Plant Archives Vol. 14 No. 2, 2014 pp. 773-777 ***ISSN 0972-5210***

HETEROSIS FOR GRAIN YIELD AND ITS COMPONENT TRAITS IN SINGLE CROSS HYBRIDS OF MAIZE (*ZEA MAYS* L.)

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Abstract

The study was undertaken to estimate heterosis for yield and yield related traits in maize. Twenty four crosses were generated by crossing eight lines and three testers using line × tester mating design. A total of thirty five treatments comprising eleven parents and their twenty four crosses were evaluated in a complete randomized block design with two replications. Heterosis was obtained for most of the traits under study. All the cross combinations except KDM-2111 × C-4 revealed significant and positive heterosis for grain yield plant^{-1}. The maximum significant positive mid parent and better parent heterosis was estimated for KDM-2113 × KDM-914A followed by KDM-2113 × KDM-343A and KDM-2122 × KDM-343A. These crosses also elucidated desired and significant heterosis for shelling percentage, 100 grain weight, grain depth, kernels row^{-1} and kernel rows cob^{-1}. Thus, these crosses in future could be exploited commercially for higher yield in maize.

Key words : Heterosis, maize, line × tester, yield.

Introduction

Maize (*Zea mays* L.) is the world's third leading cereal crop after rice and wheat but ranks first with respect to its production and productivity. Maize is not only of worldwide importance as a food, feed and as a source of diverse industrially important products, but is also a model genetic organism with immense genetic diversity. It has a very high yield potential as compared to other cereals and that is why it is referred to as "queen of cereals".

Maize, being a cross pollinated crop, is endowed with significant amounts of heterosis for grain yield and other agronomic traits. With the introduction of heterosis concepts in maize, there has been a breakthrough in yield of this crop. Heterosis works as a basic tool in the form of F_1 hybrids. Therefore, heterotic studies can provide the basis for the exploitation of valuable combinations in the future breeding programmes and their commercial utilization. The presence of sufficient hybrid vigour is an important prerequisite for successful production of hybrid varieties. A large number of workers have conducted experiments to ascertain the amount of exploitable heterosis for grain yield and its various component traits in various F_1 maize populations. Therefore, the present investigation was undertaken to estimate heterosis for grain yield and its various contributing traits in hybrids involving inbred lines.

Materials and Methods

Genetic material, experimental design and data collection

The basic material for the present investigation comprised of eight diverse maize inbred lines (KDM-2104, KDM-2107, KDM-2111, KDM-2113, KDM-2117, KDM-2121, KDM-2122 and KDM-2123) and three testers (SMC-4, KDM-914A and KDM-343A). Twenty four crosses were obtained from the set of parents using the methodology of line × tester mating design.as suggested by Kempthorne (1957) during *rabi* 2012-13 at Winter Nursery Centre, Hyderabad. The crosses along with their parents were evaluated at two locations during *kharif* 2013 in a complete randomized block design with two replications at both the locations. The experimental plot comprised of two rows each of 4 metre length with a planting geometry of 75 × 20 cm. Recommended agronomic practices were followed to raise a good crop at both the locations. Observations on various traits were recorded on five randomly selected competitive plants except for maturity traits (days to 50 per cent anthesis and days to 50 per cent silking) where data was recorded on plot basis. Heterosis (pooled over environments) was estimated as per cent increase or decrease of the F_1's over mid parent and better parent.

Heterosis estimation

Heterosis for various traits was estimated as per cent increase or decrease of F_1's over mid and better parent and was mathematically calculated by the following formulae:

$$\text{Heterosis (\%) over mid-parent (M.P.)} = \frac{\overline{F_1} - \overline{MP}}{\overline{MP}} \times 100$$

Where,

$$\overline{MP} = \frac{\overline{p}_1 + \overline{p}_2}{2}$$

$\overline{p}_1$ = Mean Performance of the first parent

$\overline{p}_2$ = Mean performance of the second parent

$\overline{F}_1$ = Mean performance of the F_1 hybrid

$$\text{S.E. for } \overline{MP} = \frac{\pm\sqrt{3 \text{ x Me}}}{R}$$

CD = S.E (d) x't' value at error degree of freedom at 5 per cent level of significance.

$$\text{Heterosis (\%) over better parent (B.P)} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

Where,

$\overline{F}_1$ = Mean performance of F1 hybrid

$\overline{BP}$ = Parent having highest performance in the desired direction.

$$\text{S.E for } \overline{BP} = \frac{\pm\sqrt{2 \text{ x Me}}}{2}$$

Results and Discussion

Heterotic effects over mid parent and better parent using pooled data were estimated for all twenty-four cross combinations (table 1). Significant and desirable heterosis was observed for all the traits except protein content. However, the magnitude of heterosis varied widely with the traits under study. Out of twenty-four cross combinations, heterosis over mid and better parent for grain yield plant^{-1} was significant and positive in all the crosses except KDM-2111 × C-4. None of the cross combination displayed significant positive heterosis over mid parent and better parent in desirable direction. The most promising F_1's were KDM-2113 × KDM-914A (284.27 %) KDM-2113 × KDM-343A (267.52%), KDM-2122 × KDM-343A (190.86%), KDM-2122 × KDM-914A (161.63%) and KDM-2121 × C-4 (126.28%) manifesting significantly high heterobeltiosis.

The F_1 heterosis over better parent for data taken for days to 50 per cent tasseling ranged from -10.58% (KDM-2107 × C-4 and KDM-2122 × C-4) to 16.48% (KDM-2111 × KDM-343A); for days to 50 per cent silking ranged from -9.45% (KDM-2122 × C-4) to 14.04% (KDM-2111 × KDM-343A); for plant height ranged from 15.36% (KDM-2117 × C-4) to 105.29% (KDM-2123 × KDM-914A); for ear height ranged from 20.17% (KDM-2107 × KDM-343A) to 91.07% (KDM-2122 × KDM-343A).; for prolificacy ranged from -27.27% (KDM-2107 × KDM-343A; KDM-2113 × KDM-343A and KDM-2117 × KDM-343A) to 15.91% (KDM-2104 × KDM-914A); for kernel rows‘ cob^{-1} ranged from -34.34% (KDM-2107 × KDM-914A) to 52.16% (KDM-2122 × KDM-343A); for kernel rows^{-1} ranged from -49.88% (KDM-2107 × C-4) to 40.32% (KDM-2123 × KDM-343A); for grain depth ranged from -0.32 per cent (KDM-2121 × KDM-343A) to 19.29 per cent (KDM-2122 × KDM-914A); for 100 grain weight ranged from -29.14% (KDM-2111 × C-4) to 19.66% (KDM-2121 × C-4) and for shelling percentage ranged from -7.77% (KDM-2104 × C-4) to 25.14% (KDM-2122 × KDM-914A). Significant heterosis for yield, yield component traits and flowering traits have been reported by several workers (Alam *et al*., 2008; Amiruzzaman *et al*., 2010; Amanullah *et al.,*2011; Jawaharlal *et al.,* 2012; Ali *et al*., 2012; Abauli *et al*., 2012; Izhar and Chakraborty, 2013; Singh *et al*., 2013; Rajesh *et al*., 2014 and Jain & Bharadwaj, 2014).

Conclusion

From the results of heterosis it can be concluded that the most worthy cross combination *viz*., KDM-2113 × KDM-914A for grain yield plant^{-1} also showed desirable and significant better parent heterosis for shelling percentage, 100 grain weight, grain depth, kernels row^{-1}, kernel rows cob^{-1}, days to 50 per cent tasseling and days to 50 per cent silking. The cross combinations KDM-2122 × C-4 (days to 50 per cent tasseling), KDM-2122 × C-4 (days to 50 per cent silking), KDM-2117 × C-4 (plant height), KDM-2104 × KDM-343A (ear height), KDM-2104 × KDM-914A (prolificacy), KDM-2122 × KDM-343A (kernel rows cob^{-1}), KDM-2123 × KDM-343A (kernels row^{-1}), KDM-2122 × KDM-914A (grain depth), KDM-2121 × C-4 (100 grain weight) and KDM-2122 × KDM-914A (shelling percentage) superseded their parents in terms of average heterosis and heterobeltiosis. The results suggested the presence of non additive gene action for the traits under study. Thus, these crosses could be commercially exploited for hybrid breeding

Table 1 : Estimation of heterosis (%) over mid and better parent for different traits in maize (*Zea mays* L.)

Crosses	Days to 50% tasselling		Days to 50% silking		Plant height (cm)	
	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
KDM-2104 × C-4	-5.99**	-4.49**	-5.74**	-4.88**	-3.70**	36.67**
KDM-2104 × KDM-914A	-8.31**	-1.43*	-6.35**	-0.34	68.53**	73.86**
KDM-2104 × KDM-343A	-6.96**	2.62**	-6.95**	1.05	56.74**	69.40**
KDM-2107 × C-4	-10.86**	-10.58**	-9.31**	-9.17**	11.82**	28.36**
KDM-2107 × KDM-914A	-7.74**	-2.14**	-7.87**	-3.04**	47.62**	85.15**
KDM-2107 × KDM-343A	-2.93**	5.62**	-1.63**	5.61**	6.10**	17.85**
KDM-2111 × C-4	-2.30	0.01	-2.18**	0.00	16.46**	24.38**
KDM-2111 × KDM-914A	-2.42	0.71	-0.33	2.70**	37.65**	87.25**
KDM-2111 × KDM-343A	10.09**	16.48**	8.51**	14.04**	33.39**	59.62**
KDM-2113 × C-4	-2.24**	-1.92**	-3.33**	-2.74**	23.30**	52.17**
KDM-2113 × KDM-914A	-8.08**	-2.50**	-8.92**	-3.38**	53.88**	79.36**
KDM-2113 × KDM-343A	-3.27**	5.24**	-2.76**	5.26**	45.99**	51.68**
KDM-2117 ×C-4	-0.676	3.47**	0.95	5.30**	-6.81**	15.36**
KDM-2117 ×KDM-914A	0.01	1.43*	0.33	1.35	45.59**	69.22**
KDM-2117 ×KDM-343A	-0.90	3.00**	0.51	3.51**	28.96**	33.63**
KDM-2121 ×C-4	-5.05**	0.01	-1.60**	3.72**	17.74**	27.74**
KDM-2121 ×KDM-914A	-3.20**	-2.86**	-2.70**	-2.70**	24.03**	65.63**
KDM-2121 ×KDM-343A	1.28*	4.12**	2.24**	4.21**	38.13**	62.49**
KDM-2122 ×C-4	-11.85**	-10.58**	-10.41**	-9.45**	25.14**	46.72**
KDM-2122 ×KDM-914A	-7.49**	-0.71	6.81**	-0.68**	59.80**	96.04**
KDM-2122 ×KDM-343A	0.34	10.49**	0.32	9.12**	59.51**	73.61**
KDM-2123 ×C-4	-6.91**	-4.39**	-7.17**	-5.10**	17.72**	31.94**
KDM-2123 ×KDM-914A	-4.17**	-1.43*	-2.95**	0.01	59.48**	105.29**
KDM-2123 ×KDM-343A	-2.31**	3.00**	-1.50*	3.51**	43.38**	63.08**

*,**Significant at 5 and 1 percent levels, respectively.

Table 1 contd….

Crosses	Ear height (cm)		Prolificacy		Kernel rows cob^{-1}	
	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
KDM-2104 × C-4	-12.74**	20.64**	17.24**	8.51*	21.66**	12.66**
KDM-2104 × KDM-914A	40.76**	40.46**	21.43**	15.91**	22.15**	12.76**
KDM-2104 × KDM-343A	60.95**	75.56**	1.05	-12.73**	47.11**	35.98**
KDM-2107 × C-4	19.06**	43.00**	-8.05*	-14.89**	-3.12**	-18.08**
KDM-2107 × KDM-914A	49.29**	68.62**	-4.76	-9.09*	-12.36**	-34.34**
KDM-2107 × KDM-343A	16.36**	20.17**	-15.79**	-27.27**	-8.50**	-31.39**
KDM-2111 × C-4	30.82**	38.19**	-8.05*	-14.89**	-4.63**	-8.10**
KDM-2111 × KDM-914A	24.79**	61.39**	0.01	-4.55	20.26**	0.33
KDM-2111 ×KDM-343A	32.96**	55.73**	-1.05	-14.55**	4.09**	-13.06**
KDM-2113 ×C-4	17.55**	32.86**	-8.05*	-14.89	23.12**	13.90**
KDM-2113 ×KDM-914A	31.91**	58.32**	-4.76	-9.09*	54.28**	42.56**
KDM-2113 ×KDM-343A	47.06**	60.68**	-15.79**	-27.27**	29.83*	20.13**

Table 1 contd….

Table 1 contd….

Crosses	Ear height (cm)		Prolificacy		Kernel rows cob^{-1}	
	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
KDM-2117 × C-4	1.54	23.05**	-8.05*	-14.89**	10.35**	3.57**
KDM-2117 × KDM-914A	31.13**	46.87**	-4.76	-9.09*	37.42**	25.20**
KDM-2117 × KDM-343A	27.54**	30.69**	-15.79**	-27.27**	42.59**	30.08**
KDM-2121 × C-4	18.30**	30.05**	-8.05*	-14.89**	8.90**	0.36
KDM-2121 × KDM-914A	23.92**	53.22**	-4.76	-9.09*	28.09**	18.82**
KDM-2121 × KDM-343A	45.96**	63.94**	-15.79**	-27.27**	14.03**	5.92**
KDM-2122 × C-4	42.43**	82.79**	-8.05*	-14.89**	8.58**	-3.23**
KDM-2122 × KDM-914A	76.76**	87.97**	-4.76	-9.09*	49.14**	43.28**
KDM-2122 × KDM-343A	86.52**	91.07**	1.05	-12.73**	58.16**	52.16**
KDM-2123 × C-4	20.82**	33.05**	-8.05*	-14.89**	-9.03**	-13.62**
KDM-2123 × KDM-914A	37.50**	69.69**	-4.76	-9.09*	11.04**	-8.49**
KDM-2123 × KDM-343A	47.37	65.23**	-3.16	-16.36**	26.91**	4.71**

*,** Significant at 5 and 1 percent levels, respectively.

Table 1 contd…

Crosses	Kernels row^{-1}		Grain depth (cm)		100-grain weight (g)	
	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
KDM-2104 × C-4	-27.25**	-42.67**	-7.76**	-16.81**	-0.24	-8.22**
KDM-2104 × KDM-914A	20.19**	19.76**	3.34**	-0.64	7.33**	4.43**
KDM-2104 ×KDM-343A	21.88**	18.54**	4.19**	0.32	15.84**	10.69**
KDM-2107 ×C-4	-27.68**	-49.88**	-3.76**	-14.01**	9.01**	-0.18
KDM-2107 ×KDM-914A	33.52**	11.81**	8.11**	2.89**	1.00	-2.22
KDM-2107 ×KDM-343A	17.23**	-4.27**	1.18**	-3.55**	-12.67**	-16.96**
KDM-2111 ×C-4	-23.90**	-36.23**	-14.57**	-14.57**	-24.64**	-29.14**
KDM-2111 ×KDM-914A	13.42**	4.71**	-3.29**	-9.52**	1.88	-9.23**
KDM-2111 ×KDM-343A	1.03	-3.93**	-6.75**	-12.89**	-15.94**	-23.85**
KDM-2113 ×C-4	-18.62**	-43.13**	-0.62	-10.64**	27.32**	17.78*
KDM-2113 ×KDM-914A	41.84**	20.21**	10.07**	5.47**	13.98**	11.56**
KDM-2113 ×KDM-343A	64.73**	36.09**	17.65**	12.90**	20.76**	16.07**
KDM-2117 ×C-4	-7.58**	-31.74**	-9.91**	-13.45**	-0.33	-4.97**
KDM-2117 ×KDM-914A	23.89**	13.61**	4.69**	1.82**	4.34**	-5.82**
KDM-2117 ×KDM-343A	0.34	-10.56**	6.73**	3.65**	-0.63	-8.77**
KDM-2121 ×C-4	5.20**	-8.51**	2.40**	-8.96**	22.39**	19.66**
KDM-2121 ×KDM-914A	-20.42**	-29.41**	-4.19**	-4.50**	18.24**	14.06**
KDM-2121 ×KDM-343A	-1.79	-10.39**	-0.16	-0.32	-10.25**	-11.83**
KDM-2122 ×C-4	-6.08**	-28.22**	1.60**	-11.20**	-9.25**	-13.52**
KDM-2122 ×KDM-914A	2.42	-1.49	28.37**	19.29**	20.36**	19.17**
KDM-2122 ×KDM-343A	6.49**	-0.61	15.08**	7.10**	12.32**	11.34**
KDM-2123 ×C-4	-8.81**	-24.59**	-5.69**	-11.76**	12.71**	8.97**
KDM-2123 ×KDM-914A	21.42**	13.82**	14.15**	14.15**	11.76**	9.01**
KDM-2123 ×KDM-343A	45.25**	40.32**	2.74**	2.57**	14.32**	13.59**

*,** Significant at 5 and 1 percent levels, respectively.

Table 1 contd….

Table 1 contd….

Crosses	Shelling percentage (%)		Grain yield plant^{-1} (g)		Protein content (%)	
	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
KDM-2104 × C-4	-3.56**	-7.77**	68.19**	60.03**	-20.09**	-28.45**
KDM-2104 × KDM-914A	8.68**	6.67**	88.50**	49.25**	-12.82**	-20.29**
KDM-2104 × KDM-343A	13.16**	12.39**	169.17**	118.81**	-12.57**	-20.50**
KDM-2107 × C-4	3.78**	0.35	70.50**	60.90**	-23.35**	-31.59**
KDM-2107 × KDM-914A	14.07**	10.72**	126.09**	95.37**	-8.28**	-16.41**
KDM-2107 × KDM-343A	5.25**	3.37**	67.75**	49.39**	-19.33**	-26.89**
KDM-2111 × C-4	2.22**	2.15**	16.08**	-6.04**	-12.65**	-23.44*
KDM-2111 × KDM-914A	10.04**	3.44**	95.44**	36.81**	-24.78**	-32.71**
KDM-2111 × KDM-343A	7.27**	1.99**	48.97**	6.43**	-18.69**	-27.66**
KDM-2113 × C-4	15.31**	7.84**	145.25**	97.85**	-20.85**	-32.08**
KDM-2113 × KDM-914A	21.63**	21.04**	294.28**	284.27**	-17.50**	-27.80**
KDM-2113 × KDM-343A	16.51**	14.58**	289.92**	267.52**	-13.39**	-24.59**
KDM-2117 × C-4	-3.22**	-5.02**	95.50**	84.47**	-22.98**	-30.85**
KDM-2117 × KDM-914A	5.97**	-2.19**	157.37**	102.46**	-20.97**	-27.54**
KDM-2117 × KDM-343A	4.29**	-2.66**	108.90**	68.67**	-27.39**	-33.79**
KDM-2121 × C-4	8.53**	6.56**	171.29**	126.26**	-22.41**	-28.87**
KDM-2121 × KDM-914A	25.03**	19.54**	68.83**	20.86**	-13.25**	-18.74**
KDM-2121 × KDM-343A	7.37**	3.84**	38.85**	1.57**	-20.96**	-26.38**
KDM-2122 × C-4	6.15**	-0.38	111.18**	74.47*8	-14.43**	-27.14**
KDM-2122 × KDM-914A	25.27**	25.14**	162.86**	161.63**	-6.71**	-19.00**
KDM-2122 × KDM-343A	19.46**	17.92**	199.67*8	190.86**	-6.48**	-19.22**
KDM-2123 × C-4	1.68**	1.01*	73.90**	42.25**	-15.71**	-23.19**
KDM-2123 × KDM-914A	11.28**	5.19**	99.36**	40.65**	-15.21**	-21.07**
KDM-2123 × KDM-343A	11.08**	6.20**	185.81**	105.89**	-16.05**	-22.29**

*,**Significant at 5 and 1 percent levels, respectively.

programmes in maize.

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