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Combining Ability and Heterosis For Grain Yield and its Components in Maize (*Zea mays* L.)

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ABSTRACT

Combining ability and heterosis were carried out for grain yield and its components in forty five single cross hybrids derived by crossing in a half diallel fashion along with ten diverse elite early inbreds and two checks. The material was evaluated in randomized block design with three replications at College Farm, College of Agriculture, Rajendranagar, Hyderabad during *kharif,* 1999. The general combining ability effects revealed that parents P4, P6, P7 and P10 were good general combiners for grain yield. Five single cross hybrids P3 x P6, P5 x P9, P5 x P7, P5 x P9, P7 x P9 were identified as potential cross combinations with high *SCA* effects for grain yield per plot. The cross P8 x P10 for number of kernel rows per ear, P6 x P9 for number of kernels per row and P5 x P9 for 100 kernel weight and grain yield per plot recorded highest standard heterosis. These hybrid combinations may be exploited for commercial cultivation after extensive multiplocation trials.

Key words : Combing Ability, Heterosis, Maize, Yield and yield components.

Maize (*Zea mays* L.) is one of the most important cereal crops in the world next to rice and wheat. It occupies a prominent position in global agriculture. Maize crop owes its importance to the grain (seed) meant for human consumption, poultry feed, live stock feed and green fodder to animals. Increasing the grain yield is of paramount importance and in this direction efforts have been intensified intensified by the plant breeders to develop new varieties/hybrids. The development of commercial seed industry is testimony of the breeding methods that have been evolved for economic production of high yielding maize hybrids and have been accepted and demanded by the modern farmers.

Combining ability analysis is extensively used to study nature and magnitude of genotypic variability and to facilitate choice of parents in a hybrid breeding programme. the analysis of genetic variance was also an equally important objective to gain knowledge regarding the nature and magnitude of gene action, which has importance in the choice of most appropriate and efficient breeding procedures for enhanced performance of hybrids derived. Exploitation of additive genetic variance is suitable for the development of composites and non-additive genetic variance is suitable for exploitation of heterosis through various selection methods. Exploitation of hybrid vigour is considered as major accomplishment of plant breeding. The magnitude of heterosis shown by hybrids depends largely on the heterotic pattern and genetic divergence between parental inbred lines. Development of single cross hybrids in maize depends on the per se performance of inbreds and their combining ability for important characters. The present study was conducted to investigate combining ability of parents along with heterotic patterns which facilitate the breeders in the selection and development of single cross hybrids.

MATERIAL AND METHODS

Forty five F_1's derived through half diallel mating from ten selected diverse pre released early maize genotypes of which five (P_1 to $P_{5)}$ lines are of dent grain types and the remaining five lines (p_6 to p_{10}) were of flint grain type. The pedigrees of the parents were as follows:

The Forty five F_1's, ten parents and two checks *viz.,* KH 510 and Bio 9637 were evaluated in a randomized block design with three replications at College Farm, College of Agriculture, Rajendranagar, Hyderabad, during *kharif,* 1999. Each entry was grown in a single row of 5m length and 75cm between rows with an inter plant distance of 20cm. The recommended package of practices

S. No.	Parent	Pedigree
1	P_1	POP DMR C5-HS-B-1#-1#-1-1 x B
2	P_2	P31 DMR x B
3	P_3	G18C19 MH100 x B
4	P_4	Lo DANA-B-#-1-5 x B
5	P_5	SRRL-8-b-1-11#-2-1 x B
6	P_6	COMP B 29 FSB-2-1-#-2-1- x B
7	P_7	SRRL 66B-B-1-1-#-1 x B
8	P_8	DMV 114-OP-1-2-7-2 x B
9	P_9	KH 302 B96-0P1-1-3 x B
10	P_{10}	CO-1-B-1-#-1 x B

were adopted to raise the healthy crop. Data were recorded for ten traits *viz.,* days to 50% tasselling, days to 50% silking, plant height, ear height, ear length, ear girth, number of kernel rows per ear, number of kernels per row, 100 kernel weight and grain yield per plot. Means were subjected to statistical analysis following the combining ability estimates of fixed effects model as proposed in method II model 1 of Griffing, 1956. Heterotic effect over best check was worked for all the characters to establish heterotic patterns among hybrids following standard methods.

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for all characters studied indicating the existence of sufficient variation in the material. The combining ability analysis of variance (Table 1) revealed significant differences among parents and crosses for all the characters. The estimates of components of variances due to *GCA* and *SCA* indicated that *sca* variance was greater in magnitude indicating the preponderance of non additive gene action for all the characters studied. Similar results were reported by Ikramullah *et al*., (2011), Premlatha and Kalamani, (2011) and Suchindra, (1999).

Significant *gca* effects of a parent is a function of breeding value. In the present study, two inbreds P1 and P5 were good general combiners (Table 2) for days to 50% tasselling and days to 50% silking. *Gca* effects of the parental inbreds for grain yield per plot was positive and highest for P_6 and P_7. These inbreds had also resulted in the production of best single crosses (P_7 x P_9), (P_3 x P_6), (P_5 x P_6),(P_3 x P_7), (P_4 x P_7) and (P_5 x P_7) with high *Sca*. Therefore, these superior lines can be used for the improvement of flowering, grain yield simultaneously through hybridization. Further, they had recorded significant and desirable *sca* effects for various yield component characters and concluded to be good general combiners with good potential in hybrid breeding programmes. The possibility of production of superior crosses with high *sca* from high yielding and high *sca* inbreds was also reported earlier in maize Abdel *et al*. (2009). The superiority of these inbreds was also reflected in terms of their production of greater number of heterotic crosses. In contrast, the inbreds, P_1 and P_3 were found to be poor general combiners. The findings are in conformity with previous observations Abdel *et al*. (2009, Tagoor verma, (1998) and Nagesh Kumar *et al.* (1999).

The estimates of specific combining ability effects elucidated that out of forty five crosses (Table 3) evaluated, eleven hybrids viz., P1 x P9, P1 x P10, P3 x P6, P4 x P7, P4 x P8, P4 x P9, P5 x P7, P5 x P9, P5 x 010, P6 x P9 and P7 x P9 observed to posses desirable positive and significant *sca* effects for grain yield along with other characters. The highest significant *sca* effects for yield observed in the crosses P3 x P6 and P5 x P9, which involved at least one parent as good general combiner. These findings are in accordance with the earlier reports of Beck and Vasal, (1990), Abdel *et al*. (2009), Joshi *et al.* (1998) and Sundararajan and Senthil Kumar, (2011). With regard to grain type, most high yielding hybrids (viz., P3 x P6, P5 x P9 and P5 x P7) were between dent grain type and flint grain type parents. This reiterates the known potential of dent x flint crosses contributing to high yield. Similar results were reported by Aliu *et al*. (2008).

The specific combining ability effects revealed significant and desirable effects for yield in 11 crosses *viz.,* (P_1 x P_9), (P_1 x P_{10}), (P_3 x P_6), (P_4 x P_7), (P_4 x P_8), (P_4 x P_9), (P_5 x P_7), (P_5 x P_9), (P_5 x P_{10}), (P_6 x P_9) and (P_7 x P_9). The highest *sca* effects showed crosses for yield ((P_3 x P_6) and (P_5 x P_9) had one good and one poor general combining parents. While most of other high *sca* crosses also showed the same behaviour (high x low) indicating the possibility of obtaining superior crosses with high x low combination of parents. The findings are in consonance with earlier reports Ojo *et al*. (2007) and Lilan *et al*. (2011). Such

Table 1. Combining ability analysis of variance for yield and yield component characters in maize.

Source	df	Days to 50% tasseling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Eargirth (cm)	No. of Kernel rows / ear	No. of Kernels / row	100 Kernel wt. (g)	Grain yield / Plot (kg)
GCA	9	8.2193**	8.4065**	134.2389**	17.6488*	0.7719**	0.7619**	0.8277**	1.9132*	5.2745**	0.0900**
SCA	45	4.2460**	5.5147**	69.2220**	15.5952*	0.6564**	0.6078**	0.6963**	1.5810*	2.5233**	0.0595**
Error	108	0.5135	0.5420	10.4417	9.4095	0.0317	0.0481	0.3027	0.8845	0.2075	0.0070
σ^2 *GCA*	—	0.329	0.2400	5.396	0.1704	0.009	0.012	0.010	0.02	0.228	0.002
σ^2 *SCA*	—	3.732	4.972	58.780	6.1907	0.624	0.5597	0.3936	0.6965	2.318	0.04
σ^2 *GCA* /σ^2 *SCA*	—	0.08	0.40	0.09	0.02	0.0144	0.02	0.02	0.03	0.09	0.05

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

Table 2. General combining ability effects of the inbred lines for yield and yield component characters in maize

Source	Days to 50% tasseling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear Girth (cm)	No. of Kernel rows / ear	No. of Kernels / row	100 Kernel wt. (g)	Grain yield / Plot (kg)
P_1	-1.36**	-1.59**	-1.99*	-1.12	-0.33**	-0.30**	-0.44**	-0.69**	-0.90**	-0.16**
P_2	-0.09	-0.20	0.42	-0.57	-0.04	-0.10	-0.03	-0.07	-0.02*	-0.03
P_3	0.56	-0.45*	-5.56**	-1.32	-0.32**	-0.28**	0.06	0.07	-0.03**	-0.08**
P_4	0.36	0.52	2.46**	-1.37	0.45**	0.45**	0.34*	-0.32	0.61**	0.07**
P_5	-0.76**	-0.56**	-3.44**	-0.76	0.25**	0.28**	0.29*	0.44	-0.27*	0.00
P_6	1.24**	1.24**	0.74	1.88*	-0.00	-0.00	0.12	0.35	1.09**	0.10**
P_7	0.05	0.13	2.52**	1.01	0.08	0.10*	0.14	-0.14	0.57**	0.10**
P_8	-0.17	-0.17	0.37	-0.08	-0.02	0.02	-0.26	0.14	-0.12	-0.00
P_9	1.30**	1.16**	6.14**	0.96	-0.23	-0.27**	0.07	0.06	-0.14	-0.05
P_{10}	-0.01	-0.09	-1.68	-1.36	0.16**	0.10*	-0.31*	0.13	0.22	0.06**
S.E. (gi)	0.2348	0.24	1.66	1.54	0.05	0.06	0.17	0.32	0.14	0.02
S.E. (gi-gi)	0.2926	0.31	1.31	1.25	0.07	0.09	0.22	0.38	0.18	0.03

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

crosses could be utilized in the production of high performing hybrids on a commercial *sca*le. Significant highest positive effects for days to 50 per cent taselling, days to 50 per cent silking and maturity were registered by P_3 x P_7. Whereas cross P_3 x P_6 showed highest *sca* effect for 100 kernel weight in addition to grain yield per plot. Cross P_4 x P_8 had highest *sca* effects for ear length and ear girth. Highest *sca* effects for number of kernel rows per ear was registered by P1 x P8 for number of kernels per row by P5 x P7.

Three cross combinations *viz.,* P2 x P6, P7 x P9 and P4 x P9 registered significant standard heterosis (Table 4) for days to 50% taselling and days to 50% silking. Maximum heterosis over the check for traits ear length and ear girth was recorded by the cross P4 x P9. For 100 kernel weight and grain yield per plot, two crosses P5 x P6 and P3 x P5 recorded high standard heterosis. Average standard heterosis was maximum for grain yield followed by 100 kernel weight, ear girth, number of kernel rows per ear, ear length, ear height

Table 3. Specific combining ability effects of the inbred lines for yield and yield component characters in maize

Source	Days to 50% tasseling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Eargirth (cm)	No. of Kernel rows/ear	No. of Kernels / row	100 Kernel wt. (g)	Grainyield / Plot (kg)
P_1 x P_9	0.1212*	0.2096	0.0144	1.5275	0.4258**	0.5210**	0.1859	0.4354	-0.7919*	0.2196**
P_1 x P_{10}	-0.5732	-0.8737	6.5394*	2.2248	1.1646**	1.0821**	-0.5641	0.2298	-0.3011	0.2052**
P_3 x P_6	2.3712**	1.6540**	-7.594**	-0.3641	0.0258	-0.0652	0.4914	0.5798	2.9195**	0.3552**
P_3 x P_7	2.8990**	2.432**	1.3255	0.9359	-0.8965**	-0.8374**	0.2747	0.8131	1.4470**	0.1777**
P_4 x P_7	-1.3510*	-1.2071*	10.162**	6.5692**	0.4896**	0.4182**	0.3914	0.9465	0.5120	0.2260**
P_4 x P_8	-1.4621*	-1.902**	15.587**	9.4359**	1.0924**	0.8932**	-1.1975**	0.1187	0.2317	0.2160**
P_4 x P_9	-2.2677**	-2.568**	-7.386**	-1.5086	1.4702**	1.5571**	-1.1364*	0.0020	1.8475**	0.2060**
P_5 x P_6	-0.7677	-0.5682	2.0839	2.775	0.2785	0.1321	0.2581	-0.8591	1.1350**	0.1360**
P_5 x P_7	0.0934	-0.7904	2.1699	0.1442	0.6896**	0.6265**	0.4414	1.7076*	0.7425*	0.2852**
P_5 x P_9	-0.1566	-0.1515	-1.9439	-1.0669	-0.8298**	-0.8679**	0.5136	-0.7035	2.7181	0.3085**
P_5 x P_{10}	-0.5177	-0.5682	-5.5856*	-0.9030	-0.5242**	-0.7068**	0.6970	-0.5758	-1.7544**	0.2541**
P_6 x P_9	-0.4899	-0.6237	-11.60**	-2.1530	-0.4659**	-0.5152**	0.4859	-0.2758	1.6931**	0.2252**
P_7 x P_9	-2.6288**	-2.179**	0.7200	-0.5864	-0.6215**	-0.6540**	0.6692	-0.1758	2.3806**	0.2343**
S.E. (Sij)	0.5917	0.6079	2.6682	2.5329	0.1471	0.1812	0.4543	0.7766	0.3761	0.0689
S.E. (Sij-Sik)	0.9763	0.9968	4.3753	4.1534	0.2412	0.2971	0.7449	1.2734	0.6167	0.1130

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

Table 4. Standard heterosis for yield and yield component characters in maize.

Source	Days to 50% tasseling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Eargirth (cm)	No. of Kernel rows / ear	No. of Kernels / row	100 Kernel wt. (g)	Grainyield / Plot (kg)
P_2 x P_6	-12.045**	-13.76**	-1.3779	-2.2428	-6.0099**	-6.6667**	-9.6234**	1.8831	-11.390**	-10.133**
P_7 x P_9	-10.929**	-10.88**	-2.6275	0.7001	-1.4706	-3.2621**	8.8496**	0.3039	18.044**	28.424**
P_4 x P_9	-10.326**	-12.02**	-7.6523**	-2.6127	11.9588**	13.0435**	-3.2680	-3.7901	14.3727**	26.570**
P_3 x P_5	0.0200	-2.890**	3.4525*	5.4407	11.6279**	10.7623**	2.4499	-8.5551**	2.9915*	30.862**
P_5 x P_9	-4.0011**	-5.630**	-5.5218**	-2.7017	-0.2132	-2.0548	11.3122**	-5.5238**	20.5898**	41.743**
Range	-12.07 – 5.88	-13.75 – 4.65	-14.89 – 10.81	-10.36 – 15.12	-10.11 – 11.95	-11.30 – 13.04	-10.02 – 12.27	-8.69 – 6.01	-11.90 – 20.58	-10.13 – 41.74

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

and plant height. The results are in consonance with the work of Ojo *et al*. (2007) and Beck and Vassal, (1990).

Study concludes that hybrids with high *SCA* and standard heterosis can be suggested for their future testing in multi location to confirm their consistency before exploiting themcommercially. The best combining lines identified from the study can be further tested with newer lines and also be utilized in developing narrow based synthetics to serve as elite pools for evolving superior inbred lines.

LITERATURE CITED

Abdel M A, Attia AN, El Emery M I, Fayed E A 2009 Combining ability and heterosis for some agronomic traits in crosses of maize. Pak J Biol Sci. 1; 12(5):433-8.

Aliu S, Fetahu Sh Salillari A 2008 Estimation of heterosis and combining ability in maize (*Zea mays L.)* for ear weight using the diallel crossing method. *Latvian Journal of Agronomy*, 11: 7-12.

Beck D and Vasal L 1990 Heterosis and combining ability of CIMMYT's tropical early and intermediate maize germplasm. Maydica 35 (3): 279-285.

Griffing B 1956 Concept of general and specific combining ability in relation to diallel crossing system. *Australian Journal of Biological Sciences,* 19: 463-493.

Hallauer A R 1962 Estimates of maturity and its inheritance in maize. Crop Science 2 : 289-294.

Inone Y and Kaneko L 1974 The relations between genetic divergence, F_1 yields and *sca* effects in inbreds lines of maize. Research Bulletine of the Hokkaido National Agricultural experiment Station 108: 170-175.

Ikramullah Iftikhar, Hussain Khalil, Muhammad Noor and Mohammad Kausar Nawaz Shah 2011 Heterotic effects for yield and protein content in white quality protein maize. *Sarhad Journal of Agricultural, 27:3-8.*

Joshi V N, Pandiya N K and Dubey R B 1998 Heterosis and combining ability for quality and yield in early maturing single cross hybrids of maize (*Zea mays* L.) *Indian Journal of Genetics and Plant Breeding,* 58(4): 519-524.

Lilan G., Kiarie Njoroge, Jane Ininda and Lorroki Peter 2011 Combining ability of grain yield and agronomic traits in diverse maize lines with maize streak virus resistance for Eastern Africa region. *Agriculture and Biology Journal of North America,* 24: 1129-31.

Nagesh Kumar M V, Sudheer Kumar S and Ganesh M 1999 Studies on combining ability for yield in maize. *Indian Journal of Genetics and Plant Breeding,* 59 (1): 98-100.

Ojo G O S, Adedzwa1 D K and Bello L L 2007 Combining ability estimates and heterosis for grain yield and yield components in maize (*Zea mays L.*). *Journal of Sustainable Development in Agriculture & Environment,* 3:49-57

Premlatha M and Kalamani K 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.

Suchindra B 1999 Genetic analysis for oil and grain yield improvement in maize (*Zea mays* L.). M.Sc.(Ag). Thesis submitted to Acharya N.G. Ranga Agricultural University, Hyderabad – 500 030.

Sundararajan R and Senthil Kumar P 2011 Studies on combining ability through line x tester analysis in maize (*zea mays* l.). Plant Archives. 11 (1):75-77

Verma T 1998 Genetic analysis of oil and grain yield in maize (*Zea mays* L.) through L x T design. M.Sc.(Ag) Thesis submitted to Acharya N.G. Ranga Agricultural University, Hyderabad – 500 030

Vasal S K, Srinivasan G and Pandey S I 1993 Heterosis and combining ability of CIMMYT's quality protein maize germplasm. *Lowland Tropical Crop Science,* 33 (1): 46-51.

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