USING EGYPTIAN RESTORER LINES IN GRAIN SORGHUM HYBRIDS PRODUCTION (*Sorghum bicolor* L. MOENCH)

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ABSTRACT

Three advanced generation genotypes released from the Egyptian Sorghum Breeding Program were used for crossing with seven cytoplasmic male sterile lines I n order to involve the adapted restorer gene in our released grain sorghum hybrids. The twenty-one crosses and their parents were evaluated in a randomized complete block design at two locations, Shandwell Agric. Res. Farm and Assiut Agric. Res. Farm, in 2002 season. The genetic parameters were estimated by using line x tester analysis.

The obtained data at the both locations revealed that crosses had highly significant differences among all studied traits. All the crosses were earlier at Assiut than at Shandwell. For grain yield at Shandwell, eight crosses had higher grain yield than the check (Shandweel-6) one of them (ICSA-89003 x Ad.1) (120.69 g/plant) was significantly higher than the check (95.13 g/plant) while, non of the crosses yielded more than the check at Assiut, that may be due to Assiut farm is coarse 'sandy soil and that is clear in the heterosis which was high at Assiut compare with the heterosis at Shandwell and that due to the lines were unable to yield under the harsh environments at Assiut as crosses did. For general combining ability (GCA) of grain yield, the restorer line Ad.1 had positive and highly significant GCA effect at Shandwell (loamy-soil), while, Ad.2 had the same trend at Assiut that means the genotype Ad.2 more adapted for the coarse sandy soil. For specific combining ability (SCA) of grain yield at Shandwell, ten crosses had positive and significantly, SCA affect while, at Assiut, seven crosses had positive and significantly SCA effect. The cross (ICSA-89003 x Ad.1) at Shandwell, which was yielded significantly more than the check, can be tested in a large SCAle before using it as a commercial hybrid in clay and loamy soil.

INTRODUCTION

Development of hybrids in Egypt still depends on exotic cytoplasmic male sterile and restorer lines. In this study, attempts were made, for first time, to use an Egyptian restorer lines to study the magnitude of heterosis, the general and specific combining ability in relation to line x tester analysis in grain sorghum genotypes. Badhe and Patil (1997) used line x tester analysis of four male sterile and eight pollinator lines. They reported that additive gene action was observed for plant height, and non-additive gene action was predominant for grain yield and other traits. They added that Specific combining ability variance was largely present for grain yield. The female parent ms-2077A and male parent SPV-386 were the best combiners for almost all studied traits, except plant height and 1000-grain weight.Changang *et al.* (1998) reported that combining ability variance was significant for plant height, panicle length, days to 50% flowering; panicle weight, grain weight per panicle, number of grains per panicle and 1000-grain weight, and additive effects were prominent in inheritance. General combining ability (GCA) effects were significantly higher in A2F4A than in the other four male sterile

lines for all eight characters studied. Among the nine R lines, R8643 had the highest general combining ability for plant height, panicle weight, grain weight per panicle and days to 50% flowering. El-Bakry (1998) reported that crosses were superior to their better parents for all traits, panicle length, panicle width, 1000 grain weight, no. of grains per panicle, grain yield per plant, plant height, leaf area index, days to 50% heading and number of green leaves plant at harvest time under all soil moisture regimes. Haussmann *et al.* (1998) reported that mean hybrid superiority over mid parents values was 54% for grain yield and 35% for above ground biomass. The highest values were found for number of seeds per head and 1000-grain weight. The average relative hybrid superiority over the better parent for grain yield was 32%. Salunke and Deore (1998) concluded that hybrids (36642A x SPV 489, 36641A x RS67 and 42A x RS67) exhibited higher heterosis for physiological traits, which was reflected in heterosis for grain yield. Haussmann *et al.* (1999) revealed that the relative hybrid mean superiority over the mid parent values was highest for grain yield followed by plant height. Hybrid vigor was expressed in earlier anthesis Heterosis for number of grains/panicle and 1000-grain weight contributed most to heterosis for grain yield. Shakoor and qureshi (1999) reported that additive genetic effects were important for grain yield/plant, panicle length, number of grains/panicle and1000-grain weight. In addition, dominance effects were important for grain yield/plant and 1000-grain weight. Epistasis was not important for the desired traits. Hovny (2000) studied combining ability and heterosis in F_1 grain sorghum hybrids derived from four introduced cytoplasmic male sterile lines (CMS) and ten restorer lines. They indicated that crosses had highly significant differences for all studied traits at two successive growing seasons and combined over two seasons. Also the restorer lines R22808-3XS$_3$ PL-1, R-22808-3 and PLI-42 were good combiners for earliness while, the restorer line ICSR-112 was good combiner for grain yield/plant with all studied female lines Heterosis for grain yield/plant was 103.09% for cross (ICSA-1xICSR-112). Combining ability (general and specific combining ability) were detected for grain yield and other related component traits in some crosses. Cross (ICSA-1 x ICSR 112) gave high grain yield/plant and high specific combining ability and out-yielded the check hybrid Shandaweel-2. Hovny *et al.* (2000) studied heterosis and combining ability in 60 top cross grain sorghum hybrids derived from thirty exotic cytoplasmic male sterility lines (cms) with two restorer lines. They revealed that twenty hybrids involving NES-1007 gave significantly higher yield than the restorer lines NES-1007 and the check variety Dorado. Also, most of the hybrids involving the restorer line local-129 had significantly higher yield than the check variety Giza-15. The additive genetic variance was important for all studied traits except for yield were the non-additive variance played the major role for the inheritance of this trait. Some of cytoplasmic male sterility lines (cms) had significant and positive general combining ability effects for grain yield and one or more other traits. Also, some lines gave good combinations when crosses with the restorer line NES-1007 and some other lines were good combiners with local 129. Hovny *et al.* (2001) evaluated thirty grain sorghum hybrids [derived from three introduced cytoplasmic male sterile (cms) and ten restorer lines]. They reported that the

genotypes showed highly significant differences for all studied traits. Also, the female line ATX-629 gave the earliest cross and ICSA-1 gave the latest ones, when they were crossed with the same restorer line Dorado-V -9.ICSA -40 and the restorer lines ICSA -138, followed by ICSR-93002,Dorado-V-9 and ICSR-89037 had a positive highly significant specific combining ability for grain yield. Crosses, (ICSA-1 x ICSR-93002) and (ICSA-40 x ICSR-89037) had higher grain yield than the check, Shandaweel-2. Mustafa and EL-Menshawi (2001) estimated combining ability in 12 grain sorghum hybrids (derived from crossing between four restorer lines in a complete diallel cross system). They reported significant general and specific combining ability and reciprocal effects for all the studied traits. The estimate of general and specific combining ability variances indicated that additive gene effect was more important than non-additive effects. Also, the two parents ICSR-89022 and ICSR-89016 are good combiners for grain yield. The best direct cross combinations for grain yield are (M36565 x ICSR-89022), (Dorado x ICSR-89022) and (Dorado x ICSR-89016).

MATERIALS AND METHODS

Three advanced generation genotypes released from the Egyptian sorghum Breeding Program (as 3 R-lines) were used for crossing with seven cytoplasmic male sterile (7 CMS) in order to involve the adapted restorer gene in our released grain sorghum hybrids. The origin and the agronomic characteristics of both the seven CMS and the three advanced generation genotypes (3 R-lines) are presented in Table 1. The twenty one crosses and their parents were evaluated in a randomized complete block design at two locations, Shandwell Agric. Res. Farm and Assiut Agric. Res. Farm, in 2002 season.

Table (1): Origin and agronomic traits of the parental lines and the check at Shandwell in 2001season.

No.	Genotype	Origin	Days to 50% flowering	Plant height (cm.)	Seed index (g)	Grain *Yield/plant* (g)
		I- CMS lines :				
1	ATX-ARG-1	USA	73	121	22	41
2	ATX-2-1	USA	67	108	21	56
3	ATX-407	USA	68	115	26	54
4	ATX-BON-44	USA	71	117	23	38
5	SPDM-94002	USA	79	141	23	36
6	ICSA-88010	India	66	152	28	49
7	ICSA-89003	India	72	127	29	44
		II- Restorer lines:				
1	Ad-1	Egypt	64	244	34	80
2	Ad-2	Egypt	65	200	31	73
3	Ad-3	Egypt	78	139	24	64
		III- Check (Shandaweel-6) :				
1	Sh-6	Egypt	70	180	28	95

The experiment was sown at Shandwell and Assiut locations on June 29 and June 20, respectively. An experiment with three replications and one row plot was used, rows were 4 meters long and 60 cm, apart with 15 cm, between hills. Three weeks after sowing, plants were thinned to two plants / hill after hoeing. All other cultural practices were done as recommended for grain sorghum production and recommended plant protection measures were applied as necessary. The mechanical analysis of the soil was loamy at Shandwell and coarse sandy soil at Assiut. Data were recorded on days to 50% flowering, plant height (cm), 1000-grain weight, grain yield / plant with 14% adjusted grain moisture. Data in each location were subjected to the analysis of variance of randomized complete blocks design (RCBD) according to Steel and Torrie (1980).The genetic analysis was recorded out using line x tester analysis according to Kempthorne (1957). General combining ability (GCA) effects for the female parents (7 CMS), testers (3 R-lines) and specific combining ability (SCA) effects for hybrids were estimated according to Singh and Chaudhry (1977).

RESULTS AND DISCUSSION

1-Mean performance and heterosis:
The analysis of variances for all studied traits showed highly significant differences among genotypes in both locations (Table 2). Also, the data indicated highly significant differences among parents, parents vs. crosses, crosses, their partitions (females, males and females x males), except for few cases.
For days to 50% flowering at Shandwell, results in (Table 3) showed that the 50% flowering for the female parents ranged from 60.0 (ICSA-88010) to 79.3 days (SPDM-94002). At Assiut it ranged from 63.0 (ICSA-88010) to 76.3 days (SPDM-94002). For the male parents days to 50% flowering at Shandwell was 64.33 (Ad-1), 62.3 (Ad-2) and 75.0 days (Ad-3). At Assiut it was 61.3 (Ad-1), 62.3 (Ad-2) and 75.0 days (Ad-3). Days to 50% flowering for the crosses ranged from 60.0 (ICSA-89003 x Ad-1), (ICSA-880100 x Ad-1) and (ATX-BON-44 x Ad-1) to 74.6 days (ATX-BON-44 x Ad-3). At Assiut, it ranged from 57.3 (ICSA-88010 x Ad-1) to 71.3 days (ATX-BON-44 x Ad-3). Also, from (Table 3) it can be concluded that at Shandwell 13 crosses from 21 crosses were significantly earlier than the check (Sh-6). AT Assiut, 19 crosses from 21 crosses were significantly earlier than the check (Sh-6). The heterosis of days to 50% flowering (Table 4) showed that at Shandwell 6 crosses out of 21 had significantly negative heterosis, while 3 crosses had significantly positive heterosis, at Assiut 7 crosses out of 21 had significantly negative heterosis, while 3 crosses had significantly positive heterosis. Negative heterosis means that crosses were earlier than the early parent and positive heterosis means that crosses were late than the early parent.
For plant height at Shandwell data (Table 3) showed that the plant height for the female parents ranged from 108.33 (ATX-2-1) to 151.67 cm, (ICSA-88010). While, at Assiut it ranged from 81.67 (ATX-ARG-1) to 120.00 cm, (ICSA-89003).

Table 2. Analysis of variance of all genotypes without check for the studied traits at two locations in 2002 season.

Source of Variance	d.f	Shadwell				Assiut			
		Days to 50% blooming	Plant height (cm)	Seed index (g)	Grain Yield/plant (g)	Days to 50% blooming	Plant height (cm)	Seed index (g)	Grain Yield/plant (g)
Replicates	2	0.785	1489.33*	14.22	142.36	1.075	18.011	32.984**	16.655
Genotypes	30	83.60**	6653.17**	57.07**	1468.0**	81.372**	2198.154**	48.001**	415.69**
Crosses	20	67.81**	2339.46**	28.22*	598.50**	65.076**	283.611**	22.039**	146.813**
P. Vs.C.	1	421.76**	102217.22**	663.12**	25921.8**	396.004**	32335.73**	55.105**	9214.6**
Parents	9	81.11**	5620.96**	53.84**	683.40**	82.626**	3104.074**	104.903**	35.535**
Female	6	17.04**	1020.03*	30.49	290.53*	16.661**	268.519**	45.252**	149.865**
Male	2	515.87**	18608.78**	77.60**	161.94	492.333**	1192.063**	59.700**	80.786**
Female x male	12	18.52**	287.63	18.86	825.20**	18.074**	139.749*	4.156	156.292**
Error	60	2.86	345.08	14.57	116.53	2.678	60.556	4.545	6.701

Mean squares

*, ** significant at 0.5 and 0.01 probability levels, respectively.

Table (3): Performance of the crosses, their parental lines and check at two locations in 2002 season.

No.	Pedigree	Shadwell				Assiut			
		Days to 50% blooming	Plant Height (cm)	Seed index (g)	Grain Yield (g)	Days to 50% blooming	Plant Height (cm)	Seed index (g)	Grain Yield (g)
1	ATX-ARG1 x Ad.1	65.00	252.33	32.53	83.58	62.00	176.67	30.53	55.33
2	ATX-ARG1 x Ad.2	62.67	195.67	30.00	95.18	60.00	168.33	28.93	53.40
3	ATX-ARG1 x Ad.3	72.00	176.33	27.47	86.30	69.33	161.67	26.00	50.53
4	ATX-2-1 x Ad.1	62.33	232.67	30.67	69.05	60.00	155.00	29.07	51.20
5	ATX-2-1 x Ad.2	62.67	201.67	31.33	98.23	59.67	151.67	25.87	54.13
6	ATX-2-1 x Ad.3	68.33	214.33	29.20	97.45	65.00	151.67	26.40	52.67
7	ATX-407 x Ad.1	63.00	248.33	37.73	76.48	60.67	170.00	34.53	50.67
8	ATX-407 x Ad.2	64.33	221.67	33.07	85.17	61.33	151.67	33.07	64.80
9	ATX-407 x Ad.3	69.67	191.00	35.20	91.09	66.67	163.33	30.27	50.80
10	ATX-BON44 x Ad.1	60.00	241.67	37.33	97.34	57.67	168.33	30.27	36.87
11	ATX-BON44 x Ad.2	70.67	230.00	28.40	72.86	67.67	155.00	28.80	51.20
12	ATX-BON44 x Ad.3	74.67	193.33	29.87	87.38	71.33	173.33	28.27	53.53
13	SPDM-94002 x Ad.1	62.33	258.33	31.87	108.03	59.33	165.00	30.67	69.73
14	SPDM-94002 x Ad.2	62.00	205.00	29.67	66.28	59.00	155.00	27.63	51.53
15	SPDM-94002 x Ad.3	69.67	176.00	30.27	84.61	67.33	161.67	27.33	56.13
16	ICSA-88010 x Ad.1	60.00	246.00	29.73	88.01	57.33	170.00	27.20	53.13
17	ICSA-88010 x Ad.2	65.00	208.33	33.67	77.53	62.00	151.67	23.73	51.93
18	ICSA-88010 x Ad.3	72.00	191.33	31.60	103.15	69.00	148.33	26.93	54.47
19	ICSA-89003 x Ad.1	60.00	256.67	38.13	120.69	57.67	176.67	34.00	61.53
20	ICSA-89003 x Ad.2	62.00	244.00	31.60	109.07	58.67	145.00	29.60	66.60
21	ICSA-89003 x Ad.3	73.00	211.00	28.93	74.33	70.33	151.67	29.20	47.93
1	ATX-ARG1	72.67	121.00	22.40	40.94	70.00	81.67	21.67	30.13
2	ATX-2-1	67.33	108.33	21.47	55.51	64.33	86.67	24.93	29.93
3	ATX-407	67.67	114.67	25.60	53.60	64.33	106.67	24.47	31.87
4	ATX-BON44	71.00	116.67	22.53	37.56	68.00	95.00	21.87	31.00
5	SPDM-94002	79.33	140.67	22.87	35.89	76.33	118.33	21.47	28.20
6	ICSA-88010	66.00	151.67	27.60	49.03	63.00	116.67	25.73	33.27
7	ICSA-89003	71.67	127.33	29.03	44.12	69.00	120.00	30.67	32.40
1	Ad.1	64.33	244.00	34.13	80.10	61.33	175.00	40.60	41.67
2	Ad.2	65.33	200.00	31.07	73.41	62.33	171.67	30.93	37.13
3	Ad.3	78.00	139.00	24.40	64.06	75.00	135.00	29.87	36.47
1	Check Sh-6	69.67	180.00	28.30	95.13	72.00	166.67	25.73	81.67
	LSD.05	2.66	31.05	5.91	16.76	2.58	12.28	2.85	4.51
	LSD.01	3.50	40.70	7.75	21.97	3.38	16.16	3.75	5.92

Table (4): Useful heterosis as a percentage of the best parent for 4 traits of 21 hybrids at two locations in 2002 season.

No.	Pedigree	Shadwell				Assiut			
		Days to 50% blooming	Plant height (cm)	Seed index (g)	Grain Yield (g)	Days to 50% blooming	Plant height (cm)	Seed index (g)	Grain Yield (g)
1	ATX-ARG1 x Ad.1	1.04	3.42	-4.69	4.34	1.09	0.95	-24.79**	43.39**
2	ATX-ARG1 x Ad.2	-4.08	-2.17	-3.43	29.65*	-3.74	-1.94	-6.47	43.84**
3	ATX-ARG1 x Ad.3	-0.92	26.86*	12.57	34.71*	-0.95	19.75**	-12.95*	38.65**
4	ATX-2-1 x Ad.1	-3.11	-4.64	-10.16	-13.81	-2.17	-11.43**	-28.41**	32.76**
5	ATX-2-1 x Ad.2	-4.08	0.83	0.86	33.81**	-4.28*	-11.65**	-16.38**	45.74**
6	ATX-2-1 x Ad.3	1.49	30.22**	19.67	52.13**	1.04	12.35**	-11.61*	44.40**
7	ATX-407 x Ad.1	-2.07	1.78	10.55	-4.52	-1.09	-2.86	-14.94**	31.20**
8	ATX-407 x Ad.2	-1.53	10.83	6.44	16.02	-1.60	-11.65**	6.90	74.53**
9	ATX-407 x Ad.3	2.96	37.41**	37.50**	42.21**	3.63	20.99**	1.34	39.27**
10	ATX-BON44 x Ad.1	-6.74**	-0.96	9.38	21.51	-5.978**	-3.81	-25.45**	-4.46
11	ATX-BON44 x Ad.2	8.16**	15.00*	-8.58	-0.74	8.56**	-9.71**	-6.90	37.74**
12	ATX-BON44 x Ad.3	5.16**	39.09**	22.40	36.41**	4.90*	28.40**	-5.36	46.81**
13	SPDM-94002 x Ad.1	-3.11	5.87	-6.64	34.86**	-3.26	-5.71	-24.47**	80.72**
14	SPDM-94002 x Ad.2	-5.10*	2.50	-4.51	-9.71	-5.35*	-9.71**	-10.67	38.76**
15	SPDM-94002 x Ad.3	-10.68**	25.12**	24.04	32.07*	-10.22**	19.75**	-8.48	54.02**
16	ICSA-88010 x Ad.1	-6.74**	0.82	-12.89	9.88	-6.52**	-2.86	-33.00**	37.66**
17	ICSA-88010 x Ad.2	-0.51	4.17	8.37	5.61	-0.53	-11.65**	-23.28**	39.83**
18	ICSA-88010 x Ad.3	9.09**	26.15**	14.49	61.02**	9.52**	9.88*	-9.82	49.55**
19	ICSA-89003 x Ad.1	-6.74**	5.19	11.72	50.66**	-5.98**	0.95	-16.26**	59.41**
20	ICSA-89003 x Ad.2	-5.10*	22.00**	1.72	48.57**	-5.88**	-15.53**	-4.31	79.31**
21	ICSA-89003 x Ad.3	1.86	51.80**	-0.34	16.04	1.93	12.35**	-4.78	31.57**

*, ** significant at 0.5 and 0.01 probability levels, respectively.

For the male parents the plant height at Shandwell was 139 (Ad.3), 200.00 (Ad.2) and 244.00 cm, (Ad.1).While, at Assiut it was 135.00 (Ad.3), 171.67 (Ad.2) and 175.00 (Ad.1).The plant height of the crosses at Shandwell ranged from 176.00 (SPDM-94002 x Ad.3), to 258.33 cm, (SPDM-94002 x Ad.1) while, at Assiut it ranged from 145.00 (ICSA-89003 x Ad.2) to 176.67 cm (ATX-ARG-1 x Ad.1) and (ICSA-89003 x Ad.1). Also, from Table 3 it can be concluded that at Shandwell 11 crosses from 21 were significantly taller than the check (Sh-6) while, at Assiut non of the crosses were significantly taller than the check (Sh-6). The heterosis of the plant height (Table 4) showed that at Shandwell, 9 crosses out of 21 had significantly positive heterosis, while at Assiut 7 crosses out of 21 had significantly negative heterosis and 7 crosses had significantly positive heterosis. Negative heterosis means at crosses were shorter than the tall parent and positive heterosis means at crosses were taller than the tall parent.

For seed index at Shandwell, data (Table 3) showed that the seed index for the female parents ranged from 21.47 (ATX-2-1) to 29.03 g, (ICSA-89003).While, at Assiut male parents the seed index at Shandwell was 24.40 (Ad.3), 31.07 (Ad.2) and 34.13 g, (Ad.1). While , at Assiut it was 29.87 (Ad.3), 30.93 (Ad.2) and 40.60 g, (ad.1). The crosses at Shandwell ranged from 27.47 (ATX-ARG-1 x Ad.3) to 38.13 g, (ICSA-89003 x Ad.1). While, at Assiut it ranged from 23.73 (ICSA-88010 x Ad.2) to 34.53 g, (ATX-407 x Ad.1). Also, from Table 3 it can be concluded that at Shandwell 4 crosses from 21 had significantly higher seed index than the check (Sh-6) while, at Assiut 12 crosses had significantly higher seed index than the check (Sh-6). The heterosis of the seed index (Table 4) showed that at Shandwell, one cross out of 21 had significantly positive heterosis while, at Assiut non of the crosses had significantly positive heterosis. Positive heterosis means at crosses had higher seed index than the best parent.

For grain yield / plant at Shandwell, data (Table 3) showed that the grain yield / plant for the female parents ranged from 35.89 (SPDM-94002) to 55.51 g, (ATX-2-1). While, at Assiut it ranged from 28.20 (SPDM-94002) to 33.27 g, (ICSA-88010). For the male parents the grain yield / plant at Shandwell was 64.06 (Ad.3), 73.41 (Ad.2) and 80.10 g, (Ad.1). While, at Assiut it was 36.47 (Ad.3), 37.13 (Ad.2) and 41.67 g, (Ad.1). The crosses at Shandwell ranged from 66.28 (SPDM-94002 x Ad.2), 120.69 g, (ICSA-89003 x Ad.1). While, at Assiut it ranged from 36.87 (ATX-BON-44 x Ad.1) to 69.73 g, (SPDM-94002 x Ad.1). Also, from Table 3 it can be concluded that at Shandwell one cross, (ICSA-89003 x Ad.1) 120.69 g, out of 21 crosses had significantly higher grain yield / plant than the check (Sh-6) while, at Assiut non of the crosses had significantly higher grain yield / plant than the check (Sh-6). The heterosis of grain yield / plant at Shandwell showed that 11 crosses out of 21 had significantly positive heterosis, while, at Assiut 20 crosses had significantly positive heterosis. Positive heterosis means at crosses had high weight of grain yield / plant than the best parent. Similar results were obtained by Radwan et al. (1997), Badhe and patil (1997), El-Bakry (1998), Haussmann et al. (1998), Salunke and Deore (1998), Haussmann et al. (1999), Shakoor and Qureshi (1999), Hovny et al. (2001) and Mustafa and El-Menshawi (2001). They concluded that most of the

crosses were earlier, taller had heavy seed index and higher grain yield / plant compared with the check. Most of their studied crosses had positive and significant heterosis for many of the studied traits compared with the best parent.

2- Combining ability:
a- General combining ability:

Data of general combining ability (GCA) (Table 5), revealed that for days to 50% flowering the GCA effect at Shandwell was positive and highly significant for the female line ATX-BON-44 and two lines of them had negative and significant GCA effect (ATX-2-1 and SPDM-94002) while, at Assiut the same female line ATX-BON-44 had positive and highly significant GCA effect and the other one (female line) was negative and significant (ATX-2-1)0. For the male lines, at Shandwell, the GCA effect was positive and highly significant for (Ad.3) and it was negative and highly significant for (Ad.1 and Ad.2), while at Assiut the male lines had the same trend. Negative GCA effect indicates that the lines have genes for earliness and vice versa. So, it can be expected to get early blooming hybrids by combining the male and female lines which have negative GCA effect.

With respect to plant height, the GCA effect at Shandwell was positive and highly significant for the female line ICSA-89003 but it was negative and significant for the female line (ATX-2-1) while, at Assiut the female line ATX-ARG-1 had positive and highly significant GCA effect and it was negative and highly significant for (ATX-2-1). For the male lines at Shandwell, the GCA effect was positive and highly significant for (Ad.1) and it was negative and highly significant for (Ad.3 while, at Assiut the male line (Ad.1) had positive and highly significant GCA effect and negative highly significant for (Ad.2). Negative GCA effect indicates that the lines have genes for dwarf ness and vice versa. So, it can be expected to get dwarf hybrids by combining the male and female lines which have negative GCA effect.

For seed index, the GCA effect at Shandwell was positive and highly significant for the female line ATX-407 while, at Assiut the female lines ATX-407 and ICSA-89003 had positive and highly significant GCA effect. However, two female lines (ATX-2-1 and ICSA-88010) had negative and highly significant GCA effect. For the male lines at Shandwell, the GCA effect was positive and highly significant for (Ad.1). While, at Assiut the same male line (Ad.1) had positive and highly significant GCA effect and it was negatively significant for (Ad.3). Positive GCA effect indicates that the lines have genes for heavier grain weight and vice versa. So, it can be expected to get heavier seed for favorable grain sorghum hybrids by combining the male and female lines which have positive GCA effect.

For grain yield / plant the GCA effect at Shandwell was positive and highly significant for the female line ICSA-89003 while, at Assiut the female lines SPDM-94002 and ICSA-89003 had positive and highly significant gsa effect. However, one female line (ATX-BON-44) had negative and highly significant GCA effect. For the male lines at Shandwell, non of the three male lines had negative or positive GCA effect. While, at Assiut the male line (Ad.2) had positive and highly significant GCA effect and negative highly

significant for (Ad.3). Positive GCA effect indicates that the lines have genes for higher grain yield / plant and vice versa. So, it can be expected to get higher grain yield / plant for favorable grain sorghum hybrids by combining the male and female lines which have positive GCA effect. Similar results were obtained by Radwan *et al.* (1997), Badhe and patil (1997), El-Bakrv (1998), Haussmann *et al.* (1998), Salunke and Deore (1998), Haussmann *et al.* (1999), Shakoor and Qureshi (1999), Hovny *et al.* (2001) and Mostafa and El-Menshawi (2001). They reported that the general combining ability (GCA) effects differed in magnitude among female and male lines with respect to different studied traits.

b- Specific Combining Ability (SCA):

Data Specific combining ability (SCA) (Table 6) revealed that:-

For days to 50% flowering, the SCA effect at Shandwell was positive significant in 3 crosses out of 21. However, 2 crosses out of 21 had negative and significant SCA effect.. While, at Assiut 4 crosses had positive and significant SCA effect and 3 crosses had negative and significant SCA effect. Negative SCA effect indicates that the crosses were earliness and vice versa. For plant height SCA at Shandwell no of the crosses had positive or negative significant effect. However, at Assiut, 2 crosses out of 21 had positive and significant SCA effect. Positive SCA effect indicates that the crosses tall plants and vice versa.

For seed index SCA at both locations, no of the crosses had positive or negative significant effect.

For grain yield / plant, SCA effect was positive and significant in 5 crosses out of 21. However, 2 crosses out of 21 had negative and significant SCA effect. While, at Assiut 6 crosses had positive and significant SCA effect and 5 crosses had negative and significant SCA effect. Positive SCA effect indicates that the crosses had high grain yield / plant and vice versa. These results are in harmony with those obtained by Radwan *et al.* (1997), Badhe and patil (1997), El-Bakry (1998), Haussmann *et al.* (1998), Salunke and Deore (1998), Haussmann *et al.* (1999), Shakoor and Qureshi (1999), Hovny *et al.* (2001) and Mustafa and El-Menshawi (2001). They concluded that SCA effects differed in magnitude among grain sorghum genotypes (male and female lines).

In general, crosses had highly significant differences among all studied traits. All the crosses were earlier at Assiut than at Shandwell., For grain yield at Shandwell eight crosses had higher grain yield than the check (.Shandaweel-6) one of them (ICSA-89003 x Ad-1) (120.69 g / plant) was significantly higher than the check (95.13 g / plant) while, the no of the crosses yielded more than the check at Assiut. This may be attributed to the coarse sandy soil of Assiut farm. It is clear that heterosis was higher at Assiut compared with the heterosis at Shandwell. It is possible that lines were unable to yield under the harsh environment of Assiut as crosses did. For general ability (GCA) of grain yield, the restorer line Ad-1 had positive but insignificant GCA effect at Shandwell (loamy soil) while, Ad-2 had positive and highly significant GCA effect at Assiut ,which means that the genotypes Ad-2may be more adapted for the coarse sandy soil.

Table (5): Estimates of general combining ability effects for four traits of seven CMS and three restorer lines at two locations in 2002 season.

No.	Parents	Shadwell				Assiut			
		Days to 50% blooming	Plant height (cm)	Seed index (g)	Grain Yield (g)	Days to 50% blooming	Plant height (cm)	Seed index (g)	Grain Yield (g)
	Female lines								
1	ATX-ARG1	0.778	-9.143	-1.822	-0.783	0.825	8.333**	-0.478	-1.097
2	ATX-2-1	-1.333*	-12.143*	-1.422	-0.892	-1.397*	-7.778**	-1.856**	-1.531
3	ATX-407	-0.111	3.079	3.511**	-4.883	-0.063	1.111	3.656**	1.209
4	ATX-BON44	2.667**	4.413	0.044	-3.273	2.603**	5.000	0.144	-7.016**
5	SPDM-94002A	-1.111*	-4.144	-1.222	-2.829	-1.063	0.000	-0.422	4.945**
6	ICSA-88010	-0.111	-2.032	-0.156	0.431	-0.175	-3.889	-3.011**	-1.005
7	ICSA-89003	-0.778	19.968**	1.067	12.228**	-0.730	-2.778	1.967**	4.495**
	Restorer lines								
1	Ad. 1	-3.968**	30.746**	2.178**	2.749	-3.714**	8.254**	1.929**	-0.139
2	Ad.2	-1.587**	-2.063	-0.717	-2.804	-1.762**	-6.508**	-0.733	2.027**
3	Ad.3	5.556**	-28.683**	-1.460	0.056	5.476**	-1.746	-1.195*	-1.888**

*,** significant at 0.5 and 0.01 probability levels, respectively.

Table(6): Estimates the specific combining ability effects of the crosses for four studied traits at two locations in 2002 season.

No.	Pedigree	Shadwell				Assiut			
		Days to 50% blooming	Plant height (cm)	Seed index (g)	Grain Yield (g)	Days to 50% blooming	Plant height (cm)	Seed index (g)	Grain Yield (g)
1	ATX-ARG1 x Ad.1	2.410*	13.480	0.360	-7.520	1.940*	-0.480	0.120	2.370
2	ATX-ARG1 x Ad.2	-2.300*	-10.380	0.720	9.630	-2.020*	5.950	1.180	-1.710
3	ATX-ARG1 x Ad.3	-0.110	-3.100	-1.070	-2.110	0.080	-5.480	-1.290	-0.660
4	ATX-2-1 x Ad.1	1.860	-3.190	-1.910	21.940**	2.160*	-6.030	0.030	-1.300
5	ATX-2-1 x Ad.2	-0.190	-1.380	1650	12.790*	-0.130	5.400	-0.510	-0.570
6	ATX-2-1 x Ad.3	-1.670	4.570	0.260	9.150	-2.030*	0.630	0.480	1.870
7	ATX-407 x Ad.1	1.300	-2.750	0.220	-10.520	1.490	0.080	-0.020	-4.640**
8	ATX-407 x Ad.2	0.250	3.400	-1.550	3.720	0.210	-3.490	1.180	7.390**
9	ATX-407 x Ad.3	-1.560	-0.650	1.330	6.800	-1.700	3.410	-1.160	-2.740
10	ATX-BON44 x Ad.1	-4.476**	-10.746	3.289	8.729	-4.175**	-5.476	-0.773	-10.180**
11	ATX-BON44 x Ad.2	3.810**	10.397	-2.749	-10.195	3.873**	-4.048	0.422	1.943
12	ATX-BON44 x Ad.3	0.667	0.349	-0.540	1.466	0.302	9.524*	0.351	8.236**
13	SPDM-94002 x Ad.1	1.630	14.480	-0.910	18.970**	1.160	-3.810	0.190	10.730**
14	SPDM-94002 x Ad.2	-1.080	-6.050	-0.220	-17.220**	-1.130	0.950	-0.180	-9.640**
15	SPDM-94002 x Ad.3	-0.560	-8.430	1.130	-1.750	-0.030	2.860	-0.020	-1.100
16	ICSA-88010 x Ad.1	-1.708	0.030	-4.110	-4.300	-1.730	5.080	-0.680	0.070
17	ICSA-88010 x Ad.2	0.920	-4.830	2.720	-9.230	0.980	1.510	-1.490	-3.290*
18	ICSA-88010 x Ad.3	0.780	4.790	1.390	13.530*	0.750	-6.590	2.170	3.220*
19	ICSA-89003 x Ad.1	-1.030	-11.300	3.070	16.580**	-0.840	10.630*	1.140	2.960*
20	ICSA-89003 x Ad.2	-1.410	8.840	-0.570	10.510	-1.790	-6.270	-0.600	5.880**
21	ICSA-89003 x Ad.3	2.440*	2.460	-2.500	-27.080**	2.630**	-4.370	-0.540	-8.830**

*, **, signi:ficant at 0.5 and 0.01 probability levels, respectively.

For specific combining ability (SCA) of grain yield at Shandwell, five crosses had positive and significant SCA effect while, at Assiut six crosses had positive and significant SCA effect. The cross (ICSA-89003 x Ad-1) at Shandwell, which yielded significantly more than the check . can be tested on large SCAle before being used as commercial hybrid in clay and loamy soils.

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استخدام سلالات مصرية معيدة للخصوبة في إنتاج هجن ذرة الحبوب الرفيعة

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تم استخدام ٣ سلالات كسلالات معيدة للخصوبة وذلك من الأجيال المتقدمة التي أنتجت من برنامج بحوث الذرة الرفيعة فى التهجين مع ٧ سلالات عقيمة عقم ذكري سيتوبلازمي بغرض إدخال الجينات الموجودة في التراكيب الوراثية المتأقلمة في مصر في الهجن المنتجة محليا. تم تقييم الـ٢١ هجين والآباء الداخلة فيها في تجربة مصممة فى صورة قطاعات كاملة العشوائية وذلك في موقعين أحدهما بمزرعة محطة بحوث جزيرة شندويل والأخر بمزرعة محطة بحوث أسيوط وذلك في سنة ٢٠٠٢.

وتم تحليل النتائج للحصول علي القياسات الوراثية باستخدام نظام تحليل السلالة X الكشاف.

والنتائج المتحصل عليها في كل من الموقعين توضح أن الهجن تختلف اختلافا معنويا في كل من الصفات تحت الدراسة. وكانت كل الهجن أكثر تبكيرا في أسيوط عنها في شندويل أما بالنسبة لصفة محصول النبات في شندويل فان ٨ هجن أعطت محصولا أعلى من هجين المقارنة شندويل- ٦ وواحد فقط كان أعلى بدرجة معنوية من هجين المقارنة والهجين هو -ICSA (89003 x Ad.1) ومحصوله (١٢٠,٦٩ جم / نبات) مقارنة بشندويل-٦ (٩٥,١٣ جم / نبات) .في حين أنه في أسيوط لم يتفوق أي من الهجن علي هجين المقارنة وذلك ربما يعزي إلـى أن طبيعة التربة الرملية الخشنة فيها وهذا واضح من تفوق درجة التوريث في أسيوط عنهـا فـي شندويل وذلك ربما يعزي هذا الى أن السلالات لم تعطي محصول عالي مقارنة بـالهجن لـنفس الموقع.

بالنسبة للقدرة العامة علي الائتلاف فأن السلالة الأمية(ICSA-89003) أعطت قـدرة معنوية عالية علي الائتلاف في كلا الموقعين فى حين أن السلالة معيدة الخصوبة Ad.1 أعطـت قدرة معنوية عالية علي الائتلاف في شندويل في الوقت الذى تفوقت فيه السلالة Ad.2 و أعطـت قدرة معنوية عالية علي الائتلاف في أسيوط وذلك ربما يعزي أن السلالة Ad.2 ليا القدرة علـي التأقلم في ظروف الأراضي الرملية الخشنة كما هو الحال في أسيوط . أما بالنسبة للقدرة الخاصة علي الائتلاف في أسيوط فان ١٠هجن أعطت قدرة معنوية موجبة في حين ٧ هجن فقط أعطـت قدرة معنوية موجبة في أسيوط بالنسبة لمحصول النبات.

الهجن (ICSA-89003 x Ad.1)- والذي أعطي محصولا أعلي من محصول هجين المقارنـة (شندويل-٦) في مزرعة شندويل(أراضى طميية)- يمكن أن يختبر علي نطاق واسع وذلك قبـل إنتاجه علي نطاق تجاري مع التوصية بزراعته في الأراضي الطينية والطميية .