Assiut J. Agric. Sci., (46) No. (5) 2015 (1-10) *ISSN: 1110-0486*
Website: http://www.aun.edu.eg/faculty_agriculture/arabic *E-mail: ajas@aun.edu.eg*

Combining Ability Studies in Grain Sorghum (*Sorghum bicolor* (L.) Moench) under Water Stress by Using Line × Tester Analysis

*** Hassaballa, S.A.[1] ; B.R.Bakheit [1]; M.R.A.Hovny[2] and Y.M. El-Kady[2]**
[1]Departement of Agronomy, Fac. of Agric., Assiut Univ., Egypt
[2]Sorghum Research Department, Field Crop Research Institute, ARC, Egypt
*E-mail: elsayed.hasaballah@agr.au.edu.eg

Abstract:

Forty F_1 grain sorghum crosses, their parents (eight CMS A-lines and five male R-lines) and one commercial hybrid (H-306) as check were evaluated for grain yield/plant and some other traits in 2011 and 2012 seasons at Shandaweel Agric. Res. Station, Sohag, Egypt under three irrigation levels (100, 70% and 40% from optimum water irrigation level). The combined analysis across the three levels of irrigation at each of the two years showed highly significant mean squares due to irrigation levels, and genotypes and their interaction for all studied traits, indicating genetic variability for all studied traits. In addition, highly significant mean squares were found due to interaction of genotype × irrigation, indicating differential response for different genotypes under different levels of irrigation for all studied traits except for days of 50% flowering. Also, high significant differences among genotypes, crosses, parents were found, for all studied traits in the two seasons. These results reflect the important roles of both additive and non-additive in the inheritance of number of days to 50% flowering, plant height, 1000-grain weight and grain yield/plant. Female lines (ASH-6, ASH-11, ICSA-37 and ICSA-88003) and the male lines (ICSR-92003 and ICSV-273) had positive and highly significant general combining ability effects for grain yield under the three irrigation levels over the two seasons. These lines had favorable genes and would be considered good combiners for high yielding ability. The crosses (ASH-8 × ICSR-89028) and (ICSA-37 × ICSR-92003) had positive and highly significant SCA effects under the three of irrigation treatments over the two seasons and would be considered the best combinations for grain yield.

Key words: *Sorghum bicolor, CMS lines, R-lines, combining ability.*

Received on: 6 /12/2015 **Accepted for publication on:** 28/12/2015

Referees: Prof. Mohamed A. El-Morshedy Prof. Eman M. Taha

Introduction:

In Egypt, grain sorghum [*Sorghum bicolor* (L.) Moench] ranks the fourth cereal crop. In 2012. The cultivated area was 148764 ha and the total production was 800,000 metric tons (FAO, 2012). Sorghum is considered an adapted cereal crop under harsh conditions. Seventy percent of the sorghum area is located in Assiut and Sohag Governorates. Developing high yielding hybrids with high quality characters under stress conditions has become less difficult after using the cytoplasmic male sterile lines. Many investigations have been established on grain sorghum genotypes under stress conditions. Younis and El-Aref (2000) found significant variance for most studied traits. These results indicated that both additive and non-additive variances were important for the inheritance of these traits. Mahmoud (2002) reported that both additive and non-additive effects were involved in the inheritance of days to 50% flowering, plant height, 1000-grain weight and grain yield/plant. The additive effect played the major role in the inheritance of plant height, but the non-additive effect played the major role in the inheritance of grain yield/plant. Also, all the crosses had negative significant specific combining ability effects for flowering. Moreover, the male parents (restorer lines) were more important in the inheritance of all the studied traits. Kenga *et al.* (2004) showed that highly significant GCA effects of males were found for all traits under study. Significant SCA was detected in all traits except inflorescence length. Hovny *et al.* (2005) found that general combining ability effects for 1000-grain weight and grain yield/plant were positive and highly significant. Specific combining ability effects for 1000- grain weight and grain yield/plant were positive and highly significant for the cross (SPRU-94009(A) × RTX-430) which gave the highest yield. Amir (2008) found that the cross (ICSA-88005 × MR- 812) showed positive and significant specific combining ability (SCA) for days to 50% flowering, plant height and grain yield/plant. The female line ICSA-89002 and male line MR-812 were good combiners for most of the studied traits. Hafez (2010) found that the best general combiners for grain yield/plant and some of the other studied traits were the female lines ICSA-88003 and ICSA-88005 and the male lines ICSR-89036, MR-812 and ICSR-92003 under normal and drought conditions. The best hybrids were (ICSA-88005 × ICSR-92003, ATX-629 × ICSR-93001, and ATX-629 × ZSV-14) under drought conditions for grain yield per plant and some of the other studied traits. Mahmoud *et al.* (2013) found that both additive and non additive gene effects were important in the inheritance of all studied traits, and the non-additive gene effect played the major role in the inheritance of all the studied traits.

The objective of this study was to estimate general and specific combining ability effects and identify the best parental combiner lines ant the best hybrid combination under drought stress by using line × tester analysis.

Material and Methods:

Eight cytoplasmic male sterile lines (CMS-lines) namely (ASH-6, ASH-8, ASH-10, ASH-11, ASH-13, ASH-17, ATX-37 and ICSA-88003) were crossed with five (R-lines) namely (Adv-6/2009, ICSR-89028, ICSR-92003, ICSV-273 and Kymoun) released from Egyptian program at Shandaweel, in a line × tester design at Shandaweel Agric. Res. Station, Sohag, Egypt, in 2010 growing summer season.

The forty crosses and their parental lines along with the check (SH-306) were evaluated under three irrigation levels in 2011 and 2012 seasons. Three experiments were conducted separately for each irrigation level (the first experiment with 100% irrigation, the second experiment with 70% irrigation and the third experiment with 40% from optimum water irrigation level). A randomized complete block design with three replications was used. The experimental plot was one row, four meter long and 60 cm apart and 20 cm between hills. After full emergence, seedlings were thinned to two plants/hill. Sowing date in both seasons were on 27th and 29th June, respectively. The recommended cultural practices of sorghum production in the two seasons were implemented, except water irrigation. Data were recorded on days from sowing date to 50% flowering, plant height (cm), 1000 grain weight (g) and grain yield per plant (g). Grain yield was adjusted with grain moisture of 14%.

Data of plot mean for each season and combined over two seasons were subjected to analysis of variance according to Gomez and Gomez (1984). General combining ability (GCA) effects for females and males and specific combining ability (SCA) effects for hybrids were estimated according to Singh and Chaudhary (1977). In this analysis the mean squares for male and female parents are considered independent estimates of general combining ability (GCA) and the male× female interaction mean squares provides an estimate of specific combining ability (SCA). The proportional contribution of lines, testers and their interactions to total variance were estimated and the variance for males and females considered equivalent to GCA (additive) and the variance for lines × testers considered equivalent to SCA (non-additive).

I-Analysis of variance

The combined analysis of variance across the two years Table (1), showed highly significant differences between years, irrigation treatments and among genotypes for all studied traits. The interactions years × genotypes, irrigation levels × genotypes and year × irrigation × genotype were highly significant for all the studied traits, except for days to 50% flowering, reflecting the differential response of genotypes to water stress. Moreover, parents and crosses had significant differences for most studied traits. Results also indicated significant mean squares due to parents vs. crosses, indicating the presence of significant heterosis.

Table (1): Combined mean squares of fifty-four grain sorghum genotypes under three irrigation levels across two years for the studied traits.

S.O.V	d.f	Days to 50% flowering	Plant height (cm)	1000-grain weight (g)	Grain yield per plant (g)
Years (Y)	1	149.343**	1531.276**	103.006**	415.886**
Irrigation (I)	2	1614.075**	69739.065**	1233.713**	35065.648**
Y x I	2	0.620	95.822**	5.085**	7.708
Rep. (Y x I) (Ea)	12	7.465	14.076	0.668	11.012
Genotypes (G)	53	82.879**	33705.331**	111.846**	3828.787**
G x Y	53	7.049**	43.806**	4.307**	354.477**
G x I	106	2.872	141.522**	1.089**	73.163**
G x Y x I	106	1.742	29.623**	0.615**	24.784**
Error (Eb)	636	3.811	13.793	0.367	7.640

** Significant at 0.01 level of probability.

The combined analysis of variance of 53 genotypes (40 crosses and 13 parental lines) of grain sorghum under three levels of irrigation in the two seasons for all the studied traits is presented in Table (2). Results showed high significant differences among the three levels of irrigation for all the studied traits in 2011 and 2012 seasons, reflecting the different response of genotypes to irrigation levels.

Analysis of variances revealed highly significant differences among F_1 crosses. Moreover, highly significant differences were detected among males, females and males × females for all the studied traits. However, the mean square due to males were higher than those among females and males × females for all studied traits. These higher values indicate the large effect of the testers on crosses performance in all studied traits. Similar results were obtained by Abd El-Halim (2003), Sayed (2003), Hassaball *et al* (2005), Amir (2008), Hafez (2010) and Mahmoud *et al* (2013).

Table (2): Mean square for studied traits of fifty-three genotypes of grain sorghum under the three levels of irrigation in 2011 and 2012 seasons.

S.O.V	d.f	Days to 50% heading		Plant height (cm.)		1000 grain weight (g.)		Grain yield/plant (g.)	
		2011	2012	2011	2012	2011	2012	2011	2012
Irrigation (I)	2	766.64**	809.29**	34077.12**	35135.72**	573.08**	651.08**	16991.55**	17651.22**
Rep/irrigation	6	6.95	7.87	13.00	13.01	0.39	1.10	11.87	12.26
Genotypes G)	52	49.32**	40.58**	16775.47**	17586.04**	56.32**	61.79**	2158.30**	2070.96**
Crosses (C)	39	37.28**	37.94**	5183.83**	5208.57**	46.78**	58.86**	1444.33**	1363.39**
P vs. C	1	747.99**	392.75**	596312.97**	634614.45**	555.42**	439.62**	47105.00**	45136.13**
Parents (p)	12	30.24**	19.82**	6153.52**	6393.77**	45.70**	39.81**	733.12**	781.77**
G x I	104	1.45	3.21	93.54**	78.61**	0.92**	0.79**	49.02**	50.40**
C x I	78	1.35	3.02	96.12**	87.13**	0.80**	0.72**	45.03**	47.55**
C x P x I	2	2.11	11.44	692.89**	315.1**	7.66**	5.21**	551.48**	585.03**
P x I	24	1.69	3.13	35.2**	31.23**	0.76**	0.66**	20.11**	.15.11**
Females (F)	7	100.56**	105.38**	5643.31**	6307.42**	151.36**	186.37**	2107.09**	2413.65**
F x I	14	0.87	2.13	51.44**	72.37**	1.50**	1.26**	37.94**	32.21**
Male (M)	4	119.59**	115.28**	27169.69**	26912.05**	143.69**	218.74**	5477.66**	5212.27**
M x I	8	0.80	0.61	165.09**	230.45**	1.33**	0.51	79.89**	124.95**
M x F	28	9.7**	10.03**	1928.12**	1833.36**	6.80**	4.14**	702.45**	550.96**
M x F x I	56	1.56	3.59	97.43**	70.35**	0.55*	0.62**	41.82**	40.33**
Error	312	3.87	3.80	13.08	14.51	0.38	0.35	7.59	7.70

*, ** Significant at 0.05 and 0.01 levels of probability, respectively

II -Combining ability

A-General combining ability:

General combining ability (GCA) effects of parental lines over two seasons are presented in table (3).

For days to 50% flowering the GCA effect was positive and highly significant for the female lines (ASH-11 and ASH-17) and the male line (ICSV-273). However, it was negative and highly significant for the female lines (ASH-6 and ICSA-88003) and two male lines (Adv.6/2009 and ICSR-92003) over two seasons. Negative GCA effect indicated that these lines have the genes for earliness and vice versa. So, it is expected to get early blooming hybrids by combining the male and female lines of negative GCA effects.

Respect to plant height, the GCA effect was positive and highly significant for the female lines (ICSA-37 and ICSA-88003) and the male lines (Adv-6/2009 and ICSV-273) These lines had favorable gene action for tallness. However, the female lines (ASH-6, ASH-8, ASH-10, ASH-13 and ASH-17) and the male lines (ICSR-89028, ICSR-92003 and Kymoun) had negative and highly significant general combining ability effects over the two years. These lines had favorable gene action for shortness and it is expected to obtained a short favorable hybrids of grain sorghum by combining the male and female lines of negative GCA effects.

For 1000-grain weight, four CMS-lines (ASH-8, ASH-11, ICSA-37 and ICSA-88003) and three R-lines (Adv-6/2009, ICSR-92003 and ICSV-273) had positive highly significant GCA effects, indicating that these lines had favorable gene action for heavy grain weight that may contribute to increase grain yield.

Table (3): Estimates of general combining ability (GCA) effects for four studied traits under three levels of irrigation over two seasons.

	No.	Genotypes	Combined over two seasons											
			Days to 50% flowering			Plant height			1000- grain weight			Grain yield / plant		
			100%	70%	40%	100%	70%	40%	100%	70%	40%	100%	70%	40%
Female lines	1	B SH-6	-2.12**	-1.88**	-2.38**	-9.94**	-7.16**	-5.68**	-2.49**	-2.38**	-2.29**	4.63**	4.78**	5.62**
	2	B SH-8	0.17	0.37	0.34	-8.07**	-6.46**	-7.18**	1.44**	1.42**	1.26**	-6.92**	-6.54**	-8.60**
	3	B SH-10	-0.76*	-0.92*	-1.32**	-4.90**	-4.47**	-2.08	-1.02**	-1.08**	-1.43**	-6.27**	-5.36**	-5.43**
	4	B SH-11	1.50**	1.37**	1.74**	0.058	-0.36	-1.35	1.83**	1.82**	2.109**	8.70**	8.40**	7.84**
	5	B SH-13	0.73*	0.74	0.64*	-5.17**	-6.06**	-6.95**	-1.06**	-1.21**	-1.57**	-6.92**	-7.62**	-6.75**
	6	B SH-17	1.47**	1.44**	1.61**	-9.57**	-8.10**	-8.98**	-2.14**	-1.95**	-2.34**	-3.28*	-4.91**	-7.47**
	7	BTX-37	0.70*	0.91*	1.37**	27.92**	22.06**	22.67**	1.49**	1.53**	1.97**	4.47**	5.12**	6.24**
	8	ICSB-88003	-1.69**	-2.05**	-2.02**	9.69**	10.56**	9.57**	1.95**	1.86**	2.29**	5.60**	6.12**	8.54**
		S.E	0.348	0.393	0.282	0.837	0.853	0.901	0.162	0.140	0.153	0.77	0.65	0.64
Male lines	1	Adv-6\ 2009	-1.54**	-1.46**	-1.75**	23.68**	21.61**	16.45**	0.47*	0.81**	0.86**	3.95**	4.71**	1.64
	2	ICSR-89028	0.53	0.60	0.62**	-19.56**	-17.09**	-17.50**	-1.14**	-1.20**	-1.17**	-8.98**	-8.96**	-12.55**
	3	ICSR-92003	-1.23**	-1.08**	-1.06**	-22.08**	-20.22**	-17.89**	1.89**	1.51**	1.52**	4.94**	5.31**	8.50**
	4	ICSV-273	1.20**	1.14**	1.35**	21.29**	16.65**	17.97**	0.96**	0.93**	0.90**	6.57**	6.96**	9.20**
	5	Kymoun	1.03**	0.80*	0.85**	-3.33**	-0.95	0.95	-2.19**	-2.04**	-2.11**	-6.49**	-8.03**	-6.80**
		S.E	0.275	0.311	0.223	0.661	0.635	0.708	0.126	0.112	0.121	0.61	0.52	0.49

*, ** significant at 0-05 and 0.01 probability levels, respectively.

Regarding grain yield/plant, GCA effects showed that the female lines (ASH-6, ASH-11, ICSA-37 and ICSA-88003) and the male lines (ICSR-92003 and ICSV-273) had positive and highly significant GCA effects under water stress condition in the two studied seasons and combined over the two season. These lines would be considered the best combiners for grain yield/plant.

Generally, the female lines (ASH-11, ICSA-37 and ICSA-88003) and the R-lines (ICSR-92003 and ICSV-273) were good combiners for most studied traits for drought tolerance. Similar results were obtained by Mahmoud (2002), Sayed (2003), Bakheit *et al.* (2004) and Hafez (2010). They found significant general combining ability effects for grain yield/plant, which differed in magnitude among male and female lines.

Specific combining ability:

The estimates of specific combining ability (SCA) effects for each irrigation level over seasons are presented in Tables (4&5).

Combined data over the two seasons for days to 50% flowering showed that, the crosses no. 16 and 27 had negative and significant SCA effects under 40% of irrigation level. This means that these crosses could be considered as good combinations for earliness under stress condition. While, the cross no. 28 had positive and significant SCA effects under 40% and 70% irrigation levels.

For plant height the crosses no. 4, 13, 16, 19, 25, 27, 32, 35 and 38 had positive and highly significant SCA effects under the three irrigation levels indicating that these crosses could be considered the best combiners for tallness. On the other hand, the crosses no. 1, 2, 14, 18, 20, 22, 30, 33, 34 and 39 had negative and significant SCA effects indicating that these crosses could be considered the best combination for shortness.

Regarding SCA effect for 1000-grain weight, the crosses No. 9, 12 and 29 had positive and significant SCA effect under the three irrigation levels.

Assiut J. Agric. Sci., (46) No. (5) 2015 (1-10) *ISSN: 1110-0486*
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Table (4): Specific combining ability (SCA) effects for days to 50% flowering and plant height under the three levels of irrigation over two seasons.

No.	Genotypes	Combined over years					
		50% flowering			plant height		
		100%	70%	40%	100%	70%	40%
1	ASH-6 x Adv-6	1.55	1.59	2.05**	-15.12**	-12.97**	-8.29**
2	ASH-6 x ICSR-89028	-0.71	-0.30	-0.98	-20.03**	-35.10**	-31.83**
3	ASH-6 x ICSR-92003	-0.10	-0.45	-0.63	9.65**	8.85**	6.56*
4	ASH-6 x ICSV-273	-0.37	0.33	-0.55	26.77**	33.64**	29.68**
5	ASH-6 x Kymoun	-0.37	-1.18	0.12	-1.26	5.58*	3.87
6	ASH-8 x Adv-6	-0.25	-0.34	-1.02	-5.98**	-0.01	0.21
7	ASH-8 x ICSR-89028	-1.17	-1.07	0.78	-6.40**	-5.80*	-3.50
8	ASH-8 x ICSR-92003	-1.23	-0.88	-0.70	-1.55	2.65	3.56
9	ASH-8 x ICSV-273	0.66	0.89	1.55*	4.40*	-3.22	-3.47
10	ASH-8 x Kymoun	1.99*	1.39	-0.62	9.53**	6.38*	3.21
11	ASH-10 x Adv-6	-0.15	-0.20	0.15	-1.15	0.82	2.61
12	ASH-10 x ICSR-89028	0.26	0.57	0.28	-7.07**	-3.13	-0.77
13	ASH-10 x ICSR-92003	0.53	-0.41	-0.03	14.61**	14.48**	7.96**
14	ASH-10 x ICSV-273	-0.40	0.03	-0.45	-7.25**	-8.72**	-9.41**
15	ASH-10 x Kymoun	-0.24	0.02	0.05	0.86	-3.45	-0.39
16	ASH-11 x Adv-6	-1.09	-0.50	-1.58*	11.37**	15.72**	15.87**
17	ASH-11 x ICSR-89028	-0.34	0.43	1.05	0.462	3.92	-2.167
18	ASH-11 x ICSR-92003	-0.23	0.95	0.40	-17.35**	-23.77**	-20.43**
19	ASH-11 x ICSV-273	1.33	-0.11	-0.02	10.10**	15.34**	16.35**
20	ASH-11 x Kymoun	0.33	-0.77	0.15	-4.60*	-11.21**	-9.62**
21	ASH-13 x Adv-6	0.18	-0.37	0.02	18.11**	0.92	0.31
22	ASH-13 x ICSR-89028	1.59*	1.57	0.48	-11.63**	-5.87*	-9.73**
23	ASH-13 x ICSR-92003	-1.47	-1.41	-1.00	1.71	-6.74**	-0.50
24	ASH-13 x ICSV-273	-1.07	0.36	0.08	-12.99**	2.712	-1.05
25	ASH-13 x Kymoun	0.76	-0.14	0.41	4.80*	8.98**	10.97**
26	ASH-17 x Adv-6	-0.55	-0.24	-0.45	-12.15**	-4.87*	-5.49
27	ASH-17 x ICSR-89028	-0.14	-0.80	-1.32*	16.09**	13.66**	20.46**
28	ASH-17 x ICSR-92003	0.30	1.88*	2.70**	8.12**	5.28*	4.362
29	ASH-17 x ICSV-273	1.19	-0.34	0.12	-2.59	0.07	-3.51
30	ASH-17 x Kymoun	-0.80	-0.51	-1.05	-9.46**	-14.15**	-15.82**
31	ICSA-37 x Adv-6	-0.29	-0.70	0.45	-2.32	-1.21	-4.66
32	ICSA-37 x ICSR-89028	0.80	-0.10	-0.42	25.76**	28.32**	25.80**
33	ICSA-37 x ICSR-92003	1.90*	0.09	-0.23	-25.71**	-17.87**	-16.80*
34	ICSA-37 x ICSV-273	-1.04	-0.64	-0.98	-2.59	-16.75**	-13.67**
35	ICSA-37 x Kymoun	-1.37	1.36	1.18	4.86*	7.51**	9.34**
36	ICSA-88003 x Adv-6	0.61	0.76	0.35	7.24**	1.62	-0.56
37	ICSA-88003 x ICSR-89028	-0.30	-0.30	0.15	2.82	3.99	1.73
38	ICSA-88003 x ICSR-92003	0.29	0.22	-0.50	10.51**	17.12**	15.29**
39	ICSA-88003 x ICSV-273	-0.30	-0.51	0.25	-15.85**	-23.08**	-14.91**
40	ICSA-880٠٣ x Kymoun	-0.31	-0.18	-0.26	-4.73*	0.35	-1.55
S.E.		0.79	0.88	0.63	2.14	1.89	2.02

*,** Significant at the 0.05 and 0.01 levels, respectively.

Over the two seasons. These crosses were considered as best combiners for heavier 1000-grain weight.

For grain yield/plant, data showed that crosses no. 1, 7, 13, 16, 19, 25, 33, 36 and 37 had positive highly significant SCA effects, indicating that these crosses considered the favorable combinations for grain yield/plant. Also, the crosses 19, 25 and 30 had highly significantly and positive SCA effects under 40% of irrigation level over two season, these crosses were good combinations under stress conditions. Similar results were obtained by Abd El-Halim (2003) and Bakheit *et al.* (2004), Hoveny *et al.*(2005), Amir (2008), Hafez (2010), Mahmoud *et al* (2013). They reported that SCA effects differed in magnitude among male and female parents in most studied traits.

Table (5): Specific combining ability (SCA) effects for 1000-grain weight and grain yield/ plant under the three levels of irrigation in over two seasons.

No.	Genotypes	Combined over years					
		1000-grain weight			grain yield/ plant		
		100%	70%	40%	100%	70%	40%
1	ASH-6 x Adv-6	0.16	-0.16	0.04	2.55	3.98**	11.20**
2	ASH-6 x ICSR-89028	-0.95**	-0.90**	-1.13**	-1.16	2.16	-5.43**
3	ASH-6 x ICSR-92003	0.71	1.29**	1.36**	-10.41**	-9.77**	-7.48**
4	ASH-6 x ICSV-273	0.05	-0.15	-0.25	4.60*	6.73**	5.30**
5	ASH-6 x Kymoun	0.03	-0.08	-0.02	4.42	-3.10*	-3.59*
6	ASH-8 x Adv-6	0.30	-0.26	0.20	2.54	0.23	2.104
7	ASH-8 x ICSR-89028	-0.41	0.06	0.30	9.47**	13.00**	12.96**
8	ASH-8 x ICSR-92003	-0.96**	-1.15**	-0.93**	-7.03**	-5.94**	-10.25**
9	ASH-8 x ICSV-273	1.11**	1.20**	0.79*	-3.05	-2.93*	1.125
10	ASH-8 x Kymoun	-0.04	0.13	-0.22	-1.93	-4.35**	-5.94**
11	ASH-10 x Adv-6	-0.17	-0.17	-0.04	-7.00**	-4.78**	-10.39**
12	ASH-10 x ICSR-89028	1.04**	2.15**	2.06**	-2.35	-2.34	2.21
13	ASH-10 x ICSR-92003	0.33	0.12	-0.40	8.31**	8.70**	10.25**
14	ASH-10 x ICSV-273	-1.16**	-1.02**	-0.99**	3.51	1.71	2.20
15	ASH-10 x Kymoun	-0.04	-1.07**	-0.62	-2.46	-3.28*	-4.28**
16	ASH-11 x Adv-6	0.29	0.68*	0.47	10.65**	10.28**	6.48**
17	ASH-11 x ICSR-89028	-0.23	-0.60	-0.07	-8.23**	-13.11**	-7.48**
18	ASH-11 x ICSR-92003	0.65*	0.21	0.03	-3.26	-2.89*	-3.20*
19	ASH-11 x ICSV-273	-0.17	-0.31	-0.28	5.36**	6.28**	8.59**
20	ASH-11 x Kymoun	-0.54	0.02	-0.14	-4.52*	-0.55	-4.39**
21	ASH-13 x Adv-6	-0.02	0.82*	0.67*	-2.04	-4.51**	-6.24**
22	ASH-13 x ICSR-89028	0.52	0.36	0.18	3.06	0.75	2.36
23	ASH-13 x ICSR-92003	-0.44	-0.63	-0.28	-1.28	-0.77	-3.10*
24	ASH-13 x ICSV-273	-0.53	-0.73*	-0.69*	-2.16	-1.68	-1.39
25	ASH-13 x Kymoun	0.46	0.18	0.12	2.43	6.23**	8.36**
26	ASH-17 x Adv-6	-0.17	-0.73*	-0.76*	1.91	7.01**	2.14
27	ASH-17 x ICSR-89028	-0.32	-0.68*	-1.08**	6.75**	1.86	-2.08
28	ASH-17 x ICSR-92003	-0.61	-0.32	-0.41	0.15	-3.91*	3.12
29	ASH-17 x ICSV-273	1.37**	0.99**	1.74**	-8.47**	-6.73**	-9.92**
30	ASH-17 x Kymoun	-0.26	0.74*	0.52	-0.35	1.76	6.75**
31	ICSA-37 x Adv-6	-0.40	-0.52	-0.41	-6.37**	-5.35**	-1.57
32	ICSA-37 x ICSR-89028	-0.16	-0.48	-0.60	-12.82**	-7.99**	-10.21**
33	ICSA-37 x ICSR-92003	0.91**	0.55	0.79*	13.10**	12.38**	11.23**
34	ICSA-37 x ICSV-273	-0.19	0.51	0.57	5.17**	-0.76	-1.30
35	ICSA-37 x Kymoun	-0.14	-0.06	-0.35	0.91	1.73	1.86
36	ICSA-88003 x Adv-6	0.01	0.34	-0.16	-2.25	-6.85**	-3.71
37	ICSA-88003 x ICSR-89028	0.52	0.09	0.34	5.27**	5.66**	7.65**
38	ICSA-88003 x ICSR-92003	-0.61	-0.07	-0.17	0.42	2.22	-0.56
39	ICSA-88003 x ICSV-273	-0.47	-0.51	-0.73*	-4.95**	-2.60	-4.60**
40	ICSA-880٠٣ x Kymoun	0.54	0.14	0.72*	1.50	1.56	1.23
S.E.		0.327	0.312	0.35	1.76	1.47	1.50

*,** Significant at the 0.05 and 0.01 levels, respectively.

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دراسة القدرة علي الائتلاف في الذرة الرفيعة للحبوب تحت الاجهاد المائي باستخدام تحليل السلالة × الكشاف.

السيد عبد السلام حسب الله[1] ، باهي راغب بخيت[1]، محمد رزق الله حفني[2] ، يوسف محمد يوسف القاضي[2]
[1] قسم المحاصيل – كلية الزراعة – جامعة أسيوط
[2] قسم بحوث الذرة الرفيعة - معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – مصر

الملخص:

تم تقييم عدد ٤٠ هجين من الذرة الرفيعة للحبوب وآبائهم (٨ سلالات عقيمة A lines ، ٥ آباء معيدة للخصوبة R- lines) والهجين التجاري شندويل ٣٠٦ للمقارنة وذلك لصفة محصول الحبوب للنبات وبعض الصفات الأخرى وذلك في موسمي ٢٠١١ و ٢٠١٢ في محطة بحوث شندويل تحت ثلاث مستويات من الري (التجربة الأولي تحت مستوي ١٠٠% من المعدل الأمثل ، التجربة الثانية تحت ٧٠% من المعدل الأمثل، التجربة الثالثة تحت ٤٠% من المعدل الأمثل). وقد أظهرت نتائج تحليل التباين المشتركه للسنتين معا وجود اختلافات معنوية بين التراكيب الوراثية وهذا يشيرإلي وجود اختلافات معنوية بين هذه التراكيب لجميع الصفات تحت الدراسه كما وجدت إختلافات معنويه جدا بين مستويات الري المختلفة وذلك لجميع الصفات محل الدراسة. بالإضافة الى ذلك وجد تفاعل معنوي بين التراكيب الوراثيه والري وهذا يشير إلى أن التراكيب الوراثية مختلفة فى استجابتها للاحتياجات المائية خصوصا تحت المستوى المنخفض من الري لكل الصفات المدروسه ما عدا عدد الأيام حتي ٥٠% تزهير.

وجد أيضا أن هناك اختلافات معنوية بين التراكيب الوراثية بين الهجن وابائها في كل الصفات تحت الدراسه للموسمين وقد سجل البحث اختلافات معنويه جدا للأباء مقابل الهجن لكل الصفات في كل من السنتين.

كما أوضحت النتائج أن فعل الجين التجميعي و فعل الجين الغير تجميعى(السيادى) يساهمان فى توضيح السلوك الجينى لصفات عدد الايام حتي ٥٠% تزهير، إرتفاع النباتات و وزن الـ ١٠٠٠ حبة وصفة المحصول.

أوضحت النتائج أن السلالات (ICSA-88003, ICSA-37, ASH-11, ASH-6) والسلالات المعيدة للخصوبة (ICSV-273 , ICSR- 92003) أعطت قيما موجبة وعالية المعنوية للقدرة العامة علي الائتلاف علي مستوي السنتين و هذه السلالات تحمل جينات تعمل علي توريث صفة المحصول العالي.

أعطت الهجن (ASH-8 × ICSR-89028) و (ICSA37 × ICSR-92003) قيم موجبة وعالية المعنوية القدرة الخاصة علي الائتلاف وتعتبر اتحادات وراثية جديدة جيدة لصفة المحصول.