GENE ACTION AND PROGENY PERFORMANCE FOR VARIOUS TRAITS IN MAIZE

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The present research was carried out to estimate combining ability effects for grain yield and various components in six elite maize inbred lines. Progeny performance showed that hybrids were 18-76 % better than inbred lines for all the parameters. Variances due to specific combining ability were greater in magnitude and more important for all the characters except ears per plant and kernels per ear row than the variances due to general combining ability. This indicated that the inheritance of these parameters was under the control of non-additive and over-dominant types of gene action and suggested that progeny selection might be effective for genetic improvement of all parameters in the advanced generation except kernels per ear row. It was also suggested from the relative general and specific combining ability performances that inbred lines (B-42 and A-556) and direct cross (OH-54-3A×B-42) was better in grain yield per plant and might be useful if exploited in future maize breeding programs.
Keywords: Combining ability, gene action, maize, grain yield.

INTRODUCTION

Maize is third important leading cereal crop after wheat and rice in respect of area and production in Pakistan. Among all the crop plants, maize is the most versatile one as it has great nutritive value 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar, 17% ash (Chaudhary, 1983). Maize has maximum grain yield potential per unit area as compared to other cereal food crops and therefore plays a vital role in the economy of Pakistan. In Pakistan it accounts for 4.8% of the total cropped area and 3.5% of the value of agricultural output. It is planted on estimated area of 981.76 thousand hectares with the annual production of 2797.0 thousand tonnes with an average of 2.85 tonnes per hectare (FAO, 2005). It is relatively short duration cereal crop capable of utilizing solar energy more efficiently. It attains great priority in the areas of high altitude where chilling condition and snow fall limit the growing period for other cereal crop.

Under the circumstances breeders should genuinely be interested in the development of hybrids, which are highly productive. Production of hybrid seed depends upon the selection of superior parents which requires technical skill and professional efficiency. Increased production per unit area is the primary objective in maize breeding program. Use of adapted maize hybrids can boost maize production in the country. The practical phase of maize breeding is based upon the development of inbred lines and evaluation of these lines in the hybrid combinations. Combining ability of inbred lines is the crucial factor in determining their future usefulness for developing maize synthetics and hybrids (Vasal *et al.,* 1992).

The study of general and specific combining ability provides opportunities to eliminate undesirable inbred lines and select the most desirable ones to constitute various hybrid combinations i.e., single crosses, double crosses, synthetic, and composite varieties. This study was planned with a view to estimate the various components due to combining ability effects for various quantitative characters. The information so derived might be useful in the selection of inbred lines for their utilization locally adapted and highly productive synthetics or hybrids.

MATERIALS AND METHODS

The present study was carried out in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, during the year 2003-04. The material consisted of six maize inbred lines such as A-509, A-556, AES-204, OH-54-3A, W-83-2 and B-42. The inbred lines were sown in a crossing block during spring season, 2004. All possible single crosses and their reciprocals were attempted. The F_1 seed along with the parental lines were sown in a randomized complete block design with two replications during summer 2004. Sowing was done by dibbling two seed per hill, later thinned to single having plant-to-plant and row-to-row distances 15 and 75 cm, respectively in a single row plot of 5.3 m long. Identical and uniform agronomic practices were applied to all entries in the experiment. Ten plants were taken from each parent and cross in each replication. The data were recorded for plant height (cm), flag leaf area (cm^2), number of ears per plant, number of kernel rows per ear, number of kernels per row, 100-grain weight (g) and grain yield per plant (g). The data was subjected to diallel analysis using method-1, model-II (Griffing, 1956). The general and specific combining abilities were computed for the 6 parent inbred lines, 15 F_1 hybrids and their 15 reciprocal crosses. Progeny performances were also calculated using the procedure of Baker (1978).

RESULTS AND DISCUSSION

Mean squares in all crosses were partitioned into components, such as general combining ability, specific combining ability and reciprocal effects (Table 1).

Table 1. Mean squares for general, specific and reciprocal effect estimates for some polygenic parameters in maize.

SOV	df	Plant height (cm)	Flag leaf area (cm^2)	Ears per plant	Kernel rows per ear	Kernels per ear row	100-grain weight (g)	Grain yield per plant (g)
Gca	5	344.10**	1389.20**	0.01^NS	4.99**	1.55^NS	19.23**	436.55**
Sca	15	111.65**	1048.14**	0.01^NS	4.31**	7.28**	16.61**	235.30**
Reciprocal	15	145.15**	909.06**	0.00^NS	4.61**	5.73**	18.59**	201.93**
Error	70	27.87	58.44	0.003	1.17	1.89	2.24	43.98
Gca/gca+sca		0.76	0.56	0.45	0.54	0.18	0.54	0.65

Where: gca/gca+sca = progeny performance, NS = non-significant, ** = significant at 1% level of significance, SOV = source of variation, df =degree of freedom.

Mean squares for general combining ability were significant for all characters except kernels per ear row and ears per plant which were non-significant. Mean squares for specific combining ability and reciprocal effects were highly significant for all characters except number of ears per plant. Significant mean squares of general and specific combing ability indicated that inheritance of these parameters also controlled by both additive and non-additive types of gene action. Vacaro *et al.* (2002) also reported in maize that the inheritance of plant height and yield was under the control of additive genes. Progeny performance (Table 1) indicated that hybrids were better than parents for all parameters. Similarly Olakojo and Olaoye (2005) reported in maize that hybrid were 40% better than inbred parents for grain yield.

Relative general, specific and reciprocal combing ability effects

Regarding plant height, (Table 2) inbred line OH-54-3A showed good general combining ability with a value of 6.27, whereas the inbred line B-42 showed poor general combining ability with a negative value of -6.66. The results were in accordance to various research workers in maize (Geetha, 2000; Vales, 2001). F_1 hybrid A-509×AES-204 was found batter in case of plant height as expressed highest specific combining ability effects with the value 9.14, whereas A-556 × B-42 with negative value -10.61 was found poor (Table 3). The results are in accordance to Beck *et al. (*1990). Maximum reciprocal effects 26.37 for plant height were obtained form reciprocal cross B-42×AES-204 and cross W-83-2×A-509 yielded negative reciprocal effects with value of -4.65 (Table 4). Inbred line B-42 with a value of 17.26 proved to be a good general combiner for flag leaf area. However, the inbred line A-509 was poor general combiner with negative value of -12.44 (Table 2). For flag leaf area (Table 3), direct cross AES-204×OH-54-3A expressed highest specific combining ability (31.74), while direct cross OH-54-3A×W-83-2 had poor specific combining ability effect. For flag leaf area reciprocal cross W-83-2×AES-204 exhibited maximum reciprocal effects (38.97). The cross B-42×OH-54-3A had negative value -28.8 for reciprocal effects (Table 4). For ears per plant the inbred line A-509 (Table 2) was a good general combiner, while Inbred line AES-204 and W-83-2 had least general combining ability effects. Direct cross AES-204×W-83-2 expressed highest specific combining ability effect with the value of 0.06 for ears per plant. But cross OH-54-3A×B-42 yielded highest negative value of -0.01 (Table 3). All the reciprocal effects were equal to Zero in case of ears per plant (Table 4).

Regarding number of kernel row per ear inbred line B-42 proved to be a good general combiner (0.99), but on the other hand inbred line A-509 was poor general combiner with negative value of -0.79 (Table 2). With regard to number of kernel rows per ear, direct cross A-556×W-83-2 showed maximum specific effects with the value of 2.05. The highest negative value of specific combining ability effect (-1.60) was obtained from single cross OH-54-3A×W-83-2 (Table 3). Lee-Wonkoo *et al*. (1995) was reported similar results in maize. With respect to number of kernel rows per ear (Table 4), highest value (3.62) was exhibited by reciprocal cross W-82-3×A-556, however lowest effect (-1.92) was obtained form reciprocal cross B-42×W-83-2.

Table 2. Relative general combing ability estimates for some polygenic parameters in maize

Inbred	Plant height (cm)	Flag leaf area (cm^2)	Ears Per plant	Kernel rows per ear	Kernels per ear row	100-grain weight (g)	Grain yield per plant (g)
A-509	6.11	-12.44	0.01	-0.79	-0.37	1.53	4.34
A-556	3.63	-2.00	-0.01	0.43	0.12	1.40	6.36
AES-204	3.05	-3.04	-0.02	-0.28	-0.07	0.02	3.45
OH-54-3A	6.27	7.61	0.01	-0.42	0.51	-1.28	-9.71
W-83-2	-0.22	-7.38	-0.02	0.08	-0.41	-0.30	-1.13
B-42	-6.66	17.26	0.01	0.99	0.22	-1.38	-3.59

Table 3. Relative specific combing ability estimates for some polygenic parameters in maize

Direct crosses	Plant height (cm)	Flag leaf area (cm^2)	Ears per plant	Kernel rows per ear	Kernels per ear row	100-grain weight (g)	Grain yield per plant (g)
A-509× A-556	-0.68	23.28	-0.01	0.21	0.09	-1.12	-16.47
A-509× AES-204	9.14	-2.49	0.02	1.66	0.27	5.07	6.66
A-509× OH-54-3A	-4.92	4.11	-0.01	0.75	-2.08	-2.45	3.98
A-509× W-83-2	-3.69	-0.23	0.02	1.21	-0.31	0.46	5.70
A-509× B-42	1.43	-20.60	-0.01	-1.39	-0.78	1.29	-2.05
A-556× AES-204	3.54	-13.13	0.02	-0.64	2.08	2.63	2.94
A-556× OH-54-3A	1.02	-19.19	-0.01	0.75	3.29	-0.90	2.56
A-556× W-83-2	6.72	0.39	0.02	2.05	-2.64	0.64	2.61
A-556× B-42	-10.61	-4.90	-0.01	-1.39	-0.48	1.70	-5.08
AES-204×OH-54-3A	7.30	31.74	0.02	0.32	-2.81	1.97	-6.95
AES-204× W-83-2	4.13	6.89	0.06	-0.54	0.40	0.39	-2.63
AES-204× B-42	0.36	-19.60	0.02	-0.87	1.59	-0.99	14.12
OH-54-3A× W-83-2	7.88	-22.06	0.02	-1.60	0.09	4.00	-12.83
OH-54-3A× B-42	-2.60	-19.24	-0.01	1.01	1.03	1.64	19.34
W-83-2× B-42	-4.70	-13.36	0.02	-1.30	1.58	0.91	-1.89

In case of number of kernel per row (Table 2), inbred line OH-54-3A was good general combiner (0.51), but on the other hand inbred line W-83-2 was found poor general combiners with the value of -0.41. For number of kernel per row (Table 3) direct cross A-556×OH-54-3A gave highest specific combining ability 3.29. With respect to number of kernel rows per ear, highest value (3.51) was exhibited by reciprocal cross W-83-2×AES-204, however highest negative effect was obtained form reciprocal cross AES-204×A-509 with the value -4.53 (Table 4).

Inbred line A-509 was found to be a best general combiner with the value of 1.53 in case of 100-grain weight. Inbred line W-82-3 was found poor general combiner with a negative value -0.30 (Table 2). For 100-grain weight the highest specific combining ability effect was exhibited by direct cross A-509×AES-204 with a value of 5.07. Direct cross A-509×OH-54-3A yielded the lowest specific combining ability with negative value –2.45 (Table 3). The results are accordance to the findings of Lee-Wonkoo *et al.* (1995). In case of 100-grain weight (Table 4) maximum reciprocal effect was exhibited by W-83-2×A -509 (6.57). Whereas reciprocal cross W-83-2×OH -54 -3A gave negative reciprocal effect with the value of -5.05. In case of grain yield per plant (Table 2) inbred line A-556 proved to be the best general combiner with a value of 6.36, but on the other hand OH-54-3A yielded poor general combining ability with negative value of -9.71. The findings by various research workers in maize were in accordance to this study (Beck *et al.,* 1990; Navado and Cross, 1990). The greatest specific combining ability effect (Table 3) for grain yield was observed for direct cross OH-54-3A×B-42 with the value of 19.34, however, lowest specific combining ability was obtained from the cross A-509×A-556 with the negative value of -16.47. Similar finding in maize were reported (San-Vicente *et al*., 1998; Pateriani *et al*., 2000; Desai and Singh, 2001). For grain yield per plant, high reciprocal effects (Table 4) were exhibited by cross OH-54-3A×A-556 scoring value of 20.52, but

B-42×AES-204 gave maximum negative reciprocal effects (-16.85).

The over all effect regarding general combining ability and specific combining ability and their reciprocal effects were indicated that inbred line B-42 have greatest relative effect for flag leaf area with the value of 17.26 followed by inbred line OH-54-3A with the value of 7.61. Whereas inbred line A-509 showed lowest for flag leaf area with the value of -12.44. The over all assessment regarding specific combining ability effects indicated that the highest value was found in a direct cross AES-204× OH-54-3A with the value of 31.74 for flag leaf area followed by cross A-509 ×A-556 with the value 23.28 for flag leaf area whereas direct cross OH-54-3A×W-83-2 had lowest value for specific combining ability (-22.06) for flag leaf area. The results were in agreement with the findings of various research workers in maize (Lee-Wonkoo *et al.*, 1995; Singh *et al.*, 1983; Mathur *et al.*, 1998). In case of reciprocal effects the cross combination W-82-3×AES-204 displayed the best reciprocal effect with the value of 38.97 followed by cross W-82-3×AES-204 with the value of 36.22 for flag leaf area. But the reciprocal cross B-42×OH-54-3A showed lowest reciprocal effect with the value -28.8.

Table 4. Relative reciprocal effect estimates for some polygenic parameters in maize

Reciprocal crosses	Plant height (cm)	Flag leaf area (cm^2)	Ears per plant	Kernel rows per ear	Kernels per ear row	100-grain weight (g)	Grain yield per plant (g)
A-556× A-509	1.62	5.55	0.00	-0.50	0.91	0.70	-2.07
AES-204× A-509	0.67	11.27	0.00	-1.52	-4.53	-3.97	0.62
OH-54-3A× A-509	0.87	9.55	0.00	-1.72	-3.23	-1.27	2.30
W-83-2× A-509	-4.65	27.60	0.00	-0.45	-4.13	6.57	7.90
B-42× A-509	14.75	-1.77	0.00	-0.45	-1.22	-2.02	-6.97
AES-204× A-556	-0.12	22.47	0.00	1.90	-0.20	-3.35	13.52
OH-54-3A× A-556	-0.73	-6.17	0.00	0.80	1.33	2.55	20.52
W-83-2× A-556	-3.62	8.22	0.00	3.62	-0.99	-1.92	3.22
B-42× A-556	4.82	11.07	0.00	-1.00	-1.90	0.20	18.22
OH-54-3A× AES-204	-0.62	27.42	0.00	1.35	1.02	-4.10	8.70
W-83-2× AES-204	2.75	38.97	0.00	-0.40	3.51	-1.60	-36.5
B-42× AES-204	26.37	3.52	0.00	-0.07	-1.14	-0.92	-16.85
W-83-2× OH-54-3A	9.15	36.22	0.00	-1.00	-2.47	-5.05	-9.25
B-42× OH-54-3A	2.07	-28.80	0.00	1.87	0.80	-2.50	0.02
B-42× W-83-2	-1.62	10.20	0.00	-1.92	-1.84	0.85	-1.86

Table 5. Relative proportion estimates of general (gca), specific (sca) and reciprocal components of variance for some polygenic parameters in maize

Parametes	gca	sca	Reciprocal	gca/sca ratio
Plant height (cm)	19.60	48.65	58.64	40.3
Flag leaf area (cm^2)	31.08	574.67	425.31	5.5
Ears per plant	-0.00	0.00	0.00	-0.0
Kernel rows per ear	0.06	1.82	1.72	3.2
Kernels per ear row	-0.46	3.13	4.52	3.1
100-grain weight (g)	0.26	8.34	8.17	3.1
Grain yield per plant (g)	17.29	111.08	78.98	15.5

Gene action

The proportions of variance components were calculated in percentage (%) in order to obtain an estimate of relative importance of additive and non-additive types of gene action. The variance components (Table 5) for plant height due to general combining ability (gca) were 19.60 % of the total variance. But the variance components due to specific combining ability (sca) and reciprocal effects were 48.65 and 58.64 % respectively of the total variance. This indicated that non-additive gene action was more important in the inheritance of plant height. The ratio of gca/sca is more than one so over-dominance was present. The variance for flag leaf area due to general combining ability was 31.08 % and value of specific combining ability (574.7 %) and reciprocal (425.31%) of the total variance. Specific combining ability contributing more which was due to non-additive type of gene action, whereas the ratio of general combining ability and specific combining ability was more than one, so over-dominant type of gene action was apparent for this character.

In case of ears per plant, the variance components due to general combining ability and specific combining ability were 0.00 % and 0.00% of the total variance respectively. The ratio of gca/sca is less than 1, so no dominance was present. This was due to the additive type of gene action. For kernel rows per ear, the variance components due to general combining ability and specific combining ability and reciprocal effects were 0.06 %, 1.82 % and 1.72 % respectively of the total variance, thereby indicating non-additive type of gene action was responsible for the inheritance of this trait. The ratio of gca/sca was more than 1, so over-dominant type of gene action was present.

Regarding kernels per row, the variance components due to general and specific combining effects were -0.46 % and 3.13 % respectively, of the total variance. The variance components due to reciprocal effects were 4.5 % of the total variance, thereby showing predominance of non-additive type of gene action for this parameter. The ratio of gca/sca was more than 1, so over-dominance was present. In case of 100-grain weight, the variance components for general combining ability, specific combining ability and reciprocal effects were 0.3 %, 8.3 % and 8.2 % respectively, of the total variance which indicate non-additive type of gene action was more importance for the inheritance of this trait. These results were in agreement with the findings of Vasilj *et al*. (1983). The variance components due to general and specific combining effects were 17.30 % and 111.08 % respectively of the total variance. The variance components for reciprocal effects were 78.98 % of the total variance. The ratio of gca/sca was more than 1, so over dominance was more evident. Vasilj *et al*. 1983 also found similar results in maize crop. In view of the present findings it may be inferred that general combining ability variance was low for all characters than specific combining ability variance. The results were in accordance to Genova (1984), while these results contradict the findings of Naspolini *et al.* (1981); Baktash *et al*. (1985) who reported non-additive type of gene action to be more important for grain yield its related traits in maize. The discrepancy may be due to different genetic material used and the different environment under which study was made.

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