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Research Article

GENETIC ANALYSIS OF YIELD AND ITS COMPONENTS IN MAIZE (*Zea mays* L.) INBRED LINES USING LINE X TESTER ANALYSIS

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Abstract- Estimates of combining ability analysis are important genetic attributes for maize breeders to look forward improvement in productivity through hybridization and selection. The analysis of variance revealed that the sufficient variability was present in the material studied. Relatively higher estimates of GCV were obtained for grain yield/plot, cob yield/plot, ear height, cobs/plot and final plant stand. High heritability coupled with high genetic advance was recorded for the traits, plant height, 1000 grain weight, ear height and final plant stand that depicts the existence of additive gene effects. Mean sum of squares was highly significant for traits such as grain yield, 1000 grain weight, days to 50% pollen shed and silking, plant and ear height, ear length, ear girth, cobs/plot etc. Mean sum of squares due to lines, testers and line×testers were found significant for almost all the characters studied from combining ability point of view. Though the variance due to lines and testers were not significant for cob yield/plot and grain yield/plot, but their effect for rest traits and interaction line x tester effect were found significant for all the characters, indicating that the parents used in this study differ significantly and there was a preponderance of non additive gene action for the characters. Variance due to sca was greater than gca variance for almost all the traits except for plant height and cob length. Among testers BML-6 (for traits grain yield/plot, cob yield/plot, ear height, plant height, ear girth, cobs/plot and final plant stand) and HKI 1344 (for traits days to 50% pollen shed and silking, days to 80% maturity, plant and ear height, ear length, ear girth) were observed as good testers and among the lines IAMI 24, IAMI 22, IAMI 13, V 938-37 and Z 486-7 were found to be good for various important traits. Hybrids IAMI 24/BML 6, IAMI 31/BML 6 and IAMI 22/BML 6 were identified as promising on the basis of SCA effect, heterosis and mean *per se* performance.

Keywords- Combining Ability, Heterosis, Line X Tester Analysis, Maize, Inbred, Yield, Morphological Traits.

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Introduction

Maize (*Zea mays* L.) is an exciting and leading crop contributing significantly to world agriculture and more importantly to world's food basket of roughly 2000 million metric tons [1]. Renowned Noble Laureate Dr Norman E. Borlaug, father of green revolution was of the view "after the last two decades saw the revolution in rice and wheat, the next few decades will be known as maize era". In India, the production of maize witnessed a significant increase of more than 14 times from a mere 1.73 million tons in 1950-51 to 24.17 million tons in 2014-15. Presently it occupies 9.23 million hectare area with the mean yield of 2.56 tons/hectare (ICAR-IIMR, 2015). In Chhattisgarh maize occupies 225.85 thousand hectare land with the productivity of 1825 Kg/ha in *Kharif* 2013-14. It is cultivated mainly in Bastar, Dantewara, Jashpur, Kanker, Korba, Koriya, Surajpur, Balrampur and Sarguja districts. These are pre-dominantly tribal regions. It occupies about 2.72 per cent of the total cropped area in the state with all the maize-prominent districts showing an increasing trend in the maize yield. The state has got very good potential for maize, but the productivity is very low due to cultivation of open pollinated varieties (OPVs) and improper input management practices. The real potential can be realized by the adoption of hybrid maize with full package of practices. As the major chunk of maize acreage of the state is rain-fed, there is a need to popularize single cross hybrids, which have better adaptability under stress environments. For the development of a good economically viable hybrid maize variety, combining ability of the lines is very important. Knowledge on the heterotic patterns and combining ability among maize germplasm are essential in capitalizing the usefulness of hybrid development. Thus, the study of combining ability analysis will help in identifying suitable combination to exploit heterosis or link up fixable favourable gene(s) that may lead to the development of superior hybrids. The line x tester analysis, which is similar to North Carolina Design-2, which is, also known as Factorial Design [2] is one of them [3]. Several workers like Joshi *et al.,* 2002[4]; Sharma *et al.,* 2004 [5] have used this design in maize and is still continuing to be applied widely in quantitative genetic studies in crop plants. Recently developed inbreds are available at the AICRP on Maize, Raj Mohini Devi College of Agriculture and Research Station, Ambikapur, Chhattisgarh whose combining ability has not yet been studied. Thus, the present investigation was carried out to unravel the genetics of yield and other important trait, nature and magnitude of gene action lines and crosses of maize for yield and other important traits and to study the magnitude of heterosis in maize.

Materials & Method

The experimental/biological materials used in the research work comprised of ten maize inbred lines *viz*., V938-37, Z486-7, P62C6, IAMI-8, IAMI-12, IAMI-13, IAMI-18, IAMI-22, IAMI-24,IAMI-31 and three well established inbreds *viz*., HKI-1344, BML-7 and BML-6 as tester. Total thirty crosses were made by adopting line x tester design. Five checks *viz.,* NK-30, Hishell, Pro 4212, DHM 117 and NMH 731 were also included to evaluate the standard heterosis. The parents were grown in different sowing dates to raise good crop during *Spring-Summer* 2015, in such a way so as to ensure synchronization in flowering for the purpose of hybridization. The above crosses and their parents were sown in a RCBD (Randomized Complete Block Design) with three replications at Research field of Ajirma farm, RMD, CARS, Ambikapur, which is located at a latitude of 20⁰8'N, longitude of 83⁰15'E and altitude of 592.62 m MSL (mean sea level). Each genotype was sown as four rows of 4 meter lengths with row-to-row and plant-to-plant distance of 75 cm and 25 cm respectively. Recommended agronomical packages and practices were followed during the crop growth period**.** Observations were recorded on traits namely plant height, ear height, ear length, ear girth, cobs per plot, day to 50% pollen shed, day to 50% silking, day to 80% maturity, cob yield per plot, grain yield per plot, final plant stand, shelling percentage and 1000-grain weight. The data so obtained were analyzed and genetic parameters (GCV, PCV, heritability and genetic advance), combining ability effects (GCA & SCA) and all kinds of heterosis were worked out.

Result & Discussion

The results of the various analyses are summarized in [Table–1-3]. Genotypic coefficient of the variation's (GCV's) were not much differ with their respective phenotypic coefficient of the variation's (PCV's), indicating the less influence of the environment on the expression of the traits. Reasonably higher estimates of GCV for grain yield/plot, cob yield/plot, ear height, cobs/plot and final plant stand suggest that the selection can be effective for these traits. High heritability estimates for almost all the traits indicates the preponderance of additive gene action. High heritability along with high genetic advance was recorded for the traits, plant height, 1000 grain weight, ear height and final plant stand that describes the additive gene effects. Thus, such characters should be improved through selection. Most of these findings are in harmony with those obtained by Devi *et al.* (2001)[6], Sofi and Rather (2007)[7], Rafiq *et al.* (2010)[8] and Wannows *et al.* (2010)[9].

Table-1 *Genotypic and phenotypic coefficient of variance (GCV and PCV), heritability (h^2) and genetic advance as a percentage of mean for different characters in maize*

S.No.	Characters	Range	GCV %	PCV %	Heritability (h^2)	GA as percentage of mean
1	Final Plant Stand	38.67-80.00	22.05	23.42	88.66	24.00
2	Day to 50% Pollen Shed	47.00-62.33	5.90	6.00	96.63	6.59
3	Day to 50% Silking	50.00-65.33	5.63	5.71	97.35	6.63
4	Day to 80% Maturity	90.00-107.67	4.66	4.77	95.39	9.33
5	No. of Cobs/Plot	38.00-80.33	22.66	24.17	87.87	24.34
6	Plant height (cm)	149.93-265.80	14.88	16.39	82.36	60.38
7	Ear height (cm)	43.13-118.73	20.64	23.30	78.43	32.75
8	Ear length (cm)	10.67-18.80	11.00	13.50	66.29	2.89
9	Ear girth (cm)	10.70-15.87	8.85	10.68	68.65	2.04
10	1000 grain weight (gm)	238.93-339.67	8.07	8.37	92.95	45.88
11	Shelling Percentage (%)	72.97-78.30	0.75	3.12	5.70	0.28
12	Cobs Yield/Plot (kg)	1.60-11.80	51.16	52.63	94.50	5.45
13	Grain Yield/Plot (kg)	1.20-9.10	53.02	54.41	94.96	4.18

Analysis of variance for parents, crosses and parents vs. crosses were highly significant for all the traits except shelling percentage [Table-2]. This indicated the presences of sufficient variability among parents and hybrids. The mean sum of squares were found highly significant for the traits days to 50 per cent pollen shed, days to 50 per cent silking, days to maturity, plant height, ear height, cob yield, grain yield, 1000-grain weight, considering only hybrids which indicate that hybrids showed diverse performance of different cross combinations for these traits and hence, selection is possible to identify the most desirable crosses. The parents versus hybrids mean sum of squares were highly significant for all traits revealing the presence of average heterosis due to the significant differences in the mean performances of hybrids and parents.

GCA mean squares of the Line and Tester were found highly significant for most of the traits *viz.*, 1000 grain weight, days to pollen shed and silking, plant and ear height, grain yield, cob yield [Table-3]. Character wise estimation of GCA effects of testers revealed that BML 6 is a good combiner for most of the traits *viz*., grain yield/plot, cob yield/plot, ear height, plant height, ear girth, cobs/plot and final plant stand. HKI 1344 is found to be a good combiner for traits *viz*., days to 50% pollen shed and silking, days to 80% maturity, plant and ear height, ear length, ear girth with a view of earliness and short stature plant. BML 7 is in between these two. Lines IAMI 24, IAMI 13, IAMI 12 are good for grain yield/plot, cob yield/plot and cobs/plot. IAMI 22 and V 938-37 are better than others for the short stature of the plant. IAMI 24, IAMI 22 and Z 486-7 are good for earliness. Analysis of variance for SCA also showed highly significant differences for grain yield, 1000 grain weight, plant height and ear height, days to pollen shed, silking, maturity. Both positive and negative and significant estimates of SCA effects were observed among the crosses for grain yield. Out of the 30 hybrids, twenty two hybrids have shown significant SCA effects (eleven positive and eleven negative). The hybrid V938-37 x HKI-1344 (2.19) followed by IAMI-31 x BML-6 (1.87) showed positive significant effect. Highly significant SCA effects of the crosses indicate that significant deviation from what would have been predicted based on their parental performances. Estimates of SCA effects [Table-4] of hybrids revealed that highest SCA effect shown by IAMI 12/HKI 1344 for 1000 grain weight. Crosses IAMI 31/BML 6, IAMI 22/BML 6, IAMI 18/BML 6, IAMI 8/HKI 1344, V 938-37/HKI 1344 are good for grain yield and other yield attributing characters like cob yield, number of cobs. With the character earliness crosses IAMI 24/HKI 1344, V 938-37/BML 7, IAMI 12/BML 7, IAMI 18/BML 7, IAMI 8/BML 6 are found to be good. Crosses V 938-37/BML 7, IAMI 8/BML 6 are also good from the short plant stature point of view. The results of analysis of combining abilities obtained from this study indicated the importance of both additive and non-additive gene actions in controlling in these agronomical important traits such as 1000 grain weight, days to pollen shed and silking, plant and ear height, grain yield. Therefore, both additive and non-additive variances are important in determining for the exploitation breeding behavior of the genetic potential of the inbred lines in variety development program. Nevertheless the variance due to lines and testers were not significant for trait cob yield/plot and grain yield/plot, but their effect for the rest of the traits and the interaction (line x tester) effect were found significant for all the characters, signifying that the parents used in this study differ appreciably and there was a preponderance of non additive gene action for the characters [10-17].

Heterosis was observed for several combinations and the lines with high values of combining ability will be further selfed to generate stable inbred lines that will be evaluated in commercial breeding programs. A high degree of relative heterosis and heterobeltiosis was observed for grain yield in all the hybrids. The highest significant positive average heterosis was recorded by cross IAMI-31/BML-6 (494.87 %) followed by IAMI-13/BML-6 (393.33%) and IAMI-24/BML-6 (377.65%). Highest significant positive heterosis over better parent recorded by cross IAMI-31/BML-6 (494.87%) followed by P62C6/BML-7 (376.32%) and IAMI-13/BML-6 (374.36%). The standard heterosis (over NK-30) ranged from -15.05 % (IAMI-31/BML-6) to -79.12% (V938-37/BML-7). High standard heterosis was recorded against check Pro 4212 and DHM 117 for this trait in crosses *viz*., IAMI 24/BML 6, IAMI 22/BML 6, IAMI 18/BML 6, IAMI 31/BML 6, IAMI 13/BML 6, IAMI 13/BML 7, IAMI 8/HKI 1344, IAMI 12/HKI 1344, V 938-37/HKI 1344 and P62C6/BML 7 [Table-5]. These findings are in confirmatory with the results [18-20].

Table–2 *ANOVA for L x T and Combining Ability Analysis*

SV	Degree of freedom	Final Plant Stand	Day to 50% Pollen Shed	Day to 50% Silking	Day to 80% Maturity	No. of Cobs/Plot	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear girth (cm)	1000 grain weight (gm)	Shelling percentage (%)	Cob Yield/Plot (Kg)	Grain Yield/Plot (Kg)
		1	2	3	4	5	6	7	8	9	10	11	12	13
Replication	2	73.976*	21.44**	23.77**	52.32**	80.86*	1184.68**	340.41	3.99	1.46	426.79**	7.69	1.51*	0.68
Parent	12	57.367**	33.19**	28.45**	48.31**	59.3**	1142.34**	593.02**	14.67**	3.4**	1106.6**	6.79*	0.48*	0.26*
Crosses	29	331.91**	24.26**	25.78**	64.33**	348.89**	987.13**	426.42**	3.17**	1.15*	1260.6**	3.57	10.37**	5.96**
Parent Vs Hybrid	1	9569.7**	176.61**	176.3**	333.62**	9943.1**	103030**	24486.02**	181.69**	155.3**	19697.5**	10.2	536.27**	312.3**
Line effect	9	205.732	28.496**	25.91**	71.58**	224.48**	881.05**	901.55**	2.96*	1.986**	3285.00**	2.91	3.85	2.38
Tester effect	2	282.63	67.517*	78.48**	259.37**	338.81	5562.08**	674.5*	24.85**	2.92*	617.16	0.84	23.27	13.40
Line x Tester Effect	18	400.48**	17.349**	19.87**	39.031**	412.21**	531.84*	177.4*	0.875	0.547	319.98**	4.206	12.197**	6.933**
Error	84	19.05	0.386	0.299	0.897	21.2	221.83	89.94	1.63	0.682	37.58	5.56	0.421	0.235
Total	128	21632.37	1354.1	1338	2959	22716	166369	52494.72	595.041	290	73547.95	678.8	881.4	509.85
Variance GCA		-8.015	1.572	1.657	6.484	-6.695	137.93	31.31	0.668	0.098	83.64	-0.119	0.0701	0.0493
Variance SCA		125.53	5.662	6.525	12.762	128.69	96.64	309.88	-0.04	0.263	93.4	-0.05	4.011	2.299
Variance GCA/SCA		-0.064	0.278	0.254	0.508	-0.052	1.427	0.101	-16.700	0.372	0.896	2.380	0.0175	0.0214

*=significant of p=0.05 level **= significant of p=0.01 level

Table-3 *General Combining Ability Effects of Parents for grain yield and its components in maize.*

Characters	Final Plant Stand	Day to 50% Pollen Shed	Day to 50% Silking	Day to 80% Maturity	No. of Cobs/Plot	Plant height (cm)	Ear height (cm)	Ear length(cm)	Ear girth(cm)	1000 grain weight (gm)	Shelling percentage (%)	Cob Yield/Plot (kg)	Grain Yield/Plot (kg)
	1	2	3	4	5	6	7	8	9	10	11	12	13
Parents													
Line													
V938-37	-7.71**	1.63**	1.40**	3.10**	-8.36**	-5.00	-9.26**	0.70**	-0.09	-21.47**	-0.97	-0.80**	-0.68**
Z486-7	-2.71*	1.30**	1.07**	-2.34**	-3.36*	3.77	6.07**	-0.50	-0.98**	-13.96**	-0.60	-0.54**	-0.44**
P62C6	-5.16**	0.52**	0.29**	-1.01**	-5.13**	-3.16	2.82	-0.45	-0.03	-30.59**	-0.37	-0.59**	-0.48**
IAMI-8	0.07	1.52**	1.62**	1.66**	0.53	-1.96	-0.71	0.12	0.69**	22.28**	0.83	-0.34	-0.22
IAMI-12	5.18**	2.63**	2.73**	3.21**	5.31**	21.88**	16.78**	0.61*	-0.11	15.61**	0.22	0.33	0.28
IAMI-13	4.51**	-0.37**	-0.60**	2.32**	4.87**	-1.56	3.49	-0.03	-0.18	-7.77**	-0.29	0.67**	0.49**
IAMI-18	-1.60	-1.48**	-1.04**	-0.57**	-1.91	1.15	-2.33	-0.43	0.43**	6.43**	0.58	-0.37	-0.26
IAMI-22	-1.60	2.70**	-2.60**	-3.57**	-0.58	-17.69**	-20.66**	0.44	-0.09	0.06	-0.18	0.08	0.06
IAMI-24	7.62**	-1.92**	-1.82**	-4.57**	7.76**	-2.52	-2.40	-0.99**	0.53**	29.19**	0.41	1.30**	1.00**
IAMI-31	1.40	-1.14**	-1.04**	1.77**	0.87	5.08	6.20*	0.52*	-0.16	0.21	0.35	0.26	0.25
SE (Lines)	1.29	0.16	0.14	0.23	1.35	4.11	2.57	0.26	0.16	1.67	0.55	0.20	0.15
Testers													
HKI 1344	-0.83	-1.18**	-1.11**	-3.38**	-0.91	-15.59**	-1.50	-0.86**	-0.32**	5.24**	-0.14	-0.82**	-0.63**
BML-7	-2.57**	1.69**	1.86**	1.39**	-2.81**	6.04**	-3.81**	0.95**	0.03	-2.58**	0.19	-0.12	-0.08
BMLL-6	3.40**	-0.51**	-0.74**	1.99**	3.72**	9.56**	5.31**	-0.09	0.30**	-2.65**	-0.05	0.93**	0.70**
SE(Testers)	0.61	0.07	0.07	0.11	0.64	1.94	1.21	0.12	0.07	0.79	0.26	0.10	0.07

*=significant of p=0.05 level **=significant of p=0.01 level

Table-4 *Specific Combining Ability Effects of crosses for grain yield and its components in maize.*

Crosses	Final Plant Stand	Day to 50% Pollen Shed	Day to 50% Silking	Day to 80% Maturity	No. of Cobs /Plot	Plant height (cm)	Ear height(cm)	Ear length(cm)	Ear girth(cm)	1000 grain weight (gm)	Shelling Percentage(%)	Cob Yield/Plot (kg)	Grain Yield/Plot (kg)
	1	2	3	4	5	6	7	8	9	10	11	12	13
V938-37 * HKI 1344	15.94**	-2.93**	-3.00**	-1.07**	16.02**	2.39	-0.01	0.50	0.17	12.62**	-0.26	2.93**	2.19**
V938-37 * BML-7	-11.32**	-1.80**	-1.97**	-2.17**	-11.41**	-24.10**	-12.77**	-0.31	-0.05	-3.99	0.55	-3.04**	-2.25**
V938-37 * BML-6	-4.62*	4.73**	4.97**	3.23**	-4.61*	21.71**	12.78**	-0.20	-0.12	-8.63**	-0.29	0.11	0.06
Z486-7 * HKI1344	0.28	-1.60**	-1.67**	0.04	0.36	2.95	-4.21	0.37	0.12	-2.56	-0.32	0.09	0.06
Z486-7 * BML-7	7.68**	0.87**	0.70**	3.94**	7.92**	2.59	0.76	-0.11	-0.16	4.26	-0.39	0.99**	0.71**
Z486-7 * BML-6	-7.96**	0.73**	0.97**	-3.99**	-8.28**	-5.53	3.44	-0.26	0.03	-1.70	0.71	-1.09**	-0.77**
P62C6 * HKI 1344	-9.61**	1.18**	1.11**	-3.29**	-9.20**	-5.59	-6.90	-0.21	-0.36	-3.12	1.11	-1.75**	-1.27**
P62C6 * BML-7	18.79**	1.31**	1.14**	1.61**	18.70**	-0.95	2.28	0.18	0.09	4.40	-0.32	2.22**	1.68**
P62C6 * BML -6	-9.18**	-2.49**	-2.26**	1.68**	-9.50**	6.53	4.62	0.03	0.28	-1.27	-0.79	-0.47	-0.40
IAMI-8 * HKI 1344	12.50**	2.18**	2.78**	1.04**	12.80**	12.61	5.90	0.68	0.06	-1.12	0.14	2.19**	1.70**
IAMI-8 * BML-7	-2.10	2.31**	1.81**	-0.06	-2.30	10.05	6.34	-0.20	-0.49*	1.70	-1.69*	0.73*	0.46*
IAMI-8 * BML-6	-10.40**	-4.49**	-4.59**	-0.99**	-10.50**	-22.67**	-12.24**	-0.48	0.43	-0.57	1.55*	-2.92**	-2.16**
IAMI-12 * HKI 1344	8.39**	1.07**	1.67**	-2.51**	9.02**	12.70*	5.88	-0.61	0.32	24.54**	-1.45	1.76**	1.24**
IAMI-12 * BML-7	-3.21	-2.47**	-2.97**	-1.94**	-3.74	-0.12	-2.28	0.38	0.37	-7.30**	1.32	-0.27	-0.14
IAMI-12 * BML-6	-5.18**	1.40**	1.30**	4.46**	-5.28**	-12.58*	-3.60	0.23	-0.70**	-17.24**	0.12	-1.49**	-1.09**
IAMI-13 * HKI 1344	-5.28**	0.40	0.33**	-3.62**	-4.87*	8.75	11.10**	-0.10	-0.34	-7.41**	0.43	0.62*	-0.44*
IAMI-13 * BML-7	0.79	-0.80**	-0.97**	-1.06**	0.03	-4.68	-5.32	-0.51	0.11	-2.06	-0.70	0.55	0.38
IAMI-13 * BML-6	4.49*	0.40	0.63**	4.68**	4.83**	-4.07	-5.78	0.60	0.23	9.47**	0.27	0.07	0.06
IAMI-18 * HKI 1344	-8.83**	2.18**	2.44**	5.93**	-9.09**	-10.76	-4.81	-0.90*	-0.45*	-2.28	0.96	-1.57**	-1.15**
IAMI-18 * BML-7	-0.43	-1.69**	-1.52**	-4.17**	-0.52	1.21	-1.30	0.02	-0.17	1.67	0.10	0.53	0.43**
IAMI-18 * BML-6	9.27**	-0.49*	-0.92**	-1.77**	9.61**	9.56	6.11	0.87*	0.62*	0.61	-1.07	1.04**	0.72**
IAMI-22 * HKI 1344	-8.50**	-0.27	-0.67**	0.27	-8.76**	-17.05*	-3.01	0.04	-0.36	-5.90*	-0.38	-1.33**	-1.04**
IAMI-22 * BML-7	-5.43**	0.53*	1.03**	3.50**	-5.19**	9.12	3.83	-0.24	0.42	1.92	-0.48	-0.63*	-0.52**
IAMI-22 * BML-6	13.93**	-0.27	-0.37	-3.77**	13.94**	7.93	-0.82	0.20	-0.05	3.98	0.86	1.96**	1.56**
IAMI-24 * HKI 1344	8.94**	-2.04**	-2.44**	3.27**	8.58**	-3.03	-0.41	0.33	0.55*	-3.37	1.30	0.89**	0.78**
IAMI-24 * BML-7	-8.99**	0.76**	1.26**	-0.50	-7.86**	-1.92	1.03	0.31	-0.07	4.18	0.53	-1.27**	-0.93**
IAMI-24 * BML-6	0.04	1.29**	1.19**	-2.77**	-0.72	4.96	-0.62	-0.64	-0.48*	-0.82	-1.83*	0.38	0.15
IAMI-31 * HKI 1344	-13.83**	-0.16	-0.56**	-0.07	-14.87**	-2.96	-3.54	-0.12	0.30	-11.39**	-1.54	-2.61**	-2.06**
IAMI-31 * BML-7	4.23*	0.98**	1.48**	0.83*	4.37*	8.81	7.43*	0.47	-0.05	-4.77	1.07	0.19	0.19
IAMI-31 * BML-6	9.60**	-0.82**	-0.92**	-0.77*	10.5**	-5.84	-3.89	-0.35	-0.25	16.16**	0.47	2.14**	1.87**
Sem ±	1.83	0.22	0.20	0.32	1.91	5.81	3.63	0.37	0.22	2.36	0.78	0.29	0.21

*=significant of p=0.05 level **=significant of p=0.01 level

Thakur Sunil, Sinha S. K., Mehta Nandan and Thakur Dinesh

Table-5 *Average (MP-parent) Heterosis, Heterobeltiosis and Standard heterosis for grain yield in maize.*

Cross combination	Grain Yield (Kg/plot)						
	Average Heterosis (%)	Heterobeltiosis (%)	Standard Heterosis (%)				
			NK 30	Hishell	Pro 4212	DHM	NMH 731
V938-37							
V938-37 * HKI 1344	340.51**	335.00**	-36.26**	-20.55**	18.37**	7.41**	-10.77**
V938-37 * BML-7	46.15**	42.50**	-79.12**	-73.97**	-61.22**	-64.81**	-70.77**
V938-37 * BML-6	279.75**	275.00**	-45.05**	-31.51**	2.04**	-7.41**	-23.08**
Z486-7							
Z486-7 * HKI1344	151.61**	116.67**	-57.14**	-46.58**	-20.41**	-27.78**	-40.00**
Z486-7 * BML-7	232.61**	183.33**	-43.96**	-30.14**	4.08**	-5.56**	-21.54**
Z486-7 * BML-6	183.87**	144.44**	-51.65**	-39.73**	-10.20*	-18.52**	-32.31**
P62C6							
P62C6 * HKI 1344	97.40**	94.87**	-72.20**	-65.34**	-48.37**	-53.15**	-61.08**
P62C6 * BML-7	376.32**	376.32**	-33.74**	-17.40**	23.06**	11.67**	-7.23**
P62C6 * BML -6	268.83**	264.10**	-48.02**	-35.21**	-3.47**	-12.41**	-27.23**
IAMI-8							
IAMI-8 * HKI 1344	249.49**	188.33**	-36.59**	-20.96**	17.76**	6.85**	-11.23**
IAMI-8 * BML-7	210.20**	153.33**	-44.29**	-30.55**	3.47**	-6.11**	-22.00**
IAMI-8 * BML-6	95.96**	61.67**	-64.51**	-55.75**	-34.08**	-40.19**	-50.31**
IAMI-12							
IAMI-12 * HKI 1344	300.00**	262.50**	-36.26**	-20.55**	18.37**	7.41**	-10.77**
IAMI-12 * BML-7	246.51**	210.42**	-45.38**	-31.92**	1.43**	-7.96**	-23.54**
IAMI-12 * BML-6	231.03**	200.00**	-47.25**	-34.25**	-2.04**	-11.11**	-26.15**
IAMI-13							
IAMI-13 * HKI 1344	246.67**	233.33**	-52.42**	-40.68**	-11.63**	-19.81**	-33.38**
IAMI-13 * BML-7	362.16**	350.00**	-37.36**	-21.92**	16.33**	5.56	-12.31**
IAMI-13 * BML-6	393.33**	374.36**	-32.20**	-15.48**	25.92**	14.26**	-5.08**
IAMI-18							
IAMI-18 * HKI 1344	75.51**	45.76**	-68.46**	-60.68**	-41.43**	-46.85**	-55.85**
IAMI-18 * BML-7	209.28**	154.24**	-45.05**	-31.51**	2.04**	-7.41**	-23.08**
IAMI-18 * BML-6	271.43**	208.47**	-33.30**	-16.85**	23.88**	12.41**	-6.62**
IAMI-22							
IAMI-22 * HKI 1344	106.25**	73.68**	-63.74**	-54.79**	-32.65**	-38.89**	-49.23**
IAMI-22 * BML-7	175.79**	129.82**	-51.98**	-40.14**	-10.82**	-19.07**	-32.77**
IAMI-22 * BML-6	352.08**	280.70**	-20.55**	-0.96**	47.55**	33.89**	11.23**
IAMI-24							
IAMI-24 * HKI 1344	328.24**	295.65**	-33.30**	-16.85**	23.88**	12.41**	-6.62**
IAMI-24 * BML-7	250.00**	219.57**	-46.15**	-32.88**	0.00	-9.26**	-24.62**
IAMI-24 * BML-6	377.65**	341.30**	-25.60**	-7.26**	38.16**	25.37**	4.15**
IAMI-31							
IAMI-31 * HKI 1344	89.74**	89.74**	-72.86**	-66.16**	-49.59**	-54.26**	-62.00**
IAMI-31 * BML-7	310.39**	305.13**	-42.09**	-27.81**	7.55**	-2.41**	-18.92**
IAMI-31 * BML-6	494.87**	494.87**	-15.05**	5.89**	57.76**	43.15**	18.92**

*=significant of p=0.05 level **=significant of p=0.01 level

Conflict of Interest: None declared

References

[1] Vasal S. K., Srinivasan F. Ganeson, Beck D. L., Crossa J., Pandey S. and Leon C. De (1992) *Maydica*, 37(2), 217-223.

[2] Comstock R. E. and Robinson H.F. (1952) *Estimation of average dominance of genes. In heterois, Iowa State College Press, Ames*. 494-516.

[3] Kempthorne O. (1957) *An Introduction to Genetics Statistics.John Wiley and Sons.Inc. New York*.

[4] Joshi V. N., Dubey R. B. and Marker S. (2002) *Indian J. Genet. Plant Breed*. 62, 312-315.

[5] Sharma S., Dass S. and Kumar R. (2004) *Annals-of-Agri-Bio-Research*, 9(1), 19-20.

[6] Devi I. S., Muhammad S. and Muhammad S. (2001) *Crop Res. Hisar*, 21, 355-359.

[7] Sofi P. A. and Rather A. G. (2007) *Maize genetics Cooperation Newsletter.* 81.

[8] Rafiq M., Rafiq M., Hussain A. and Altaf M. (2010) *Journal Agric.Res*., 48(1), 35-38.

[9] Wannows A. A., Azzam H. K. and Ahmad S. A. AL. (2010) *Agric. Biol. J. N. Am*., 1(4), 630-637.

[10] Pal S. S., Khera A. S. and Dhillon B. S. (1986) *Maydica,* 31, 153-162.

[11] Satyanarayana E., Kumar R. S. and Sharma M. Y. (1994) *Mysore J. Agric. Sci*., 28(1), 25-30.

[12] Prasad S. K. and Kumar P. (2003) *J Res.(RAU).,* 13, 68-72.

[13] Vijayabharathi A., Anandkumar C. R. and Gnanamalar R. P. (2009) *Electronic J. Plant Breeding*, 1, 28-32.

[14] Kanagarasu S., Nallathambi G. and Ganesan K. N. (2010) *Electronic Journal of plant Breeding*, 1(4), 915-920.

[15] Abrha S.W., Zeleke H. Z. and Gissa D.W. (2013) *Asian J. Plant Sci. Res*., 3(5), 12-19.

[16] Gowda K., Kage U. K., Lohithasa H. C., Shekara B. G. and Shobha D. (2013) *Molecular Plant Breeding*, 4(14), 116-127.

[17] Alamine A., Wali M. C., Salimath P. M. and Jagadeesha B. C. (2006) *Karnataka J.Agric. Sci*., 19, 13-16.

[18] Hussain Ali, M. and Ibraheem S. R. (2011) *Journal of Tikrit University for Agricultural Sciences*, 11(2), 359-383.

[19] Mohammed A. S. A. (2005) *J. of Tik.Unvi. Agri.,* 2(5),1-9.

[20] Muraya A. B. M. M, C. M. Ndirangu A and E. O. Omolo A. (2006) *Aust. J. of Exp.Agri.,* 46(3), 387–394.