II.3 GENETICAL STUDIES ON BARLEY PRODUCTIVITY IN RELATION TO LEAF RUST INFECTION

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Abstract

The present experiment was carried out at Sakha Agricultural Research Station during the three successive seasons 2007/08, 2008/09 and 2009/010, to find out the type of gene action using the six populations (P_1, P_2 , F_1 , F_2, BC_1 and BC_2) of five crosses of barley; cross 1 (Giza 123×Giza 2000); cross 2 (Giza 123× Line-2); cross 3 (Rihane-03×Line-1), cross 4 (Rihane-03×Line-2) and cross 5 (Giza 2000×Line-2) and their six populations grown under normal conditions. Grain yield and its components and some growth attributes and resistance to leaf rust disease were investigated. Results indicated the presence of non-allelic interaction for most studied traits in all crosses under study. Also, the relative importance of additive and dominance effects varied among traits and crosses. Regarding the epistatic components, the dominance×dominance effect was greater in magnitude in most studied traits. Positive heterotic effects relative to the mid-parent and better parent were found for most of the studied traits. Heritability estimates in broad sense were relatively high for all studied traits in all crosses, but narrow sense estimates were low to high for all studied traits in all crosses. The expected genetic advance as percent of F_2 ranged from low to high in all crosses for all traits. Results also indicated the possibility of practicing selection in early generations to obtain high-yielding genotypes. Generally, crosses 1 and 3 for grain yield and crosses 1 and 5 for leaf rust resistance were higher in magnitude with high genetic advance associated with high heritability and could be promising in barley breeding program.

Keywords: *Hordeum vulgare* L., gene effects, heritability, genetic advance, heterosis, *Puccinia hordei.*

INTRODUCTION

Barley (*Hordeum vulgare* L.) is as ancient as the origin of agriculture itself. The antiquity of barley is documented to periods of 5000 to 7000 B.C. or earlier. It is said that barley is the most widely adapted of all grains. It is more tolerant to drought, saline and alkaline soils than other cereals. Barley is the world's fourth most important crop, the fourth ranking cereal in the USA and the second ranking cereal in Canada and some other countries.

Until the sixteenth century, barley flour was used instead of wheat to make bread (Bukantis and Goodman, 1980). In Egypt, barley is one of the most important cereal crops mainly used for animal feed (grain and straw) and bread making by some 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 Sinai, it also grows over a wide range of soil variability and under many diverse climatic conditions compared with many other cereal crops.

Therefore, the main objective of the present study was to develop new promising barley genotypes that are able to produce high yield and are more resistant to leaf rust disease.

MATERIALS AND METHODS

The present study was carried out at the Experimental Farm of Sakha Agricultural Research Station, North region of Nile Delta, Agricultural Research Center (ARC), Egypt, during the three successive seasons 2007/2008 to 2009/2010. The experimental material comprised five parental cultivars /lines of barley and their crosses; cross 1 (Giza 123 × Giza2000); cross 2 (Giza 123 × Line-2); cross 3 (Rihane-03 × Line-1), cross 4 (Rihane-03 × Line-2) and cross 5 (Giza 2000 × Line-2). Name and pedigree of parental genotypes are given in Table 1.

Table 1. Name and pedigree of the five barley genotypes.

No.	Genotype	Pedigree
1	Giza 123 (P_1)	Giza 117//FAO86
2	Giza 2000 (P_2)	Cr366-13-1/Giza121
3	Rihane-03 (P_3)	AS46//Avt/Aths
4	Line-1 (P_4)	ACSAD618//Aths/Lignee686
5	Line-2 (P_5)	Lignee527/NK1272/3/Nacha2//Lignee640/ Harma-01

In 2007/2008 growing season, the parental genotypes were crossed to obtain F_1 seeds. In 2008/2009 growing season the hybrid seeds of the five crosses were sown to give F_1 plants, thereafter, these plants were selfed to produce F_2, while some of the F_1 plants of each cross were backcrossed to each of the two parents to produce the backcrosses (BC_1 and BC_2). In 2009/2010 growing season the six populations P_1, P_2, F_1, F_2, BC_1 and BC_2 of the five crosses were sown in a randomized complete block design (RCBD) with three replications under normal condition. Each experimental unit consisted of two rows of each genotype of the two parents and F_1 and three rows of each of the two backcrosses and 10 rows of the F_2 populations.

Rows were 1.5 m in length, 30 cm apart and 15 cm between seeds within a row. Data were recorded on 30, 30, 300 and 75 plants selected at random for both parents, F_1, F_2 and backcrosses of each cross, respectively. The traits studied were; days to maturity, plant height, spike length, number of spikes per plant, number of grains per spike, 100-grain weight, grain yield per plant and response to leaf rust disease, which was estimated as infection severity multiplied by assigned constant values ranged from 1 to 9 according to Line et al. (1974). 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 calculate scaling test as outlined by Mather (1949) and Hayman and Mather (1955) to determine the presence of non-allelic interactions. The means of the six populations in each cross were used to estimate the six parameters of gene effects, using the Gamble's procedure (1962). The standard error of a, d, aa, ad and dd was obtained by calculating the square root of their respective variance. 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). Also, this expected gain was expressed as a percentage of F_2 mean ($\Delta g\%$) according to Miller et al. (1958).

RESULTS AND DISCUSSION

Mean performance

Mean and variance of the studied traits in the five crosses for the six populations P_1, P_2, F_1, F_2, BC_1 and BC_2 are presented in Table 2.

The F_1 mean values exceeded the mid values of the two parental means for most of the studied traits in the five crosses. The F_2 population mean performance values were intermediate (between the two parents and less than F_1 mean performance values for grain yield and its components; number of spikes $plant^{-1}$, number of grains spike^{-1}, 1000-grain weight indicating the importance of non-additive components of genetic variance for the studied traits. However, the two backcrosses (BC_1 and BC_2) mean performance values varied in each trait towards the mean of its recurrent parent. Similar results were obtained by El-Sayed (2007) and El-Shawy (2008).

Heterosis, inbreeding depression and potence ratio

Heterosis was expressed as the percentage deviation of F_1 mean performance from the better and mid parents for all traits. In this concern, percentages of heterosis over better and mid parent values are presented in Table 3. Positive significant or highly significant heterosis over mid and better parent values were obtained for; days to maturity in all crosses except for cross 3 over mid parent, plant height in all crosses except for cross 10 over mid and better parents and cross 4 over mid parent (the lowest parent is considered as the better parent for plant height); spike length in all crosses except for cross 1 and cross 2; number of spikes plant^{-1} in cross 3 and cross 4; number of grains spike^{-1} in all crosses except for cross 1 and cross 2; 100-grain weight in cross 3 and cross 4; for grain yield plant^{-1} in all crosses and for leaf rust in cross 2. While negative significant heterosis for mid and better parents were obtained for, spike length and number of grains spike^{-1} in cross 2 and leaf rust in cross 4. Similar results were obtained by El-Seidy and Khattab (2000), Budak (2000), Sharma et al. (2002), El-Bawab (2003), El-Sayed (2007), El-Shawy (2008), Amer (2010) and Eid (2010).

Table 2. Mean (X) and variance (S2) of P1, P2, F1, F2, BC1 and BC2 populations of five barley crosses for days to maturity, plant height, spike length and number of spikes plant-1.

Trait	Cross	Statistical Parameter	P_1	P_2	F_1	F_2	BC_1	BC_2
Days to maturity (day)	Giza 123 x Giza 2000	$\bar{X}$ (cm)	94.6	91.40	95.2	94.56	97.08	96.76
		S^2	1.42	2.94	1.27	9.93	7.51	7.08
	Giza 123 x Line 2	$\bar{X}$ (cm)	94.6	94.17	95.53	93.70	96.57	95.73
		S^2	1.42	1.73	1.36	11.74	9.41	9.90
	Rihane-03 x Line 1	$\bar{X}$ (cm)	92.53	93.9	94.2	92.18	94.52	94.23
		S^2	2.60	2.64	1.89	13.93	9.39	10.58
	Rihane-03 x Line 2	$\bar{X}$ (cm)	92.53	94.17	94.57	93.17	97.45	97.04
		S^2	2.60	1.73	0.81	12.18	9.28	9.90
	Giza 2000 x Line 2	$\bar{X}$ (cm)	91.40	94.17	95.6	92.60	96.75	94.37
		S^2	2.94	1.73	1.35	10.19	9.65	9.40
Plant height (cm)	Giza 123 x Giza 2000	$\bar{X}$ (cm)	115.17	118.87	126.73	121.46	118.97	116.57
		S^2	4.14	10.19	11.17	78.53	59.59	57.03
	Giza 123 x Line 2	$\bar{X}$ (cm)	115.17	111.47	118.03	116.97	115.27	107.57
		S^2	4.14	6.33	9.55	63.57	57.20	51.44
	Rihane-03 x Line 1	$\bar{X}$ (cm)	100.33	93.53	102.57	103.29	97.8	97.04
		S^2	6.51	6.26	5.56	40.84	34.14	26.77
	Rihane-03 x Line 2	$\bar{X}$ (cm)	100.33	111.47	106.47	107.48	101.92	103.85
		S^2	6.51	6.33	12.88	69.40	48.62	46.18
	Giza 2000 x Line 2	$\bar{X}$ (cm)	118.87	111.47	109.03	117.36	103.44	101.32
		S^2	10.19	6.33	13.00	78.17	58.87	54.30
Spike length (cm)	Giza 123 x Giza 2000	$\bar{X}$ (cm)	8.73	7.70	8.42	7.51	8.23	8.33
		S^2	0.37	0.32	0.42	1.41	1.10	1.18
	Giza 123 x Line 2	$\bar{X}$ (cm)	8.73	7.63	7.35	7.23	8.23	7.53
		S^2	0.37	0.17	0.30	2.74	1.95	2.01
	Rihane-03 x Line 1	$\bar{X}$ (cm)	8.25	7.62	8.87	8.21	8.36	7.69
		S^2	0.27	0.34	0.43	1.79	1.1	1.12
	Rihane-03 x Line 2	$\bar{X}$ (cm)	8.25	7.63	9.23	8.25	8.24	7.79
		S^2	0.27	0.17	0.37	1.86	1.36	1.58
	Giza 2000 x Line 2	$\bar{X}$ (cm)	7.70	7.63	8.13	7.34	7.83	6.98
		S^2	0.32	0.17	0.31	1.94	1.14	1.40
No. of spikes plant^{-1}	Giza 123 x Giza 2000	$\bar{X}$	14.03	11.8	13.93	12.11	11.49	13.19
		S^2	3.69	4.03	4.89	16.94	10.44	13.86
	Giza 123 x Line 2	$\bar{X}$	14.03	12.57	14.13	12.79	13.51	13.43
		S^2	3.69	3.70	3.77	21.77	11.82	17.90
	Rihane-03 x Line 1	$\bar{X}$	11.73	10.53	12.73	11.78	12.28	11.13
		S^2	2.00	3.98	4.62	21.94	19.15	10.71
	Rihane-03 x Line 2	$\bar{X}$	11.73	12.57	16.3	13.14	14.4	11.68
		S^2	2.00	3.70	6.70	26.07	17.49	17.63
	Giza 2000 x Line 2	$\bar{X}$	11.8	12.57	12.57	13.03	11.37	13.43
		S^2	4.03	3.70	3.98	24.49	17.75	17.03

Table 2. (Cont'd.) Mean $\bar{X}$ and variance (S2) of P1, P2, F1, F2, BC1 and BC2 populations of five barley crosses for number of grains spike-1, 100-grain weight, grain yield plant-1, leaf rust disease.

Trait	Crosses	Statistical Parameter	P_1	P_2	F_1	F_2	BC_1	BC_2
No. of grains spike^{-1}	Giza 123 x Giza 2000	$\bar{X}$ (cm)	67.40	61.80	65.8	59.82	66.40	65.60
		S^2	29.01	15.27	18.58	86.78	59.68	75.24
	Giza 123 x Line 2	$\bar{X}$ (cm)	67.40	62.00	59.20	58.56	66.16	61.68
		S^2	29.01	18.21	29.13	159.98	101.16	96.87
	Rihane-03 x Line 1	$\bar{X}$ (cm)	67.00	62.40	70.80	66.66	68.32	63.84
		S^2	15.10	21.35	18.37	88.54	57.30	72.62
	Rihane-03 x Line 2	$\bar{X}$ (cm)	67.00	62.00	69.60	67.22	66.64	65.55
		S^2	15.10	18.21	28.80	93.26	68.67	80.17
	Giza 2000 x Line 2	$\bar{X}$ (cm)	61.80	62.00	66.40	60.97	67.36	59.60
		S^2	15.27	18.21	14.73	155.45	82.29	100.54
100-grain weight (g)	Giza 123 x Giza 2000	$\bar{X}$ (cm)	5.04	5.91	5.89	5.09	4.93	5.20
		S^2	0.11	0.05	0.03	0.31	0.26	0.27
	Giza 123 x Line 2	$\bar{X}$ (cm)	5.04	4.08	4.82	4.39	4.42	4.09
		S^2	0.11	0.03	0.09	0.29	0.23	0.21
	Rihane-03 x Line 1	$\bar{X}$ (cm)	4.11	4.04	4.55	4.23	4.17	4.28
		S^2	0.19	0.02	0.09	0.31	0.24	0.25
	Rihane-03 x Line 2	$\bar{X}$ (cm)	4.11	4.08	4.63	4.23	4.28	4.11
		S^2	0.19	0.03	0.02	0.30	0.20	0.21
	Giza 2000 x Line 2	$\bar{X}$ (cm)	5.91	4.08	5.43	5.08	4.81	4.55
		S^2	0.05	0.03	0.07	0.36	0.31	0.29
Grain yield Plant^{-1} (g)	Giza 123 x Giza 2000	$\bar{X}$ (cm)	34.45	31.26	38.37	29.17	27.11	32.63
		S^2	6.19	4.56	9.60	135.14	90.75	94.06
	Giza 123 x Line 2	$\bar{X}$ (cm)	34.45	31.92	36.04	25.53	28.92	23.20
		S^2	6.19	7.66	5.39	129.93	101.76	115.12
	Rihane-03 x Line 1	$\bar{X}$ (cm)	29.15	19.22	33.60	25.30	27.41	26.68
		S^2	5.49	10.65	12.05	151.60	91.00	92.62
	Rihane-03 x Line 2	$\bar{X}$ (cm)	29.15	31.92	42.12	30.64	32.01	26.41
		S^2	5.49	7.66	27.39	201.77	175.62	153.82
	Giza 2000 x Line 2	$\bar{X}$ (cm)	31.26	31.92	34.48	26.84	25.37	27.75
		S^2	4.56	7.66	13.94	169.82	147.17	138.87
Leaf rust disease	Giza 123 x Giza 2000	$\bar{X}$	4.70.	4.57	4.6	5.15	4.71	4.63
		S^2	0.36	0.32	0.39	3.33	2.07	2.32
	Giza 123 x Line 2	$\bar{X}$	4.70	8.30	6.57	6.10	5.39	6.49
		S^2	0.36	0.56	0.32	2.52	2.00	2.25
	Rihane-03 x Line 1	$\bar{X}$	8.23	5.40	6.30	6.42	6.84	5.43
		S^2	0.46	0.39	0.70	2.50	1.97	1.92
	Rihane-03 x Line 2	$\bar{X}$	8.23	8.30	7.83	7.66	7.13	7.29
		S^2	0.46	0.56	0.42	2.06	1.66	1.75
	Giza 2000 x Line 2	$\bar{X}$	4.57	8.30	6.10	6.30	5.53	7.00
		S^2	0.32	0.56	0.44	2.48	1.95	1.86

Inbreeding depression measured as reduction in performance of F_2 generation relative to F_1 is presented in Table 3. Results showed significant positive values for, spike length in all studied crosses except for cross 2; number of spikes plant-1 in cross 1 and cross 4; 100-grain weigh in all studied crosses; grain yield plant^{-1} in cross 1 and cross 2 and leaf rust in cross 2. Potence ratio refers to over dominance for most crosses in all studied traits, where its values exceeded unity. On the other hand, some values of potence ratio in some crosses were less than unity indicating partial dominance in these crosses. Similar results were obtained by Yadav et al. (2002), El-Seidy (1997a), El-Bawab (2003), El-Sayed (2007) and El-Shawy (2008).

Estimation of type of gene action

Six-parameter model was employed to estimate the additional parameters that are necessary to specify the effects of interaction of non-allelic genes. Testing for non-allelic interaction with the six-parameter model and type of epistasis is given in Table 4.

The estimate of mean parameter (m) for all studied attributes that reflected the contribution was found to be highly significant for the five crosses in all traits except for number of spikes plant^{-1} in cross 3 and cross 5; number of grains spike^{-1} in cross 4 and leaf rust in cross 5 . Additive gene effect (a) was quite small in magnitude relative to the dominance gene effects. Additive gene effect was positive and significant or highly significant for; plant height in cross 2; spike length in all crosses except cross 1; number of spikes plant^{-1} in cross 4; number of grains spike^{-1} in the crosses; 2, 3 and 5; 100-grain weight in crosses; 4 and 5; grain yield plant^{-1} in crosses; 2 and 4 suggesting the potential for obtaining further improvement of these traits by using pedigree selection program. On the other hand, significant or highly significant negative additive effects were obtained for; number of spikes plant^{-1} in crosses; 1 and 5, as well as for 100-grain weight and grain yield plant^{-1} in cross 1 indicating that the additive effects were less important in the inheritance of these traits. And also in leaf rust resistance in crosses; 2 and 5 indicating that the additive effects were more important in the inheritance of this trait. These results are in harmony with those obtained by Bhatnagar et al. (2001), Singh et al. (2002), Eid (2006), El-Sayed (2007) and El-Shawy (2008).

The estimates of dominance (d) effects (Table 4) were significant or highly significant and positive for; days to maturity in all crosses, spike length in crosses; 1 and 2, number of spikes plant^{-1} in crosses; 2 and 4, number of grains spike^{-1} in crosses; 1, 2 and 5, 100-grain weight in cross 3 and grain yield plant^{-1} in crosses; 1 and 3 indicating the importance of dominance gene effects in the inheritance of these traits and selecting desirable traits could be effective in late generations. However, the other crosses showed significant or highly significant negative and insignificant values.

Table 3. Heterosis, inbreeding depression and potence ratio in five barley crosses for all studied traits.

Trait	Cross	Heterosis% MP	Heterosis% BP	Inbreeding depression %	Potence ratio%
Days to maturity (day)	(Giza 123 × Giza 2000)	2.03 **	2.77 **	2.42	2.79
	(Giza 123 × Line 2)	1.22 **	1.52 **	2.90	-3.48
	(Rihane-03 × Line 1)	0.57	1.25 **	2.42	-0.85
	(Rihane-03 × Line 2)	1.54 **	2.21 **	3.35	-2.33
	(Giza 2000 × Line 2)	2.06 **	3.12 **	2.94	-2.01
Plant height (cm)	(Giza 123 × Giza 2000)	8.30 **	10.14 **	4.16	-5.25
	(Giza 123 × Line 2)	4.16 **	5.88 **	0.90	2.55
	(Rihane-03 × Line 1)	5.82 **	9.67 **	-0.70	1.67
	(Rihane-03 × Line 2)	0.54	6.12 **	-0.95	-0.10
	(Giza 2000 × Line 2)	-5.33 **	-2.19 **	-7.64	-1.66
Spike length (cm)	(Giza 123 × Giza 2000)	2.43 **	-3.55 **	10.77 **	0.39
	(Giza 123 × Line 2)	-10.18 **	-15.81 **	1.61	-1.52
	(Rihane-03 × Line 1)	11.76 **	7.52 **	7.42 **	2.95
	(Rihane-03 × Line 2)	16.26 **	11.88 **	10.70 **	4.19
	(Giza 2000 × Line 2)	6.09 **	5.58 **	9.82 **	14.00
No. of spikes $Plant^{-1}$	(Giza 123 × Giza 2000)	7.87 **	-0.71	13.09 **	0.91
	(Giza 123 × Line 2)	6.27 **	0.71	9.50	1.14
	(Rihane-03 × Line 1)	14.37 **	8.53 **	7.46	2.46
	(Rihane-03 × Line 2)	34.16 **	29.67 **	19.37 **	-9.96
	(Giza 2000 × Line 2)	3.15 **	0.00	-3.66	-1.00
No. of Grains $Spike^{-1}$	(Giza 123 × Giza 2000)	3.30 **	-2.37 *	9.09	1.11
	(Giza 123 × Line 2)	-8.50 **	-12.17 **	1.08	-2.04
	(Rihane-03 × Line 1)	9.43 **	5.67 **	5.85	2.65
	(Rihane-03 × Line 2)	7.91 **	3.88 **	3.42	2.04
	(Giza 2000 × Line 2)	6.24 **	7.10 **	8.18	39.00
100-grain weight (g)	(Giza 123 × Giza 2000)	7.61 **	-0.34 **	13.69 **	-0.95
	(Giza 123 × Line 2)	5.81 **	-4.37 **	9.00 **	0.55
	(Rihane-03 × Line 1)	11.62 **	10.61 **	7.07 **	14.20
	(Rihane-03 × Line 2)	13.19 **	12.65 **	8.63 **	40.50
	(Giza 2000 × Line 2)	8.61 **	-8.12 **	6.36 **	0.47
Grain yield $Plant^{-1}$ (g)	(Giza 123 × Giza 2000)	17.26 **	11.38 **	23.97 *	3.27
	(Giza 123 × Line 2)	8.59 **	4.62 **	29.16 *	2.26
	(Rihane-03 × Line 1)	36.18 **	15.27 **	24.7	2.00
	(Rihane-03 × Line 2)	37.94 **	31.95 **	27.26	-8.34
	(Giza 2000 × Line 2)	9.15 **	8.02 **	22.17	-8.72
Leaf rust disease	(Giza 123 × Giza 2000)	-1.43 **	0.66 **	-11.88 **	-0.67
	(Giza 123 × Line 2)	1.29 **	39.79 **	7.16 **	-0.05
	(Rihane-03 × Line 1)	-7.58 **	16.67 **	3.23	-0.36
	(Rihane-03 × Line 2)	-5.24 **	-4.86 **	2.21	13.00
	(Giza 2000 × Line 2)	-5.18 **	33.48 **	0.05	0.18

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

Table 4. Type of gene action estimated by generation means in five barley crosses for all studied traits.

Trait	Cross	Gene action					
		(m)	(a)	(d)	(aa)	(ad)	(dd)
Days to maturity	(Giza 123 ×Giza 2000)	127.66 **	-0.31	19.28 **	16.68 **	-1.24 **	-25.88 **
	(Giza 123 × Line 2)	127.33 **	0.32	18.56 **	16.88 **	0.80	-21.90 **
	(Rihane-03 × Line 1)	126.69 **	0.24	12.27 **	11.53 **	1.11 *	-11.96 **
	(Rihane-03 × Line 2)	126.67 **	1.09 *	23.52 **	21.53 **	1.94 **	-29.45 **
	(Giza 2000 × Line 2)	127.41 **	2.00 **	15.58 **	12.93 **	3.32 **	-15.73 **
Plant height	(Giza 123 ×Giza 2000)	121.46 **	2.40	-5.03	-14.75 **	4.25 **	31.15 **
	(Giza 123 × Line 2)	116.97 **	7.69 **	-17.50 **	-22.21 **	5.84 **	39.23 **
	(Rihane-03 × Line 1)	103.29 **	0.76	-17.90 **	-23.47 **	-2.57 **	32.92 **
	(Rihane-03 × Line 2)	107.48 **	-1.93	-17.79 **	-18.36 **	3.63 **	31.55 **
	(Giza 2000 × Line 2)	117.36 **	2.12	-66.05 **	-59.92 **	-1.58	98.80 **
Spike length	(Giza 123 ×Giza 2000)	7.51 **	-0.10	3.29 **	3.09 **	-0.62 **	-2.96 **
	(Giza 123 × Line 2)	7.23 **	0.71 **	1.76 **	2.59 **	0.16	-3.05 **
	(Rihane-03 × Line 1)	8.21 **	0.67 **	0.19	-0.74	0.36	2.25 **
	(Rihane-03 × Line 2)	8.25 **	0.45 *	0.37	-0.93	0.15	3.22 **
	(Giza 2000 × Line 2)	7.34 **	0.85 **	0.75	0.29	0.82 **	1.69 *
No. of spikes Plant^{-1}	(Giza 123 ×Giza 2000)	12.11 **	-1.69 **	1.94	0.92	-2.81 **	3.42
	(Giza 123 × Line 2)	12.79 **	0.08	3.54 *	2.71	-0.65	-1.71
	(Rihane-03 × Line 1)	11.78 **	1.15	1.38	-	-	-
	(Rihane-03 × Line 2)	13.14 **	2.72 **	3.74 *	-0.41	3.14 **	5.15
	(Giza 2000 × Line 2)	13.03 **	-2.05 **	-2.12	-	-	-
No, of grains Spike^{-1}	(Giza 123 ×Giza 2000)	59.82 **	0.80	26.82 **	24.72 **	-1.10	-29.72 **
	(Giza 123 × Line 2)	58.56 **	4.48 **	15.94 **	21.44 **	1.78	-29.32 **
	(Rihane-03 × Line 1)	66.66 **	4.48 **	3.78	-2.32	2.18	9.00
	(Rihane-03 × Line 2)	67.22 **	1.09	0.59	-	-	-
	(Giza 2000 × Line 2)	60.97 **	7.76 **	13.94 **	10.04 *	7.66 **	-6.16
100-kernel weight	(Giza 123 ×Giza 2000)	5.09 **	-0.27 **	0.32	-0.10	0.17	2.60 **
	(Giza 123 × Line 2)	4.39 **	0.34 **	-0.27	-0.53 **	-0.14	2.28 **
	(Rihane-03 × Line 1)	4.23 **	-0.11	0.48 *	0.01	-0.14	0.32
	(Rihane-03 × Line 2)	4.23 **	0.17 *	0.38	-0.16	0.16	0.85 *
	(Giza 2000 × Line 2)	5.08 **	0.26 **	-1.17 **	-1.60 **	-0.66 **	3.71 **
Grain yield Plant^{-1}	(Giza 123 ×Giza 2000)	29.17 **	-5.52 **	8.44 *	2.79	-7.25 **	19.92 **
	(Giza 123 × Line 2)	25.53 **	5.71 **	4.97	2.13	4.46 *	32.09 **
	(Rihane-03 × Line 1)	25.30 **	0.73	15.89 **	6.97	-3.74 *	1.40
	(Rihane-03 × Line 2)	30.64 **	5.60 **	5.88	-5.70	6.99 **	34.16 **
	(Giza 2000 × Line 2)	26.84 **	-2.38	1.78	-1.12	-2.05	27.02 **
Leaf rust disease	(Giza 123 ×Giza 2000)	5.15 **	0.08	-1.99 **	-1.92 **	-0.02	1.79
	(Giza 123 × Line 2)	6.10 **	-1.11 **	-0.54	-0.63	0.68 **	2.97 **
	(Rihane-03 × Line 1)	6.10 **	1.41 **	-0.37	0.15	0.00	1.55
	(Rihane-03 × Line 2)	7.66 **	-0.16	-2.22 **	-1.79 **	-0.13	5.13 **
	(Giza 2000 × Line 2)	6.10 **	-1.47 **	0.35	-	-	-

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

These results are in agreement with El-Seidy (1997a, b), Eid (2006), El-Sayed (2007) and El-Shawy (2008). Significant or highly significant positive additive × additive (aa) types of epistasis was detected for; days to maturity in all crosses, spike length in crosses; 1 and 2, number of grains spike^{-1} in the crosses; 1, 2 and 5, indicating that these traits had accumulating genes and selection for its development could be effective. While, the other crosses showed significant or highly significant negative and insignificant values (Table 4). Similar results were obtained by El-Hosary et al. (1992), Abul-Naas et al. (1993), El-Seidy (1997a, b), Nawar et al. (1999), Bhatnagar et al. (2001) and Sharma et al. (2003).

Significant or highly significant positive additive × dominance (ad) types of epistasis was found for; days to maturity in the three crosses; 3, 4 and 5, plant height in the crosses; 1, 2 and 4, spike length in cross 5, number of spikes plant^{-1} in the cross 4, number of grains spike^{-1} in cross 5, grain yield plant^{-1} in crosses; 2 and 4 and leaf rust in cross 2. However, the other crosses showed significant or highly significant negative and insignificant values. The dominance × dominance (dd) epistasis gene effect were significant or highly significant positive for; plant height in all crosses, spike length in the three crosses;3, 4 and 5; 100-grain weight and grain yield plant^{-1} in all crosses except for cross 3 and for leaf rust in crosses; 2 and 4. These results confirm the important role of dominance x dominance gene action in the genetic system. Similar approaches were reported by Abul-Naas et al. (1993), El-Seidy (1997b), Eid (2006), El-Sayed (2007) and El-Shawy (2008).

Heritability and expected genetic advance from selection

Heritability estimates in both broad and narrow sense and expected genetic advance from selection for studied traits are presented in Table 5. Heritability estimates in broad sense were relatively high for all studied traits in all crosses, ranging from 68.54% in cross 3 for 100-grain weight to 95.27% in cross 2 for grain yield plant^{-1}. While, heritability estimates in narrow sense were low to high for all studied traits in all crosses, ranging from 10.49% in cross 5 for days to maturity to 82.39 % in cross 5 for number of grains spike^{-1}, indicating that these traits were greatly affected by additive and non-additive effects. These results coincide with those reported by Abul-Naas et al. (1993), El-Seidy (1997b), Singh and Singh (1999), El-Bawab (2003), Eid (2006), El-Sayed (2007) and El-Shawy (2008).

The expected genetic advance as percent of F_2 ranged from (1.07%) for days to maturity in cross 3 to (79.08%) for grain yield plant^{-1} in cross 3. These results indicated the possibility of practicing selection in early generations and obtain high-yielding genotypes. Therefore, selection in those particular populations should be effective and satisfactory for successful breeding purposes. The results of this study indicated that estimate of epistasis, dominance and additive gene action may have been influenced by genotype-environment interactions.

Table 5. Heritability percentage in broad (h2b) and narrow (h2n) senses and expected genetic advance from selection (Δg) in five barley crosses for all the studied traits.

Trait		Cross	Heritability percentage		Expected genetic advance	
			$h^2(b)$	$h^2(n)$	Δg	Δg %
Days to maturity	1	(Giza 123 × Giza 2000)	75.37	38.61	1.99	1.56
	2	(Giza 123 × Line 2)	82.06	35.12	2.31	1.81
	3	(Rihane-03 × Line 1)	76.84	20.08	1.35	1.07
	4	(Rihane-03 × Line 2)	76.43	24.75	1.54	1.21
	5	(Giza 2000 × Line 2)	82.79	10.49	0.69	6.76
Plant height	1	(Giza 123 × Giza 2000)	88.33	51.49	9.40	7.74
	2	(Giza 123 × Line 2)	88.37	29.11	4.78	4.09
	3	(Rihane-03 × Line 1)	84.80	50.87	6.70	6.48
	4	(Rihane-03 × Line 2)	86.10	63.41	10.88	10.12
	5	(Giza 2000 × Line 2)	86.40	55.22	10.06	8.57
Spike length	1	(Giza 123 × Giza 2000)	72.87	38.24	0.93	12.44
	2	(Giza 123 × Line 2)	89.61	55.24	1.88	26.03
	3	(Rihane-03 × Line 1)	79.48	76.18	2.10	25.59
	4	(Rihane-03 × Line 2)	83.95	41.89	1.18	14.26
	5	(Giza 2000 × Line 2)	85.69	68.78	1.97	26.84
No. of spikes Plant^{-1}	1	(Giza 123 × Giza 2000)	74.18	56.57	4.80	39.61
	2	(Giza 123 × Line 2)	82.84	63.50	6.10	47.73
	3	(Rihane-03 × Line 1)	82.85	63.91	6.17	52.34
	4	(Rihane-03 × Line 2)	81.69	65.31	6.87	52.27
	5	(Giza 2000 × Line 2)	83.99	57.96	5.91	45.36
No, of grains Spike^{-1}	1	(Giza 123 × Giza 2000)	79.94	44.52	8.54	14.28
	2	(Giza 123 × Line 2)	83.52	76.21	19.86	33.91
	3	(Rihane-03 × Line 1)	79.33	53.26	10.32	15.49
	4	(Rihane-03 × Line 2)	75.63	40.41	8.04	11.96
	5	(Giza 2000 × Line 2)	91.16	82.39	21.16	34.71
100-kernel weight	1	(Giza 123 × Giza 2000)	81.92	26.51	0.30	5.99
	2	(Giza 123 × Line 2)	73.85	46.75	0.52	11.74
	3	(Rihane-03 × Line 1)	68.54	43.32	0.50	11.75
	4	(Rihane-03 × Line 2)	78.86	64.5	0.73	17.15
	5	(Giza 2000 × Line 2)	84.51	31.57	0.39	7.68
Grain yield Plant^{-1}	1	(Giza 123 × Giza 2000)	94.68	63.25	15.15	51.93
	2	(Giza 123 × Line 2)	95.27	33.08	7.77	30.42
	3	(Rihane-03 × Line 1)	92.27	78.88	20.01	79.08
	4	(Rihane-03 × Line 2)	91.58	36.72	10.75	35.08
	5	(Giza 2000 × Line 2)	94.10	31.56	8.47	31.56
Leaf rust disease	1	(Giza 123 × Giza 2000)	88.31	68.06	2.56	49.71
	2	(Giza 123 × Line 2)	83.97	31.49	1.03	16.90
	3	(Rihane-03 × Line 1)	77.73	45.48	1.49	24.41
	4	(Rihane-03 × Line 2)	77.38	34.38	1.02	13.26
	5	(Giza 2000 × Line 2)	82.55	48.56	1.59	25.24

It could be concluded that the degree of improving the studied traits are based on the high heritability and positive additive genetic advance as shown by the different traits, especially; number of spikes plant^{-1}, 100-grain weight and grain yield plant^{-1}. Determinant genetic effects of the phenotypic expression of these traits were fundamentally of the additive type. For this reason, a high response should be achieved after several selection cycles. Generally, the most promising crosses 1 and 3, which were found to be higher in magnitude, which had high genetic advance associated with high heritability and would be helpful in breeding programs for evolving better barley yield under normal conditions.

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٢-٣ دراسات وراثية على إنتاجية الشعير وعلاقته بالإصابة بمرض صدأ الاوراق

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أجريت هذه الدراسة بمزرعة محطة البحوث الزراعية بسخا خلال ثلاثة مواسم متتالية؛ ٢٠٠٧/٢٠٠٨ ، ٢٠٠٨/٢٠٠٩ ، ٢٠٠٩/٢٠١٠ لدراسة تأثير الفعل الجيني باستخدام نظام العشائر الست (الأب الأول، الأب الثاني، الجيل الأول، الجيل الثاني، الهجين الرجعي الأول و الهجين الرجعي الثاني) لخمسة هجن من الشعير هي : الهجين الأول (جيزة ١٢٣ x جيزة ٢٠٠٠)، الهجين الثاني (جيزة ١٢٣ x سلالة– ٢)، الهجين الثالث (ريحان–٣ x سلالة– ١)، الهجين الرابع (ريحان–٣ x سلالة–٢) والهجين الخامس (جيزة ٢٠٠٠ x سلالة– ٢). تم زراعة العشائر الست لهذه الهجن تحت الظروف الطبيعية من الري والتسميد. تم دراسة محصول الحبوب ومكوناته وبعض الصفات الخضرية المرتبطة به. أظهرت النتائج أن متوسطات الأجيال كانت عالية المعنوية بالنسبة لكل الصفات في جميع الهجن. تشير النتائج بصورة عامة إلى وجود تفاعل بين العوامل غير الأليلية بالنسبة لكل الصفات في معظم الهجن، كما أشارت النتائج إلى أهمية تأثيرات كل من الفعل الوراثي المضيف والسيادي والتي اختلفت تبعا للصفات والهجن. أما بالنسبة لمكونات التفاعل فإن التفاعل السيادي x السيادي كان ذو تأثير أكبر من تأثير الفعل الوراثي المضيف x المضيف والمضيف x السيادي في معظم الصفات المدروسة. وقد تم الحصول على تقديرات عالية المعنوية موجبة بالمقارنة بمتوسط الأبوين والأب الأفضل فى معظم الصفات المدروسة. أما بالنسبة للتقديرات الخاصة بدرجة التوريث فإن درجة التوريث بالمعني الواسع كانت مرتفعة في جميع الهجن في كل الصفات أما درجة التوريث بالمعنى الضيق فتراوحت مابين منخفضة إلى مرتفعة وذلك بالنسبة لجميع الصفات في كل الهجن. كما أن التقدم الوراثي المتوقع نتيجة الانتخاب تراوح مابين منخفض إلى مرتفع بالنسبة لمعظم الصفات المدروسة في جميع الهجن. وتشير هذه النتائج إلى إمكانية إجراء الانتخاب فى الأجيال الانعزالية المبكرة والحصول على تراكيب وراثية عالية المحصول. بصورة عامة فإن أفضل الهجن المبشرة كانت الهجين الأول والثالث حيث أعطيا قيما عالية للتقدم الوراثي المتوقع نتيجة للانتخاب وكذلك ارتفاع درجة التوريث مما يشير إلى أهمية هذه الهجن فى برامج التربية لتحسين الإنتاجية في الشعير. أما بالنسبة للمقاومة لمرض صدأ الأوراق فى الشعير فيعتبر الهجينان الأول والخامس أفضل الهجن التي يمكن الانتخاب فيها لتحسين المقاومة لهذا المرض.