	5.75	19.05**	5.49
L_4 xT_3	-	-	14.69**	4.63	5.39	3.81	14.08*	5.75	6.28	6.13
L_5 xT_3	-	-	14.44**	4.89	9.25**	3.68	1.62	5.61	11.11	5.64
L_6 xT_3	-	-	-	-	14.80**	3.84	-	-	-	-
L_7 xT_3	-	-	0.70	4.21	6.86	3.64	16.05**	5.74	2.94	4.66
L8 xT_3	-	-	-	-	6.42	3.55	-	-	15.91**	5.76
L_9 xT_3	-	-	7.94	4.45	5.32	3.56	4.48	5.59	0.00	-
$L_{10}xT_3$	-	-	0.49	4.37	14.38**	3.79	7.26	5.26	23.89**	5.61
$L_{11}xT_3$	-	-	17.03**	4.85	5.99	3.47	-	-	60.00**	7.25
$L_{12}xT_3$	-3.12	2.13	5.24	4.27	3.21	3.71	-	-	2.04	5.18
$L_{13}xT_3$	-	-	28.88**	4.80	17.47**	3.83	6.61	5.67	16.67**	6.04
$L_{14}xT_3$	0.00	-	13.51**	4.66	13.16**	3.72	4.99	5.46	37.50**	6.34
$L_{15}xT_3$	-	-	18.51**	4.61	11.80**	3.75	-	-	20.00**	5.64

Table 3 : Contd………

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	Biological yield per plant	SE	Harvest index	SE	Protein content	SE	Starch content	SE
L_1xT_1	3.12	2.78	17.67**	4.47	-	-	2.70**	1.02
L_2 xT_1	-	-	28.15**	4.47	2.32**	5.52	2.98**	1.00
L_3 xT_1	-	-	23.49**	4.47	23.57**	5.52	-	-
L_4 xT_1	-	-	28.64**	4.47	18.51**	5.52	-	-
L_5 xT_1	-	-	20.77**	4.47	27.37**	5.32	0.24	0.97
L_6 xT_1	-	-	10.93**	4.06	29.05**	5.52	-	-
L_7 xT_1	-	-	10.48**	4.47	25.56**	5.21	7.20**	1.02
L_8 xT_1	-	-	10.97*	4.47	14.46**	5.31	9.25**	1.02
L_9 xT_1	6.95*	3.09	-	-	30.53**	5.43	-	-
L_{10} xT_1	15.43**	2.94	-	-	33.41**	5.32	-	-
L_{11} xT_1	43.70**	3.24	-	-	27.24**	5.31	1.64	1.00
L_{12} xT_1	3.97	2.31	1.67	4.47	14.69**	5.52	1.53	0.95
L_{13} xT_1	9.81**	3.28	10.63**	4.01	6.47**	5.52	-	-
L_{14} xT_1	32.70**	3.17	7.43	4.36	16.56**	5.10	-	-
L_{15} xT_1	16.75**	2.67	3.37	4.47	15.98**	5.52	1.52	1.00
L_1xT_2	2.77	2.78	1.32	3.98	48.74**	6.08	9.92**	1.00
L_2 xT_2	-	-	-	-	12.00**	5.84	-	-
L_3 xT_2	-	-	6.21	3.98	10.27**	6.56	-	-
L_4 xT_2	1.43	2.94	12.53**	3.98	-	-	0.50	0.94
L_5 xT_2	-	-	9.23*	3.98	9.36	5.32	1.61	0.97
L_6 xT_2	-	-	17.99**	3.98	12.06**	5.96	0.41	0.98
L_7 xT_2	-	-	7.88	3.98	19.40**	5.21	8.09**	1.00
L_{8v} xT_2	-	-	8.95*	3.98	15.34**	5.31	-	-
L_9 xT_2	-	-	9.77*	3.98	7.23**	5.43	-	-
L_{10} xT_2	1.93	2.94	5.80	3.98	29.37**	5.32	0.40**	0.96
L_{11} xT_2	17.33**	3.24	-	-	15.14**	5.31	9.90**	1.00
L_{12} xT_2	-	-	3.02	3.98	60.31**	6.26	-	-
L_{13} xT_2	21.40**	3.28	-	-	34.90**	6.56	-	-
L_{14} xT_2	21.96**	3.17	10.29*	3.98	19.17**	5.10	3.80**	0.95
L_{15} xT_2	-	-	7.02	3.98	21.15**	5.63	4.67**	1.00
L_1xT_3	5.25	2.78	4.80	4.57	39.28**	6.08	6.30**	1.02
L_2 xT_3	-	-	11.59*	4.57	11.91*	5.84	-	
L_3 xT_3	-	-	17.06**	4.48	49.22**	6.65	-	
L_4 xT_3	-	-	24.31**	4.55	26.44**	5.59	-	
L_5 xT_3	-	-	12.42**	4.57	8.72	5.32	-	
L_6 xT_3	-	-	9.60*	4.06	54.80**	5.96	-	
L_7 xT_3	-	-	15.39**	4.57	12.00*	5.21	3.55**	1.02
L8 xT_3	-	-	24.31**	4.57	21.65**	5.31	1.45	1.02
L_9 xT_3	-	-	0.49	3.98	24.44**	5.43	-	-
$L_{10}xT_3$	13.93**	2.94	8.62*	4.16	35.01**	5.32	-	-
$L_{11}xT_3$	38.62**	3.24	8.07	4.57	31.59**	5.31	6.84**	1.00
$L_{12}xT_3$	-	-	25.77**	4.57	52.17**	6.26	-	-
$L_{13}xT_3$	14.83**	3.28	1.51	4.01	66.93**	6.65	-	-
$L_{14}xT_3$	27.48*	3.17	7.70	4.36	5.60	5.10	-	-
$L_{15}xT_3$	1.81	2.67	16.62**	4.57	-	-	4.99**	1.00

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

Hybrid L_{14} x T_2 exhibited maximum mean value for grain yield per plant. While hybrid L_{13} x T_2 exhibited minimum value for days to 50 per cent tasseling and days to 50 per cent silking. Out of 45 hybrids, 17 hybids exhibited maximum value of anthesis silking intervals.

In case of yield and yield contributing traits number of hybrids exhibiting significant positive heterobeltiosis ranged from 3 (100 grain weight) to 25 (ear length) and for quality traits it varied from 13 (starch content) to 35 (protein content). The presence of heterobeltiosis indicated that over dominance played an important role in the expression of all these traits. However, its magnitude of number of hybrids, which exhibited significant heterobeltiosis were variable. Heterosis over better parent for grain yield was also reported by Ganguli *et al*. (1989) and Beck *et al.* (1990). Sain *et al*. (1998) reported hetrobeltiosis for yield, plant type and maturity traits in maize. Towov and Min (1990) reported heterobeltiosis for starch content in maize, whereas Sinha (2002) reported heterobeltiosis for starch and protein content in maize.

On the basis of *per se* performance and heterobeltiosis with referance to grain yield, it was observed that single cross hybrid L_{12}x T_1 revealed high heterobeltiosis (15.51%) for grain yield per plant.

Out of 45 hybrids, 25 hybrids revealed significant positive heterbeltiosis for grain yield per plant. The highest estimate of significant positive heterobeltiosis for grain yield per plant was exhibited by Hybrid L_{11} x T_3 (CD(W) -15-2-1 x CM400), while the hybrid L_{13} x T_3 (HP(A) 67-2-1-1 x CM400) and L_1 x T_2 (Shweta 74-1-2 # 1-2-1xHP(B)33-3-1) exhibited highest estimates of significant positive heterobeltiosis for protein and starch content, respectively. Similar findings for identification of superior parental lines, testers and hybrids based on gca and sca effects for grain yield and its componetn trait in maize were reported by Vasal *et al.* (1992); Wang *et al*. (1994); Gama *et al.* (1995) and Sain *et al.* (1997).

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