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HETEROSIS AND LINE X TESTER ANALYSIS OF COMBINING ABILITY IN GRAIN SORGHUM [*Sorghum bicolor* (L.) Moench]

Abo-Elwafa*, A.; T.A. Ahmed; E.A. Hassaballa and M.A. Sayed

Dept. of Agronomy, Fac. of Agric., Assiut Univ., Egypt.

*Corresponding author: atif@acc.eun.edu.eg

Abstract: Fifty-six top crosses of grain sorghum were developed from eight introduced cytoplasmic male sterile lines and seven restorer lines using line X tester mating design. These hybrids, their parents and two checks were evaluated at two locations of Assiut and Sohag in 2002 season. Randomized Complete Block Design with three replications was used at each location.

Results indicated that highly significant differences for days to 50% flowering, plant height, leaf area, panicle length, width and weight, threshing percentage, grain yield/plant and 1000 grain weight among parents, males, females and crosses. The interaction between locations and each of genotypes, crosses, parents and males were significant for all studied traits except leaf area. Males X females X locations interaction was significant for all studied traits except leaf area and panicle weight. The interaction between females and locations was significant for studied traits except leaf area and panicle length.

The higher mean square values for males than males X females indicate the large effect of the testers on cross performance in all studied traits.

Thirteen out of the fifty-six crosses were significantly superior to the check variety Dorado in days to 50% flowering, plant height, panicle length and weight and grain yield/plant.

The heterosis values of the better parent ranged from -12.37% in earliness to 106.82% in grain yield/plant.

The female lines ICSA-20 and ICSA-89002 had significantly negative and positive GCA effects for days to 50% flowering and grain yield/plant, respectively. This result indicates that these lines had desirable gene action and could be considered good combiners for both traits.

Thirteen crosses had negative and significant SCA effects for days to 50% flowering and they were considered to be the best combiners for earliness. Eight crosses (Nos. 6, 12, 19, 26, 33, 42, 44, and 55) showed positive and significant SCA for grain yield/plant. Crosses nos. 12 and 44 out of these crosses gave negative and highly significant for earliness, demonstrating that both crosses could produce early and high yield hybrids .

Key words: heterosis, line x tester analysis, combining ability, grain sorghum

Introduction

In Egypt, grain sorghum is the fourth cereal crop, ranking after wheat, maize and rice. In 2002 season, the area cultivated with grain sorghum was 148,764 ha and the total production was 800,000 metric tons (FAO 2002). Seventy percent of the area is sown in Assiut and Sohag Governorates. Because of progressive consumption that attributed to growth of population, the harvested production is inadequate for local uses. Consequently, the base of any current studies is concentrating on high grain yield potential and other its attributes in grain sorghum.

The discovery of cytoplasmic male sterile (CMS) lines in sorghum facilitates the production of hybrids. Development of hybrids in Egypt is still depending on exotic CMS and restorer lines. Selection among these lines to produce hybrids depends on their good ability in general and specific combining abilities as a first step for hybrid program.

El-Menshawy (1996), Amir (1999) and Bakheit *et al*. (2004) reported that the hybrids were earlier, taller and had higher 1000 grain weight and grain yield than their better parents. Better parent heterosis showed wide variation reaching to 50.9% for plant height (Mahmoud, 1997) and 16.0, 69.6, 24.2 and 26.0% for earliness, plant height, grain weight and grain yield, respectively (El-Menshawy, 1996).

General combining ability effects for male parents were positive and significant for plant height, days to 50% flowering, panicle length and width, 1000 grain weight and grain yield. Also, general combining ability effects for females and restorers were positive and significant for all the studied traits except for 1000 grain weight (Mahmoud, 1997). General combining ability was found to be more important than specific combining ability for plant height and grain weight (Radwan *et al*., 1997). Twelve crosses out of eighty had positive significant differences in specific combining ability for grain yield (Hovny *et al*., 2000). The objectives of the present study were to evaluate some grain sorghum genotypes and their hybrids for potential and estimate the general and specific combining abilities, as well as heterosis in obtained hybrids.

Materials And Methods

Fifty-six top cross of grain sorghum hybrids were developed at Agric. Res. Farm, Assiut University, Egypt in 2001 season. These hybrids were developed from eight introduced cytoplasmic male sterile line (A-lines) and seven restorer lines (R-lines) using line X tester mating design. The origin of the eight male sterile lines and the seven restorer lines are presented in Table 1.

Table (1): The origin of parental lines used in the study.

Line	Genotype	Origin
	Male sterile lines	
1	ICS.A-14	ICRISAT [(a)]
2	ICS.A-20	"
3	ATX-629	Texas [(b)]
4	ICS.A-89002	ICRISAT
5	ICS.A-504	"
6	ICS.A-516	"
7	ICS.A-608	"
8	ICS.A-610	"
	Restorer lines	
1	R-628	Zambabwi [(c)]
2	M.R-36565	New Mexico [(d)]
3	ICS.R-93001	ICRISAT
4	ICS.R-92003	"
5	ICS.R-93004	"
6	ICS.R-110	"
7	ICS.R-120	"

a= International Crop Research Institute for Semi-Arid Tropics (ICRISAT), India.

b= Texas A&M University, U.S.A.

c= Zambabwi

d= New Mexico State University, U.S.A.

In 2002 season, the fifty-six crosses, their parents (eight male sterile lines and seven restorer lines) and two checks (hybrid Shandaweel-6 and Dorado as a dwarf variety) were grown at Shandaweel Agric. Res. Station, Sohag and Agric. Res. Farm, Assiut Univ., Assiut. The genotypes in both locations were sown on 29th and 30th June, 2002, respectively. A randomized Complete Block Design with three replications was used at each location. Plot size was one row with 4 meter long and 70 cm apart. Sowing was done in hills spaced 20 cm. Thinning was done to two plants/hill after hoeing and after three weeks from sowing at both locations. Cultural practices were done and followed the recommendations for growing grain sorghum production in Egypt in both locations.

The following agronomic traits were measured on a random sample of ten guarded plants from each plot, days to 50% flowering, plant height, leaf area/plant, panicle length, width and weight, threshing percentage, grain yield/plant and 1000-grain weight.

A combined analysis over the two locations was done according to Gomez and Gomez (1984) for all studied traits. The combining ability effects were estimated using line X tester analysis according to Kempthorne (1957) as illustrated by Singh and Chaudhary (1977). Estimates of narrow-sense heritability were calculated according to Kempthorne (1957). Heterosis was calculated as the percentage of deviation from best parent and its significance was tested by the appropriate L.S.D. test.

Results And Discussion

I- Mean performance of the genotypes:

The combined analysis of variance over two locations (Table 2) indicated highly significant differences for all studied characters among parents, males, females and crosses. Also, the genotype X location, cross X location, parent X location, and males X locations interaction variances were significant for all studied characters except for leaf area was insignificant. The mean square values for males were higher than those of males X females for all studied traits. These higher values indicate the large effect of the testers on cross performances in all studied traits. The interaction between males X females X locations was significant for all studied traits except leaf area and panicle weight. Also, the interaction between female and locations was significant for all studied traits except leaf area and panicle length.

Results in Table 3 show that, 13 (ICS.A-14 x R-628, ICS.A-14 x ICSR-110, ICS.A-20 x R-628, ICS.A-20 x CSR-110, ATX-629 x R-628, ATX-629 x ICS.R-92003, ATX-629 x ICS.R-110, ATX-629 x ICS.R-120, ICS.A-89002 x R-628, ICS.A-89002 x ICS.R-93001, ICS.A-89002 x ICS.R-110, ICS.A-504 x R-628 and ICS.A-516 x R-628) out of 56 crosses were significantly superior to the check variety Dorado in days to 50% flowering, plant height, panicle length and weight, and grain yield/plant. The female parent ATX-629 gave the earliest and heavier crosses, ICS.A-20 gave the heavier panicle and largest leaf area, ICS.A-14 exhibited tallest plant and longest panicle, ICS.A-89002 exerted largest panicle width and ICS.A-504 gave the highest average of grain yield/plant and threshing percentage compared to the other

Table (2): Combined mean squares of all grain sorghum genotypes without checks for the studied traits over two locations (Assiut and Sohag) in 2002 season.

Source of variations	D.F.	Mean squares								
		Days to 50% flowering	Plant height (cm)	Leaf area (m^2)	Panicle length (cm)	Panicle width (cm)	Panicle weight (g)	Threshing percentage	1000-grain weight (g)	Grain yield/plant (g)
Locations (L)	1	2236.38**	2843.00**	0.01	112.81	1.25	9831.00**	325.25**	729.09**	2174.75**
Reps/Loc.	4	24.94	32.75	0.02	15.45	7.60	249.00	14.25	27.36	124.00
Genotypes (G)	70	165.06**	4164.33**	0.05**	37.62**	2.53**	2214.74**	207.12**	78.63**	1361.36**
Parents (P)	14	104.23**	2453.46**	0.10**	41.70**	2.81**	1130.46**	371.72**	235.69**	1229.60**
P vs C	1	395.50**	137602.60**	0.31**	866.69**	23.42**	41954.5**	41.47	264.68**	18150.41**
Crosses (C)	55	176.53**	2173.67**	0.03**	21.51**	2.08**	1768.19**	168.23**	35.27**	1089.65**
Female (F)	7	138.45**	4897.57**	0.06**	70.02**	6.01**	4619.07**	150.05**	73.75**	2162.14**
Male (M)	6	1322.90**	9753**	0.10**	75.41**	5.08**	3870.50**	476.31**	135.06**	2528.19**
F×M	42	18.88**	517.88**	0.01	5.72**	1.00**	992.71**	127.25**	14.60**	705.39**
G×L	70	5.34**	9.17**	0.01	3.34**	0.49**	254.09**	48.94**	11.61**	170.21**
P×L	14	3.97**	12.08**	0.01	5.19**	0.60*	210.21**	53.68**	7.74**	161.67**
P vs C×L	1	0.25	15.38**	0.06**	7.28*	0.01	20.00	34.03*	29.16**	0.84
C×L	55	5.79**	8.33**	0.004	2.80**	0.47**	269.55**	48.01**	12.28**	175.47**
F×L	7	2.63**	10.71*	0.001	2.25	0.72*	189.71**	40.11*	14.21**	147.46**
M×L	6	12.94**	10.00**	0.01	4.13*	0.98**	574.33**	35.10**	53.63**	203.25**
F×M×L	42	5.30**	7.69**	0.001	2.70*	0.36	239.32**	51.17**	6.05**	176.16**
Error	280	1.36	2.17	0.01	1.75	0.30	65.36	11.79	2.56	33.77

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

Table(3): Combined mean of studied traits for sorghum genotypes over two locations in 2002 season.

No.	Male lines Pedigree	Male lines mean	ICS. A-14	ICS. A-20	ATX. -629	ICS.A-89002	ICS. A-504	ICS. A-516	ICS. A-608	ICS. A-610	Average
			Mean of crosses								
	1-Days to 50% flowering										
1	R-628	67.33	59.33	59.00	59.30	60.67	60.50	59.83	61.83	61.17	60.20
2	M.R-36565	76.50	73.00	72.67	65.33	72.83	73.50	74.67	70.83	76.00	72.35
3	ICS.R-93001	73.34	71.50	71.50	67.17	66.00	68.33	69.83	71.83	73.17	69.91
4	ICS.R-92003	73.67	72.50	68.67	66.00	67.33	72.67	73.67	73.83	72.67	70.91
5	ICS.R-93004	74.67	73.17	69.17	68.00	72.00	78.83	72.17	72.50	73.83	71.70
6	ICS.R-110	62.83	60.33	60.50	60.33	59.67	58.17	60.00	62.67	63.17	60.60
7	ICS.R-120	73.67	67.50	68.00	66.33	70.33	70.50	71.66	73.66	74.00	70.24
	Average	$(71.72)^m$	68.19	67.07	64.63	66.97	68.07	68.83	69.59	70.57	$(67.98)^c$
	Female line means		75.17	68.17	63.17	68.67	69.17	68.67	68.83	71.50	$(69.17)^f$
Checks:	Dorado = 68.17		Shandaweel-6= 72.00			$L.S.D._{(G)\,0.05}$= 1.31			$L.S.D._{(G)\,0.01}$= 1.73		
	2-Plant height.										
1	R-628	172.33	199.8	197.00	199.90	192.23	179.70	171.63	196.23	183.50	189.99
2	M.R-36565	134.93	230.76	188.40	189.77	188.00	180.80	160.10	193.43	187.90	189.89
3	ICS.R-93001	176.20	228.70	218.98	199.30	204.00	190.30	179.53	192.23	192.86	200.73
4	ICS.R-92003	177.47	248.50	229.70	226.23	204.96	196.80	194.93	201.20	206.90	213.65
5	ICS.R-93004	165.92	213.10	218.13	197.36	198.90	177.30	159.30	194.83	189.90	193.60
6	ICS.R-110	143.70	200.76	193.36	195.53	190.61	167.00	153.56	189.73	179.43	183.74
7	ICS.R-120	159.34	249.20	208.03	187.23	200.46	186.20	201.43	195.73	184.46	201.59
	Average	$(161.42)^m$	224.40	207.65	199.33	197.02	182.58	174.35	194.76	189.27	$(196.18)^c$
	Female line means		150.40	129.64	124.37	129.54	162.57	119.73	164.14	171.94	$(144.04)^f$
Checks:	Dorado = 144.57		Shandaweel6=191.64			$L.S.D._{(G)\,0.05}$= 1.69			$L.S.D._{(G)\,0.01}$= 2.21		
	3-Leaf area.										
1	R-628	0.860	0.808	0.906	0.839	0.885	0.882	0.749	0.938	0.908	0.864
2	M.R-36565	0.649	0.793	0.840	0.827	0.707	0.692	0.639	0.734	0.699	0.741
3	ICS.R-93001	0.836	0.705	0.877	0.823	0.760	0.736	0.731	0.772	0.763	0.770
4	ICS.R-92003	0.891	0.773	0.900	0.904	0.842	0.811	0.767	0.788	0.771	0.819
5	ICS.R-93004	0.931	0.811	0.897	0.870	0.918	0.865	0.824	0.834	0.865	0.860
6	ICS.R-110	0.703	0.833	0.827	0.837	0.797	0.720	0.773	0.820	0.916	0.815
7	ICS.R-120	0.756	0.748	0.892	0.888	0.800	0.779	0.867	0.790	0.867	0.828
	Average	$(0.811)^m$	0.781	0.877	0.855	0.815	0.783	0.764	0.810	0.827	$(0.814)^c$
	Female line means		0.597	0.691	0.654	0.645	0.670	0.579	0.791	0.948	$(0.697)^f$
Checks:	Dorado = 0.774		Shandaweel-6 =0.842			$L.S.D._{(G)\,0.05}$= 0.114			$L.S.D._{(G)\,0.01}$= 0.149		
	4-Panicle length.										
1	R-628	26.09	31.00	29.73	31.40	28.57	29.17	27.90	29.28	28.53	29.44
2	M.R-36565	19.60	27.40	27.42	27.02	24.88	24.32	24.40	27.47	26.43	26.16
3	ICS.R-93001	26.05	31.13	28.65	29.35	28.68	27.51	28.23	29.60	28.73	28.98
4	ICS.R-92003	28.60	31.30	30.08	31.33	29.78	28.92	27.95	29.62	28.85	29.72
5	ICS.R-93004	26.00	31.62	34.62	28.43	27.92	28.85	27.17	31.17	29.18	29.87
6	ICS.R-110	24.57	30.45	30.45	31.23	28.47	26.27	27.90	28.78	28.77	29.04
7	ICS.R-120	25.52	30.77	30.50	30.85	28.17	26.92	26.68	29.20	28.52	28.95
	Average	$(25.20)^m$	30.52	30.20	29.94	28.06	27.42	27.17	29.30	28.43	$(28.88)^c$
	Female line means		27.87	25.74	26.04	23.42	23.04	21.32	28.50	28.37	$(25.54)^f$
Checks:	Dorado = 26.24		Shandaweel-6 =34.44			$L.S.D._{(G)\,0.05}$= 1.49			$L.S.D._{(G)\,0.01}$= 1.96		
	5-Panicle width.										
1	R-628	7.17	7.08	6.63	7.22	8.65	7.82	7.42	7.83	7.15	7.47
2	M.R-36565	7.19	7.57	7.63	7.47	8.82	7.42	8.20	8.60	7.78	7.93
3	ICS.R-93001	6.74	7.07	6.93	7.20	7.87	6.87	7.40	7.17	7.12	7.20
4	ICS.R-92003	7.02	7.58	7.03	6.80	8.35	7.30	7.87	7.10	7.25	7.42
5	ICS.R-93004	6.54	6.47	7.10	7.03	8.03	7.55	6.28	6.63	6.05	6.89
6	ICS.R-110	7.44	7.05	7.33	6.77	7.57	6.30	8.12	7.50	7.90	7.32
7	ICS.R-120	6.33	7.25	6.73	6.95	8.13	7.16	7.13	6.90	6.93	7.14
	Average	$(6.92)^m$	7.15	7.07	7.06	8.20	7.20	7.49	7.39	7.16	$(7.34)^c$
	Female line means		6.22	5.80	5.53	7.05	6.05	6.92	7.95	7.60	$(6.64)^f$
Checks:	Dorado =6.47		Shandaweel-6 =8.30			$L.S.D._{(G)\,0.05}$= 0.62			$L.S.D._{(G)\,0.01}$= 0.81		

Table(3): Cont.

No.	Male lines Pedigree	Male lines mean	Mean of crosses ICS. A-14	ICS. A-20	ATX. -629	ICS.A-89002	ICS. A-504	ICS. A-516	ICS. A-608	ICS. A-610	Average
					6-Panicle weight.						
1	R-628	105.33	141.93	120.59	139.83	136.80	135.77	114.63	105.50	98.97	124.25
2	M.R-36565	74.67	124.67	137.33	120.88	111.33	120.11	112.78	125.75	111.17	120.50
3	ICS.R-93001	92.58	112.92	131.00	119.75	111.50	130.50	125.50	112.67	116.33	120.02
4	ICS.R-92003	115.67	109.42	113.17	132.58	122.58	122.58	121.67	109.11	111.67	117.84
5	ICS.R-93004	98.67	82.67	125.37	109.23	122.25	120.33	74.50	69.83	72.42	97.08
6	ICS.R-110	103.33	126.00	129.15	118.17	133.07	122.20	111.75	98.77	124.52	120.45
7	ICS.R-120	87.33	109.75	137.48	124.33	127.47	124.50	140.92	79.00	82.66	115.76
	Average	$(96.82)^{m}$	119.62	127.28	123.54	123.57	125.14	114.53	100.09	102.53	$(116.56)^{c}$
	Female line means		79.25	73.25	82.53	78.33	90.42	85.02	111.34	105.84	$(88.25)^{f}$
Checks:	Dorado =98.83		Shandaweel6=182.50			$L.S.D._{(G)\,0.05}$= 9.15			$L.S.D._{(G)\,0.01}$= 12.02		
					7-Threshing percentage.						
1	R-628	64.38	58.04	59.67	56.16	65.05	64.14	67.40	66.64	62.96	62.51
2	M.R-36565	53.86	58.42	62.56	57.52	59.56	72.35	65.16	70.62	66.45	64.08
3	ICS.R-93001	72.66	68.27	65.67	66.69	68.81	70.22	69.20	73.42	68.61	68.86
4	ICS.R-92003	72.75	66.24	63.63	66.48	68.05	71.07	68.37	71.27	68.54	67.95
5	ICS.R-93004	69.60	55.95	67.54	67.07	66.26	68.24	52.43	52.25	53.88	60.45
6	ICS.R-110	65.63	66.66	59.15	62.67	60.69	62.57	60.91	63.43	63.68	62.47
7	ICS.R-120	73.56	67.67	62.96	64.01	65.94	69.73	59.06	54.12	54.87	62.29
	Average	$(67.49)^{m}$	63.03	63.02	62.94	64.91	68.33	63.21	64.53	62.71	$(64.08)^{c}$
	Female line means		53.85	56.96	54.41	60.23	61.55	65.28	70.16	63.85	$(60.78)^{f}$
Checks:	Dorado =62.71		Shandaweel-6=58.42			$L.S.D._{(G)\,0.05}$= 3.89			$L.S.D._{(G)\,0.01}$= 5.11		
					8-1000-grain weight.						
1	R-628	30.70	28.45	27.05	27.04	24.29	26.39	25.12	31.13	29.68	27.39
2	M.R-36565	33.58	30.09	31.94	31.28	26.70	30.54	27.98	30.82	29.07	29.80
3	ICS.R-93001	32.06	28.70	29.72	29.26	25.65	28.14	29.49	29.42	26.11	28.31
4	ICS.R-92003	34.94	30.37	28.53	31.12	26.29	29.44	31.85	29.93	28.08	29.45
5	ICS.R-93004	38.38	32.14	34.22	35.06	28.44	30.68	31.78	27.93	26.54	30.72
6	ICS.R-110	20.62	26.62	25.21	25.52	24.45	25.97	25.58	28.44	25.35	25.89
7	ICS.R-120	33.01	29.61	30.67	30.50	26.35	29.10	30.78	30.57	29.05	29.58
	Average	$(31.90)^{m}$	29.43	29.62	29.97	26.45	28.61	28.94	29.75	27.70	$(28.76)^{c}$
	Female line means		22.68	23.41	22.00	18.44	24.55	23.31	24.22	20.57	$(22.40)^{f}$
Checks:	Dorado =28.53		Shandaweel-6 =31.17			$L.S.D._{(G)\,0.05}$= 1.79			$L.S.D._{(G)\,0.01}$= 2.35		
					9-Grain yield/plant.						
1	R-628	67.97	82.41	71.90	78.61	88.88	86.67	77.23	69.75	62.32	77.22
2	M.R-36565	40.21	72.86	85.79	69.53	67.53	86.91	73.60	88.92	73.66	77.35
3	ICS.R-93001	66.99	77.33	85.99	79.89	76.64	91.47	86.75	82.67	79.55	82.53
4	ICS.R-92003	83.86	72.65	71.44	88.15	83.49	86.74	82.98	77.57	76.21	79.90
5	ICS.R-93004	68.74	46.09	84.96	73.06	80.52	82.11	39.11	36.49	39.03	60.17
6	ICS.R-110	66.50	82.38	76.43	74.13	79.73	76.33	62.23	62.38	79.29	74.11
7	ICS.R-120	64.03	74.35	86.57	79.33	83.96	86.62	82.99	42.76	45.53	72.76
	Average	$(65.46)^{m}$	72.58	80.44	77.53	80.10	85.26	72.13	65.79	65.08	$(74.97)^{c}$
	Female line means		42.77	41.48	38.71	47.01	55.70	55.59	78.01	67.19	$(53.31)^{f}$
Checks:	Dorado =62.73		Shandaweel6=106.71			$L.S.D._{(G)\,0.05}$= 6.52			$L.S.D._{(G)\,0.01}$= 8.57		

f, m, c and ch average of females, males, crosses and checks, respectively.

female parents. Also, the male parent, R-628 gave the earliest, higher panicle weight and largest in leaf area, while ICSR-93004 gave the longest panicle and heaviest 1000-grain weight, ICS.R-92003 exerted tallest plants, M.R-36565 recorded largest panicle width, ICSR-93001 gave the highest values of grain yield/plant and threshing percentage compared to the other male parents. Other studies (Mahmoud, 1997; Radwan *et al*., 1997; Hussin, 2001 and Bakheit *et al*., 2004) also reported that most CMS X restorer crosses were earlier, taller, have longest panicle, heavy seed weight and out yielded than their parents.

II- Heterosis:

Estimates of useful heterosis for the fifty-six F_1 crosses as a percentage of the better parent average over the two locations for all studied traits are presented in Table 4. The crosses showed wide range of heterosis with negative and positive values. The highest estimates of favorable heterosis were -12.37% in earliness, 56.4% in plant height, 26.45% in leaf area, 33.15 and 22.67% in panicle length and width, 83.92% in panicle weight, 17.55% in threshing percentage, 22.94% in 1000 grain weight and 106.82% in grain yield/plant. Mostafa and El-Menshawi (2001) reported heterosis values for grain yield up to 52.4%, 1000 grain weight and grain yield up to 43.1 and 67.8% respectively over better parent. Bakheit *et al.* (2004) reported that the highest estimates of favourable heterosis were 4.6% in earliness, 49.4% in plant height, 58.8% in leaf area, 23.2 and 28.3 in panicle length and width, 33.8% in 1000 grain weight, and 87.8% in grain yield/plant.

III- Combining ability:

A- General combining ability (G.C.A.):

General combining ability (gca) of an inbred line is the average contribution that the inbred makes to hybrid performance in a series of hybrid combinations in comparison to the contribution of other inbred lines to hybrid performance in the same series of hybrid combinations. It is not possible from visual observation to predict the contribution of an inbred line to hybrid performance. The gca of an inbred line is evaluated by crossing it with other inbred lines comparing to the overall performance of the single-cross progenies. General combining ability evaluates the additive portion of the genetic effects (Poehlman and Sleper, 1995).

General combining ability (GCA) effects of the parental lines over the two locations are presented in Table 5. GCA for days to 50% flowering revealed that female line

Table (4): Useful heterosis as a percentage of the high parent of fifty-six hybrids average over two locations in 2002 season.

No.	Pedigree	Days to 50% flowering	Plant height (cm)	Leaf area (m2)	Panicle length (cm)	Panicle width (cm)	Panicle weight (g)	Threshing percentage	1000-grain weight (g)	Grain yield/plant (g)
1	ICS.A-14 × R-628	-11.88**	15.94**	-6.05	11.23**	-1.26	34.75**	-9.85*	-7.33*	21.24**
2	ICS.A-14 × M.R-36565	-2.89**	53.43**	22.19*	-1.69	5.29	57.31**	8.47*	-10.39*	70.35**
3	ICS.A-14 × ICS.R-93001	-2.51**	29.80**	-15.67*	11.70**	4.90	21.97**	-6.04*	-10.48**	15.44**
4	ICS.A-14 × ICS.R-92003	-1.59**	40.02**	-13.24*	9.44**	7.98	-5.40	-8.95**	-13.08**	-13.37**
5	ICS.A-14 × ICS.R-93004	-2.01**	28.40**	-12.89*	13.46**	-1.07	-16.22**	-19.61**	-16.26**	-32.95**
6	ICS.A-14 × ICS.R-110	-3.98**	33.48**	18.49*	9.26**	-5.24	21.94**	1.57	17.37**	23.88**
7	ICS.A-14 × ICS.R-120	-8.38**	56.40**	-1.06	10.41**	14.53**	25.67**	-8.01**	-10.30**	16.12**
8	ICS.A-20 × R-628	-12.37**	14.32**	5.35	13.95**	-7.53	14.49**	-7.32*	-11.89**	5.78
9	ICS.A-20 × M.R-36565	6.70**	39.63**	21.56**	6.53*	6.12	83.92**	9.83**	-4.88	106.82**
10	ICS.A-20 × ICS.R-93001	4.88**	24.28**	4.90	9.98**	2.82	41.50**	-9.62**	-7.30*	28.36**
11	ICS.A-20 × ICS.R-92003	0.73	29.43**	1.01	5.17	1.57	-2.16	-12.54**	-18.35**	-14.81**
12	ICS.A-20 × ICS.R-93004	1.47	31.43**	-3.65	33.15**	8.56	27.06**	-2.96	-10.84**	23.60**
13	ICS.A-20 × ICS.R-110	-3.71**	28.59**	17.64*	18.30**	-1.48	24.99**	-9.87**	7.69	14.93**
14	ICS.A-20 × ICS.R-120	-0.25	30.56**	17.99*	18.49**	6.32	57.43**	-14.41**	-7.09*	35.20**
15	ATX.629 × R-628	-6.08**	16.00**	-2.44	20.35**	0.70	32.75**	-12.77**	-11.92**	15.65**
16	ATX.629 × M.R-36565	3.42**	40.64**	26.45**	3.76	3.89	46.47**	5.72	-6.85*	72.92**
17	ATX.629 × ICS.R-93001	6.33**	13.11**	-1.56	12.67**	6.82	29.35**	-8.22**	-8.73**	19.26**
18	ATX.629 × ICS.R-92003	4.48**	27.48**	1.46	9.55**	-3.13	14.62**	-8.62**	-10.93**	5.12
19	ATX.629 × ICS.R-93004	7.65**	18.91**	-6.55	9.18**	7.49	10.70*	-3.64	-8.65**	6.28
20	ATX.629 × ICS.R-110	-3.98**	36.07**	19.06*	19.93**	-9.01*	14.36**	-4.51	16.00**	11.47*
21	ATX.629 × ICS.R-120	5.00**	17.50**	17.46*	18.47**	9.79*	42.37**	-12.98**	-7.60**	23.90**
22	ICS.A-89002 × R-628	-9.89**	11.55**	2.91	9.51**	20.64**	29.88**	1.04	-20.88**	30.76**
23	ICS.A-89002 × M.R-36565	6.06**	39.33**	8.94	6.23	22.67**	42.13**	-1.11	-20.49**	43.65**
24	ICS.A-89002× ICS.R-93001	-3.89**	15.78**	-9.09	10.10**	11.63**	20.44**	-5.30	-19.99**	14.41**
25	ICS.A-89002 × ICS.R-92003	-1.95**	15.49**	-5.50	4.13	18.44**	5.97	-6.46*	-24.76**	-0.44
26	ICS.A-89002 × ICS.R-93004	4.85**	19.84**	-1.40	7.38*	13.90**	23.90**	-4.80	-25.90**	17.14**
27	ICS.A-89002 × ICS.R-110	-5.03**	32.64**	13.37	15.87**	1.75	28.78**	-7.53*	18.57**	19.89**

Table (4): Cont.

No.	Pedigree	Days to 50% flowering	Plant height (cm)	Leaf area (m2)	Panicle length (cm)	Panicle width (cm)	Panicle weight (g)	Threshing percentage	1000-grain weight (g)	Grain yield/plant (g)
28	ICS.A-89002 × ICS.R-120	2.42*	25.81**	5.82	10.38**	15.32*	45.96**	-10.36**	-20.18**	31.13**
29	ICS.A-504 × R-628	-10.14**	4.28**	2.56	11.81**	9.07*	28.90**	-0.37	-14.04**	27.51**
30	ICS.A-504 × M.R-36565	6.26**	11.21**	3.28	5.56	3.20	32.84**	17.55**	-9.05**	56.03**
31	ICS.A-504 × ICS.R-93001	-1.92*	8.00**	-11.96	5.60	1.93	40.96**	-5.30	-12.23**	36.54**
32	ICS.A-504 × ICS.R-92003	5.06**	10.89**	-8.98	1.12	3.99	5.97	-2.31	-15.74**	3.43
33	ICS.A-504 × ICS.R-93004	5.29**	6.84**	-7.09	10.96**	15.44**	21.95**	-1.95	-20.06**	19.45**
34	ICS.A-504 × ICS.R-110	-7.42**	2.72**	2.42	6.92*	-15.32**	18.26**	-4.66	5.78	14.78**
35	ICS.A-504 × ICS.R-120	1.92*	14.54**	3.04	2.25	13.11*	37.69**	-5.21	-11.84**	35.28**
36	ICS.A-516 × R-628	-11.14**	-0.41	-12.91	6.94*	3.49	8.83*	3.25	-18.18**	13.62**
37	ICS.A-516× M.R-36565	8.74**	18.65**	-1.54	14.45**	14.05**	32.65**	-0.18	-16.68**	32.40**
38	ICS.A-516 × ICS.R-93001	1.69	1.89**	-12.56	8.37**	6.94	35.56**	-4.76	-8.02**	29.50**
39	ICS.A-516 × ICS.R-92003	7.28**	9.84**	-13.92*	-2.27	12.11**	5.19	-6.02*	-8.84**	-1.05
40	ICS.A-516 × ICS.R-93004	5.10**	-4.02**	-11.49	4.50	-16.60**	-24.50**	-24.67**	-17.20**	-43.10**
41	ICS.A-516 × ICS.R-110	-4.50**	6.86**	9.96	13.55**	9.12*	18.26**	-7.19*	9.74*	2.60
42	ICS.A-516 × ICS.R-120	4.35**	26.42**	14.68	4.55	3.03	61.36**	-19.71**	-6.76*	29.61**
43	ICS.A-608 × R-628	-8.17**	13.87**	9.07	2.74	-1.51	-5.25	-5.02	1.40	-10.59*
44	ICS.A-608 × M.R-36565	2.91**	17.84**	-7.21	-3.61	8.18*	12.94**	0.66	-8.22**	13.99**
45	ICS.A-608 × ICS.R-93001	4.36**	9.10**	-7.66	3.86	-9.81*	1.19	1.05	-8.23**	5.97
46	ICS.A-608 × ICS.R-92003	7.26**	13.37**	-11.56	3.57	-10.69**	-5.67	-2.03	-14.34**	-7.50
47	ICS.A-608 × ICS.R-93004	5.53**	17.39**	-10.42	9.37**	-16.60**	-37.28**	-25.53**	-27.23**	-53.22**
48	ICS.A-608 × ICS.R-110	-0.25	15.59**	3.67	0.98	-5.66	-11.29**	-9.59**	17.42**	-20.04**
49	ICS.A-608 × ICS.R-120	7.02**	19.25**	-0.13	2.46	-13.21**	-29.05**	-26.41**	-7.39**	-45.19**
50	ICS.A-610× R-628	-9.15**	6.48**	-4.22	0.56	-5.92	-6.49	-2.21	-3.32	-8.31
51	ICS.A-610× M.R-36565	6.29**	9.28**	-26.27**	-6.84*	2.37	5.04	4.07	-13.43**	9.63
52	ICS.A-610× ICS.R-93001	2.34*	9.46**	-19.51**	1.27	-6.32	9.91*	-5.57*	-18.56**	18.40**
53	ICS.A-610× ICS.R-92003	1.64	16.58**	-18.67**	0.87	-4.61	-3.46	-5.79*	-19.63**	-9.12*
54	ICS.A-610× ICS.R-93004	3.26**	10.45**	-8.76	2.86	-20.39**	-31.48**	-22.59*	-30.85**	-43.22**
55	ICS.A-610× ICS.R-110	0.54	4.37**	-3.38	1.41	3.95	17.65**	-2.97	22.94**	18.01**
56	ICS.A-610× ICS.R-120	3.50**	7.28**	-8.54	0.53	-8.82*	-21.90**	-25.41**	-12.00**	-32.24**

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

ICS.A-20, ATX-629 and ICS.A-89002 had negative and highly significant GCA effects, also for male lines R-628 and ICS.R-110 had negative and significant GCA effects, indicating that these lines had favorable gene action and will be considered as good general combiners for earliness. Also, for plant height, the three female lines (ICS.A-14, ICS.A-20 and ATX-629) and the three male lines (ICS.R-93001, ICS.R-92003 and ICS.R-120) had positive and highly significant GCA effects, indicating that these lines had favorable gene action for tallness and will be considered as good general combiners for tallness. For leaf area, two female lines (ICS.A-20 and ATX-629 and three male lines (R-628, ICS.R-93004 and ICS.R-120) had positive and highly significant GCA effects, indicating that these genotypes had desirable gene action for increasing the leaf area while three female lines (ICS-A-14, ICS.A-516 and ICS.A-504) and two male lines (MR-36565 and ICS.R-93001) had negative and highly significant GCA effects, indicating that these lines had desirable gene action for decreasing leaf area. For panicle length, the female lines ICS.A-14, ICS.A-20 and ATX-629 had positive and significant GCA effect. The same trend was found for male lines R-628, ICS.R-93003 and ICS.R-93004. This indicating that these lines had favorable gene action for elongation of the panicle length. For panicle width, the female line ICS.A 89002 and male line MR 36565 had positive and highly significant GCA effects, indicating that these lines had favorable gene action for increasing panicle width and will be considered as good combiners for this trait. For panicle weight the female lines ICS.A-20, ATX-629, ICS.A-89002 and ICS.A-504 and male line R-628 and MR-36565 had positive and highly significant GCA effects indicating that these lines had desirable gene action for increasing panicle weight. Female line ICS.A-504 and male lines ICS.R-93001 and ICS.R-92003 had highly significant GCA effects, indicating that these lines possessed desirable gene action for threshing percentage. For 1000 grain weight, the female line ATX 629 and the male line ICS.R-93004 had positive and significant GCA effects, indicating these lines had favorable gene action for increasing 1000 grain weight. For grain yield/plant the female lines ICS.A-20, ICS.A-89002 and ICS.A-504 as well as the male lines ICS.R-93001 and ICS.R-92003 had positive and highly significant GCA effects indicating these lines had desirable gene action and will be considered good combiners for increasing the grain yield. Similar results were obtained by Gite *et al.* (1997), Mahmoud (1997), Radwan *et al.* (1997), Ali (2000), Hussin (2001), Mostafa and El-Menshawi (2001)

Table (5): stimates of general combining ability effects for nine-traits of seven grain sorghum restorers and eight CMS-lines at Assiut, Sohag and over two locations in 2002 season.

No.	parents	Days to 50% flowering	Plant height (cm)	Leaf area (m^2)	Panicle length (cm)	Panicle width (cm)	Panicle weight (g)	Threshing percentage	1000-grain weight(g)	Grain yield/plant (g)
	Female lines									
1	ICS.A-14	0.196	28.227**	-0.034**	1.639**	-0.189	-1.223	-1.041	0.673	-2.390
2	ICS.A-20	-0.922**	11.482**	0.062**	1.322**	-0.270*	11.167**	-1.052	0.865	5.467**
3	ATX-629	-3.351**	3.156**	0.041**	1.061**	-0.280*	6.980**	-1.134	1.214*	2.554
4	ICS.A-89002	-1.017**	0.848	0.000	-0.817**	0.860**	7.011**	0.828	-2.730**	5.135**
5	ICS.A-504	0.077	-13.591**	-0.032**	-1.462**	-0.139	8.583**	4.253**	-0.145	10.291**
6	ICS.A-516	0.839**	-21.820**	-0.051**	-1.708**	0.145	-2.023	-0.861	0.187	-1.991
7	ICS.A-608	1.601**	-1.405**	0.002	0.418	0.047	-16.469**	0.373	0.993	-9.178**
8	ICS.A-610	2.577**	-6.896**	0.011	-0.453*	-0.173	-14.026**	-1.366	-1.057	-9.888
	S.E. gi	0.250	0.505	0.0052	0.231	0.131	2.125	0.977	0.581	1.873
	Male lines									
1	R-628	-7.785**	-6.177**	0.048**	0.564**	0.132	7.693**	-1.646*	-1.359*	2.244
2	M.R-36565	4.360**	-6.281**	-0.074**	-2.717**	0.593**	3.944*	0.000	1.049	2.376
3	ICS.R-93001	1.922**	4.562**	-0.044**	0.103	-0.140	3.461	4.783**	-0.443	7.563**
4	ICS.R-92003	2.922**	17.476**	0.004	0.845**	0.080	1.288	3.878**	0.696	4.931**
5	ICS.R-93004	3.714**	-2.573**	0.053**	0.985**	-0.448**	-19.483**	-3.624**	2.094**	-14.797**
6	ICS.R-110	-7.389**	-12.428**	0.0003	0.155	0.025	3.892	-1.608*	-2.861**	-0.109
7	ICS.R-120	2.255**	5.418**	0.013**	0.065	-0.192	-0.795	-1.783*	0.824	-2.208
	S.E. gi	0.234	0.472	0.0048	0.216	0.123	1.988	0.914	0.544	1.752

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

and Bakheit *et al.* (2004). They stated that general combining ability effect differed in magnitude among male and female lines for days to 50% flowering, plant height, leaf area, panicle length and width, panicle weight, grain yield/plant, and 1000 grain weight.

B- Specific combining ability (SCA):

Specific combining ability (sca) is the contribution of an inbred line to hybrid performance in across with a specific inbred line, in relation to its contributions in crosses with an array of specific inbred lines. Specific combining ability evaluates non-additive gene action and is utilized to identify the inbred X inbred cross combinations with superior performance. The inbred lines identified as having superior gca are crossed to create single crosses, which are then evaluated in yield trials for sca. The two particular inbreds combine to produce a high yielding single cross depends upon the extent that the favorable genes for yield from the two parent inbreds complement each other (Pohelman and Sleper, 1995).

Estimates of SCA effects (Table 6) revealed that 13 crosses had negative and significant SCA effects for days to 50% flowering over the two locations and they were considered to be the best combination for earliness. For plant height seventeen crosses had positive and highly significant SCA effects and these crosses were considered as good combinations for tallness. For leaf area fourteen crosses had positive and highly significant SCA effects, respectively. For panicle length, one cross (No. 12) was positive and significant, this cross was considered as the best combination for panicle length. For panicle width, the crosses number 33 and 55 had positive and significant SCA effects and these crosses were the best combinations for panicle width. For panicle weight seven crosses (Nos. 1, 12, 26, 33, 42, 44 and 55) had positive and highly significant SCA effects and these were considered to be the best combinations for increasing of panicle weight. Six crosses possessed positive and significant SCA effect for threshing percentage. For 1000 grain weight one cross no. 50 had positive and significant SCA effects. Eight crosses (Nos. 6, 12, 19, 26, 33, 42, 44 and 55) showed positive and significant SCA for grain yield/plant, whereas eleven crosses had significant negative effect for grain yield/plant.

Similar results were obtained by Pillai *et al.* (1995), Mahmoud (1997), Hovny *et al.* (2000), Mostafa and El-Menshawi (2001) and Bakheit *et al.* (2004). They reported that specific combining ability effects differed in magnitude among male and female parents for most of studied traits.

Table(6): Estimates the specific combining ability effects of crosses for nine studied traits at Assiut, Sohag and over the tow location in 2002 season.

No.	Pedigree	Days to 50% flowering	Plant height (cm)	Leaf area (m^2)	Panicle length (cm)	Panicle width (cm)	Panicle weight (g)	Threshing percentage	1000-grain weight (g)	Grain yield/plant (g)
1	ICS.A-14 × R-628	-1.0714	-18.4273**	-0.0226	-0.0874	-0.2017	18.9041**	-3.3460	0.3861	7.5752
2	ICS.A-14 × M.R-36565	0.4494	12.6434**	0.0858**	-0.4052	-0.1788	5.3864	-4.6193	-0.3826	-2.1047
3	ICS.A-14 × ICS.R-93001	1.3869*	-0.2669	-0.0314*	0.5062	0.0544	-5.8802	0.4506	-0.2845	-2.8132
4	ICS.A-14 × ICS.R-92003	1.3869*	6.6184**	-0.0133	-0.0687	0.3503	-7.2072	-0.6739	0.2431	-4.8583
5	ICS.A-14 × ICS.R-93004	1.2619	-8.7315**	-0.0235	0.1083	-0.2372	-13.1843*	-3.4595	0.6223	-11.6889*
6	ICS.A-14 × ICS.R-110	-0.4672	-11.2127**	0.0517**	-0.2291	-0.0767	6.7718	5.2343*	0.0544	9.9089*
7	ICS.A-14 × ICS.R-120	-2.9464**	19.3768**	-0.0466**	0.1770	0.2898	-4.7906	6.4137*	-0.6388	3.9813
8	ICS.A-20 × R-628	-0.2857	-4.4821**	-0.0206	-1.0375	-0.5708	-14.8291**	-1.7138	-1.2108	-10.7895*
9	ICS.A-20 × M.R-36565	1.2351	-12.9779**	0.0363**	-0.0729	-0.0312	5.6614	-0.4672	1.2704	2.9754
10	ICS.A-20 × ICS.R-93001	2.5059**	6.7616**	0.0440**	-1.6604**	0.0021	-0.1885	-2.1405	0.5419	-2.0163
11	ICS.A-20 × ICS.R-92003	-1.3273*	4.5637**	0.0238	-0.9687	-0.0185	-15.8489**	-3.2717	-1.7837	-13.9347**
12	ICS.A-20 × ICS.R-93004	-1.6190*	13.0470**	-0.0337	3.4249*	0.4770	17.1239**	8.1409**	2.5071	19.3213**
13	ICS.A-20 × ICS.R-110	0.8184	-1.8675	-0.0506**	0.0875	0.2874	-2.4697	-2.2667	-1.5474	-3.9007
14	ICS.A-20 × ICS.R-120	-1.3273*	-5.0468**	0.0008	0.2270	-0.1458	10.5510	1.712	0.2225	8.3448
15	ATX.629 × R-628	2.4761**	6.7440**	-0.0673**	0.8910	0.0220	8.5994	-5.1414*	-1.5648	-1.1699
16	ATX.629 × M.R-36565	-3.6696**	-3.2851*	0.0433**	-0.2110	-0.1883	-6.6016	-5.4198*	0.2664	-10.3749*
17	ATX.629 × ICS.R-93001	0.6011	-4.5955**	0.0102	-0.6985	0.2782	-7.2516	-1.0348	-0.2654	-5.2001
18	ATX.629 × ICS.R-92003	-1.5654*	9.4232**	0.0419**	0.5431	-0.3425	7.7546	-0.3394	0.4522	5.6898
19	ATX.629 × ICS.R-93004	-0.3571	0.6065	-0.0245	-2.4964**	0.4199	5.1775	7.7482**	2.9930	10.3325*
20	ATX.629 × ICS.R-110	3.0803**	8.6253**	-0.0207	1.1327	-0.2696	-9.2662	1.3350	-1.5898	-3.2845
21	ATX.629 × ICS.R-120	-0.5654	-17.5184**	0.0171	0.8389	0.0803	1.5879	2.8516	-0.2915	4.0077
22	ICS.A-89002 × R-628	1.4761*	1.3845	0.0207	-0.0636	0.3148	5.5351	1.7918	-0.3722	6.5223
23	ICS.A-89002 × M.R-36565	1.4970*	-2.7446*	-0.0339*	-0.4657	0.0211	-16.1825**	-5.3514*	-0.3709	-14.9559**
24	ICS.A-89002× ICS.R-93001	-2.8988**	2.4116	-0.0110	0.5133	-0.1955	-15.5326**	-0.8814	0.0654	-11.0294*
25	ICS.A-89002 × ICS.R-92003	-2.5654**	-9.5362**	0.0214	0.8717	0.0669	-2.2763	-0.7377	-0.4268	-1.5444
26	ICS.A-89002 × ICS.R-93004	1.3095	4.4470**	0.0495**	-1.1345	0.2794	18.1632**	4.9749	0.3206	15.2149**
27	ICS.A-89002 × ICS.R-110	0.0803	6.0158*	-0.0181	0.2446	-0.6101	5.6028	-2.6077	1.2860	-0.2671
28	ICS.A-89002 × ICS.R-120	1.1011	-1.9779	-0.0285*	0.0342	0.1232	4.6903	2.8116	-0.5022	6.0601
29	ICS.A-504 × R-628	0.2142	3.2917*	0.0501**	1.1815	0.4815	2.9303	-2.5410	-0.8607	-0.8404

Table (6): Cont.

No.	Pedigree	Days to 50% flowering	Plant height (cm)	Leaf area (m^2)	Panicle length (cm)	Panicle width (cm)	Panicle weight (g)	Threshing percentage	1000-grain weight (g)	Grain yield/plant (g)
30	ICS.A-504 × M.R-36565	1.0684	4.4958**	-0.0172	-0.3872	-0.3788	-8.9706	4.0156	0.8861	-0.7321
31	ICS.A-504 × ICS.R-93001	-1.6607*	3.1521*	-0.003	-0.0080	-0.1955	1.8959	-2.8943	-0.0273	-1.3589
32	ICS.A-504 × ICS.R-92003	1.6726*	-3.2624*	0.0229	0.6503	0.0696	-3.8477	-1.1406	0.1336	-3.4573
33	ICS.A-504 × ICS.R-93004	1.0476	-2.7124*	0.0283*	0.4440	0.7961*	14.6751**	3.5337	-0.0205	11.6487*
34	ICS.A-504 × ICS.R-110	-2.5148**	-3.1603*	-0.0631**	-1.3101*	-0.8768*	-6.8352	-4.1522	0.2232	-8.8233
35	ICS.A-504 × ICS.R-120	0.1726	-1.8040	-0.0179	-0.5705	0.1565	0.1522	3.1787	-0.3334	3.5639
36	ICS.A-516 × R-628	-1.2142	3.4535**	-0.0637**	0.1601	-0.2041	-7.5958	5.8289*	-2.4608	1.9983
37	ICS.A-516× M.R-36565	1.4732*	-7.9755**	-0.0512**	-0.0586	0.1187	-5.6968	1.9389	-2.0095	-1.7566
38	ICS.A-516 × ICS.R-93001	-0.9226	0.6140	0.0119	0.9538	0.0520	7.5031	1.1956	0.9969	6.2014
39	ICS.A-516 × ICS.R-92003	1.9107**	3.0994*	-0.0019	-0.0711	0.2979	5.8427	1.2727	2.2079	5.0631
40	ICS.A-516 × ICS.R-93004	-0.3809	-12.4839**	0.0061	-0.9940	-0.7562*	-20.5510**	-7.1595**	0.7421	-19.0725**
41	ICS.A-516 × ICS.R-110	-1.4430*	-8.3651**	0.0096	0.5684	0.6541	-6.6781	-0.7006	-0.4958	-4.6462
42	ICS.A-516 × ICS.R-120	0.5773	21.6537**	0.0892**	-0.5586	-0.1625	27.1760**	-2.3762	1.0191	12.2127*
43	ICS.A-608 × R-628	0.0238	7.6393**	0.0715**	-0.5827	0.3101	-2.2839	3.2311	2.7391	1.7131
44	ICS.A-608 × M.R-36565	-3.122**	4.9434**	-0.0092	0.8818	0.6163	21.7150**	6.1694*	0.0204	20.7531**
45	ICS.A-608 × ICS.R-93001	0.3154	-7.1002**	-0.0013	0.1943	-0.0836	9.1150	4.1894	0.1203	9.3179
46	ICS.A-608 × ICS.R-92003	1.3154*	-11.0481**	-0.0345*	-0.5306	-0.3711	7.7379	2.9432	-0.5133	6.8445
47	ICS.A-608 × ICS.R-93004	-0.8095	2.6351*	0.0129	0.8797	-0.3086	-10.7724	-8.5740**	-3.9185*	-14.501**
48	ICS.A-608 × ICS.R-110	0.4613	7.3872**	0.0018	-0.6744	0.1351	-5.2162	0.5848	1.5558	-3.3014
49	ICS.A-608 × ICS.R-120	1.8154**	-4.4565**	-0.0413**	-0.1681	-0.2982	-20.2953**	-8.544**	-0.0058	-20.8258**
50	ICS.A-610× R-628	-1.6190*	0.3964	0.0318*	-0.4613	-0.1517	-11.2601*	1.8904	3.3451*	-5.0088
51	ICS.A-610× M.R-36565	1.0684	4.9006**	-0.0538**	0.7199	0.0211	4.6888	3.7337	0.3197	6.1962
52	ICS.A-610× ICS.R-93001	0.6726	-0.9764	-0.0193	0.1991	0.0871	10.3388	1.1154	-1.1471	6.8993
53	ICS.A-610× ICS.R-92003	-0.8273	0.1422	-0.0603**	-0.4258	0.0003	7.8450	1.9475	-0.3111	6.1976
54	ICS.A-610× ICS.R-93004	-0.4523	3.1922*	-0.0152	-0.2321	-0.6705*	-10.6319	-5.2048*	-3.2502*	-11.2546*
55	ICS.A-610× ICS.R-110	-0.0148	2.5776	0.0895**	0.1803	0.7565*	18.0909**	2.5724	0.5134	14.3149**
56	ICS.A-610× ICS.R-120	1.1726	-10.2327**	0.0273*	0.0199	-0.0434	-19.0715**	-6.0547*	0.5301	-17.3444**
	S.E.sij	0.661	1.336	0.0137	0.612	0.347	5.623	2.585	1.539	4.957

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

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قوة الهجين و تحليل السلالة فى الكشاف للقدرة على الائتلاف فى ذرة الحبوب الرفيعة [*Sorghum bicolor* (L.) Moench]

عاطف أبو الوفا ، طلعت عبد الفتاح أحمد ، السيد عبدالسلام حسب الله ، محمد عبد العزيز سيد

قسم المحاصيل – كلية الزراعة – جامعة أسيوط

تم اجراء ٥٦ هجين قمى فى ذرة الحبوب الرفيعة من خلال تهجين ثمانية سلالات مستوردة عقيمة زكريا سيتوبلازميا مع سبعة سلالات معيدة للخصوبة بنظام تزاوج السلالة بالكشاف . تم تقييم هذه الهجن وآبائها بالاضافة إلى صنفين قياسيين فى منطقتين هما أسيوط وسوهاج فى موسم ٢٠٠٢ . تم استخدام تصميم القطاعات كاملة العشوائية فى ثلاث مكررات فى كل منطقة .

أظهرت النتائج وجود اختلافات عالية المعنوية لصفات عدد الأيام حتى ٥٠% تزهير ، طول النبات ، المساحة الورقية ، طول وعرض ووزن القنديل ونسبة التفريط ومحصول النبات الفردى من الحبوب ووزن ١٠٠٠ حبة بين الاباء والسلالات الأبوية والأمية والهجن .

أظهرت النتائج وجود تفاعل معنوى بين المناطق وكل من التراكيب الوراثية والهجن والاباء والسلالات الأبوية والأمية لكل الصفات المدروسة عدا المساحة الورقية . وكان التفاعل معنوى بين السلالات الذكرية والأمهات والمناطق لجميع الصفات المدروسة عدا المساحة الورقية ووزن القنديل . كما كان التفاعل معنوياً بين الأمهات والمناطق لجميع الصفات عدا المساحة الورقية وطول القنديل .

القيم العالية للتباين بالنسبة للاباء الذكرية عن تفاعل الاباء الذكرية مع الامهات يوضح التأثير العالى لهذه الاباء على أداء الهجن فى جميع الصفات تحت الدراسة . وقد أظهرت ثلاثة عشر هجين من بين ٥٦ هجين تفوقاً معنوياً على الصنف القياسى دورادو فى صفات عدد الأيام حتى ٥٠% تزهير وطول النبات وطول ووزن القنديل ومحصول النبات الفردى .

تراوحت قيم قوة الهجين بالنسبة لأفضل الاباء من -١٢,٣٧% للتبكير إلى ١٠٦,٨٢% لمحصول النبات الفردى .

أعطت السلالات الأمية ICS.A-89002 و ICS.A-20 تأثير معنويا للقدرة العامة للائتلاف سالبا وموجبا لكل من عدد الأيام حتى ٥٠% تزهير ومحصول النبات الفردى على الترتيب . تدل هذه النتائج على أن هذه السلالات لها فعل جينى مرغوب ويمكن اعتبارها آباء جيدة لكلا الصفتين . كما أن هناك ثلاثة عشر هجين أظهرت تأثيراً معنوياً سالباً للقدرة الخاصة على الائتلاف لصفة عدد الأيام حتى ٥٠% تزهير وهذه الهجن تفيد جيداً للتبكير . كما أن هناك ثمانية هجن (٦ ، ١٢ ، ١٩ ، ٢٦ ، ٣٣ ، ٤٢ ، ٤٤ ، ٥٥) أظهرت تأثير موجباً معنوياً للقدرة الائتلافية الخاصة لصفة محصول النبات الفردى .

الهجينان رقم ١٢ و ٤٤ من بين هذه الهجن أظهرا تأثيرا معنويا سالبا للتبكير ولذا يمكن اعتبارهما هجينين مرغوبين للمحصول والتبكير.