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HETEROSIS, GENOTYPIC AND PHENOTYPIC CORRELATIONS IN SUNFLOWER (*Helianthus annuus* L.) HYBRIDS UNDER NORMAL IRRIGATION AND DROUGHT STRESS CONDITIONS

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ABSTRACT

Six parental sunflower representing different agronomic characters were crossed in a diallel fashion, excluding reciprocal in 2007 season and evaluated under normal conditions (plants watered every 15 days) and stress conditions (prevented irrigation after the first irrigation until harvest) during 2008 season at Kafr-El-Hamam Agricultural Experiment Station of Agricultural Research Center, Sharkia Governorate, Egypt to determinate heterosis, genotypic and phenotypic correlations for sunflower traits.

The results indicated that, genotypes, parents and their F_1 crosses mean squares were highly significant for all studied characters under both normal irrigation and drought stress conditions. Interaction mean squares between irrigation and genotypes were highly significant for all studied traits, except earliness and head diameter characters. Parents versus crosses mean squares as an indication to average of heterosis overall crosses were highly significant for all studied characters under both normal irrigation and drought stress conditions.

All the cross combinations in F_1 generation exhibited heterosis or hybrid vigour for all characters studied. The greater increase of F_1 over mid-parent was achieved for osmotic pressure P2 x P6 (194.81 %) and seed yield per plant P3 x P6 (175.63 %) under drought stress conditions. The average increase of F_1 was greater in mid parent than better parent for most of the studied characters and the crosses in the positive direction.

The results indicated that under both normal and drought stress conditions, a highly significant and positive phenotypic and genotypic correlations were found between seed yield/plant and all studied traits, except oil percentage under normal irrigation, which was non-significantly correlated at both the phenotypic and genotypic levels.

Keywords: Sunflower, Heterosis (Hybrid vigour), Genotypic and phenotypic correlations, Drought

INTRODUCTION

In Egypt, sunflower (*Helianthus annuus* L.) is the most promising crop of increasing domestic production of edible oil and hence, reducing imports from abroad. Among the environmental stresses, drought is considered the most limiting factor of the plant productivity in the most areas of the world. Heterosis (hybrid vigour) plays a major role in improving crop productivity and quality in order to feed the ever-increasing human population particularly in developing countries. The development of hybrids in the world major food crops and methods of hybrid seed production are critical for achieving this goal.

Regarding mean performance of some physiological and yield characters, El-Sabbagh (2003) revealed that irrigation sunflower plants every 14 days significantly increased seed yield/plant, seed yield/faddan, seed oil % and oil yield/faddan compared other treatments. He added that Euroflower cultivar was superior in seed yield/plant and seed yield/faddan. Petcu *et al.*, (2003) showed that hydric stress significantly reduced leaf area. Kiani *et al.*, (2007) showed that the analysis of variance for osmotic pressure, osmotic pressure at full turgor and osmotic adjustment of the 78 recombinant inbred lines (RIL) and their parents (PAC2 and RHA 266) were highly significant for water treatments, sunflower genotypes and their interaction.

With respect to Heterosis (Hybrid vigour), Stoenescu *et al.* (1985) in Romania, found that in a recent investigation of F_1 hybrids, the growth period was in many instances 20.25 % shorter than the mid parental value. Vranceanu and Pirvu (1988) also in Romania, indicated that as a result of breeding for heterosis on the basis of inbred lines, an annual rate of increase of 1.17 % was achieved for achene yield, 0.47 % for oil content, 1.79% for oil yield and 21.14 % for degree of self fertility.

Concerning genotypic and phenotypic correlation, Tahir *et al.* (2002) in Pakistan, under water stress and normal irrigation, evaluated twenty-five inbred lines of sunflower. Their results revealed that highly significant and positive correlated was recorded between yield per plant and days to flower, days to maturity, plant height, leaf area, head diameter, 100-seed weight and stem dry weight.

Therefore, the present investigation was designed to determinate of heterosis, genotypic and phenotypic correlations for some morpho-physiological, earliness, yield characters and oil percentage under both normal irrigation and drought stress conditions.

MATERIALS AND METHODS

Six parental sunflower representing different agronomic characters were crossed in a diallel fashion, excluding reciprocal in 2007 season and evaluated under normal irrigation conditions (plants watered every 15 days) and stress conditions (prevented irrigation after the first irrigation until harvest) during 2008 season at Kafr-El-Hamam Agricultural Experiment Station of Agricultural Research Center, Sharkia Governorate, Egypt to estimate heterosis, genotypic and phenotypic correlations for some sunflower traits. The genetic materials used in this investigation as parents included six sunflower genotypes, representing a wide range of diversity for physiological and several agronomic characters. The parental genotypes i.e., L92, Giza 102, L 34, L230, Sakha53 and L245 were chosen, from the 35 studied sunflower genotypes, after identification in their drought tolerance based on osmotic adjustment which is highly inherited and well correlated with yield under field stress conditions. The screening was done in 2007 season before flowering stage at 40 days after sowing. At flowering stage, diallel crossing technique excluding reciprocal was used among six parental genotypes to produce 15 F_1s seeds during 2007 season.

The name and origin of the used parents are given in Table 1:

Table 1: The name and origin of the used parents

Name of Inbred line		Origin
P1	L92	Bulgaria
P2	Giza102	Egypt
P3	L34	Egypt
P4	L230	Bulgaria
P5	Sakha53	Egypt
P6	L245	Bulgaria

Cultural practices:

The preceding winter crop was flax (*Linum ussitatissmum* L.). Two separate field experiments were conducted, the first represents normal irrigation treatment (plants watered every 15 days as control treatment) and the second represents drought stress treatment (prevented irrigation after the first irrigation until harvest). Each experiment was in a randomized complete blocks with three replications to evaluate 15 F_{1S} crosses together with the six parental sunflower genotypes included check cultivars i.e. Sakha 53 and Giza 102. Each plot had single ridge plot, 60 cm apart and 4 m long, inter-plant spacing was 30 cm, the experimental unit area was 2.4 m^2 and plant population density was 5.56 plants/m^2. Within each block, genotypes plot were contiguous and randomly arranged. Planting date was on June 10 in 2007 and 2008 seasons.

Phosphorus fertilizer was added in the form of calcium super phosphate (15.5 % P_2O_5) at the rate of 100 kg/fed during seed-bed preparation. Seeds were sown in hills spaced of 30 cm apart with 2 to 3 seeds/hill. Nitrogen fertilizer in the form of ammonium nitrate (33.5 % N) at a rate of 30 kg N/fed. was applied as top dressing immediately after thinning to one plant/hill before the first irrigation (15 days from sowing). Hoeing was practiced before and after the first irrigation.

Some physical and chemical analysis for soil of the experimental field are presented in Table (2).

Table 2: Some physical and chemical analysis of soil for the experimental field

Season	Available (p.p.m)			PH	E.C mmh/cm	$CaCo_3$ %	Clay %	Silt %	Fine sand %	Water table (m)	Texture
	N	P	K								
2008	75.0	17.0	496.0	8.5	0.31	2.7	31.6	31.6	15.7	2.23	Clay

Protocol hybridization (emasculation and pollination):

Each head from parents was covered with a paper bag a day before start of anthesis and was kept covered until seed harvesting. To prepare the inflorescence for emasculation, the portion of the receptacle that has completed anthesis in previous days is broken a way. A sharp tool, such as a curved-blade knife, is used to remove the florets approaching anthesis. After the anther filaments elongate and the anther tube appears above the corolla tube, emasculation is performed by removing the anther tube with a forceps. Free pollen is washed off with water. Water also will abort undesirable pollen grains on the immature stigmas. Stigmas will be fully elongated and receptive

1 to 2 hours after emasculation. The pollen grains were collected for pollination is completed on the day of emasculation for the highest seed set and covered again.

Collected data:

A- Physiological characters:

Before flowering stage at 40 days after sowing, the third leaf from the top of the plant in different treatments were used for measuring osmotic pressure (OP) and osmotic pressure at full turgor, and observations were made 14.00 h. where, half the lamina of sampled leaf (without the midrib vein) was used to determine osmotic pressure and the remaining leaf (lamina with midrib vein) was used for measuring osmotic pressure at full turgor.

1-Osmotic pressure (OP): Osmotic pressure was determined using TSS (Total soluble solids) in leaf sap according to Gossav (1960). The leaves were directly taken from different treatments, immediately freezed, the sap was then extracted in the laboratory with a piston press when the frozen tissues had been thawed. Then TSS values converted to OP from Gossav table.

2-Osmotic pressure at full turgor (OP_{ft}): The remaining half (without the midrib vein) from different treatments was immediately placed in a container, with distilled water for 12 h.. The sap was then extracted in the laboratory with a piston press when the saturation tissues had been turgid. Then Total Soluble Solids converted to OP_{ft} from Gossav table.

3-Osmotic adjustment (OA): The osmotic adjustment (OA) is determined using the following equation according to Kiani *et al.* (2007): OA = Ψ_sFT (ww) - Ψ_sFT (ws), where: Ψ_sFT (ww) is the osmotic pressure at full turgor of well watered plants and Ψ_sFT (ws) is the osmotic pressure at full turgor of water–stressed plants.

B-Earliness characters: 1-Flowering date, 2- Seed filling period.

C- Growth characters and yield attributes: 1-Leaf area index (LAI): according to **Watson (1958)**: = Total leaf area of plant/land area of plant, 2- Number of green leaves/plant at the end of pollination, 3- Stem diameter (cm), 4- Plant height (cm), 5- Head diameter (cm), 6- 100-seed weight (g), 7- Seed yield per plant (g) and 8-Seed oil percentage: according to A.OA.C. (1980).

Statistical analysis:

The data were analyzed on plot mean basis in both parents and F_1 generation. All obtained data were subjected to the statistical analysis of the randomized complete block design to test the differences among various genotypes under each irrigation treatment according to Snedecor and Cochran (1980). While, mean squares for genotypes (parents and F_1's) were partitioned among parents, F_1 crosses and parents vs. crosses according to Mather and Jinks (1982) as presented in Table 3. Combined analysis was performed between the experiments (normal and drought conditions) to indicate the irrigation effects according to Waller and Duncan (1969) as presented in Table 4.Treatments were compared using the least differences values (LSD) at 5% probability according to Gomez and Gomez (1984).

Table 3: Form of analysis of variance

S.O.V	D.F.	M.S	E.M.S
Replication (r)	r-1 =2	Mr	$\sigma^2 e + g\sigma^2 r$
Genotypes (G.)	g-1 =20	Mg	$\sigma^2 e + r\sigma^2 g$
Parents (P.)	p-1 =5	Mp	$\sigma^2 e + r\sigma^2 p$
F_1	F-1 =14	Mc	$\sigma^2 e + r\sigma^2 c$
P. vs F_1	1		$\sigma^2 e + r\sigma^2 h$
Error	(g-1)(r-1) =10	Me	$\sigma^2 e$

Table 4: Form of the combined analysis of variance

S.O.V	D.F.	M.S	E.M. S
Irrigation (I)	I-1	MI	$\sigma^2 e + rGK^2 I$
Error	I (r-1)	Me	$\sigma^2 e + GK^2 r I$
Genotypes (G)	G-1	MG	$\sigma^2 e + rK^2 GI + rIK^2 G$
Error	I (r – 1) (G-1)		$\sigma^2 e + rGK^2 I$
G x I	(I – 1)(G - 1)		$\sigma^2 e + rK^2 GI$

Where, I= Number of irrigations, G= Number of Genotypes, P= Number of Parents, C= Number of Crosses, h= Average of heterosis and $\sigma^2 e$= Error variance.

Genotypic, phenotypic, and environmental (treatment) correlation coefficients between some related characters with drought tolerance and both of yield determinations under stress and control treatments were calculated according to Kown and Torrie (1964).

The phenotypic (r_{ph}) and genotypic (r_g) correlations for any pair of traits could be calculated according to the following equation:

a- Phenotypic correlation (r_{ph}) = $Cov\ ph_{12}/(\sigma^2 ph_1 . \sigma^2 ph_2)^{½}$

b- Genotypic correlation (r_g) = $Cov\ g_{12}/ (\sigma^2 g_1 . \sigma^2 g_2)^{½}$

The significance of the phenotypic (r_{ph}) and genotypic (r_g) correlations were tested by using (T. test) at 5% and 1% levels of probability as described by Steel and Torrie (1960).

Estimation of Heterosis:

Heterosis as proposed by Mather and jinks (1982) was determined for individual crosses as the percentage deviation of F_1 means from mid-parent (M.P) and better parent (B.P) means and expressed as percentages for each environment normal irrigation and drought stress conditions:

1-Heterosis over the mid-parent % (M P) = (F_1 – M P)/ F_1 x 100

2-Heterosis over the better-parent % (B P) = (F_1 – B P) / B P x 100

where: F_1= mean values of the first generation, M P= mean of the mid parent calculated by using average mean of the two parents and B P= mean values of the better parent

The significance of heterosis effect for F_1 values from the mid-parent and better-parent were tested according to the following formula:

LSD for mid parent heterosis: $t_{0.05}$ x $(3MS_e/2r)^{½}$

LSD for better parent heterosis: $t_{0.05}$ x $(2MS_e/r)^{½}$

Where: t= tabulated (t) value at a stated level of probability for the experimental error degree of freedom, MS_e= Mean squares of the experimental error from the analysis of variance and r= Number of replicates

RESULTS AND DISCUSSION

A-Mean performance of sunflower genotypes:

The results given in Tables (5, 6 and 7) indicated that, genotypes, parents and their F_1 crosses mean squares were highly significant for morpho-physiological and yield characters under both normal irrigation and drought stress conditions. Interaction mean squares between irrigation and genotypes were highly significant for all the studied traits except earliness characters and head diameter. Parents versus crosses mean squares as an indication to average heterosis overall crosses were highly significant for the studied characters under both normal irrigation and drought stress conditions. These results are in agreement with those reported by Petcu, *et al.* (2003) and Kiani *et al.* (2007).

As shown in the same Tables (5, 6 and 7), the sunflower genotypes P5 and P6 and their F1 crosses P2 x P5, P2 x P6 and P3 x P6 exhibited the highest values of morpho-physiological, yield characters and oil percentage. Concerning earliness characters, the parental inbred lines P1 and P2 and their F1 crosses P1 x P2, P1 x P3, P2 x P3, P2 x P4, P2 x P5, P2 x P6 and P3 x P6 were the earliest genotypes under both normal irrigation and drought stress conditions. Therefore, these genotypes are the promising ones.

Table 5: Mean squares of studied characters for parents and their F_1 crosses from the combined analysis between the two irrigation treatments.

S.O.V	d.f	Osmotic pressure (bar)	Osmotic pressure at full turgor (bar)	Leaf area index	Flowering date (day)
Irrigation (I)	1	1740.89**	22.27**	17.61**	363.46**
Error	4	2.57	0.01	0.001	0.889
Genotypes(G)	20	149.17**	2.11**	1.132**	49.11**
I x G	20	42.86**	0.41**	0.203**	1.98
Error .	80	1.82	0.01	0.0001	1.54
S.O.V	**d.f**	**Seed filling period (day)**	**Plant height (cm)**	**No. of green leaves/plant**	**Stem diameter (cm)**
Irrigation (I)	1	346.68**	48832.39**	377.18**	36.98**
Error	4	9.561	45.33	1.718	0.006
Genotypes(G)	20	257.04**	13377.23**	110.99**	1.308**
I x G	20	1.53	219.00**	4.33	0.19
Error	80	1.62	23.50	2.19	0.007
S.O.V	**d.f**	**Head diameter (cm)**	**100-seed weight (g)**	**Seed yield/plant (g)**	**Oil percentage (%)**
Irrigation (I)	1	235.07**	94.47**	38866.96**	927.47**
Error	4	3.74	0.17	20.04	0.07
Genotypes(G)	20	84.55**	10.14**	11279.27**	30.68**
I x G	20	3.26	1.69**	463.78**	17.30**
Error	80	3.53	0.18	11.96	1.02

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

Table 6: Mean squares for studied characters under both normal and drought stress conditions

S.O.V	d.f	Osmotic pressure (bar)		Osmotic pressure at full turgor (bar)		Leaf area index		Flowering date (day)	
		N	D	N	D	N	D	N	D
Genotypes	20	18.07**	173.97**	0.38**	2.14**	0.57**	0.77**	25.24**	25.84**
Parents (P)	5	3.60**	33.58**	0.06**	0.55**	0.51**	0.58**	19.26**	11.12**
Crosses (C)	14	11.75**	151.45**	0.20 **	1.59**	0.25**	0.54**	7.93**	18.50**
P x C	1	178.9**	1191.2**	4.50*	17.79**	5.35*	4.94**	297.48**	202.20**
Error	40	0.66	2.98	0.01	0.014	0.0004	0.0005	1.74	1.34
S.O.V	**d.f**	**Seed filling period (day)**		**Plant height (cm)**		**No. of green leaves/plant**		**Stem diameter (cm)**	
		N	D	N	D	N	D	N	D
Genotypes	20	127.75**	130.91**	5608.57**	7987.65**	57.50**	57.82**	1.03**	0.47**
Parents (P)	5	126.86**	94.36**	3571.83**	4458.18**	26.24**	42.55**	0.48**	0.19**
Crosses (C)	14	101.52**	125.28**	4723.24**	6034.86**	34.36**	39.48**	0.73**	0.24**
P x C	1	499.42**	392.48**	28186.89**	52974.06**	537.76**	390.93**	7.98**	5.09**
Error	40	2.74	2.50	16.10	30.91	2.89	1.50	0.007	0.007
S.O.V	**d.f**	**Head diameter (cm)**		**100-seed weight (g)**		**Seed yield/plant (g)**		**Oil percentage (%)**	
		N	D	N	D	N	D	N	D
Genotypes	20	35.98**	51.83**	6.04**	5.79**	4987.44**	6755.61**	17.02**	30.97**
Parents (P)	5	9.74	25.18**	3.50**	3.04**	2191.79**	3461.79**	24.20**	46.26**
Crosses (C)	14	24.64**	29.79**	2.24**	4.28**	2287.22**	5129.30**	10.69**	18.33**
P x C	1	325.94**	493.64**	71.94**	40.68**	56768.77**	45993.05**	69.74**	131.48**
Error	40	3.50	3.55	0.24	0.13	6.00	17.92	1.07	0.97

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

Heterosis studies:

Higher osmotic pressure and osmotic pressure at full turgor contributes to drought tolerance. Therefore, for osmotic pressure and osmotic pressure at full turgor heterosis in the positive direction are desirable. Results given in Table 8, indicated that 14 cross combinations manifested positive highly significant heterosis of mid parent for osmotic pressure under normal irrigation and better parent for osmotic pressure and osmotic pressure at full turgor. Under both normal irrigation and stress conditions, while all the cross combinations depicted positive highly significant heterosis over mid parent for osmotic pressure and osmotic pressure at full turgor under stress conditions and for only osmotic pressure at full turgor under normal irrigation. Maximun positive heterosis over mid parent value was observed in cross combination P2 x P6 (124.53 %) followed by P2 x P5 (108.73 %) for osmotic pressure and P2 x P6 (90.69 %) followed by P2 x P5 (81.46 %) for osmotic pressure at full turgor under normal irrigation; while under stress condition, P2 x P6 (194.81 %) followed by P3 x P6 (179.27 %) for osmotic pressure and P2 x P6 (128.65 %) followed by P3 x P6 (117.04 %) for osmotic pressure at full turgor. In case of better parent, maximum positive heterosis was observed in cross combination P3 x P6 followed by P2 x P6 for osmotic pressure and osmotic pressure at full turgor under both normal irrigation and stress conditions.

Table 7: Mean performance of sunflower genotypes for various characters under two irrigation treatments

Character / Genotype	Osmotic pressure (bar)		Osmotic pressure at full turgor (bar)		Leaf area index	
	N	D	N	D	N	D
P1	6.53	7.83	1.27	1.40	2.30	1.17
P2	3.85	5.13	0.90	1.03	1.17	0.70
P3	5.54	6.29	1.11	1.24	1.90	0.49
P4	5.20	8.52	1.08	1.64	1.47	1.14
P5	6.69	12.23	1.29	2.01	1.95	1.36
P6	6.50	13.66	1.19	2.09	2.05	1.70
P1 X P2	4.96	6.90	1.16	1.35	2.44	1.27
P1 X P3	7.67	8.86	1.45	1.67	2.33	1.26
P1 X P4	7.85	13.48	1.59	2.37	2.74	1.42
P1 X P5	10.58	20.79	1.93	3.05	2.78	1.69
P1 X P6	11.43	27.23	1.96	3.52	2.88	2.20
P2 X P3	7.67	8.92	1.51	1.67	1.94	0.73
P2 X P4	8.01	13.70	1.59	2.42	1.83	1.44
P2 X P5	11.00	21.93	1.99	3.19	2.44	1.77
P2 X P6	11.62	27.70	1.99	3.57	2.68	2.31
P3 X P4	8.19	14.06	1.61	2.50	2.40	1.47
P3 X P5	11.23	22.51	2.04	3.24	2.51	1.76
P3 X P6	11.91	27.85	2.01	3.62	2.68	2.27
P4 X P5	9.73	18.92	1.77	2.78	2.34	1.67
P4 X P6	9.85	22.49	1.72	3.05	2.34	2.00
P5 X P6	10.08	23.19	1.75	3.16	2.37	2.01
F. test	**	**	**	**	**	**
LSD 5%	1.53		0.12		0.03	
Mean	**8.38**	**15.82**	**1.57**	**2.41**	**2.26**	**1.52**

Character / Genotype	Flowering date (day)		Seed filling Period (day)		Plant height (cm)	
	N	D	N	D	N	D
P1	44.33	41.33	33.00	30.00	184.40	119.70
P2	44.33	40.00	29.00	25.67	188.47	138.20
P3	48.33	45.00	28.00	25.33	166.23	114.53
P4	46.67	43.00	40.67	37.00	231.87	182.63
P5	50.33	44.00	42.00	37.00	234.73	188.27
P6	44.33	41.00	41.67	36.33	252.77	204.47
P1 X P2	40.33	37.33	26.33	23.00	189.40	149.67
P1 X P3	41.00	37.00	24.67	22.33	177.27	128.40
P1 X P4	42.00	39.00	30.67	28.00	261.73	218.47
P1 X P5	41.33	38.00	31.00	27.00	269.00	228.53
P1 X P6	41.00	38.33	30.67	26.00	279.37	253.53
P2 X P3	40.00	36.00	24.67	21.33	182.60	152.47
P2 X P4	40.33	36.33	26.67	22.67	262.80	223.60
P2 X P5	40.00	36.00	26.33	22.67	275.87	248.00
P2 X P6	40.33	36.67	26.33	23.00	295.60	277.73
P3 X P4	41.67	37.67	25.00	21.33	274.27	233.73
P3 X P5	43.00	38.67	24.33	21.00	271.53	256.07
P3 X P6	40.33	37.00	26.00	22.67	302.67	276.67
P4 X P5	45.67	44.33	39.67	38.00	264.93	222.73
P4 X P6	43.33	42.33	39.33	38.00	271.40	227.00
P5 X P6	43.33	41.67	40.67	38.67	270.07	235.73
F. test	N.S	N.S	N.S	N.S	**	**
LSD 5%	-		-		5.51	
Mean	**42.95**	**39.56**	**31.27**	**27.95**	**273.19**	**203.82**

Table 7: continued

Character / Genotype	Stem diameter (cm)		Head diameter (cm)		No. of green leaves/plant	
	N	D	N	D	N	D
P1	2.91	2.46	20.07	15.87	22.23	15.53
P2	2.41	1.92	28.83	20.87	17.20	14.53
P3	2.89	1.73	19.80	13.67	15.93	12.53
P4	3.23	2.06	21.23	19.67	21.13	19.40
P5	3.46	2.17	24.07	20.37	21.13	20.20
P6	3.43	2.19	23.47	19.67	23.40	22.27
P1 X P2	3.08	2.63	24.13	23.27	23.00	17.40
P1 X P3	2.93	2.52	20.07	17.20	24.00	16.93
P1 X P4	3.86	2.96	25.87	24.78	27.33	24.80
P1 X P5	4.06	3.03	28.27	26.27	28.93	25.40
P1 X P6	4.20	3.11	29.73	25.13	31.40	27.53
P2 X P3	2.99	2.06	23.47	21.07	17.93	15.40
P2 X P4	3.87	2.53	26.93	26.33	26.27	23.67
P2 X P5	4.25	2.85	29.27	28.20	27.33	23.47
P2 X P6	4.23	2.99	30.47	28.80	29.93	24.73
P3 X P4	3.72	2.56	26.80	24.67	27.33	24.53
P3 X P5	4.45	2.87	29.13	27.00	28.13	26.20
P3 X P6	4.48	2.99	30.60	28.13	30.80	25.47
P4 X P5	3.84	2.60	26.07	22.40	24.60	20.87
P4 X P6	3.80	2.51	26.93	23.07	26.13	23.07
P5 X P6	3.87	2.47	26.47	21.80	26.73	24.40
F. test	**	**	N.S	N.S	**	**
LSD 5%	0.10		-		1.68	
Mean	3.62	2.53	25.51	22.78	24.81	21.35

Character / Genotype	100-seed weight (g)		Seed yield/plant (g)		Oil percentage (%)	
	N	D	N	D	N	D
P1	8.41	5.38	65.79	19.29	48.73	38.75
P2	7.45	4.87	76.58	25.96	48.92	35.49
P3	5.41	4.76	40.33	18.18	42.49	34.29
P4	7.60	7.32	111.00	92.09	44.11	43.75
P5	6.28	5.95	109.03	74.79	43.12	39.45
P6	7.61	6.59	89.30	79.42	44.11	43.48
P1 X P2	8 91	5.81	99.71	33.96	46.78	39.52
P1 X P3	8.49	5.70	88.97	26.92	45.84	38.95
P1 X P4	10.00	7.20	163.19	137.37	48.33	40.16
P1 X P5	10.17	7.60	163.40	116.38	49.11	42.41
P1 X P6	10.59	8.43	147.29	132.63	49.82	43.82
P2 X P3	8.70	5.16	103.41	37.62	46.99	37.77
P2 X P4	10.22	9.15	165.73	140.58	49.17	46.11
P2 X P5	10.56	7.71	170.13	121.65	49.89	43.16
P2 X P6	10.62	8.89	150.12	139.36	50.13	46.24
P3 X P4	9.49	8.60	168.74	141.14	44.87	44.36
P3 X P5	8.11	7.68	174.96	126.003	43.77	42.36
P3 X P6	10.04	8.44	152.81	134.51	47.99	43.87
P4 X P5	8.97	8.29	155.73	127.84	42.21	43.00
P4 X P6	8.67	7.86	161.29	131.97	46.46	42.95
P5 X P6	8.83	7.38	161.32	123.50	47.31	41.32
F. test	**	**	**	**	**	**
LSD 5%	0.49		3.93		1.15	
Mean	8.82	7.08	129.47	94.34	46.91	41.49

* and ** = significant at 0.05 and 0.01 probability, respectively
N=normal irrigation and D = drought stress conditions

Positive heterosis for leaf area index is important because higher leaf area index helps to synthesize photosynthates in greater quantities that are translocated to seed during seed filling. Results given in Table 8 revealed that all of the cross combinations manifested positive highly significant heterosis over mid parent and better parent for leaf area index under both normal irrigation and drought stress conditions. Cross combination P2 x P6 (66.15 %) showed maximum positive heterosis over mid parent followed by P2 x P5 (55.85 %) for leaf area index under normal irrigation as well as P3 x P6 (106.93 %) followed by P2 x P6 (92.49 %) under drought stress conditions. For better parent under normal irrigation, cross combination P3 x P6 (30.76 %) exhibited positive highly significant heterosis followed by P2 x P6 (30.62 %); while under drought stress condition, single cross P3 x P6 (33.37 %) exhibited positive highly significant heterosis followed by P2 x P6 (35.55 %).

Early flowering provide sufficient time for seed formation process and if flowering date is delayed the seed filling period is altered resulting in poor seed formation especially loss of seed weight. Hence for early flowering and minimum number of seed filling period negative heterosis is desirable. Results given in Table 8 revealed that most of the cross combinations manifested negative highly significant heterosis over mid parent and better parent for flowering date and seed filling period under both normal irrigation and stress conditions. Under normal irrigation conditions, highest negative heterotic effect was recorded by single cross P2 x P5 (-15.49 %) over mid parent followed by P2 x P3 (-13.67 %) for flowering date; while under stress conditions of the same trait, cross combination P2 x P3 (-15.29 %) showed highly significant and negative heterosis over mid parent followed by P3 x P4 (-14.93 %). In case of better parent for flowering date, cross combination P3 x P5 (-11.03 %) showed negative highly significant heterosis followed by P3 x P4 (-10.71 %) under normal irrigation. On the other hand, cross combination P3 x P4 (-12.40 %) showed negative highly significant heterosis followed by P3 x P5 (-12.12 %) under drought stress conditions. However, highest negative heterotic effect was recorded by cross combination P3 x P5 over mid parent and better parent for seed filling period followed by P3 x P4 under both normal irrigation and drought stress conditions.

Short-stature sunflower plants are preferred because plants with greater height are likely to lodge during wind storm. Therefore, for plant height heterosis in the negative direction is desirable. The results of heterosis (Table 8) revealed that none of the crosses depicted negative heterosis for plant height.

Positive heterosis for both stem and head diameter are important because its are an effective yield related parameters. Heterotic studies for both stem and head diameter showed that most of the cross combinations manifested positive highly significant heterosis of mid parént and better parent under both normal irrigation and drought stress conditions. Under normal irrigation conditions, maximum positive highly significant heterosis over mid parent was depicted by single cross P2 x P6 (44.86 %) followed by P2 x P5 (44.55 %) for stem diameter and P3 x P6 (41.45 %) followed by P1 x P6 (36.60 %) for head diameter; also the cross combination P3 x P6 (30.73 %) showed maximum positive heterosis for stem diameter over better parent followed by P3 x P5 (28.59 %) and P3 x P6 (30.04 %) followed by P2 x P6 (29.83 %) for head diameter. Under drought stress conditions, cross combination P3 x P6 for both stem and head diameters showed positive and highly significant heterosis of mid parent and better parent.

Positive heterosis for No. of green leaves/plant at the end of pollination is important because it is an effective yield related parameter. Heterotic studies for No. of green leaves/plant showed that most of the cross combinations expressed highly significant heterosis of mid parent and better parent in the desired direction (positive). Under normal irrigation conditions, maximum positive heterosis over mid parent value was demonstrated by cross combination P3 x P6 (56.61 %) followed by P3 x P5 (51.80 %); while cross combination P1 x P6 (34.19 %) for this trait showed maximum positive heterosis of better parent followed by P3 x P5 (33.12 %). Under drought stress conditions, maximum positive and highly significant heterosis for No. of green leaves/plant depicted by crosses P3 x P5 (60.08 %) and (29.70 %) followed by crosss P3 x P4 (53.65 %) and (26.46 %) for both mid parent and better parent, respectively.

Data in Table 8 revealed that most of the cross combinations manifested highly significant and positive heterosis over mid parent and better parent value for 100-seed weight under both normal irrigation and drought stress conditions. Cross combination P3 x P6 (54.24 %) for 100-seed weight showed maximum positive heterosis over mid parent followed by P2 x P5 (53.82 %) under normal irrigation; while under drought stress conditions, maximum increase of 55.20% in 100-seed weight over mid parent was recorded for cross combination P2 x P6 followed by P2 x P4 (50.09 %) for 100-seed weight. For better parent of 100-seed weight under normal irrigation, cross combination P2 x P5 (41.79 %) exhibited positive highly significant heterosis followed by P2 x P6 (39.62 %); whereas under drought stress conditions, single cross P2 x P6 (34.99 %) showed positive highly significant followed by P2 x P5 (29.57 %).

Data in Table 8 revealed that all the cross combinations manifested positive highly significant heterosis over mid parent and better parent value for seed yield/plant under both normal irrigation and water stress conditions. Maximum increase of 135.76 % in seed yield/plant over mid parent was given by P3 x P6 followed by P3 x P5 (134.28 %) under normal irrigation conditions; whereas under drought stress conditions, maximum positive highly significant heterosis over mid parent value was demonstrated by cross combination P3 x P6 (175.63 %) followed by P3 x P5 (171.11 %) for seed yield/plant. For better parent of seed yield/plant under normal irrigation condition, cross combination P3 x P6 (71.13 %) exhibited positive highly significant heterosis followed by P2 x P6 (68.11 %); whereas, under drought stress condition, single cross P2 x P6 (75.48 %) showed positive highly significant followed by P3 x P6 (69.37 %).

Sunflower cultivars with higher percentage of oil are needed for higher oil yield per unit area, therefore, highly significant and positive heterosis is desirable. Heterosis studies for oil percentage under both normal irrigation and drought stress conditions showed that most of the cross combinations expressed highly significant heterosis over mid parent and better parent in the desired direction (positive). Maximum positive heterosis over mid parent value for oil percentage under normal irrigation was demonstrated by cross combination P3 x P6 (10.84 %) followed by P5 x P6 (8.47 %); whereas under drought stress conditions, cross combination P2 x P6 gave maximum increase of (17.10 %) over mid parent for oil percentage followed by P2 x P4 (16.37 %). For better parent of oil percentage under normal irrigation, cross combination P3 x P6 (8.80 %) showed maximum positive heterosis followed by P4 x P5 (7.02 %); whereas under drought stress condition, maximum positive highly significant heterosis of better parent was depicted by cross P2 x P5 (9.41 %) followed by P1 x P5 (7.50 %). The results agreed with those obtained by Stoenescu *et al.* (1985) for earliness characters, Vranceanu and Pirvu (1988) for seed yield/plant and oil percentage.

Table 8: Percentage heterosis over mid parent (M.P) and better parent (B.P) for F_1 crosses for all studied characters under both normal irrigation and drought stress conditions

Trait / Cross	Osmotic pressure (bar)				Osmotic pressure at full turgor (bar)			
	N		D		N		D	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
P1 X P2	-4.49**	-24.09**	6.43**	-11.91**	7.21**	-8.45**	11.00**	-3.79**
P1 X P3	27.11**	17.50**	25.43**	13.07**	22.41**	14.68**	26.29**	19.07**
P1 X P4	33.86**	20.26**	64.86**	58.22**	35.24**	25.26**	55.72**	44.33**
P1 X P5	59.56**	57.65**	107.28**	70.03**	51.02**	49.50**	78.73**	51.52**
P1 X P6	75.45**	75.08**	153.45**	99.41**	59.74**	54.70**	101.37**	68.04**
P2 X P3	63.38**	38.43**	56.18**	41.81**	50.40**	36.13**	47.07**	34.44**
P2 X P4	76.96**	53.95**	100.65**	60.76**	60.55**	46.94**	81.48**	47.56**
P2 X P5	108.73**	64.43**	152.62**	79.33**	81.46**	53.67**	109.87**	58.47**
P2 X P6	124.53**	78.73**	194.81**	102.80**	90.69**	67.40**	128.65**	70.53**
P3 X P4	52.37**	47.70**	89.87**	65.02**	47.51**	45.71**	73.40**	52.26**
P3 X P5	83.55**	67.82**	143.13**	84.10**	70.00**	57.77**	99.39**	61.10**
P3 X P6	97.69**	83.10**	179.27**	103.95**	75.50**	69.59**	117.04**	72.81**
P4 X P5	63.68**	45.49**	82.39**	54.74**	49.43**	37.12**	52.37**	38.25**
P4 X P6	68.29**	45.49**	102.85**	54.74**	51.74**	37.12**	63.41**	38.25**
P5 X P6	52.76**	51.47**	79.18**	64.70**	29.02**	44.90**	53.92**	45.72**
LSD5%	1.4	1.4	2.9	2.9	0.14	0.14	0.20	0.20
LSD1%	1.9	1.9	3.97	3.97	0.19	0.19	0.27	0.27
Trait / Cross	Leaf area index				Flowering date (day)			
	N		D		N		D	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
P1 X P2	40.46**	6.00**	36.77**	9.19**	-9.02**	-9.02**	-8.20**	-6.67**
P1 X P3	10.77**	1.04**	51.48**	7.73**	-11.51**	-7.52**	4.29**	-10.48**
P1 X P4	45.24**	18.95**	23.44**	22.06**	-7.69**	-5.26**	-7.51**	-5.64**
P1 X P5	30.81**	20.95**	33.81**	24.17**	-12.68**	-6.77**	-10.94**	-8.06**
P1 X P6	32.49**	25.21**	53.26**	29.08**	-7.52**	-7.52**	-6.88**	-6.51**
P2 X P3	26.62**	2.43**	23.17**	5.18**	-13.67**	-9.77**	-15.29**	-10.00**
P2 X P4	38.71**	24.73**	57.47**	26.78**	-11.36**	-9.02**	-12.45**	-9.17**
P2 X P5	55.85**	24.67**	72.57**	30.35**	-15.49**	-9.77**	-14.29**	-10.00**
P2 X P6	66.15**	30.62**	92.49**	35.55**	-9.02**	-9.02**	-9.46**	8.33**
P3 X P4	42.59**	26.46**	80.50**	29.24**	-12.28**	-10.71**	-14.93**	-12.40**
P3 X P5	30.20**	28.30**	90.07**	29.39**	-12.84**	-11.03**	-13.11**	-12.12**
P3 X P6	35.77**	30.76**	106.93**	33.37**	-12.95**	-9.02**	-13.95**	-9.76**
P4 X P5	36.76**	19.75**	33.52**	22.63**	-5.84**	-2.14	1.92	3.10**
P4 X P6	33.22**	19.75**	40.80**	22.63**	-4.76**	-2.14	0.79	3.10**
P5 X P6	18.64**	14.36**	31.38**	17.51**	-8.45**	-2.26*	-1.96	3.25**
LSD5%	0.02	0.02	0.05	0.05	2.3	2.3	1.97	1.97
LSD1%	0.023	0.023	0.07	0.07	3.03	3.03	2.66	2.66

Table 8: Continued

Trait / Cross	Seed filling period (day)				Plant height (cm)			
	N		D		N		D	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
P1 X P2	-15.06**	-9.20**	-17.37**	-10.39**	1.59	2.71	16.07**	25.04**
P1 X P3	-19.13**	-11.90**	-19.28**	-11.84**	1.11	6.64	9.63*	12.11*
P1 X P4	-16.74**	-7.07**	-16.42**	-6.67**	25.75**	41.94**	44.52**	82.51**
P1 X P5	-17.33**	-6.06**	-19.40**	-10.00**	28.36**	45.88**	48.41**	90.92**
P1 X P6	-17.86**	-7.07**	-21.61**	-13.33**	27.81**	51.50**	56.42**	111.81**
P2 X P3	-13.45**	-11.90**	-16.34**	-15.79**	2.96	9.85**	20.66**	33.12**
P2 X P4	-23.44**	-8.05**	-27.66**	-11.69**	25.04**	39.44**	39.39**	61.80**
P2 X P5	-25.82**	-9.20**	-27.66**	-11.69**	30.37**	46.37**	51.93**	79.45**
P2 X P6	-25.47**	-9.20**	-25.81**	-10.39**	33.99**	56.84**	62.10**	100.97**
P3 X P4	-27.19**	-10.17**	-31.55**	-15.79**	37.79**	64.99**	57.31**	104.08**
P3 X P5	-30.48**	-13.10**	-32.62**	-17.10**	35.44**	63.35**	69.13**	123.58**
P3 X P6	-25.36**	-7.14**	-26.49**	-10.52**	44.47**	82.07**	73.46**	141.56**
P4 X P5	-4.03**	-2.46	2.70*	2.70*	13.56**	14.26**	20.10**	21.96**
P4 X P6	-4.46**	-2.46	3.64**	2.70*	12.00**	14.26**	17.28**	21.96**
P5 X P6	-2.79	-3.28	5.46**	4.59**	10.80**	17.05**	20.05**	24.29**
LSD5%	**2.8**	**2.8**	**2.69**	**2.69**	**6.8**	**6.8**	**9.5**	**9.5**
LSD1%	**3.8**	**3.8**	**3.63**	**3.63**	**9.2**	**9.2**	**12.78**	**12.78**

Trait / Cross	Stem diameter (cm)				No. of green leaves/plant			
	N		D		N		D	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
P1 X P2	15.77**	5.84**	20.23**	6.90**	16.36**	2.99**	15.75**	12.02**
P1 X P3	0.83**	0.48**	20.34**	2.43**	25.44**	7.46**	20.67**	9.01**
P1 X P4	25.67**	19.51**	31.11**	20.30**	25.77**	22.39**	41.99**	27.84**
P1 X P5	27.45**	17.33**	30.67**	22.90**	33.13**	29.55**	42.17**	25.74**
P1 X P6	32.40**	22.47**	33.46**	26.15**	37.32**	34.19**	45.68**	23.65**
P2 X P3	12.82**	3.46**	13.13**	7.62**	8.25**	4.26**	13.80**	5.97**
P2 X P4	37.06**	19.72**	27.48**	23.14**	37.05**	24.29**	39.49**	22.00**
P2 X P5	44.55**	22.64**	39.32**	31.20**	42.61**	29.34**	35.13**	16.17**
P2 X P6	44.86**	23.43**	45.35**	36.21**	44.50**	25.36**	34.42**	11.08**
P3 X P4	21.61**	15.26**	33.36**	24.60**	47.47**	29.32**	53.65**	26.46**
P3 X P5	40.12**	28.59**	47.03**	32.12**	51.80**	33.12**	60.08**	29.70**
P3 X P6	41.77**	30.73**	52.28**	36.21**	56.61**	31.62**	46.36**	14.37**
P4 X P5	14.84**	10.97**	23.16**	19.95**	16.41**	16.41**	5.39**	3.30**
P4 X P6	14.08**	10.97**	18.12**	19.95**	17.37**	16.41**	10.72**	3.30**
P5 X P6	12.25**	10.80**	13.36**	14.46**	20.06**	11.68**	14.91**	3.59**
LSD5%	**0.14**	**0.14**	**0.14**	**0.14**	**2.9**	**2.9**	**2.08**	**2.08**
LSD1%	**0.19**	**0.19**	**0.19**	**0.19**	**3.9**	**3.9**	**2.81**	**2.81**

Table 8: Continued

Trait / Cross	Head diameter (cm)				100-seed weight (g)			
	N		D		N		D	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
P1 X P2	12.51**	5.69**	26.68**	11.50**	12.39**	6.00**	13.37**	8.01**
P1 X P3	0.84	0.17	16.48**	8.40**	22.86**	1.00**	11.21**	5.95**
P1 X P4	25.26**	21.83**	39.96**	26.44**	24.98**	19.00**	13.43**	-1.59**
P1 X P5	28.10**	17.45**	44.99**	28.97**	38.42**	20.95**	34.12**	27.72**
P1 X P6	36.60**	26.70**	41.46**	27.79**	32.26**	26.00**	40.93**	28.08**
P2 X P3	10.09**	2.78**	22.01**	0.96**	35.32**	16.84**	5.97**	5.97**
P2 X P4	22.29**	17.96**	29.93**	26.20**	35.87**	34.51**	50.09**	25.01**
P2 X P5	24.81**	21.61**	36.78**	35.14**	53.82**	41.79**	42.46**	29.57**
P2 X P6	31.61**	29.83**	42.10**	38.02**	41.11**	39.62**	55.20**	34.99**
P3 X P4	30.63**	26.22**	48.00**	25.42**	45.83**	24.85**	42.29**	17.45**
P3 X P5	32.82**	21.05**	58.67**	32.57**	38.59**	29.00**	43.40**	29.12**
P3 X P6	41.45**	30.04**	68.80**	43.05**	54.24**	31.99**	48.66**	28.07**
P4 X P5	15.09**	8.31**	11.91**	9.98**	29.19**	18.00**	24.95**	13.26**
P4 X P6	20.51**	8.31**	17.29**	9.98**	13.94**	18.00**	12.99**	13.26**
P5 X P6	11.36**	14.77**	8.91**	17.29**	27.06**	13.88**	17.73**	7.35**
LSD5%	**3.19**	**3.19**	**3.21**	**3.21**	**0.83**	**0.83**	**0.61**	**0.61**
LSD1%	**4.3**	**4.3**	**4.33**	**4.33**	**1.12**	**1.12**	**0.83**	**0.83**

Trait / Cross	Seed yield/plant (g)				Oil percentage (%)			
	N		D		N		D	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
P1 X P2	40.06**	30.20**	50.13**	30.84**	-4.20**	-4.38**	6.46**	1.99*
P1 X P3	67.67**	35.23**	43.70**	39.59**	0.49	-5.94**	6.66**	0.52
P1 X P4	84.61**	47.02**	146.66**	49.16**	4.11**	-0.82	-2.64**	-8.21**
P1 X P5	86.93**	49.87**	147.41**	55.61**	6.94**	0.78	8.46**	7.50**
P1 X P6	89.94**	64.94**	168.74**	67.00**	7.31**	2.22*	6.59**	0.79
P2 X P3	76.90**	35.03**	70.46**	44.93**	2.81**	-3.95**	8.25**	6.42**
P2 X P4	76.70**	49.31**	138.17**	52.65**	5.70**	0.51	16.37**	5.39**
P2 X P5	83.32**	56.05**	141.50**	62.66**	8.41**	1.98*	15.18**	9.41**
P2 X P6	81.00**	68.11**	169.51**	75.48**	7.77**	2.47**	17.10**	6.35**
P3 X P4	123.00**	52.02**	155.98**	53.26**	3.62**	1.71	13.67**	1.39
P3 X P5	134.28**	60.48**	171.11**	68.51**	2.24**	1.49	14.89**	7.39**
P3 X P6	135.76**	71.13**	175.63**	69.37**	10.84**	8.80**	12.81**	0.89
P4 X P5	41.56**	40.30**	53.21***	38.82**	8.24**	7.02**	3.37**	-1.71*
P4 X P6	61.05**	40.30**	53.89**	38.82**	5.31**	7.02**	-1.52	-1.71*
P5 X P6	62.69**	45.31**	60.18**	43.30**	8.47**	5.31**	-0.35	-1.82*
LSD5%	4.17	4.17	7.21	7.21	1.77	1.77	1.68	1.68
LSD1%	5.63	5.63	9.73	9.73	2.38	2.38	2.27	2.27

*** and ** = significant at 0.05 and 0.01 probability, respectively**
N=normal irrigation and D = drought stress conditions

Correlation:

Genotypic and phenotypic correlation coefficients between seed yield/plant and some sunflower traits under both normal irrigation and drought stress conditions are shown in Table 9. Under both normal irrigation and drought stress conditions, the magnitude of genotypic and phenotypic correlations was nearly the same, indicating the minimal influence of environment on relationships. Also, under both normal irrigation and drought stress conditions, a highly significant and positive correlation was found between seed yield/plant and all studied traits, except oil percentage under normal irrigation conditions (Control) which was non significantly positively correlated at both the phenotypic and genotypic levels.

In general, to increase seed yield/plant under both normal irrigation and drought stress conditions, selection should be carried out for higher osmotic pressure, osmotic pressure at full turgor, plant height, No. of green leaves/plant, 100-seed weight and oil percentage, large leaf area index, stem diameter and head diameter. These results agreed with those reported by Tahir *et al.* (2002).

Table 9: Genotypic and phenotypic correlation coefficients between seed yield/plant and some sunflower traits under both normal irrigation and drought stress conditions

Treatment \ Character		OP (bar)	OP_{ft} (bar)	Leaf area index	No. of green leaves/ plant	Plant height (cm)	Stem diam. (cm)	Head diam. (cm)	100-seed weight (g)	Oil %
Control	r_g	0.78**	0.83**	0.56**	0.84**	0.88**	0.87**	0.90**	0.74**	0.38
	r_p	0.77**	0.82**	0.56**	0.82**	0.88**	0.87**	0.86**	0.72**	0.37
Drought	r_g	0.88**	0.87**	0.79**	0.94**	0.95**	0.68**	0.83**	0.96**	0.85**
	r_p	0.80**	0.87**	0.79**	0.93**	0.94**	0.68**	0.80**	0.95**	0.84**

OP, OP_{ft} = osmotic pressure and osmotic pressure at full turgor, respectively
*** and ** = significant at 0.05 and 0.01 probability, respectively**

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قوة الهجين و الأرتباط الوراثي والمظهري في هجن دوار الشمس تحت ظروف الري الطبيعي والجفاف

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- *** قسم المحاصيل-كلية الزراعة-جامعة المنصورة- مصر**
- **** قسم بحوث المحاصيل الزيتية-معهد بحوث المحاصيل الحقلية-مركز البحوث الزراعية- مصر**

أقيمت تجربتان حقليتان بمحطة بحوث كفر الحمام بمحافظة الشرقية-مصر أثناء الموسم الصيفي للأعوام ٢٠٠٧ و ٢٠٠٨ ، هجن ٦ اباء لدوار الشمس لدياليل نصف حلقي ٦ x ٦ في الموسم الصيفي ٢٠٠٧، وقيمت الهجن والأباء تحت معاملتي ري ، المعاملة الأولي الري الطبيعي كل ١٥ يوم ، والمعاملة الثانية (معاملة الجفاف) حيث منع الري بعد رية المحاياه وحتى الحصاد في الموسم الصيفي ٢٠٠٨ ، وذلك لتقدير قوة الهجين و الأرتباط الوراثي والمظهري للصفات المورفوفسيولوجية ، التبكير ، المحصول ومكوناته ونسبة الزيت

أشارت نتائج تحليل التباين إلي وجود فروق عالية المعنوية بين كل من التراكيب الوراثية والأباء والهجن لكل الصفات المدروسة تحت ظروف كل من الري الطبيعي والجفاف.

كانت قيم التباين الرلجعة للتفاعل بين الري والتراكيب الوراثية عالية المعنوية لكل الصفات المدروسة ماعدا صفات التبكير وقطر القرص.

أظهرت النتائج أن كل التوليفات الجديدة في الجيل الأول أظهرت قوة هجين في الصفات المدروسة. .
تحققت أكبر زيادة عن متوسط الأباء لصفتي الضغط الأسموزي P2 X P6 (١٩٤,٨١%) ومحصول البذور/نبات P3 x P6 (١٧٥,٦٣%) تحت ظروف الجفاف. في حين كان متوسط الزيادة للجيل الأول الهجين أكبر بالنسبة لمتوسط الأباء عن أفضل الأباء لمعظم الصفات والهجن في الأتجاه الموجب.

أشارت النتائج تحت ظروف كل من الري الطبيعي والجفاف إلي وجود أرتباط وراثي ومظهري موجب وعالي المعنوية بين محصول البذور/نبات وكل الصفات المدروسة ما عدا نسبة الزيت تحت ظروف الري حيث كانت موجبة ولكن لم تصل إلي مستوي المعنوية علي المستويين الوراثي والمظهري.