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HETEROSIS AND COMBINING ABILITY IN LINE × TESTER CROSSES OF GRAIN SORGHUM (*Sorghum bicolor* (L.) Moench)

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ABSTRACT

Six male genetic-cytoplasmic sterile lines (ICSA-14, ICSA-44, ICSA-93, ICSA-155, ICSA-88010and ICSA-ATX2-2) and six testers (ICSR-93002, ICSR-93004, ICSR-91022, ICSR-89025, ICSR-89028 and ICSR-93018) were crossed in line x tester design in 2008 season at Shandweel Agric. Res. Station, Sohag, Egypt to produce 36 hybrid combinations. These hybrids along with their twelve parents were grown in a randomized block design with three replications in 2009 and 2010 seasons. The samples for estimation of four characters (50% flowering, plant height (cm), 1000-grain weight (gm) and grain yield/plant.) were taken. The analysis of variance indicated significant differences for the studied characters in all the genotypes, comparing with local and check hybrid. The obtained data also clearly show that the crosses had highly significant differences among all studies traits at two growing seasons 2009 & 2010 and combined over the two seasons, the cross ICSA-ATX2-2× ICSR93002 was earliest genotype and it has lowest negative heterosis relative to better parent, the combination ICSA-14 × ICSR93004 was the best cross in plant height trait and the cross ICSA-93× ICSR-93018 recorded highest value of heteosis of 1000-grain weight, while the cross ICSA-ATX2-2 × ICSR93004 was the best cross for grain yield/plant.

The parents ICSR-93002, ICSA-93, ICSA-88010 and ICSA-ATX2-2 were good combiners for 50% flowering and the parents ICSR-93002, ICSR-89028, ICSR-93018, ICSA-14 and ICSA-44 were good combiners for plant height and the parents ICSR-93002, ICSR-93004, ICSR-93018 and ICSA-93 were good combiners for 1000-grain weight while the parents ICSR-93004, ICSR-93018, ICSA-155, ICSA-88010 and ICSA-ATX2-2 were good combiners for grain yield/plant.

Some hybrids had positive sca effects for some traits, but ICSA-88010×ICSR-91022 was the only hybrid which had negative highly significant specific combining ability for 50% flowering. For plant height, the crosses ICSA-93×ICSR93002, ICSA-ATX2 -2 × ICSR-89028 and ICSA-88010 × ICSR-91022 had highly positive sca effects, respectively. The crosses ICSA-44×ICSR-89025, ICSA-14×ICSR-89028 and ICSA-ATX2-2×ICSR93004 were observed and had highly positive sca effects for1000-grain weight. For grain yield/plant, The crosses ICSA-88010 × ICSR-89028, ICSA-14 × ICSR-89028 and ICSA-44 × ICSR93002 showed the greatest positive sca effect.

These combinations could be utilized in the hybrids programs of grain sorghum

INTRODUCTION

Sorghum (*Sorghum bicolor.* (L.)Moench) is one of the most crops in the world that ranks fifth in acreage after wheat, rice, maize and barley. Sorghum plays a very important role in providing nutrition to human race along with wheat, rice, maize and barley in many countries of the world. It is one of the most important food and feed crops of Egypt. Thus, improvement of sorghum is much emphasized owing to its importance as food and fodder crop. The demand for fodder sorghum is fast increasing. To meet the demand increase in the production should come from same or even less area in the present situation of shrinking agricultural land. Improvement of the genetic potential of the crop in order to maximize the economic gain per unit of input remains the most possible means of increasing the production. Genetic cytoplasmic male sterility can be used to facilitate cross-pollination. Several studies have been established on grain sorghum and emphasized on gene action, general and specific combining ability, heterosis and their effects to develop new hybrids in grain sorghum. Present study have been established on grain sorghum and emphasized on general and specific combining ability, heterosis and their effects to develop new grain sorghum hybrids. The combining ability analysis gives useful information regarding the selection of parents in terms of the performance of their hybrids. Further, their analysis elucidates the nature and magnitude of various types of gene actions involved in the expression of quantitative traits (Dhillon, 1975). Line x tester mating design is used routinely to generate material for estimation of combining ability effects which provide basic idea about the genetic potential of parents. The objective of this study was to determine the combining ability of 12 parents for grain yield. The study investigated assessing general combining ability of parents and specific combining ability of crosses by following a line x tester mating design.

Rawlings and Thompson (1962). used line x tester analysis to estimate gca and sca of inbred parents and various genetic parameters would provide guide lines to the sorghum breeders to launch effective breeding strategies.

MATERIALS AND METHODS

Thirty six grain sorghum crosses were developed at Shandweel Agric.Res. Station, Sohag, Egypt. These hybrids were made from six introduced genetic-cytoplasmic male sterile lines (A-lines) and male lines as restorer lines (R-line).The origin and agronomic characters of the six A-lines and the six R-lines are shown in Table1. A field experiment was conducted in two successive seasons 2009 and 2010 to evaluate the 36 F_1 crosses, their parents (B-lines & six R-lines) and Shandaweel-6 as a check hybrid. In both seasons the genotypes were cultivated on 15th of May. The trial was laid out in a randomized complete block design with three replications. Each plot consisted of one row with 4 meters long and 60 cm apart. Hills were spaced with 20 cm along the row and two plants/hill. All cultural practices were carried out as recommended. In each season data were recorded on days to 50% flowering, plant height (cm), 1000-grain weight (gm) and grain yield/plant (gm). Data of each season and combined over the two seasons were subjected to regular analysis of variance of randomized complete block design. The analysis of variance by using line × tester analysis according to Kempthorne (1957). General and specific combining ability (gca & sca) effects were estimated according to Singh and Chaudhry (1977).

Heterosis was determined as the percentage of increase or decrease of F_1 mean over the better parent:

$$\text{Heterosis \%} = \frac{\overline{F_1} - \overline{B.P}}{\overline{B.P}} \times 100$$

$$\text{LSD for better-parent heterosis} = t \times \sqrt{\frac{2MSe}{r}}$$

Where: t is the tabular t value at a stated level of probability for the experimental error degree of freedom, MSe is mean squares of the experimental error from the analysis of variance and r is number of replication.

Table 1: Origin and agronomic traits of female and male lines which used in top crosses at Shandweel in 2008 season.

Lines	Origin	Days to 50% flowering	Plant height	1000-grain weight (gm)
Restorer (R)				
ICSR-93002	Indian	72	180	77
ICSR-93004	Indian	75	165	65
ICSR-91022	Indian	76	166	70
ICSR-89025	Indian	78	160	67
ICSR-89028	Indian	74	170	66
ICSR-93018	Indian	74	167	70
Female (A) line				
ICSA-14	Indian	75	145	56
ICSA-44	Indian	74	160	50
ICSA-39	Indian	69	168	53
ICSA-155	Indian	67	100	47
ICSA-88010	Indian	70	115	44
ICSA-ATX2-2	U.S.A	68	122	42

RESULTS AND DISCUSSION

The combined analysis of variance was shown in Table 2.

The combined analysis of variance over the two seasons for all studied traits show highly significant differences between two years. Also, there are significant differences among genotypes for all studied traits. The interaction between genotypes and years was highly significant for all studied characters except days to 50% flowering trait. Moreover, the Table show that highly significant differences were detected for all studied characters among parents, crosses, their partitions (males, females, females×males) and parents vs. crosses traits (except plant height). Also, the interactions between parents and years was significant in only grain yield/plant and the interactions between parents vs. crosses and years was significant in only grain yield/plant, the interactions between crosses and years was highly significant. The interactions between males and years was significant except 50% flowering. Also, the interactions between females and years was significant except 1000-grain weight. Moreover, the interactions among males, females and years was significant except 50% flowering.

Table 2: Combined analysis of variance of the studied genotypes (without check) for four traits over two growing seasons 2009 & 2010

Source of variation	d.f	Days to 50% flowering	Plant height (cm)	1000-grain weight (gm)	Grain yield / plant (gm)
Year (Y)	1	906.67**	847**	21.10*	1009.67**
Rep/Year	4	2.88	5.79	1.75	6.90
Genotypes (G)	47	100.23**	4887.88**	78.28**	1334.27**
Parents (P)	11	78.98**	4113.64**	61.48**	670.47**
Crosses (C)	35	76.50**	1078.08**	73.56**	455.77**
P vs. C	1	1164.36**	146747.51	428.27**	39383.63**
Male (M)	5	71.32**	1225.68**	196.35**	530.56**
Female (F)	5	388.48**	4181.56**	179.97**	1014.15**
F×M	25	15.14**	427.87**	27.72**	329.13**
G×Y	47	4.90	47.4**	3.30**	59.75**
P×Y	11	1.55	21.52	1.49	34.68**
P vs. C×Y	1	0.33	11.09	1.19	87**
C×Y	35	6.09**	56.57**	3.92**	66.85**
M×Y	5	2.07	65.03**	7.35**	32.28*
F×Y	5	18.13**	59.75*	1.54	137.94**
F×M×Y	25	4.49	54.24**	3.72**	59.54**
Error	188	3.68	21.07	1.32	10.46

Table 3 show combined means over two years of the studied characters of the crosses and their parents. Many means of crosses were high in all studied characters comparison with check variety.

Regarding to Days to 50% flowering, the combined data over the two seasons cleared that highly significant for most studied genotypes and the mean range of crosses was from 65.2 to79.2 and for R-Lines was from 72.5 to 79.5 and for A-Line was from 68.5 to 76.5. The data indicated that the earlier genotypes were the crosses ICSA-88010 × ICSR-91022 and ICSA-ATX2-2× ICSR93002 (65.2), equally.

With regard to plant height, the cross ICSA-93×ICSR93002 was the tallest genotype and the tallest R-Line was ICSR-93002 while the tallest A-Line was ICSA-93, the mean of trait ranged from 99.0 to 225.2 cm.

Concerning 1000-grain weight, the means showed that the highest genotypes was the cross ICSA-93× ICSR-93018, quitely. The mean of crosses ranged from 22.8 to 35.53

and ranged for R-Line from 23.98 to 30.4and for A-Line it ranged from 20.5 to 25.52. As for grain yield/ plant, the data appeared that highly significant for most studied genotypes and the mean range of crosses was from 67.4 to 99.33 and for R-Lines was from 61.86 to 71.77 and for A-Line was from 42.46 to 52.62.

The data indicated that the highest genotypes were the cross ICSA-ATX2-2× ICSR93004

All these results agreed with those obtained by Tadasse and Debelo (1995), Khaled (1997), Amir (1999), Pattanashetti *et al.,* (2005) and Prakash *et al* (2010).

Table 3: The combined means over two years of the studied characters of the crosses and their parents.

Number	Genotypes	Days to 50% flowering	Plant height (cm)	1000-grain weight (gm)	Grain yield / plant (gm)
1	ICSA-14 × ICSR93002	71.2**	223.0**	30.22**	91.62**
2	------------ × ICSR93004	73.3**	219.8**	29.70**	85.20**
3	------------ × ICSR-91022	79.2	211.7**	23.92**	77.81**
4	------------ × ICSR-89025	74.2**	206.3**	29.03**	75.00**
5	------------ × ICSR-89028	76.5	226.5**	30.62**	89.75**
6	------------ × ICSR-93018	77.5	222.5**	26.67**	75.68**
7	ICSA-44 × ICSR93002	69.5**	205.5**	27.45**	88.03**
8	------------ × ICSR93004	73.0**	209.7**	24.63**	78.30**
9	------------ × ICSR-91022	72.7**	208.3**	22.80*	73.31**
10	------------ × ICSR-89025	70.7**	206.0**	28.20**	69.36**
11	------------ × ICSR-89028	72.8**	206.3**	23.49**	71.03**
12	------------ × ICSR-93018	73.7**	220.0**	30.52**	93.14**
13	ICSA-93× ICSR93002	65.8**	225.2**	34.99**	70.95**
14	------------ × ICSR93004	67.2**	192.7**	34.63**	79.45**
15	------------ × ICSR-91022	66.5**	203.8**	24.65**	83.66**
16	------------ × ICSR-89025	68.7**	200.2**	30.33**	81.60**
17	------------ × ICSR-89028	68.7**	192.2**	31.71**	67.40**
18	------------ × ICSR-93018	67.7**	220.7**	35.53**	84.68**
19	ICSA-155× ICSR93002	66.2**	206.7**	27.73**	89.49**
20	------------ × ICSR93004	68.3**	205.5**	24.65**	94.10**
21	------------ × ICSR-91022	73.0**	208.8**	24.00**	81.69**
22	------------ × ICSR-89025	67.2**	193.3**	23.73**	81.07**
23	------------ × ICSR-89028	69.3**	203.3**	24.47**	75.72**
24	------------ × ICSR-93018	70.7**	208.5**	29.02**	93.40**
25	ICSA-88010× ICSR93002	65.8**	210.5**	27.28**	79.77**
26	------------ × ICSR93004	68.2**	202.5**	31.27**	84.84**
27	------------ × ICSR-91022	65.2**	209.5**	24.66**	89.35**
28	------------ × ICSR-89025	66.2**	184.0**	24.42**	79.22**
29	------------ × ICSR-89028	68.2**	191.2**	29.22**	97.73**
30	------------ × ICSR-93018	66.2**	197.7**	31.05**	95.58**
31	ICSA-ATX2-2× ICSR93002	65.2**	180.5**	29.29**	83.94**
32	------------ × ICSR93004	68.0**	188.0**	32.10**	99.33**
33	------------ × ICSR-91022	67.2**	171.8**	25.07**	89.70**
34	------------ × ICSR-89025	68.5**	177.5**	25.01**	93.63**
35	------------ × ICSR-89028	71.2**	199.0**	26.97**	85.28**
36	------------ × ICSR-93018	69.0**	199.5**	30.76**	98.36**
	ICSR-93002	72.5**	182.5**	30.40**	70.84**
R-Line	ICSR-93004	76.0*	162.5**	27.99**	62.00**
	ICSR-91022	78.0	167.7**	29.02**	61.86**
	ICSR-89025	79.5	159.5**	28.32**	71.77**
	ICSR-89028	76.8	173.0**	23.98**	63.85**
	ICSR-93018	77.7	169.0**	26.17**	68.51**
	ICSA-14	76.5*	145.7**	25.52**	52.62**
A-Line	ICSA-44	75.7*	161.8**	20.94	48.88*
	ICSA-93	71.3**	164.5**	23.80**	49.08*
	ICSA-155	68.5**	99.0	20.50	49.08*
	ICSA-88010	71.2**	115.3**	23.07**	42.46
	ICSA-ATX2-2	69.7**	120.0**	23.09**	43.98
	Check	72.5**	192.65**	28.15**	83.59**
	L.S.D. 5%	3.06	7.34	1.83	5.18
	L.S.D. 1%	4.02	9.63	2.41	6.78

Heterosis:

Estimates of combined heteosis relative to better parent are given in Table 4.

The usefulness of a particular cross in exploiting heterosis is judged by the sca effect of component lines. According to Sprague and Tatum (1942) the sca is controlled by non-additive gene action. The sca effect is an important criterion for the evaluation of hybrids.

Results revealed significant heterosis effects better parent for all studied characters.

For Days to 50% flowering, the heterosis values ranged from-10.19 to 7.14 percent from better parent and the cross ICSA-ATX2-2× ICSR93002 was earliest genotype and has a lowest negative heterosis value.

Heterosis to higher parent for the plant height ranged from -1.1 to 35.28. Significant positive heterosis higher parent were observed in crosses like ICSA-14 × ICSR93004, ICSA-14 × ICSR-93018 and ICSA-14 × ICSR-89028, respectively, and the cross ICSA-14 × ICSR93004 was the superior.

Concerning 1000-grain weight, heterosis values ranged from-21.42 to 35.76. Best crosses were ICSA-93× ICSR-93018, ICSA-93× ICSR-89028 and ICSA-93×ICSR93004, respectively.

With respect grain yield/plant, most crosses had a highly positive significant heterosis percentages to the better parent, the highest three crosses were ICSA-ATX2-2 × ICSR93004, ICSA-88010 × ICSR-89028 and ICSA-155 × ICSR93004 were the greatest crosses and had a positive and highly significant of heterosis, the heterosis values ranged from -3.35 to 60.22 percent.

Significant sca effects and heterosis over standard check Shandaweel -6 are indicating the importance of non additive gene action which could be exploited for developing hybrids in sorghum.

These results are in harmony with those obtained by Reddy and Joshi (1993), El-Menshawy (1996), Khaled (1997), Amir (1999), Hovny (2000), Pattanashetti *et al.,* (2005), Iyanar and Gopalan (2006) and Prakash *et al* (2010). They mentioned that, the heterosis was useful in grain sorghum crosses for yield and yield components.

General combining ability effects:

General combining ability (gca) effects of the parental lines for studied characters over two seasons are shown in Table 5.

General combining ability is defined as average performance of a line in a series of crosses. According to Sprague and Tatum (1942), general combining ability is due to genes which are largely additive in their effects .

Concerning days to 50% flowering, the gca effects for the R-Line, the ICSR-93002 line has lowest negative gca effects and highly significant.

Also, the lines ICSA-88010, ICSA-93 and ICSA-ATX2-2 for A-Line had negative high significant gca effects, respectively, The negative effect means that the line has favorable gene action for earliness and like these lines will be considered as good combiner for earliness. While the positive effect means that the line has favorable gene action for lateness and like these lines will be considered as a good combiner for lateness.

Table 4: Estimates heterosis relative of the better parent of thirty six crosses over two growing seasons, 2009 and 2010.

Cross no.	Genotypes	Days to 50% flowering	Plant height (cm)	1000-grain weight (gm)	Grain yield / plant (gm)
1	ICSA-14 × ICSR93002	-2.67	22.19**	-0.6	29.34**
2	------------ × ICSR93004	-2.16	35.28**	6.13**	37.42**
3	------------ × ICSR-91022	2.56	26.24**	-17.58**	25.77**
4	------------ × ICSR-89025	-2.14	29.36**	2.53**	4.51
5	------------ × ICSR-89028	1.28	30.92**	19.98**	40.56**
6	------------ × ICSR-93018	2.56	31.66**	1.92*	10.46**
7	ICSA-44 × ICSR93002	-4.44**	12.6**	-9.71**	24.27**
8	------------ × ICSR93004	-2.6	29.03**	-12.01**	26.3**
9	------------ × ICSR-91022	-2.56	24.25**	-21.42**	18.5**
10	------------ × ICSR-89025	-6.41**	27.29**	-0.41	-3.35
11	------------ × ICSR-89028	-3.85*	19.27**	-2.03*	11.24**
12	------------ × ICSR-93018	-2.56	30.18**	16.64**	35.94**
13	ICSA-93× ICSR93002	-7.34**	23.38**	15.09**	0.16
14	------------ × ICSR93004	-5.05**	17.12**	23.73**	28.15**
15	------------ × ICSR-91022	-5.5**	21.57**	-15.06**	35.23**
16	------------ × ICSR-89025	-2.29	21.68**	7.01**	13.7**
17	------------ × ICSR-89028	-2.75	11.08**	32.25**	5.55*
18	------------ × ICSR-93018	-6.42**	30.58**	35.76**	23.59**
19	ICSA-155× ICSR93002	-1.43	13.24**	-8.77**	26.33**
20	------------ × ICSR93004	1.9	26.46**	-11.92**	51.77**
21	------------ × ICSR-91022	7.14**	24.55**	-17.28**	32.05**
22	------------ × ICSR-89025	-1.43	21.21**	-16.19**	12.96**
23	------------ × ICSR-89028	1.43	17.53**	2.04*	18.59**
24	------------ × ICSR-93018	4.29**	23.37**	10.88**	36.32**
25	ICSA-88010× ICSR93002	-7.76**	15.34**	-10.26**	12.61**
26	------------ × ICSR93004	-4.11**	24.62**	11.73**	36.84**
27	------------ × ICSR-91022	-8.22**	24.95**	-15.01**	44.44**
28	------------ × ICSR-89025	-6.85**	15.36**	-13.77**	8.82**
29	------------ × ICSR-89028	-4.11**	10.5*	21.88**	53.05**
30	------------ × ICSR-93018	-6.85**	16.96**	18.67**	39.5**
31	ICSA-ATX2-2× ICSR93002	-10.19**	-1.1	-3.65**	18.49**
32	------------ × ICSR93004	-6.02**	15.69**	14.72**	60.22**
33	------------ × ICSR-91022	-6.94**	2.49	-13.61**	45.00**
34	------------ × ICSR-89025	-5.56**	11.29**	-11.67**	30.46**
35	------------ × ICSR-89028	2.78	15.03**	12.48**	33.56**
36	------------ × ICSR-93018	-1.39	18.05**	17.53**	43.56**
	L.S.D. 5%	3.06	7.34	1.83	5.18
	L.S.D. 1%	4.02	9.63	2.41	6.78

With respect to plant height, the lines ICSR-93018 and ICSR-93002 for R-Line and ICSA-14 and ICSA-44 for A-Line had positive high significant gca effects. These results explain that these lines are good combiners because they had observed tall genes, so that these lines become good combiner for plant height trait.

As for 1000-grain weight, the gca effects for the R-Line, the ICSR-93018, ICSR-93004 and ICSR-93002 lines has highest positive gca effects and highly significant, respectively. Moreover, the line ICSA-93 for A-Line has positive high significant gca effects. these lines are good combiners for this character.

Regarding to grain yield/ plant, the male lines ICSR-93018 and ICSR-93004, and female lines ICSA-ATX2-2, ICSA-88010 and ICSA-155 had positive highly significant gca effects for grain yield/plant, respectively. This result clears that these lines had desirable gene action and can be considered as good combiners for improving this character.

This result coincide with those of Wang et al.(1990), Khaled (1997), Amir (1999), Pattanashetti et al (2005) and Prakash *et al* (2010).

Table 5: General combining ability (gca) effects for studied characters over two seasons.

	Genotypes	Days to 50% flowering	Plant height (cm)	1000-grain weight (gm)	Grain yield / plant (gm)
R-Line	ICSR-93002	-2.52**	4.72**	1.44**	-0.12
	ICSR-93004	-0.13	-0.81	1.45**	2.79**
	ICSR-91022	0.81	-1.51	-3.87**	-1.50*
	ICSR-89025	-0.44	-9.28**	-1.26**	-4.29**
	ICSR-89028	1.31**	-0.76	-0.30	-2.94**
	ICSR-93018	0.98*	7.64**	2.54**	6.05**
A-Line	ICSA-14	5.50**	14.47**	0.31	-1.57*
	ICSA-44	2.25**	5.47**	-1.87**	-5.22**
	ICSA-93	-2.38**	1.94	3.92**	-6.13**
	ICSA-155	-0.69	0.52	-2.45**	1.83*
	ICSA-88010	-3.19**	-4.62**	-0.07	3.48**
	ICSA-ATX2-2	-1.50**	-17.78**	0.15	7.62**
	L.S.D. 5%	0.89	2.12	0.53	1.49
	L.S.D. 1%	1.16	2.78	0.70	1.96

Specific combining ability effects (sca):

Sca effects for the crosses are shown in Table 6.

There is a relationship between sca effects and heterosis. The cross combination which showed significant heterosis for some characters, it was mostly due to high sca effects and as such there was a close correspondence between high heterosis and sca effects. Sca effects represented dominance and epistatic interaction which could be related with heterotic vigor in sorghum.

Specific combining ability is defined as the deviation in the performance of hybrids from the expected productivity based up on the average performance of lines involved in the hybrid combination. Sprague and Tatum (1942) reported that the specific combining ability is due to the genes with dominance or epistatic effect.

The cross of ICSA-88010×ICSR-91022 showed the highest negative sca effect (-2.25) for days to 50% flowering indicating that this cross was earliest than their parents. While the crosses ICSA-14 ×ICSR-91022 and ICSA-155× ICSR-91022 were the latest crosses.

For plant height, the highest negative sca effect was for cross ICSA-93 × ICSR-89028, while the crosses ICSA-93× ICSR93002, ICSA-ATX2-2× ICSR-89028 and ICSA-88010 × ICSR-91022 had highly positive sca effects, respectively.

With respect1000-grain weight, the crosses ICSA-44×ICSR-89025, ICSA-14×ICSR-89028 and ICSA-ATX2-2× ICSR93004 had highly positive sca effects.

The cross ICSA-88010 × ICSR-89028 showed the greatest positive sca effect for grain yield/plant (13.10), followed by ICSA-14 × ICSR-89028 (10.17) and ICSA-44 × ICSR93002 (9.29)

The results were corroborated with the findings of El-Menshawy (1996), Khaled (1997), Amir (1999), Pattanashetti *et al* (2005) and Iyanar and Gopalan (2006).

Table 6: Estimates the specific combining ability effects of thirty six crosses over two growing seasons, 2009 and 2010.

Cross no.	Genotypes	Days to 50% flowering	Plant height (cm)	1000-grain weight (gm)	Grain yield / plant (gm)
1	ICSA-14 × ICSR93002	-1.6	-0.02	0.41	9.23**
2	------------ × ICSR93004	-1.83	2.34	-0.10	-0.09
3	------------ × ICSR-91022	3.05**	-5.13	-0.58	-3.20
4	------------ × ICSR-89025	-0.69	-2.68	1.93**	-3.22
5	------------ × ICSR-89028	-0.11	8.95**	2.57**	10.17**
6	------------ × ICSR-93018	1.22	-3.44	-4.23**	-12.88**
7	ICSA-44 × ICSR93002	-0.03	-8.52**	-0.18	9.29**
8	------------ × ICSR93004	1.07	1.17	-3.00**	-3.34
9	------------ × ICSR-91022	-0.20	0.53	0.49	-4.06*
10	------------ × ICSR-89025	-0.95	5.98*	3.28**	-5.21**
11	------------ × ICSR-89028	-0.53	-2.22	-2.39**	-4.89**
12	------------ × ICSR-93018	0.63	3.06	1.8**	8.22**
13	ICSA-93× ICSR93002	0.94	14.67**	1.57*	-6.89**
14	------------ × ICSR93004	-0.11	-12.3**	1.21**	-1.29
15	------------ × ICSR-91022	-1.73	-0.44	-3.45**	7.19**
16	------------ × ICSR-89025	1.69	3.67	-0.38	7.93**
17	------------ × ICSR-89028	-.06	-12.86**	0.04	-7.62**
18	------------ × ICSR-93018	-0.73	7.27**	1.01	0.67
19	ICSA-155× ICSR93002	-0.42	-2.41	0.69	3.7*
20	------------ × ICSR93004	-0.64	1.95	-2.39**	5.39**
21	------------ × ICSR-91022	3.07**	5.98*	2.27**	-2.72
22	------------ × ICSR-89025	-1.50	-1.74	-0.61	-0.55
23	------------ × ICSR-89028	-1.09	-0.27	-0.83	-7.25**
24	------------ × ICSR-93018	0.58	-3.49	0.87	1.43
25	ICSA-88010× ICSR93002	1.75	6.56*	-2.15**	-7.67**
26	------------ × ICSR93004	1.69	4.08	1.84**	-5.51**
27	------------ × ICSR-91022	-2.25*	11.78**	0.54	3.29
28	------------ × ICSR-89025	0.00	-5.93*	-2.31**	-5.17**
29	------------ × ICSR-89028	0.25	-7.3	1.54*	13.10**
30	------------ × ICSR-93018	-1.42	-9.19**	0.53	1.96
31	ICSA-ATX2-2× ICSR93002	-0.61	-10.27**	-0.35	-7.65**
32	------------ × ICSR93004	-0.17	2.76	2.46**	4.84**
33	------------ × ICSR-91022	-1.94	-12.71**	0.73	-0.51
34	------------ × ICSR-89025	1.46	0.73	-1.93**	6.21**
35	------------ × ICSR-89028	1.55	13.69**	-0.93	-3.5
36	------------ × ICSR-93018	-0.28	5.81*	0.02	0.59
	L.S.D. 5%	2.17	5.19	1.30	3.65
	L.S.D. 1%	2.84	6.81	1.70	4.78

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قوة الهجين والقدرة على الإئتلاف فى الذرة الرفيعة للحبوب بتحليل هجن السلالة فى الكشاف

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تضمنت هذه الدراسة إنتاج ٣٦ هجيناً من الذرة الرفيعة للحبوب وذلك من ستة آباء بها عقم وراثى سيتوبلازمى (أمهات) وستة آباء معيدة للخصوبة (آباء ملقحة) وقد تم التهجين بينهم فى صيف ٢٠٠٨ , وفى موسم ٢٠٠٩ و٢٠١٠ تم تقييم الهجن والآباء بجانب هجين محلى شندويل-٦ للمقارنة وذلك فى تصميم القطاعات الكاملة العشوائية فى ثلاث مكررات بمزرعة محطة البحوث الزراعية بشندويل بمحافظة سوهاج وقد أخذت القياسات على صفات الأيام حتى ٥٠% تزهير وطول النبات ووزن الألف حبة ومحصول النبات الواحد وقد تم تحليل البيانات باستخدام نظام السلالة X الكشاف وكانت النتائج كالآتى:-

أظهر تحليل التباين وجود فروق معنوية بين كل التراكيب الوراثية المستخدمة فى كل الصفات المدروسة كما أن متوسطات كثير من الهجن المدروسة كانت أفضل بدرجة ملحوظة فى كل الصفات بالمقارنة بالهجين المحلى .

أظهر تقدير قوة الهجين وجود معنوية واضحة بين الهجن لكل الصفات المدروسة كنسبة مئوية عن أفضل الأبوين وكانت أفضل قوة هجين سالبة ومنخفضة لصفة الأيام حتى ٥٠% تزهير للتركيب ICSA-ATX2-2× ICSR93002 وكانت أعلى قوة هجين موجبة فى صفة طول النبات للتركيب ICSA-14 × ICSR93004 وكانت أكبر قوة هجين موجبة فى صفة وزن الألف حبة للهجين ICSA-93× ICSR-93018 وقد كان الهجين ICSA-ATX2-2 × ICSR93004 أعلى قوة هجين موجبة فى صفة محصول النبات الواحد.

أظهر تحليل القدرة العامة على الإئتلاف أن الأباء ICSA-88010, ICSA-ATX2-2, ICSA-93, ICSR-93002 كانت عالية التوافق بالنسبة لصفة الأيام حتى ٥٠% تزهير , كما أن الآباء ICSA-44 , ICSA-14, ICSR-93018, ICSR-89028, ICSR-93002 لها قدرة عالية على التوافق فى صفة طول النبات , كذلك فإن السلالات ICSR-93018, ICSR-93004, ICSR-93002, ICSA-93 , بها قدرة عالية على الإئتلاف فيما يتعلق بصفة وزن الألف حبة , كما أن السلالات ICSR-93004, ICSR-93018, ICSA-155, ICSA-88010,ICSA-ATX2-2 تمتلك قوة توافق مرتفعة فى صفة محصول النبات الواحد.

أظهر تحليل القدرة الخاصة على الإئتلاف وجود فروق معنوية واضحة بهذا الخصوص وأن التركيب الوراثى ICSA-88010×ICSR-91022 كان له أقل قدرة خاصة وسالبة مما يعنى التبكير فى التزهير والنضج, كما أن الهجن ICSA-88010×ICSR-91022, ICSA-ATX2-2×ICSR-89028, ICSA-93×ICSR93002

كان لها أعلى قدرة خاصة فى صفة طول النبات على الترتيب , كذلك فإن التوافيق ICSA-44×ICSR-89025, ICSA-14×ICSR-89028,ICSA-ATX2-2×ICSR93004 أظهرت أعلى قدرة خاصة على التوافق بالنسبة لصفة وزن الألف حبة, أيضاً فإن الهجن ICSA-88010×ICSR-89028, ICSA-14 × ICSR-89028,ICSA-44 × ICSR93002 إمتلكت أعلى قدرة خاصة على الإئتلاف فى صفة محصول النبات الواحد وعلى التوالى مما يدعم الحصول على قوة هجين عالية .

وخلصت الدراسة بالإضافة إلى ما سبق أن إستغلال العقم الذكرى فى إنتاج الهجن كان مفيداً جداً فى تحسين محصول السورجم وفى برامج إنتاج الهجن وفى الإنتاج التجارى.

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