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LINE X TESTER ANALYSIS FOR GRAIN YIELD AND YIELD RELATED TRAITS IN MAIZE VARIETY SARHAD-WHITE

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Abstract

This experiment was carried out at Agricultural University, Peshawar during 2011 to test 15 maize S_2 lines of maize variety Sarhad White in test cross combinations. During spring season (February-June) S_2 lines of maize variety Sarhad-White variety were out crossed at three isolations with 2 hybrids; WD3×6, Kiramat and an open pollinated variety Jalal. Performance of the resulting testcrosses was evaluated with their parents in July-October. Randomized complete block design with 2 replications was used in the experiment. Parents and crosses for yield traits showed highly significant differences. The traits were further analyzed for general combining ability and specific combining ability effects. Maximum ear length (18.83cm) was produced when S_2 Line No.5 was crossed with WD3×6 as a tester. Maximum general combining ability value 1.81 was observed for S_2 Line No.2. Least desirable specific combining ability effect was observed for S_2 Line No.4 using WD2×8 a tester. Maximum kernel rows ear^{-1} (17) was observed for test crosses TC_6 and 14, using WD3×6 as a tester. Maximum desirable general combining ability (1.70) was recorded for S_2 Line No. 6(1.59). S_2 Line No.15 was good specific combiner with testers WD2×8 (1.99) and Jalal (1.81). Heaviest grains were produced by test cross TC_7 (39.5 g), using WD2×8 as a tester. For grain yield S2 line no. 2 was the best general combiner, followed by S_2 line 9. For SCA, S2 line 2, 3 and 6 were the best specific combiners when crossed with tester WD2 x 8, Jalal and WD3x6, respectively.

Introduction

Based on genetic makeup, hybrids of several types are possible in maize; however those derived from inbred lines are commonly used for commercial production. The theory of specific combining ability (SCA) and general combining ability (GCA) established by Sprague & Tatum, (1942) have been used broadly in breeding of several economic species of crop. For maize yield, they observed that the importance of general combining ability was relatively more than specific combining ability for unselected inbred lines, while specific combining ability was more important than general combining ability for previously selected lines. They also stated that the general combining ability is largely due to the additive effect of genes while in specific combining ability dominance or epistatic effects of genes are commonly involved.

Rojas & Sprague, (1952) compared estimates of the variances of general combining ability and specific combining ability for yield and their interaction with locations and years. They stressed that the variance of specific combining ability includes not only the non-additive deviations due to dominance and epistasis but also a considerable portion of the genotype × environment interaction. The International Maize and Wheat Improvement Center (CIMMYT) have used measures of general combining ability and specific combining ability effects to establish heterotic patterns among its maize populations and pools (Vasal *et al.*, 1992). Although both inbred and non-inbred progenitors can be used to form new heterotic groups, inbred progenitors will provide better source germplasm suitable for hybrid development. New synthetic populations developed from inbred lines, in general, have lower inbreeding depression and tend to be promising sources of new superior inbred lines (Eberhart, 1939; Vasal *et al*., 1992; Shah *et al*., 2012).

Sprague & Eberhart, (1977) recommended two replications per location and three to five environments for evaluation of maize crosses, because the additive by environment interaction is usually a significant factor. They also concluded that hybrid maize could produce a yield superior to open-pollinated varieties. Increasing the number of environments reduces the contribution of both the pooled error and the additive by environment interaction to the phenotypic variance, whereas increasing replications only reduces the pooled error contribution (Eberhart *et al*., 1995, Hidayatullah *et al*., 2011).

The production of hybrid seed requires the development and preservation of inbred lines and subsequent controlled crosses to produce commercial seed. In maize breeding programs early testing of S2 lines is considered an efficient approach by maize breeders to identify good performing lines by early testing which are then evaluated for grain yield and yield related traits. The present study was aimed at evaluating the combining ability patterns of selected maize S_2 lines obtained from maize variety Sarhad-White for grain yield and yield related traits and to identify and select superior hybrid combinations based on crosses of selected lines with testers.

Materials and Methods

This experiment was conducted to evaluate maize S2 lines derived from maize variety Sarhad-White and its performance with 3 testers for grain yield and other desirable morphological traits at Agricultural University Peshawar, Pakistan during 2011. The research was pursued in 2 seasons. In the spring season (February – June) S_2 lines of Open Pollinated Variety (OPV) Sarhad-white were crossed with three testers comprising two hybrids; WD 3 x 6, Kiramat and an OPV Jalal in three isolations. In the second season (July – October) the test crosses were evaluated along with their S_2 parents, testers and a check variety. The experiment was laid out in randomized complete block design with 2 replications. The total entries were 64 having 17 parents (14S_2 lines + 3 testers) and 42 testcrosses as well a check. Each entry was grown in single row plot, with row length of 5m, having row to row and plant to plant distance of 0.75 and 0.25 m, respectively. Two seeds hill^{-1} were planted, which were thinned to one plant hill^{-1} at 4-5 leaf stage. Data were recorded on the following parameters. For data recording five randomly selected ears were used to calculate the average ear length. Similarly a random sample of 100 grains per plot from selected ears was used to obtain 100 kernel weight.

At physiological maturity, the cobs were dehusked and harvested from each plot in the field and fresh weight of each entry was taken with the help of weighing balance in kg. Grain yield was obtained by adjusting the grain moisture at 15% and converted to the grain yield ha^{-1} with the help of the following formula (Carangal *et al*., 1971).

$$\text{Grain yield (kg ha}^{-1}) = \frac{\text{Fresh ear weight (kg plot}^{-1}) \text{ X (100-MC) X 0.8 X 10000}}{\text{(100-15) x Area harvested (plot size)}}$$

Fresh cob weight = Fresh weight of the cob row^{-1}
0.8 = Shelling coefficient
85 = Standard value of grain moisture at 15%
MC = Moisture content (%) in grains at harvest

Statistical analysis: The data recorded was subjected to analysis of variance (ANOVA) technique appropriate for 8×8 partially balanced lattice square design using program MS-Excel package. Analysis for general combining ability and specific combining ability was carried out following the method of Kempthorne (1957).

Results and Discussion

Ear length (cm): Ear length is a major yield component and is directly proportional to grains ear^{-1}. Longer the ear length, higher will be the grain yield. Ear length significantly differed among testcrosses, lines, testers, and for line × tester effect in the current research. The longest ears were produced when S_2 Line No.5 was crossed with WD3×6. Most of the S_2 Lines were good general combiners (Table 1). Of the S_2 lines, 53.33% had desirable general combining ability effect. For ear length, positive general combining ability is desirable because increase in ear length is of utmost importance in improvement of maize yield. S_2 Line No.2 was good general combiner by expressing the maximum general combining ability value. The lowest general combining ability was observed for S_2 Line No.9, closely followed by S_2 Line No.15. S_2 Line No.4 was good specific combiner when Jalal was used as tester, followed by S_2 Line No.5, using WD3×6 as a tester. Similarly minimum desirable effect of specific combining ability was observed for S_2 Line No.4 but when WD2×8 was used as a tester. On average basis, 48.89% of the total testcrosses showed desirable specific combining ability effects. Our results have similarity with those of Mendoza *et al*., (2000), Konak *et al*., (2001) and Rahman *et al*., (2010) who also noted variation among GCA and SCA effects for S_2 lines in maize.

Table 1. Means, GCA effects of parents and SCA effects of 15 testcrosses with testers obtained from S_2 lines of maize variety Sarhad - White for ear length.

S_2 line	Parent mean	GCA	Testers					
			WD2×8 (T1)		Jalal (T2)		WD3×6 (T3)	
			Ear length (cm)	SCA	Ear length (cm)	SCA	Ear length (cm)	SCA
1	11.00	1.22	15.83	0.06	15.42	0.17	16.17	-0.23
2	11.33	1.81	17.08	0.73	14.58	-1.25	17.50	0.52
3	11.33	1.25	15.83	0.04	17.50	2.22	14.17	-2.26
4	9.67	0.28	12.00	-2.82	18.08	3.78	14.50	-0.96
5	15.50	0.17	13.58	-1.13	11.83	-2.36	18.83	3.49
6	13.83	0.56	14.08	-1.02	13.08	-1.50	18.25	2.52
7	7.50	1.00	13.75	-1.80	16.50	1.47	16.50	0.32
8	8.67	0.68	13.67	-1.56	15.13	0.42	17.00	1.14
9	10.58	-2.40	12.88	0.73	9.00	-2.62	14.67	1.89
10	13.00	-1.39	13.17	0.01	12.58	-0.05	13.83	0.04
11	12.17	-0.81	15.50	1.76	12.58	-0.64	13.25	-1.12
12	9.50	0.42	14.67	-0.30	15.75	1.31	14.58	-1.01
13	11.67	-1.03	16.00	2.48	12.83	-0.16	11.83	-2.32
14	12.58	0.58	15.00	-0.13	12.08	-2.53	18.42	2.66
15	11.50	-2.33	15.17	2.95	13.42	1.72	8.17	-4.68

Number of kernel rows ear^{-1}: Kernel rows ear^{-1} plays vital role in determination of grain yield. More rows ear^{-1} is desirable in maize because of its direct relationship with number of grains and hence grain yield. Means for S_2 Lines with three testers are presented in Table 2. Maximum rows ear^{-1} were observed for test crosses TC_6 and 14 when WD3×6 was used as a tester, while least was recorded for test cross TC_15, using WD3×6 as a tester. Maximum desirable GCA was recorded for S_2 Line No.6 (1.59) whereas; the least was recorded for S_2 Line No.15. On average, 53.33% lines showed desirable GCA effects while rest of the lines had undesirable general combining ability effects. Geetha, (2000) reported that crossing of better parent's results in greater number of grain rows ear^{-1}. S_2 Line No.15 was good specific combiner with testers WD2×8 (1.99) and Jalal (1.81) while, worse combiner with tester WD3×6 (-3.79). Thus, the same line was good as well as worse combiner but with different testers.

Table 2. Means, GCA effects of parents and SCA effects of 15 testcrosses from S_2 lines of maize variety Sarhad-White for kernel rows ear^{-1}

S_2 line	Parent mean	GCA	Testers					
			WD2×8 (T1)		Jalal (T2)		WD3×6 (T3)	
			Kernel rows ear-1	SCA	Kernel rows ear-1	SCA	Kernel rows ear-1	SCA
1	12.00	0.04	15.00	1.32	13.00	-0.86	14.00	-0.46
2	12.00	-0.91	12.00	0.10	12.00	-0.75	14.00	0.65
3	14.00	0.37	15.00	0.99	14.00	0.31	13.00	-1.29
4	12.00	0.65	12.00	-1.63	15.00	1.03	15.00	0.60
5	13.00	-0.35	13.00	-0.13	14.00	0.36	13.00	-0.24
6	15.00	1.59	15.00	-0.07	14.00	-0.91	17.00	0.99
7	9.00	0.31	12.00	-1.63	15.00	0.53	15.00	1.10
8	12.00	0.15	12.00	-0.96	14.00	0.53	15.00	0.43
9	12.00	-1.02	12.00	-0.63	13.00	-0.14	14.00	0.76
10	15.00	0.20	14.00	0.32	14.00	-0.19	14.00	-0.13
11	15.00	-0.35	13.00	0.21	14.00	0.36	13.00	-0.57
12	9.00	-0.41	14.00	0.76	12.00	-0.91	14.00	0.15
13	11.00	-0.85	12.00	-0.29	13.00	0.03	13.00	0.26
14	12.00	1.70	15.00	-0.35	14.00	-1.19	17.00	1.54
15	13.00	-1.13	14.00	1.99	14.00	1.81	9.00	-3.79

Tester Means = T1 (9.5), T2 (11), T3 (15)
Grand mean for testcrosses = 13.2

100 grain weight: Grain weight is of utmost importance in selection of high yielding maize genotypes Analysis of variance revealed significant variation among test crosses, lines, testers and line × tester effect for grain weight. The heaviest grains were produced by test cross TC_7 and TC_8, using WD2×8 as a tester, whereas the lightest grains were produced by test cross TC_15, using WD3×6 as a tester (Table 3). Altinbas & Tosun, (1998) reported that parental lines screening and crosses performed based on 100-grain weight can give efficient results. GCA was greater for S_2 Line No.3 followed by S_2 Line No.6, while lowest general combining ability was observed for S_2 Line No.14. Only 40% of the tested lines had desirable general combining ability effects. Among the S_2 lines, Line No .7 was good specific combiner with WD2×8, followed by Line No.1 with tester WD3×6. The lowest specific combining ability effect was observed for S_2 Line No.15, using WD3×6 as a tester. These results are in conformity to those obtained by Singh & Singh (1998), Mendoza *et al*., (2000) & Konak *et al*., (2001) who also reported higher specific combining ability and general combining ability effects for different S_2 lines in maize. Lines with greater specific combining ability effects could be used for hybrid development while those having greater general combining ability could be used effectively for synthetic cultivars development.

Grain yield: Most of the plant breeding programs are designed with the objective to improve grain yield. For grain yield highly significant differences were obtained among the lines, crosses, testers and line × tester interaction accompanied with low coefficient of variability. Maximum grain yield was observed for S_2 Line No.6, using WD3×6 as a tester, while least was observed for S_2 line No.12, using WD2×8 as a tester. Maximum general combining ability effect was observed for S_2 Line No.2, followed by S_2 Line No.9 (Table 4). Similarly, least general combining ability effect was observed for Line No.12, followed by S_2 Line No.13. Among the tested lines, 58.33% showed desirable general combining ability effect while for rest of the lines the effect was undesirable. Maximum specific combining ability effect was observed for S_2 Line No.14, using WD2×8 as a tester, followed by S_2 Line No.6, using WD3×6 as a tester. Likewise, least specific combining ability effect was observed for S_2 Line No.3, using WD2×8 as a tester followed by S_2 Line No.2, using Jalal as tester. Looking into the proportion of desirable specific combining ability effects, it was 48.89 % for grain yield. Our results are in agreement with those of Tanner & Smith (1987) and Rahman *et al*., (2012) who observed highly significant variation for grain yield with various exotic maize testers.

Table 3. Means, GCA effects of parents and SCA effects of 15 testcrosses with three testers obtained from S_2 lines of maize variety Sarhad-White for grain wt.

S_2 line	Parent mean	GCA	Testers					
			WD2×8 (T1)		Jalal (T2)		WD3×6 (T3)	
			Grain weight (g)	SCA	Grain weight (g)	SCA	Grain weight (g)	SCA
1	24.60	-1.77	25.00	-6.53	31.70	1.65	35.10	4.88
2	26.30	-0.60	33.80	1.15	26.20	-5.03	35.20	3.87
3	23.10	4.88	38.30	0.17	36.10	-0.67	37.30	0.51
4	28.30	-0.19	33.90	0.85	27.80	-3.84	34.70	2.99
5	29.70	1.43	38.50	3.79	31.30	-2.01	31.60	-1.79
6	29.80	1.79	32.90	-2.20	35.90	2.22	33.70	-0.02
7	26.40	1.05	39.50	5.21	32.40	-0.48	28.30	-4.72
8	24.30	1.71	38.90	3.89	28.80	-4.77	34.50	0.88
9	20.10	-1.12	32.80	0.70	30.20	-0.58	30.70	-0.12
10	29.50	0.96	31.50	-2.70	35.80	3.03	32.60	-0.33
11	20.20	-0.67	31.70	-0.91	33.00	1.78	30.40	-0.86
12	26.10	-0.50	30.10	-2.71	32.10	0.72	33.40	1.99
13	27.20	-1.00	29.60	-2.68	34.80	3.96	29.70	-1.29
14	25.20	-3.40	28.40	-1.43	27.60	-0.83	30.80	2.25
15	27.40	-2.59	34.10	3.41	34.10	4.85	21.10	-8.26

Tester Means (g) = T1 (27), T2 (32), T3 (34)

Table 4. Means, GCA effects of parents and SCA effects of 15 testcrosses with 3 testers obtained from S_2 lines of maize variety Sarhad-White for grain yield.

S_2 line	Parent mean	GCA	Testers					
			WD2×8 (T1)		Jalal (T2)		WD3×6 (T3)	
			Grain yield (kg ha-1)	SCA	Grain yield (kg ha-1)	SCA	Grain yield (kg ha-1)	SCA
1	4561	104.7	6690	-67.50	7204	-52.8	9139	730.3
2	5548	631.2	9273	1379.00	5983	-1799.9	9356	420.9
3	5319	475.3	5915	-1823.1	9102	1474.9	9128	348.2
4	3535	429.6	7631	-61.6	8744	1162.8	7633	1101.3
5	6153	144.5	8369	962.4	5935	-1361.3	8848	398.8
6	6525	152.3	6881	-533.7	5823	-1480.5	10471	2014.2
7	3787	380.9	7541	-102.9	7371	-161.3	8949	264.2
8	4879	380.7	6295	-1347.8	7344	-188.6	10221	1536.4
9	3542	479.3	7912	170.3	8540	909.4	7704	1079.7
10	6740	-189.8	6600	-472.8	6445	-517.3	9105	990.1
11	5406	-546.8	7420	704.3	6907	302.3	6751	1006.7
12	2745	-1539.9	5092	-631.1	6277	665.6	6730	-34.5
13	6469	-1047.9	5801	-413.5	7115	1011.7	6658	-598.2
14	4767	-7.6	9462	2207.0	6206	-938.1	7028	1268.9
15	6751	153.3	8057	640.9	8278	972.9	6844	1613.8

Tester Means (kg h^{-1}) = T1 (5245), T2 (6714), T3 (8594)
Grand mean for testcrosses = 6953 kg h^{-1}

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