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Combining Ability of Some Maize Inbred Lines and its Crosses Under Non-Stressed and Water Stressed Conditions

Sultan, M. S.[1]; M. A. Abdel-Moneam[1]; A. E. M. K. EL- Galfy[2] and Hend E. El-Awady[3]
[1] Department of Agronomy, Faculty of Agriculture, Mansoura University, Egypt.
[2] Maize Research Section, Field Crop Research Institute, ARC, Egypt.
[3] Seed Technology, Field Crop Research Institute, ARC, Egypt.

ABSTRACT

In 2012, six maize inbred lines were crossed in all possible combinations without reciprocals by using a half diallel cross mating design to obtain 15 single crosses. 15 F_1 single crosses were evaluated through 2013 season under 2 irrigation treatments, every 12 day (Normal irrigation) and every 18 days (stress), to assess the role of general and specific combining ability of inbreds in hybrid behavior under recommended irrigation and water stress conditions. Results showed that mean squares due to crosses, general (GCA) and specific (SCA) combining abilities were significant or highly significant for all studied traits under both non-stressed and water stressed conditions, except of SCA for plant height under both conditions, which was insignificant. This result indicated that both additive and non-additive gene effects are very important in the inheritance of these traits. The ratio of GCA/SCA were less than unity for anthesis date under both conditions, silking date under normal irrigation, ear leaf area at stress condition, ear length under both conditions, and ears yield per plant at stress condition, indicating that the non- additive genetic effects were more important and played the major role in the inheritance of these traits under these conditions. On the other hand, GCA/SCA ratios were more than unity for silking date under stress condition, ear leaf area at normal irrigation, plant height under both normal and stress conditions, and ears yield per plant at normal condition, indicating that the additive genetic effects were more important and played the major role in the inheritance of these traits under these conditions. The best general combiners were: P_2(Rg5) and P6(B 73) under both conditions, and P4 (R39) under normal for earliness;P1(Inb. 209),P5(Sids7) under normal, and P2 (Rg5) under both conditions for ear leaf area; P5(sids7) under normal, and P6(B73) under both conditions for plant height(shortness);P1(Inb.209) and P3(sids34) under both conditions for ear length; and P1 (Inb.209) under normal, and P2 (Rg 5) under both conditions and P4 (R39) under stress for ears yield per plant. The best cross combinations were: eight crosses (No. 3, 4, 5, 6 , 9, 10, 12 and 13) under normal, and five crosses (No. 2, 3, 6, 9 and 13) under stress for earliness; two crosses No. 2 and No. 12 under normal, and three crosses No. 6, 13 and 15 under stress for ear leaf area; crosses No. 5 and 6 under normal and cross No.5 under water stress for plant height (shortness);four crosses i.e. No.4, 8,10and 12 under normal, and four crosses No. 2, 12,13 and 15 under stress for ear length; and three crosses i.e. No. 1, 12 and 13 under normal, and six crosses No. 2, 4, 6, 12, 13 and 15 under stress for ears yield per plant.

Keywords: Maize, Crosses, combining ability, water stress

INTRODUCTION

Over the past few years, there has been little serious drought in the world, but it is easy to recall the grim years of the early 1970’s when severe drought occurred in Asia and Africa in the latitudes just below the Tropic of Cancer. Many thousands of people and animals were affected and many lives were missing (Swindale and Bidinger, 1981).

The difficulties are found to be the adoption of proper techniques of detecting and selecting tolerant genotypes to soil water stress and conducting an efficient breeding program to such a complicated character. Estimation of combining ability and type of gene action for a certain traits is very important to design an appropriate breeding program for improving these traits. The literature on the combining ability of traits related to drought tolerance in maize is very scarce. Betran, *et al*. (2003), found that GCA and SCA genetic variance components for grain yield were smaller for water stressed environments than for well-watered environments. The relative importance of GCA vs. SCA, expressed as the ratio between additive vs. total genetic variance components, increased with water stress level when comparing trials grown at the same location and through the same season, and this recommends the need for drought tolerance in both parental lines to achieve acceptable hybrid behavior under severe drought stress. El-Morshidy *et al.* (2003), directed that the δ^2 GCA and δ^2 SCA were larger for most of the traits under water stress than under non-stress environment. δ^2 SCA was higher than δ^2 GCA for all traits under both environments, showing the importance of non-additive gene effects in the inheritance of the traits under study. Kandil, *et al*.(2006a,b) decided that mean squares for general combining ability (GCA) were significant for all studied traits under different drought stress and non-stress treatments in both seasons. Mean squares for specific combining ability (SCA) were significant for all studied traits under non-drought, moderate and severe drought in both seasons, except silking date at moderate drought, stem diameter at non-drought in the second season, rows number/ear at moderate and severe drought, kernels number/row at non-drought in the first season. Barakat and Osman (2008) showed that the tested inbred lines and testers exhibited significant GCA effects vary greatly according to the studied traits; the magnitude of variance due to GCA for tested and tester lines was larger than that due to SCA for all traits under study, this point toward that additive genetic variance was the major source of variation accountable for the inheritance of these traits; tester inbred line Gm-4 was the best general combiners for improving grain yield. Also, Abdel-Moneam (2009) found similar results in his studied maize inbred lines and their maize hybrids under non-stressed and water stressed conditions.

Therefore, the present investigation was designed to assess the role of general and specific combining abilities of some inbred lines in hybrid behavior under non-stressed and stressed watering conditions.

MATERIALS AND METHODS

The present investigation compares the performance of some experimental maize single crosses, which derived from crossing mad between six different inbred lines under normal and drought conditions to identify genetic variation of tolerance to water stress and water response.

The used genetic materials in this investigation were six maize inbred lines of varied genetic background. Sources of these parental inbred lines are shown in Table (1).

Table 1. The names and sources of the studied parental inbred lines of maize.

NO.	Name	Source
P1	Inb. 209	Locally developed, ARC, Egypt
P2	Rg 5	Locally developed, ARC, Egypt
P3	Sds 34	Locally developed, ARC, Egypt
P4	R39	Locally developed, from Quality Techno- Seeds Company, Egypt
P5	Sds 7	Locally developed, ARC, Egypt
P6	B 73	Imported from USA

In 2012 summer season, the six maize parental inbred lines were crossed in all possible combinations excluding reciprocals by using a half diallel crosses mating design to obtain 15 single crosses. F_1 single crosses (15) and two checks (SC 168 and SC 10) were evaluated through 2013 growing season under two irrigation treatments in 2 separated filed trials. First experiment was recommended irrigation every 12 days (recommended, N), and the second experiment was irrigation every 18 days (drought, D).

Each experiment arranged in a Randomized Complete Blocks Design (RCBD) with 3 replications in the 2013 growing season. The plot size was one ridge, 3 meters long and 70 cm wide. Experiments of 2012 and 2013 growing seasons were conducted at the Experiments Station of the Agriculture Faculty, Mansoura University, Governorate of El-Dakahlia. Maize seed were hand sown on May 15 and June 1 in 2012 and 2013 seasons, respectively. Two grains were sown per hill at 25 cm spacing. plants were thinned after emergence of seedlings to one plant per hill. Each experiment was hoed twice, before the 1st and the 2nd watering. All agricultural follows were applied as optimum recommendations.

The studied characters were: anthesis date (day), silking date (day), ear leaf area per plant (cm^2), plant height (cm), ear length (cm) and ears yield per plant.

Data recorded from experiments conducted in 2013maize growing season were subjected to statistical analysis using randomized complete block design with three replicates for each experiment, as defined by Gomez and Gomes (1984). Means of crosses were compared by using the appropriate Least Significant Difference test (LSD).

Data of entrances in each experiment for each of watering treatments (stressed and non-stressed) were exposed to single analysis of variance of randomized complete blocks design and shown at Table, 2.

Table 2. The mean squares and the expected mean squares for variance components.

S.V	d.f	MS	EMS
Replicate (r)	r-1		
Cross (c)	c-1	M_2	$\sigma^2_e + r\sigma^2_G$
Error	(r-1) (c-1)	M_1	σ^2_e

Diallel analysis for general (GCA) and specific (SCA) combining abilities:

Fifteen F_1 crosses comprise a half diallel among 6 parental inbreds. Data of all 15 F_1 cross combination for each watering level were analyzed as randomized complete blocks. Sum squares of crosses was divided to general (GCA) and specific (SCA) combining abilities, following Method 4 Model 1 (Fixed effects) of Griffing (1956), as presented at Table, 3.

Table 3. The analysis of variance and the expected mean squares for combining ability analysis.

S.V	d.f	M.S	E.M.S
Crosses	14		
GCA	5	M_g	$\sigma^2_e + \sigma^2_s + 2(n-2)\sigma^2_g$
SCA	9	M_s	$\sigma^2_e + \sigma^2_s$
Error	28	M_e	σ^2_e

General (GCA) and specific (SCA) combining abilities effects and their respective LSD were computed using formulae given in Griffing (1956).

RESULTS AND DISCUSSION

A-Analysis of Variance:

Results in Table (4) show that the mean squares due to crosses, general (GCA) and specific (SCA) combining abilities were significant or highly significant for all studied traits under both normal and stress conditions, except of SCA for plant height under both conditions, which was insignificant. This result indicated that both additive and non-additive gene effects are very important in the inheritance of these traits. The ratio of GCA/SCA were less than unity for anthesis date under both conditions, silking date under normal irrigation, ear leaf area at stress condition, ear length under both conditions, and ears yield per plant at stress condition, indicating that the non- additive genetic effects were more important and played the major role in the inheritance of these traits under these conditions. On the other hand, GCA/SCA ratios were more than unity for silking date under stress condition, ear leaf area at normal irrigation, plant height under both normal and stress conditions, and ears yield per plant at normal condition, indicating that the additive genetic effects were more important and played the major role in the inheritance of these traits under these conditions. Similar results were reported by El-Morshidy *et al*., (2003), Kandil, *et al*. (2006a,b), Barakat and Osman (2008), Abdel-Moneam (2009), Attia, *et al*. (2015) and Abdel-Moneam, *et al*. (2015)

Table 4. Mean squares of crosses, general combining ability (GCA) and specific combining ability (SCA) for studied maize traits under normal and water stress conditions.

Traits		50%Anthesis		50%Silking		Ear leaf area (cm^2)	
S.V.	**d.f.**	**Normal**	**Stress**	**Normal**	**Stress**	**Normal**	**Stress**
Crosses	14	13.470**	10.057**	18.562**	20.69**	50105.1**	37003.5**
GCA	5	3.95**	2.57**	5.12**	14.91**	38102.9**	9548.2*
SCA	9	4.79**	3.79**	6.78**	2.45**	4812.19**	13872.32**
Error	28	0.34	0.46	0.01	0.08	1178.95	2840.58
GCA/SCA	-	0.20	0.16	0.19	1.56	2.54	0.15
Traits		**Plant height (cm)**		**Ear length(cm)**		**Ears yield per plant (g)**	
S.V.	**d.f.**	**Normal**	**Stress**	**Normal**	**Stress**	**Normal**	**Stress**
Crosses	14	1680.3**	1305.3**	13.38**	13.08**	11266.69**	4868.3**
GCA	5	1450.7**	912.83**	7.63**	7.39**	7550**	992**
SCA	9	65.31	169.71	2.70**	2.68**	1647.36**	1972.79**
Error	28	41.69	147.15	0.28	0.40	527.85	126.62
GCA/SCA	-	14.92	8.48	0.76	0.77	1.57	0.12

***and**significant at 5% and 1% probability levels, respectively.**

B- The performance means of crosses:

1-Anthesis date: The differences between number of days to 50% anthesis for all crosses were earlier than both checks SC168 and SC10. Out of 15 crosses; 12 hybrids were significantly earlier than the both checks SC 168 and SC 10. Cross No. 9 (P_2 x P_6) was the earliest cross (52 days) and cross No. 11(P_3 x P_5) was the latest cross (59.67 days) under normal irrigation condition. While under water stress condition, Out of 15 crosses; five cross combinations were significantly earlier than the both checks SC 168 and SC 10. Cross No. 9 (P_2 x P_6) was the earliest cross (50 days) and crosses No. 1, 2, 10, 14 and 15were the latest crosses, where they recorded the same value (55.0 days), as presented in Table (5).

Table 5. Means performance of 10 single crosses maize for anthesis date, silking date and area of ear leaf (cm^2) under normal and water stress conditions during 2013 season.

Traits	Days to 50% anthesis		Days to 50% silking		Ear leaf area (cm^2)	
Cross	**Normal**	**Stress**	**Normal**	**Stress**	**Normal**	**Stress**
P_1 XP_2	57.000	55.000	61.333	58.000	885.933	537.700
P_1 XP_3	57.000	55.000	65.000	59.000	912.933	471.533
P_1 XP_4	55.000	53.333	58.000	56.333	799.267	390.767
P_1 XP_5	55.333	51.333	58.000	58.333	902.400	476.133
P_1 XP_6	54.000	51.000	58.000	55.000	643.200	437.767
P_2 XP_3	55.333	54.000	58.000	58.333	775.033	736.900
P_2 XP_4	54.667	53.000	58.000	58.000	717.100	606.267
P_2 XP_5	55.000	51.333	58.000	58.000	870.767	469.633
P_2 XP_6	52.000	50.000	55.000	52.000	617.133	353.267
P_3 XP_4	57.667	55.000	59.667	63.000	565.633	493.333
P_3 XP_5	59.667	53.333	62.000	62.667	635.533	373.267
P_3 XP_6	55.000	53.333	59.000	58.000	659.933	490.000
P_4 XP_5	55.000	50.333	59.000	59.000	687.367	662.267
P_4 XP_6	59.000	55.000	62.000	58.000	495.033	350.133
P_5 XP_6	59.000	55.000	62.000	58.000	685.300	519.267
SC168 (check)	60.000	55.000	63.000	63.000	672.900	509.000
SC 10(check)	60.000	55.000	62.000	62.000	877.033	682.500
F-test	**	**	**	**	**	**
LSD at 5%	1.59	1.87	0.77	0.98	112.54	145.73
1%	2.13	2.51	1.03	1.31	150.99	195.52

2-Silking date: The differences among days to 50% silking for crosses were highly significant under both normal and stress conditions. Out of 15 studied crosses, there were 11 hybrids were significantly earlier than both SC168 and 10. The earliest cross was cross No. 9 (P_2 x P_6) (55 days), while cross No. 2(P_1 x P_3) was the latest cross (65.0 days) under normal irrigation condition. While, under water stress condition, Out of 15 crosses, 13 cross combinations were significantly earlier than the both checks SC 168 and SC 10. Cross No. 9 (P_2 x P_6) was the earliest cross (52.0 days). While, cross No. 10 (P3 x P4)was the latest cross, where it recorded the highest value (63.0 days), as presented in Table (5).

3-Ear leaf area (cm^2): Ear leaf area was significantly differed by crosses under both normal and water stress irrigation. Ear leaf area ranged from 495.03 cm2for cross No. 14 (P4 x P6) to 912.93 cm2for cross No. 2 (P1 x P3) under normal irrigation condition. While under water stress condition, cross No. 14 (P4 x P6) recorded the lowest value of ear leaf area (350.13 cm2), however cross No. 6 (P2 x P3) gave the highest value (736.90 cm2) of ear leaf area, as shown in Table (5).

4-Plant height (cm): Results in Table (6) show that the differences between plant height for crosses were highly significant. Plant height ranged from 205.00 cm for cross No. 14 (P4 x P6) to 283.33 cm for cross No. 2 (P1 x P3) under normal irrigation condition. Meanwhile, four crosses out of the evaluated new 15 single crosses were significantly taller than SC 10.On the other side, under water stress condition, plant height ranged from 180.00 cm for cross No. 15 (P5 x P6) to 246.67 for crosses No. 2 and 3 (P1 x P3 and P1 x P4). Meanwhile, all of the evaluated new crosses were significantly taller than the check SC 168.

5- Ear length(cm): Results in Table (6) show that the differences between length of ear for hybrids were highly significant under both normal and water stress conditions. Ear length ranged from 17.50 cm for cross No. 14 (P4 x P6) to 24.5 cm for crosses No. 2 (P1 x P3) and No. 4 (P1 x P5) under normal irrigation condition. Meanwhile, no crosses out of the evaluated new 15 single crosses surpassed significantly over both checks SC 168 and SC 10, under normal irrigation condition.On the other side, under water stress condition, ear length ranged from15.00 cm for cross No. 14 (P4 x P6) to 23.00 for cross No. 2 (P1 x P3). Meanwhile, one cross No.6(P2xP3) evaluated new crosses significantly surpassed the both checks SC 168 and SC 10.

6-Ears yield per plant (g): The differences between Ear yield per plant (g) for crosses were highly significant under both normal and water stress conditions. Ear yield per plant (g)ranged from 56.94 for cross No. 10 (P3 x P4) to 301.87for cross No. 1 (P1 x P2) under normal irrigation condition. On the other side, under water stress condition, Ear yield per plant (g)ranged from 44.32 for cross No. 11 (P3 x P5) to 201.88 for cross No. 6 (P2 x P3).

Table 6. Means performance of 10 single crosses maize for plant height (cm), ear length(cm) and Ear yield per plant (g)under normal irrigation and water stress conditions.

Traits	Plant height (cm)		Ear length (cm)		Ears yield per plant (g)	
Cross	Normal	Stress	Normal	Stress	Normal	Stress
P_1 X P_2	268.333	221.667	22.500	21.500	301.873	157.877
P_1 XP_3	283.333	246.667	24.500	23.000	201.800	194.770
P_1 XP_4	265.000	246.667	20.333	18.167	132.507	168.800
P_1 X P_5	261.667	231.667	24.500	21.000	215.883	167.287
P_1 X P_6	235.000	198.333	20.500	18.000	169.940	132.827
P_2 X P_3	226.667	215.000	22.833	22.167	160.380	201.883
P_2 X P_4	230.000	201.667	17.833	17.667	126.783	200.673
P_2 X P_5	225.000	196.000	22.667	18.833	145.390	120.383
P_2 X P_6	218.333	206.667	20.500	18.500	96.673	157.820
P_3 XP_4	236.667	192.333	22.000	18.000	56.940	135.800
P_3 X P_5	223.333	201.333	19.833	18.000	73.020	44.320
P_3 X P_6	226.667	193.333	23.500	21.000	135.970	192.250
P_4 X P_5	215.000	185.000	20.833	19.667	137.173	185.420
P_4 X P_6	205.000	193.333	17.500	15.000	102.910	161.953
P_5 X P_6	206.667	180.000	21.000	19.500	110.513	163.240
SC168 (check)	200.000	171.667	24.500	21.500	110.890	222.150
SC 10(check)	251.667	266.667	23.167	21.333	223.970	241.010
F-test	**	**	**	**	**	**
LSD at 5%	18.78	33.58	1.56	1.85	61.71	51.43
1%	25.20	45.05	2.09	2.49	82.80	69.01

C: General combining ability effects (gi)

High positive GCA effects would be interest for all studied traits, except flowering traits (days to 50% anthesis and silking),as well as plant height, where negative GCA effects would be useful for the breeder's point of view.

1-Anthesis date: Results of GCA effects for days to 50% anthesis in Table (7) show that parental inbred line P_2 (Rg5) had highly negative significant GCA effects. On the other side, parental inbred line P5(Sids 7) had highly negative significant GCA effects, under water stress condition. These results indicating that parental inbred lines P_2(Rg 5) and P5(Sids 7) could be considered as a good general combiners for earliness under normal and stress conditions, respectively.

2-Silking date: Results of GCA effects for Days to 50 % silking in Table (7) show that parental inbred lines P2(Rg 5), P4 (R39) and P6 (B73) had negative and highly significant GCA effects, under normal irrigation condition. On the other hand, parental inbred lines P2(Rg 5) and P6 (B 73) had highly negative significant GCA effects, under water stress condition. These results indicating that parental inbred lines P_2(Rg 5) and P6(B 73) under both conditions, and P4 (R39) under normal, could be considered as a good general combiners for earliness.

3-Ear leaf area: Results in Table (7) show that parental inbred lines P1(Inb.209) , P2 (Rg5) and p5 (sids 7) had positive significant GCA effects, while P4 (R39) and P6 (B73) had negative and highly significant GCA effects under normal irrigation condition.On the other hand, parental inbred line P2 (Rg5) had positive significant GCA effects , under water stress condition. These results indicating that parental inbred lines P1(Inb. 209) ,P5(Sids7) under normal, and P2 (Rg5) under both conditions, could be considered as a good general combiners for increasing ear leaf area.

Table 7. G.C.A. effects of five inbred parents maize for days to 50% anthesis, days to 50% silking andear leaf area under normal irrigation and water stress conditions.

Traits	Days to 50% anthesis		Days to 50% silking		Ear leaf area	
Parent	Normal	Stress	Normal	Stress	Normal	Stress
P1 (Inb.209)	-0.47	0.08	0.67**	-0.97**	131.55**	-35.52
P2 (Rg 5)	-1.56**	-0.50	-1.83**	-1.56**	62.11**	61.94*
P3 (Sids 34)	1.11**	1.33**	1.50**	2.61**	-17.11	27.26
P4 (R 39)	0.28	0.33	-0.25**	0.94**	-88.28**	11.63
P5 (Sids 7)	0.94**	-1.00**	0.33**	1.36**	40.96*	11.08
P6(B 73)	-0.31	-0.25	-0.42**	-2.39**	-129.23**	-76.39**
LSD (gi)[1] 5%	0.55	0.63	0.11	0.26	32.10	49.82
1%	0.74	0.85	0.15	0.36	43.30	67.21
LSD(gi-gj)[2] 5%	0.85	0.98	0.17	0.41	49.72	77.18
1%	1.14	1.32	0.23	0.55	67.08	104.13

***, **significant at 0.05 and 0.01 level of probability, respectively**
1, Least significant difference for an GCA effects.
2, Least significant difference for the difference between two estimates of GCA effects

4-Plant height: Results of GCA effects for plant height in Table (8) show that parental inbred lines P5 (sids 7) and P6(B73) had negative and highly significant GCA effects, at normal irrigation condition. On the other hand, parental inbred lineP6(B73) had highly negative significant GCA effects, at water stress condition. These results indicated that parental inbred lines P5 (sids7) under normal, and P6 (B73) under both conditions, could be considered as a good general combiners for shortness, However, the other parental lines could be considered as a good general combiner for tallness.

Table 8. Estimates of G.C.A. effects of five inbred parents maize for Plant height (cm), Ear length(cm)and Ear yield per plant (g) under normal irrigation andwater stress conditions

Traits	Plant height		Ear length		Ears yield per plant	
Parent	Normal	Stress	Normal	Stress	Normal	Stress
P_1 (Inb.209)	34.44**	27.11**	1.35**	1.25**	74.85**	6.62
P_2 (Rg 5)	-1.81	1.11	-0.15	0.5	27.13*	10.88*
P_3 (Sids 34)	5.28	3.03	1.43**	1.38**	-23.62*	-6.52
P_4 (R 39)	-5.97	-4.39	-2.11**	-2.04**	-41.57**	14.39**
P_5 (Sids 7)	-10.97**	-10.64	0.47	0.08	-10.15	-28.61**
P_6(B 73)	-20.97**	-16.22**	-0.99**	-1.17**	-26.64*	3.25
LSD (gi)[1] 5%	6.04	11.34	0.50	0.59	21.48	10.52
1%	8.14	15.30	0.67	0.80	28.97	14.19
LSD(g_i-g_j)[2] 5%	9.35	17.57	0.77	0.91	33.27	16.30
1%	12.62	23.70	1.04	1.23	44.89	21.98

***, **significant at 0.05 and 0.01 level of probability , respectively**
1, Least significant difference for an GCA effects.
2, Least significant difference for difference between two GCA effects

5-Ear length(cm): Results in Table (8) show that parental inbred lines P1(Inb.209) and P3(sids34) had highly positive significant GCA effects, under normal irrigation. On the other hand, parental inbred lines P1(Inb.209) and P3(sids34) had positive significant GCA effects, under water stress condition. These results indicating that parental inbred linesP1(Inb.209) and P3(sids34) under both conditions, could be considered as a good general combiners for (increasing ear length).

6-Ears yield per plant: Results of GCA effects for ears yield per plant in Table (8) show that parental inbred lines P1 (inb.209) and P2 (Rg 5) had highly positive significant GCA effects, under normal irrigation condition. On the other hand, parental inbred lines P2 (Rg 5) and P4 (R39) had positive significant GCA effects, under water stress condition. These results indicating that parental inbred lines P1 (inb.209) under normal irrigation condition, and P2 (Rg 5) under both conditions and P4 (R39) under water stress condition, could be considered as a good general combiners for this trait,

D: Specific combining ability effects (S_{ij})

The most desirable crosses were those showing the highest positive SCA effects for all the studied traits, except the flowering traits (days to 50% anthesis and silking), plant height, where favorable specific combining ability (SCA) effects should be lowest negative ones.

1-Anthesis date: Results in Table (9) show that crosses No. 4, 5, 9, 12 and 13 had highly significant negative SCA effects under normal irrigation condition. On the other side, crosses No.5, 9 and 13 had highly negative significant SCA effects under water stress condition .These results indicating that these crosses could be considered as the best combinations for earliness.

2-Silking date: Results in Table (9) show that eight crosses (No. 3, 4, 5, 6 , 9, 10, 12 and 13) out of the studied crosses had negative and highly significant SCA effects under normal condition. Whereas, five crosses (No. 2, 3, 6, 9 and 13) had negative and highly significant SCA effects under water stress condition, indicating that these crosses are the best combinations for earliness.

Table 9. S.C.A. effects of 15 F_1 maize crosses for days to 50% anthesis, days to 50% silking and ear leaf area under normal irrigation and water stress conditions.

Traits		Days to 50% anthesis		Days to 50% silking		Ear leaf area	
Cross		Normal	Stress	Normal	Stress	Normal	Stress
$P_1 X P_2$		2.98**	2.35**	2.97**	2.42**	-31.24	20.08
$P_1 XP_3$		0.32	0.52	3.30**	-0.75**	74.99**	-11.40
$P_1 XP_4$		-0.85	-0.15	-1.95**	-1.75**	32.49	-76.54
$P_1 X P_5$		-1.18*	-0.82	-2.53**	-0.17	6.38	9.38
$P_1 X P_6$		-1.27**	-1.90**	-1.78**	0.25	-82.63**	58.48
$P_2 X P_3$		-0.27	0.10	-1.20**	-0.83**	6.53	156.50**
$P_2 X P_4$		-0.10	0.10	0.55**	0.50*	19.76	41.50
$P_2 X P_5$		-0.43	-0.23	-0.03	0.08	44.19	-94.59*
$P_2 X P_6$		-2.18**	-2.32**	-2.28**	-2.17**	-39.25	-123.49**
$P_3 XP_4$		0.23	0.27	-1.12**	1.33**	-52.48	-36.75
$P_3 X P_5$		1.57**	-0.07	0.63**	0.58*	-111.82**	-156.27**
$P_3 X P_6$		-1.85**	-0.82	-1.62**	-0.33	82.77**	47.93
$P_4 X P_5$		-2.27**	-2.07**	-0.62**	-1.42**	11.18	148.10**
$P_4 X P_6$		2.98**	1.85**	3.13**	1.33**	-10.96	-76.30
$P_5 X P_6$		2.32**	3.18**	2.55**	0.92**	50.06	93.38*
LSD (Sij)[1]	5%	0.93	1.07	0.19	0.45	54.47	84.55
	1%	1.25	1.45	0.26	0.61	73.49	114.07
LSD (Sij-Sik)[2]	5%	1.47	1.70	0.30	0.71	86.12	133.68
	1%	1.98	2.29	0.41	0.96	116.19	180.36
S. E. (Sij-Skl)[3]	5%	1.20	1.38	0.25	0.58	70.32	109.15
	1%	1.62	1.87	0.33	0.78	94.87	147.26

***, ** significant at 0.05 and 0.01 level of probability, respectively.**
1, , Least significant difference for an SCA effects.
2, , Least significant difference for difference between two SCA effects for a common parent.
3, , Least significant difference for difference between two SCA effects for a non-common parent.

3-Ear leaf area: Estimates of SCA effects for ear leaf area (Table,9) indicated that two crosses i.e. No. 2 (P1 x P3) and No. 12 (P3 x P6) show highly significant and positive SCA effects under normal irrigation condition. Whereas, three crosses No. 6 (P2 x P3), 13 (P4 x P5) and 15 (P5 x P6) show significant or highly significant and positive SCA effects under stress condition. These results indicating these crosses could be considered as the best combinations for increasing ear leaf area.

4-Plant height: Results of SCA effects for plant height in Table (10) show that crosses No. 5 and 6 had significant and negative SCA effects under normal irrigation condition. On the other hand, cross No.5 had significant and negative significant SCA effects under water stress condition, indicating that these crosses are the best combinations for plant shortness.

5-Ear length: Estimates of SCA effects for ear length (Table,10) indicated that four crosses i.e. No.4 (P1 x P5), No. 8 (P2 x P5), No. 10 (P3 x P4) and No.12 (P3x P6)show significant or highly significant and positive SCA effects under normal irrigation condition. Whereas, four crosses No. 2 (P1 x P3), 12 (P3 x P6),13 (P3x P5)and 15 (P5 x P6) show significant or highly significant and positive SCA effects under stress condition. These results indicating that these crosses could be considered as the best combinations for increasing ear length.

Table 10. S.C.A. effects of 15 F_1 maize crosses for plant height, ear length and ears yield per plant under normal irrigation and water stress conditions.

Traits		Plant height		Ear length		Ears yield per plant	
Cross		Normal	Stress	Normal	Stress	Normal	Stress
$P_1 X P_2$		0.58	-13.87	-0.08	0.42	55.37**	-18.64*
$P_1 XP_3$		8.50	9.22	0.33	1.04*	6.05	35.65**
$P_1 XP_4$		1.42	16.63	-0.29	-0.37	-45.30*	-11.22
$P_1 X P_5$		3.08	7.88	1.29**	0.33	6.66	30.26**
$P_1 X P_6$		-13.58*	-19.87*	-1.25**	-1.42**	-22.79	-36.06**
$P_2 X P_3$		-11.92*	3.55	0.17	0.96	12.35	38.50**
$P_2 X P_4$		2.67	-2.37	-1.29**	-0.12	-3.29	16.38
$P_2 X P_5$		2.67	-1.78	0.96*	-1.08*	-16.10	-20.91*
$P_2 X P_6$		6.00	14.47	0.25	-0.17	-48.33*	-15.33
$P_3 XP_4$		2.25	-13.62	1.29**	-0.67	-22.39	-31.09**
$P_3 X P_5$		-6.08	1.63	-3.46**	-2.79**	-37.73*	-79.57**
$P_3 X P_6$		7.25	-0.78	1.67**	1.46**	41.72*	36.50**
$P_4 X P_5$		-3.17	-7.28	1.08	2.29**	44.38*	40.63**
$P_4 X P_6$		-3.17	6.63	-0.79	-1.13*	26.61	-14.70
$P_5 X P_6$		3.50	-0.45	0.12	1.25*	2.79	29.59**
LSD (Sij)[1]	5%	10.24	19.24	0.84	1.00	36.45	17.85
	1%	13.82	25.96	1.14	1.35	49.17	24.08
LSD (Sij-Sik)[2]	5%	16.20	30.43	1.33	1.58	57.63	28.23
	1%	21.85	41.05	1.80	2.13	77.75	38.08
S. E. (Sij-Skl)[3]	5%	13.22	24.84	1.09	1.29	47.05	23.05
	1%	17.84	33.52	1.47	1.74	63.48	31.09

***, ** significant at 0.05 and 0.01 level of probability, respectively.**
1, , Least significant difference for an SCA effects.
2, , Least significant difference for the difference between two SCA effects for a common parent.
3, , Least significant difference for the difference between two SCA effects for a non-common parent.

6-Ears yield per plant: Estimates of SCA effects for ears yield per plant(Table,10) indicated that three crosses i.e. No. 1 (P1 x P2), No. 12 (P3 x P6), and No.13 (P4x P5) show significant or highly significant and positive SCA effects under normal irrigation condition. Whereas, six crosses No. 2 (P1 x P3), 4 (P1 x P5), 6 (P2x P3), 12 (P3 x P6), 13 (P4x P5) and No. 15

(P5 x P6) show significant or highly significant and positive SCA effects under stress condition. These results indicating these crosses could be considered as the best combinations for increasing Ear yield per plant.

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القدرة على التآلف لبعض سلالات الذرة الشامية والهجن الناتجة منها تحت ظروف الري الطبيعي والإجهاد المائي

محمود سليمان سلطان[١] ، مأمون أحمد عبد المنعم[١] ، علاء الدين محمود خليل الجلفى[٢] و هند السيد العوضي[٣]

[١]قسم المحاصيل – كلية الزراعة – جامعة المنصورة- مصر.

[٢]قسم بحوث الذرة الشامية - معهد المحاصيل الحقلية – مركز البحوث الزراعية - مصر

[٣]قسم تكنولوجيا البذور - معهد المحاصيل الحقلية – مركز البحوث الزراعية- مصر

أجري البحث خلال موسمي٢٠١٢ و٢٠١٣، في الموسم الأول تم إجراء التهجين بين ستة سلالات نقية من الذرة الشامية (أربعة من مركز البحوث الزراعية وسلالة حمراء من شركة تكنوسيدزكواليتى وسلالة أخرى صفراء من أمريكا) بنظام التزاوج نصف الدائري (في اتجاه واحد) للحصول على ١٥ هجين فردي مع استبعاد الهجن العكسية ، ثم في الموسم الثاني (٢٠١٣) تم تقييم الهجن الفردية تحت تجربتين مستقلتين لمعاملتين ري : الأولى للري الطبيعي(الري كل ١٢ يوم) ، والثانية للإجهاد المائي (الري كل ١٨ يوم) وذلك لتحديد القدرة على التآلف بين السلالات النقية في سلوك الهجن الناتجة تحت ظروف الري العادي والجفاف. أوضحت نتائج تحليل التباين أن متوسطات المربعات لكل من الهجن و القدرة العامة والقدرة الخاصة على التآلف كانت معنوياًأو عالية المعنوية لكل الصفات المدروسة سواء تحت ظروف الري العادي أو ظروف الجفاف ، ما عدا طول الكوز تحت ظروف الري العادي ، قطر الكوز تحت ظروف الجفاف. كان متوسط مربعات القدرة الخاصة على التآلف معنويا لكل الصفات المدروسة تحت كلا ظروف الري العادي و الجفاف ، باستثناء القدرة الخاصة على التآلف لصفة ارتفاع النبات تحت كلا ظروف الري العادي والجفاف والتي كانت غير معنوية. هذه النتيجة تشير إلى أهمية تأثير كلاً من الفعل الجيني المضيف وغير المضيف في وراثة هذه الصفات. كانت النسبة بين القدرة العامة على التآلف والقدرة الخاصة على التآلف أقل من الواحد الصحيح لصفات ميعاد انتثار حبوب اللقاح تحت كلا معاملتي الري ، وميعاد خروج الحريرة تحت ظروف الري الطبيعي ، مساحة ورقة الكوز تحت ظروف معاملة الإجهاد المائي ، طول الكوز تحت كلا معاملتي الري و محصول الكيزان للنبات تحت ظروف معاملة الإجهاد المائي وهذا يشير إلى أن الفعل الجيني غير التجميعي كان أكثر أهمية ولعب الدور الرئيسي في وراثة هذه الصفات تحت تلك الظروف.على الجانب الأخر كانت هذه النسبة أكبر من الواحد الصحيح لصفات ميعاد طرد الحريرة تحت ظروف الإجهاد ، مساحة ورقة الكوز تحت ظروف الري العادي ، ارتفاع النبات تحت كلا ظروف الري العادي والإجهاد و محصول الكيزان للنبات تحت ظروف معاملة الري العادي وهذا يشير إلى أن الفعل الجيني التجميعي كان أكثر أهمية ولعب الدور الرئيسي في وراثة هذه الصفات تحت هذه الظروف. بالنسبة لتأثير القدرة العامة على التآلف ، كانت أفضل الآباء مشاركة وقدرة عامة على التآلف هي: السلالتين (Rg 5) و (B 73) تحت كلا ظروف الري العادي والإجهاد والسلالة (R39) تحت ظروف الري العادي وذلك لصفات التبكير في النضج ، والسلالتين (Sids7) ,(Inb. 209)تحت ظروف الري العادي والسلالة (Rg5) تحت كلا الظروف بالنسبة لصفة مساحة ورقة الكوز ، والسلالة (sids7) تحت ظروف الري العادي والسلالة (B73) تحت كلا ظروف الري والإجهاد المائي بالنسبة لصفة ارتفاع النبات (القصر) ، والسلالتين (Inb.209)و (Sids34) تحت كلا معاملتي الري والجفاف بالنسبة لصفة طول الكوز ، والسلالة (Inb.209) تحت ظروف الري العادي والسلالة (Rg 5) تحت كلا الظروف والسلالة (R39) تحت ظروف الإجهاد المائي بالنسبة لصفة محصول الكيزان للنبات. بالنسبة لتأثير القدرة الخاصة على التآلف ، كانت أفضل الهجن هي: ثماني هجن أرقام ٣ ، ٤ ، ٥ ، ٦ ، ٩ ، ١٠ ، ١٢ ، ١٣ تحت ظروف الري العادي و ست هجن أرقام ٢ ، ٣ ، ٤ ، ٦ ، ٩ ، ١٣ تحت ظروف الإجهاد المائي وذلك لصفة التبكير في طرد الحريرة ، والهجينين رقم ٢ ، ١٢ تحت ظروف الري العادي و وثلاث هجن أرقام ٦ ، ١٣ ، ١٥ تحت ظروف الإجهاد المائي لصفة مساحة ورقة الكوز ، والهجينين رقم ٥ ، ٦ تحت ظروف الري العادي والهجين رقم ٥ تحت ظروف الإجهاد المائي لصفة ارتفاع النبات (قصر الساق) ، وأربع هجن أرقام ٤ ، ٨ ، ١٠ ، ١٢ تحت ظروف الري الطبيعي و أربع هجن أيضًا أرقام ٢ ، ١٢ ، ١٣ ، ١٥ تحت ظروف الإجهاد المائي لصفة طول الكوز ، وثلاث هجن أرقام ١ ، ١٢ ، ١٣ تحت ظروف الري العادي و ست هجن أرقام ٢ ، ٤ ، ٦ ، ١٢ ، ١٣ ، ١٥ تحت ظروف الإجهاد المائي وذلك لصفة محصول الكيزان للنبات.