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Estimation of heterosis for kernel yield and its attributing traits in maize (*Zea mays* L.)

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Abstract
The present study was undertaken to estimate the magnitude of heterosis of forty-five hybrids derived from fourteen parents (9 line and 5 tester) of maize through line × tester mating design. These hybrids were evaluated for kernel yield and its component characters to study the heterosis over better parent and standard check. The analysis revealed that the heterobeltiosis for kernel yield per plant ranged from -36.33 to 68.64 per cent, while the standard heterosis for kernel yield per plant ranged from -10.56 to 100.99 per cent. The cross *viz*., BLD 2 × BLD 103, BLD 2 × BLD 98, WNC 40406 × BLD 125, WNC 40080 × BLD 125 and BLD 2 × VL 109178 were possessed highest value of heterobeltiosis in significant and desirable direction. While crosses *viz*., BLD 114 × IMR 113, BLD 2 × BLD 103 and WNC 52646 × BLD 125 were recorded significant and positive standard heterosis over the standard check GAYMH 1.

Keywords: Heterobeltiosis, standard heterosis, line × tester, kernel yield per plant

Introduction
Maize (*Zea mays* L.) is one of the most important cereal crop in the world after rice and wheat. It is one of the most versatile emerging crop having wider adaptability. There is no cereal on the earth, which has such immense potential as maize therefore, it occupies the unique place as "Queen of cereals". Being a C_4 plant, it is physiologically more efficient as well as resilient to changing climatic conditions and able to grow successfully throughout the world over a wide range of environmental conditions. Maize serves as a raw material and ingredient for various industrial goods, including oil, protein, starch, alcoholic beverages, pharmaceutical, cosmetic, film, textile, gum, packaging, and paper sectors. Being highly cross pollinated crop, the scope for the exploitation of hybrid vigour will depend on the magnitude and direction of heterosis and the type of gene action involved for the trait. Heterosis is a powerful tool for developing economically viable variety (Abuali *et al.* 2012) [1]. Estimation of heterosis helps to identify hybrids having high yielding ability along with high heterotic potential by comparing them with the available standard checks. With this perspective, the present study was undertaken to identify superior hybrids on the basis of better parent and standard heterosis.

Material and Methods
Plant materials
An experimental material comprised of 60 genotypes consisting of 45 hybrids resulting from line × tester mating design involved 9 lines and 5 testers and one standard check (GAYMH 1).

Field experiments
The experimental material, comprising of 60 entries including 14 parents, their 45 crosses and one commercial check was raised in Randomized Block Design with three replications in *Kharif* 2020 at Maize Research Station, Sardarkrushinagar Dantiwada Agricultural University, Bhiloda. Plot size was two row of 4.0 m length with plant-to-plant spacing of 20 cm. Different thirteen observations were recorded *viz*., days to tasseling (days), days to silking (days), anthesis-silking interval (days), days to maturity, plant height (cm), ear height (cm), cob length (cm), cob girth (cm), kernels row per cob, kernels per row, 100 kernel weight (g), kernels yield per plant (g) and shelling percentage (%). All the observations were recorded from randomly selected five plants from each genotype in each replication.

Statistical analysis

The mean performance of parents as well as hybrids was subjected to statistical analysis. Analysis of variance was carried out to test the significance for each character as per methodology suggested by Panse and Sukhatme (1985) [10]. Better parent heterosis was calculated by the formula given by Fonseca and Patterson (1968) [4] and Standard heterosis by Meredith and Bridge (1972) [7].

Result and Discussion

The analysis of variance for all the yield and component traits studied are presented in Table 1. The analysis of variance revealed that presence of significant differences among all the 59 genotypes for all the characters studied, which indicating a high degree of variability in the material. The mean sum of square due to parents were highly significant for all the characters. The mean sum square due to hybrid shows the highly significant difference for all the traits under study except plant height.

The estimation of heterosis over better parent (BP) and over standard check (SC) shows that out of 45 hybrids, hybrids exhibited significant heterosis in desired direction for days to tasseling (7, 4), days to silking (5, 1), anthesis-silking interval (3, 0), plant height (0, 13), ear height (0, 16), days to maturity (4, 0), cob length (5, 2), cob girth (5, 0), kernels row per cob (4, 8), kernels per row (5, 1), 100 kernel weight (5, 0), kernels yield per plant (9, 24) and shelling percentage (3, 4). (Table 3-5)

For kernel yield per plant, the heterobeltiosis varied from -36.33% (BLD 2 × IMR 113) to 68.64% (BLD 2 × BLD 103). Out of 45 hybrids, 9 hybrids showed significant positive heterobeltiosis. The hybrid BLD 2 × BLD 103 (68.64%) exhibited maximum significant desirable heterobeltiosis followed by BLD 2 × BLD 98 (45.45%) and WNC 40406 × BLD 125 (38.01%). The standard heterosis ranged from -10.56% (WNC 40456 × BLD 103) to 100.99% (WNC 40406 × BLD 125). Among all the hybrids, 24 hybrids manifested significant and desired standard heterosis for kernel yield per plant. The cross WNC 40406 × BLD 125 (100.99%) exhibited the highest standard heterosis over GAYMH 1 followed by BLD 2 × BLD 103 (96.20%) and BLD 114 × IMR 113 (68.73%).

The hybrid, BLD 109 × IMR 113 for days to tasseling, BLD 109 × IMR 113 for days to silking, BLD 2 × IMR 113 and WNC 52313 × IMR 113 for anthesis silking interval, BLD 109 × VL 109178 for days to maturity, WNC 40456 × BLD 125 for cob length, BLD 109 × IMR 113 for cob girth, WNC 40080 × BLD 125 for kernel rows per cob, BLD 2 × VL 109178 for kernels per row, BLD 109 × BLD 98 and BLD 114 × BLD 98 for 100 kernel weight, BLD 2 × BLD 103 for kernel yield per plant and BLD 2 × BLD 103 for shelling percentage showed significant heterosis over better parent in desirable direction.

The hybrid, WNC 40324 × BLD 98 for days to tasseling, WNC 40324 × BLD 98 for days to silking, BLD 2 x BLD 98 for plant height, WNC 52313 × VL 109178 for ear height, WNC 40456 × BLD 125 for cob length, WNC 40324 × BLD 125 for cob girth, WNC 40080 × BLD 125 for kernel rows per cob, WNC 40406 × BLD 125 for kernels per row, BLD 109 × BLD 98 and BLD 114 × BLD 98 for 100 kernel weight, WNC 40406 × BLD 125 for kernel yield per plant and BLD 114 × IMR 113 for shelling percentage showed significant heterosis over standard check GAYMH 1 in desirable direction. Similar results were also reported by Bekele *et al*. (2013) [3], Rajitha *et al*. (2014) [12], Mir *et al*. (2015) [8], Reddy *et al*. (2015) [13], Matin *et al*. (2016) [6], Patel *et al*. (2016) [11], Nandhitha *et al*. (2018) [9], Reddy *et al*. (2018) [14] and Aswin *et al*. (2020) [2].

Five superior hybrids in relation to *per se* value and heterosis for kernel yield per plant with useful component characters showing desirable heterosis placed in Table 2. The crosses WNC 40406 × BLD 125, BLD 2 × BLD 103, BLD 114 × IMR 113, WNC 40080 × BLD 125 and WNC 52646 × BLD 125 showed higher per se performance for kernel yield per plant. The hybrid WNC 40406 × BLD 125 had higher heterobeltiosis and standard heterosis for kernel yield per plant and also found in desirable direction for the characters *viz*., days to tasseling, days to silking, cob girth, kernel per row, shelling percentage. The cross BLD 2 × BLD 103 exhibited significant and positive heterobeltiosis and standard heterosis for kernel yield per plant and also found in desirable direction for the characters *viz*., cob length, cob girth, kernel row per cob, shelling percentage. The cross BLD 114 × IMR 113 had significant and positive standard heterosis for kernel yield per plant and also show desirable standard heterosis for plant height, ear height, cob girth, kernel row per cob, 100 kernel weight, shelling percentage.

Table 1: Analysis of variance (mean sum of square) for kernel yield and its component characters in maize

Source of variation	d.f.	Days to tasseling	Days to silking	ASI	Plant height (cm)	Ear height (cm)	Days to maturity	Cob length (cm)	Cob girth (cm)	Kernels row per cob	Kernels per row	100 kernels weight (g)	Kernel yield per plant (g)	Shelling (%)
Replications	2	9.77**	16.48**	2.06**	1112.77**	263.07*	2.82	7.89**	6.88**	3.93**	37.67**	22.90**	658.66**	4.01
Parents	13	21.58**	19.05**	1.15**	1302.49**	496.07**	12.34**	2.23**	0.59**	1.10**	10.28**	35.99**	243.46**	13.90**
Females	8	32.26**	27.23**	1.25	1589.00**	474.31**	15.20**	0.90	1.28	6.37	40.68*	315.74	13.80	1.28
Males	4	1.43	4.67	1.10	298.90	312.17	9.10	0.10	0.95	16.85*	33.57	157.48	15.55	0.95
Female vs Male	1	16.76**	11.12*	0.58	3024.80**	1405.77**	2.38	0.03	0.28	15.22**	8.14	9.11	7.95	0.28
Hybrids	44	4.07**	5.44**	0.83**	247.01	160.95**	9.22**	0.52**	1.79**	6.77**	22.88**	474.64**	22.16**	1.79**
Parent vs hybrid	1	153.41**	152.15**	0.02	14406.08**	7787.31**	4.95	3.82**	2.11*	8.57**	2.07	121.26*	0.01	2.11*
Error	116	1.97	2.14	0.37	175.65	60.31	1.88	0.40	0.25	0.35	1.21	2.31	25.75	4.71

* and ** indicate level of significance at 5% and 1%, respectively

Table 2: Promising hybrids in relation to per se value and heterosis for kernel yield per plant with useful component characters showing desirable heterosis

Sr. No.	Cross	KY/P	Heterosis for Kernel yield per plant over		Useful and significant heterosis over BP for component trait	Useful and significant heterosis over SC for component trait
			BP	SC		
1	WNC 40406 × BLD 125	95.13	38.01**	100.99**	DT, DS, CG, K/R, Shelling%	DT, DS, PH, EH, CG, K/R, SI, Shelling%
2	BLD 2 × BLD 103	92.87	45.45**	96.20**	CL, CG, KR/C, Shelling%	PH, EH, CL, CG, KR/C, K/R, SI, Shelling%
3	BLD 114 × IMR 113	79.87	7.73	68.73**	DT, DS, CG, KR/C, Shelling%	PH, EH, CG, KR/C, SI, Shelling%
4	WNC 40080 × BLD 125	79.07	32.51**	67.04**	CG, KR/C, Shelling%	DT, DS, PH, EH, KR/C, SI, Shelling%
5	WNC 52646 × BLD 125	75.73	25.94**	60.00**	CL, CG, KR/C, Shelling%	DT, EH, CG, KR/C, SI, Shelling%
* and ** indicate level of significance at 5% and 1%, respectively						

(DT = Days to tasseling, DS = Days to silking, ASI = Anthesis silking interval, PH = Plant height, EH = Ear height, DM = Days to maturity, CL = Cob length, CG =Cob girth, KR/C = Kernels row per cob, K/R = Kernels per row, SI = 100 kernels weight, KY/P = Kernel yield per plant, Shelling (%) = Shelling percentage.)

Table 3: Heterobeltiosis and standard heterosis for days to tasselling, days to silking, anthesis silking interval, plant height and ear height

S.N.	Crosses	DT		DS		ASI		PH		EH	
		BP	SC	BP	SC	BP	SC	BP	SC	BP	SC
1.	BLD 2 × VL 109178	0.68	2.78	-0.63	2.60	-16.67	0.00	36.90**	-7.41	45.81**	-12.12
2.	BLD 2 × BLD 98	-2.07	-1.39	-1.29	-0.65	10.00	10.00	21.93*	-17.54**	31.84**	-20.54**
3.	BLD 2 × BLD 103	4.11	5.56*	3.77	7.14**	-0.00	30.00	32.35**	-10.49	46.93**	-11.45
4.	BLD 2 × BLD 125	-0.69	0.00	-2.55	-0.65	-16.67	0.00	35.83**	-8.14	43.02**	-13.80
5.	BLD 2 × IMR 113	-4.67*	-0.69	-7.27**	-0.65	-28.57**	0.00	38.77**	-6.15	56.98**	-5.39
6.	BLD 109 × VL 109178	-2.04	0.00	-3.14	0.00	0.00	0.00	46.52**	-16.27**	99.28**	-7.41
7.	BLD 109 × BLD 98	0.00	0.69	2.58	3.25	40.00**	40.00*	48.42**	-15.19**	71.74**	-20.20**
8.	BLD 109 × BLD 103	-4.79*	-3.47	-4.40	-1.30	30.00*	30.00	73.42**	-0.90	122.46**	3.37
9.	BLD 109 × BLD 125	-2.07	-1.39	0.00	1.95	50.00**	50.00**	80.38**	3.07	134.78**	9.09
10.	BLD 109 × IMR 113	-8.67**	-4.86*	-9.70**	-3.25	20.00	20.00	77.53**	1.45	121.01**	2.69
11.	BLD 114 × VL 109178	-0.68	1.39	-1.26	1.95	-8.33	10.00	13.73	-5.61	20.41*	-20.54**
12.	BLD 114 × BLD 98	-1.38	-0.69	0.65	1.30	30.00*	30.00	5.31	-10.31	15.91	-14.14
13.	BLD 114 × BLD 103	-1.37	0.00	-1.26	1.95	8.33	30.00	19.11**	1.45	36.82**	1.35
14.	BLD 114 × BLD 125	-2.07	-1.39	-0.64	1.30	16.67	40.00*	16.94*	-0.40	33.64**	-1.01
15.	BLD 114 × IMR 113	-1.35	1.39	-0.62	3.25	8.33	30.00	21.32**	-3.25	16.82	-13.47
16.	WNC 40080 × VL 109178	-3.40	-1.39	-2.52	0.65	44.44**	30.00	37.43**	-11.03*	40.94**	-18.86*
17.	WNC 40080 × BLD 98	-1.38	-0.69	-0.00	0.65	33.33*	20.00	39.94**	-9.40	56.73**	-9.76
18.	WNC 40080 × BLD 103	-1.37	0.00	-0.63	2.60	55.56**	40.00*	41.90**	-8.14	49.71**	-13.80
19.	WNC 40080 × BLD 125	4.14	4.86*	4.46	6.49**	44.44**	30.00	43.58**	-7.05	48.54**	-14.48*
20.	WNC 40080 × IMR 113	-5.33*	-1.39	-6.79**	-1.95	0.00	-10.00	39.66**	-9.58	49.12**	-14.14
21.	WNC 40324 × VL 109178	-1.38	-0.69	0.64	1.95	27.27*	40.00*	14.45	-11.21*	34.04**	-15.15*
22.	WNC 40324 × BLD 98	-7.59**	-6.94**	-7.10**	-6.49**	0.00	0.00	10.96	-13.92*	24.47*	-21.21**
23.	WNC 40324 × BLD 103	-2.07	-1.39	-1.28	0.00	9.09	20.00	24.48**	-3.44	47.87**	-6.40
24.	WNC 40324 × BLD 125	0.00	0.69	1.28	2.60	18.18	30.00	13.75	-11.75*	23.94*	-21.55**
25.	WNC 40324 × IMR 113	-4.14	-3.47	-3.85	-2.60	-0.00	10.00	19.58**	-7.23	51.06**	-4.38
26.	WNC 40406 × VL 109178	-0.70	-1.39	-1.30	-1.30	-9.09	0.00	19.46*	-11.21*	25.00*	-17.51*
27.	WNC 40406 × BLD 98	-1.40	-2.08	-1.95	-1.95	0.00	0.00	19.46*	-11.21*	15.38	-19.19*
28.	WNC 40406 × BLD 103	-4.20	-4.86*	-3.90	-3.90	-0.00	10.00	19.71*	-11.03*	29.33**	-9.43
29	WNC 40406 × BLD 125	-0.70	-1.39	-0.65	-0.65	-0.00	10.00	23.60**	-8.14	18.27*	-17.17*
30	WNC 40406 × IMR 113	0.70	0.00	1.95	1.95	18.18	30.00	23.36**	-8.32	30.77**	-8.42
31	WNC 40456 × VL 109178	-5.44*	-3.47	-4.40	-1.30	30.00*	30.00	5.23	-12.66*	23.98*	-18.18*
32	WNC 40456 × BLD 98	0.69	1.39	1.29	1.95	10.00	10.00	1.82	-8.86	3.38	-17.51*
33	WNC 40456 × BLD 103	-2.05	-0.69	-3.14	0.00	10.00	10.00	3.23	-7.59	5.49	-15.82*
34	WNC 40456 × BLD 125	-2.07	-1.39	-3.18	-1.30	0.00	0.00	9.49	-1.99	16.03*	-7.41
35	WNC 40456 × IMR 113	-4.67*	-0.69	-6.06**	0.65	30.00*	30.00	21.54**	-3.07	23.18**	-8.75
36	WNC 52313 × VL 109178	0.70	-0.69	-1.28	0.00	-8.33	10.00	5.66	-12.30*	12.76	-25.59**
37	WNC 52313 × BLD 98	0.00	-1.39	-1.29	-0.65	10.00	10.00	-1.83	-12.66*	4.17	-15.82*
38	WNC 52313 × BLD 103	4.23	2.78	3.21	4.55*	-0.00	30.00	2.24	-9.04	12.92	-8.75
39	WNC 52313 × BLD 125	2.11	0.69	1.92	3.25	16.67	40.00*	10.77	-1.45	15.00	-7.07
40	WNC 52313 × IMR 113	-1.41	-2.78	-3.85	-2.60	-28.57**	0.00	16.55*	-7.05	27.27**	-5.72
41	WNC 52646 × VL 109178	-2.84	-4.86*	-3.87	-3.25	0.00	20.00	10.24	-8.50	35.71**	-10.44
42	WNC 52646 × BLD 98	-1.42	-3.47	-0.65	0.00	50.00**	50.00**	6.24	-4.52	7.91	-8.08
43	WNC 52646 × BLD 103	-2.13	-4.17	-2.58	-1.95	-0.00	30.00	-0.99	-9.40	9.49	-6.73

44	WNC 52646 × BLD 125	0.71	-1.39	0.65	1.30	16.67	40.00*	10.28	0.90	11.07	-5.39
45	WNC 52646 × IMR 113	0.00	-2.08	-1.94	-1.30	-21.43*	10.00	21.54**	-3.07	19.55*	-11.45
	S.Em. ±	1.15	1.15	1.19	1.19	0.50	0.50	10.82	10.82	6.34	6.34
	Range Minimum	-8.67	-6.94	-9.70	-6.49	-28.57	-10	-1.83	-17.54	3.38	-25.59
	Range Maximum	4.23	5.56	4.46	7.14	55.56	50	80.38	3.07	134.78	9.09
	Total significant	7	6	5	4	15	8	28	13	33	16
	Number of +ve significant	0	2	0	3	12	8	28	0	33	0
	Number of –ve significant	7	4	5	1	3	0	0	13	0	16

Note: * and ** indicate level of significance at 5% and 1%, respectively.
(DT = Days to tasseling, DS = Days to silking, ASI = Anthesis silking interval, PH = Plant height, EH = Ear height)

Table 4: Heterobeltiosis and standard heterosis for days to maturity, cob length, cob girth, kernel row per cob and kernels per row

S.N.	Crosses	DM		CL		CG		KR/C		K/R	
		BP	SC	BP	SC	BP	SC	BP	SC	BP	SC
1.	BLD 2 × VL 109178	-0.80	2.90*	7.73*	-0.56	2.68	2.77	1.01	5.26	25.90**	5.11
2.	BLD 2 × BLD 98	-1.21	1.24	0.53	-8.17**	-0.09	1.39	0.00	4.21	-5.26	-13.51**
3.	BLD 2 × BLD 103	0.40	4.98**	4.32	2.48	4.56	4.65	2.02	6.32	-2.22	6.01
4.	BLD 2 × BLD 125	5.83**	5.39**	9.21**	2.16	5.63*	5.72*	4.04	8.42*	-5.52	-7.51
5.	BLD 2 × IMR 113	0.79	5.81**	1.53	1.12	-2.41	-2.33	-5.88	1.05	-7.39	-2.10
6.	BLD 109 × VL 109178	-5.20**	-1.66	1.56	-6.25*	4.84	3.62	-9.28*	-7.37*	12.41*	-7.51
7.	BLD 109 × BLD 98	-0.40	2.07	-1.05	-9.62**	1.28	2.77	-1.03	1.05	-6.91	-15.02**
8.	BLD 109 × BLD 103	-4.76**	-0.41	-5.51	-7.17*	3.87	2.01	4.12	6.32	-22.16**	-15.62**
9.	BLD 109 × BLD 125	2.50	2.07	-2.18	-8.49**	-1.83	-1.88	2.06	4.21	-9.51*	-11.41**
10.	BLD 109 × IMR 113	-3.56**	1.24	-3.22	-3.61	6.89*	6.13*	1.96	9.47**	-1.99	3.60
11.	BLD 114 × VL 109178	-1.60	2.07	0.56	-7.17*	-2.40	-1.70	-4.30	-6.32	-0.93	-3.90
12.	BLD 114 × BLD 98	2.02	4.56**	5.13	-3.13	0.04	1.52	1.09	-2.11	-2.79	-5.71
13.	BLD 114 × BLD 103	1.62	4.15**	-3.71	-5.41	-2.31	-1.61	0.00	-3.16	-13.02**	-5.71
14.	BLD 114 × BLD 125	6.67**	6.22**	-5.27	-11.38**	-0.89	-0.18	-3.19	-4.21	-6.75	-8.71*
15.	BLD 114 × IMR 113	0.81	3.32*	-2.65	-3.04	0.09	0.81	2.94	10.53**	-14.20**	-9.31*
16.	WNC 40080 × VL 109178	-2.40	1.24	-7.70*	-12.10**	4.16	2.95	9.68*	7.37*	2.00	-8.11
17.	WNC 40080 × BLD 98	-1.62	0.83	3.24	-1.68	2.73	4.25	16.30**	12.63**	-3.29	-11.71**
18.	WNC 40080 × BLD 103	-1.20	2.49	-5.06	-6.73*	1.14	-0.67	3.26	-0.00	-6.09	1.80
19.	WNC 40080 × BLD 125	5.42**	4.98**	-0.80	-5.53	1.66	1.61	17.02**	15.79**	-7.06	-9.01*
20.	WNC 40080 × IMR 113	-3.20*	0.41	-4.14	-4.53	-0.27	-0.98	-3.92	3.16	-6.53	-1.20
21.	WNC 40324 × VL 109178	0.41	2.07	9.07**	6.01*	2.15	3.89	6.12	9.47**	9.32*	2.10
22.	WNC 40324 × BLD 98	-2.04	-0.41	-4.86	-7.53*	-3.87	-2.24	-7.14	-4.21	-9.32*	-15.32**
23.	WNC 40324 × BLD 103	-0.82	0.83	-4.32	-6.01*	-0.53	1.16	-4.08	-1.05	-16.07**	-9.01*
24.	WNC 40324 × BLD 125	2.92*	2.49	-5.77	-8.41**	5.23*	7.02*	0.00	3.16	-12.88**	-14.71**
25.	WNC 40324 × IMR 113	-1.22	0.41	-1.85	-2.24	4.49	6.26*	0.00	7.37*	-9.09*	-3.90
26.	WNC 40406 × VL 109178	1.23	2.49	-6.79*	-8.13**	1.90	3.35	-5.38	-7.37*	-4.33	-7.21
27.	WNC 40406 × BLD 98	0.41	1.66	-11.91**	-13.18**	-1.81	-0.36	-2.17	5.26	-1.55	-4.50
28.	WNC 40406 × BLD 103	-0.00	1.24	-9.27**	-10.58**	2.12	3.58	-1.09	-4.21	-16.34**	-9.31*
29	WNC 40406 × BLD 125	5.83**	5.39**	-1.14	-2.56	1.15	2.59	-6.38	-7.37*	15.34**	12.91**
30	WNC 40406 × IMR 113	4.92**	6.22**	-2.25	-2.64	3.70	5.19	-5.88	1.05	-3.98	1.50
31	WNC 40456 × VL 109178	1.60	5.39**	7.38*	-0.88	5.61*	4.38	8.60*	6.32	16.55**	1.50
32	WNC 40456 × BLD 98	4.45**	7.05**	-3.20	-11.58**	-1.63	-0.18	-6.52	-9.47**	-4.28	-12.61**
33	WNC 40456 × BLD 103	1.19	5.81**	-4.28	-5.97*	2.00	0.18	-1.09	-4.21	-10.53**	-3.00
34	WNC 40456 × BLD 125	4.17**	3.73**	16.53**	9.01**	5.68*	5.64*	-5.32	-6.32	7.36	5.11
35	WNC 40456 × IMR 113	-2.37	2.49	-1.69	-2.08	2.34	1.61	-5.88	1.05	-2.84	2.70
36	WNC 52313 × VL 109178	-1.21	1.24	-3.00	-5.49	-4.31	0.40	-2.06	-0.00	3.77	-0.90
37	WNC 52313 × BLD 98	1.21	3.73**	-10.03**	-12.34**	-6.14*	-1.52	-6.19	-4.21	-7.23	-11.41**
38	WNC 52313 × BLD 103	-1.62	0.83	-3.71	-5.41	-8.78**	-4.29	-3.09	-1.05	-5.26	2.70
39	WNC 52313 × BLD 125	4.17**	3.73**	-3.37	-5.85*	-4.52	0.18	-7.22	-5.26	-3.99	-6.01
40	WNC 52313 × IMR 113	-1.62	0.83	-4.83	-5.21	0.68	5.64*	-4.90	2.11	-0.57	5.11
41	WNC 52646 × VL 109178	0.82	2.07	3.82	-0.84	0.81	-0.18	3.19	2.11	0.61	-0.30
42	WNC 52646 × BLD 98	4.92**	6.22**	-4.36	-8.65**	-0.13	1.34	-1.06	-2.11	2.12	1.20
43	WNC 52646 × BLD 103	5.33**	6.64**	0.24	-1.52	-2.08	-3.04	-4.26	-5.26	-8.31*	-0.60
44	WNC 52646 × BLD 125	3.75**	3.32*	4.03	-0.64	0.13	0.09	3.19	2.11	-1.21	-2.10
45	WNC 52646 × IMR 113	3.28*	4.56**	-1.69	-2.08	2.12	1.39	-12.75**	-6.32	-8.24*	-3.00
	S.Em. ±	1.12	1.11	0.52	0.48	0.40	0.40	0.48	0.42	0.90	0.96
	Range Minimum	-5.2	-1.66	-11.91	-13.18	-8.78	-4.29	-12.75	-9.47	-22.16	-15.62
	Range Maximum	6.67	7.05	16.53	9.01	6.89	7.02	17.02	15.79	25.9	12.91
	Total significant	17	21	10	22	7	6	6	12	17	15
	Number of +ve significant	13	21	5	2	5	0	4	8	5	1
	Number of –ve significant	4	0	5	20	2	6	2	4	12	14

Note: * and ** indicate level of significance at 5% and 1%, respectively.
(DM = Days to maturity, CL = Cob length, CG =Cob girth, KR/C = Kernels row per cob, K/R = Kernels per row)

Table 5: Heterobeltiosis and standard heterosis for 100 kernels weight, Kernel yield per plant and Shelling percentage

S.N.	Crosses		100 kernels weight		Kernel yield per plant		Shelling percentage	
			BP	SC	BP	SC	BP	SC
1.	BLD 2 × VL 109178		-0.00	23.40**	31.06**	56.90**	-1.90	0.78
2.	BLD 2 × BLD 98		-0.86	22.34**	45.45**	48.73**	-0.73	0.18
3.	BLD 2 × BLD 103		-13.22**	11.70**	68.64**	96.20**	6.31**	7.29**
4.	BLD 2 × BLD 125		2.59	26.60**	-2.01	23.52**	2.50	3.44
5.	BLD 2 × IMR 113		-4.31	18.09**	-36.33**	-8.17	-2.13	0.21
6.	BLD 109 × VL 109178		8.00*	14.89**	8.60	35.21**	-1.69	1.62
7.	BLD 109 × BLD 98		17.92**	32.98**	-14.93*	5.92	-2.96	0.31
8.	BLD 109 × BLD 103		1.65	30.85**	-13.01	8.31	-6.17**	-3.01
9.	BLD 109 × BLD 125		1.74	24.47**	25.70**	58.45**	-10.86**	-7.86**
10.	BLD 109 × IMR 113		0.00	21.28**	-4.88	37.18**	-6.98**	-3.84
11.	BLD 114 × VL 109178		12.63**	13.83**	-25.99**	15.92	-4.72*	-1.63
12.	BLD 114 × BLD 98		17.92**	32.98**	-2.88	52.11**	-0.27	2.97
13.	BLD 114 × BLD 103		-6.61*	20.21**	-31.47**	7.32	-1.85	1.33
14.	BLD 114 × BLD 125		-4.35	17.02**	-25.36**	16.90	-5.02*	-1.93
15.	BLD 114 × IMR 113		-12.28**	6.38	7.73	68.73**	5.55*	8.98**
16.	WNC 40080 × VL 109178		-19.83**	3.19	-7.88	10.28	1.17	3.93
17.	WNC 40080 × BLD 98		-23.97**	-2.13	17.17*	30.70**	-0.21	-2.36
18.	WNC 40080 × BLD 103		-10.74**	14.89**	18.64*	38.03**	4.81*	3.12
19.	WNC 40080 × BLD 125		-24.79**	-3.19	32.51**	67.04**	3.79	4.55
20.	WNC 40080 × IMR 113		-6.61*	20.21**	1.07	45.77**	-0.52	1.86
21.	WNC 40324 × VL 109178		-9.09**	6.38	-6.35	12.11	1.45	4.68
22.	WNC 40324 × BLD 98		4.55	22.34**	-6.04	5.21	-7.81**	-4.88
23.	WNC 40324 × BLD 103		-14.05**	10.64**	5.33	22.54*	1.01	4.22
24.	WNC 40324 × BLD 125		-13.91**	5.32	-7.15	17.04*	-5.19*	-2.18
25.	WNC 40324 × IMR 113		-6.14	13.83**	-31.25**	-0.85	-5.50*	-2.50
26.	WNC 40406 × VL 109178		-11.86**	10.64**	-26.89**	6.48	-1.41	1.28
27.	WNC 40406 × BLD 98		-13.56**	8.51*	-16.34**	21.83*	0.52	-1.83
28.	WNC 40406 × BLD 103		-8.26**	18.09**	5.42	53.52**	2.35	0.70
29	WNC 40406 × BLD 125		-11.86**	10.64**	38.01**	100.99**	2.19	2.94
30	WNC 40406 × IMR 113		-14.41**	7.45	-6.77	35.77**	-0.91	1.46
31	WNC 40456 × VL 109178		11.46**	13.83**	-3.65	15.35	-1.05	1.65
32	WNC 40456 × BLD 98		-15.09**	-4.26	-0.14	2.11	4.31	1.36
33	WNC 40456 × BLD 103		-19.01**	4.26	-23.12**	-10.56	-0.26	-1.87
34	WNC 40456 × BLD 125		-10.43**	9.57*	8.04	36.20**	0.56	1.29
35	WNC 40456 × IMR 113		-6.14	13.83**	7.62	55.21**	-2.13	0.21
36	WNC 52313 × VL 109178		0.00	5.32	-13.53*	24.23**	1.73	5.48*
37	WNC 52313 × BLD 98		1.89	14.89**	-30.10**	0.42	-2.81	0.78
38	WNC 52313 × BLD 103		-12.40**	12.77**	-16.67**	19.72*	0.41	4.11
39	WNC 52313 × BLD 125		-5.22	15.96**	-31.86**	-2.11	-9.60**	-6.26*
40	WNC 52313 × IMR 113		-7.02*	12.77**	-30.27**	0.56	-2.50	1.10
41	WNC 52646 × VL 109178		-0.00	23.40**	-10.20	14.08	-3.19	0.06
42	WNC 52646 × BLD 98		-0.00	23.40**	-12.97	10.56	-2.24	1.04
43	WNC 52646 × BLD 103		-11.57**	13.83**	-22.28**	-1.27	-10.55**	-7.54**
44	WNC 52646 × BLD 125		-11.21**	9.57*	25.94**	60.00**	2.16	5.59*
45	WNC 52646 × IMR 113		-1.72	21.28**	-25.49**	7.46	-1.99	1.30
	S.Em. ±		1.24	1.20	20.72	20.31	1.77	1.91
	Range	Minimum	-24.79	-4.26	-36.33	-10.56	-10.86	-7.86
		Maximum	17.92	32.98	68.64	100.99	6.31	8.98
	Total significant		28	35	25	24	13	7
Number of +ve significant			5	0	9	24	3	4
Number of –ve significant			23	35	16	0	10	3

Note: * and ** indicate level of significance at 5% and 1%, respectively.

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