Proceed. Third Pl. Breed. Conf. *Egypt. J. Plant Breed. 7 (1): 55-75*
April 26, 2003 (Giza) *Special Issue (2003)*

COMBINING ABILITY AND TYPE OF GENE ACTION IN MAIZE UNDER FAVOURABLE AND WATER STRESS ENVIRONMENTS

M.A. El-Morshidy[1], E.A. Hassaballa[1], Sh.F. Abou-ElSaad[2] and M.A. Abd-El-Moula[2]

1-Agron. Dept., Fac. of Agric., Assiut University.
2- Maize Sect., Crop Sci. Inst., A.R.C.

ABSTRACT

Thirty five yellow S_1 lines of maize were topcrossed to three testers: the base population pop-45, single cross-156 and SC-159. The 105 top crosses were evaluated under water stress and non-stress (favourable) environments to estimate combining ability and type of gene action for grain yield and other agronomic traits. Highly significant differences were found among crosses, lines and line x tester (LxT) interaction for all studied traits under both environments. Combined analysis showed significant mean squares for environments (E), LxT, LxE, TxE and LxTxE interactions for most of the studied traits.

The magnitude of σ^2_{GCA} and σ^2_{SCA} were high for most of the studied traits under water stress than under non-stress environment. The magnitude of σ^2_{SCA} was larger than σ^2_{GCA} for all studied traits under both environments, indicating the importance of non-additive gene effects in the inheritance of the studied traits. The variance of interaction between σ^2_{GCA} x E was high than that of σ^2_{SCA} x E for all studied traits.

The yellow S_1 lines no. 7 and 22 showed significant and positive GCA effects for grain yield under both environments. The S_1 lines no. 4, 30, 36 and 113 under favourable and no. 3, 18, 27, 28, 31, 33, 83 and 229 under water stress environment showed significant and positive GCA effects for grain yield. These lines should be directly utilized in breeding programmes to develop high yielding hybrid(s).

Results showed that 14 and 11 topcrosses showed significant and positive SCA effects for grain yield under non-stress and water stress environments, respectively.

Key words: ***Maize, Combining ability, S_1 lines, Gene action, Water stress.***

INTRODUCTION

Top cross (Test cross) method using broad and/or narrow base testers is used to evaluate new improved lines for combining ability in maize hybrid breeding programmes. Procedures for developing and improving inbred lines of maize were reported by Bauman (1981) and Hallauer and Miranda (1981) who concluded that improved inbred lines increased grain yield and modified maturity. Top cross procedure was first suggested by Davis (1927) as an early testing to determine the usefulness of the lines for hybrid development programmes. The concept of general (GCA) and specific (SCA) combining ability was firstly defined by Sprague and Tatum (1942). They and other investigators (Hassaballa *et al* 1980, Mahmoud 1989, Konak *et al* 1999 and Zelleke 2000) reported that the variance components due to SCA for grain yield and other agronomic traits was larger than that due to GCA, indicating the importance of non-additive type of gene action in the inheritance of these traits.

Significant GCA x Environment interactions for grain yield were found for both lines and testers (Hede *et al* 1999, Nass *et al* 2000 and El-Zeir *et al* 2000).

Mathur *et al* (1998) found that general combining ability analysis revealed significant GCA variances for days to 50% silking, ear length, no. of rows/ear and no. of kernels/row under stress and non-stress environments. The SCA variance was significant for ear length under the normal environment and for grain yield under the stress environment.

The main objectives of this investigation were to estimate combining ability and type of gene action of a group of lines of under normal and water stress environments.

MATERIALS AND METHODS

Thirty five yellow S_1 lines of maize derived from the yellow population 45 were top crossed to each of three testers: the single cross hybrids SC-159 and SC-156 and the original population (pop-45). The 105 yellow top crosses were made during the 1999 summer season at Sids Agric. Res. Station. In 2000 season, 105 yellow top crosses were evaluated under normal irrigation (experiment 1) and water stress (preventing irrigation after the 2^{nd} irrigation to the end of the season) conditions, (experiment 2) using RCBD with four replications for each trail. The experimental plot was one row, 6 meters long with 80 cm between rows. Planting was in hills spaced 25 cm apart. Data were recorded on silking date, plant height, ear height, grain yield and yield components (ear length, ear diameter, no. of rows/ear and 100-kernel weight).

Analysis of variance was carried out separately for each environment and combined across environments according to Steel and Torrie (1980). Combining ability analysis was carried out for each environment according to Kempthorne (1957).

RESULTS AND DISCUSSION

Analysis of variance

Analysis of variance is the studied traits under favourable and water stress environments is presented in Tables 1 and 2.

Significant differences existed among crosses, lines and testers for all studied traits evaluated under the two environments. Mean squares due to line x tester interaction were also significant for all studied traits under both environments.

Combined analysis of variance for the studied traits over the two environments for the 105 yellow topcrosses is presented in Table (3). Results revealed significant differences among the two environments for all studied traits of topcrosses, suggesting remarkable differences between the two environments. Mean squares due to lines and testers in their respective topcrosses were significant for all studied traits. Variance due to line x tester interaction was also significant for all studied traits. These results indicate that there was a wide genetic diversity between lines and testers and that the testers ranked S_1 lines differently.

Mean squares due to line x env. and testers x env. interactions were significant for most of the studied traits. These interactions with environments were indicative of different ranking of lines and testers from one environment to another. Mean squares due to lines x testers x env. interactions were significant for all studied traits except, days to 50% silking and grain yield. This interaction indicates that crosses between lines and testers differed from environment to another.

Our results are in good agreement with those obtained by El-Morshidy and Hassaballa (1982), Zambezi *et al* (1986), El-Itriby *et al* (1990), Mathur *et al* (1998), Singh and Singh (1998), Zelleke (2000) and Soliman *et al* (2001).

General Combining Ability Effects

For S_1 lines

1. Days to 50% silking

Results in Table (4) show that S_1 lines no. 18, 21, 31, 43, 50, 95, 100, 223 and no. 229 had negative (favourable) while S_1 lines no. 3, 4, 7, 36, 42, 113 and 227 had positive and significant GCA effects under favourable and water stress environments. Yellow S_1 line no. 192 showed negative

Table 1.Mean squares (MS) of silking date, plant and ear height for 105 yellow top crosses evaluated under favourable (Fav.) and water stress (W.St.) environments.

S.O.V.	d.f.	Mean squares					
		Silking date		Plant height		Ear height	
		Fav.	W.St	Fav.	W.St.	Fav.	W.St.
Replications	3	10.52**	132.68**	1515.02**	18221.10**	573.89**	7072.16**
Crosses	104	6.93**	3.49**	1433.95**	1721.98**	691.99**	405.79**
Lines (L)	34	5.74**	5.17**	919.97**	905.24**	583.31**	301.64**
Testers (T)	2	195.15**	45.25**	41423.85**	49180.64**	19704.29**	10073.28**
L x T	68	1.99*	2.11*	514.77**	734.51**	187.13*	173.53**
Error	312	1.49	1.65	196.71	327.7	109.24	97.04

*, ** Significant at 5% and 1% levels of probability, respectively.

Table 2.Mean squares (MS) of yield and yield components for 105 yellow top crosses evaluated under favourable (Fav.) and water stress (W.St.) environments.

S.O.V.	d.f.	Mean squares									
		100-kernel weight		Ear length		Ear diameter		No. of rows/ear		Grain yield (ardab/fed.	
		Fav.	W.St	Fav.	W.St	Fav.	W.St	Fav.	W.St	Fav.	W.St
Replications	3	57.87**	220.85**	147.20**	102.28**	1.38**	2.53**	24.54**	2.77**	922.40**	93.99**
Crosses	104	22.04**	141.62**	6.02**	10.21**	0.096*	0.207**	1.52**	1.78**	47.22**	25.18**
Lines (L)	34	27.37**	144.39**	68.22**	5.30**	0.157**	0.167**	1.87**	2.93**	33.35**	16.54**
Testers (T)	2	163.10**	687.48**	257.92**	204.35**	0.280**	2.49**	5.71**	9.84**	1276.47**	402.07**
L x T	68	15.23*	124.18**	75.61**	6.96**	0.06	0.159**	1.23**	0.97**	18.0*	18.41**
Error	312	8.73	43.13	21.32	2.81	0.045	0.047	0.59	0.38	12.98	4.39

*, ** Significant at 5% and 1% levels of probability, respectively.

Table 3. Analysis of variance of the combined data over two environments for some agronomic and yield traits of 105 yellow top crosses of maize.

S.O.V.	d.f.	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	No. of rows/ear	100-kernel weight	Grain yield
Environment	1	537.60**	5333300.1**	178675.0**	2490.56**	69.89**	9.16**	12874.33**	49933.41**
Reps. (Env.)	6	71.60	9868.05	3823.02	82.37	1.95	13.65	139.36	508.19
Crosses (C)	104	8.80**	2612.81**	927.56**	12.63**	0.185**	2.32**	83.60**	50.30**
Lines (L)	34	9.85**	1496.89**	730.27**	5.73**	0.223**	3.68**	92.45**	28.28**
Testers (T)	2	209.52**	89742.68**	28633.04**	352.14**	2.13**	14.70**	755.14**	1503.98**
L x T	68	2.37**	668.12**	211.34**	6.10**	0.11**	1.27**	59.42**	18.55*
C x Env.	104	2.07**	543.12*	151.67*	3.61*	0.117**	0.98**	80.06**	22.10**
L x Env.	34	1.05	688.31*	154.68**	2.76	0.10*	1.11**	79.31*	21.61*
T x Env.	2	30.88**	861.81**	1145.13**	3.21	0.65**	0.85*	95.43**	174.55**
L x T x Env.	68	1.73	641.15**	149.32*	4.04*	0.11**	0.92*	79.99**	17.86
Error	624	1.57	262.20	103.14	2.99	0.046	0.48	25.9	8.86

*, ** Significant at 5% and 1% levels of probability, respectively.

Table 4. Estimates of GCA effects for days to 50% silking, plant height, ear height and ear length of lines under favourable (F) and water stress (W.St) environments.

Serial no. of S_1 line	50% silking		Plant height		Ear height		Ear length	
	F.	W.St	F	W.St	F	W.St	F.	W.St
3	0.545*	0.779**	16.002**	16.645**	9.750**	8.502**	0.097	1.205**
4	1.212**	0.779**	10.418**	1.229	9.833**	1.836	-0.153	-0.095
7	1.462**	1.362**	17.418**	13.312**	7.167**	3.002*	0.413	-0.195
10	0.712**	0.195	-9.832*	2.145	-8.250**	-1.081	-0.370	0.238
18	-0.871**	-0.888**	-6.332*	11.229**	-2.583	4.252**	0.147	1.405**
21	-1.371**	-0.638*	-20.582**	-18.021**	-17.167**	-9.498**	-1.103	-0.412
22	0.212	0.445*	-3.248	-12.355**	-3.333*	-1.081	-0.237	0.088
24	-0.288	-0.805**	6.168*	6.729*	2.833	4.002**	0.113	-0.995**
27	0.212	-0.305	6.168*	10.312**	5.167*	9.836**	-0.520	0.538*
28	0.211	-0.471*	8.668**	1.895	2.333	0.919	-0.620	-0.711*
30	0.379*	0.195	2.502	-3.855	2.583	1.834	-0.487	-0.462
31	-0.871**	-0.971**	-0.665	3.479	-0.500	0.919	-0.237	0.405
33	0.371*	0.029	-4.915*	6.062*	-5.917**	2.836*	0.963	0.721*
36	0.712**	1.029**	0.418	5.562*	6.917**	3.752*	-0.587	-0.445
38	0.379	0.195	10.335**	7.395*	7.917**	8.252**	-1.170	-0.278
40	-0.538*	-0.221	-9.915**	3.812	-8.917**	3.169*	-0.587	-0.695*
42	1.129**	0.445*	-7.748*	2.562	4.417*	2.252	-0.720	0.505*
43	-0.371*	-1.139**	9.335**	3.729	-1.333	-1.164	-0.320	0.521*
48	0.295	0.779*	9.418**	3.812	5.250**	1.919	-0.503	0.571*
50	-0.788**	-0.971**	-1.748	-3.938	-2.000	2.002	-0.420	0.738*
72	-0.538*	-0.138	-5.582*	-20.438**	-6.833**	-11.331**	0.970	-1.178**
75	-0.212	0.779**	5.168*	-3.855	4.917*	-1.414	-0.537	0.588*
78	0.795**	-0.055	-7.415*	-10.605**	-6.417**	-5.248**	0.770	-0.095
83	-0.038	-0.305	-6.415*	-4.938	-3.167*	-1.831	0.263	0.671*
92	-0.455*	-0.305	-6.082*	-5.771*	-6.000**	-5.248**	-0.370	-0.462
93	0.129	-0.055	6.252*	-0.855	6.500**	1.336	-0.487	-0.695*
95	-1.038**	-0.638**	3.918	5.895*	2.583	0.669	-0.253	0.605*
100	-0.455*	-0.471*	-15.165**	-15.355**	-10.500**	-10.664**	-0.487	-0.029
113	0.795**	0.862**	-3.803	5.729*	13.500**	2.002	-1.353	0.738*
173	-0.038	0.112	12.835**	4.895	9.833**	1.419	-0.787	-0.978**
180	-0.038	0.279	-3.165	-7.855**	-1.000	-4.248**	-1.370	-0.995**
192	-0.455*	0.445*	-2.582	-0.688	-1.583	-2.831*	13.397**	-0.212
223	-0.455*	-0.388*	-8.249**	-11.355**	-8.833**	-9.498**	0.130	-0.745*
227	0.795**	0.816**	-0.165	0.395	-3.000	0.252	-0.437	-0.145
229	-0.871**	-0.805**	-1.415	3.062	-4.167*	0.169	0.330	0.288
T1	-1.348**	-0.648**	-19.853**	-21.183**	-13.698**	-9.586**	-1.526**	-1.223**
T2	0.852**	0.231*	10.452**	14.431**	6.674**	6.536**	0.532	1.192**
T3	0.495**	0.417**	9.402**	6.752**	7.024**	3.050**	0.994*	0.030
S.E.g_i	0.176	0.185	2.024	2.612	1.508	1.421	0.666	0.242
S.E.g_i	0.051	0.054	0.593	0.764	0.441	0.416	0.195	0.071

*,**Significant at 5% and 1% levels of probability, respectively.

under favourable while positive and significant GCA effects under water stress environments.

2. Plant height

General combining ability effects for plant height (Table 4) indicate that 24 and 18 S_1 lines showed significant GCA effects under favourable and water stress environments, respectively. The S_1 lines no. 21, 72, 78, 92, 100 and 223 had negative, while no. 3, 7, 24, 27 and 38 had positive and significant GCA effects under both favourable and water stress environments. Lines no. 18 and no. 33 did not show the same trend under the two environments.

3. Ear height

General combining ability effects for plant height (Table 4) of 25 and 17 lines were significant under favourable and water stress environments, respectively. Lines no. 21, 72, 78, 92, 100 and 223 had negative, while no. 3, 7, 27, 36 and 38 had positive and significant GCA effects under both favourable and water stress environments.

4. Ear length

Estimates of GCA effects for ear length of 35 S_1 lines under favourable and water stress environments are presented in Table 4. It is clear that the S_1 line no. 192 had positive and significant GCA effect (the best combiner) for ear length under favourable environment. Yellow S_1 lines no. 3, 18, 27, 33, 42, 43, 48, 50, 75, 83, 95 and 113 showed positive and significant GCA effects under water stress environment.

5. Ear diameter

GCA effects for ear diameter (Table 5) indicate that 23 and 28 yellow S_1 lines showed significant GCA effects under favourable and water stress environments, respectively. Positive and significant GCA effects were obtained for the yellow S_1 lines no. 7, 10, 28, 40, 42, 173 and 227 under both environments. The S_1 lines no. 18, 24, 50, 83, 113, 180, 192 and 223 showed positive and significant GCA effects under the water stress environment only.

6. Number of rows/ear

GCA effects for no. of rows/ear (Table 5) indicate that S_1 lines no. 7, 28, 36, 48, 173, 192 and 227 had positive and significant GCA effects under both environments. Yellow S_1 lines no. 10 and 22 under favourable and lines

Table 5. Estimates of GCA effects for ear diameter, no. of rows/ear, 100-kernel weight and grain yield of lines under favourable (F) and water stress (W.St) environments.

Serial no. of S_1 line	Ear diameter		No. of rows/ear		100-kernel weight		Grain yield	
	F.	W.St	F	W.St	F	W.St	F.	W.St
3	0.004	-0.019	0.187	-0.489**	0.769	3.796**	0.529	1.593**
4	0.070*	-0.086**	-0.496**	-0.239**	-0.641	3.744**	2.616**	-0.009
7	0.154**	0.064*	0.737**	0.261**	0.671	1.189	3.096**	1.912**
10	0.154**	0.080**	0.454**	-0.055	0.964*	1.247	0.942	-0.837**
18	-0.129**	0.130**	-0.613**	-0.872**	1.262**	-1.478	-0.766	0.951**
21	-0.046	-0.019	-0.213	-0.589**	-0.845*	-0.953	-0.791	-0.253
22	-0.096**	-0.103**	0.220*	-0.655**	1.818**	2.516*	1.384*	1.252*
24	-0.046	0.064*	0.187	0.178*	-0.301	-1.135	-0.018	0.318
27	0.070*	0.047	0.020	0.195*	-1.027**	-2.432*	-1.373*	2.603**
28	0.095**	0.064*	0.304*	0.311**	1.757**	-2.147*	-0.813	1.113**
30	0.037	-0.203**	-0.146	-0.155	-2.077**	-2.951**	3.253**	-0.853*
31	-0.013	0.047	-0.113	0.011	-1.725**	0.635	0.776	0.626*
33	-0.079*	-0.153**	-0.529**	-0.789**	0.221	-3.147**	-0.849	2.119**
36	0.137**	-0.153**	0.437**	0.428**	-1.289**	-0.992	1.395*	-1.469**
38	0.120**	0.030	0.154	0.111	-1.201**	0.424	-0.713	-0.619*
40	0.220**	0.147**	0.087	0.611**	1.342**	2.465**	-0.801	-0.352
42	0.070*	0.180**	0.087	0.911**	-0.698	15.278**	0.468	-1.259**
43	-0.046	-0.036	0.004	-0.039	0.625	2.004*	0.273	0.299
48	0.187**	-0.003	0.387*	0.311**	2.252**	-2.841**	-0.620	-1.503**
50	-0.013	0.097**	-0.396*	0.328**	0.571	1.943*	0.856	-0.058
72	-0.063*	-0.186**	-0.020	0.295**	1.896**	-4.325**	-3.228**	-0.685*
75	-0.029	-0.103**	-0.071	0.261**	-0.612	-2.904**	-1.536**	0.039
78	-0.046	-0.136**	0.120	-0.389**	-1.079*	-1.665	-3.351**	-2.433**
83	-0.113**	0.080**	-0.129	0.795**	1.897**	-0.699	0.736	1.370**
92	-0.163**	-0.186**	0.070	0.111	-2.071**	-1.804*	-1.436*	-0.233
93	-0.096**	-0.169**	-0.179	-0.689**	3.190**	-1.622	-1.776**	-0.354
95	-0.279**	-0.103**	-0.879**	-0.122	-0.639	-0.821	-0.554	0.278
100	-0.113**	-0.136**	-0.229*	-0.722**	0.250	-4.029**	-1.512**	-2.004**
113	0.037	0.214**	0.170	0.178*	-2.091**	-0.281	3.834**	0.281
173	0.137**	0.097**	0.437**	0.345**	-1.334**	-2.531**	1.065*	-0.932**
180	0.004	0.080**	-0.679**	-0.922**	-0.001	1.295	-0.754	-0.738*
192	0.020	0.097**	0.306*	0.511**	-0.057	-1.137	0.324	0.251
223	-0.129**	0.064*	-0.246*	-0.288**	3.454**	-1.301	0.742	-0.853**
227	0.120**	0.130**	0.954**	0.811**	0.087	0.637	0.789	-0.826**
229	-0.129**	0.080**	-0.413**	0.045	2.246**	4.022**	-2.185**	1.266**
T1	-0.039*	-0.150**	0.229**	0.300**	-1.245**	-2.541**	-3.474**	-1.747**
T2	-0.049*	0.106**	-0.153**	-0.097**	0.564**	1.532**	1.995**	1.637**
T3	-0.010	0.044*	-0.067*	-0.203**	0.681**	1.008**	1.479**	0.109
$S.E.g_i$	0.030	0.031	0.111	0.088	0.426	0.947	0.520	0.302
$S.E.g_i$	0.008	0.009	0.032	0.026	0.125	0.277	0.152	0.088

*,**Significant at 5% and 1% levels of probability, respectively.

no. 24, 27, 40, 42, 50, 72, 75, 83 and 113 under water stress environment showed positive and significant GCA effects for no. of rows/ear.

7. 100-kernel weight

GCA effects for 100-kernel weight of the 35 S_1 lines under two environments are presented in Table 5. The S_1 lines no. 22, 40 and 229 had positive while no. 27, 30, 92 and 73 had negative and significant GCA effects under both environments. theS_1 lines no. 10, 18, 28, 48, 72, 83, 93 and 223 under favourable and no. 3, 4, 42, 43 and no. 50 under water stress environments showed positive and significant GCA effects for 100-kernel weight. Lines no. 28, 48 and 72 did not show the same trend for GCA effects under the two environment.

8. Grain yield

Estimates of GCA effects for grain yield (Table 5) of the yellow S_1 lines no. 7 and 22 were positive while those of no. 72, 78 and 100 were negative and significant under both environments. The S_1 lines no. 4, 30, 36 and 113 under favourable and no. 3, 18, 27, 28, 31, 33, 83 and 229 under water stress environment showed positive and significant GCA effects for grain yield. Some of these lines differed in the sign of GCA effect from one environment to another (no. 30, 36 and 229).

For testers

The results showed that the tester Pop.-45 came in the first place as a general combiner for days to 50% silking, plant and ear height and no. of rows/ear, in the second for ear diameter and ear length and in the third for 100-kernel weight and grain yield. The single cross tester SC-156 came in the first place as a general combiner for ear length, ear diameter, 100-kernel weight and grain yield, and in the third place for days to 50% silking plant and ear height and no. of rows/ear.

The tester SC-159 came in the second place as a general combiner for days to 50% silking plant and ear height, 100-kernel weight and grain yield.

For grain yield the best general combiners were the SC-156 under both environments and SC-159 under favourable environment. On the other hand, negative GCA effects for grain yield were exhibited by the tester Pop.-45 under both environments.

The highest positive and significant GCA effects obtained for SC-156 and SC-159 is expected since these are the most elite single crosses and have a high frequency of favourable alleles for grain yield.

Specific Combining Ability Effects

1. Days to 50% silking

Estimates of SCA effects for top crosses revealed that top crosses between S_1 lines no. 3, 31, 72, 83, 173 and 223 and the tester Pop.-45; the lines no. 24, 27, 42 and 75 x SC-156 and no. 21, 33, 36, 48 and 78 x SC-159 had negative and significant SCA effects for days to 50% silking under water stress environment. Negative and significant SCA effects under favourable environment were obtained by the top crosses between S_1 lines no. 28 x Pop.-45; no. 3, 31, 38, 93 and no. 113 x SC-156 and no. 22, 33, 36, 43, 192 and no. 227 x SC-159. The other top crosses have inconsistent trends under different environments (Table 6).

2. Plant height

Results indicated that yellow top crosses between lines no. 4, 22, 33, 50, 113, 173 and 192 x tester Pop.-45; no. 3, 7, 24 and 30 x tester SC-156 and no. 10, 22, 27, 72 and 78 x tester SC-159 had negative and significant SCA effects under the favourable environment. The crosses between lines no. 22, 29, 38, 40, 42, 50 and 75 x tester Pop.-45; no. 21, 31, 38, 83, 92, 100 and 192 x tester SC-156 and lines no. 72, 78, 113, 223 and 227 x tester SC-159 had negative and significant SCA effects under the water stressed environment. Positive and significant SCA effects were obtained by crosses 78 x Pop.-45; 36 and 72 x SC-156; 42 and 50 x SC-159 under both favourable and water stress environments (Table 6).

3. Ear height

The top crosses between lines no. 4, 33, 36, 50, 75 and 173 x Pop.-45; no. 3, 7, 24, 42, 43, 48, 78 and 113 x SC-156 and no. 10, 22, 36, 72 and 78 x SC-159 had negative and significant SCA effects for ear height under the favourable environment (Table 7). Crosses between lines no. 22, 27, 33, 36, 38 and 40 x Pop.-45; no. 21, 38 and 83 x SC-156 and no. 72, 78, 113 and 229 x SC-159 had negative and significant SCA effects under the water stress environment. Positive and significant SCA effects were obtained by crosses 78 x Pop.-45, 113 x Pop.-45, 10 x SC-156, 36 x SC-156, 38 x SC-159 and 50 x SC-159 under both environments.

Table 6. **SCA effects for days to 50% silking and plant height for top crosses of S_1 lines with each of 3 testers under favourable (F) and water stress (W.St) conditions.**

Serial no. of S_1 line	Days to 50% silking						Plant height					
	Pop.-45		SC-156		SC-159		Pop.-45		SC-156		SC-159	
	F	W.St	F	W.St	F	W.St	F	W.St	F	W.St	F	W.St
3	-0.15	-0.69*	-0.60*	0.44	0.76*	0.25	4.85*	6.18	-9.20**	-2.18	4.35*	-4.00
4	-0.07	-0.44	-0.02	-0.06	0.09	0.50	-13.31**	6.85	6.38*	-1.76	6.93*	-5.09
7	-0.57	-0.27	0.73*	-0.15	-0.16	0.42	12.44**	-2.98	-12.87**	4.90	0.43	-1.92
10	-0.07	-0.35	-0.52	0.02	0.59	0.33	3.44	12.43**	6.13*	5.07	-9.57**	-17.50**
18	-0.24	-0.52	-0.44	0.35	0.67*	0.17	-6.06*	-6.90	3.63	-0.01	2.43	6.91
21	0.26	0.48	-0.44	0.35	0.17	-0.83*	-0.31	-6.40	-037	-12.32**	0.68	18.66**
22	-0.07	0.65*	1.23**	-0.48	-1.16**	-0.17	11.35**	-14.57**	2.80	13.32**	-14.15**	1.25
24	0.93*	0.65*	-0.52	-0.98**	-0.41	0.33	11.69**	1.35	-10.62**	5.74	-1.07	-7.09
27	-0.57	1.15**	-0.52	-0.98**	1.09**	-0.17	4.94*	-16.73**	4.88*	4.40	-9.82**	12.33**
28	-0.74*	0.06	0.31	0.44	0.42	-0.50	7.94**	-6.32	-6.12**	16.07**	-1.82	-9.75*
30	0.26	-0.60	-0.17	0.02	-0.08	0.58	6.85**	-4.32	-8.45*	-5.82	1.60	-1.50
31	0.26	-0.69*	-0.93**	0.19	0.67*	0.50	8.27**	5.39	-5.04*	-10.62*	-3.24	4.91
33	1.51**	0.31	-0.19	0.94**	-1.33**	-1.25**	-8.23**	-5.48	2.22	1.65	6.02*	3.83
36	0.18	1.31**	0.98**	-0.31	-1.16**	-1.00**	-4.56*	-6.98	10.13**	13.90**	-5.57*	-6.92
38	0.26	-0.10	-0.69*	0.27	0.42	-0.17	5.77*	-13.82**	-6.54*	-17.68**	0.77	31.50**
40	0.18	0.55	0.23	-0.31	-0.41	-0.25	-1.48	-16.98**	4.22*	1.65	-2.74	15.33**
42	0.26	0.65*	-0.44	-0.98**	0.17	0.33	21.10**	-13.73**	-39.45	7.15	18.35**	6.58
43	0.26	-0.52	0 .56	0.35	-0.83*	0.17	-2.48	-9.90*	-0.54	5.49	3.02	4.41
48	-0.65*	0.31	0.40	0.69*	0.26	-1.00**	-3.81	-2.73	-1.12	-6.10	4.93*	8.83
50	-0.07	0.06	-0.52	0.44	0.59	-0.50	-16.90**	-21.23**	3.55	0.65	13.35**	20.85**
72	-0.32	-0.77*	0.73*	0.60	-0.41	0.17	-2.06	10.27*	17.88**	5.15	-15.82**	-15.41**
75	-0.07	1.31**	-0.52	-0.81*	0.59	-0.50	-1.81	-11.82*	3.13	7.57	-1.32	4.25
78	-0.65*	1.40**	1.15**	-0.48	-0.50	-0.92**	11.27**	10.93*	-1.54	14.32**	-9.74**	-25.25**
83	-0.87*	-0.85*	0.73*	1.02**	0.09	-0.17	0.02	8.77	2.72	-13.60**	-2.74	4.83
92	0.10	-0.60	-0.35	-0.48	0.26	1.08**	5.69*	5.85	-4.37**	-9.26*	-1.32	3.41
93	0.51	0.65*	-0.69*	-0.23	0.17	-0.42	3.85*	1.18	-1.45	-5.18	-2.40	4.00
95	-0.32	-0.27	-0.27	-0.15	0.59	0.42	0.69	0.68	1.63	-8.93	-2.32	8.25
100	-0.40	-0.44	-0.10	-0.06	0.51	0.50	-2.98	4.43	2.22	-11.18*	0.77	6.75
113	0.10	-0.02	-0.85*	-0.40	0.76*	0.42	-35.51**	15.60**	15.85**	1.74	19.65**	-17.34**
173	-0.34	-1.02**	-0.23	0.35	0.09	0.67*	-11.73**	5.18	3.22	-1.68	8.52**	-3.50
180	0.18	0.06	-0.019	-0.31	-0.16	0.25	0.77	17.68**	0.22	-1.43	-0.99	-16.25**
192	0.35	-0.10	0.40	0.02	-0.75*	0.08	-7.56*	5.77	2.63	-13.85**	4.93*	8.08
223	0.35	-0.77*	-0.10	1.10**	-0.25	-0.33	-0.15	16.68**	12.80**	-6.43	-12.65**	-10.25*
227	0.60*	-0.27	0.65*	-0.15	-1.25**	0.42	-2.48	24.43**	-2.79	7.07	5.27*	-31.50**
229	-0.49	-0.35	0.56	-0.23	-0.08	0.58	0.52	1.27	4.22*	0.15	-4.74*	-1.42
S.E. S_{ij}	0.31	0.32					3.51	4.53				

Table 7. SCA effects for ear height and ear length for top crosses of S_1 lines with each of 3 testers under favourable (F) and water stress (W.St) conditions.

Serial no. of S_1 line	Ear height						Ear length					
	Pop.-45		SC-156		SC-159		Pop.-45		SC-156		SC-159	
	F	W.St	F	W.St	F	W.St	F	W.St	F	W.St	F	W.St
3	1.11	-1.33	-8.51**	3.55	7.39*	-2.22	-0.14	1.66**	0.90	-1.11*	-0.08	-0.55
4	-12.22**	-1.66	5.66*	-0.27	6.56*	1.95	0.46	1.11*	-0.95	-0.81	0.49	-0.30
7	8.20**	-2.58	-6.17*	5.30*	-2.02	-2.72	0.64	-0.94*	-0.02	-0.51	-0.63	1.45**
10	3.86	6.50*	6.99*	5.13*	-10.86**	-11.63**	0.83	1.42**	0.02	-1.45**	-0.84	0.12
18	-4.05	-2.58	5.83*	-1.20	-1.77	3.78	-0.39	-0.44	0.95	-1.41**	-0.56	1.85**
21	-1.72	-0.58	-1.34	-6.95*	3.06	7.53**	-0.09	-1.68**	0.30	0.36	-0.21	1.32**
22	7.44*	-6.00*	6.08*	4.38	-13.52**	1.62	-0.36	-1.08*	1.09	0.57	-0.73	0.42
24	7.78**	-0.58	-10.34**	5.55*	2.56	-4.97	0.34	-1.49**	0.19	0.69	-0.53	0.80
27	-0.55	-9.91**	3.08	3.96	-2.52	5.95*	-0.47	-1.08*	1.27	-0.24	-0.79	1.32**
28	6.03*	-3.50	-3.59	8.13**	-2.44	-4.63	0.53	-0.73	-0.58	0.61	0.06	0.12
30	1.78	1.59	-4.09	-0.54	2.31	-1.05	0.49	0.17	-0.07	-0.79	-0.43	0.62
31	4.61	2.00	-3.26	-4.37	-1.36	2.37	0.34	0.26	0.14	-2.16**	0.48	1.90**
33	-7.47*	-6.41*	0.91	1.96	6.56*	4.45	0.04	0.34	0.84	-1.73**	-0.88	1.39**
36	-6.30*	-5.33*	12.08**	7.80**	-5.77*	-2.47	0.34	-0.69	0.44	0.49	-0.78	0.20
38	0.45	-5.33*	-3.42	-13.20**	2.98	18.53**	0.78	-1.26**	0.62	-0.13	-1.39	1.30**
40	4.53	-7.00*	-1.34	-1.87	-3.19	8.87**	1.29	-0.99*	-0.27	-0.11	-1.03	1.10**
42	8.95**	-3.33	-9.17**	2.80	0.23	0.53	0.28	-1.69**	0.97	0.54	-1.24	1.15**
43	-1.30	0.84	-5.42*	0.96	6.73*	-1.80	1.53	-0.46	0.77	0.62	-2.29*	-0.16
48	0.86	-3.50	-5.01	1.38	4.14	2.12	1.66	-0.06	-0.95	-0.53	-0.71	-0.59
50	-13.89**	-3.33	2.74	-4.20	11.14**	7.53**	0.03	-1.18**	-0.13	0.06	0.11	1.12*
72	2.95	7.50*	3.08	-1.87	-6.02*	-5.63*	1.33	-0.01	0.57	1.42**	-1.84	-1.46**
75	-6.80*	-4.16	4.58	5.21*	2.23	-1.05	1.54	-0.03	-0.52	0.76	-1.03	-0.73
78	12.28**	1.92	-5.59*	8.05**	-6.69*	-9.97**	2.78*	0.61	0.62	2.69**	-3.39*	-3.30**
83	-0.72	6.00*	1.41	-9.12**	-0.69	3.12	-0.31	0.34	0.64	0.02	-0.33	-0.36
92	4.61	5.92	-3.51	-3.20	1.11	-2.72	0.48	1.27**	0.42	-1.29**	-0.89	0.02
93	-1.89	0.57	0.49	-4.54	1.39	3.95	0.44	0.16	0.99	0.49	-1.43	-0.65
95	-4.97	-1.00	3.66	-2.37	1.31	3.37	0.46	-0.29	-0.10	-0.11	-0.36	0.40
100	1.36	3.84	0.49	-3.79	-1.86	0.05	-0.71	0.29	1.69	0.52	0.98	-0.81
113	5.36*	9.42**	-5.51*	2.30	0.14	-11.72**	0.56	0.77	-0.55	0.26	-0.01	-1.03*
173	-9.97**	-0.50	-1.59	-1.62	11.56**	2.12	-0.71	1.49**	0.99	0.07	-0.28	-1.56**
180	-0.64	5.92*	3.99	-4.70	-3.36	-1.22	-0.07	0.36	1.92	0.79	-1.84	-1.15**
192	-2.05	1.00	2.58	-4.37	-0.52	3.37	-14.29**	0.82*	-13.95**	0.71	28.24**	-1.53**
223	-1.05	4.42	4.08	-2.20	-3.02	-2.22	-0.62	1.46**	1.37	0.39	-0.74	-1.85**
227	-2.89	10.17	2.24	1.55	0.64	-11.72**	1.04	2.11**	0.19	-0.16	-1.23	-1.95**
229	-3.72	1.00	7.91**	2.38	-4.19	-3.38	-0.02	-0.53	0.22	0.41	-0.19	0.12
S.E. Sij	2.61	2.46					1.15	0.42				

*,**Significant at 5% and 1% levels of probability, respectively.

4. Ear length

Results revealed that positive and significant SCA effects were obtained by crosses between S_1 lines no. 3, 4, 10, 92, 173, 192, 223 and 227 x Pop.-45; lines no. 72 and 78 x SC-156 and lines no. 7, 18, 21, 27, 31, 33, 38, 40, 42 and 50 x SC-159 under the water stress environment. Positive and significant SCA effects for ear length were obtained by crosses 78 x Pop.-45 and 192 x SC-159 under the favourable environment (Table 7).

5. Ear diameter

Positive and significant SCA effects for ear diameter were obtained by crosses between yellow lines no. 3, 18, 28, 75, 83, 93, 113, 173, 180, 192, 227 and 229 x Pop.-45; lines no. 36, 38, 42, 43, 72, 78 and 100 x SC-156 and lines no. 7, 21, 24, 27, 33, 36, 38, 40, 48, 50 and 92 x SC-159 under the water stress environment. The crosses between yellow lines no. 3 and 36 x Pop.-45 had positive and significant SCA effects under the favourable environment (Table 8).

6. Number of rows/ear

Results of Table (8) indicate that 7 and 11 top crosses involving Pop.-45; 9 and 8 crosses involving SC-156 and 3 and 8 crosses involving SC-159 showed positive and significant SCA effects for no. of rows/ear under favourable and water stress environments, respectively. The crosses between yellow S_1 lines no. 7, 18 and 192 x Pop.-45; no. 48 and 223 x SC-156 and no. 7, 28, 36, 40, 42, 48, 173, 192 and 227 x SC-159 showed positive and significant SCA effects for rows/ear under both favourable and water stress environments (Table 8).

7. 100-kernel weight

Results from Table (9) indicate that positive and significant SCA effects for 100-kernel weight were detected for 7 and 4 top crosses involving pop.-45; 7 and 4 involving SC-156 and 7 and 5 involving SC-159 under favourable and water stress environments, respectively. The highest positive and significant SCA effects were obtained for lines no. 21 and 42 x Pop.-45; 223 x SC-156 and no. 173 x SC-159 under the favourable environment. The highest significant SCA effects for kernel weight were obtained for lines no. 27, 100, 180 and 229 x Pop.-45; no. 36, 43, 78 and 223 x SC-156 and no. 10, 31, 33, 38 and 42 x SC-159 under the water stress environment (Table 9).

Table 8. SCA effects for ear diameter and no. of rows/ear for top crosses of S1 lines with each of 3 testers under favourable (F) and water stress (W.St) conditions.

Serial no. of S_1 line	Ear diameter						No. of rows/ear					
	Pop.-45		SC-156		SC-159		Pop.-45		SC-156		SC-159	
	F	W.St	F	W.St	F	W.St	F	W.St	F	W.St	F	W.St
3	0.21*	0.32**	-0.08	-0.24*	-0.12	-0.08	0.04	-0.30*	0.39*	-0.10	-0.39*	0.40*
4	0.09	0.03	-0.20	-0.12*	0.11	0.09	0.14	0.50**	-0.23	-0.25	-0.09	-0.25
7	0.16	-0.07	-0.08	-0.07	-0.07	0.14	0.66**	0.35*	-0.46*	-0.20	-0.19	-0.15
10	0.11	-0.03	-0.08	-0.04	-0.02	0.07	-0.36	-0.43*	-0.28	0.36*	0.64**	0.07
18	-0.06	0.17**	-0.05	-0.24**	0.11	0.07	0.91**	0.28	-0.91**	-0.32*	0.01	0.04
21	0.11	-0.18**	-0.08	-0.09	-0.02	0.27**	0.31	0.20	0.39*	-0.50**	-0.69**	0.30*
22	-0.04	0.00	-0.03	0.04	0.08	-0.04	0.67**	0.07	-0.45*	-0.49**	-0.22	0.42*
24	0.01	-0.22**	-0.13	0.03	0.13	0.19	-0.50**	0.53**	0.14	-0.67**	0.36	0.14
27	-0.01	-0.05	-0.05	-0.06	0.06	0.11*	-0.73**	-0.93**	-0.20	0.41*	0.97**	0.52**
28	0.09	0.13*	-0.02	-0.07	-0.07	-0.06	0.19	0.40*	-0.18	-0.10	-0.01	-0.30
30	-0.13	0.05	0.04	-0.11*	0.09	0.06	-0.36	-0.13	0.52*	-0.24	-0.16	0.37*
31	-0.03	0.00	-0.07	-0.06	0.09	0.06	0.40*	0.20	-0.11	0.10	-0.29	-0.30
33	-0.11	-0.15**	0.15	-0.11*	-0.04	0.26**	-0.68**	-0.40*	-0.30	0.20	0.97**	0.20
36	0.22*	-0.45**	-0.17	0.34**	-0.06	0.11*	1.26**	-0.47*	-0.31	0.48**	-0.94**	-0.01
38	0.09	-0.33**	0.00	0.11*	-0.09	0.22*	0.09	-0.55**	-0.43*	-0.00	0.34	0.55**
40	-0.06	-0.25**	0.05	0.09	0.01	0.16**	-0.70**	-0.70**	0.34	0.55**	0.36	0.15
42	0.19	-0.18**	-0.05	0.11*	-0.14	0.07	0.26	0.30*	-0.61**	-0.30	0.36	0.00
43	0.06	-0.02	0.07	0.13*	-0.12	-0.11*	-0.06	-1.78**	0.27	0.35*	-0.21	-0.35*
48	-0.13	-0.20**	0.09	0.04	0.04	0.16**	-1.15**	-0.50**	0.59**	0.40*	0.56*	0.10
50	0.02	-0.20**	-0.07	0.04	0.04	0.16**	0.19	-0.52**	0.02	0.23	-0.21	0.29
72	0.02	0.08	-0.02	0.18**	-0.01	-0.26**	0.22	-0.58**	-0.35	0.36*	0.13	0.22
75	0.134	0.10	-0.10	-0.06	-0.04	-0.04	-0.44*	0.25	0.24	-0.05	0.19	-0.20
78	-0.19	-0.22*	0.12	0.43**	0.08	-0.21**	-0.13	-0.50**	-0.15	0.30	0.28	0.20
83	-0.13	0.27**	0.19	-0.29**	-0.06	0.02	-0.08	0.92**	0.40*	-0.64**	-0.32	-0.28
92	-0.13	0.08	-0.02	-0.22**	0.14	0.14**	-0.33	0.10	0.20	-0.00	0.13	-0.10
93	0.06	0.12*	0.02	0.06	-0.07	-0.18**	-0.13	-0.40*	0.70**	-0.20	-0.57*	0.60**
95	-0.01	0.05	0.05	0.04	-0.04	-0.09	0.07	0.33*	-0.35	-0.27	0.28	-0.06
100	-0.13	-0.02	0.09	0.13*	0.04	-0.11*	0.12	0.03	-0.05	0.03	-0.07	-0.06
113	-0.08	0.13*	-0.07	0.08	0.14	-0.21**	0.42*	0.23	-0.55**	-0.07	0.13	-0.16
173	-0.08	0.30**	0.09	-0.16**	-0.01	-0.14**	0.36	-0.08	-0.06	-0.39*	-0.29	0.47**
180	0.11	0.22**	-0.08	-0.09	-0.02	-0.13*	0.07	0.53**	0.05	-0.07	-0.12	-0.46**
192	-0.01	0.10	0.10	0.04	-0.091	-0.14**	0.49*	0.45**	0.47*	0.25	-0.96**	-0.70**
223	-0.21*	0.08	0.20*	0.08	0.01	-0.16**	-0.56**	0.40*	0.52*	0.85**	0.04	-1.25**
227	-0.01	0.22**	0.15	0.06	-0.14	-0.28**	-0.06	-0.05	0.02	0.55**	0.04	-0.50**
229	-0.11	0.12*	0.05	-0.04	0.06	-0.08	-0.55**	0.47**	0.74**	-0.54**	-0.19	0.07
S.E. Sij	0.11	0.05					0.19	0.15				

*,**Significant at 5% and 1% levels of probability, respectively.

Table 9. SCA effects for 100-kernel weight and grain yield for top crosses of S1 lines with each of 3 testers under favourable (F) and water stress (W.St) conditions.

Serial no. of S_1 line	100-kernel weight						Grain yield					
	Pop.-45		SC-156		SC-159		Pop.-45		SC-156		SC-159	
	F	W.St	F	W.St	F	W.St	F	W.St	F	W.St	F	W.St
3	-3.36**	2.42	1.51*	-0.10	1.85*	-2.32	0.06	2.22**	-0.29	-1.20*	0.22	-1.02
4	0.51	-2.00	-0.28	2.56	-0.22	-0.56	-3.58**	2.53**	2.85**	-2.87**	0.74	0.34
7	-0.51	1.84	-0.18	-1.04	0.69	-0.80	1.47	-1.17*	-2.36**	-0.61	0.89	1.78**
10	-1.51*	-0.44	0.87	-3.79*	0.64	4.23**	2.15*	0.92	-2.39**	0.33	0.24	-1.25*
18	0.90	1.57	0.56	-2.04	-1.45*	0.47	1.40	-0.17	-0.18	-2.89**	-1.22	3.05**
21	4.01**	-2.71	0.91	1.20	-4.91**	1.51	-2.48**	-2.68**	2.60**	-2.14**	-0.12	4.82**
22	1.56*	-3.59*	-0.12	2.49	-1.46*	1.10	-1.75	-3.01**	0.12	1.45**	1.63	1.56**
24	-1.28	0.18	0.23	-2.98	1.05	2.80	2.96**	-0.75	-2.84**	0.73	-0.12	0.02
27	0.54	3.65*	1.70*	1.36	-2.24**	-5.01**	-0.20	-1.66**	0.38	-0.69	-0.18	2.35**
28	0.69	-0.22	-0.28	1.49	-0.41	-1.27	2.60**	-0.29	-1.86*	-0.61	-0.74	0.89
30	0.57	2.11	-1.08	-1.22	0.51	-0.89	-2.32**	0.45	3.69**	0.20	-1.37	-0.65
31	2.06**	-1.56	-2.68**	-5.09**	0.63	6.66**	-1.61	0.90	1.77*	-1.21*	-0.15	0.31
33	-0.55	1.08	-1.35	-5.10**	1.90*	4.02*	1.60	-2.13**	0.48	-0.47	-2.07*	2.60**
36	-0.59	2.50	-0.06	3.00	0.65	-5.51**	-0.3	-1.72**	-1.52	3.87**	1.74	-2.15**
38	1.43	-4.36**	1.36	-0.63	-2.80**	4.99**	0.14	-1.87**	-1.45	-1.60**	1.31	3.47**
40	-1.01	-4.03*	1.62*	2.71	-0.61	1.32	1.32	-1.14*	-1.99*	0.06	0.67	1.08*
42	3.07**	-16.44**	0.06	-12.86**	-3.12**	29.29**	-0.58	-0.80	2.77**	1.20*	-2.19*	-0.40
43	-0.61	-3.59*	-1.92**	4.22**	2.53**	-0.63	-0.17	-1.33*	-0.40	1.19*	0.57	0.14
48	1.72*	1.25	-2.31**	-1.80	0.59	0.56	-1.37	-1.16*	1.28	0.64	0.09	0.52
50	0.12	-0.17	-1.59*	2.29	1.47*	-2.12	-3.02**	-1.72**	1.27	1.02	1.75	0.70
72	-0.32	2.43	1.86*	-0.32	-1.54*	-2.11	2.52**	-1.17	2.28**	4.68**	-4.80**	-3.51**
75	0.20	-0.44	-1.08	1.55	0.88	-1.10	1.01	-1.75**	-0.12	3.55**	-0.89	-1.80**
78	1.08	-2.51	0.43	6.93**	-1.51*	-4.43**	3.73**	0.31	-1.33	1.75**	-2.39**	-2.06**
83	0.73	2.46	0.57	-1.69	-1.30	-0.77	2.30*	0.72	-1.08	-1.53**	-1.22	0.81
92	1.90**	2.48	-1.67*	-0.22	-0.24	-2.26	-0.19	0.87	-0.17	-1.44**	0.36	0.57
93	-0.17	-0.26	-0.89	1.02	1.05	-0.76	-2.18*	0.35	2.87**	1.32*	-0.69	-1.67**
95	-0.41	0.86	0.79	-1.05	-0.38	0.20	-1.85*	1.69**	-0.16	-2.36**	2.01	0.67
100	-2.86**	4.63**	1.35	-1.84	1.51*	-2.79	0.93	1.70**	-0.77	-1.80**	-0.16	0.11
113	-1.26	-1.65	-0.61	2.04	1.87*	-0.39	0.05	1.79**	-1.31	0.71	1.26	-2.51**
173	-3.24**	2.37	-0.15	-1.01	3.40**	-1.36	-3.45**	1.59**	0.24	-0.08	3.21**	-1.51**
180	-1.15	5.05**	-0.09	0.57	1.24	-5.61**	-0.49	2.32**	-1.30	-0.25	1.79	-2.07**
192	0.06	-0.27	-0.00	1.31	-0.06	-1.04	-0.04	0.57	-0.80	0.42	0.84	-0.99
223	-3.29**	0.51	3.82**	4.34**	-0.53	-4.85**	-1.16	2.27**	2.35**	0.18	-1.19	-2.45**
227	0.95	1.25	-1.92**	1.25	0.97	-2.50	1.21	1.50**	-1.77*	0.10	0.56	-1.60**
229	0.03	5.60**	0.62	2.45	-0.65	-8.05**	1.21	1.81**	-0.85	-1.65**	-0.37	-0.16
S.E. Sij	0.74	1.64					0.90	0.52				

8. Grain yield

Estimates of SCA effects for grain yield (Table 9) varied as expected, in sign and magnitude with different testers and environments. Lines in crosses showing high positive SCA effects for grain yield involving a certain tester exhibited negative SCA effects when interned in crosses with other tester(s). Example of these inconsistencies due to testers is shown by the line no. 72 which exhibited positive SCA effect with tester SC-156 but gave negative SCA effect with the tester SC-159.

Example of the inconsistency between environments in SCA effects for grain yield is the cross between line 4 and tester Pop.-45 which exhibited high positive SCA effect under the water stress but gave negative SCA effect under the favourable environment.

Results in Table 9, revealed that positive and significant SCA effects were obtained for 6 and 10 yellow top crosses involving Pop.-45; 8 and 8 crosses involving SC-156 and 5 and 8 crosses involving SC-159 under favourable and water stress environments, respectively.

The highest positive and significant SCA were obtained for the crosses involving lines no. 24, 28, 72, 78 and 83 x Pop.-45; 4, 21, 30, 42, 72, 93 and 223 x SC-156 and no. 95 and 173 x SC-159 under the favourable environment.

The highest positive and significant SCA effects for grain yield were detected for the crosses between lines no. 3, 4, 180 and 223 x Pop.-45; no. 36, 72 and 75 x SC-156 and no. 18, 21, 27, 33 and 38 x SC-159 under the water stress environment.

Variance components

The estimates of GCA variances for the S_1 lines (σ^2_{GCAL}) and testers (σ^2_{GCAT}) and SCA variances (σ^2_{SCA}) of the top crosses evaluated under favourbale and water stress environments are presented in Table 10.

Results in Table 10, revealed that values of σ^2_{GCAL} and σ^2_{GCAT} under water stress were higher in magnitude than those under favourable conditions for ear length, no, of rows/ear and 100-kernel weight. Average variance of half-sibs (σ^2_{GCA} average) was higher under water stress than under the favourable environment for plant height, ear length, no. of rows/ear and 100-kernel weight. The variance of σ^2_{GCAT} was higher than σ^2_{GCAL} for silking date, plant and ear height, ear length, no. of kernels/row, 100-kernel weight

Table 10. Variance components for grain yield and yield components and other agronomic traits of 105 yellow top crosses evaluated under favourable (Fav.) and water stress (W.St.) environments.

Traits	σ^2_{GCA} lines		σ^2_{GCA} tester		σ^2_{GCA} average		σ^2_{SCA}	
	Fav.	W.St	Fav.	W.St	Fav.	W.St	Fav.	W.St
Silking date	0.312	0.255	1.379	0.308	0.021	0.008	0.125	0.115
Plant height	33.770	14.228	292.210	346.044	3.859	4.146	79.515	101.203
Ear height	33.015	10.676	139.412	70.713	2.119	0.975	19.472	19.123
Ear length	-0.616	-0.138	1.259	1.410	0.004	0.014	13.572	1.038
Ear diameter	0.008	0.001	0.002	0.017	0.0002	0.0002	0.004	0.028
No. of rows/ear	0.053	0.163	0.032	0.063	0.001	0.003	0.160	0.148
100-kernel weight	1.012	1.684	1.056	4.024	0.029	0.073	1.625	20.265
Grain yield	1.279	-0.156	8.989	2.740	0.123	0.028	1.255	3.505

Table 11. Variance components for grain yield and yield components and other agronomic traits of 105 yellow top crosses (data are combined over two environments).

Traits	σ^2_{GCA} lines		σ^2_{GCA} tester		σ^2_{GCA} average		σ^2_{SCA}	
	Fav.	W.St	Fav.	W.St	Fav.	W.St	Fav.	W.St
Silking date	0.340	0.636	0.613	-0.057	0.208	-0.046	0.080	0.040
Plant height	32.560	317.33	294.85	3.930	1.580	3.880	3.370	94.730
Ear height	21.390	97.940	91.890	0.447	7.110	1.020	7.750	11.550
Ear length	0.038	1.240	1.150	-0.110	-0.005	-0.013	0.260	0.260
Ear diameter	0.005	0.007	0.060	0.003	0.040	0.040	0.000	0.016
No. of rows/ear	0.090	0.050	0.050	0.020	0.0005	0.020	0.040	0.110
100-kernel weight	1.410	2.490	2.400	0.060	0.110	0.250	2.570	13.520
Grain yield	0.250	4.750	4.390	0.310	1.120	1.030	0.088	2.250

All negative estimates of variance were considered to be equal zero.

and grain yield under both environments. These results indicate that most of the total GCA variance was due to GCA of the testers.

The variance among full-sibs (σ^2_{SCA}) under water stress was higher in magnitude than that under the favourable environment for some of the studied traits while the opposite was true for the other traits.

The magnitude of σ^2_{SCA} was larger than that of σ^2_{GCA} for all studied traits under both environments, indicating that the non-additive was found to be more important than additive gene effect for all studied traits. These results are in good agreement with those obtained by Mostafa *et al* (1995), Abd El-Moula (1997), El-Zeir *et al* (2000) and Soliman *et al* (2001).

Estimates of σ^2_{GCAL}, σ^2_{GCAT}, σ^2_{SCA} combined over the two environments and their interaction with environments are presented in Table 11.

The results revealed that estimates of σ^2_{GCAT} were higher in magnitude than those of σ^2_{GCAL} for all studied traits except, no. of rows/ear, indicating that most of the total GCA variance was due to the testers. The variances among full-sibs (σ^2_{SCA}) were larger than those of σ^2_{GCA} for 100-kernel weight, indicating that the non-additive were more important than additive gene effects in the inheritance of this trait. On the other hand, σ^2_{GCA} exceeded that of σ^2_{SCA} for all studied traits, indicating that the largest part of genetic variability associated with those traits was a result of additive gene action.

The variances interaction of σ^2_{GCAT} x E were larger than those of σ^2_{GCAL} x E for all studied traits except, plant height and no. of rows/ear, indicating that σ^2_{GCA} for testers was more affected by environments than that for lines.

Furthermore, the magnitude of σ^2_{SCA} x E interaction was higher than that of σ^2_{GCA} x E interaction for all studied traits, except, ear diameter. These findings indicated that the non-additive type of gene action is more affected by environmental conditions than the additive type. Similar results were observed by El-Itriby *et al* (1990), Soliman and Sadek (1999) and Soliman *et al* (2001).

REFERENCES

Abd El-Moula, M.A. (1997). Combining ability of grain yield and other agronomic traits under different environments. M.Sc. Thesis, Agron. Dept., Assiut University.

Bauman, L.F. (1981). Review of methods used by breeders to develop superior inbreds. P. 199-200. In Proc. Annu. Corn Sorghum Ind. Res. Conf. 36th Chicago, IL 9-11 Dec. Ann. Seed Trade Assoc., Washington, D.C.

Davis, R.L. (1927). Report of the plant breeding. Ann. Rep. Pureto Rico Agric. Exp. Stat. p: 14-15.

El-Itriby, H.A.; H.Y. El-Sherbieny, M.M. Ragheb and M.A.K. Shalaby (1990). Estimation of combining ability of maize inbred lines in top crosses and its interaction with environments. Egypt. J. Appl. Sci. 5 (8): 354-370.

El-Morshidy, M.A. and E.A. Hassaballa (1982). Relative values of five testers in evaluating combining ability of maize inbred lines. Assiut J. of Agric. Sci. 13 (1): 95-102.

El-Zeir, F.A., E.A. Amer, A.A. Abd El-Aziz and A.A. Mahmoud (2000). Combining ability of new maize inbred lines and type of gene action using top crosses of maize. Egypt. J. Appl. Sci. 15 (2): 116-128.

Hallauer, A.R. and J.B. Miranda (1981). Quantitative Genetics in Maize Breeding. Iowa State Univ. Press, Ames, USA.

Hassaballa, E.S., M.A. El-Morshidy, M. Khalifa and E.M. Shalaby (1980). Combining ability analysis in maize. I- Flowering. Res. Bull. Fac. of Agric., Ain Shams Univ. 1291, 8 pp.

Hede, A.R., G. Srinivasan, G. Stolen and S.K. Vasal (1999). Identification of heterotic pattern in tropical inbred maize lines using broad-based synthetic testers. Maydica 44 (4): 325-331.

Kempthorne, O. (1975). An Introduction to Genetic Statistics. John Wiley & Sons Inc., New York.

Konak, G., A. Unay, E. Serter and H. Basal (1999). Estimation of combining ability effects, heterosis and heterobeltiosis by line x tester method in maize. Turkish J. of Field Crops 4 (1): 1-9. [C.F. Pl. Br. Abst. 69 (11): 10711].

Mahmoud, A.A. (1989). Genetic studies through diallel cross of maize inbred lines. M.Sc. Thesis, Fac. Agric. Cairo University.

Mathur, R.K., Chunilal, S.K. Bhatnagar and V. Singh (1998). Combining ability for yield, phenological and ear characters in white seeded maize. Indian J. of Genet. & Plant Breed. 58 (2): 177-182.

Mostafa, M.A.N., F.A. Salama and A.A. Abd El-Aziz (1995). Combining ability of white maize populations with inbred testers. J. Agric. Sci. Mansoura Univ. 20 (1): 143-149.

Nass, L.L., M. Lima, R. Vencovsky and P.B. Gallo (2000). Combining ability of maize inbred lines evaluated in three environments in Brazil. Scientia Agricola, 57 (1): 129-134. [C.F. Pl. Br. Abst. 70 (9): 9438].

Singh, D.N. and I.S. Singh (1998). Line x tester analysis in maize (*Zea mays* L.). J. of Res. Birsa Agric. Univ. 10 (2): 177-182. [C.F. Pl. Br. Abst. 69 (6): 5113].

Soliman, M.S.M., A.A. Mahmoud, F.A. El-Zeir, Afaf A.I. Gaber and F.H. Soliman (2001). Utilization of narrow base tester for evaluating combining ability of newly developed maize inbred lines (*Zea mays* L.). Egypt. J. Plant Breed. 5: 61-76.

Soliman, F.H.S. and S.E. Sadek (1999). Combining ability of new maize inbred lines and its utilization in the Egyptian hybrid program. Bulletin of Fac. of Agric., Cairo Univ. 50 (1): 1-20.

Sprague, G.F. and L.A. Tatum (1942). General vs. specific combining ability in single crosses of corn. J. Amer. Soc. Agron. 34: 923-932.

Steel, R.G.D. and J.H. Torrie (1980). Principles and Procedures of Statistics. A Biometrical Approach 2nd Ed. New York. U.S.A.

Zambezi, B.T., E.S. Horner and F.G. Martin (1986). Inbred lines as testers for general combining ability in maize. Crop Sci., 26: 908-910.

Zelleke, H. (2000). Combining ability for grain yield and other agronomic characters in inbred lines of maize (*Zea mays* L.). Indian J. of genet. & Plant Breed. 60 (1): 63-70.

القدرة على الإئتلاف وطرز فعل الجين فى الذرة الشامية تحت الظروف المثلى وظروف الإجهاد المائى

محمد عبدالمنعم المرشدى[1] ، السيد عبد السلام حسب الله[1]، شوقى فريد أبوالسعد[2]،
مجدى أحمد عبد المولى[2]
١- قسم المحاصيل - كلية الزراعة - جامعة أسيوط
٢- قسم الذرة الشامية - معهد المحاصيل الحقلية - مركز البحوث الزراعية

هجنــت خمســة وثلاثون سلالة ذرة شامية صفراء فى جيل الاخصاب الذاتى الأول (S_1) مع ثلاثة كشافات هى مجتمع أصفر - ٤٥ (العشيرة الأصلية) وهجين فردى ١٥٦ ، وهجين فردى ١٥٩. قيمــت الهجــن القمــية (١٠٥ هجين) تحت ظروف الرى الحقلى المثلى وتحت ظروف الجفاف وذلك لتقدير القدرة على الإئتلاف وطراز فعل الجين لمحصول الحبوب والصفات المحصولية الأخرى . وجدت اخــتلافات معنوية بين الهجن القمية ، السلالات ، الكشافات ، السلالات × الكشافات لكل الصفات تحت الدراسة . وكذلك وجدت إختلافات بين البيئات ، البيئات × الهجن القمية ، البيئات × السلالات ، البيئات × الكشافات والتفاعل الثلاثى الكشافات × السلالات × البيئات لمعظم الصفات تحت الدراسة فى التحليل المجمــع . كانــت قــيمة تبايــن القدرة العامة وتباين القدرة الخاصة على الإئتلاف عالية لكل الصفات المدروســة تحــت ظروف الجفاف . أيضاً كان تباين القدرة الخاصة أعلى من تباين القدرة العامة على الإئــتلاف تحت كلاً من الظروف المثلى وظروف الجفاف مما يوضح أهمية فعل الجين الغير مضيف فى وراثــة الصفات المدروسة . كان تباين التفاعل بين القدرة الائتلافية الخاصة × البيئات أعلى من تباين القــدرة الائتلافية العامة × البيئات لكل الصفات تحت الدراسة . أظهرت السلالات أرقام ٧ ، ٢٢ قدرة إئتلافــية عامة عالية وموجبة تحت كلا البيئتين والسلالات أرقام ٤ ، ٣٠ ، ٣٦ ، ١١٣ تحت الظروف المــثلى والســلالات أرقام ٣ ،١٨، ٢٧، ٢٨ ، ٣١ ، ٣٣ ، ٨٣ و ٢٢٩ تحت ظروف الجفاف لصفة محصول الحبوب ، وهذه السلالات يجب أن تستعمل فى برامج التربية لإنتاج هجن عالية المحصول .

وقــد أوضــحت النتائج أن هناك ١٤ و ١١ هجين قمى أظهرت قدرة إئتلافية خاصة معنوية وموجبة لصفة محصول الحبوب تحت الظروف المثلى من الرى وظروف الجفاف على التوالى .

مجلد المؤتمر الثالث لتربية النبات-الجيزة ٢٦ أبريل ٢٠٠٣
المجلة المصرية لتربية النبات ٧ (١): ٥٥-٧٥(عدد خاص)