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Heterosis and Combining Ability Studies for Grain Yield and its Component traits in Maize (Zea Mays L.)

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ABSTRACT

Combining ability and heterosis for grain yield and its component traits were studied in maize through line x tester mating design using sixty three lines and two testers along with check DHM 117. The studies on combining ability in maize provide information to identity potential parents of hybrids and single cross hybrids. The results revealed that the existence of non-additive gene action for all the characters studied. The lines RSK-5, RSK-6, RSK-16 and RSK-47 and the tester BML-7 had recorded significant *gca* for yield and most of the yield component traits studied. The hybrid, RSK-105 x BML-6 recorded significant values for earliness while considering days to 50 percent tasselling and days to 50 percent silking. Three superior hybrids *viz*., RSK 5 x BML-7, RSK-109 x BML-6 and RSK-19 x BML-7 were identified for higher grain yield based on *per se* performance, *sca* effects and standard heterosis and will be proposed for multilocation testing across locations under AICRP.

Key words : Combining ability, Heterosis, Linex tester analysis, Maize.

Maize (*Zea mays* L.) is a versatile crop grown in 170 countries of the world. The area, production and productivity of maize in the world is around 162 mha, 820 mt and more than 5 t/ha, respectively (USDA, 2011). In India, maize area, production and productivity are estimated to be 8.3 mha, 20.23 mt and 2.4 t/ha, respectively in 2010-11 (DACNET). This was possible primarily due to high genetic potential of the existing genotypes of various maturity groups in different growing conditions. In recent years, the focused research on single cross hybrids has helped in increasing production and productivity of maize with impressive growth rate in area, production and productivity and led to expansion of the crop in non traditional areas. However, to further enchance the production and productivity in favourable as well as marginal environments, there is a need to widen the genetic base of SCH's presently under cultivation.

Parental selection is very important in SCH development. The value of any inbred line in hybrid breeding ultimately depends on its ability to combine very well with other lines to produce heterotic hybrids. Combining ability study is a good approach for screening the germplasm on the basis of gca and sca variances and effects and to understand the nature of gene action involved in the expression of various quantitative traits. Line x tester approach proposed by Kempthrone (1957) is the most convenient model to test a large number of genotypes for their combining ability. This method has been extensively used to identify good general combiner inbred lines and superior single cross hybrids with high specific combining ability effects which can be exploited directly as single cross hybrids. Accordingly, the present study was undertaken to have an insight into the nature of combining ability and standard heterosis for yield and its related characters in sixty three lines and two testers.

MATERIAL AND METHODS

Sixty three inbred lines were crossed with two inbred testers in a line x tester mating desing in *rabi*, 2010 to generate 126 hybrids. All the 126 crosses and a standard check DHM-117 were evaluated during *kharif*, 2011 at WALAMTARI, Rajendranagar. Each genotype was grown in one row plot of four meters length with 75 x 20 cm spacing in a randomized block design with two replications. The trial was conducted in a black loamy soil. All the recommended agronomic practices were followed to raise a normal crop. Data were recorded on five randomly selected plants in each treatment for eight characters viz., plant height, ear height, ear length, ear girth, number of kernels per row, number of kernel rows, shelling % and grain yield per plant and on plot basis for 50 percent tasselling, days to 50 percent silking, The data collected were subjected to analysis of variance as suggested by Panse and Sukhatme (1964). The combining ability analysis was done according to Kempthorne (1957). The magnitude of standard heterosis was estimated (Virmani *et al.,*(1982) over standard check DHM-117.

RESULTS AND DISCUSSION

The analysis of variance for most of the traits studied was highly significant indicating the existence of sufficient variation in the materials studied. Among the crosses, significant differences were observed for all the traits except days to 50 percent tasselling. Analysis of variance for combining ability revealed that the mean squares due to lines were significant for plant height. The testers showed significant differences for all the traits except ear girth, shelling percent and grain yield per plant indicating that there was a good level of genetic difference among the testers. The contribution of testers for total variation was of higher proportion compared to lines for all characters except ear girth (Table : 1). The variance due to line x tester interaction was significant for all the characters studied except days to 50 percent tasselling indicating predominant role of non additive gene action for all the characters. This was further confirmed by the higher magnitude of *sca* variances compared to *gca,* (Table : 1). This was also reported by Jayakumar and Sundaram (2007) and Premlatha and Kalamani (2010) in Maize.

The parents having high *gca* effects would be useful since the *gca* effect is due to additive gene action and is fixable and heritable (Sprague and Tatum, 1942). Premlatha and Kalamani (2010) also identified good general combiners and superior hybrids in maize. In the present study, the lines, RSK-11 and RSK-106 possessed low *per se* and turned out to be good general combiners for days to 50 percent tasselling and days to 50 percent silking and contributed maximum favorable genes for earliness. Thus, they can be used as potential donors for inducing earliness. Similar results were reported by Jebaraj *et al.*,(2010) and Murali Krishna *et al.*,(2012) in Maize. The line, RSK-19 contributed maximum favorable genes for plant height, ear height, ear girth, number of kernels per row and number of kernel rows (Table 2).

Grain yield is a complex character and is influenced by number of component traits. RSK-15 and RSK-16 were good combiners as evidenced by their significant gene effects for ear length, ear girth, number of kernel rows and grain yield per plant suggesting that for improving yield, these parents would play a key role. Such good combiners could also be inter crossed to develop high yielding composites. Inbreds *viz*., RSK-15, RSK-67 and RSK-108 were good combiners for shelling percentage. The tester BML-7 had significant *gca* for most of the traits (Table 2). The parents with high *gca* could produce superior segregates in the F_2 as well as in later generations. The lines, RSK-5, RSK-6, RSK-16, RSK-47 and the tester BML-7 had recorded higher gca for most of the yield and yield contributing characters, therefore, these may be utilized in the hybridization programme for selecting superior recombinants.

The *sca* effects are the manifestation of non additive components of genetic variation and are highly valuable for discrimination of crosses for their genetic worth as breeding material. The significance of *sca* effects elucidates the presence of genetic diversity among the breeding material tested and illustrated the contribution of dominance and epistatic effects which is non fixable in nature and is a chief cause of heterosis.

Earliness is a desirable character as these hybrids mature early and mostly suited for rainfed and low rainfall areas and also intercropping. In the present investigation also, the hybrid, RSK-105 x BML-6 exhibited high and significant negative sca for earliness and is resultant of non-additive gene action which could be improved through suitable population improvement programme in addition to utilizing them in heterosis breeding. The crosses, RSK-22 x BML-6, had high sca for plant height while RSK-45 x BML-7 possessed high *sca* effect for ear height, ear girth, number of kernels per row and shelling percentage. The crosses, RSK-66 x BML-6, RSK-88 x BML-6 and RSK-104 x BML-7 recorded high and significant *sca*

Table 1. ANOVA for Line x Tester analysis for yield and yield components in maize.

	df	Days to tasseling	Days to silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear girth (cm)	Kernels/ row	Kernel rows	Shelling %	Grain yield/ plant (g)
Replicates	1.00	5.37	0.06	43.25	1.14	0.05	0.24	0.04	1.06	0.87	0.02
Crosses	125.00	8.77	10.95***	374.57 ***	413.51***	4.74***	2.92***	35.86***	4.40 ***	43.29 ***	1737.89***
Line Effect	62.00	8.60	10.12	475.28**	389.95	4.51	3.20	37.69	3.97	45.86	2068.21
Tester Effect	1.00	44.59*	94.11**	1444.76 *	9762.67 ***	109.48***	0.56	170.04*	67.06 ***	64.70	4646.59
Line * Tester Eff.	62.00	8.37	10.44***	256.60***	286.28 ***	3.29***	2.67***	31.87***	3.81 ***	40.38	**1360.66 ***
Error	125.00	6.57	5.08	126.60	18.58	0.29	0.44	1.00	0.59	21.99	512.40
Total	251.00	7.66	7.99	249.76	215.19	2.51	1.67	18.36	2.49	32.51	1120.66
?² gca		0.31	0.72	12.82	77.81	0.87	0.02	1.58	0.54	0.51	43.77
?² sca		0.90	2.68	65.00	133.85	1.50	1.12	15.43	1.61	9.19	424.13

* : Significant at (P<0.05) ** : Significant at (P<0.01) *** : Significant at (P<0.001)

effects for number of kernel rows. RSK-109 x BML-6 cross revealed high and significant *sca* effects for ear length, ear girth and grain yield. The hybrids RSK-19 x BML-7 and RSK-5 x BML-7 had significant sca effect for ear length and grain yield. These hybrids exhibited 27.0 to 44.84 per cent superiority of grain yield over the check hybrid, DHM-117. None of the parents were good general combiners and hence these crosses could be utilized for heterosis breeding. Similar results in maize have been reported by Premlatha and Kalamani (2010) and Murali Krishna *et al.,* (2012). Further, Jebaraj *et al.* (2010) reported that the expression of high positive sca effects might be due to dominant x recessive interactions. These hybrids were expected to produce desirable segregants in the subsequent generations and could also be improved through recombination breeding.

The commercial hybrid, DHM-117 was used as a standard check. Negative heterosis was considered desirable for days to 50 percent tasselling and days to 50 percent silking. In similar lines, the hybrids, RSK-11 x BML-7, RSK-48 x BML-7, RSK-50 x BML-7, RSK-68 x BML-7, RSK-94 x BML-7, RSK-105 x BML-6 and RSK-107 x BML-7 had negative heterosis for days to 50 percent tasselling and days to 50 percent silking, RSK-19 X BML-7 for plant height, ear length, ear girth, number of kernels per row and grain yield per plant, RSK-31 x BML-6 and RSK-40 x BML-6 and for ear height, RSK-67 x BML-7 for ear length, ear girth, number of kernel rows, shelling percentage, RSK-56 x BML-6 and RSK-88 x BML-6 for number of kernel rows, RSK-5 x BML-7, RSK-19 x BML-7 and RSK-109 x BML-6 for ear length, ear girth and grain yield per plant exhibited highest significant positive standard heterosis. Similar results were reported by Singh *et al.,* (2010) and Premlatha and Kalamani (2010) in Maize.

To develop a commercial hybrid, *per se* performance, *sca* effects and the extent of heterosis are chiefly considered (Murali Krishna *et al.,* 2012). Among the 126 hybrids, RSK-5 x BML-7, RSK-19 x BML-7 and RSK-109 x BML-6 had significant *per se* performance, *sca* effects and standard heterosis for ear girth, ear length and grain yield per plant (Table 2). Therefore, these hybrids were of considerable practical importance which were proved to be superior over popular commercial hybrid.

Table 2. Mean performance, combining ability and heterotic combinations of the best parents and crosses for yield and yield components in maize.

Characters	Lines	Testers	*Per se* performance of the best crosses	Good specific combiners	Heterotic combinations
Days to tasseling	RSK-11 (-3.472 **) RSK-106(-2.722 *)	Nil	RSK-48 x BML-7 (48 days) RSK-105 x BML-6 (48 days) RSK-107 x BML-7 (47 days)	RSK-105 x BML-6 (-3.671 *)	RSK-48 x BML-7 (-14.80 **) RSK-11 x BML-7 (-12.13 **)
Days to silking	RSK-11(-3.532 **) RSK-106 (-2.532 *)	BML-7 (-0.611 **)	RSK-48 x BML-7 (51.0 days) RSK-105 x BML-6 (51.0 days) RSK-107 x BML-7 (49 days)	RSK-105 x BML-6 (-3.361 *)	RSK-11 x BML-7 (-8.04 *) RSK-48 x BML-7 (-9.82 *)
Plant height (cm)	RSK-19 (21.309 ***)	BML-6 (2.394 *)	RSK-19 x BML-7 (247 cm)	RSK-22 x BML-6(22.856 **) RSK-44 x BML-7 (16.979 *) RSK-95 x BML-7 18.647 *)	RSK-19 x BML-7 (10.31 *)
Ear height (cm)	RSK-19 (8.310 ***)	BML-6 (6.224 ***)	RSK-31x BML-6 (134.15)	RSK-45 x BML-7 (13.149 ***)	RSK-40 x BML-6 (12.951 ***) RSK-31 x BML-6 (10.451 ***)
Ear length (cm)	RSK-15(1.683 ***) RSK-16 (2.308 ***)	BML-7 (0.659 ***)	RSK-5 x BML-7 (18.0) RSK-19 x BML-7 (18.0) RSK-109 x BML-6 (18.0)	RSK-109 x BML-6 (2.309 ***) RSK-19 x BML-7 (1.191 **) RSK-5 x BML-7 (0.966 *)	RSK-67 x BML-7 (42.61 **) RSK-19 x BML-7 (22.24 **) RSK-109 x BML-6 (22.24 **) RSK-5 x BML-7 (20.54 **)
Ear girth (cm)	RSK-15(1.009 **) RSK-16(1.109 **) RSK-19(0.709 *)	Nil	RSK-109 x BML-6 (15.0)	RSK-109 X BML-6 (1.553 **) RSK-45 x BML-7 (1.122 *)	RSK-19 x BML-7 (13.42 **) RSK-67 x BML-7 (13.42 **) RSK-109 x BML-6 (13.42 **)
Number of Kernels/ row	RSK-15(2.460 ***) RSK-19(2.960 ***)	BML-7 (0.821 ***)	RSK-45 x BML-7 (39.0) RSK-5 x BML-7 (38.0) RSK-19 x BML-7 (38.0)	RSK-45 x BML-7 (6.179 ***) RSK-5 x BML-7 (1.429 *)	RSK-19 x BML-7 (21.41 **)
Number of Kernel rows	RSK-19 (1.421 ***)	BML-6 (0.516 ***)	RSK-88 x BML-6 (18.0)	RSK-104 x BML-7 (2.016 ***) RSK- 66 x BML-6 (1.984 ***) RSK-88 x BML-6 (1.984 ***)	RSK-56 x BML-6 (26.67 **) RSK-88 x BML-6 (20.00 **)
Shelling %	RSK-15(5.825 *) RSK-67(5.747 *) RSK-108(4.705 *)	Nil	RSK-67 x BML-7 (93.00)	RSK-45 x BML-7 (7.082 *)	RSK-67 x BML-7 (15.62 **)
Grain yield/ plant gm	RSK-16 (52.128***) RSK-47 (45.13***) RSK-5 (39.28***) RSK-6 (39.13***) RSK-15(35.378 **)	BML-7(4.294 *)	RSK-5 x BML-7 (239.5) RSK-109 x BML-6 (2 14.0) RSK-19 x BML-7 (210.0)	RSK-109 x BML-6 (46.794 **) RSK-19 x BML-7 (39.456 *) RSK-5 x BML-7 (39.306 *)	RSK-5 x BML-7 (44.84**) RSK-109 x BML-6 (29.42**) RSK-19 x BML-7 (27.00**)

* : Significant at (P<0.05) ** : Significant at (P<0.01) *** : Significant at (P<0.001)

LITERATURE CITED

Jayakumar, J and Sundaram T 2007 Combining ability studies for grain yield and other yield components in maize (*Zea mays L.*). *Crop Research*, 33 (1, 2 & 3): 179-186.

Jebaraj S, Selva Kumar, A and Shanthi P 2010 Study of gene, action in maize hybrids. *Indian Journal of Agriculture Research.* 44 (2): 136-140.

Kempthorne O 1957 An Introduction to Genetic Statistics. *John Wiley and Sons, INC.*, New York, pp.458-71.

Murali Krishna K, Ranga Reddy R and Sai Kumar R 2012 Heterosis and Combining abilityfor yield and its traits in maize (*Zea mays* L.). *Maize Journal,* I(1): 40-45 (April 2012).

Panse V G and Sukhatme P V 1964 Statistical methods for Agricultureal Research Workers. ICAR, New Delhi, P.381.

Premlatha and Kalamani A 2010 Heterosis and combining ability studies for grain yield and growth characters in maize (*Zea mays* L.). *Indian Journal of Agricultural Research,* 44(1): 62-65.

Sprague G F and Tatum L A 1942 General Vs Specific Combining ability in single crosses of corn. J.Amer. Soc. Agron. 34: 923-32.

Singh A K, Shahi J P and Rakshit S 2010 Heterosis and combining ability for yield and its related traits in maize (*Zea mays* L.) in contrasting environments. *Indian Journal of Agricultural Sci*ences, 80(3): 248-49.

Virmani S S, Aquino R O and Khush G S 1982 Heterosis breeding in Rice (*Oryza sativa* L.).*Theoritical and Applied Genetics,* 63: 373-380.

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