Research Article

Combining Ability Analysis for Morphological Traits in 6 × 6 Diallel Crosses of Maize (*Zea Mays* L.) Opvs in Nowshehra (KPK) Pakistan

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Abstract | Six maize (*Zea mays* L.) open pollinated varieties (OPVS) viz; PSEV-3, Azam, Sarhad white, Jalal, Iqbal and Pahari were used in this experiment to determine their combining ability through 6 x 6 diallel mating design. The research was laid out in randomized complete block design with three replications at Cereal Crop Research Institute (CCRI) Pirsabak, Nowshehra (K.P.K) Pakistan during the year 2015. The results displayed highly significant (P≤0.01) variation among above six OPVS for days to germination, plant height, leaf area, number of grains ear^{-1}, grains moisture % at harvest, grain yield and biological yield. Mean square values due to general combining ability were highly significant (P≤0.01) for all the experimental parameters except grain yield and biological yield. Highly significant specific combining ability for direct and reciprocal crosses shows highly significant differences for all the studied parameters. PSEV-3 proved best combiner for days to germination and grains moisture % at harvest while Azam for grain yield and biological yield. Sarhad White was the best combiner for grain yield. Reciprocal effects of Jalal x Iqbal exhibited best combination for leaf area and number of grains ear^{-1} while Pahari × Sarhad White for grain yield.

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Introduction

Maize (*Zea mays* L.) the sole cultivated member of genus *Zea* is one of the permanent cereal crops and is a cross pollinated plant. It is an angiosperm and monocot. There are various sub-specious of maize based on their use as food including flour corn - *Zea mays* L. subsp. *mays* Amylacea Group, popcorn -*Zea mays* L. subsp. *mays* Everta Group, Dent corn – *Zea mays* L. subsp. *mays* Indentata Group, Flint corn – *Zea mays* L. subsp. *mays* Indurata Group and sweetcorn - *Zea mays* L. subsp. *mays* Saccharata Group. (Zamarud et al., 2009). It is short duration and a well-established crop. It contains starch, protein, fat, oil, sucrose in prosthetic form. (Nawab et al., 1999). Maize improvement programs often include hybridization, evaluation and selection of adaptable varieties. It is equally cultivated in tropical and subtropical areas of the world. Evaluation of maize cultivars is carried out regularly for preferable adaptation, yield potential, insect pest and disease resistance in diverse agro ecological zones (Olaoya, 2009). Its potential yield in Pakistan is low due to old cultivars and specific geographical and environmental conditions (Tahir et al., 2008). Combining ability assists is evaluation of cultivars on account of their genetic value, to select suitable genotypes for hybridization programme and identification of superior cross combinations (Aliu et al, 2008). Diallel crossing design is often exercised to attain information about combining ability estimates and genetic values of inbred lines. Modern maize breeding methods involve the isolation of commercially acceptable inbred lines and their evaluation inbreds. The estimation of combining ability is also elementary tools for selection of desirable genotype. The concept of combining ability was introduced by (Sprauge and Tatum, 1942). GCA and SCA are related with additive and non-additive effects of genes, respectively. The GCA effect of a genotypes is an indicator of the relative position of the genotypes in terms of frequency of favorable genes and of its dispersion, as compared to the other genotypes (Alius, 2008). The SCA effect of two genotypes expresses the variation of gene frequencies between them and their divergence, as compared to the diallel genotypes (Asif et al., 2015). The mating design most often employed in the assessment of combining ability is the diallel (Griffing, 1956).

The present research work was conducted to evaluate the maize OPVS in term of their combining ability for hybrid production by using (Graffing, 1956) Method1 analysis which was focused on statistical analysis of main effects, i.e., GCA, SCA and reciprocal effects component.

Material and Methods

This research on maize was conducted during spring season 2015 to find out the general combining abilities and specific combining abilities. The research material comprised six OPVS via (PSEV-3, Azam, S.W, Jalal, Iqbal and Pahari) of maize which have different dates of release, performance, pedigree, yield production and its components. The OPVS were sown and crossed in a complete-diallel fashion to get seeds of 30 single crosses including reciprocals. The seed of six OPVS were sown in the field in a non-replicated crossing-block in summer season 2015. The plot had six rows of 5 meters' length, every line planted at a spacing distance of 20 and 75 cm between plants and rows, respectively to facilitate crossing and to handle the research material carefully. Sowing was done on ridges using 2-3 seeds hill^{-1} with the help of a dibbler. The OPVS were crossed in a full diallel matting design in summer season 2015. Ten plants line^{-1} were pollinated for each combination to collect sufficient seed for planting the F_1 crop. All precautionary measurements were applied to avoid undesirable contamination of genetic material while conducting bulking of pollen and pollinating subsequently. The crosses, sibs and reciprocals were made according to complete diallel fashion design. The crosses were harvested after physiological maturity and carefully shelled for raising F_1 generation.

Cultural practices such as fertilizer, hoeing, weeding, irrigation and plant protection procedures were carried out as suggested for maize production in the area and the crop maintained under suitable conditions. The data of ten plants from every plot were recorded on traits such as germination, plant height, leaf area, number of grains ear^{-1}, grains moisture % at harvest, grain yield and biological yield.

Statistical analysis

Standard techniques of variance (Steel and Torrie, 1984) were used for the collected data analysis, to determine significant variation among different maize genotypes. The attributes with significant variance 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 results of variance in Table 1 showed that mean squares due to progenies and parents were mostly significant i.e days to germination (5.74), plant height (3.46), leaf area (9.95) and number of grains ear^{-1} (1.12).

Table 1 and Table 2 shows highly significant ($P \leq 0.01$) differences amongst the mean squares. The SCA effects for direct and reciprocal crosses expressed that PSEV-3 × Iqbal (Table 3) and Pahari × Iqbal (Table 4) are best crosses. The values of GCA effects for Azam and Iqbal i.e number of grains ear^{-1} and grain moisture % are (0.95), (0.21) and (1.56%), (0.22%) at harvest proved that Azam and Iqbal are the best general combiners (Table 2). In SCA effects the direct and reciprocal crosses showed that PSEV-3 × Iqbal (Table 3) and Pahari × Iqbal (Table 4) are best combiners. The SCA effects for direct crosses of PSEV-3 x Azam for grain moisture % is (-0.53) and for PSEV-3 × Pahari the number of grain ear^{-1} is (-0.31) (Table 3),

Table 1: *Mean squares for days to germination, plant height, leaf area, number of grains ear^{-1}, grain moisture %, grain and biological yield in maize genotypes. Mean Squares.*

SOV	D F	Days to germination	Plant height	Leaf area	No of grains Ear^{-1}	Grain moisture %	Grain yield	Biological yield
Replication	02	1.44	4.88	2.53	1.05	.004	934453.90	882389.43
Genotypes	35	5.74**	3.46**	9.95**	1.12**	.05	1222379.00	1126359.70
Error	70	0.88	2. 96	5.98	2.53	.564	6554432.09	6254412.44
GCA	05	8.45**	. 93**	7.85**	1.87**	.450	345686.87	435891.97
SCA	15	1.87**	0.51	1.01**	1.50**	.341	345437.98**	556546.94**
Reciprocal	15	0. 67	0.60**	2.48**	0.84**	345	5346579.45**	618999.73**
Error	70	0.73	0.46	3.80	0.45	342	234537.10	357897.72
O^2 GCA	-	0.43	0.35	2.47	4.12	.004	5456.87	6235.47
O^2 SCA	-	069	0.62	2.98	0.89	05	54678.89	65743.49
O^2 Replication	-	0.96	.78	3.85	0.67	.564	230078.45	360568.29
O^2 A	-	1.98	.92	2.01	0.32	450	8679.98	9427.94
O^2 D	-	0.43	23	6.48	0.54	341	50645.18	61743.25

Table 2: *Estimation of GCA effects for days to germination, plant height, leaf area, number of grains ear^{-1}, grain moisture %, grain and biological yield in maize genotypes.*

Parents	Days to germination	Plant height	Leaf area	Number of grains ear^{-1}	Grain moisture %	Grain yield	Biological yield
PSEV-3	0.24	0.64	0.51	0.89	0.24	-268.31	298.64
Azam	0.18	0.53	0.32	0.95	0.21	-98.88	102.24
Sarhad White	0.14	0.45	0.52	8.56	0.12	-9.89	20.23
Jalal	0.09	0.49	0.01	6.76	0.29	6.45	7.73
Iqbal	0.28	0.42	0.42	1.56	0.22	18.27	23.43
Pahari	0.06	0.48	0.31	3.44	0.18	3.57	4.92

while for reciprocal crosses the SCA effects for Jalal × Sarhad White and Pahari × Jalal for biological yield (23.3) and (54.4) (Table 4) exhibits best combiners. The GCA effects for grain moisture % and grain yield among six genotypes showed non-significant results. The SCA effects for direct crosses of Azam × PSEV-3 and PSEV-3 × Sarhad White for grain moisture % and grain yield are (values) (Table 3), while among the reciprocal crosses of Jalal × Iqbal and Jalal × PSEV-3 for (parameters) are (values) (Table 4) showed best combiners.

Combining ability analysis splits the whole variation into parental GCA 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 germination, plant height and kernel rows ear^{-1} in later generations will be more effective till the accumulation of maximum favorable alleles and recurrent selection will be the more suitable method. These results are in consonance with the previous studies of Aliu et al., (2008) for days to germination, who also reported negative GCA effects which showed earliness in germination mechanism and thus might be attributed to early maturity. Thus PSEV-3 and Azam could be selected as the best general combiners for early maturing genotypes. Aminu et al. (2014) also reported similar findings for ear length and kernels rows ear^{-1} in various maize crosses. Pahari and Jalal were selected for plant height, while Sarhad White and PSEV-3 were selected as best combiners for leaf area. Significant SCA effects for grains ear^{-1}, grain yield and biological were observed depicting dominance and partial dominance type of gene action for these traits and thus selection of specific cross combinations is of greater importance. Furthermore,

Table 3: *Estimates of SCA performance for days to germination, plant height, leaf area, number of grains ear^{-1}, grain moisture %, grain and biological yield in maize genotypes.*

Direct Crosses	Days to germination	Plant height	Leaf area	No of grains ear^{-1}	Grain moisture %	Grain yield	Biological yield
PSEV-3 × Azam	-0.35	120	326	0.68	-.053	399.65	.326
PSEV-3 × Sarhad White	0.58	172	388	1.28	.047	-95.41	.487
PSEV-3 × Jalal	-0.27	102	172	-0.58	.061	-36.51	.102
PSEV-3 × Iqbal	-0.46	-350	400	0.44	.037	-52.79	.182
PSEV-3 × Pahari	0.19	-390	182	-0.31	.008	196.78	.291
Azam × Sarhad White	-0.24	250	287	-0.37	.004	-313.47	.004
Azam × Jalal	0.18	198	198	0.26	.05	677.56	.564
Azam × Iqbal	-0.16	282	315	1.43	.564	92.92	.129
Azam × Pahari	-0.13	278	295	-0.41	.450	-34.89	-37.3
Sarhad White × Jalal	0.14	359	287	0.29	.341	148.96	123.3
Sarhad White × Iqbal	-0.18	345	378	-0.41	.345	152.99	145.4
Sarhad White × Pahari	-1.16	190	390	0.32	.342	98.69	-57.5
Jalal × Iqbal	-0.41	189	365	-0.65	.034	357.12	309.2
Jalal × Pahari	-0.54	391	290	-0.13	.091	-370.62	354.4
Iqbal × Pahari	0.89	282	369	0.12	.320	5.94	343.3

Table 4: *Estimates of SCA effects for days to germination, plant height, leaf area, number of grains ear^{-1}, grain moisture %, grain and biological yield in maize genotypes.*

Reciprocal Crosses	Days to germination	Plant height	Leaf area	No of grains ear^{-1}	Grain moisture %	Grain yield	Biological yield
Azam × PSEV-3	-1.01	110	336	0.69	-.053	318.10	32.6
Sarhad White × PSEV-3	0.48	112	398	0.38	.047	-281.8	48.7
Jalal × PSEV-3	-0.37	92	182	-0.56	.061	51.70	10.2
Iqbal × PSEV-3	-0.36	390	300	0.14	.037	-85.67	18.2
Pahari × PSEV-3	0.10	-380	82	0.03	.008	190.97	29.1
Sarhad White × Azam	-1.54	210	187	0.47	.004	-37.47	00.4
Jalal × Azam	0.16	-98	108	0.29	.05	91.33	56.4
Iqbal × Azam	-0.16	282	215	.49	.564	176.70	12.9
Pahari × Azam	-0.19	298	95	0.00	.450	-64.67	-37.3
Jalal × Sarhad White	0.27	350	357	0.29	.341	515.17	23.3
Iqbal × Sarhad White	-1.20	325	278	.81	.345	497.3	45.4
Pahari × Sarhad White	0.86	190	315	2.42	.342	961.47	99.5
Iqbal × Jalal	0.31	199	65	.05	.034	878.83	09.2
Pahari × Jalal	0.64	301	190	1.13	.091	-95.60	54.4
Pahari × Iqbal	-1.09	-352	169	0.82	.320	650.50	43.3

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) and Fan et al. (2008) for plant height, grains ear^{-1} and grain yield. Thus, Iqbal × PSEV-3 with maximum plant height, Pahari × Sarhad white for days to germination and leaf area Pahari × Jalal for number of grains ear^{-1} and 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% germination, plant height and number of grains ear^{-1} were under control of additive type of gene action, while plant height, ear height, number of grains 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 maize OPVS PSEV-3 and Azam were the best general combiner for most of the traits. SCA effects in direct crosses revealed that all crosses performed variably for the studied traits, Sarhad White × Pahari proved to be best combiners for grain yield, while in reciprocal crosses, Pahari × Sarhad White for days to germination, leaf area, No of grains ear^{-1}, moisture %, grain and biological yield.

Author's Contribution

Zakiullah conducted research. M. Fareed Khan helped in article writing. M. Iqbal helped in field work. M. Mohibullah helped in data analysis. Irfanullah, Faheemullah, Madiha Urooj and Uzma Arif helped in datacollection.

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