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EVALUATION OF MAIZE S_2 LINES FOR YIELD ATTRIBUTES IN TESTCROSS COMBINATIONS

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ABSTRACT

A research trial was planned to evaluate maize S_2 lines for yield attributes in testcross combinations. Twenty-seven S_2 lines were each crossed to two testers at Research Farm of The University of Agriculture, Peshawar, Pakistan, during spring crop season 2008. After discarding 18 testcrosses at harvest for no or low seed setting, the remaining 36 testcrosses along with two testers and 18 parents were evaluated using lattice design with three replications at New Developmental Farm of The University of Agriculture Peshawar, during summer crop season 2008. The results revealed that the testcrosses differed significantly ($P \leq 0.05$) for grain rows ear^{-1} while non-significant variations ($P \geq 0.05$) among testcrosses were observed for ear length, 100-grain weight and grain yield. Highest grain yield (6106.9 kg ha^{-1}) was recorded for testcross SW-17 x Jalal. Maximum 100-grain weight (34.7 g) was observed for SW-16 x Jalal. Maximum ear length (17.6 cm) was recorded for SW-3 x Jalal. The highest number of grain rows ear^{-1} (16.3) was observed for SW-17 x WD-2x8 while lines SW-14 and SW-24 were the best general combiners for grain yield. Lines SW-9 and SW-24 proved to be good general combiners for 100-grain weight. Lines SW-5 and SW-17 were good general combiners for grain rows ear^{-1} while lines SW-3 and SW-24 were good general combiners for ear length. WD-2x8 showed good GCA against grain rows ear^{-1}and ear length while Jalal showed good GCA for 100-grain weight and grain yield. Line SW-24 can be used to improve more than one trait simultaneously. SW-24 was a good general combiner for grain yield, 100-grain weight and ear length. SW-17 x Jalal and SW-3 x Jalal were good specific combiners for grain yield. SW-16 x Jalal, SW-6 x Jalal, SW-22 x WD-2x8 and SW-27 x WD-2x8 were good specific combiners for 100-grain weight. SW-11 x Jalal was a good specific combiner for grain row ear^{-1}. A good specific combiner for ear length was SW-3 x Jalal. These testcrosses can be further evaluated while breeding for high yielding varieties and are recommended to be included in subsequent breeding programs for improvement of maize gene pool.

Keywords: maize, S_2 lines, testcross, grain yield, general combining ability (GCA), specific combining ability (SCA).

INTRODUCTION

Maize (*Zea mays)* is the world's leading cereal crop. In Pakistan, during 2010-11, maize was cultivated on 974.2 thousand hectares with total production of 3707.0 thousand tons and productivity of 3805 kg ha^{-1} (Agricultural Statistics of Pakistan 2010-11). Maize is the second most important summer cereal crop after wheat and is sown on about 27% of the total cropped area annually in Khyber Pakhtunkhwa of Pakistan (Khan *et al*., 2004). Maize is often grown as dual-purpose crop, producing grain as well as fodder and it is also used in industries for making starch, oil, polishes, etc. (Aziz *et al*., 1992).

Several procedures are available for the improvement of maize populations; of these, selfed progeny *per se* selection and selection based on testcross progeny performance using an inbred or single-cross tester are of particular interest to breeders (Horner *et al*., 1989). In any breeding scheme the identification of the superior germplasm is the most important pre-requisite for genetic progress, without such identification, selection is at random and genetic progress is by chance.

Due to increasing interest in hybrid maize production, information about combining ability of inbred lines is essential to maximize their use in hybrid development. Therefore, shortcut but efficient methods are needed for isolation and identification of superior genotypes. An ideal evaluation procedure would permit the identification of elite genotypes early in the breeding scheme at minimum cost. This would allow breeders to discard unpromising material early and concentrate on the promising portion. Evaluation of early generation inbred lines has been the primary method used in maize breeding. Early generation testing of inbreds for general combining ability (GCA), first proposed by Jenkins (1935), has become a matter of great interest to maize breeders and is commonly used.

In the standard maize breeding, tests for combing ability are deferred until the third, fourth or fifth generation of selfing. In early generation testing scheme, the original selection (S_0) or first generation selection (S_1), plants are out crossed to a tester and the resulting progeny is evaluated for yield and general performance. Lines with poor combining abilities are then eliminated, and only the promising lines are further inbred. Early generation testing is based on the assumptions that S_0 or S_1 plants differ in combining ability and these differences can be detected by a testcross. The mating of S_0 plants to a tester for evaluation of combining ability is a technique widely used for both intra-population and inter-population improvement of cross-pollinated species. The superior individual lines identified as part of recurrent selection program can be inbred for potential use as a cross pollinated cultivar or as a parent of synthetic or hybrid cultivars (Fehr, 1987).

Evaluation of early generation inbred lines in testcrosses has been the primary method used in maize breeding. Greater attention is received by S_1 and S_2 performance for superior genotypes. For many agronomic traits, S_1 and S_2 family tests do provide more precise evaluation of genotypes than do other types of families; thus greater progress should be possible (Walden, 1978).

This study was conducted with the objective to evaluate the best performing S_2 lines based on testcross progeny performance derived from maize variety 'Sarhad White' and to identify superior testcrosses for yield traits. Another objective was to determine combining abilities and their potential as parents in the production of superior hybrid/variety adaptive to the agro-climatic conditions of Peshawar valley.

MATERIALS AND METHODS

The experiment "Evaluation of maize S_2 lines for yield attributes in testcross combinations" was conducted at the New Developmental Farm of the University of Agriculture, Peshawar. The experiment was carried out in two growing seasons during 2008, i.e., spring (February-June) and summer (July-October). Experimental material comprised second selfed generation (S_2) lines derived from maize variety 'Sarhad White'. It is a white semi dent variety having medium tall stature, semi dense tassel with profuse branching. An open pollinated variety (OPV) Jalal and a single cross hybrid, WD-2x8, developed at Cereal Crop Research Institute, Pirsabak, Nowshera, were used as testers. During spring season (February-June) 2008, 27 S_2 lines, derived from maize variety Sarhad White, were each crossed to two testers, Jalal and WD-2x8 at Agricultural Research Farm, University of Agriculture Peshawar in two well isolated fields. The S_2 lines along with testers were sown in isolation in a ratio of two female rows to one male row. Row length was 4.0 m while the plant to plant distance and row to row distance was 0.25 m and 0.75 m, respectively. Regular visits to the farm were made to detassel those lines that showed tassels. The detasseled S_2 lines were allowed to be pollinated naturally by the testers. As initially sowing was delayed due to a prolonged rain spell, so at the time of pollination temperature was very high and to eliminate the risk of low or no kernel setting, manual pollinations were also carried out. The top of the ear shoot was cut 2-3 cm to allow uniform silk emergence for effective pollination and the next morning pollen from tester plants were collected and bulked to pollinate the lines. At physiological maturity (black layer formation at hilum of maize kernel) plants were hand harvested. Each line was harvested and shelled separately. Testcrosses that had no or very low seed setting were discarded. During summer season (July-October) 2008, 36 testcrosses along with two checks and 18 parents were evaluated in a replicated yield trial using 14 x 4 rectangular lattice design with three replications at the Research Farm of the University of Agriculture, Peshawar. Row length was kept at 5 m with plant to plant spacing of 0.25 m and row to row spacing of 0.75 m. Two seeds hill^{-1} were sown to ensure uniform emergence and later thinned to one seedling hill^{-1} at knee height stage. In both seasons standard cultural practices were carried out. Fertilizer was applied in the form of di ammonium phosphate (DAP) and urea at the rate of 120 and 60 kg ha^{-1}, respectively. Entire DAP was applied at the time of sowing while half of urea was applied before sowing and rest was applied when plants were at knee high. The crop was irrigated as when needed. Data were recorded on grain rows ear^{-1}, ear length, 100-grain weight and grain yield. Grain yield was calculated by the following formula.

$$\text{Grain yield (kg ha}^{-1}\text{) (15\% moisture)} = \frac{\text{Fresh ear weight (kg plot}^{-1}\text{) x (100-MC) x 0.8 x 10.000}}{\text{(100-15) x area harvested (plot size)}}$$

where

MC = Moisture content (%) in grains at harvest.
0.8 = Shelling coefficient.
Area harvested plot^{-1} = 3.75 m^2
1 hectare = 10,000 m^2
100-15 = required moisture percentage at storage.

The data were statistically analyzed using "General Linear Model (GLM) procedure" appropriate for 14 x 4 rectangular lattice design, using statistical software "SAAS". LSD test was also applied at 5% level of significance. Analysis for GCA and SCA was carried out, following Singh and Chaudhary (1985).

Formula for GCA effects

(a) Lines

$$g_l = \frac{x_{l..}}{t\,r} - \frac{x_{...}}{l\,t\,r}$$

where

l = no. of lines
t = no. of testers
r = no. of replications.

(b) Testers

$$\text{gca (tester)} = g_t = \frac{x_{.j}}{l\,r} - \frac{x_{...}}{l\,t\,r}$$

Formula for SCA effects

$$s_{ij} = \frac{x_{ij.}}{r} - \frac{x_{i..}}{t\,r} - \frac{x_{.j.}}{l\,r} + \frac{x_{...}}{l\,t\,r}$$

RESULTS

Grain rows ear^{-1}

The differences among the testcrosses for grain rows ear^{-1} were highly significant ($P \leq 0.01$) among genotypes while significant ($P \leq 0.05$) among crosses and lines. The analysis of variance showed non-significant ($P \geq 0.05$) differences among testers, lines x testers, crosses vs. lines, crosses vs. testers and lines vs. testers. Co-efficient of variation for number of grain rows ear^{-1} was 7.75% (Table-1).

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The highest number of grain rows ear^{-1} (16.3 grain rows ear^{-1}) was observed for SW-17 x WD-2x8, followed by SW-5 x WD-2x8 (16.2 grain rows ear^{-1}) and SW-19 x WD-2x8 (15.8 grain rows ear^{-1}) while the lowest number of grain rows ear^{-1} (12.6 grain rows ear^{-1}) was recorded for SW-27 x WD-2x8, followed by SW-27 x Jalal (13.3 grain rows ear^{-1}) and SW-3 x WD-2x8 (13.3 grain rows ear^{-1}). The mean number of grain rows ear^{-1} of all the testcrosses was observed to be 14.5 (Table-2).

It is shown in Table-3 that 8 lines out of 18, showed positive GCA values for grain rows ear^{-1}. SW-5 and SW-17 showed maximum positive GCA value for grain rows ear^{-1} while maximum negative GCA value was shown by SW-21, followed by SW-25. WD-2x8 showed positive GCA value while Jalal showed negative GCA value for grain rows ear^{-1}.

The estimates of SCA for grain rows ear^{-1}are presented in Table-4. It is evident from the Table that 17 testcrosses out of 36 showed positive SCA values for grain rows ear^{-1}. The perusal of Table revealed that the cross combination SW-11 x Jalal had the highest positive SCA value while four and fourteen testcrosses in combination with Jalal and WD-2x8, respectively exhibited highest negative SCA value for grain rows ear^{-1}.

Ear length (cm)

Table-1 shows highly significant variations ($P \leq 0.01$) among the genotypes, crosses vs. testers and lines vs. testers's interaction while non-significant differences ($P \geq 0.05$) among crosses, testers, lines x testers and crosses vs. lines for ear length. The analysis of variance was significant ($P \leq 0.05$) among lines. The co-efficient of variation for ear length was 11.51%. Maximum ear length (17.6 cm) was recorded for SW-3 x Jalal, followed by SW-25 x Jalal (16.0 cm) while minimum ear length (12.3 cm) was obtained for SW-19 x Jalal. The calculated mean ear length for all the testcrosses was 14.4 cm. (Table-2).

The GCA effects for ear length of parents are presented in Table-3. GCA values of 8 genotypes were found positive while 10 genotypes exhibited negative GCA effects for ear length. Among these, SW-3 showed highest positive value of GCA, followed by SW-24. The poorest line was SW-20 with highest negative GCA value, followed by SW-11. Tester WD-2x8 showed positive GCA value while Jalal showed negative GCA value for ear length.

Similarly, out of 36 testcrosses, 27 showed positive SCA value for ear length. SW-3 x Jalal showed highest positive SCA value while highest negative SCA values were shown by testcrosses SW-9 x Jalal, SW-15 x Jalal, SW-19 x Jalal, SW-22 x Jalal, SW-3 x WD-2x8, SW-5 x WD-2x8, SW-6 x WD-2x8, SW-17 x WD-2x8 and SW-25 x WD-2x8 for ear length (Table-4).

100-grain weight (g)

Data presented in Table-1 indicated highly significant ($P \leq 0.01$) differences among the genotypes and crosses vs. testers and non-significant ($P \geq 0.05$) among crosses, lines, testers, lines x testers, crosses vs. lines and lines vs. testers. The co-efficient of variation for 100-grain weight was 15.38%. Maximum grain weight was observed for SW-16 x Jalal (34.7 g) and SW-27 x WD-2x8 (34.4 g) while minimum 100-grain weight was recorded for SW-3 x WD-2x8 (22.9 g). The grand mean 100-grain weight for the testcrosses was 28.8 g (Table-2).

The GCA values for 100-grain weight are presented in the Table-3. It is indicated from the table that 50% of the total genotypes showed positive GCA effects while the remaining 50% genotypes indicated negative GCA values for 100-grain weight. The maximum positive GCA value was obtained by SW-9, followed by SW-24 while maximum negative value was obtained by SW-18, followed by SW-11. The OPV Jalal showed positive GCA value while WD-2x8 showed negative GCA value for 100-grain weight.

The SCA values for 100-grain weight are presented in Table-4. It is shown in the Table that SCA values of 25 crosses were found positive while 11 crosses showed negative SCA values for 100-grain weight. The maximum positive SCA value was shown by the cross SW-16 x Jalal, followed by SW-6 x Jalal, SW-22 x WD-2x8 and SW-27 x WD-2x8 while maximum negative SCA value was shown by a cross SW-5 x Jalal, SW-25 x Jalal, SW-3 x WD-2x8, SW-14 x WD-2x8 and SW-17 x WD-2x8 for 100-grain weight.

Grain yield (Kg ha^{-1})

The analysis of variance (ANOVA) regarding grain yield revealed highly significant variations ($P \leq 0.01$) among genotypes and crosses vs. testers while non-significant ($P \geq 0.05$) among crosses, lines, testers, lines x testers and crosses vs. lines. Differences were significant ($P \leq 0.05$) in lines vs. testers. The co-efficient of variation for grain yield was 32.05% (Table-1).

The highest grain yield (6106.9 kg ha^{-1}) was recorded for SW-17 x Jalal, followed by SW-14 x WD-2x8 with grain yield of 6043.9 kg ha^{-1}and SW-6 x Jalal with grain yield of 5581.8 kg ha^{-1}(Table-2). The lowest grain yield (2476.3 kg ha^{-1}) was shown by SW-27 x WD-2x8. The overall mean grain yield for 36 testcrosses was 4419.4 kg ha^{-1}(Table-2).

The general combining ability (GCA) effects for grain yield of parents are presented in Table-3. GCA values of 11 genotypes were found positive and 7 genotypes showed negative GCA effects. The maximum positive GCA value was expressed by SW-14, followed by SW-24 while highest negative GCA value was shown by SW-16, followed by SW-20. The open pollinated variety (OPV) Jalal showed positive GCA value while WD-2x8 showed negative GCA value for grain yield.

The specific combining ability (SCA) effects of testcrosses for grain yield are presented in Table-4. It is evident from the Table that 50% of the total cross combinations showed positive SCA effects while the remaining 50% of the testcrosses showed negative SCA values for grain yield. The cross SW-17 x Jalal showed maximum positive SCA value for grain yield, followed by SW-3 x Jalal while maximum negative SCA value was show by SW-27 x Jalal, followed by SW-9 x Jalal for grain yield.

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Table-1. Mean squares for grain rows ear^{-1}, ear length, 100-grain weight and grain yield of testcross progenies.

Source of variation	DF	Grain rows ear^{-1}	Ear length	100-grain weight	Grain yield
Replication	2	0.17^{NS}	21.79**	299.60**	10147632.0*
Genotypes	55	3.77**	13.57**	56.34**	6046189.9**
Crosses	35	2.02*	3.45^{NS}	30.62^{NS}	2552063.88^{NS}
Lines	17	3.29*	4.16*	31.08^{NS}	3087987.05^{NS}
Testers	1	0.82^{NS}	0.01^{NS}	29.24^{NS}	5394396.01^{NS}
Lines x Testers	17	0.82^{NS}	2.95^{NS}	30.24^{NS}	1848944.70^{NS}
Crosses vs. Lines	1	1.52^{NS}	16.91^{NS}	0.43^{NS}	1204571.2^{NS}
Crosses vs. Testers	1	4.13^{NS}	235.96**	447.56**	177252240.8**
Lines vs. Testers	1	3.95^{NS}	99.16**	78.05^{NS}	16700298.7*
Error	110	1.27	2.45	18.17	1398195.2
CV%		7.75	11.51	15.38	32.05

* = Significant at 5% level of significance
** = Significant at 1% level of significance
NS = Non-Significant
CV = Coefficient of Variance

Table-2. Mean values for grain rows ear^{-1}, ear length, 100-grain weight and grain yield of 36 testcrosses, parents and checks.

S. No.	Entries	Grain rows ear^{-1}	Ear length (cm)	100-grain weight (g)	Grain yield (kg ha^{-1})
1.	SW-2 x Jalal	14.0	14.5	30.1	4851.1
2.	SW-3 x Jalal	14.2	17.6	26.8	5282.5
3.	SW-5 x Jalal	15.3	14.1	23.7	4983.6
4.	SW-6 x Jalal	14.1	14.9	31.9	5581.8
5.	SW-9 x Jalal	13.8	14.2	32.9	4723.9
6.	SW-11 x Jalal	14.6	13.9	29.9	5232.6
7.	SW-13 x Jalal	14.2	13.8	29.1	3425.6
8.	SW-14 x Jalal	14.0	13.7	32.6	5126.6
9.	SW-15 x Jalal	15.4	13.9	30.4	5260.8
10.	SW-16 x Jalal	14.0	14.5	34.7	4763.4
11.	SW-17 x Jalal	15.2	14.9	31.8	6106.9
12.	SW-18 x Jalal	14.2	12.7	29.0	3349.7
13.	SW-19 x Jalal	14.9	12.3	25.0	3590.0
14.	SW-20 x Jalal	14.5	14.9	28.1	3755.8
15.	SW-22 x Jalal	14.8	13.4	25.1	3995.5
16.	SW-24 x Jalal	14.3	15.6	31.3	5374.0
17.	SW-25 x Jalal	14.4	16.0	28.4	5274.4
18.	SW-27 x Jalal	13.3	13.6	27.9	2891.7
19.	SW-2 x WD-2x8	14.8	15.5	25.3	4092.0
20.	SW-3 x WD-2x8	13.3	14.6	22.9	2941.7
21.	SW-5 x WD-2x8	16.2	13.1	26.9	4141.3
22.	SW-6 x WD-2x8	13.5	14.1	24.6	3401.7
23.	SW-9 x WD-2x8	14.0	15.5	31.7	4474.1

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24.	SW-11 x WD-2x8	13.9	14.7	27.7	5216.5
25.	SW-13 x WD-2x8	15.7	14.5	33.5	4373.1
26.	SW-14 x WD-2x8	14.2	14.8	29.4	6043.9
27.	SW-15 x WD-2x8	14.9	15.2	27.9	4471.0
28.	SW-16 x WD-2x8	13.5	15.4	24.6	3523.2
29.	SW-17 x WD-2x8	16.3	12.8	26.7	3455.0
30.	SW-18 x WD-2x8	14.4	12.9	28.6	3784.3
31.	SW-19 x WD-2x8	15.8	13.0	23.4	3441.7
32.	SW-20 x WD-2x8	14.6	13.7	28.6	4497.2
33.	SW-22 x WD-2x8	15.1	14.8	31.4	4994.3
34.	SW-24 x WD-2x8	15.2	15.1	31.7	5171.2
35.	SW-25 x WD-2x8	14.2	13.7	30.5	5028.3
36.	SW-27 x WD-2x8	12.6	14.9	34.4	2476.3
Mean of TC		14.5	14.4	28.8	4419.4
Mean of parents		14.8	11.8	25.3	2200.4
Mean of checks		14.0	16.1	29.1	3958.8
$LSD_{(0.05)}$		1.82	2.53	6.89	1911.63

Table-3. General combining ability effects for yield and yield components of 18 parental lines and 2 checks.

S. No.	Parents	Grain rows ear^{-1}	Ear length (cm)	100-grain weight (g)	Grain yield (kg ha^{-1})
1.	SW-2	-0.07	0.66	-1.14	52.19
2.	SW-3	-0.75	1.78	-3.99	-307.25
3.	SW-5	1.25	-0.78	-3.54	143.13
4.	SW-6	-0.68	0.14	-0.62	72.40
5.	SW-9	-0.58	0.49	3.44	179.65
6.	SW-11	-0.23	-0.06	-0.04	805.22
7.	SW-13	0.48	-0.23	2.44	-520.00
8.	SW-14	-0.40	-0.09	2.13	1165.92
9.	SW-15	0.65	0.17	0.29	446.52
10.	SW-16	-0.73	0.61	0.81	-276.09
11.	SW-17	1.25	-0.51	0.41	361.57
12.	SW-18	-0.17	-1.58	-0.02	-852.34
13.	SW-19	0.87	-1.68	-4.62	-903.50
14.	SW-20	0.08	-0.04	-0.51	-292.82
15.	SW-22	0.48	-0.28	-0.59	75.58
16.	SW-24	0.27	1.01	2.63	853.24
17.	SW-25	-0.18	0.47	0.61	731.97
18.	SW-27	-1.52	-0.11	2.33	-1735.37
19.	Jalal	-0.09	-0.01	0.52	223.42
20.	WD-2x8	0.09	0.01	-0.52	-223.42

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Table-4. Specific combining ability effects for yield and its components of 36 testcross combinations.

S. No.	F_1 cross combinations	Grain rows ear^{-1}	Ear length (cm)	100-grain weight (g)	Grain yield (kg ha^{-1})
1.	SW-2 x Jalal	0	0	2	155
2.	SW-3 x Jalal	0	2	2	947
3.	SW-5 x Jalal	-1	0	-1	198
4.	SW-6 x Jalal	0	0	4	866
5.	SW-9 x Jalal	0	-1	1	-99
6.	SW-11 x Jalal	1	0	1	-216
7.	SW-13 x Jalal	-1	0	-2	-697
8.	SW-14 x Jalal	0	0	2	-682
9.	SW-15 x Jalal	0	-1	1	171
10.	SW-16 x Jalal	0	0	5	396
11.	SW-17 x Jalal	-1	1	3	1102
12.	SW-18 x Jalal	0	0	0	-441
13.	SW-19 x Jalal	0	-1	1	-150
14.	SW-20 x Jalal	0	1	0	-595
15.	SW-22 x Jalal	0	-1	-3	-723
16.	SW-24 x Jalal	-1	1	0	-123
17.	SW-25 x Jalal	0	1	-1	-101
18.	SW-27 x Jalal	0	0	-3	-16
19.	SW-2 x WD-2x8	0	1	-2	-157
20.	SW-3 x WD-2x8	-2	-1	-1	-947
21.	SW-5 x WD-2x8	-1	-1	3	-198
22.	SW-6 x WD-2x8	-1	-1	-2	-867
23.	SW-9 x WD-2x8	-1	1	1	98
24.	SW-11 x WD-2x8	-1	1	0	215
25.	SW-13 x WD-2x8	0	1	3	697
26.	SW-14 x WD-2x8	-1	1	-1	682
27.	SW-15 x WD-2x8	-1	0	0	-172
28.	SW-16 x WD-2x8	-1	0	-4	-397
29.	SW-17 x WD-2x8	-1	-1	-1	-1103
30.	SW-18 x WD-2x8	-1	0	1	440
31.	SW-19 x WD-2x8	0	0	0	149
32.	SW-20 x WD-2x8	-1	0	2	593
33.	SW-22 x WD-2x8	-1	1	4	722
34.	SW-24 x WD-2x8	-1	0	2	121
35.	SW-25 x WD-2x8	-1	-1	3	100
36.	SW-27 x WD-2x8	-1	1	4	15

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DISCUSSIONS

Early generation testing is used in self and crossed pollinated crops to estimate the genetic potential of individual lines or populations at an early stage of inbreeding. The objective is to eliminate lines or populations that do not merit consideration for further inbreeding and selection (Genter, 1962).

Grain rows ear^{-1} along with ear length, ear diameter and grain weight contributes to the final grain yield. Manivannan (1998) suggested that ear girth and number of kernel rows ear^{-1} should be given more importance while doing selection for grain yield improvement in maize. Significant differences were observed among testcrosses for number of grain rows ear^{-1}. Observing the mean grain rows ear^{-1} of all testcrosses, it becomes clear that 41.67% of testcrosses contained more grain rows ear^{-1} than the overall mean of testcrosses and 2.78% of testcrosses had equal to that of mean of testcrosses. The remaining 55.56% of testcrosses contained less number of grain rows ear^{-1} than the mean of testcrosses. Significant differences were also recorded by Carlone and Russell (1989) for number of grain rows ear^{-1}in testcross evaluation of maize synthetic 'BSSS' lines.

Like other yield associated traits that affects the final grain yield, ear length also has considerable effect on the final grain yield. Manivannan (1998) found that ear girth, kernel rows, kernels row^{-1} and ear length had significant and positive correlation with grain yield. Analysis of variance showed non-significant differences among testcrosses for ear length. Observing the mean ear length of all testcrosses, it becomes obvious that 52.78% of the testcrosses had greater ear length than the mean of all testcrosses. On the other hand, 47.22 % testcrosses had less ear length than mean of testcrosses. Contrary to our results, significant differences were obtained by Carlone and Russell (1989) for ear length among lines of maize synthetic 'BSSS' after testcross evaluation. This difference in results may be due to the different experimental material and climatic conditions encountered at experimental sites.

Grain weight is an important yield component that contributes to the final grain yield. According to Dash (1992) 100-seed weight along with plant height and ear length are the major factors contributing to yield, therefore, selection should be based on these criteria. Debnath and Khan (1990) also recommended 1000-kernel weight as an effective component in selection for improving grain yield. Analysis of variance showed non-significant variations among testcrosses for 100-grain weight. About 50% testcrosses gave more while 50% testcrosses gave less 100-grain weight than the mean of all testcrosses. Similar non-significant differences were observed by Carlone and Russell (1989) for 300-kernel weight among the testcrosses of S_2 lines maintained in maize.

Grain yield improvement is the ultimate goal virtually in every plant breeding program (Welsh, 1981). Procedures often used for the improvement of grain yield in maize are of four main types: mass selection, selection based on half sib (testcrosses or top cross) progeny performance, full sib progeny selection and selfed progeny selection (Horner *et al*., 1969). Realized progress with any breeding scheme, however, depends largely upon breeder's ability to identify superior genotypes (Genter, 1973).

Analysis of variance showed non-significant differences among testcrosses for grain yield which shows the testcrosses were similar in yield potential. Looking at the mean grain yield of all the testcrosses, it is observed that 44.44% of the testcrosses gave performance which was inferior to the mean of all the testcrosses. On the other hand, 55.56% of the testcrosses gave grain yield which was well above the combined mean of all the testcrosses. The mean grain yield of the checks (3959 kg ha^{-1}) was less than mean grain yield (4419 kg ha^{-1}) of testcrosses which showed the better performance of the test crosses in comparison with the checks. Carlone and Russell (1989) observed non-significant results for grain yield in testcrosses of S_2 line derivatives with two unrelated testers. Bernardo (1990) also observed non-significant results for grain yield in testcrosses of S_2 lines derivatives with two unrelated testers.

A perusal of GCA effects (Table-3) reveals that four parental lines SW-14, SW-24, SW-11 and SW-25 had good GCA effects for grain yield. Lines SW-9 and SW-24 had high GCA for 100-grain weight. Lines SW-5 and SW-17 were best combiners for grain rows ear^{-1}. High GCA values were obtained for lines SW-3 and SW-24 for ear length. Line SW-24 showed greater GCA effects for yield and its related components.

Normally, breeding is done for improving more than one character simultaneously. So overall the line which performed well for more than one character was SW-24.

The values of SCA for different cross combinations recorded for different parameters revealed that the cross combination of SW-17 x Jalal was the best for grain yield. Testcross SW-16 x Jalal was the best specific combiner for 100-grain weight. Cross SW-11 x Jalal was the best for grain rows ear^{-1}. Testcross SW-3 x Jalal showed the highest SCA effect for ear length. These testcross combinations can be used for improving various yield related traits.

CONCLUSIONS AND RECOMMENDATIONS

Maximum grain yield was produced by SW-17 x Jalal. Maximum positive GCA values for grain yield were recorded for SW-14, followed by SW-24, proved to be the best general combiners for grain yield. The highest positive SCA value was obtained from SW-17 x Jalal and SW-3 x Jalal and thus the best specific combiner for grain yield. Maximum 100-grain weight was observed for SW-16 x Jalal. Maximum positive GCA value was shown by SW-9, followed by SW-24 and proved to be good general combiners for 100-grain weight. The good specific combiners were SW-16 x Jalal, followed by SW-6 x Jalal, SW-22 x WD-2x8 and SW-27 x WD-2x8. The maximum number of grain rows ear^{-1} was observed for SW-17 x WD-2x8. Maximum positive GCA values were shown by SW-5 and SW-17 and are good general combiners for

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grain rows ear^{-1}. The good specific combiner was SW-11 x Jalal. For ear length, maximum value was recorded for SW-3 x Jalal. Maximum positive GCA value was shown by SW-3 and this line was also a good general combiner for ear length. The good specific combiner was SW-3 x Jalal. Based on these conclusions it can be recommended that the testcross SW-17 x Jalal, which gave the highest yield, followed by SW-14 x WD-2x8 and SW-6 x Jalal, can be further evaluated to test their potential as parents in breeding programs. Line SW-24 is a good general combiner for grain yield, 100-grain weight and ear length, SW-3 is a good general combiner for ear length, SW-11 and SW-25 are good general combiners for grain yield and SW-17 is a good general combiner for grain rows ear^{-1}. SW-9 is a good general combiner for 100-grain weight. Tester WD-2x8 showed good GCA against grain rows ear^{-1} and ear length, while Jalal showed good GCA against grain yield and 100-grain weight. These testcross combinations can be used for improving various yield related traits in Peshawar Valley.

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