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UTILIZATION OF HETEROSIS FOR GRAIN YIELD AND ITS COMPONENTS IN MAIZE INBREDS OVER ENVIRONMENTS (*ZEA MAYS* L.)

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ABSTRACT
The experiment was carried out at Agricultural Research Station Madhira during *rabi*, 2012-13. Selected 15 diverse inbred lines were crossed with 4 testers in line x tester (L x T) mating design to obtain 60 cross combinations. During *kharif 2013*, a set of 60 crosses along with 19 parents and three checks *viz*., DHM-117, 30 V 92 and 900 M Gold were sown in randomized block design replicated thrice over three locations *viz*., Heterosis was estimated in 60 hybrids for these characters at three locations *viz*., Tandur, Warangal and Madhira and pooled analysis was carried out and expressed as heterosis over mid parent, superior parent and standard checks *viz.*, DHM 117, 30 V 92 and 900 M Gold.

KEYWORDS: cross combinations, *kharif*, heterosis.

INTRODUCTION

Maize (*Zea mays* L.) is the world's most widely grown cereal and is the primary staple food in many developing countries. It is a versatile crop with wider genetic variability and able to grow successfully throughout the world covering tropical, subtropical and temperate agro-climatic conditions. Maize acreage and production have an increasing tendency with the introduction of hybrids due to its high yield potential. The utilization of hybrid vigour in practical breeding has had greatest success in maize. The essential feature of the breeding technique is the evaluation of combining ability of inbred lines. Hybrid seed is produced by combining the appropriate lines in single, double and other crosses. The theoretical possibility of obtaining a homozygous line equal in vigour to the best hybrids appears to be beyond reach because of the large number of dominant vigour genes involved. This fact diverts current attention toward improvement in technique directed toward cheaper production of hybrid seed.

MATERIAL & METHODS

The experiment was carried out at Agricultural Research Station Madhira during *rabi*, 2012-13. Selected 15 diverse inbred lines were crossed with 4 testers in line x tester (L x T) mating design to obtain 60 cross combinations. During *kharif 2013*, a set of 60 crosses along with 19 parents and three checks *viz*., DHM-117, 30 V 92 and 900 M Gold were sown in randomized block design replicated thrice over three locations *viz*., Agricultural Research Station, Madhira, Khammam district, Agricultural Research Station, Tandur, Ranga Reddy district and Regional Agricultural Research Station, Warangal. Each entry was sown in a row of 5 m length with a spacing of 75 cm between rows and 20 cm between the plants. The recommended fertilizers of N, P and K were applied in the ratio of 120 : 80 : 60 kg ha-[1]. The entire P and K and half dose of nitrogen was applied as basal, while remaining half dose of N in two equal split doses at knee height and tasseling stages. Intercultural operations like weeding and irrigation schedules were followed. Necessary plant protection measures were taken to protect the crop from pests and diseases so as to raise a healthy crop.

RESULT & DISCUSSION

Observations on 11 different quantitative characters viz., days to 50 per cent tasseling, days to 50 per cent silking, days to maturity, plant height (cm), ear height (cm), ear length (cm), ear girth (cm), number of kernel rows per ear, number of kernels per row, 100 - seed weight (g), and grain yield per plant (g) were recorded on five random plants except for days to 50 per cent tasseling, days to 50 per cent silking and days to maturity. Heterosis was estimated in 60 hybrids for these characters at three locations *viz*., Tandur, Warangal and Madhira and pooled analysis was carried out and expressed as heterosis over mid parent, superior parent and standard checks *viz.*, DHM 117, 30 V 92 and 900 M Gold.

In pooled analysis, for days to 50 per cent tasseling 47 hybrids recorded significant average negative relative heterosis, ranging from -17.21 (MRC 1544 X BML 14) to 6.86 per cent (MRC 1176 X BML 13). The significant negative heterobeltiosis was recorded in 56 hybrids which, ranged from -23.19 (MRC 1544 X BML 14) to 0.41 per cent (MRC 1123 X BML 13).

While for days to 50 per cent silking, 45 hybrids recorded significant relative heterosis, ranging from -16.50 (MRC 1544 X BML 14) to 6.57 per cent (MRC 1176 X BML 13). The standard heterosis over DHM-117, 30 V 92 and 900 M Gold ranged from -16.02 (MRC 1544 X BML 14) to 1.37 per cent (MRC 1604 X BML 13), -17.47 (MRC 1544 X BML 14) to -0.38 per cent (MRC 1604 X BML 13) and -19.32 (MRC 1544 X BML 14) to -2.63 per cent (MRC 1604 X BML 13) respectively. Forty six, 48 and 41

hybrids recorded negatively significant standard heterosis over DHM-117, 30 V 92 and 900 M Gold, respectively for days to maturity (Table 1).

Days to 50 per cent tasseling, days to 50 per cent silking and days to maturity indicate the earliness of a genotype. Earliness is a desirable character as it useful in multiple cropping and increases water and land use efficiency. Heterosis for earliness in maize was also reported by Sadaiah *et al.* (2013) and Tajwar Izhar and Chakraborty (2013).

Significant positive relative heterosis was recorded for plant height in 60 hybrids which ranged from -6.80 (MRC 1179 X BML 13) to 101.73 per cent (MRC 1604 X BML 7) while significant positive heterobeltiosis was recorded in 57 hybrids with a range of - 4.57 (MRC 1179 X BML 13) to 59.79 per cent (MRC 1358 X BML 13) (Table 2). These results are in agreement with the earlier findings of Kumar Bupesh *et al.* (2013), Rajesh *et al*. (2014) and Rajitha *et al.* (2014).

Sixty hybrids recorded positive significant relative heterosis with a range of 12.59 (MRC 1176 X BML 5) to 68.66 per cent (MRC 1123 X BML 13) for ear length while significant heterobeltiosis was recorded in 35 hybrids with a range of -12.80 (MRC 1176 X BML 14) to 46.61 per cent (MRC 1358 X BML 13). Significant standard heterosis was recorded in twelve hybrids over DHM-117 with a range of -12.99 (MRC 1601 X BML 14) to 18.83 per cent (MRC 1123 X BML 13), while over 30 V 92 check four hybrids recorded significant positive standard heterosis with a range of -15.72 (MRC 1601 X BML 14) to 15.09 per cent (MRC 1123 X BML 13) (. Positive significant relative heterosis and heterobeltiosis for ear length was also reported by Patil *et al.* (2012) and Rajesh *et al*. (2014).

The character number of kernel rows per ear recorded positive significant average heterosis in 58 hybrids and positive significant heterobeltiosis in 42 hybrids. Positive significant standard heterosis was observed in three hybrids ranging from -16.90 (MRC 1176 X BML 14) to 8.45 per cent (MRC 1601 X BML 7) when compared with check DHM-117. Sixty hybrids recorded positive significant relative heterosis for number of kernels per row with a range of 22.25 (MRC 1601 X BML 14) to 137.19 per cent (MRC 1209 X BML 7). The significant standard heterosis was recorded in 9 hybrids over DHM-117 and it ranged from -24.13 (MRC 1601 X BML 14) to 19.05 per cent (MRC 1561 X BML 5), while over 30 V 92 check, seven hybrids recorded significant positive standard heterosis with a range of -24.61 (MRC 1601 X BML 14) to 18.30 per cent (MRC 1561 X BML 5) for this trait. Positive heterosis estimation for number of kernels per row was also reported by Netra Hiremath *et al.* (2013) and Rajesh *et al*. (2014).

100-seed weight recorded positive significant relative heterosis in 20 hybrids which ranged from -18.25 (MRC 1176 X BML 14) to 34.75 per cent (MRC 1358 X BML 13) while positive significant standard heterosis was observed in 12 hybrids ranging from -18.90 (MRC 1176 X BML 14) to 14.96 (MRC 1123 X BML 13) over DHM-117, from -15.23 (MRC 1176 X BML 14) to 20.16 (MRC 1123 X BML 13) over 30 V 92 and -8.04 (MRC 1176 X BML 14) to 30.36 (MRC 1123 X BML 13) over 900 M Gold (Table 3). Kumar Bupesh *et al.* (2013) and Rajitha *et al.* (2014) also reported significant positive heterosis for 100-seed weight. Most of the hybrids exhibited significant positive relative heterosis and heterobeltiosis at all the three locations for grain yield per plant. In pooled analysis, 60 hybrids recorded significant positive relative heterosis ranging from 27.30 (MRC 1582 X BML 7) to 181.02 per cent (MRC 1358 X BML 13) and positive significant heterobeltiosis ranging from -11.67 (MRC 1179 X BML 14) to 106.20 per cent (MRC 1358 X BML 13). Significant standard heterosis over DHM-117 ranged from -15.57 (MRC 1179 X BML 14) to 32.87 per cent (MRC 1123 X BML 13), while over 30 V 92, it ranged from of -11.19 (MRC 1179 X BML 14) to 39.76 per cent (MRC 1123 X BML 13) and -6.24 (MRC 1179 X BML 14) to 47.55 per cent (MRC 1123 X BML 13) over 900 M Gold. Positive heterosis for grain yield per plant was also reported by Sandeep Kumar and Mohan Reddy (2013) and Rajesh *et al*. (2014).

The highest standard heterosis for grain yield per plant was recorded for hybrids, MRC 1123 X BML 13, MRC 1358 X BML 13, MRC 1123 X BML 14, MRC 1123 X BML 7 and MRC 1176 X BML 7 along with *per se*, average heterosis, heterobeltiosis and with high *sca* effects. These hybrids may be further exploited in multilocation evaluation before releasing them for commercial cultivation.

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TABLE 1: Estimates of heterosis, heterobeltiosis and standard heterosis pooled over locations for days to 50 % tasseling, days 50 % silking and days to maturity in maize hybrid

Cross	Days to 50 % tasseling					Days to 50 % silking					Days to maturity				
	Heterosis	Hetero beltiosis	Standard heterosis			Heterosis	Hetero beltiosis	Standard heterosis			Heterosis	Hetero beltiosis	Standard heterosis		
			DHM-117	30 V 92	900 M Gold			DHM-117	30 V 92	900 M Gold			DHM-117	30 V 92	900 M Gold
MRC1112 X BML5	-12.25 **	-19.37 **	-9.52 **	-11.72 **	-13.81 **	-12.11 **	-18.84 **	-9.96 **	-11.52 **	-13.51 **	-4.45 **	-8.07 **	-4.39 **	-4.74 **	-3.66 **
MRC1112 X BML7	-4.50 **	-10.88 **	-3.31 **	-5.66 **	-7.89 **	-5.32 **	-11.41 **	-4.49 **	-6.14 **	-8.26 **	-3.66 **	-9.51 **	-1.00	-1.37	-0.25
MRC1112 X BML13	1.07	-1.87	-2.07	-4.44 **	-6.71 **	0.61	-2.16	-2.73 *	-4.41 **	-6.57 **	-2.69 **	-6.49 **	-2.51 **	-2.87 **	-1.77 *
MRC1112 X BML14	-14.49 **	-20.34 **	-13.25 **	-15.35 **	-17.36 **	-13.73 **	-19.35 **	-12.89 **	-14.4 **	-16.32 **	-7.91 **	-12.46 **	-6.64 **	-6.99 **	-5.93 **
MRC 1123 X BML5	-7.98 **	-14.94 **	-4.55 **	-6.87 **	-9.07 **	-7.87 **	-14.44 **	-5.08 **	-6.72 **	-8.82 **	-3.42 **	-6.39 **	-2.63 **	-3.00 **	-1.89 *
MRC 1123 X BML7	-5.28 **	-11.07 **	-3.52 **	-5.86 **	-8.09 **	-5.1 **	-10.69 **	-3.71 **	-5.37 **	-7.50 **	-4.00 **	-9.16 **	-0.63	-1.00	0.13
MRC 1123 X BML13	2.76 *	0.41	0.21	-2.22	-4.54 **	2.01	-0.20	-0.78	-2.50 *	-4.69 **	-3.41 **	-6.49 **	-2.51 **	-2.87 **	-1.77 *
MRC 1123 X BML14	-9.74 **	-15.40 **	-7.87 **	-10.10 **	-12.23 **	-9.62 **	-15.01 **	-8.20 **	-9.79 **	-11.82 **	-6.87 **	-10.81 **	-4.89 **	-5.24 **	-4.17 **
MRC 1176 X BML5	-2.07 *	-12.92 **	-2.28	-4.65 **	-6.90 **	-1.96	-12.15 **	-2.54 *	-4.22 **	-6.38 **	-0.26	-7.11 **	-3.38 **	-3.75 **	-2.65 **
MRC 1176 X BML7	3.38 **	-6.68 **	1.24	-1.21	-3.55 **	2.40 *	-7.07 **	0.20	-1.54	-3.75 **	-0.31	-9.28 **	-0.75	-1.12	0.00
MRC 1176 X BML13	6.86 **	0.21	0.00	-2.42 *	-4.73 **	6.57 **	0.39	-0.20	-1.92	-4.13 **	2.71 **	-4.45 **	-0.38	-0.75	0.38
MRC 1176 X BML14	-4.22 **	-13.69 **	-6.00 **	-8.28 **	-10.45 **	-4.09 **	-13.02 **	-6.05 **	-7.68 **	-9.76 **	-4.28 **	-11.87 **	-6.02 **	-6.37 **	-5.30 **
MRC 1179 X BML5	-8.05 **	-15.68 **	-5.38 **	-7.68 **	-9.86 **	-7.93 **	-15.14 **	-5.86 **	-7.49 **	-9.57 **	0.13	-6.99 **	-3.26 **	-3.62 **	-2.53 **
MRC 1179 X BML7	-3.48 **	-10.11 **	-2.48 *	-4.85 **	-7.10 **	-4.17 **	-10.51 **	-3.52 **	-5.18 **	-7.32 **	-0.44	-9.62 **	-1.13	-1.50	-0.38
MRC 1179 X BML13	-0.86	-3.94 **	-4.14 **	-6.46 **	-8.68 **	-1.21	-4.13 **	-4.69 **	-6.33 **	-8.44 **	1.17	-6.13 **	-2.13 *	-2.50 **	-1.39
MRC 1179 X BML14	-10.22 **	-16.54 **	-9.11 **	-11.31 **	-13.41 **	-9.88 **	-15.91 **	-9.18 **	-10.75 **	-12.76 **	-3.52 **	-11.4 **	-5.51 **	-5.87 **	-4.80 **
MRC 1209 X BML5	-10.01 **	-14.58 **	-4.14 **	-6.46 **	-8.68 **	-9.61 **	-13.91 **	-4.49 **	-6.14 **	-8.26 **	-7.45 **	-8.67 **	-5.01 **	-5.37 **	-4.29 **
MRC 1209 X BML7	-8.21 **	-11.45 **	-3.93 **	-6.26 **	-8.48 **	-7.88 **	-11.05 **	-4.10 **	-5.76 **	-7.88 **	-7.56 **	-11 **	-2.63 **	-3.00 **	-1.89 *
MRC 1209 X BML13	-5.68 **	-6.16 **	-5.38 **	-7.68 **	-9.86 **	-5.57 **	-6.03 **	-5.66 **	-7.29 **	-9.38 **	-5.12 **	-6.49 **	-2.51 **	-2.87 **	-1.77 *
MRC 1209 X BML14	-12.14 **	-15.40 **	-7.87 **	-10.10 **	-12.23 **	-11.9 **	-15.01 **	-8.20 **	-9.79 **	-11.82 **	-10.55 **	-12.81 **	-7.02 **	-7.37 **	-6.31 **
MRC 1271 X BML5	-11.25 **	-19.19 **	-9.32 **	-11.52 **	-13.61 **	-11.24 **	-18.66 **	-9.77 **	-11.32 **	-13.32 **	-4.25 **	-7.71 **	-4.01 **	-4.37 **	-3.28 **
MRC 1271 X BML7	-5.47 **	-12.60 **	-5.18 **	-7.47 **	-9.66 **	-5.56 **	-12.32 **	-5.47 **	-7.10 **	-9.19 **	-7.85 **	-13.29 **	-5.14 **	-5.49 **	-4.42 **
MRC 1271 X BML13	-2.27 *	-6.02 **	-6.21 **	-8.48 **	-10.65 **	-2.44 *	-5.89 **	-6.45 **	-8.06 **	-10.13 **	-3.87 **	-7.45 **	-3.51 **	-3.87 **	-2.78 **
MRC 1271 X BML14	-13.49 **	-20.15 **	-13.04 **	-15.15 **	-17.16 **	-13.06 **	-19.35 **	-12.89 **	-14.40 **	-16.32 **	-7.59 **	-11.99 **	-6.14 **	-6.49 **	-5.43 **
MRC 1358 X BML5	-9.88 **	-17.53 **	-7.45 **	-9.70 **	-11.83 **	-9.84 **	-16.90 **	-7.81 **	-9.40 **	-11.44 **	-1.48	-7.83 **	-4.14 **	-4.49 **	-3.41 **
MRC 1358 X BML7	0.82	-6.30 **	1.66	-0.81	-3.16 **	-0.68	-7.25 **	0.00	-1.73	-3.94 **	-3.13 **	-11.45 **	-3.13 **	-3.50 **	-2.40 **
MRC 1358 X BML13	0.00	-3.32 **	-3.52 **	-5.86 **	-8.09 **	-1.21	-4.13 **	-4.69 **	-6.33 **	-8.44 **	-0.58	-7.09 **	-3.13 **	-3.50 **	-2.40 **
MRC 1358 X BML14	-12.09 **	-18.44 **	-11.18 **	-13.33 **	-15.38 **	-11.82 **	-17.72 **	-11.13 **	-12.67 **	-14.63 **	-5.34 **	-12.46 **	-6.64 **	-6.99 **	-5.93 **
MRC 1544 X BML5	-14.92 **	-22.14 **	-12.63 **	-14.75 **	-16.77 **	-14.07 **	-20.95 **	-12.30 **	-13.82 **	-15.76 **	-3.94 **	-8.92 **	-5.26 **	-5.62 **	-4.55 **
MRC 1544 X BML7	-9.86 **	-16.22 **	-9.11 **	-11.31 **	-13.41 **	-9.82 **	-15.94 **	-9.38 **	-10.94 **	-12.95 **	-5.5 **	-12.49 **	-4.26 **	-4.62 **	-3.54 **
MRC 1544 X BML13	-4.29 **	-7.47 **	-7.66 **	-9.90 **	-12.03 **	-4.26 **	-7.27 **	-7.81 **	-9.40 **	-11.44 **	-2.28 **	-7.45 **	-3.51 **	-3.87 **	-2.78 **
MRC 1544 X BML14	-17.21 **	-23.19 **	-16.36 **	-18.38 **	-20.32 **	-16.50 **	-22.24 **	-16.02 **	-17.47 **	-19.32 **	-7.46 **	-13.28 **	-7.52 **	-7.87 **	-6.82 **
MRC 1556 X BML5	-12.53 **	-20.11 **	-10.35 **	-12.53 **	-14.6 **	-12.18 **	-19.37 **	-10.55 **	-12.09 **	-14.07 **	-4.50 **	-9.28 **	-5.64 **	-5.99 **	-4.92 **
MRC 1556 X BML7	-3.70 **	-10.69 **	-3.11 *	-5.45 **	-7.69 **	-3.41 **	-10.14 **	-3.13 **	-4.80 **	-6.94 **	-1.60 *	-8.71 **	-0.13	-0.50	0.63
MRC 1556 X BML13	-0.65	-4.15 **	-4.35 **	-6.67 **	-8.88 **	-0.61	-3.93 **	-4.49 **	-6.14 **	-8.26 **	-0.70	-5.77 **	-1.75 *	-2.12 *	-1.01
MRC 1556 X BML14	-14.78 **	-21.1 **	-14.08 **	-16.16 **	-18.15 **	-14.40 **	-20.43 **	-14.06 **	-15.55 **	-17.45 **	-8.01 **	-13.63 **	-7.89 **	-8.24 **	-7.2 **
MRC 1561 X BML5	-13.56 **	-15.31 **	-4.97 **	-7.27 **	-9.47 **	-12.65 **	-14.26 **	-4.88 **	-6.53 **	-8.63 **	-6.91 **	-7.90 **	-2.13 *	-2.50 **	-1.39
MRC 1561 X BML7	-10.15 **	-10.50 **	-2.90 *	-5.25 **	-7.50 **	-10.65 **	-11.05 **	-4.10 **	-5.76 **	-7.88 **	-9.82 **	-11.11 **	-2.76 **	-3.12 **	-2.02 *
MRC 1561 X BML13	-4.99 **	-8.46 **	-1.45	-3.84 **	-6.11 **	-4.55 **	-7.86 **	-1.56	-3.26 **	-5.44 **	-4.52 **	-5.42 **	0.50	0.12	1.26
MRC 1561 X BML14	-14.91 **	-15.40 **	-7.87 **	-10.10 **	-12.23 **	-14.00 **	-14.47 **	-7.62 **	-9.21 **	-11.26 **	-10.54 **	-10.69 **	-4.76 **	-5.12 **	-4.04 **
MRC 1564 X BML5	-8.00 **	-16.24 **	-6.00 **	-8.28 **	-10.45 **	-6.73 **	-14.61 **	-5.27 **	-6.91 **	-9.01 **	-2.58 **	-6.87 **	-3.13 **	-3.5 **	-2.40 **
MRC 1564 X BML7	-5.06 **	-12.21 **	-4.76 **	-7.07 **	-9.27 **	-4.69 **	-11.59 **	-4.69 **	-6.33 **	-8.44 **	-5.52 **	-11.8 **	-3.51 **	-3.87 **	-2.78 **
MRC 1564 X BML13	0.97	-2.90 *	-3.11 *	-5.45 **	-7.69 **	0.51	-3.14 **	-3.71 **	-5.37 **	-7.50 **	-1.07	-5.53 **	-1.50	-1.87 *	-0.76

MRC 1358 X BML13	64.58 **	59.79 **	-4.30	7.36 **	12.73 **	84.85 **	84.85 **	-11.23 **	6.35	9.49 *	65.55 **	46.61 **	12.34 **	8.81 **	25.36 **
MRC 1358 X BML14	65.23 **	30.88 **	-21.62 **	-12.07 **	-7.66 **	65.81 **	46.97 **	-29.42 **	-15.44 **	-12.95 **	48.26 **	26.27 **	-3.25	-6.29	7.97 *
MRC 1544 X BML5	26.81 **	15.35 **	-28.02 **	-19.25 **	-15.21 **	29.31 **	17.58 **	-33.26 **	-20.05 **	-17.69 **	17.19 **	0.00	-2.60	-5.66	8.70 *
MRC 1544 X BML7	73.30 **	30.05 **	-18.85 **	-8.97 **	-4.41	113.27 **	56.04 **	-11.43 **	6.10	9.23 *	26.81 **	-0.67	-3.25	-6.29	7.97 *
MRC 1544 X BML13	41.27 **	34.48 **	-16.09 **	-5.86 *	-1.15	65.08 **	52.38 **	-13.51 **	3.61	6.67	36.1 **	9.33 **	6.49	3.14	18.84 **
MRC 1544 X BML14	43.5 **	11.99 **	-30.12 **	-21.61 **	-17.68 **	32.23 **	9.34	-37.94 **	-25.65 **	-23.46 **	21.03 **	-6.00	-8.44 *	-11.32 **	2.17
MRC 1556 X BML5	38.3 **	24.58 **	-20.54 **	-10.86 **	-6.4 *	38.04 **	27.12 **	-29.83 **	-15.94 **	-13.46 **	16.94 **	2.11	-5.84	-8.81 **	5.07
MRC 1556 X BML7	60.86 **	19.84 **	-23.57 **	-14.25 **	-9.96 **	103.83 **	50.47 **	-16.94 **	-0.50	2.44	25.11 **	0.00	-7.79 *	-10.69 **	2.90
MRC 1556 X BML13	36.06 **	28.19 **	-18.24 **	-8.28 **	-3.68	52.06 **	42.18 **	-21.52 **	-5.98	-3.21	43.35 **	17.61 **	8.44 *	5.03	21.01 **
MRC 1556 X BML14	56.12 **	20.88 **	-22.9 **	-13.51 **	-9.17 **	41.89 **	18.64 **	-34.51 **	-21.54 **	-19.23 **	20.89 **	-4.23	-11.69 **	-14.47 **	-1.45
MRC 1561 X BML5	45.24 **	33.73 **	-18.75 **	-8.85 **	-4.28	59.86 **	33.33 **	-7.28 *	11.08 **	14.36 **	35.51 **	19.42 **	7.79 *	4.40	20.29 **
MRC 1561 X BML7	88.64 **	42.83 **	-13.22 **	-2.64	2.23	93.93 **	33.63 **	-7.07 *	11.33 **	14.62 **	26.79 **	2.16	-7.79 *	-10.69 **	2.90
MRC 1561 X BML13	61.08 **	55.31 **	-5.64 *	5.86 *	11.16 **	67.99 **	42.00 **	-1.25	18.31 **	21.79 **	36.52 **	12.95 **	1.95	-1.26	13.77 **
MRC 1561 X BML14	65.97 **	30.78 **	-20.54 **	-10.86 **	-6.40 *	64.72 **	26.31 **	-12.16 **	5.23	8.33 *	38.74 **	10.79 **	0.00	-3.14	11.59 **
MRC 1564 X BML5	28.35 **	16.63 **	-27.05 **	-18.16 **	-14.06 **	10.83 *	-7.61	-35.65 **	-22.91 **	-20.64 **	26.58 **	14.50 **	-2.60	-5.66	8.70 *
MRC 1564 X BML7	81.32 **	35.95 **	-14.96 **	-4.60	0.18	83.53 **	26.42 **	-11.95 **	5.48	8.59 *	35.19 **	11.45 **	-5.19	-8.18 *	5.80
MRC 1564 X BML13	29.46 **	23.1 **	-23 **	-13.62 **	-9.29 **	29.51 **	9.40 *	-23.80 **	-8.72 *	-6.03	32.43 **	12.21 **	-4.55	-7.55 *	6.52
MRC 1564 X BML14	44.75 **	12.86 **	-29.41 **	-20.8 **	-16.84 **	11.59 *	-14.48 **	-40.44 **	-28.64 **	-26.54 **	31.78 **	7.63	-8.44 *	-11.32 **	2.17
MRC 1582 X BML5	30.04 **	11.07 **	-19.83 **	-10.06 **	-5.55 *	36.48 **	21.75 **	-27.86 **	-13.57 **	-11.03 **	19.07 **	1.32	-0.65	-3.77	10.87 **
MRC 1582 X BML7	43.64 **	2.91	-25.72 **	-16.67 **	-12.49 **	63.55 **	18.07 **	-30.04 **	-16.19 **	-13.72 **	25.42 **	-1.99	-3.90	-6.92 *	7.25
MRC 1582 X BML13	23.59 **	10.08 **	-20.54 **	-10.86 **	-6.4 *	35.66 **	22.81 **	-27.23 **	-12.83 **	-10.26 *	35.54 **	8.61 *	6.49	3.14	18.84 **
MRC 1582 X BML14	46.27 **	8.59 **	-21.62 **	-12.07 **	-7.66 **	39.81 **	13.68 *	-32.64 **	-19.30 **	-16.92 **	23.08 **	-4.64	-6.49	-9.43 **	4.35
MRC 1601 X BML5	36.00 **	34.28 **	-29.56 **	-20.98 **	-17.02 **	53.91 **	53.91 **	-28.48 **	-14.32 **	-11.79 **	19.50 **	6.67	-6.49	-9.43 **	4.35
MRC 1601 X BML7	95.10 **	55.66 **	-18.34 **	-8.39 **	-3.80	116.00 **	69.13 **	-21.41 **	-5.85	-3.08	28.18 **	4.44	-8.44 *	-11.32 **	2.17
MRC 1601 X BML13	40.89 **	35.97 **	-23.31 **	-13.97 **	-9.66 **	65.46 **	62.77 **	-21.83 **	-6.35	-3.59	36.28 **	14.07 **	0.00	-3.14	11.59 **
MRC 1601 X BML14	54.66 **	28.91 **	-32.38 **	-24.14 **	-20.34 **	56.22 **	40.49 **	-34.72 **	-21.79 **	-19.49 **	22.94 **	-0.74	-12.99 **	-15.72 **	-2.90
MRC 1604 X BML5	61.00 **	51.91 **	-12.45 **	-1.78	3.14	64.85 **	39.02 **	-5.93	12.70 **	16.03 **	33.05 **	22.05 **	0.65	-2.52	12.32 **
MRC 1604 X BML7	101.73 **	55.56 **	-10.35 **	0.57	5.61 *	95.13 **	35.48 **	-8.32 *	9.84 *	13.08 **	52.83 **	27.56 **	5.19	1.89	17.39 **
MRC 1604 X BML13	53.19 **	51.56 **	-12.65 **	-2.01	2.90	67.30 **	43.01 **	-3.22	15.94 **	19.36 **	51.38 **	29.92 **	7.14 *	3.77	19.57 **
MRC 1604 X BML14	83.74 **	47.64 **	-14.91 **	-4.54	0.24	70.63 **	32.10 **	-10.60 **	7.10	10.26 *	41.9 **	17.32 **	-3.25	-6.29	7.97 *
MRC 1661 X BML5	37.56 **	24.67 **	-21.57 **	-12.01 **	-7.60 **	66.02 **	62.86 **	-24.32 **	-9.34 *	-6.67	26.05 **	13.64 **	-2.60	-5.66	8.70 *
MRC 1661 X BML7	64.09 **	22.8 **	-22.75 **	-13.33 **	-8.99 **	130.75 **	83.26 **	-18.09 **	-1.87	1.03	27.19 **	4.55	-10.39 **	-13.21 **	0.00
MRC 1661 X BML13	37.66 **	30.54 **	-17.88 **	-7.87 **	-3.26	97.98 **	91.13 **	-8.21 *	9.96 *	13.21 **	38.12 **	16.67 **	0.00	-3.14	11.59 **
MRC 1661 X BML14	55.42 **	20.93 **	-23.92 **	-14.66 **	-10.38 **	73.32 **	58.6 **	-29.11 **	-15.07 **	-12.56 **	30.23 **	6.06	-9.09 **	-11.95 **	1.45

*Significant at 5% level, ** Significant at 1% level

TABLE 3: Estimates of heterosis, heterobeltiosis and standard heterosis pooled over locations for ear girth, number of kernel rows per ear and number of kernels per row in maize hybrids

Cross	Ear girth				Number of kernel rows per ear				Number of kernels per row			
		Standard heterosis				Standard heterosis				Standard heterosis		
	Heterosis	Heterobeltiosis	DHM-117	30 V 92	900 M Gold	Heterosis	Heterobeltiosis	DHM-117	30 V 92	900 M Gold	Heterosis	Heterobeltiosis	DHM-117	30 V 92	900 M Gold
MRC1112 X BML5	35.03 **	11.76 **	-6.99 **	-0.75	-1.48	48.98 **	24.79 **	2.82	6.57 **	0.00	39.81 **	-3.21	-4.13	-4.73	-5.03
MRC1112 X BML7	27.36 **	7.56 *	-10.49 **	-4.48	-5.19	43.72 **	22.22 **	0.70	4.38	-2.05	54.96 **	2.56	1.59	0.95	0.63
MRC1112 X BML13	23.36 **	10.92 **	-7.69 **	-1.49	-2.22	43.72 **	22.22 **	0.70	4.38	-2.05	60.2 **	4.49	3.49	2.84	2.52
MRC1112 X BML14	17.87 **	2.52	-14.69 **	-8.96 **	-9.63 **	27.36 **	15.38 **	-4.93 *	-1.46	-7.53 **	33.02 **	-9.62 **	-10.48 **	-11.04 **	-11.32 **
MRC 1123 X BML5	54.19 **	36.63 **	-3.50	2.99	2.22	58.76 **	33.91 **	8.45 **	12.41 **	5.48 *	70.8 **	27.57 **	-1.59	-2.21	-2.52
MRC 1123 X BML7	53.01 **	38.61 **	-2.10	4.48	3.70	48.22 **	26.96 **	2.82	6.57 **	0.00	92.44 **	36.21 **	5.08	4.42	4.09
MRC 1123 X BML13	48.98 **	44.55 **	2.10	8.96 **	8.15 **	50.25 **	28.70**	4.23	8.03 **	1.37	107.1 **	44.03 **	11.11 **	10.41 **	10.06 **
MRC 1123 X BML14	49.21 **	39.6 **	-1.40	5.22	4.44	41.9 **	29.57 **	4.93 *	8.76 **	2.05	65.07 **	20.58 **	-6.98 *	-7.57 *	-7.86 **
MRC 1176 X BML5	28.78 **	3.94	-7.69 **	-1.49	-2.22	14.93 **	-10.56 **	-10.56 **	-7.30 **	-13.01 **	52.38 **	6.67 *	1.59	0.95	0.63
MRC 1176 X BML7	37.8 **	13.39 **	0.70	7.46 **	6.67 *	27.68 **	0.70	0.70	4.38	-2.05	72.57 **	15.33 **	9.84 **	9.15 **	8.81 **
MRC 1176 X BML13	27.93 **	11.81 **	-0.70	5.97 *	5.19	23.21 **	-2.82	-2.82	0.73	-5.48 *	73.16 **	14.00 **	8.57 **	7.89 **	7.55 *
MRC 1176 X BML14	14.42 **	-3.15	-13.99 **	-8.21 **	-8.89 **	-0.42	-16.9 **	-16.9 **	-13.87 **	-19.18 **	46.6 **	0.67	-4.13	-4.73	-5.03
MRC 1179 X BML5	27.36 **	4.07	-10.49 **	-4.48	-5.19	35.29 **	10.4 **	-2.82	0.73	-5.48 *	56.41 **	12.96 **	-3.17	-3.79	-4.09
MRC 1179 X BML7	30.73 **	8.94 **	-6.29 *	0.00	-0.74	40.10 **	16.00 **	2.11	5.84 *	-0.68	63.34 **	12.22 **	-3.81	-4.42	-4.72
MRC 1179 X BML13	26.61 **	12.20 **	-3.50	2.99	2.22	36.23 **	12.80 **	-0.70	2.92	-3.42	83.56 **	24.07 **	6.35 *	5.68	5.35
MRC 1179 X BML14	13.74 **	-2.44	-16.08 **	-10.45 **	-11.11 **	19.09 **	4.80	-7.75 **	-4.38	-10.27 **	44.50 **	2.22	-12.38 **	-12.93 **	-13.21 **
MRC 1209 X BML5	46.82 **	33.68 **	-11.19 **	-5.22	-5.93 *	41.62 **	23.58 **	-7.75 **	-4.38	-10.27 **	95.39 **	61.41 **	-5.71	-6.31 *	-6.60 *
MRC 1209 X BML7	59.32 **	48.42 **	-1.40	5.22	4.44	40.43 **	24.53 **	-7.04 **	-3.65	-9.59 **	137.19 **	83.7 **	7.30 *	6.62 *	6.29 *
MRC 1209 X BML13	37.89 **	37.89 **	-8.39 **	-2.24	-2.96	44.68 **	28.3 **	-4.23	-0.73	-6.85 **	128.67 **	73.37 **	1.27	0.63	0.31
MRC 1209 X BML14	28.96 **	24.21 **	-17.48 **	-11.94 **	-12.59 **	21.39 **	15.09 **	-14.08 **	-10.95 **	-16.44 **	96.62 **	58.15 **	-7.62 *	-8.20 **	-8.49 **
MRC 1271 X BML5	41.18 **	21.10 **	-7.69 **	-1.49	-2.22	42.41 **	21.43 **	-4.23	-0.73	-6.85 **	68.12 **	28.89 **	-7.94 **	-8.52 **	-8.81 **
MRC 1271 X BML7	39.27 **	22.02 **	-6.99 **	-0.75	-1.48	37.11 **	18.75 **	-6.34 **	-2.92	-8.90 **	85.89 **	34.67 **	-3.81	-4.42	-4.72
MRC 1271 X BML13	30.39 **	22.02 **	-6.99 **	-0.75	-1.48	36.08 **	17.86 **	-7.04 **	-3.65	-9.59 **	90.63 **	35.56 **	-3.17	-3.79	-4.09
MRC 1271 X BML14	24.87 **	12.84 **	-13.99 **	-8.21 **	-8.89 **	22.71 **	13.39 **	-10.56 **	-7.30 **	-13.01 **	61.42 **	20.89 **	-13.65 **	-14.2 **	-14.47 **
MRC 1358 X BML5	40.91 **	26.53 **	-13.29 **	-7.46 **	-8.15 **	45.74 **	25.69 **	-3.52	0.00	-6.16 **	51.94 **	10.11 **	-6.67 *	-7.26 *	-7.55 *
MRC 1358 X BML7	53.33 **	40.82 **	-3.50	2.99	2.22	39.27 **	22.02 **	-6.34 **	-2.92	-8.9 0**	65.76 **	14.23 **	-3.17	-3.79	-4.09
MRC 1358 X BML13	41.97 **	39.80 **	-4.20	2.24	1.48	47.64 **	29.36 **	-0.70	2.92	-3.42	80.66 **	22.47 **	3.81	3.15	2.83
MRC 1358 X BML14	22.58 **	16.33 **	-20.28 **	-14.93 **	-15.56 **	24.51 **	16.51 **	-10.56 **	-7.30 **	-13.01 **	45.65 **	3.37	-12.38 **	-12.93 **	-13.21 **
MRC 1544 X BML5	17.59 **	-7.97 **	-11.19 **	-5.22	-5.93 *	36.27 **	11.20 **	-2.11	1.46	-4.79 *	42.86 **	2.94	-11.11 **	-11.67 **	-11.95 **
MRC 1544 X BML7	20.91 **	-3.62	-6.99 **	-0.75	-1.48	43.00 **	18.40 **	4.23	8.03 **	1.37	65.15 **	13.24 **	-2.22	-2.84	-3.14
MRC 1544 X BML13	12.45 **	-5.07	-8.39 **	-2.24	-2.96	31.40 **	8.80 **	-4.23	-0.73	-6.85 **	66.76 **	12.50 **	-2.86	-3.47	-3.77
MRC 1544 X BML14	6.19 *	-13.04 **	-16.08 **	-10.45 **	-11.11 **	18.18 **	4.00	-8.45 **	-5.11 *	-10.96 **	36.46 **	-3.68	-16.83 **	-17.35 **	-17.61 **
MRC 1556 X BML5	37.37 **	13.33 **	-4.9	1.49	0.74	57.45 **	35.78 **	4.23	8.03 **	1.37	57.76 **	13.55 **	-1.59	-2.21	-2.52
MRC 1556 X BML7	30.69 **	10.00 **	-7.69 **	-1.49	-2.22	48.69 **	30.28 **	0.00	3.65	-2.74	71.12 **	17.22 **	1.59	0.95	0.63
MRC 1556 X BML13	26.51 **	13.33 **	-4.90	1.49	0.74	36.13 **	19.27 **	-8.45 **	-5.11 *	-10.96 **	75 **	17.95 **	2.22	1.58	1.26
MRC 1556 X BML14	22.12 **	5.83	-11.19 **	-5.22	-5.93 *	38.24 **	29.36 **	-0.70	2.92	-3.42	53.77 **	8.42 *	-6.03 *	-6.62 *	-6.92 *
MRC 1561 X BML5	41.84 **	17.8 **	-2.8	3.73	2.96	37.25 **	12.00 **	-1.41	2.19	-4.11	100 **	47.06 **	19.05 **	18.3 **	17.92 **
MRC 1561 X BML7	31.00 **	11.02 **	-8.39 **	-2.24	-2.96	26.57 **	4.80	-7.75 **	-4.38	-10.27 **	66.85 **	16.47 **	-5.71	-6.31 *	-6.6 *
MRC 1561 X BML13	24.88 **	12.71 **	-6.99 **	-0.75	-1.48	24.64 **	3.20	-9.15 **	-5.84 *	-11.64 **	82.29 **	25.10 **	1.27	0.63	0.31
MRC 1561 X BML14	26.21 **	10.17 **	-9.09 **	-2.99	-3.70	20.00 **	5.60 *	-7.04 **	-3.65	-9.59 **	94.55 **	40 **	13.33 **	12.62 **	12.26 **
MRC 1564 X BML5	29.29 **	6.67 *	-10.49 **	-4.48	-5.19	26.67 **	1.53	-6.34 **	-2.92	-8.90 **	64.77 **	22.09 **	-3.49	-4.10	-4.40
MRC 1564 X BML7	29.7 **	9.17 **	-8.39 **	-2.24	-2.96	23.94 **	0.76	-7.04 **	-3.65	-9.59 **	76.00 **	23.69 **	-2.22	-2.84	-3.14
MRC 1564 X BML13	16.28 **	4.17	-12.59 **	-6.72 *	-7.41 **	10.8 **	-9.92 **	-16.9 **	-13.87 **	-19.18 **	71.51 **	18.47 **	-6.35 *	-6.94 *	-7.23 *
MRC 1564 X BML14	14.42 **	-0.83	-16.78 **	-11.19 **	-11.85 **	9.73 **	-5.34 *	-12.68 **	-9.49 **	-15.07 **	58.45 **	14.86 **	-9.21 **	-9.78 **	-10.06 **

MRC 1358 X BML5	21.13 **	15.2 **	-7.48 **	-3.29	4.91 *	99.07 **	54.11 **	-7.61 *	-2.82	2.59
MRC 1358 X BML7	19.35 **	13.78 **	0.79	5.35 **	14.29 **	100.18 **	64.65 **	-1.30	3.82	9.61 **
MRC 1358 X BML13	34.75 **	30.14 **	12.20 **	17.28 **	27.23 **	181.02 **	106.2 **	23.62 **	30.03 **	37.27 **
MRC 1358 X BML14	13.18 **	7.35 **	-13.78 **	-9.88 **	-2.23	95.42 **	53.97 **	-7.70 *	-2.91	2.50
MRC 1544 X BML5	-8.85 **	-29.46 **	-6.69 **	-2.47	5.80 **	44.03 **	-3.72	-6.06	-1.18	4.32
MRC 1544 X BML7	-9.80 **	-24.70 **	-0.39	4.12 *	12.95 **	60.51 **	12.06 **	9.34 **	15.01 **	21.42 **
MRC 1544 X BML13	-4.14 **	-20.83 **	4.72 *	9.47 **	18.75 **	64.6 **	5.94	3.37	8.74 **	14.79 **
MRC 1544 X BML14	-15.22 **	-34.52 **	-13.39 **	-9.47 **	-1.79	42.11 **	-3.81	-6.14	-1.27	4.23
MRC 1556 X BML5	-3.85 *	-23.3 **	-6.69 **	-2.47	5.80 **	56.98 **	5.88	-0.26	4.91	10.76 **
MRC 1556 X BML7	-14.98 **	-26.54 **	-10.63 **	-6.58 **	1.34	49.09 **	5.14	-0.95	4.19	9.99 **
MRC 1556 X BML13	-14.39 **	-26.86 **	-11.02 **	-7.00 **	0.89	52.30 **	-1.19	-6.92 *	-2.09	3.36
MRC 1556 X BML14	-11.38 **	-29.45 **	-14.17 **	-10.29 **	-2.68	55.11 **	5.97	-0.17	5.00	10.85 **
MRC 1561 X BML5	3.08	-17.16 **	-1.18	3.29	12.05 **	78.10 **	20.09 **	13.24 **	19.11 **	25.74 **
MRC 1561 X BML7	-9.09 **	-20.79 **	-5.51 **	-1.23	7.14 **	33.51 **	-5.87	-11.25 **	-6.64 *	-1.44
MRC 1561 X BML13	-6.90 **	-19.80 **	-4.33 *	0.00	8.48 **	65.77 **	7.52 *	1.38	6.64 *	12.58 **
MRC 1561 X BML14	-2.88	-22.11 **	-7.09 **	-2.88	5.36 *	74.21 **	18.99 **	12.2 **	18.02 **	24.59 **
MRC 1564 X BML5	0.41	-19.61 **	-3.15	1.23	9.82 **	42.28 **	-4.35	-8.74 **	-4.00	1.34
MRC 1564 X BML7	5.46 **	-8.50 **	10.24 **	15.23 **	25.00 **	55.74 **	9.43 **	4.41	9.83 **	15.95 **
MRC 1564 X BML13	-1.33	-15.36 **	1.97	6.58 **	15.63 **	50.81 **	-2.45	-6.92 *	-2.09	3.36
MRC 1564 X BML14	-5.93 **	-24.84 **	-9.45 **	-5.35 **	2.68	41.68 **	-3.54	-7.96 *	-3.18	2.21
MRC 1582 X BML5	-2.84	-25.51 **	1.18	5.76 **	14.73 **	43.09 **	-3.96	-7.79 *	-3.00	2.40
MRC 1582 X BML7	-14.04 **	-28.99 **	-3.54	0.82	9.38 **	27.3 **	-10.72 **	-14.27 **	-9.83 **	-4.80
MRC 1582 X BML13	-5.32 **	-22.61 **	5.12 **	9.88 **	19.2 **	56.35 **	0.99	-3.03	2.00	7.68 *
MRC 1582 X BML14	-9.47 **	-30.72 **	-5.91 **	-1.65	6.70 **	39.83 **	-4.95	-8.74 **	-4.00	1.34
MRC 1601 X BML5	4.76 *	-10.12 **	-9.06 **	-4.94 *	3.13	49.16 **	3.12	-11.42 **	-6.82 *	-1.63
MRC 1601 X BML7	-4.15 *	-10.12 **	-9.06 **	-4.94 *	3.13	60.42 **	16.31 **	-0.09	5.10	10.95 **
MRC 1601 X BML13	11.34 **	3.11	4.33 *	9.05 **	18.3 **	89.22 **	25.48 **	7.79 *	13.38 **	19.69 **
MRC 1601 X BML14	-2.27	-16.34 **	-15.35 **	-11.52 **	-4.02	45.55 **	2.01	-12.37 **	-7.83 *	-2.69
MRC 1604 X BML5	8.98 **	-12.75 **	5.12 **	9.88 **	19.20 **	77.49 **	19.05 **	14.62 **	20.56 **	27.28 **
MRC 1604 X BML7	0.94	-12.42 **	5.51 **	10.29 **	19.64 **	63.08 **	14.29 **	10.03 **	15.74 **	22.19 **
MRC 1604 X BML13	-3.24 *	-16.99 **	0.00	4.53 *	13.39 **	67.01 **	7.82 *	3.81	9.19 **	15.27 **
MRC 1604 X BML14	2.25	-18.3 **	-1.57	2.88	11.61 **	72.62 **	17.25 **	12.89 **	18.74 **	25.36 **
MRC 1661 X BML5	7.93 **	-9.26 **	-3.54	0.82	9.38 **	63.77 **	13.70 **	-3.81	1.18	6.82
MRC 1661 X BML7	-5.05 **	-12.96 **	-7.48 **	-3.29	4.91 *	50.18 **	9.41 *	-7.44 *	-2.64	2.79
MRC 1661 X BML13	3.89 *	-5.93 **	0.00	4.53 *	13.39 **	67.9 **	11.76 **	-5.45	-0.55	5
MRC 1661 X BML14	-0.22	-16.3 **	-11.02 **	-7.00 **	0.89	61.37 **	13.60 **	-3.89	1.09	6.72

* Significant at 5% level; ** Significant at 1% leve