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GENETIC STUDIES ON YIELD AND ITS COMPONENTS IN SOME BARLEY CROSSES

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ABSTRACT

Grain yield and its components and some growth attributes were studied at Sakha Agriculture Research Station during the three successive seasons 2008/09, 2009/10 and 2010/11, to determine the type of gene effects by using the six populations (P_1, P_2 , F_1 , F_2, BC_1 and BC_2) of five barley crosses, namely: cross 1 (Giza 121 × Line 1); cross 2 (Giza 121 × Line 2); cross 3 (Giza 126 × Line 1), cross 4 (Giza 126 × Line 1) and cross 5 (Line 1× Line 2). Generation means were significantly different for all studied traits in all crosses; the mean for F_1 values exceeded the mid parent for all studied traits in the five crosses for days to heading and days to maturity, were earlier than the mid-parent, indicating partial dominance. The F_2 values were approximately equal to the mid parent values and less than the F_1 mean values, indicating that inbreeding depression has occurred. BC_1 and BC_2 mean values varied according to the trait itself, it was in the direction of their respective recurrent parents for the studied characters with some exceptions. Results, in general indicated presence of non-allelic interaction for all studied traits in all crosses under study; the additive effect was more important and greater than the dominance effect for most traits. Among the epistatic components, dominance × dominance was greater in the magnitudes than additive × additive and additive × dominance in the most studied traits. Positive heterotic effects relative to the mid-parent were found for most of the traits in the five crosses, except for heading and maturity dates that showed negative heterotic effects. Also positive heterotic effects relative to the better parent were found for the most of crosses. Heritability estimates in narrow sense were low to moderate for the studied characters in all crosses, ranged from 16.37% for spike length in the fifth cross to 66%for days to heading in the second cross. The predicted genetic advance was low to moderate in all studied traits. The crosses Giza 121 × line 1, Giza 126 × line 1 and line 1 × line 2 would be of interest in a breeding program, for improving characters of earliness, yield and its components.
Keywords: Barley, Heterosis, Gene action, Heritability, Genetic advance.

INTRODUCTION

In Egypt, barley *(Hordeum vulgare L.)* is one of the most important cereal crops mainly used for animal feed (grain and straw) and bread making by Bedouins. Also, it is one of the most important winter cereal crops grown mainly in rainfed areas where limited water supply is a feature such as in the Northwest Coastal region and North of Sinai, also grow over wide range of soil variability and under many diverse climatic conditions compared with many other grain crops.

The choice of an efficient breeding program depends largely on the knowledge of gene action involved in the expression of the character. Different genetic cross designs such as generation mean, line × tester and diallel analyses were used to estimate gene action of yield and its components in barley. Generation mean analysis is a simple but useful technique for estimating gene effects for a polygenic trait, its greatest merit lying in the ability to estimate epistatic gene effects such as additive × additive (aa), dominance × dominance (dd) and additive × dominance (ad) effects (Singh and Singh, 1999). Besides gene effects, breeders would also like to know how much of the variation in a crop is genetic and to what extent this variation is heritable. This is because efficiency of selection mainly depends on additive genetic variance, influence of the environment and interaction between genotype and the environment.

The present investigation was planned to determine the type of gene action and to estimate some genetic parameters in five barley crosses derived from four parental barley genotypes using six populations of each cross.

MATERIALS AND METHODS

The present study was carried out at the Experimental Farm of Sakha Agricultural Research Station (SARS), North region of Nile Delta, Agricultural Research Center (ARC), Egypt, during three winter successive growing seasons i.e., (2008/09), (2009/10) and (2010/11). The genetic materials used in this investigation included four barley genotypes representing a wide range of diversity for several agronomic characters presented in Table 1, to determine the type of gene effects using the six populations (P_1, P_2 , F_1 , F_2, BC_1 and BC_2).

Table (1): Name, pedigree and origin of the four barley genotypes.

No	Name	Origin	Pedigree
1	Giza 121	Egypt	Baladi 16/Gem
2	Giza 126	Egypt	'Baladi Bahteem'/، SD729-por12762-Bc'
3	Line 1	ICARDA	Alanda// Lignee 527/ Arar
4	Line 2	ICARDA	M64-76/ Bon/ Jo/York/3/M5/Galt//As 46/ 4/ Hj 34-80 /Astrix / 5 /NK /272

In the first season the four parental barley genotypes shown in table 1 were grown and five crosses were chosen and crossing was made by hand; *i.e.,* cross 1(Giza 121× Line 1), cross 2 (Giza 121× line 2), cross 3 (Giza 126 × Line 1), cross 4 (Giza 126 × line 2) and cross 5 (line 1× line 2). In the second season, seeds of the five F_1's were sown to produce F_1 plants. Each of F_1 plants were crossed back to their respective parent to produce first correspondent backcross (BC_1) and the correspondent second backcross (BC_2) in the same time also, the four parents were re-crossed again in the same season to produce the F_1's seeds of the five crosses, and the F_1 plants were selfed to produce F_2 seeds. In the third season, the obtained seeds of the six populations P_1, P_2, F_1, F_2, BC_1 and BC_2 of five crosses were grown together during the cropping season (2010/11) in three replications in rows, 3 m long. The spaces between rows were 30 cm, while it was 10 cm between plants. Each plot consisted of 17 rows ($1P_1$, $1P_2$, $1F_1$, $2BC_1$, $2BC_2$ and $10F_2$).

All recommended culture practices were applied at proper time as in barley production. Data were recorded on 30, 30, 300 and 75 random guarded plants for each parent, F_1, F_2 and each backcross of each cross. The studied traits were; days to heading (day), days to maturity(day), flag leaf area(cm^2), total chlorophyll content/plant, plant height (cm), spike length(cm), number of spikes/ plant, number of grains/spike, 100-grain weight (g) and grain yield/ plant (g). Various biometrical parameters were calculated for different traits only if the F_2 genetic variance was significant. Heterosis was expressed as the percentage of the deviation of F_1 hybrid over mid and better parent values. Inbreeding depression was calculated as the difference between the F_1 and F_2 means expressed as a percentage of the F_1 mean.

Statistical and genetic analysis:

The population means and the variances were used to carry on Scaling test as outlined by Mather (1949) and Hayman and Mather (1955), to determine the presence of non-allelic gene interactions. Means of the six populations in each cross were used to estimate the six parameters of gene effects, using Gamble's procedure (1962). The standard error of a, d, aa, ad and dd was obtained by taking the square root of their respective variances. **"t"** test values were calculated by dividing the effects of a, d, aa, ad and dd on their respective standard errors. Heritability estimates were computed in both broad (h^2b) and narrow senses (h^2n) for F_2 generation according to Allard (1960) and Mather (1949). While, the expected genetic advance under selection (Δg) was computed according to Johnson *et al.,* (1955). In addition, this expected gain was expressed as a percentage of F_2 mean (Δg %) according to Miller *et al.,* (1958).

RESULTS AND DISCUSSION

Mean performance.

Mean and variance of the studied traits in the five crosses for six populations P_1, P_2, F_1, F_2, BC_1 and BC_2 are presented in Table 2. Data indicated that there were significant differences among generations in all traits under study.

The F_1 mean performance values exceeded the mid values of the two parental means for most of studied traits in the five crosses except heading and maturity dates, which were earlier than the mid parent indicating the presence of partial dominance.

The F_2 population mean performance value was intermediate between the two parents and less than F_1 mean performance values for most crosses. While, F_2 populations mean performance values were late than F_1 mean values for heading and maturity dates cleared the importance of non-additive components of genetic variance for the studied traits. However, both BC_1 and BC_2 mean performance values varied according to the cross itself and tended towards the mean of its recurrent parent. Similar results were obtained by Eid (2006) and El- Sayed (2007).

Table (2): Mean performance (X¯) and ± standard error (SE) of the six populations (P_1, P_2, F_1, F_2, BC_1 and BC_2) for all studies characters in the five crosses.

character	Crosses	P_1	P_2	F_1	F_2	BC_1	BC_2
Days to heading (day)	1	90.50±0.10	87.97±0.07	89.00±0.13	92.86±0.06	91.17±0.18	90.40±0.19
	2	91.03±0.09	97.20±0.04	92.77±0.11	95.27±0.09	93.80±0.26	99.87±0.20
	3	97.40±0.07	90.27±0.12	91.02±0.11	97.84±0.04	99.69±0.12	92.27±0.16
	4	99.07±0.09	98.67±0.12	97.01±0.12	98.60±0.08	99.85±0.21	98.44±0.22
	5	88.80±0.04	96.13±0.09	90.85±0.09	97.18±0.05	91.77±0.17	96.45±0.18
Days to maturity (day)	1	136.90±0.10	135.73±0.10	135.27±0.13	137.86±0.06	138.76±0.21	136.15±0.21
	2	136.10±0.10	142.30±0.11	138.10±0.10	139.60±0.07	136.00±0.23	137.90±0.21
	3	144.80±0.07	135.60±0.10	140.07±0.08	138.86±0.06	141.81±0.19	139.45±0.18
	4	144.40±0.07	137.60±0.11	139.13±0.07	140.48±0.07	142.45±0.24	139.67±0.20
	5	135.73±0.10	143.40±0.11	137.30±0.11	138.95±0.06	136.59±0.19	139.20±0.20
Flag leaf area (cm^2)	1	13.07±0.02	3.41±0.00	13.59±0.06	10.06±0.02	8.96±0.06	7.45±0.04
	2	12.55±0.01	5.24±0.01	7.53±0.05	9.36±0.02	9.68±0.05	8.11±0.05
	3	10.45±0.02	3.42±0.00	11.38±0.06	9.00±0.01	8.04±0.05	8.18±0.05
	4	10.36±0.02	5.14±0.01	9.23±0.04	9.81±0.01	9.76±0.05	8.46±0.04
	5	3.39±0.00	5.20±0.00	6.12±0.04	6.00±0.01	5.60±0.02	6.96±0.03
Total chlorophyll Content/plant	1	38.29±0.05	35.40±0.04	39.12±0.08	37.68±0.05	37.36±0.15	36.64±0.17
	2	38.00±0.05	40.20±0.05	40.07±0.05	38.69±0.06	40.19±0.18	42.73±0.19
	3	31.70±0.07	35.60±0.04	36.11±0.06	38.25±0.07	33.81±0.20	37.06±0.21
	4	31.10±0.07	40.46±0.05	36.47±0.06	35.82±0.07	33.20±0.23	37.91±0.23
	5	35.70±0.04	39.98±0.05	40.71±0.08	37.84±0.06	37.26±0.20	40.08±0.21
Plant height (cm)	1	115.33±0.37	112.50±0.35	115.90±0.38	113.01±0.37	114.20±1.27	113.27±1.32
	2	116.20±0.38	112.33±0.48	119.00±0.48	118.63±0.24	118.30±0.73	113.43±0.79
	3	116.73±0.46	112.00±0.35	120.33±0.47	115.75±0.35	118.73±1.14	114.53±1.21
	4	117.83±0.46	111.50±0.48	121.00±0.44	113.88±0.31	119.00±0.99	113.15±0.96
	5	111.83±0.35	112.33±0.47	110.07±0.48	114.04±0.39	110.40±1.27	113.30±1.32
Spike length (cm)	1	7.87±0.01	7.77±0.01	8.37±0.01	7.02±0.01	7.91±0.02	7.75±0.03
	2	7.50±0.01	7.75±0.01	7.80±0.01	6.78±0.01	7.83±0.02	7.80±0.02
	3	4.32±0.01	7.33±0.01	5.68±0.02	5.30±0.01	4.98±0.02	7.19±0.02
	4	4.90±0.01	7.30±0.01	6.57±0.01	5.98±0.01	9.00±0.02	7.43±0.03
	5	7.51±0.01	7.43±0.01	8.00±0.01	7.32±0.01	8.04±0.02	7.510.03
Number of spikes / plant	1	12.87±0.05	12.51±0.04	14.00±0.06	11.77±0.02	13.14±0.06	12.83±0.07
	2	12.70±0.05	13.67±0.05	13.98±0.06	11.89±0.02	12.81±0.06	13.74±0.08
	3	12.82±0.03	12.44±0.04	14.07±0.04	12.93±0.03	12.97±0.11	12.53±0.09
	4	12.93±0.03	13.52±0.04	14.01±0.06	12.71±0.02	13.02±0.06	13.67±0.04
	5	12.67±0.04	13.87±0.05	13.98±0.06	12.08±0.02	12.90±0.06	13.94±0.06
Number of grains / spike	1	58.09±0.29	59.31±0.20	63.70±0.32	55.10±0.31	56.16±1.10	53.89±1.07
	2	57.00±0.29	55.73±0.26	57.50±0.30	54.30±0.33	54.77±1.19	57.80±1.16
	3	40.57±0.24	59.46±0.19	55.00±0.30	55.12±0.30	54.71±1.07	55.33±1.04
	4	40.70±0.26	55.93±0.26	52.50±0.30	51.98±0.33	53.84±1.17	55.57±1.19
	5	59.40±0.19	55.64±0.26	60.00±0.32	57.72±0.32	61.09±1.13	56.16±1.15
100-grain Weight (g)	1	5.85±0.002	4.33±0.003	6.00±0.003	4.83±0.001	5.04±0.004	4.50±0.003
	2	5.70±0.003	4.20±0.002	5.23±0.003	5.10±0.001	5.21±0.003	4.70±0.003
	3	4.82±0.002	4.35±0.003	4.84±0.003	4.29±0.001	4.80±0.002	4.15±0.003
	4	4.90±0.002	4.26±0.003	4.64±0.003	4.39±0.001	4.70±0.003	4.30±0.003
	5	4.36±0.003	4.22±0.002	5.44±0.003	4.09±0.001	4.26±0.003	4.15±0.003
Grain yield / Plant (g)	1	26.60±0.38	24.71±0.27	27.43±0.41	22.12±0.08	20.02±0.26	20.86±0.29
	2	26.77±0.37	24.19±0.28	27.15±0.38	23.13±0.10	27.32±0.31	24.70±0.33
	3	23.44±0.32	24.63±0.27	24.98±0.36	26.62±0.11	27.34±0.34	26.18±0.33
	4	23.50±0.32	24.25±0.28	24.92±0.32	23.54±0.10	24.45±0.32	24.59±0.31
	5	24.66±0.27	24.17±0.28	24.94±0.32	24.19±0.09	28.84±0.32	24.55±0.29

Cross 1= (Giza 121× Line 1), Cross 2= (Giza 121 × Line 2), Cross 3 = (Giza 126 × Line 1), Cross4 = (Giza 126 × Line 2) and Cross 5 = (Line 1× Line 2).

Estimation of type of gene action:

Generation mean analysis helps plant breeders to determine the relative importance of each type in genetic variation in the inheritance of different quantitative characters and understanding the performance of the parent, which used in the hybrid combinations. Testing for non-allelic interaction (A, B and C) together with the six parameters model and type of epitasis are given in table 3. The results revealed the presence of non-allelic interaction for most studied characters in the most studied crosses except for the fourth cross in chlorophyll content and grain yield/plant, the third cross in no. of spikes/plant and the fifth cross in no. of grains/spike it indicated the absence of non-allelic interaction. It worthy to mention that at least one of the A, B and C tests was significant for the previous characters, indicating adequacy of the six parameter model to explain the type of gene action controlling the trait in these crosses.

The determined mean parameter (m) for all studied attributes was found to be highly significant for the five crosses, it is clear that all studied traits were quantitatively inherited.

Additive gene effects (a) were quiet small in magnitude relative to the dominance gene effects. significant or highly significant positive additive gene effects were obtained for days to heading in the third and fourth crosses, days to maturity in the first, third and fourth crosses, all crosses for flag leaf area except fifth cross, plant height in the second, the third and the fourth crosses, spike length in the fourth and the fifth cross, no. of grains/spike in the fifth cross, all crosses in 100-grain except for the fifth cross and grain yield/plant in the fifth cross. On the other hand, it was negative highly significant for days to heading and maturity dates in the second and the fifth crosses; flag leaf area in the fifth cross, in chlorophyll content in all crosses except for the first cross was non-significant. These results are in harmony with those obtained by Sharma *et al., (2003),* Singh *et al*., (2002), Eid (2006), El-Sayed (2007) and El-Shawy (2008).

The estimates of dominance (d) effects Table 3 were highly significant positive in the second cross for days to heading; the third cross for days to maturity; the first and the fourth crosses in flag leaf area, the second and the fifth crosses in chlorophyll content and grain yield/plant, the fourth cross in plant height and no. of grains/spike, all crosses in spike length, the first, the second and the fifth crosses in no. of spikes/plant and the first, the third and the fifth crosses in 100-grain weight, indicating the importance of dominance gene effects in the inheritance of these traits. On the other hand, significant of (a) and (d) components indicated that both additive and dominance gene effects were important in the inheritance of these traits and selecting desirable traits would be effective in the late generations. These results are in agreement with results of Abul-Naas *et al., (*1993), El-Seidy (1997b), Eid (2006), El-Sayed (2007), El-shawy (2008) and Eshghi, and Akhundova (2009).

Table 3: Estimates of scaling tests and gene effects for all studied characters in the five crosses.

Characters	Crosses	Scaling test			Gene action						Type of Epistasis
		A	B	C	(m)	(a)	(d)	(aa)	(ad)	(dd)	
Days to Heading (day)	1	2.84**	3.83**	14.97**	92.86**	0.77	-8.53**	-8.30**	-0.5	1.63	Dupl.
	2	3.79**	9.76**	7.30**	95.27**	-6.07**	4.91**	6.25**	-2.98**	-19.81**	Dupl.
	3	10.96**	3.25**	21.66**	97.84**	7.42**	-10.26**	-7.45**	3.86**	-6.77**	Comp.
	4	3.62**	1.2	2.66	98.60**	1.41*	0.31	2.17	1.21	-6.99*	Dupl.
	5	3.89**	5.91**	22.07**	97.18**	-4.68**	-13.88**	-12.27**	-1.01	2.46	Dupl.
Days to Maturity (day)	1	5.35**	1.3	8.27**	137.86**	2.610**	-2.67	-1.62	2.03**	-5.03	Comp.
	2	-2.20*	-4.60**	3.80**	139.60**	-1.900**	-11.70**	-10.60**	1.2	17.40**	Dupl.
	3	-1.24	3.24**	-5.10**	138.86**	2.357**	6.97**	7.10**	-2.24**	-9.09**	Dupl.
	4	1.37	2.60**	1.65	140.48**	2.783**	0.46	2.33	-0.62	-6.31*	Dupl.
	5	0.14	-2.30*	2.05	138.95**	-2.610**	-6.47**	-4.21**	1.22	6.36*	Dupl.
Flag leaf Area (cm^2)	1	-8.37**	-3.90**	-10.84**	8.06**	2.51**	4.21**	-1.43	-2.23**	13.69**	Comp.
	2	-0.80	1.55**	0.62**	8.36**	2.57**	-1.23	0.13	-1.17*	-0.88	Comp.
	3	-7.68**	-2.29**	-4.41	8.00**	0.86**	-1.01	-5.56**	-2.70**	15.53**	Dupl.
	4	-2.00	0.59**	-2.63**	7.81**	1.30**	2.75**	1.22	-1.29**	0.19	Comp.
	5	-0.21**	0.63**	3.29**	6.00**	-1.36**	-0.99	-2.87**	-0.42	2.45*	Dupl.
chlorophyll/ plant	1	-2.68**	-1.24	-1.22	37.68**	0.72	-0.43	-2.7	-0.72	6.63**	Dupl.
	2	2.31*	5.19**	-3.59**	38.69**	-2.54**	12.05**	11.08**	-1.44*	-18.58**	Dupl.
	3	-0.19	2.41*	13.48**	38.25**	-3.25**	-8.80**	-11.26**	-1.30*	9.04**	Dupl.
	4	-1.17	-1.11	-1.23	35.82**	-4.71**	-0.36	-1.05	-0.03	3.33	Dupl.
	5	-1.89*	-0.54	-5.7**	37.84**	-2.82**	6.17**	3.30*	-0.68	-0.88	Dupl.
Plant Height (cm)	1	-2.83	-1.86	-7.59**	113.01**	0.93	4.88	2.90	-0.49	1.79	Comp.
	2	1.40	-4.47*	7.98**	118.63**	4.87**	-6.33	-11.06**	2.94*	14.13*	Dupl.
	3	0.40	-3.26	-6.39*	115.75**	4.20**	9.50*	3.53	1.84	-0.67	Dupl.
	4	-0.83	-6.2**	-15.80**	113.88**	5.85**	15.10**	8.77*	2.68	-1.73	Dupl.
	5	-1.10	4.20	11.87**	114.04**	-2.90	-10.79**	-8.77*	-2.65	5.67	Dupl.
Spike length (cm)	1	0.30	0.01	11.17**	7.02**	0.16	3.81**	3.25**	0.11	-2.20*	Dupl.
	2	0.26	0.009	6.98**	6.78**	0.03	4.30**	4.13**	0.16	-4.54**	Dupl.
	3	0.32	0.011	8.68**	5.30**	-2.21**	2.99**	3.13**	-0.7**	-4.46**	Dupl.
	4	2.05	0.007	23.95**	5.98**	1.57**	9.41**	8.94**	2.77*	-16.46**	Dupl.
	5	1.78	0.024	14.84**	7.32**	0.53*	2.36**	1.83**	0.49*	-1.99*	Dupl.
No. of spikes /plant	1	-0.58	-0.85	-6.31**	11.77**	0.31	6.18**	4.87**	0.13	-3.44	Dupl.
	2	-1.06	-0.17	-6.75**	11.89**	-0.93	6.32**	5.53**	-0.44	-4.30	Dupl.
	3	-0.94	-1.44	-1.68	12.93**	0.44	0.73	-0.71	0.25	3.10	Comp.
	4	-0.9	-0.19	-3.62**	12.71**	-0.65	3.31*	2.53	-0.36	-1.43	Dupl.
	5	-0.84	0.03	-6.17**	12.08**	-1.04	6.07**	5.36**	-0.44	-4.55	Dupl.
No, of grains /spike	1	-9.47**	-15.22**	-24.41**	55.10**	2.27	4.72	-0.28	2.88	24.97	Comp.
	2	-4.95*	2.37	-10.53**	54.30**	-3.03*	9.08*	7.95*	-3.66*	-5.36	Dupl.
	3	13.84**	-3.79	10.45**	55.12**	-0.63	4.59	-0.4	8.82**	-9.65	Dupl.
	4	14.48**	2.71	6.28*	51.98**	-1.73	15.09**	10.91**	5.88**	-28.10**	Dupl.
	5	2.78	-3.32	-4.16	57.72**	4.93**	6.11	3.63	3.05	-3.09	Dupl.
100-kernel Weight (g)	1	-1.77**	-1.31**	-2.85**	4.83**	0.53**	0.68**	-0.23	-0.23*	3.32**	Dupl.
	2	-0.50**	-0.02	0.06	5.11**	0.51**	-0.31	-0.59**	-0.24**	1.12**	Dupl.
	3	-0.05	-0.88**	-1.69**	4.29**	0.65**	1.02**	0.76**	0.41**	0.18	Comp.
	4	-0.14	-0.31*	-0.88**	4.39**	0.40**	0.49*	0.43*	0.08	0.03	Comp.
	5	-1.26**	-1.34**	-3.08**	4.10**	0.11	1.61**	0.47*	0.04	2.15**	Comp.
Grain yield /plant (g)	1	-13.98**	-10.41**	-17.68**	22.12**	-0.84	-4.94	-6.71*	-1.79	31.11**	Dupl.
	2	0.72	-1.93	-12.72**	23.13**	2.62	13.19**	11.52**	1.33	-10.32	Dupl.
	3	6.26**	2.74	8.43**	26.62**	1.16	1.52	0.57	1.76	-9.58	Dupl.
	4	0.47	0.01	-3.42	23.54**	-0.14	4.96	3.91	0.23	-4.4	Dupl.
	5	8.076**	-0.01	-1.94	24.19**	4.29**	10.54**	10.01**	4.04**	-18.08**	Dupl.

***, ** Significant at 0.05 and 0.01 levels, respectively, Comp. = complimentary epistasis, Dupl. = Duplicate epistasis. m= mean, a= additive effects, d=dominance effects, aa= additive× additive effects, ad= additive× dominance effects and dd= dominance × dominance effects.**

Highly significant positive additive × additive (aa) effects were detected for; spike length in all crosses; no. of spikes/plant in the first, the second and the fifth crosses, no. of grains/spike in the fourth cross, 100-grain weight in the third, fourth and fifth crosses, grain yield in the second and the fifth crosses. While, highly significant and negative additive × additive type was found for heading dates in the first, the third and the fifth crosses, maturity dates in the second and the fifth crosses, flag leaf area in the third and fifth crosses, chlorophyll content in the third cross, plant height and 100-grain weight in the second crosses. El-Hosary *et al.,* (1992), Abul-Naas *et al.,* (1993), El-Seidy (1997a), El-Seidy (1997b), Nawar *et al.,* (1999), Bhatnagar *et al.,* (2001) and Sharma *et al.,* (2003) obtained similar results.

Highly significant and positive additive × dominance (ad) effected were found for; days to heading in the third cross, days to maturity in the first cross, no. of grains/spike in third and the fourth cross, 100 grain weight in the third cross and grain yield in the fifth cross. On the other hand highly negative significant additive × dominance types of epistasis were found for; days to heading in the second cross, days to maturity in the third cross, flag leaf area in the first, the third and the fourth crosses, 100 grain weight in the first and the second crosses.

The dominance × dominance (dd) types of effects were significant or highly significantly negative for the most studied traits in most crosses except for; days to maturity in the second cross, both flag leaf area and chlorophyll content in the first and the third crosses and 100-grain weight in the first, the second and the fifth crosses and grain yield in the first cross. These results confirm the important role of dominance × dominance gene action in the genetic behavior. Abul-Naas *et al.,* (1993), El-Seidy (1997a), Eid (2006), El-sayed (2007) and El-shawy (2008) reported similar approaches.

Duplicate epistasis was observed, as revealed by differences in sings of (d) and (dd) in crosses which exhibited significant epistasis, while similar sings of (d) and (dd) in complementary epistasis. These findings illustrated that duplicate epistasis was prevailing for most traits. Chaudhay (1987) found that detected that the epistatic duplicate type being predominant over the complementary type. while, complementary epistasis was prevailing in the third cross for days to heading for, the first cross in days to maturity, the first, the second and the fourth crosses in flag leaf area, the first cross for plant height, the third cross for no. of spikes/plant, the first cross for no. of grains/plant and the third, the fourth and the fifth crosses for 100-grain weight, which was agreement with the results obtained by Soylu (2002) and Sharma *et al.,* (2003).

Heterosis, Inbreeding depression and potence ratio.

In this concern, percentages of heterosis over mid and better parent parents, inbreeding depression and potence ratio in five crosses for the studied traits are given in table 4. Heterosis was expressed as the percentage deviation of F_1 mean performance from the better or mid parent for all traits.

Significant or highly significant negative heterotic effects were found relative to mid parent in all crosses except for the first cross, heading and maturity dates, the second, the fifth and the third crosses for flag leaf area, plant height and spike length, respectively. Positive highly significant heterosis over parent mid in most crosses in most studied traits except heading and maturity dates. Highly negative heterosis significant relative to better parent values were obtained in the fourth cross in days to heading, flag leaf area, chlorophyll content and 100-grain weight, in addition, the fifth cross in plant height, the third and fourth crosses in both spike length and no. of grains/spike. On the other hand, positive highly significant heterosis over better parent in most crosses except for the first and the fifth crosses in days to maturity, the second cross in flag leaf area, chlorophyll content, spike length and 100-grain weight and the first cross for plant height were non-significant. Similar results were obtained by Budak (2000), El-Seidy and Khattab (2000), Sharma *et al*., (2002), El-Bawab (2003), El-Sayed (2007), El-shawy (2008), Amer (2010), Eid (2010) and Amer (2011).

Inbreeding depression measured as reduction in performance of F_2 generation due to inbreeding is presented in tables 4. Results showed non-significant effects for heading and maturity dates, chlorophyll content, plant height and no. of grains/spike in all crosses, the fifth cross for flag leaf area, the third cross in no. of spikes/plant and the second, the third, the fourth and the fifth crosses for grain yield/plant. Highly positive significant for inbreeding depression values for all crosses in for spike length and 100-grain weight, the first, the third and the fourth crosses for flag leaf area, the first, the second and the fifth crosses for no. of spike/plant. While, inbreeding depression values were highly negative significant for the second cross in flag leaf area. EL-Wakeel (2008), obtained similar results.

Potence ratio refers to complete dominance in the fifth and the fourth crosses for days to maturity and flag leaf area, respectively.

Partial dominance for most of the studied crosses. As follows, most crosses in days to heading except for the fourth cross. All crosses for days to maturity except the first cross, the second and the fourth crosses in flag leaf area, the second and the fourth crosses in chlorophyll content and 100-grain weight and the third and the fourth cross in both spike length and no. of spikes/plant.

The remaining studied crosses for all characters studied showed over dominance towards the higher parent. El-Seidy (1997b), Yadav *et al*., (2002) and El-Bawab (2003), El-Sayed (2007), El-Shawy (2008) and Eid *et al.,* (2011), found similar results, however, with the different barley genotypes.

Heritability and expected genetic advance from selection:

Components of variance (σ^2A, σ^2D and σ^2 E), heritability estimates in both broad and narrow senses and expected genetic advance from selection for the studied traits are presented in table 5.

Dominance gene variance (σ^2D) was greater than of Additive variance (σ^2A) for all studied traits, indicating that the selection for these traits might be non-effective in early generations to improve such traits in the five studied crosses.

Heritability estimates in broad sense were moderate to relatively high for all studied traits in all crosses and ranged from 63.44% for 100-grain weight in the third cross to 94.45% for no. of spikes/plant in the third cross, according to the cross and/or trait itself as shown in table 5. These results were coincident with those reported by Abul-Naas *et al*., (1993), El-Seidy

(1997a), Singh and Singh (1999), Zeng *et al.,* (2001), El-Bawab (2003), Eid (2006), El-Sayed (2007) and Shawy (2008).

Table 4: Estimates of heterosis, inbreeding depression percentages (ID %) and potence ratio (PR %) for all studied characters in the five crosses.

character	Crosses	Heterosis MP	Heterosis BP	ID%	PR%
Days to heading (day)	1	-0.26	1.17**	-4.34	-0.18
	2	-1.43**	1.91**	-2.69	0.44
	3	-3.00**	0.83**	-7.50	-0.79
	4	-1.88**	-1.68**	-1.64	-9.28
	5	-1.75**	2.30**	-6.96	0.44
Days to maturity (day)	1	-0.77	-0.07	-1.92	-1.80
	2	-0.79*	1.46**	-1.09	0.35
	3	-0.10	3.29**	0.86	-0.03
	4	-1.32**	1.11**	-0.97	-0.55
	5	-1.62**	1.15	-1.20	0.59
Flag leaf area (cm^2)	1	71.87**	7.00**	40.67**	1.20
	2	-15.25**	-0.40	-11.05**	-0.36
	3	69.17**	9.63 **	29.70**	1.31
	4	19.93**	-10.30**	15.44**	0.59
	5	44.54**	18.37**	1.96	-2.01
chlorophyll content /plant	1	6.17**	2.16**	3.69	1.57
	2	2.48**	-0.32	3.45	-0.88
	3	7.31**	1.43**	-5.93	-1.26
	4	1.93**	-9.86**	1.79	-0.15
	5	7.59**	1.82**	7.04	-1.34
Plant height (cm)	1	1.74*	0.49	2.49	1.40
	2	4.14**	2.40**	0.31	2.45
	3	5.22**	3.08**	3.81	2.52
	4	5.52**	2.69**	5.88	2.00
	5	-1.80**	-2.01**	-3.61	8.07
Spike Length (cm)	1	7.06**	6.35**	16.17**	10.68
	2	2.30**	0.64	13.03**	-1.40
	3	-2.49**	-22.5**	6.69**	0.10
	4	7.70**	-10.00**	8.98**	-0.39
	5	7.10**	6.52**	8.54**	13.25
No. of spikes/ plant	1	10.34**	8.78**	15.95**	7.36
	2	6.03**	2.26**	14.93**	-1.64
	3	11.38**	9.75**	8.10	7.56
	4	5.92**	3.62**	9.26*	-2.67
	5	5.38**	0.79**	13.59**	-1.19
No. of grains/ spike	1	8.52**	7.40**	13.51	-8.20
	2	2.01**	0.87**	5.57	1.79
	3	9.97**	-7.50**	-0.22	-0.53
	4	8.66**	-6.13**	0.99	-0.55
	5	4.31**	1.01**	3.80	1.32
100-grain Weight (g)	1	17.82**	2.56**	19.45**	1.19
	2	5.72**	-8.24	2.39**	0.38
	3	5.74**	0.41**	11.48**	1.12
	4	1.35**	-5.30**	5.42**	0.19
	5	26.70**	24.77**	24.71**	15.56
Grain yield/ plant (g)	1	6.92**	3.12**	19.36*	1.88
	2	6.55**	2.76**	14.80	1.30
	3	3.93**	1.42**	-6.55	-1.59
	4	4.38**	2.76**	5.54	-2.79
	5	2.16**	1.13**	3.01	2.17

Cross 1= (Giza 121× Line 1), Cross 2= (Giza 121 × Line 2), Cross 3 = (Giza 126 × Line 1), Cross4 = (Giza 126 × Line 2) and Cross 5 = (Line 1× Line 2). *, significant at 0.05 and 0.01 levels probability, respectively.**

Table 5: Estimate of additive variance (σ^2A), dominance variance (σ^2D), environmental variance (σ^2E), heritability percentage in broad (h^2b) and narrow (h^2n) senses and expected genetic advance from selection (Δg) for all studied characters in the five crosses.

Characters	Crosses	σ^2A	σ^2 D	σ^2 E	Heritability percentage		genetic advance	
					h^2(b)	h^2(n)	Δg	Δg %
Days to heading (day)	1	0.37	2.66	3.18	83.18	52.76	4.72	5.09
	2	0.46	3.34	2.57	90.01	66.56	6.95	7.30
	3	0.28	1.97	3.12	76.27	40.9	3.05	3.12
	4	0.43	3.15	3.32	86.05	64.79	6.51	6.60
	5	0.35	2.36	2.44	84.58	35.55	2.91	3.00
Days to maturity (day)	1	0.43	2.89	3.35	82.45	33.25	2.99	2.17
	2	0.44	3.03	3.12	85.13	43.45	4.10	2.94
	3	0.37	2.54	2.49	85.79	40.91	3.53	2.54
	4	0.44	2.91	2.39	87.75	31.64	2.88	2.05
	5	0.39	2.68	3.17	82.12	33.41	2.90	2.09
Flag leaf area (cm^2)	1	0.18	1.35	1.83	80.71	54.00	3.43	42.53
	2	0.20	1.45	1.33	87.80	62.94	4.28	51.17
	3	0.11	0.80	1.87	63.55	44.73	2.08	26.06
	4	0.15	1.12	1.55	80.76	61.39	3.59	46.05
	5	0.08	0.59	1.16	71.00	52.50	2.16	36.05
Chlorophyll Content /plant	1	0.32	2.17	1.79	88.04	39.14	3.11	8.27
	2	0.37	2.50	1.47	91.56	38.52	3.31	8.56
	3	0.41	2.79	1.77	91.01	43.38	3.97	10.37
	4	0.46	2.98	1.84	90.64	24.25	2.21	6.18
	5	0.41	2.70	1.83	90.02	33.35	2.94	7.77
Plant height (cm)	1	2.59	16.77	11.15	89.84	23.1	4.98	4.41
	2	1.52	10.61	13.67	80.94	40.91	7.14	6.02
	3	2.35	15.74	13.14	87.61	33.53	7.11	6.14
	4	1.95	13.44	13.64	85.30	42.03	8.34	7.32
	5	2.59	17.3	13.32	88.64	34.24	7.64	6.70
Spike length (cm)	1	0.04	0.29	0.32	84.03	46.94	1.38	19.64
	2	0.04	0.3	0.32	84.05	33.15	0.96	14.17
	3	0.04	0.29	0.40	80.00	47.5	1.38	26.11
	4	0.05	0.33	0.30	85.25	17.00	0.50	8.39
	5	0.05	0.32	0.33	83.7	16.37	0.48	6.55
No. of spikes/ plant	1	0.41	2.78	1.61	91.97	47.93	4.42	37.55
	2	0.41	2.82	1.66	91.84	47.93	4.45	37.42
	3	0.48	3.13	1.22	94.45	37.14	3.58	27.69
	4	0.39	2.56	1.41	91.89	32.12	2.76	21.69
	5	0.41	2.87	1.60	92.63	58.87	5.64	46.70
No. of grains/ spike	1	2.17	14.12	8.53	90.93	27.33	5.46	9.91
	2	2.35	15.16	8.54	91.46	23.8	4.9	9.03
	3	2.11	13.71	7.82	91.43	26.74	5.26	9.55
	4	2.36	15.12	8.36	91.53	20.93	4.28	8.24
	5	2.28	14.74	8.14	91.61	23.53	4.77	8.27
100-grain weight (g)	1	0.007	0.049	0.078	75.56	30.97	0.36	7.43
	2	0.006	0.041	0.08	69.28	33.11	0.35	6.81
	3	0.005	0.036	0.083	63.44	40.78	0.4	9.33
	4	0.006	0.044	0.078	71.98	29	0.31	7.15
	5	0.006	0.043	0.086	68.75	33.03	0.36	8.69
Grain yield/ plant (g)	1	1.63	10.98	10.99	84.99	33.34	5.88	26.57
	2	2.15	13.92	10.40	88.45	21.08	4.12	17.81
	3	2.01	12.98	9.83	88.20	19.15	3.60	13.52
	4	1.97	12.57	9.35	88.23	14.52	2.67	11.33
	5	1.68	11.25	8.88	88.44	36.40	6.57	27.17

Cross 1= (Giza 121× Line 1), Cross 2= (Giza 121 × Line 2), Cross 3 = (Giza 126 × Line 1), Cross4 = (Giza 126 × Line 2) and Cross 5 = (Line 1× Line 2).

Heritability estimates in narrow sense were low to moderate for all studied traits in all crosses and ranged from 16.37% for spike length in the fifth cross to 66.56% for days to heading in the second cross, indicating that these characters were greatly affected by non-additive and environmental effects. Eshghi, and Akhundova (2009) Eid *et al*., (2011) obtained similar results**.**

The expected genetic advance as percent of F_2 mean (Δg %) was calculated and the results are presented in table 5.

The predicted genetic advance estimates were low to moderate for all studied traits in all crosses and ranged from 2.05% for days to maturity in the fourth cross to 51.17% for flag leaf area in the second cross, these results indicated the possibility of practicing selection in early generations and obtaining high yielding genotypes; Abul-Naas *et al.,* (1993) and El-Shawy (2008), came to similar result.

Therefore, selection in the present those particular populations should be effective and satisfactory for successful breeding purposes. The results of this study indicated that estimates of epistasis, dominance and additive gene actions may have influenced by genotype by environment interactions. It can be concluded that the degree of improving the studied traits successfully based on the high heritability values and positive additive genetic advance shown by the different traits, especially; number of spikes/plant, 100-grain weight and grain yield /plant.

Generally, the most biometrical parameters resulted from the first, the third and fifth cross(Giza 121 × line 1, Giza 126 × line 1 and line 1 × line 2) were found to be higher in magnitude in comparison with those from other crosses. Consequently, it could be concluded that the above-mentioned crosses would be of interest in breeding programmes for improving traits for earliness, yield and its components.

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دراسات وراثية على المحصول ومكوناته في بعض هجن الشعير

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تم إجراء هذه الدراسة بمزرعة محطة البحوث الزراعية بسخا خلال ثلاث مواسم زراعية (٢٠٠٨/٢٠٠٩, ٢٠٠٩/٢٠١٠ و٢٠١٠/٢٠١١) باستخدام نظام العشائر الستة (الأب الأول, الأب الثاني, الجيل الأول, الجيل الثاني, الجيل الرجعى الأول و الجيل الرجعى الثاني) وكان الهدف هو دراسة تأثير الفعل الجيني ومحاوله الحصول على تراكيب وراثية جديدة يمكن الانتخاب من خلالها في الأجيال الانعزالية التالية للحصول على سلالات(تراكيب) جديدة من الشعير متفوقة في صفاتها المحصولية على الأصناف التجارية المنزرعة. وقد تم استخدام أربع إباء متباينة في صفاتها وهى (جيزة ١٢١, جيزة ١٢٦, سلاله ١, سلاله ٢) وتم عمل خمسة هجن من الشعير هي : الهجين الأول (جيزة ١٢١× سلاله ١), الهجين الثاني (جيزة ١٢١× سلاله ٢), الهجين الثالث (جيزة ١٢٦× سلاله ١), الهجين الرابع (جيزة ١٢٦× سلاله ٢) والهجين الخامس (سلاله ١× سلاله ٢) . تم زراعة العشائر الستة لكل هجين في ثلاثة تكرارات. وتم دراسة كل من الصفات الآتية: عدد الأيام حتى الطرد, عدد الأيام حتى النضج, مساحه الورقة العلم, المحتوى الكلى للنبات من صبغة الكلوروفيل, ارتفاع النبات, طول السنبلة, عدد السنابل للنبات, عدد الحبوب للسنبلة, وزن ١٠٠ حبة, محصول النبات الفردي.

وكانت أهم النتائج المتحصل عليها هي:

تفوقت قيم متوسطي الإباء لجميع الصفات المدروسة في جميع الهجن وكانت صفتي التزهير والنضج أبكر من متوسطي الإباء مما يدل على وجود سيادة جزئية في جميع الهجن تحت الدراسة كما

أوضحت قيم متوسطات الجيل الثاني وسط بين الأبوين إلا أنها كانت أقل من قيم متوسطات الجيل الأول بسبب الانخفاض الراجع للتربية الداخلية للصفات المختلفة, بالاضافه لذلك اختلفت قيم الهجن الرجعية تبعا للصفات المختلفة إلا أنها كانت معظمها في اتجاه الأب الرجعى للصفات المدروسة. أظهرت تأثيرات قوه الهجين قيما موجبة ومعنوية بالنسبة لمتوسط الأبوين لمعظم الصفات في جميع الهجن تحت الدراسة فيما عدا صفتي التزهير والنضج كذلك كانت تأثيرات قوة الهجين بالنسبة إلى الأب الأفضل موجبة في معظم الصفات. أظهر تأثير الفعل الجيني المضيف أكثر أهمية من تأثير الفعل الجيني السيادي لمعظم الصفات تحت الدراسة. كما دلت النتائج على أهمية التأثير(السيادي×السيادي) عن التأثيرات (المضيف×المضيف), (المضيف×السيادي) لمعظم الصفات. كما كانت قيم معامل التوريث بمعناها الضيق منخفضة إلى متوسطة للصفات تحت الدراسة وتراوحت ما بين ١٦,٣٧% لصفة طول السنبلة فى الهجين الخامس إلى ٦٦,٥٦% في صفه عدد الأيام حتى الطرد في الهجين الثاني, كما أظهرت النتائج أن قيم النسبة المئوية للتحسين الوراثي المتوقع من الانتخاب منخفضة لمعظم الصفات فيما عدا صفة مساحة ورقة العلم وعدد السنابل لكل نبات فكانت ٥١ز١٧%و ٤٦,٧٠ % في الهجين الثاني والهجين الخامس على التوالي.

أوضحت المحصلة النهائيه لهذه الدراسة أنه يمكن لمربى الشعير الأستفاده بالهجن (جيزة ١٢١× سلاله ١, جيزة ١٢٦× سلالة ١ و سلاله ١× سلاله ٢) في برنامج التربية لتحسين كل من صفات التبكير والمحصول ومكوناته. مما يشير إلى أهمية هذه الهجن في برامج التربية لتحسين معظم الصفات المحصولية في الشعير.

قام بتحكيم البحث

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