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HETEROSIS FOR SEED YIELD AND ITS COMPONENTS IN SUNFLOWER

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ABSTRACT

Twenty four crosses of sunflower were produced by crossing six introduced cytoplasmic male sterile lines (CMS-lines) with four restorer lines (RF-lines) using line x tester mating design at Shandaweel Agric. Res. Station, Sohag, in 2005 season. The twenty four crosses, four restorers, six fertile lines (B-lines) along with two check cultivars (Sakha53 and Giza102) were evaluated at Shandaweel Agric. Res. Station, Sohag, in 2006 and 2007 seasons. The experiment was conducted in a randomized complete block design of three replications in the two seasons. The combined analysis of variance, over the two years, showed highly significant differences between years for all studied traits except stalk diameter and 100-achene weight. Differences among genotypes were highly significant for all studied traits. The interaction among genotypes and years was highly significant for all studied traits. Also, highly significant differences were detected among parents, crosses, their partitions; lines (females), testers (males) and lines x testers and parent vs. crosses for all studied traits. The earliest cross over the two seasons was (L5 x Rf10). The cross (L19 x Rf4) had the broadest head in both seasons and at the combined level over the two years. All crosses showed broader head diameter than the check cultivar Giza102. While, it gave narrower head diameter compared to the check cultivar Sakha53. The heterotic values were estimated as percentages of the better parent for all studied traits. The best five crosses in achene oil percentage, over years, were L1 x Rf1, L21 x Rf10, L19 x Rf5, L7 x Rf4 and L5 x Rf5. A wide range of heterosis and standard heterosis was for achene yield/plot. The five heaviest yielding crosses over the two years were L5 x Rf10, L7 x Rf1, L1 x Rf4, L3 x Rf10 and L5 x Rf4.

Key words: ***Sunflower, Helianthus annus, Crosses, CMS, A&B lines, Heterosis.***

INTRODUCTION

Sunflower is one of the major vegetable oil sources in the world. It is native to North America, and was used by North American Indians before colonization of the New World. It spreads along the trade routes to Italy, Egypt, Afghanistan, India, China and Russia. Later, sunflower was grown primarily as a garden ornament. It was also grown as an ensilage crop in the late 1800s and early 1900s. Selection for high oil in Russia began in 1860 and was largely responsible for increasing oil content from 28% to almost 50%. The high oil lines from Russia were introduced to the U.S. after the World War II, which rekindled interest in the crop. However, it was the discovery of the male sterile and restorer gene system that made hybrids feasible and increased commercial interest in the crop. The cultivated sunflower (*Helianthus annus* L.) is one of the 67 species in the genus *Helianthus*. It is grown in many temperate, semi-dry regions of the world, often in rotation with small grain cereals such as wheat. Jayalakshmi *et al* (2000) recorded that among 20 hybrids tested, only one which exhibited significant heterosis over the best control for plant height., and four hybrids recorded significant heterosis for seed yield. Dagustu and Goksoy (2002) found significant positive heterotic effects for all studied traits. Khan *et al* (2004) reported highly significant genetic differences among some studied inbred lines. Besides, genetic differences among their hybrids were significant for all traits, except for head weight/plant. High levels of heterosis were observed for two hybrids for important agronomic traits, such as head weight/plant, seed weight/head and weight of filled seeds/head. Habibullah *et al* (2006) recorded highly significant differences among genotypes for all the studied plant traits. The highest heterosis and heterobeltiosis for stem girth was exhibited by crosses ORI-3 x RL-77 and ORI-3 x RL-84, respectively, in the positive direction. ORI-3 x RL-84 exhibited maximum increase over mid and better parents for 100-achene weight. The highest positive heterosis and heterobeltiosis for oil content was exhibited by ORI-6 x RL-27 and ORI-47 x RL-69, respectively. Haq *et al.* (2006) found that cross ORI-1 x RL-110 gave maximum heterobeltiosis (284.37%) for seed yield/plant. The cross ORI-43 x RL-10 produced maximum seed yield/plant (56.25g). All single crosses showed significant positive heterobeltiotic effects for plant height. Only six hybrids showed significant positive heterobeltiotic ranging from 14.35 to 52.94%. The objectives of this study were to:

1. Identify the best restorer lines and female sterile lines to obtain high yielding, earlier and shorter crosses with high oil percentage.
2. Estimate the heterosis as the best criterion for producing crosses.

MATERIALS AND METHODS

Developing experimental materials

Six introduced cytoplasmic male sterile (CMS) lines(A-lines) and four fertility restorer lines (Rf-lines) of sunflower, were planted at Shandaweel Agriculture Research Station, Agric. Res. Center in 2005 summer season, for characterization and developing twenty four crosses. The geographical origin and agronomic characteristics of the six male sterile line (CMS) and the four restorer lines (Rf-lines) along with check varieties are presented in Table (1).

The four restorer inbred lines (testers) were crossed with the six CMS lines during the flowering period. The twenty four single crosses were

Table 1. Type, geographical origin and agronomic characteristics of materials used (Shandaweel 2005 season).

No.	A. Male Sterile(A) lines and fertile (B) lines				Agronomic characteristics			
	Lines	Geographical Origin	Lines	Geographical Origin	Days to 50% flowering	Plant height, (cm)	Stalk diameter, (cm)	Head diameter, (cm)
1	**A1**	Romania	B1	Romania	56	140	2.00	16.50
2	**A3**	,,	B3	,,	54	160	2.04	18.00
3	**A5**	,,	B5	,,	52	156	2.03	14.50
4	**A7**	Local	B7	Argentine	55	158	1.81	16.00
5	**A19**	,,	B19	,,	54	145	2.05	17.00
6	**A21**	,,	B21	Russia	57	148	2.08	16.60
No.	**B. Restorer (Rf) lines**							
1	**Rf1**	Local			53	110	1.44	6.70
2	**Rf4**				54	108	1.30	7.50
3	**Rf5**				54	126	1.83	14.00
4	**Rf10**				55	118	1.40	8.50
No	**C. Check cultivars**							
1	**Sakha 53**	A. R. C.			56	177	2.11	19.50
2	**Giza 102**				52	137	1.58	12.50

obtained by bagging the sterile heads before flowering and the pollen grains were collected from each of the four restorer lines. The stigmas of the six male sterile lines (CMS) were pollinated with the collected pollen.

Evaluation of the crosses and their parental lines

The twenty four obtained sunflower crosses, the four testers, the six fertile lines (B-lines) and the two check cultivars (Sakha 53 and Giza 102) were planted at Shandaweel Research Station, Sohage Governorate on 30th July, 2006. Also these genotypes were replanted in the same location on 26th July, 2007. A randomized complete block design (RCBD) with three replications was used in the two seasons. The plot size was 2 rows, 4 meter long and 60 cm apart. Planting was done in hills spaced 20 cm apart. Seedlings were thinned to one plant per hill before the first irrigation (two weeks after planting in both seasons). The cultural practices were followed as the recommendations for oil seed sunflower production. The traits studied in this research could be divided into three groups: earliness, growth traits and yield components.

Earliness traits

1- Days to 50% flowering: number of days from sowing date until 50% of the plants showed their flowering heads.
2- Days to maturity: was measured as number of days from sowing date until the head becomes yellow.

Growth traits

The following traits were taken from a random sample of five guarded plants per plot. These samples were assigned for the following measurements.

1- Plant height (cm): average length in cm from soil level to the tip of the head.
2- Stalk diameter (cm): measured at 30cm above the soil surface with vernier-calipers, at nearest 0.1cm.
3- Head diameter (cm): estimated as an average of maximum width of the head.

Yield and yield components

1- 100-achene weight (g): One hundred seeds were counted and weighed from the bulk of the guarded plants in grams.
2- Achene yield/plant (g): estimated as average of seed weight per head.
3- Achene yield/plot (g): measured from the adjusted seed yield per plot.
4- Achene Oil percentage: determined by soxalet apparatus using petroleum ether (Bp40-60 c°) as solvent according to the official method (O.A.C., 1980).

Statistical analysis

Data on a plot mean basis in each season and combined over the two seasons were subjected to general analysis of variance for the randomized Complete Block Design (RCBD) according to **Gomez and Gomez (1984)**. The line x tester analysis was calculated according to **Kempthorne (1957)**. The sum of squares for the F_1 single crosses was partitioned into components due to testers (males), lines (females) and line x tester interaction. The mean squares of crosses x years interaction was likewise partitioned into interaction components including lines, testers and lines x testers with years.

Heterosis (H)

Heterosis (H) was calculated as the percentage of F_1 deviation from the better parent (B.P.) according to Bhatt (1971):

$$H = \frac{\overline{F1} - \overline{B.P}}{\overline{B.P}} X100$$

The significance of heterosis was estimated using L.S.D test

$$\text{L.S.D of heterosis} = \sqrt{\frac{2Mse}{r}} X\, t\alpha / _{B.P} X100$$

Where,

Mse = mean square for error

Tα = t value according to the degree of freedom for the error.

RESULTS AND DISCUSSION

Mean performance

The combined analysis of variance over the two years, showed highly significant differences between years for all studied traits except stalk diameter and 100-achene weight (Table 2). Differences among genotypes were highly significant for all studied traits. The interaction among genotypes and years was highly significant for all studied traits. Also, highly significant differences were detected among parents, crosses, their partitions; lines (females), testers (males) and lines x testers and parent *vs.* crosses for all studied traits.

For days to 50% flowering (Table 3), the combined data of average days to 50% flowering for male parents ranged from 53.67 (Rf1) to 55.33 (Rf10) with an average of 54.42 days while, for female parents it ranged from 52.67 (L5) to 56.17 (L21) with an average of 55.00 days. Average days to 50% flowering for the crosses ranged from 49.00 (L5 x Rf1) to 54.00 (L3 x Rf5 and L7 x Rf10) with an average of 51.99 days while, the average days to 50% flowering of check cultivars was 56.00 and 52.17 days for Sakha53 and Giza102, respectively. Generally, all crosses were significantly earlier compared to the check cultivar Sakha53 while only three crosses were significantly earlier than Giza102. The earliest cross over the two seasons was L5 x Rf10.

For days to maturity (Table 3), the combined data over two years showed that days to maturity for male parents ranged from 81.83 (Rf5) to 84.17 (Rf4) with an average of 82.92 days, while for female parents ranged from 83.00 (L5) to 86.17 (L1) with an average of 85.08 days. Average days to maturity for the crosses ranged from 78.83 (L5 x Rf10) to 84.33 (L7 x Rf4) with an average of 81.70 days. In general, the cross (L5 x Rf1) was the earliest (79.00days) compared to 87.17 and 82.00 days for the check cultivars.

For plant height the combined mean over the two years for male parents varied from 110.17 (Rf1) to127.50 (Rf5) with an average of 116.29cm, while, for female parents, varied from 140.33 (L1) to 160.33 (L3) with an average of 151.47cm. Plant height for the crosses varied from 158.00 (L21 x Rf4) to 194.67 (L7 x Rf10) with an average of 172.70cm.

Generally, the crosses were affected by their female-line height than the fertile line. All crosses were shorter than the check variety Sakha53. But when compared to the check cultivar Giza102 the crosses were taller than it.

With respect to stalk diameter, the combined data of average stalk diameter for male parents it varied from 1.42 (Rf10) to 1.83 (Rf5) with an average of 1.51cm while for female parents varied from 1.83 (L7) to 2.09 (L21) with an average of 2.02cm. Average stalk diameter for the crosses varied from 1.92 (L1 x Rf5) to 2.39 (L19 x Rf4) with an average of 2.08cm. In general, the cross L19 x Rf4 (2.39cm) followed by the cross L7 x Rf1 (2.15cm) showed the thickest stems.

For head diameter (Table 3) data over the two years showed that average head diameter of the male parents ranged from 6.67 (Rf1) to 14.37 (Rf5) with an average of 9.27cm, while, for female parents it ranged from 14.53 (L5) to 18.20 (L3) with an average of 16.63 cm. Average head diameter for the crosses ranged from 15.87 (L5 x Rf5) to 21.90 (L19 x Rf4) with an average of 18.00cm. Generally, all crosses showed breader head diameter than the check cultivar Giza102. While, it gave narrow head diameter compared to the check cultivar Sakha53. The cross (L19 x Rf4) had the broadest head in both seasons and at the combined level over the two years.

The combined data of average 100-achene weight for male parents ranged from 3.27 (Rf10) to 6.45 (Rf5) with an average of 4.42g; while, for female parents it ranged from 5.49 (L1) to 8.25 (L19) with an average of 7.37g. Average 100-achene weight for the crosses ranged from 5.82 (L21 x Rf5) to 9.35 (L7 x Rf4) with an average of 7.76g. In general, nine crosses displayed significantly heaviest weight than the best parent (Table 3). Besides some of the crosses had higher100-seed weight compared with the checks.

Data over the two years also showed that, average yield/plant for male parents varied from 9.13 (Rf10) to 21.91 (Rf5) with an average of 13.18g. For female parents it varied from 27.73 (L1) to 54.68 (L7) with an average of 43.70g. Average yield/plant for the crosses varied from 40.45 (L1 x Rf10) to 63.06 (L7 x Rf10) with an average of 53.58g. Generally, all crosses significantly outyielded the check cultivar Giza102, and twenty one were significantly better than Sakha53 (Table 3).

For yield/plot, the combined data for male parents varied from 123.22 (Rf10) to 297.08 (Rf5) with an average of 177.97g. For female parents, it varied from 541.00 (L19) to 847.08 (L5) with an average of 658.96g. Average yield/plant for the crosses varied from 599.95 (L5 x Rf1) to 1241.67 (L3 x Rf10) with an average of 963.12g. In general, twenty crosses significantly exceeded the better parent. Twenty three crosses were significantly higher in yield when compared to the check cultivar Giza102.

While, only one cross was significantly outyielded Sakha53 in the combined level over the two years.

For oil percentage (Table 3) data over the two years showed that average oil % for male parents ranged from 39.04 (Rf5) to 39.62 (Rf4) with an average of 39.40% The range for the female parents was from 38.38 (L7) to 41.67 (L3) with an average of 39.45%. Average oil percentage for the crosses ranged from 39.34 (L19 x Rf1) to 42.91 (L1 x RF1) with an average of 40.43%. Generally, only seven crosses out of twenty four crosses showed significantly higher percentage over the best parent. Thirteen crosses were significantly better than Sakha53, while four crosses significantly better than Giza102. These results are in harmony with those obtained by Rana *et al* (1991), Mirza *et al* (1997), Nirmala *et al* (1999), Pawan *et al* (2003) and Honda *et al* (2005). They found that most of the F_1 crosses were earlier, taller and had higher 100-achene weight and yield/plant than their parents.

Heterosis

Estimates of heterosis for the twenty four F_1 crosses as a percentage of the better parent, averaged over the two seasons, for the studied traits are presented in Table(4).

Heterosis values for days, to 50% flowering ranged from 0.32 for cross (L5 x Rf4) to -8.43 % for cross (L19 x Rf10). Seventeen crosses recorded significant or highly significant negative heterosis. These crosses were earlier than earliest parents.

Heterotic values for days to maturity, varied from -0.60 for cross (L5 x Rf4) to -5.02 % for cross (L5 x Rf10). Nine crosses registered significant or highly significant negative heterosis. Generally crosses were earlier than the earlier parents.

Heterotic values for plant height ranged from 1.66 (L3 x Rf5) to 26.84 (L1 x Rf4). All the crosses over the two season, showed significant or highly significant positive heterosis for plant height, except the cross (L3 x Rf5) and cross (L5 x Rf5), but differences were not significant, indicating that these crosses were taller than their parents. It is worthy to mention that in sunflower, positive heterosis in crosses could be expected whenever crossing two inbred lines. Thus crosses would be always taller than their parent inbred lines.

Heterotic values for stalk diameter, ranged from -14.26 for cross (L5 x Rf10) to 17.88% for cross (L7 x Rf1) and five crosses showed significant and positive heterosis. These results indicated that the heterotic values in most cases were not consistent and changed from year to year.

Heterotic values for head diameter, ranged from -11.36% for cross (L3 x Rf5) to 28.32% for cross (L19 x Rf4). Fourteen crosses showed positive and significant or highly significant heterosis. These results were expected because breeders always put selection pressure for medium size heads as these normally produce medium size grains that contain more oil as compared to large size grains (Haq *et al* 2006).

Heterotic effects for 100-achene weight ranged from -23.23% for cross (L5 x Rfl) to 65.07% for cross (L1 x Rf4) and nine crosses showed positive significant or highly significant heterotic effects. This indicates that these crosses had high 100-seed weight than the best parent. It is clear that the five crosses which showed high 100-seed weight over the two years were (L7 x Rf4), (L1 x Rf4), (L19 x Rf4), (L7 x Rfl) and (L3 x Rf4). They revealed heterosis values of 16.97%, 65.07%, 5.28%, 7.52% and 13.32% respectively.

Heterotic values for yield/plant in the combined data over the two years varied from -15.46% to 114.21% for crosses. Seventeen crosses showed highly significant positive heterosis, which indicates that these crosses had higher seed yield/plant than the better parent. It should be mentioned that the five high yielding crosses in achene yield/plant over two seasons were; L7 x Rfl0 (15.31%), L21 x Rfl (61.24%), L1 x Rf4 (114.21%), L7 x Rfl (8.45%) and L5 x Rf5 (21.32%).

Heterotic values for yield/plot ranged from -29.17% for L5 x Rfl to 116.73% for L7 x Rfl. Twenty crosses gave highly significant positive heterosis for seed yield/plot. These results mean that in sunflower, positive heterosis in crosses could be higher for seed yield/plot than the best parental inbred lines. Generally, the highest positive value of heterosis for achene yield/plot was achieved by the cross (L7 x Rfl) (116.73%). The five highest yielding crosses over the two seasons were L5 x Rfl0 (50.04%), L7 x Rfl (116.73%), L1 x Rf4 (103.95%), L3 x Rfl0 (76.15%) and L5 x Rf4 (34.73%).

Heterotic values for achene oil percentages, ranged from -5.11 (L3 x Rfl) to 6.79 (L19 x Rf4). However, highly significant positive heterotic effects were observed in eight crosses out of 24 crosses in the combined data over the two years. The cross (L19 x Rf5) exhibited maximum positive heterotic effect (6.79%), along with 41.70 mean oil percentage. Maximum oil (42.91%) was shown by cross (L1 x Rfl) with 5.81 percent heterobeltiotic effect. The best five crosses in achene oil percentage over years were (L1 x Rfl) (5.81%), (L21 x Rfl0) (6.33%), (L19 x Rf5) (6.79%), (L7 x Rf4) (3.41%) and (L5 x Rfl0) (1.91%). Similar results were obtained by Dagustu and Goksoy (2002), Uttam *et a.* (2005) and Habibullah *et al* (2006). They indicated that heterosis was manifested in yield crosses for many studied traits

Table 2. Combined analysis of variance of the genotypes (parents and crosses) for the studied traits, over the two years 2006 and 2007.

Source of variation	d.f.	Mean squares								
		Days to 50% flowering	Days to maturity	Plant height	Stalk diameter	Head diameter	100-achene weight	Achene yield /plant	Achene yield/ plot	Oil percentage
Years(Y)	1	200.02**	18.24**	2735.34**	0.003	7.30**	0.06	828.00**	22640.14	6.28**
Rep/years	4	1.23	2.23	19.04	0.03	0.37	0.18	4.37	5680.15	0.24
Genotypes(G)	33	19.72**	23.81**	2514.75**	0.31**	65.30**	11.85**	1266.98**	581354.07**	6.53**
Parents(P)	9	6.82**	14.45**	399.89**	0.53**	115.83**	21.78**	1872.64**	430204.21**	6.25**
P.vs.C	1	327.45**	269.43**	52738.21**	3.16**	770.31**	105.12**	20663.22**	10442848.41**	41.87**
Crosses(C)	23	11.39**	16.79**	2339.01**	0.10**	14.87**	3.91**	186.67**	211739.05**	5.11**
Testers(T)	3	11.64**	37.65**	1035.27**	0.13**	20.10**	10.89**	54.45**	199161.74**	2.31**
Lines(L)	5	25.61**	36.23**	139.68**	0.22**	13.07**	3.80**	347.65**	34081.73**	2.34**
L x T	15	6.6**	6.14**	359.55**	0.06*	14.43**	2.54**	159.46**	273473.61**	6.59**
G x Y	33	2.54**	3.16**	107.66**	0.05**	2.06**	0.48**	20.84**	12351.69**	30.23**
P x Y	9	4.25**	0.91	98.29**	0.02	0.78**	0.18	19.51**	1027.29	59.54**
P.vs.C x Y	1	3.07	0.03	244.24**	0.04	19.25**	0.13	5.83	170.13	268.22**
C x Y	23	1.85**	4.18**	105.39**	0.06**	1.81**	0.62**	22.02**	17312.60**	8.42**
L x Y	5	1.94	4.63**	55.86**	0.07**	2.48**	0.38*	11.58**	15467.13*	9.80**
T x Y	3	3.68**	9.16**	47.19**	0.06	1.42**	2.13**	1.27	21026.72**	12.96**
LxTxY	15	1.23	3.03**	133.54**	0.06**	1.67**	0.39**	29.65**	17184.94**	7.04**
Error	132	0.93	1.02	21.91	0.03	0.24	0.14	3.95	5166.62	0.26

*, **significant at 0.05 and 0.01 probability levels, respectively

Table 3. Mean performance of all genotypes for all studied traits (combined data over the two seasons; 2006 and 2007)

No.		Entry	Days to 50% flowering	Days to maturity	Plant height, cm	Stalk diameter, cm	Head diameter, cm	100-achene weight	Yield/plant, g	Yield/plot, g	Oil percentage
Crosses	H1	L1xRf1	52.33	81.17	173.33	2.09	16.20	7.31	43.99	789.52	42.91
	H2	L3xRf1	50.83	79.17	169.83	2.17	18.27	7.53	50.83	968.18	39.54
	H3	L5xRf1	49.00	79.00	170.17	2.05	17.57	6.20	55.81	599.95	39.95
	H4	L7xRf1	53.67	83.50	167.83	2.15	19.63	8.60	59.30	1236.72	39.95
	H5	L19xRf1	51.67	81.33	169.33	2.10	16.33	7.69	55.70	834.21	39.34
	H6	L21xRf1	50.83	80.67	176.33	2.18	18.43	7.62	61.19	1132.04	39.88
	H7	L1xRf4	52.50	84.17	178.00	2.14	20.17	9.06	59.41	1199.50	40.45
	H8	L3xRf4	51.67	82.00	178.17	1.99	16.83	8.46	53.75	1035.36	40.55
	H9	L5xRf4	52.83	82.50	180.83	2.04	17.43	7.73	49.07	1141.29	41.31
	H10	L7xRf4	52.83	84.33	175.33	2.04	17.23	9.35	56.47	816.20	41.54
	H11	L19xRf4	52.50	83.33	168.33	2.39	21.90	8.68	53.46	1127.79	39.46
	H12	L21xRf4	53.33	82.67	158.00	2.28	20.50	8.16	56.55	867.31	39.46
	H13	L1xRf5	52.50	82.00	169.67	1.92	18.63	7.66	52.99	1044.34	39.50
	H14	L3xRf5	54.00	82.33	163.00	1.95	16.13	6.85	42.96	721.60	40.11
	H15	L5xRf5	50.17	81.00	161.33	1.97	15.87	7.71	56.89	645.21	39.37
	H16	L7xRf5	53.33	83.33	169.83	2.02	18.77	8.19	53.47	1001.27	40.37
	H17	L19xRf5	52.17	81.17	167.50	2.21	17.90	7.95	56.13	892.95	41.70
	H18	L21xRf5	51.67	79.00	169.50	2.06	16.23	5.82	51.53	951.01	40.22
	H19	L1xRf10	51.83	81.17	162.67	1.99	17.33	7.18	40.45	616.50	40.93
	H20	L3xRf10	53.17	82.50	183.67	2.09	18.47	7.91	47.30	1241.67	40.59
	H21	L5xRf10	49.33	78.83	179.50	2.10	16.37	8.30	55.19	1367.26	40.28
	H22	L7xRf10	54.00	84.17	194.67	2.15	19.70	7.36	63.06	1040.40	40.69
	H23	L19xRf10	50.67	80.67	179.33	2.23	18.00	7.64	54.85	998.26	40.08
	H24	L21xRf10	50.83	80.67	178.33	2.06	16.93	7.35	55.52	987.52	42.03
Mean			51.99	81.70	172.70	2.08	18.00	7.76	53.58	963.12	40.43
Lines (Females)	1	L1	56.00	86.17	140.33	2.01	16.77	5.49	27.73	588.13	40.55
	2	L3	54.83	84.83	160.33	2.05	18.20	7.47	50.82	655.09	41.67
	3	L5	52.67	83.00	157.17	2.06	14.53	8.07	46.89	847.08	39.08
	4	L7	55.00	85.83	157.33	1.83	16.60	8.00	54.68	570.62	38.38
	5	L19	55.33	84.67	145.33	2.05	17.07	8.25	44.11	541.00	38.58
	6	L21	56.17	86.00	148.33	2.09	16.63	6.93	37.95	751.85	38.46
Mean			55.00	85.08	151.47	2.02	16.63	7.37	43.70	658.96	39.45
Testers (Males)	1	Rf1	53.67	82.33	110.17	1.43	6.67	4.54	10.71	140.89	39.39
	2	Rf4	54.50	84.17	109.00	1.36	7.50	3.43	10.96	150.69	39.62
	3	Rf5	54.17	81.83	127.50	1.83	14.37	6.45	21.91	297.08	39.04
	4	Rf10	55.33	83.33	118.50	1.42	8.53	3.27	9.13	123.22	39.53
Mean			54.42	82.92	116.29	1.51	9.27	4.42	13.18	177.97	39.40
L.S.D$_{0.05}$			1.54	1.62	7.49	0.28	0.78	0.60	3.18	115.03	0.82
Check	1	Sakha53	56.00	87.17	178.67	2.14	19.70	7.96	43.37	1174.61	39.26
	2	Giza102	52.17	82.00	137.83	1.56	12.53	7.30	31.48	597.42	40.45
L.S.D$_{0.05}$			**1.54**	**1.64**	**7.47**	**0.16**	**0.88**	**0.62**	**3.15**	**48.49**	**0.91**

Table 4. Heterosis as a percentage of the better parent in the combined level over the two seasons for all studied traits.

Traits	Female lines	Restorer lines (Males)			
		Rf1	Rf4	Rf5	Rf10
Days to 50% flowering.	L1	-2.48	-3.67*	-3.08*	-6.33**
	L3	-5.28**	-5.20**	-0.31	-3.04*
	L5	-6.96**	0.32	-4.75**	-6.33**
	L7	0.00	-3.06*	-1.54	-1.82
	L19	-3.73*	-3.67*	-3.69*	-8.43**
	L21	-5.28**	-2.14	-4.62**	8.13**
Days to maturity	L1	-1.42	0.00	0.20	-2.60**
	L3	-3.85**	2.57**	0.61	-1.00
	L5	-4.05**	-0.60	-1.02	-5.02**
	L7	1.42	0.20	1.83	1.00
	L19	-1.21	-0.99	-0.81	-3.20**
	L21	-2.02	-1.78	-3.46**	-3.20**
Plant height	L1	23.52**	26.84**	20.90**	15.91**
	L3	5.93*	11.12**	1.66	14.55**
	L5	8.27**	15.06**	2.65	14.21**
	L7	6.67**	11.44**	7.94**	23.73**
	L19	16.51**	15.83**	15.25**	23.39**
	L21	18.88**	6.52*	14.27**	20.22**
Stalk diameter	L1	4.32	6.81	-4.57	-0.75
	L3	5.86	-2.61	-4.89	2.28
	L5	-0.16	-0.97	-4.05	-14..26*
	L7	17.88**	11.86	10.31**	17.52*
	L19	2.60	16.59*	7.80*	8.62
	L21	3.90	9.08	-1.59	-1.43
Head diameter	L1	3.38	20.28**	11.13**	3.38
	L3	0.37	-7.51**	-11.36**	1.47
	L5	20.87**	19.95**	9.17**	12.61**
	L7	18.27**	3.82	13.05**	18.67**
	L19	-4.30	28.32**	4.88*	5.47*
	L21	10.82**	23.25**	-2.40	1.80

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

Table 4. Continued

Traits	Female lines	Restorer lines (Males)			
		Rf1	Rf4	Rf5	Rf10
100-achene weight	L1	33.17**	65.07**	18.87**	30.83**
	L3	0.87	13.32*	-8.28*	5.89
	L5	-23.23**	-4.29	-4.54	2.77
	L7	7.52*	16.97**	2.44	-7.98*
	L19	-6.69	5.28	-3.54	-7.30*
	L21	10.06*	17.73**	-16.03**	6.16
Achene yield/plant	L1	58.61**	114.21**	91.08**	45.84**
	L3	0.02	5.77	-15.46**	-6.93*
	L5	19.01**	4.63	21.32**	17.69**
	L7	8.45**	3.26	-2.21	15.31**
	L19	26.29**	21.21**	27.25**	24.35**
	L21	61.24**	49.02**	35.79**	46.30**
Achene yield/plot	L1	34.24**	103.95**	77.57**	18.82
	L3	47.79**	58.05**	10.15	76.15**
	L5	-29.17**	34.73**	-23.83**	50.04**
	L7	116.73**	43.04**	75.47**	81.10**
	L19	54.20**	108.46**	65.06**	81.44**
	L21	50.57**	15.36*	26.49**	29.25**
oil percentage	L1	5.81**	-0.25	-2.59*	0.94
	L3	-5.11**	-2.68**	-3.75**	-2.60**
	L5	1.42	4.26**	0.73	1.91
	L7	1.41	4.83**	3.41**	2.93**
	L19	-0.14	-0.41	6.79**	1.39
	L21	1.24	0.41	3.00**	6.33**

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

REFERENCES

A.O.A.C. (1980). Association of Official Agricultural Chemists. Official and Tentative methods of analysis of the Association Agricultural. Chemists 6th ed., Washington, D. C., U. S. A.

Bhatt, G.M. (1971). Heterotic performance and combining ability in diallel crosses among spring wheat's. (*T. aestivum*) Journal Agriculture Research, 22:359-369

Dagustu, N. and A.T. Goksoy. (2002). Combining ability and hybrid performances in sunflower (*Helianthus annuus* L.). Turkish Journal of Field Crops, 7(1): 6-14.

Gomez, K.A. and A.A. Gomez. (1984). Statistical Procedures for Agricultral Research. Jon Wiley and Sons. New York. 2nd ed.

Habibullah, H., S.S. Mehdi, Abdul Rashid, I. Saeed and M.A. Anjum. (2006). Heterosis studies in sunflower (*Helianthus annuus* L.) crosses for agronomic traits and oil yield under Faisalabad conditions. Pakistan Journal of Agricultural Sciences, 43(3/4): 131-135.

Honda, Y., Y. Mukasa and T. Suzuki. (2005). Traits of NuSun varieties of sunflower in Hokkaido Japan. Plant Production Science, 8(4): 461-464.

Haq, A., A. Rashid, M.A. Butt, M.A. Akhter, M. Aslam and A. Saeed. (2006). Evaluation of sunflower (*Helianthus annuus* L.) hybrids for yield and yield components in central Punjab. J. Agric. Res, 44(4): 277-284.

Jayalakshmi, V., B. Narendra, V. Sridhar and K.R. Devi. (2000). Heterosis in sunflower (*Helianthus annus* L.). Agricultural Science Digest, 20(2): 114-115.

Kempthorne, O. (1957). Yield stability of single, three ways and double cross hybrids. Sorghum News Letter, 33:59

Khan, M. S., I. H. Khalil and M. S. Swati. (2004). Heterosis for yield components in sunflower (*Helianthus annuus* L.). Asian Journal of Plant Sciences, 3(2): 207-210.

Mirza, S.H., M.S. Hassan and D. Nessa. (1997). Genetic diversity amongst fifty sunflower (*Helianthus annuus* L.) genotypes. Bangladesh Journal of Botany, 26(1): 51-54.

Nirmala, V.S., A. Gopalan and D. Sassikumar. (1999). *Per se* performance and combining ability in sunflower (*Helianthus annuus* L.). Madras Agric. J., 86(4/6): 221-224.

Pawan, K., M.K. Prasad and G. Jyotirmoy. (2003). Phenotypic stability of sunflower (*Helianthus annuus* L.) genotypes. J. Applied Biology, 13(1/2): 20-23.

Rana, M.A., M.A. Khan, M. Yousuf and S.M. Mirza. (1991). Evaluation of 26 sunflower cultivars at Islamabad. Helia, 14(14): 19-28.

Uttam, K. K., R. K. Sheoran and K. Rakesh. (2005). Combining ability nalysis in sunflower (*Helianthus anuus* L.). National J. Plant Improvement, 7(1): 35-39.

قوة الهجين للمحصول ومكوناتة في دوار الشمس

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استخدمت فى هذه الدراسة أربعة وعشرون هجينا من خلال التهجين ما بين ستة أباء عقيمة الذكر سيتوبلازميا (CMS-lines) مع أربعة أباء معيدة للخصوبة (RF-lines) باستخدام نظام السلالة x الكشاف خلال موسم ٢٠٠٥ فى محطة البحوث الزراعية بشندويل (سوهاج). تم تقييم هذة الهجن (٢٤ هجين) والأربع سلالات المعيدة للخصوبة وستة سلالات (B-lines) وصنفين قياسيين هما (سخا٥٣ وجيزة١٠٢) فى موسمي ٢٠٠٦ و٢٠٠٧ فى محطة البحوث الزراعية بشندويل. وكانت التجربة مصممة بنظام قطاعات كاملة العشوائية فى ثلاث مكررات. وقد اجري التحليل الإحصائي لمتوسط الموسمين وتم حساب قوة الهجين كنسبة مئوية لأفضل الأبوين باستخدام تحليل السلالة في الكشاف لكل الصفات تحت الدراسة. أوضح التحليل المشترك للسنتين وجود اختلافات عالية المعنوية بين السنتين لكل الصفات تحت الدراسة فيما عدا صفة قطر الساق و وزن ال١٠٠ بذرة. أيضا كانت هناك اختلافات معنوية عالية جدا بين التراكيب الو راثية لكل الصفات تحت الدراسة. علاوة على أن التفاعل بين التراكيب الو راثية والسنوات كان معنوى جدا لكل الصفات تحت الدراسة. كما اظهر التحليل المشترك للسنتين وجود اختلافات معنوية جدا بين الآباء والهجن ومكوناتهـــا (الآبـــاء والأمهات والتفاعل بينهما) لكل الصفات تحت الدراسة. وقد أظهرت النتائج أن أبكـــر الهجـــن هو الهجين (L5 x Rf10) ، و كان الهجين(L19 x Rf4) الأكبر في قطر القرص ، وكذلك كانت كل الهجن أفضل فى قطر القرص عن الصنف القياسي جيزة ١٠٢ ، فى حين كانت الهجن اقل في قطر القرص مقارنة بالصنف القياسى سخا ٥٣ . كما وجد ان هناك مدى واسع لقوة الهجين فى صفة محصول القطعة التجريبية، فقد كان أعلى خمسة هجن فى متوسط السنتين هي الهجن التالية: L5 x Rf4 و L3 x Rf10 و L1 x Rf4 وL7 x Rf1 و L5 x Rf10. وتعتبر هذه الهجن من أفضل الهجن فى محصول القطعة التجريبية. وكان أحسن خمسة هجن فى نسبة الزيت فى البـــذور هى L5 x Rf5 و L7 x Rf4 وL19 x Rf5 وL21 x Rf10 و L1 x Rf1. وعلى ذلك يمكن أن تدخل هذه الهجن فى برامج إنتاج الهجن التجارية.

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