

**COMBINING ABILITY ANALYSIS FOR DIFFERENT YIELD
COMPONENTS IN MAIZE (*Zea mays* L.) INBRED LINES**

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ABSTRACT

The present study was carried out to determine the combining ability of yield and yield components by crossing six diverse maize inbred lines in a half diallel mating design. Fifteen F₁ progenies along with their six parents were planted in randomized complete block design with three replications. GCA to SCA ratios were less than one for plant height, cob diameter, cob length and number of kernels row/cob indicating a preponderance of additive over non additive gene action. The crosses P₁×P₂, P₃×P₅ and P₅×P₆ were exhibited significant and positive SCA effects for yield and cob diameter, number of row/cob and number of grains/cob of yield contributing characters. The parents P₁ (IL₄), P₃ (IL₁₈) and P₅ (IL₂₃) were good general combiner for grain yield and yield attributing characters. It can be concluded that these parental lines can be desirable parents for hybrids as well as for inclusion in breeding program, since they may contribute favorable alleles in the synthesis of new varieties.

Keywords: Crossing; combiner; alleles; maize; diallel

INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal crop in the world after wheat (*Triticum aestivum* L) and rice (*Oryza sativa* L). It has great yield potential and attained the leading position among the cereals based on production as well as productivity (Keskin et al., 2005). It is the most important silage plant in the world because of its high yield, high energy forage produced with lower labor and machinery requirements than the other forage crops (Roth *et al.*, 1995). Every part of the plant has economic value; the grain, leaves, stalk, tassel are used to produce hundreds of food and non-food products (Haddadi *et al.*, 2012).

The cultivated area and production of maize is increasing day by day due to its yield potentiality. High yield potentiality and its multipurpose use as food can reduce wheat production area and maize imports. Maize is also the most demandable cereal food of the poultry industry in Bangladesh (Zaman and Alam, 2013). So, maize can play an

important role in increasing food production of Bangladesh. At present, the farmers are cultivating some imported hybrid maize varieties, but they are very expensive. So, we have to develop hybrid maize varieties. The nature and magnitude of gene action is an important factor in developing an effective breeding programme.

Combining ability studies provide information on the genetic mechanisms controlling the inheritance of quantitative traits and enable the breeders to select suitable parents for further improvement or use in hybrid breeding for commercial purposes. In biometrical genetics two types of combining abilities are considered i.e. general combining ability (GCA) and specific combining ability (SCA). General combining ability refers to the average performance of the genotype in a series of hybrid combinations and is a measure of additive gene action whereas; specific combining ability is the performance of a parent in a specific cross in relation to general combining ability (Sharief *et al.*, 2009). SCA is due to genes showing non-additive effects (Sprague and Tatum, 1942). The objectives of the present study were to evaluate GCA and SCA effects of six maize inbred lines and their F_1 s in order to determine superior breeding lines and cross combinations.

MATERIALS AND METHODS

The genetic materials used in this experiment were six parents ($IL_4=P_1$, $IL_5=P_2$, $IL_{18}=P_3$, $IL_{10}=P_4$, $IL_{23}=P_5$ and $IL_1=P_6$) and their F_1 which were $P_1 \times P_2$, $P_1 \times P_3$, $P_1 \times P_4$, $P_1 \times P_5$, $P_1 \times P_6$, $P_2 \times P_3$, $P_2 \times P_4$, $P_2 \times P_5$, $P_2 \times P_6$, $P_3 \times P_4$, $P_3 \times P_5$, $P_3 \times P_6$, $P_4 \times P_5$, $P_4 \times P_6$ and $P_5 \times P_6$. The present investigation was carried out during 26 November 2013 and 28 November 2014 seasons at the experimental field, Department of Botany, University of Rajshahi, Bangladesh. Plants at flowering stage (just before anthesis) were selected and crossed in half diallel fashion from 26 November, 2013 to January, 2014 excluding reciprocals and to obtain the F_1 seeds. The F_1 seeds of all the crosses with their parents were planted in the field on 28 November, 2014 season for evaluation in a randomized block design with three replications. The experimental unit was a single row of 3.0 m long. Inter-plant and inter-row distances were 10 and 30 cm, respectively. Fertilizers were applied at the rate of 250, 125, 120, 45 and 5 kg/ha of N, P_2O_5 , S and Zn, respectively. Necessary intercultural operations and irrigation were done during the crop period to ensure normal growth and development of the plants.

Five plants from each row were randomly selected for recording data on the studied characters such as days to tasseling, days to silking, days to maturity, plant height(cm), ear height(cm), cob length(cm), cob diameter (cm), number of rows/cob, number of kernels/row, number of kernels/cob and grain yield/plant(g). The combining ability analyses were carried out using Griffing's (1956) Method 2 Model II given in "Statistical and Biometrical Techniques in Plant Breeding by Sharma (1998) using CropStat (2007). The mean squares for GCA and SCA were tested against their respective error variances derived from ANOVA reduced to mean level.

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant difference for cob diameter, cob length, number of row/cob, number of kernels/cob and grain yield, indicating the existence of wider genetic variability among the lines. Both general combining ability (GCA) and specific combining ability (SCA) variances were found to be highly significant (Table 1) for all the characters studied which indicated that both additive and non-additive gene action played predominant role for the expression of these characters. Relative importance of GCA and SCA was calculated. In the present study GCA/SCA variance was observed to be unity for cob length, cob diameter and number of rows/cob indicating equal importance of both additive and non additive gene effects. The SCA component of variance was higher than GCA component of variance for the characters like plant height, cob diameter and number of rows/cob indicating the predominance of non-additive or dominant gene action. The influence of dominant type of gene action was also observed by Singh and Kumar (2008); Amiruzzaman *et al.* (2011) and Singh *et al.* (2012) in maize inbred lines.

Table 1. Mean square from the analysis of variance for combining ability of different characters in maize in a 6×6 half diallel cross

Source of variation	df	DT	DS	DM	PH	EH	CL
GCA	5	15.009**	10.473**	185.502**	146.110**	706.221**	11.733**
SCA	15	4.795**	4.425**	42.028**	202.268**	250.405**	6.675**
Error	40	4.795	4.632	5.098	35.546	129.636	3.645
GCA:SCA	0.33	3.159	2.366	4.414	0.721	2.820	1.758

Table 1. Contd.

Source of variation	df	CD	NRC	NKR	NGC	GYP
GCA	5	4.024*	0.433	94.069**	12916.598**	1035.173**
SCA	15	4.928**	0.581	12.116**	3571.143**	286.216**
Error	40	2.162	0.489	17.689	3376.707	270.629
GCA:SCA	0.33	0.816	0.816	7.764	3.616	3.617

*, ** indicated at 5% and 1% level of significance, GCA: General combining ability, SCA: Specific combining ability. DT: Days to tasseling, DS: days to silking, DM: days to maturity, PH: plant height, EH: ear height, CL: cob length, CD: cob diameter, NRC: number of rows/cob, NKR: number of kernels/row, NGC: number of grains/cob and GYP: grain yield/plant

Combining ability analysis revealed that estimates of SCA variances were higher than GCA variances for the characters like plant height, cob diameter and number of rows/cob under study, suggesting predominance of non-additive or dominant gene action for these characters. These results are in agreement with earlier reports of Pavan *et al.* (2011) and Singh *et al.* (2012) for number of kernels per row, number of kernels per ear, 100-grain weight and grain yield per plant, and Amiruzzaman *et al.* (2011) for quantitative like kernel yield per plant, number of kernels per ear and 1000-kernel

weight. High magnitudes of SCA component were predominant indicating the dominance and epistatic interaction for these characters. The estimated ratio between GCA and SCA was more than unity indicating the predominance of additive gene action for most of the characters except plant height, cob diameter and number of rows/cob. Uddin *et al.* (2008) also reported predominance of non additive gene action in maize. Grain yield and its contributing characters were suggested to be controlled by additive and non additive gene actions in maize inbred lines.

General Combining Ability of the Parents

Due to importance of early maturity and lower values of days to silking; P₄ which had significant negative GCA effects were considered as good combiners for this character. The estimate of GCA effects showed that the parents P₁, P₃ and P₄ were good combiners for grain yield and yield attributing characters like days to maturity, ear height, number of kernels/row, number of grains/cob and grain yield plant(Table 2.). Result indicated that the parents possess high frequency of favorable genes for these characters. The estimates of GCA effects showed that the parent P₁ was the best combiner of days to silking and maturity, ear height, grains/cob, grain yield and also for earliness. Parents P₄ and P₅ had significant positive GCA effects for ear height making them good combiners for improving the trait. Thus, the inbred lines which exhibited good general combining ability for at least one character can be used as donor parents for the accumulation of favorable genes. These findings are accordance with Khalil *et al.* (2010) and Singh *et al.* (2012) and Haddadi *et al.* (2012).

Table 2. General combining ability (GCA) effects for 11 yield and its related traits in maize

Inbreds	DT	DS	DM	PH	EH	CL
GCA						
P ₁	1.42	1.27	-4.45**	0.39	-8.39**	-0.05
P ₂	-0.74	-0.13	2.66**	0.13	-0.21	-0.02
P ₃	-0.43	-0.27	2.98**	-0.17	-1.03	0.25
P ₄	-3.55*	-2.49*	-5.40**	-0.20	-0.89	-0.20
P ₅	0.45	0.11	-0.58	-0.25	7.13**	-0.06
P ₆	-0.16	-0.49	0.79	-0.24	3.39**	0.07
S.E(gi)	0.35	0.34	0.42	1.11	2.12	0.36

Contd. Table 2.

Inbreds	CD	NRC	NKR	NGC	GYP
GCA					
P ₁	0.051	0.388	-0.237	18.422**	-8.301**
P ₂	0.336	0.132	-0.846	7.419**	-7.018**
P ₃	-0.271	0.173	1.045	19.055**	0.358
P ₄	0.320	-0.198	-1.071	-15.88**	3.178**
P ₅	-0.373	-0.252	0.789	2.703**	8.877**
P ₆	-0.063	-0.242	0.311	-2.880**	2.906**
S.E(gi)	0.274	0.130	0.783	10.828	3.065

DT: Days to tasseling, DS: days to silking, DM: days to maturity, PH: plant height, EH: ear height, CL: cob length, CD: cob diameter, NRC: number of rows/cob, NK: number of kernels/row, NGC: number of grains/cob and GYP: grain yield/plant

Table 3. Specific combining ability (SCA) effects for 11 yield and its related traits in maize

Crosses	DT	DS	DM	PH	EH	CL	CD	NRC	NKR	NGC	GYP
P ₁ × P ₂	2.476*	4.757**	2.244*	2.130**	-7.487**	-0.07	-0.102	7.61**	3.034**	56.096**	15.880**
P ₁ × P ₃	1.601	0.671	3.178**	4.121**	6.762**	0.171	2.202**	0.253	-1.253	-11.127**	-3.150**
P ₁ × P ₄	-0.203	0.614	0.192	-2.574**	7.332**	0.752	-0.248	2.248*	-0.324	3.251**	0.920
P ₁ × P ₅	0.221	-2.343**	-0.270	-7.139**	-9.197**	2.202*	-3.147**	3.398*	4.124**	16.295**	4.613**
P ₁ × P ₆	-1.201	-0.384	7.163**	-7.866**	-5.590**	-0.822	0.741	-4.80**	1.300	-5.745**	-1.626
P ₂ × P ₃	0.096	2.153**	3.319**	7.677**	5.367**	-3.17**	1.173	-2.80**	-0.058	-6.360**	-1.800
P ₂ × P ₄	1.549	0.927	1.391	-7.871**	6.191**	4.02**	0.296	-0.457	-3.58**	-32.514**	-9.205**
P ₂ × P ₅	0.054	-0.254	0.981	-3.763**	-3.174**	0.602	0.630	-0.617	-4.30**	-71.930**	20.363**
P ₂ × P ₆	-0.313	-0.678	-2.694**	-6.110**	-17.44**	3.02*	-0.103	0.093	-1.121	-13.545**	3.834**
P ₃ × P ₄	-0.569	-3.519**	3.185**	5.929**	1.986*	0.325	-2.95**	-0.480	-1.101	-26.795**	-7.585**
P ₃ × P ₅	0.958	0.708	-6.364**	-15.662**	-10.61**	-3.37*	4.36**	-5.04**	-1.635	-23.411**	-6.627**
P ₃ × P ₆	1.035	-3.427**	-4.813**	-0.155	1.394*	-2.22*	0.623	-5.247*	-2.40**	-25.542**	-7.231**
P ₄ × P ₅	0.078	-3.154**	-1.039	-1.058	-10.49**	-4.19*	0.250	0.231	3.126**	24.238**	6.861**
P ₄ × P ₆	-0.008	-0.154	1.730	2.095**	2.534**	-0.161	0.373	0.208	4.253**	7.699**	2.181**
P ₅ × P ₆	-0.230	2.146**	0.191	18.843**	10.205**	-0.304	-0.516	0.451	2.801**	25.821**	7.309**
S.E.(Sij)	0.946	0.921	1.155	3.051	5.826	0.976	0.752	0.357	2.152	2.738	8.418

ns, * and **: Non significant, significant at 5 and 1% levels, respectively.

DT: Days to tasseling, DS: days to silking, DM: days to maturity, PH: plant height, EH: ear height, CL: cob length, CD: cob diameter, NRC: number of rows/cob, NKR: number of kernels/row, NGC: number of grains/cob and GYP: grain yield/plant.

Specific Combining Ability of the Crosses

Specific combining ability effects of some crosses showed positive significant performance for many characters under study (Table 3). Among the crosses, $P_1 \times P_2$ and $P_1 \times P_5$, possessed significant SCA effect for days to tasseling and silking, plant and ear height, number rows/cob, kernels/row, grain number/cob and grain yield/plant exhibited best specific combiner for these characters followed by $P_3 \times P_5$ and $P_3 \times P_6$ for days to maturity, ear height and two to five of its component characters. The most promising crosses for improving the grain number and grain yield were ($P_1 \times P_2$) and ($P_5 \times P_6$), because it gave the highest positive significant SCA for the above-mentioned characters. High specific combination for grain yield was observed in low \times high general combiners as in the crosses $P_1 \times P_2$ and $P_2 \times P_5$. The crosses $P_4 \times P_5$ and $P_5 \times P_6$ were also good for grain yield and involved low \times average general combiners. Results obtained from this study agree with the results obtained by Uddin *et al.* (2006), Uddin (2008), Alam *et al.* (2008) and Alam (2009) and Singh *et al.* (2012). In the study, most of the cases three inbred lines (P_1 , P_3 and P_5) exhibited significant positive SCA and possessed comparatively well mean performance, although these parents could be used for developing high yielding hybrids.

CONCLUSION

Parents with good positive GCA for yield (P_1 and P_4), negative GCA for days to silking and maturity (P_1 and P_3), dwarf plant and ear height (P_5) may be extensively used in hybridization program as a donor. Better performance of $P_1 \times P_2$, $P_1 \times P_5$, $P_3 \times P_5$ and $P_3 \times P_6$ can be utilized for developing high yielding hybrid varieties as well as exploiting hybrid vigor. These crosses may be multiplicities for distribution of seeds among the farmers.

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