COMBINING ABILITY ANALYSIS IN VARIOUS INBRED LINES OF MAIZE (*ZEA MAYS* L.)

Syed Asif Imran Shah*, Shah Jehan Khan**, Abdul Aziz Baloch***, Obaid Ullah Sayal**, Kalim Ullah* and Shujaat Ali**

ABSTRACT:- An experiment to study combining ability effects through 6 × 6 diallel model in maize inbred lines, was laid out in randomized complete block design with three replications at Agricultural Research Institute, Dera Ismail Khan, Pakistan, during 2012. Variance analysis exhibited highly significant (P≤0.01) variation among genotypes for days to 50% silking, ear length, kernel rows ear^{-1}, kernels row^{-1}, kernels ear^{-1} and grain yield. Mean square values due to general combining ability were highly significant (P≤0.01) for all studied attributes except kernels ear^{-1} and grain yield. Highly significant variations for specific combining ability of direct and reciprocal effects were observed for all attributes. Azam proved good combiner for days to 50% silking and kernel rows ear^{-1} while Islamabad Gold for kernels ear^{-1} and grain yield. Islamabad White × Sadaf was the best combiner for grain yield. For reciprocal effects, BS-I × Sahiwal 2002 proved good combiner for kernels row^{-1} and kernels ear^{-1} while BS-I × Islamabad White for grain yield. Selection in early generation will be more effective in Islamabad White whereas Islamabad Gold in later generation due to dominant and additive genetic background, respectively.

Key Words: Maize; Combining Ability; Diallel Cross; Variances; Grain Yield; Pakistan.

INTRODUCTION

Maize (*Zea mays* L.) is the major cereal crop of Pakistan as it is being utilized as staple food, feed and fodder crop with remarkable nutritive value: starch (71.8%), protein (10.4%), fat (4.5%) and minerals like phosphorous, magnesium, sulphur and iron for human, livestock and poultry (Nawab et al., 1999). Its potential yield in Pakistan is low due to selection of undesirable cultivars under specific geographical and environmental conditions (Tahir et al., 2008). Evaluation of maize cultivars was carried out for preferable adaptation, yield potential, insect pests and disease resistance in several agro-ecological zones (Olaoye, 2009). Combining ability assists in evaluation of cultivars on account of their genetic value, to select suitable genotypes for hybridization programme and identification of superior cross combinations (Farshadfar et al., 2011). Diallel crossing design often utilized to attain information about combining ability estimates and genetic values of inbred lines and hybrids (Iqbal et al., 2007). The hybrid performance is associated with general (GCA) and specific (SCA) combining abilities of parental lines take part in the cross (Sprauge and

* *Cotton Research Station, Dera Ismail Khan, Pakistan.*
** *Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan.*
*** *Arid Zone Research Institute, Dera Ismail Khan, Pakistan.*
Corresponding author:iasif99@yahoo.com

Tatum, 1942). GCA and SCA are related with additive and non-additive effects of genes, respectively.

Therefore, the present experiment was conducted to evaluate the maize inbred lines in terms of their combining ability for hybrid production by using Griffing (1956) Method I, Model I analysis, which was focused on ANOVA and statistical analysis of main effect, i.e., GCA, SCA and reciprocal effect component.

MATERIALS AND METHOD

An experiment was conducted to study combining ability effects in maize inbred lines i.e., S_3 lines locally developed from open pollinated varieties viz., Islamabad White, Azam, Sadaf, Bafa Selection (BS-I), Sahiwal-2002 and Islamabad Gold, at Agricultural Research Institute, Dera Ismail Khan, Pakistan. During spring 2012, inbreds were planted in a crossing block where all possible direct and indirect crosses were performed according to 6×6 complete diallel crossing Model I. In autumn season 2012, parental lines and first filial (F_1) generations were laid out in RCB comprising three replications with single row plot, 5m in length with 25 cm plant to plant and 75 cm row to row distance, respectively. Data was collected manually for grain yield (GY in kg ha^{-1}) and ear related attributes i.e., days to 50% silking (DS), ear length (EL in cm), kernel rows (KR) ear^{-1}, kernels row^{-1} (KE) and kernels ear^{-1} (KRE).

Statistical Analysis

The data collected on various attributes were analyzed statistically using the standard techniques of analysis of variance (Steel and Torrie, 1984), to determine significant variation among parental lines and their F_1s crosses. The significant varied attributes were further analyzed for estimates of GCA and SCA of direct and reciprocal crosses, according to the procedure given by Griffing (1956) Method I, Model I.

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant ($P \leq 0.01$) differences amongst mean squares for genotypes, GCA (except for kernels ear^{-1} and grain yield), SCA and reciprocal effects for grain yield and ear related attributes (Table 1). For days to 50% silking mechanism, early behavior based on GCA effects were examined in Azam and Islamabad Gold, while Sadaf exhibited delayed silking (Table 2).

The SCA effects for direct crosses and reciprocal crosses revealed early mechanism in Sahiwal-2002 × BS-I, Sadaf × BS-I (Table 3) and BS-I × Azam (Table 4) respectively. For ear length, Sadaf and BS-I proved as best general combiners (Table 2). The SCA effects for direct and reciprocal crosses showed that Islamabad White × Sahiwal 2002 (Table 3) and Islamabad Gold × Sahiwal-2002 (Table 4) respectively, were best combiners. The GCA effects for kernel rows ear^{-1} and kernels row^{-1} revealed that Azam and Sahiwal 2002, respectively, were best general combiners (Table 2). The SCA effects for direct crosses of kernel rows ear^{-1} and kernels row^{-1} proved that Islamabad White × Islamabad Gold and Islamabad Gold x BS-I respectively (Table 3), while for reciprocal crosses BS-I × Sadaf and BS-I × Sahiwal-2002, respectively (Table 4) as best combiners. The GCA effects for kernels ear^{-1} and grain yield

Table 1. Mean squares for grain yield, days to 50% silking, ear length, kernel rows ear^{-1}, kernels row^{-1} and kernels ear^{-1} in *Zea mays* L.

SOV	Df	Mean Squares					
		DS	EL	KRE	KR	KE	GY
Replication	02	1.23	2.16	0.81	10.69	4219.59	00913179.60
Genotypes	35	6.87**	2.73**	2.92**	18.16**	4145.75**	10011199.00*
Error	70	0.69	0.94	0.67	08.23	2035.08	524211.00
GCA	05	9.71**	1.13**	2.22**	10.67**	0921.39^{NS}	299326.70^{NS}
SCA	15	0.75**	0.98**	1.05**	04.61**	1071.70**	244175.20**
Reciprocal	15	1.36**	0.77**	0.49**	05.96**	1845.47**	4347601.10**
Error	70	0.23	0.31	0.23	02.74	0678.36	174737.00
σ^2GCA	-	0.75	1.42	9.97	00.51	-0011.47	4782.62
σ^2SCA	-	0.30	0.39	0.48	01.08	0228.39	40318.94
σ^2Reciprocals	-	0.57	0.23	0.13	01.61	0583.55	130011.60
σ^2A	-	1.49	2.83	0.20	01.02	0022.93	9565.24
σ^2D	-	0.30	0.39	0.48	01.08	0228.39	40318.94

**and ** = Significant at 5% and 1% probability level, respectively.*
NS = Non-significant.

among six inbred lines showed non-significance, reflecting no variation for these attributes. The SCA effects for direct crosses in kernels ear^{-1} and grain yield exhibited that Azam × Islamabad White and Islamabad White × Sadaf, respectively (Table 3), while for reciprocal crosses BS-I × Sahiwal-2002 and BS-I × Islamabad White, respectively (Table 4) as best combiners.

Combining ability analysis divides the whole variation into parental GCA effects and SCA effects of the crosses. The parental GCA effects refer to an average combining performance of the parental lines involved in crosses for the additive variance and additive × additive epistasis, whereas SCA effects are accountable for non-additive variance (Hemalatha et al., 2014). As significant GCA effects revealed additive and additive × additive epistasis, thus selection for days to 50% silking, ear length and kernels rows ear^{-1} in later generations will be more effective till the accumulation of maximum favorable alleles and recurrent selection will be more suitable method. These findings are in consonance with the previous studies of Spanner et al. (1996) and Kalsy and Dharma (2004) for days to 50% silking, who also reported negative GCA effects which showed earliness in silking mechanism and thus might be attributed to early maturity. Thus Azam and

Table 2. Estimates of GCA effects for grain yield, days to 50% silking, ear length, kernel rows ear^{-1}, kernels row^{-1} and kernels ear^{-1} in *Zea mays* L.

Parents	DS	EL	KRE	KR	KE	GY
Azam	-1.55	-0.37	0.59	-1.88	-9.80	-163.34
Islamabad White	0.48	-0.25	-0.21	0.43	-0.55	-085.82
Sahiwal 2002	0.34	0.24	-0.58	0.62	-9.78	170.02
Sadaf	1.07	0.29	0.00	0.31	5.21	-071.65
Islamabad Gold	-0.41	-0.21	0.40	0.01	12.64	225.82
BS-I	0.07	0.29	-0.21	0.51	2.29	-075.04

Table 3. Estimates of SCA effects for grain yield, days to 50% silking, ear length, kernel rows ear^{-1}, kernels row^{-1} and kernels ear^{-1} in *Zea mays* L.

Direct Crosses	DS	EL	KRE	KR	KE	GY
Azam×Islamabad White	-0.37	0.19	0.54	0.62	26.33	387.45
Azam×Sahiwal-2002	0.60	-0.94	1.13	-1.96	10.89	-84.71
Azam×Sadaf	-0.29	0.49	-0.45	1.93	11.25	-35.21
Azam×Islamabad Gold	-0.48	-0.32	0.37	-1.59	-12.54	-51.69
Azam×BS-I	0.21	0.71	-0.23	1.38	14.93	181.68
Islamabad White×Sadaf-2002	-0.26	0.86	-0.28	1.39	10.65	-305.57
Islamabad White×Sadaf	0.02	0.61	0.13	1.00	17.31	661.26
Islamabad White×Islamabad Gold	-0.18	-0.24	1.38	-1.78	21.22	91.62
Islamabad White×BS-I	-0.15	-0.71	-0.33	-0.78	-24.32	-33.19
Sahiwal-2002×Sadaf	0.16	-0.33	0.17	0.67	13.67	136.76
Sahiwal-2002×Islamabad Gold	-0.20	0.70	-0.35	1.16	8.88	143.29
Sahiwal-2002×BS-I	-1.18	-0.78	0.26	-1.24	-8.64	-89.19
Sadaf×Islamabad Gold	-0.43	0.67	-0.59	0.51	-9.31	300.12
Sadaf×BS-I	-0.56	0.13	-0.08	-0.59	-9.49	-360.02
Islamabad Gold×BS-I	0.91	0.19	0.07	2.15	25.71	4.84

Islamabad Gold were selected as the best general combiners for early maturing genotypes. Muraya et al. (2006) also reported similar findings for ear length and kernels rows ear^{-1} in various maize crosses. Thus Sadaf

Table 4. Estimates of SCA effects for grain yield, days to 50% silking, ear length, kernel rows ear^{-1}, kernels row^{-1} and kernels ear^{-1} in *Zea mays* L.

Reciprocal Crosses	DS	EL	KRE	KR	KE	GY
Islamabad White×Azam	-1.00	0.18	-0.58	-0.73	-28.43	342.50
Sahiwal 2002×Azam	-0.50	0.12	0.33	-0.80	-03.78	-161.83
Sahiwal 2002×Islamabad White	-0.33	0.40	-0.57	1.67	03.00	048.50
Sadaf×Azam	-0.33	0.63	-0.23	0.05	01.33	-299.67
Sadaf×Islamabad White	0.00	0.70	0.02	2.27	35.98	250.67
Sadaf×Sahiwal-2002	1.67	0.15	-0.32	1.05	04.00	-647.67
Islamabad Gold×Azam	-0.33	-0.42	-0.12	1.43	21.45	086.33
Islamabad Gold×Islamabad White	-0.67	-0.98	-0.80	-1.68	-50.67	246.50
Islamabad Gold×Sahiwal-2002	-0.17	0.92	0.00	2.22	31.55	-364.67
Islamabad Gold×Sadaf	0.33	0.33	0.57	1.18	00.55	405.17
BS-I×Azam	-1.17	-0.48	-0.22	-2.57	46.33	290.83
BS-I×Islamabad White	0.83	0.78	-0.45	2.28	18.10	1011.17
BS-I×Sahiwal-2002	1.33	0.83	0.00	-2.78	37.45	738.33
BS-I×Sadaf	0.67	0.30	1.10	-0.78	27.55	-189.50
BS-I×Islamabad Gold	-1.00	-0.95	-0.55	-1.77	-55.12	699.50

and BS I were selected for ear length, while Azam and Islamabad Gold were selected as best combiners for kernels rows ear^{-1}.

Significant SCA effects for kernels row^{-1}, kernel ear^{-1} and grain yield was observed depicting dominance and partial dominance type of gene action for the traits and thus selection of specific cross combinations is of greater importance. Furthermore selection in early generations for these attributes will be more effective and thus can be successfully utilized in hybrid development. These findings are in accordance with the previous studies of Din et al. (2006), Fan et al. (2008) and Moneam et al. (2009) for kernels row^{-1}, kernel ear^{-1} and grain yield. Thus, Islamabad Gold × BS-I showed maximum kernels row^{-1}, Azam × Islamabad White for kernel ear^{-1} and Islamabad White × Sadaf for grain yield were selected as best cross hybrids in their respective traits.

Combining ability analysis revealed the significance of both additive and non-additive gene action in controlling most of the studied traits. Days to 50% silking, ear length and number of kernel rows ear^{-1} were under control of additive type of gene action. While number of ears plant^{-1}, number of kernels row^{-1}, number of kernels ear^{-1} and grain yields were under control of dominant and partial dominant type of gene action. The overall assessment regarding GCA effects revealed that inbred lines Azam and Islamabad Gold were the best general combiner for most of the traits. SCA effects in direct crosses revealed that all crosses perform variably in studied traits, Islamabad White × Sadaf proved to be best combiners for grain yield. While in reciprocal crosses, BS I × Sahiwal 2002 for number of kernels row^{-1} and number of kernels ear^{-1}, while BS I × Islamabad White proved to be the best combiner.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Syed Asif Imran Shah	Conduct experiment, Data collection and write up, Result and discussion
2.	Dr. Shah Jehan Khan	Technical input at every step
3.	Dr. Abdul Aziz Baloch	Overall management of the article
4.	Mr. Obaid Ullah Sayal	Data entry and analysis
5.	Dr. Kalim Ullah	Methodology, Result and Discussion
6.	Mr. Shujaat Ali	Introduction, Reference

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