Biolife
AN INTERNATIONAL QUARTERLY JOURNAL OF BIOLOGY & LIFE SCIENCES
1(2):-65-69, 2013
ISSN (online): 2320-4257
www.biolifejournals.com
BIOLIFE ORIGINAL ARTICLE

Heterosis in Relation to Combining Ability in Quality Protein Maize (*Zea Mays* L.)

P. K. Singh*, Nitish Singh, A. K. Singh, J. P. Shahi and M. Rao

Department of Genetics and Plant Breeding, Institute of Agricultural Sciences
Banaras Hindu University, Varanasi 2210 05, India
E-mail: pksbhu@gmail.com

ABSTRACT

Thirty nine experimental hybrids were evaluated along with thirteen advance inbred parental lines and three testers in quality protein maize during *Kharif* 2008. Analysis of variance revealed significant deference among the parents and experimental hybrids for all the character studied. Mean square due to parents *vs* hybrids were also observed significant for all the traits. The inbreds HKI-164-3(2-1), CML 451 (P2) and HUZQPM-1 were good general combiner for yield and many of the yield attributing traits. Taking in to consideration of the *per se* performance, sca effect and standard heterosis, the HKI-164-3 (2-1) X CML-169-5-4 was the best QPM hybrid yielding 35 per cent more grain yield per plot followed by CML451 (P2) X CML – 169-5-4 (29%) over the superior check single cross hybrid Shaktiman-2. Crosses between high X high and high X low gca parents exhibited greater heterosis. Heterosis for yield was generally accompanied by heterosis for yield components.

Key words : Combining ability, Grain yield, Heterosis and QPM.

INTRODUCTION

The single cross quality protein maize hybrids have become popular among Indian farmers due to their high yield potential and excellent uniformity. The success depends on the availability of productive diverse quality protein maize inbred lines and clear knowledge of gene action for specific traits to develop QPM hybrids. Combining ability is a powerful tool in identifying the best combiners for hybridization especially, when a large number of advance inbred lines are available and most promising once are to be selected on the basis of their ability to give superior quality protein maize hybrids. The present investigation was therefore, planned to estimate the extent of heterosis and combining ability of parents and crosses in QPM hybrid breeding programme using Line X Tester approach (Kampthorne, 1957).

MATERIALS & METHODS

The experimental material consisted of thirteen diverse QPM inbred lines viz. HUZQPM-1, HUZQPM-2, HUZQPM-3, HUZQPM-4, CML-172, (CML-161, CML-451)-3, HKI-164-4-(1-3)-2, (CL-G2501 CML170)-E, HKI-164-3-(2-1)-1, HKI-170(1+2), CML 451 (P2), (CML 15 X CL-CO 3618)-8, CML-171 and three testers namely CML-193-2-1, HUZQPM-467, CML-169-5-4 planted during *Rabi* 2007-08 at Agricultural research Farm, Institute of Agricultural Sciences, Banaras Hindu University Varanasi. The crosses were made in the same season in Line X Tester mating design. The resultant thirty nine single cross hybrids along with their parents and two check hybrids were evaluated in the randomized block design with three replications during *Kharif* 2008. Each entry was raised in a plot consisting of two rows of three meter length with a spacing of 70 x 20 cm. Observation on 20 competitive randomly selected plant from each replication were recorded for days to 50 per cent tasselling, days to 50 per cent silking, days to 50 per cent brown husk, plant height, ear height, ear length, ear diameter, number of kernel per row, number of kernel row per ear and yield per plot. The data were subjected to analysis of variance, computation of heterosis and combining ability adopting standard procedure.

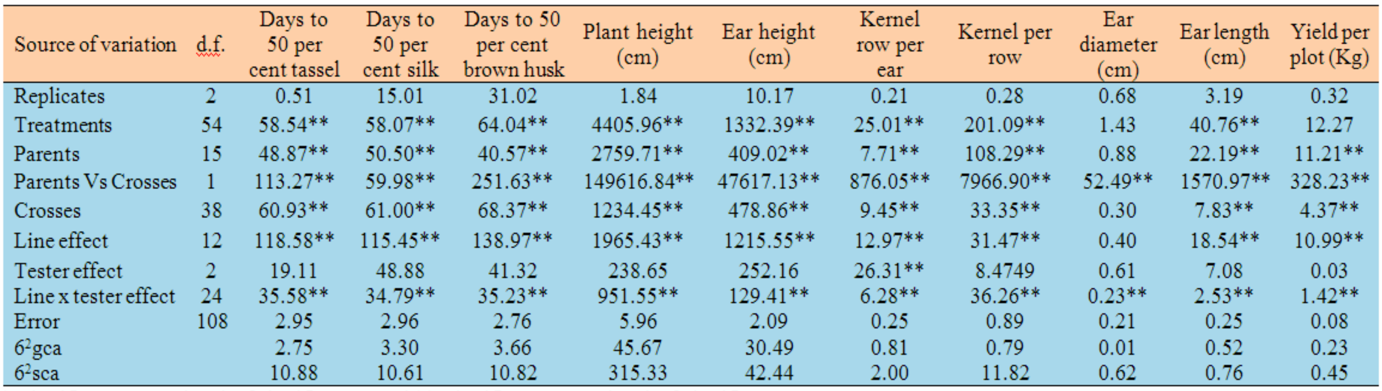
RESULTS & DISCUSSION

The analysis of variance revealed highly significant difference for all the characters studied (Table 1). The mean square due to parents also differed significantly indicating that the parents involved in the study were diverse for all the characters except ear diameter. The variance due to parents' vs crosses differs significantly indicating the presence of high heterosis response in the material studied. Significant differences were also observed among the crosses for all the characters except ear diameter. Among the lines, significant differences were observed for days to 50 per cent tassel, days to 50 per cent silk, days to 50 per cent brown husk, plant height, kernel row per ear, kernel per row, ear diameter, ear length and yield per plot while the difference for tester was non-significant for all the traits studied except kernel row per ear. The variance due to SCA was more pronounced than variance due to GCA for all the characters indicating the importance of non-additive genetic variance in the material studied which favour the production of hybrid cultivars. These results are in agreement with earlier reports of Singh *et al.* (2012).

Pronounced heterosis was observed in most of the characters. The expression and magnitude of heterosis however, varied for different traits in the same cross and even for same traits among the crosses. The two experimental hybrids namely, HKI-164-3 (2-1)-1 X CML-169-5-4 and CML-451 (P_2) X CML-169-5-4 were identified as superior hybrids and they yielded 35.0 and 29.0 per cent more grain yield, respectively ever best check hybrid Shaktiman-2. On the other hand, lowest heterosis over the best check was observed in the cross (CML-161, CML-451)-3 X CML-169-5-4 (-42.20%). This may be attributed to presence of non additive gene effect for grain yield. These results were supported by the work of Ikramullah *et al.* (2011) in quality protein maize.

The gca effects of the parents for different traits under study are presented in table 2. The parents HKI-164-3 (2-1)-1, CML-451 (P_2) and HUZQPM-1 were observed as good general combiners for grain yield. Besides grain yield for earliness and yield attributing traits. Similar pattern was reported by Singh and Kumar (2008).

Table-1: Analysis of Variance for Line x Tester mating design in QPM maize.



Source of variation	d.f.	Days to 50 per cent tassel	Days to 50 per cent silk	Days to 50 per cent brown husk	Plant height (cm)	Ear height (cm)	Kernel row per ear	Kernel per row	Ear diameter (cm)	Ear length (cm)	Yield per plot (Kg)
Replicates	2	0.51	15.01	31.02	1.84	10.17	0.21	0.28	0.68	3.19	0.32
Treatments	54	58.54**	58.07**	64.04**	4405.96**	1332.39**	25.01**	201.09**	1.43	40.76**	12.27
Parents	15	48.87**	50.50**	40.57**	2759.71**	409.02**	7.71**	108.29**	0.88	22.19**	11.21**
Parents Vs Crosses	1	113.27**	59.98**	251.63**	149616.84**	47617.13**	876.05**	7966.90**	52.49**	1570.97**	328.23**
Crosses	38	60.93**	61.00**	68.37**	1234.45**	478.86**	9.45**	33.35**	0.30	7.83**	4.37**
Line effect	12	118.58**	115.45**	138.97**	1965.43**	1215.55**	12.97**	31.47**	0.40	18.54**	10.99**
Tester effect	2	19.11	48.88	41.32	238.65	252.16	26.31**	8.4749	0.61	7.08	0.03
Line x tester effect	24	35.58**	34.79**	35.23**	951.55**	129.41**	6.28**	36.26**	0.23**	2.53**	1.42**
Error	108	2.95	2.96	2.76	5.96	2.09	0.25	0.89	0.21	0.25	0.08
6^{2}gca		2.75	3.30	3.66	45.67	30.49	0.81	0.79	0.01	0.52	0.23
6^{2}sca		10.88	10.61	10.82	315.33	42.44	2.00	11.82	0.62	0.76	0.45

* Significant at 5% level of significance and ** Significant at 1% level of significance.

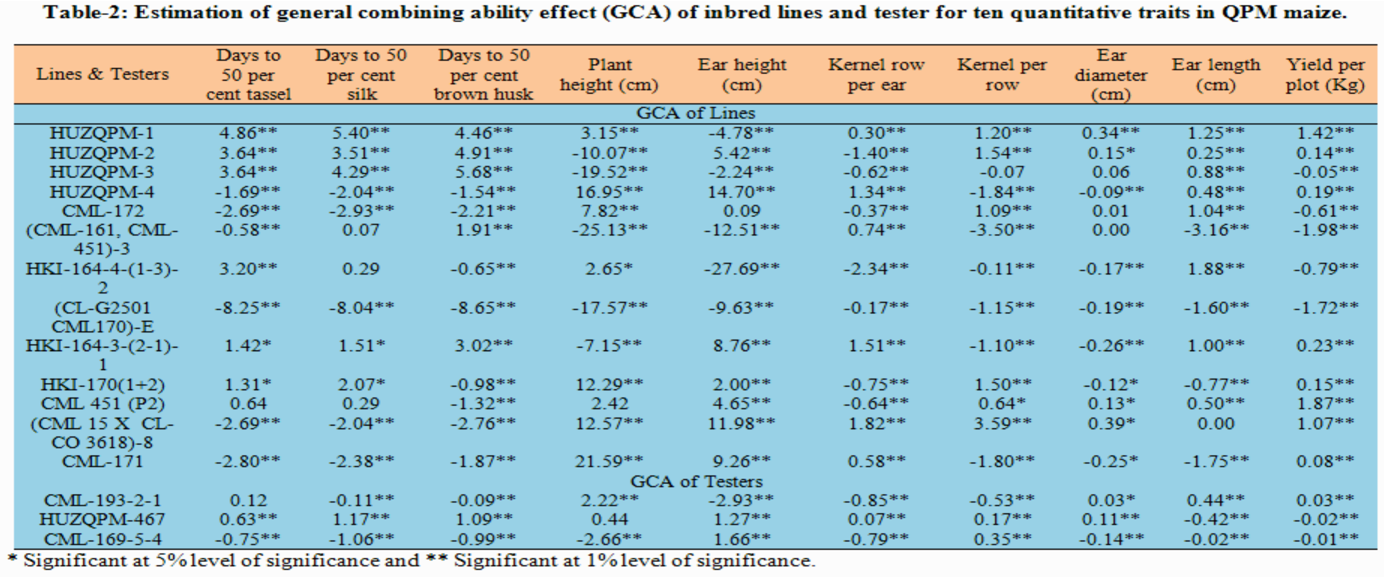


Table-2: Estimation of general combining ability effect (GCA) of inbred lines and tester for ten quantitative traits in QPM maize.

Lines & Testers	Days to 50 per cent tassel	Days to 50 per cent silk	Days to 50 per cent brown husk	Plant height (cm)	Ear height (cm)	Kernel row per ear	Kernel per row	Ear diameter (cm)	Ear length (cm)	Yield per plot (Kg)
GCA of Lines										
HUZQPM-1	4.86**	5.40**	4.46**	3.15**	-4.78**	0.30**	1.20**	0.34**	1.25**	1.42**
HUZQPM-2	3.64**	3.51**	4.91**	-10.07**	5.42**	-1.40**	1.54**	0.15*	0.25**	0.14**
HUZQPM-3	3.64**	4.29**	5.68**	-19.52**	-2.24**	-0.62**	-0.07	0.06	0.88**	-0.05**
HUZQPM-4	-1.69**	-2.04**	-1.54**	16.95**	14.70**	1.34**	-1.84**	-0.09**	0.48**	0.19**
CML-172	-2.69**	-2.93**	-2.21**	7.82**	0.09	-0.37**	1.09**	0.01	1.04**	-0.61**
(CML-161, CML-451)-3	-0.58**	0.07	1.91**	-25.13**	-12.51**	0.74**	-3.50**	0.00	-3.16**	-1.98**
HKI-164-4-(1-3)-2	3.20**	0.29	-0.65**	2.65*	-27.69**	-2.34**	-0.11**	-0.17**	1.88**	-0.79**
(CL-G2501 CML170)-E	-8.25**	-8.04**	-8.65**	-17.57**	-9.63**	-0.17**	-1.15**	-0.19**	-1.60**	-1.72**
HKI-164-3-(2-1)-1	1.42*	1.51*	3.02**	-7.15**	8.76**	1.51**	-1.10**	-0.26**	1.00**	0.23**
HKI-170(1+2)	1.31*	2.07*	-0.98**	12.29**	2.00**	-0.75**	1.50**	-0.12*	-0.77**	0.15**
CML 451 (P2)	0.64	0.29	-1.32**	2.42	4.65**	-0.64**	0.64*	0.13*	0.50**	1.87**
(CML 15 X CL-CO 3618)-8	-2.69**	-2.04**	-2.76**	12.57**	11.98**	1.82**	3.59**	0.39*	0.00	1.07**
CML-171	-2.80**	-2.38**	-1.87**	21.59**	9.26**	0.58**	-1.80**	-0.25*	-1.75**	0.08**
GCA of Testers										
CML-193-2-1	0.12	-0.11**	-0.09**	2.22**	-2.93**	-0.85**	-0.53**	0.03*	0.44**	0.03**
HUZQPM-467	0.63**	1.17**	1.09**	0.44	1.27**	0.07**	0.17**	0.11**	-0.42**	-0.02**
CML-169-5-4	-0.75**	-1.06**	-0.99**	-2.66**	1.66**	-0.79**	0.35**	-0.14**	-0.02**	-0.01**

* Significant at 5% level of significance and ** Significant at 1% level of significance.

Table-3: Elite five specific combination for grain yield and its components in QPM maize

Character	Cross	GCA effect	Heterosis	Cross	SCA
Days to 50 per cent tassel	(CL-G2501 CML170)-E X CML-169-5-4	H X H	-23.28**	(CML-161, CML-451)-3 X CML-193-2-1	5.99**
	(CL-G2501 CML170)-E X CML-193-2-1	H X L	-22.75**	HKI-170(1+2) X CML-169-5-4	4.64**
	(CML-161, CML-451)-3 X CML-169-5-4	H X H	-21.69**	HUZQPM-1 X CML-169-5-4	4.42**
	CML-172 X CML-193-2-1	H X L	-16.40**	CML 451 (P2) X CML-193-2-1	3.77**
	HUZQPM-4 X CML-169-5-4	H X H	-15.87**	HKI-164-3-(2-1)-1 X CML-169-5-4	3.17**
Days to 50 per cent silk	(CL-G2501 CML170)-E X CML-169-5-4	H X H	-20.30**	(CML-161, CML-451)-3 X CML-193-2-1	6.78**
	(CL-G2501 CML170)-E X CML-193-2-1	H X H	-19.80**	HUZQPM-1 X CML-169-5-4	5.06**
	(CML-161, CML-451)-3 X CML-169-5-4	L X H	-19.80**	HUZQPM-4 X CML-193-2-1	3.89**
	(CL-G2501 CML170)-E X HUZQPM-467	H X L	-15.23**	HKI-164-4-(1-3)-2 X HUZQPM-467	3.61**
	HUZQPM-4 X CML-169-5-4	H X H	-14.21**	HKI-170(1+2) X CML-169-5-4	3.06**
Days to 50 per cent brown husk	(CL-G2501 CML170)-E X HUZQPM-467	H X L	-13.57**	HKI-170(1+2) X CML-169-5-4	4.21**
	(CL-G2501 CML170)-E X CML-193-2-1	H X H	-11.07**	HKI-170(1+2) X CML-169-5-4	4.21**
	(CL-G2501 CML170)-E X CML-169-5-4	H X H	-10.36**	HUZQPM-4 X CML-193-2-1	4.20**
	HKI-164-4-(1-3)-2 X CML-193-2-1	H X H	-10.00**	CML 451 (P2) X CML-193-2-1	3.98**
	HUZQPM-4 X CML-169-5-4	H X H	-7.29**	(CML-161, CML-451)-3 X CML-193-2-1	3.09**
Plant height (cm)	(CL-G2501 CML170)-E X CML-193-2-1	H X L	-25.93**	HKI-164-3-(2-1)-1 X CML-169-5-4	24.38**
	HKI-164-3-(2-1)-1 X CML-193-2-1	H X L	-23.58**	(CL-G2501 CML170)-E X CML-169-5-4	22.49**

	(CML-161, CML-451)-3 X HUZQPM-467	H X L	-21.14**	HUZQPM-3 X CML-193-2-1	20.89**
	(CML-161, CML-451)-3 X CML-169-5-4	H X H	-18.58**	(CML-161, CML-451)-3 X CML-193-2-1	19.99**
	HUZQPM-3 X HUZQPM-467	H X L	-17.84**	CML-172 X CML-193-2-1	18.72**
Ear height (cm)	HKI-164-4-(1-3)-2 X HUZQPM-467	H X L	-35.73**	CML-171 X HUZQPM-467	10.84**
	HKI-164-4-(1-3)-2 X CML-193-2-1	H X H	-32.00**	HKI-164-3-(2-1)-1 X CML-169-5-4	10.78**
	HKI-164-4-(1-3)-2 X CML-169-5-4	H X L	-26.13**	(CML-161, CML-451)-3 X CML-193-2-1	8.31**
	(CML-161, CML-451)-3 X CML-169-5-4	H X L	-13.87**	CML-172 X HUZQPM-467	7.18**
	(CML-161, CML-451)-3 X HUZQPM-467	H X L	-8.75**	HUZQPM-2 X CML-169-5-4	5.79**
Kernel row per ear	(CML 15 X CL-CO 3618)-8 X CML-169-5-4	H X L	49.86**	HUZQPM-3 X CML-193-2-1	2.72**
	HKI-164-3-(2-1)-1 X CML-169-5-4	H X L	47.92**	HKI-164-3-(2-1)-1 X CML-169-5-4	1.78**
	HUZQPM-4 X CML-169-5-4	H X L	41.55**	(CML 15 X CL-CO 3618)-8 X CML-169-5-4	1.70**
	(CML-161, CML-451)-3 X CML-169-5-4	H X L	40.17**	(CML-161, CML-451)-3 X CML-169-5-4	1.61**
	CML-171 X CML-169-5-4	H X L	27.93**	HKI-170(1+2) X CML-193-2-1	1.21**
Kernel per row	HUZQPM-2 X CML-193-2-1	H X L	14.10**	HKI-164-3-(2-1)-1 X CML-169-5-4	5.34**
	HKI-164-3-(2-1)-1 X CML-169-5-4	L X H	13.77**	HKI-164-4-(1-3)-2 X CML-169-5-4	4.25**
	CML 451 (P2) X HUZQPM-467	H X H	13.66**	CML-171 X CML-193-2-1	3.95**
	CML-172 X CML-193-2-1	H X L	13.55**	HUZQPM-4 X HUZQPM-467	3.85**
	HKI-164-4-(1-3)-2 X CML-169-5-4	L X H	13.44**	CML 451 (P2) X HUZQPM-467	3.75**
Ear diameter (cm)	(CML 15 X CL-CO 3618)-8 X HUZQPM-467	H X H	28.07**	HKI-170(1+2) X CML-193-2-1	0.56**
	HKI-170(1+2) X CML-193-2-1	L X H	27.16*	HUZQPM-4 X CML-169-5-4	0.41**
	HUZQPM-1 X CML-193-2-1	H X H	26.61*	(CML-161, CML-451)-3 X CML-169-5-4	0.35**
	HUZQPM-4 X HUZQPM-467	L X H	26.24*	HUZQPM-3 X HUZQPM-467	0.31**
	HUZQPM-2 X HUZQPM-467	H X H	25.69*	HUZQPM-3 X CML-193-2-1	0.26*
Ear length (cm)	HKI-164-4-(1-3)-2 X CML-169-5-4	H X L	23.04**	(CML-161, CML-451)-3 X HUZQPM-467	1.39**
	HUZQPM-2 X CML-193-2-1	H X H	19.45**	HUZQPM-2 X CML-193-2-1	1.23**
	HUZQPM-1 X CML-169-5-4	H X L	19.03**	HKI-170(1+2) X CML-193-2-1	1.19**
	HKI-164-3-(2-1)-1 X CML-169-5-4	H X L	18.18**	(CML 15 X CL-CO 3618)-8 X CML-193-2-1	1.11**
	HKI-164-4-(1-3)-2 X HUZQPM-467	H X L	17.97**	HKI-164-3-(2-1)-1 X CML-169-5-4	0.73**
Yield per plot (Kg)	HKI-164-3-(2-1)-1 X CML-169-5-4	H X L	34.72**	HKI-164-3-(2-1)-1 X CML-169-5-4	2.00**
	CML 451 (P2) X CML-169-5-4	H X L	28.78**	HUZQPM-3 X CML-193-2-1	0.85**
	CML 451 (P2) X HUZQPM-467	H X L	28.55**	CML-172 X CML-193-2-1	0.81**
	CML 451 (P2) X CML-193-2-1	H X H	27.77**	CML-172 X HUZQPM-467	0.58**
	HUZQPM-1 X HUZQPM-467	H X L	24.33**	HUZQPM-2 X CML-169-5-4	0.41**

The five most promising combinations selected separately on the basis of heterotic effect over best check viz. Shaktiman-2 and their gca and sca effects are presented character wise in table 3. Most of these cross combinations were uniformly superior for sca as well as heterosis. The cross combinations HKI-164-3-(2-1)-1 X CML-169-5-4, HUZQPM-3 X CML-193-2-1, CML-172 X CML-193-2-1, CML-172 X HUZQPM-467 and HUZQPM-2 X CML-169-5-4 showed positive and significant response over check hybrid for yield and these crosses had high heterosis for yield components, in particular kernel rows per ear, ear diameter and kernel per row. This indicates that heterosis for yield was through individual yield components. Similar observation on high heterosis for grain yield was reported by Wali *et al.* (2010) and Singh *et al.* (2012).

CONCLUSION

A perusal of heterotic behaviour and magnitude of heterosis in the superior experimental hybrids revealed that heterosis for grain yield may be because of the fact that atleast one parent involved in these crosses had desirable and significant gca effect suggesting besides genetic diversity gca effect should also taken in to account for heterosis breeding.

The present studies, therefore, suggested that the inbreds HKI-164-3-(2-1)-1, CML-451 (P_2) and HUZQPM-1 were promising parents giving high heterosis for most of the traits has potential and being exploited in breeding programme may prove useful for improvement for yield and other component traits. The experimental hybrids HKI-164-3-(2-1)-1 X CML-169-5-4 and HUZQPM-3 X CML-193-2-1 manifested high sca as well as heterotic effect for grain yield and other traits indicating such experimental hybrids may be used in QPM hybrid breeding programmes.

REFERENCES

1. **Ikramullah, Khalil, I. H., Noor, M. and Shah, M. K. N.** 2011. *Sarhad J. Agric.* **27(3):** 403.
2. **Kampthorne, O.** (1957) *"An introduction to Genetical Statistics"*, John Willey and Sons, New York, pp 323-331.
3. **Singh, P. K. and Kumar, N.** (2008) Proceeding of the 10th Asian Regional Maize Workshop, Makassar, Indonesia, pp 72-73.
4. **Singh, P. K., Singh, A. K., Shahi J. P. and Ranjan R.** (2012) *The Bioscan* **7(2):** 337.
5. **Wali, M. C., Kachapur, R. M., Chandrashekhar, C. P., Kulkarni, V. K. and Devaranavadagi, S. B**. (2010) *Karnataka J. Agric. Sci.* **23(4):** 557.

DOI: https://dx.doi.org/10.5281/zenodo.7185563
Received: 16 April 2013;
Accepted; 28 May 2013;
Available online : 5 June 2013