Minufiya J. Agric. Res. Vol. 32 No.3: 865 - 880 (2007)

GENETICAL ARCHITECTURE OF QUANTITATIVE CHARACTERS IN RICE

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(Received: Mar. 27, 2007)

ABSTRACT : *Two crosses of rice (Sakha 102 x HR5824-B-3-2-3) cross I and (Giza 177 x HR5824-B-3-2-3) cross II, each with six populations (P1, P2, F1, F2, BC1, and BC2) were evaluated under two nitrogen fertilizer levels 40 and 80 nitrogen unit/feddan L1 and L2 respectively for yield, some of yield components and some growth attributes. Genetic parameters i.e. gene action, heterosis, inbreeding depression, potance ratio, heritability and genetic advance were estimated for all studied traits. Significant negative heterosis were detected for heading date in the cross I at L2, grain yield per plant in the two crosses at L1, panicle number per plant in the two crosses at L2 and harvest index in the cross I at L1. Significant positive heterotic effects were detected for other traits.*

Significant negative values of inbreeding depression were detected for heading date in the cross I at L2, flag leaf area in the cross II at L2, stem diameter in the cross I at L1 and in the cross II at L1 and L2, grain yield per plant in the two crosses at L1 and L2, panicle number per plant in the cross II at L1 and L2, panicle weight in the cross I and cross II at L2 and L1 respectively, 1000-grain weight in the cross I at L2 and harvest index in the cross I at L2 and the cross II at L1 and L2. However, significant positive values were found in the remaining traits except for heading date in the first cross at L1 and filled grains number per panicle in the second cross at L2.

Over dominance towards the better parent was found for flag leaf area in the cross I at L1 and L2 and in the cross II at L1, stem diameter in the two crosses at L1 and L2, grain yield per plant in the two crosses at L2, panicle number per plant in the cross I at L1, panicle weight in the cross I at L1 and in the cross II at L1 and L2, 1000-grain weight in the cross I at L1 and in the cross II at L1 and L2, filled grains number per panicle in the cross I at L1 and L2 and in the second cross at L1, and harvest index in the cross II at L1. Significant E1 and E2 were detected for most traits.

Additive gene effects (a) were significantly exhibited in all traits, in the two crosses at L1 and L2, except for flag leaf area in the two crosses at L1 and L2, grain yield per plant in the cross I at L2 and in the cross II at L1 and L2, panicle weight in the cross I at L1 and L2 and harvest index in the cross II at L2. Dominance gene effect (d) was detected to be highly significant for all traits studied except stem diameter in the cross I at L2. Significant additive x additive (a x a) epistatic types were found for all characters studied except grain yield per plant in the cross II at L1 and 1000-grain weight in the cross I *at L2. Also, additive x dominance and dominance x dominance types of gene effects were significant for most traits.*

Heritability estimates in broad sense were high in magnitude with values between 59% for plant height in the cross II at L1 to 93% for flag leaf area in the cross I at L2. High to moderate estimates of narrow sense heritability were found for most traits. High genetic gain was found to be associated with high narrow sense heritability estimates for flag leaf area and panicle weight in the two crosses.

Key words: *Quantitative characters- Rice- Heterosis- Gene action- Genetic advance under selection- Heritability- Inheritance.*

INTRODUCTION

Rice is the world's single most important food crop and a primary food source for more than a third of the world's population. More than 90% of the world's rice is grown and consumed in Asia where about 55% of the earth's people live. Therefore, it is necessary to develop rice varieties with consistent superior performance. Information about the type and magnitude of genetic variation and the relative importance of additive and non additive gene action types would assist rice breeders in carrying out the most suitable breeding programs for rice improvement. For achieving this goal, the genetic model, Gamble (1962) were proposed. The present investigation was designated to estimate the gene action, heritability, heterosis and expected genetic advance under selection for the characters under consideration in the two crosses Sakha 102 x HR5824-B-3-2-3 and Giza177 x HR5824-B-3-2-3.

MATERIALS AND METHODS

The present research was carried out at the Farm of Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt during three successive seasons 2004, 2005 and 2006. Three rice varieties Sakha 102, Giza 177 and HR5824-B-3-2-3 were used to establish the experimental materials used in this study. The three rice varieties were grown in three successive sowing dates at fifteen days intervals to overcome the differences in flowering time of these parents. Single seedlings of each parent were transplanted 30 days after sowing in the permanent field, each in five rows. Each row was five meters long and contained 25 hills. Each two rice varieties were crossed and bulk emasculation method was practiced using hot water technique (Butany 1961) and that was done in 2005 growing season. In 2005, a part of the obtained hybrid seeds of the two crosses, Sakha102 x HR5824-B-3-2-3 and Giza177 x HR5824-B-3-2-3 was sown and the rest being saved to the next season. F1 plants were self pollinated and backcrossed to both parents to obtained F2's and backcross seeds. The six populations, P1, P2, F1, F2, BC1 and BC2 were sown under two nitrogen fertilizer levels i.e. 40 kg N/fa as normal level and 80 kg/fa as high level. The two experiments were arranged in a randomized complete block design with three replicates per each level in 2006. Each replicate comprised 20 rows of F2 and 10 rows of BC1, BC2, F1 and the parents and each row was five meters long and contained 25 hills. Normal agricultural rice practices were applied as usual for the ordinary rice fields in the area. Seventy five plants of each of P1, P2, F1 and 150 plants from BC1 and BC2 and 300 plants from F2 populations per replicate were taken at random and measured as follows: plant height, heading date, flag leaf area, stem diameter, grain yield per plant, panicle number per plant, panicle weight, 1000-grain weight and harvest index.

The F- test was used to examine the existence of genetic variance in F2 populations using one tail "F" ratio i.e. F= VF2/VE, where VE= VP1+VP2+VF1/3. Heterosis, inbreeding depression, F2 deviation (E1), backcross deviation (E2) and potance ratio were calculated. Nature of gene action was studied according to the relationships illustrated by Gamble (1962). Heritability in both broad and narrow senses was estimated in F2 generation according to Mather's procedure (1949). The predicted genetic advance under selection (ΔG) was estimated according to Johnson *et al.* (1955) and also presented as percentage of the F2 mean performance following Miller *et al.,* (1958), ΔG%= ΔG/ x F2 x 100.

RESULTS AND DISCUSSION

Genetic variances among F2 plants were calculated and tested for statistical significance Table (1). All traits studied showed genetic variance in F2 plants in the two crosses (I and II) under the two nitrogen fertilizer levels 40 (L1) and 80 (L2) unit/fed. and therefore, other parameters needed were estimated. Means and variances of the six populations i.e. P1, P2, F1, F2, BC1 and BC2 for all traits studied in the two crosses i.e. Sakha 102 x HR5824-B-3-2-3 (cross I) and Giza177 x HR5824-B-3-2-3 (cross II) under two nitrogen fertilizer levels 40 (L1) and 80 (L2) unit/fed are presented in Table (2) and (3). Heterosis, inbreeding depression, potance ratio, gene action, F2 deviation and BC deviation of the two crosses for the studied characters are given in Table (4) and Table (5).

Useful heterosis expressed as the percentage deviations of F1 mean performance from the respective mid parents for all traits studied at the two nitrogen fertilizer levels in the two crosses studied are presented in Table (4). High positive values of heterosis would be of interest in all traits studied except plant height and heading date where negative values would be useful from the rice breeders point of view. Highly significant negative useful heterotic effects was found for heading date in the cross I (Sakha 102 x HR5824-B-3-2-3) at L2. This result is in agreement with those obtained by Aly (1979), Reddy and Nekar (1991), Vivekanandan and Giridharan (1995) and El-Abd and Abdallah (2002). However, significant positive useful heterotic effects was detected for flag leaf area, stem diameter, panicle weight, 1000-

Table 1. F-test of significance of the genetic variance in F2 population for agronomic characters in the two crosses studied Sakha 102 x HR5824-B-3-2-3 (cross I) and Giza177 x HR5824-B-3-2-3 (cross II) under two nitrogen fertilizer levels.

Characters	Cross I		Cross II	
	L1	L2	L1	L2
Plant height (cm)	3.14**	3.05**	2.47**	2.81**
Heading date	9.32**	9.46**	5.24**	6.78**
Flag leaf area (cm)	12.9**	13.7**	9.17**	8.79**
Stem diameter (mm)	4.61**	4.90**	5.64**	6.92**
Grain yield/plant (gm)	10.4**	7.79**	9.17**	6.19**
Panicle number/plant	3.02**	3.22**	2.12**	3.04**
Panicle weight (gm)	9.72**	7.44**	11.8**	10.9**
1000-grain weight (gm)	12.0**	11.1**	11.4**	9.21**
Filled grains No./panicle	4.34**	4.21**	6.83**	6.32**
Harvest index %	6.39**	6.23**	5.84**	8.54**

* and ** significant at 0.05 and 0.01 probability levels, respectively.
L1 = nitrogen level 40 kg/feddan L2 = nitrogen level 80 kg/feddan

Table 2. Mean and variances of P1, P2, F1, F2, BC1 and BC2 populations of the first cross Sakha 102 x HR5824-B-3-2-3 under two nitrogen fertilizer levels for all traits studied.

Characters	Mean	P1(HR5824)		P2 Sakha102		F1		F2		BC1		BC2	
	Var.	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2
Plant height (cm)	$\bar{X}$	77.91	88.5	106.4	110.0	110.5	113.9	98.08	110.9	80.41	85.36	99.71	103.5
	V	6.09	6.9	8.46	11.84	9.76	10.13	25.44	29.36	17.51	20.33	20.71	22.56
Heading date	$\bar{X}$	72.33	77.1	90.4	93.77	81.51	83.33	81.14	87.67	75.36	81.33	94.51	99.31
	V	1.02	0.96	0.85	0.81	0.87	1.07	8.51	8.96	6.17	6.45	5.93	6.27
Flag leaf area (cm)	$\bar{X}$	15.33	21.38	24.58	27.83	30.85	34.69	25.44	27.37	19.17	22.16	21.0	23.17
	V	3.17	4.01	5.01	3.42	3.17	4.02	49.15	52.33	33.77	35.82	35.17	36.63
Stem diameter(mm)	$\bar{X}$	2.58	2.31	3.27	3.99	3.27	4.07	3.79	3.89	3.15	3.55	3.47	3.75
	V	0.08	0.09	0.11	0.13	0.09	4.08	0.43	0.49	0.31	0.35	0.36	0.38
Grain yield /plant	$\bar{X}$	25.76	28.72	50.44	53.76	34.7	49.39	55.18	56.76	40.76	46.5	49.37	51.19
	V	55.46	85.31	97.65	136.5	45.71	48.22	961.3	701.3	538.1	588.4	601.1	602.1
No of panicle/plant	$\bar{X}$	12.42	16.95	21.11	24.21	19.3	19.53	16.71	18.54	16.74	19.31	22.15	23.46
	V	9.81	10.31	4.85	6.96	7.35	8.07	22.14	27.18	14.14	18.31	18.15	25.6
Panicle weight(gm)	$\bar{X}$	1.81	1.67	3.5	3.01	3.47	2.51	3.35	2.89	1.66	2.03	1.77	1.83
	V	0.14	0.17	0.21	0.46	0.52	0.16	2.82	1.96	1.71	1.45	1.53	1.67
1000-grain weight(gm)	$\bar{X}$	23	21.93	27.82	27.19	27.23	25.5	26.01	25.79	22.17	23.17	27.89	28.55
	V	0.13	0.19	0.17	0.26	0.24	0.27	2.16	2.66	1.86	1.77	1.95	1.73
No of filled grains/panicle	$\bar{X}$	62.17	81.41	119.6	122.8	117.9	117.81	120.5	90.18	73.51	77.98	105.6	115.4
	V	96.51	101.6	180.8	171.1	133.5	167.5	593.9	618.1	407.5	468.5	501.3	496.8
Harvest index%	$\bar{X}$	39.75	34.8	41.46	39.27	40.94	36.47	40.96	40.7	38.01	37.15	40.31	42.0
	V	2.76	3.15	4.65	4.58	5.13	5.34	26.71	27.15	17.16	18.55	19.36	20.0

Table 3. Mean and variances of P1, P2, F1, F2, BC1 and BC2 populations of the second cross Giza 177 x HR5824-B-3-2-3 under two nitrogen fertilizer levels for all traits studied.

Characters	Mean	P1 (HR5824)		P2 (Giza 177)		F1		F2		BC1		BC2	
	Var.	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2
Plant height (cm)	$\bar{X}$	77.91	88.5	92.2	97.2	98.6	105.4	80.01	87.79	82.51	86.75	89.41	93.41
	V	6.09	6.9	8.92	9.72	7.53	8.46	18.55	23.49	15.41	19.41	17.51	17.99
Heading date	$\bar{X}$	72.33	77.1	90.47	98.03	87.92	89.17	83.94	86.0	70.31	75.56	85.31	91.22
	V	1.02	0.96	1.29	0.99	2.01	1.99	7.54	8.9	5.9	5.83	6.31	6.79
Flag leaf area (cm)	$\bar{X}$	15.33	21.38	26.65	33.83	29.58	30.27	27.98	36.38	23.19	26.02	25.15	27.35
	V	3.17	4.01	6.08	6.18	5.55	6.17	45.23	47.91	30.15	37.15	35.18	38.16
Stem diameter (mm)	$\bar{X}$	2.58	2.31	3.88	3.92	4.23	4.39	4.51	4.68	3.01	3.19	3.6	3.59
	V	0.08	0.09	0.05	0.1	0.12	0.07	0.47	0.6	0.33	0.43	0.39	0.52
Grain yield /plant	$\bar{X}$	25.76	28.72	47.11	51.02	31.23	49.34	42.55	60.26	37.15	45.31	40.76	48.08
	V	55.46	85.31	77.33	156.0	60.71	65.22	591.3	632.4	491.3	501.3	483.6	516.4
No of panicle/plant	$\bar{X}$	12.42	16.95	18.87	20.04	16.27	16.93	17.65	19.12	13.71	14.59	17.06	18.44
	V	9.81	10.31	16.41	9.3	7.91	10.11	24.17	30.15	15.01	17.03	22.33	26.76
Panicle weight (gm)	$\bar{X}$	1.81	1.67	3.35	3.07	3.12	3.01	3.38	2.63	2.13	2.26	3.33	3.74
	V	0.14	0.17	0.11	0.17	0.31	0.35	2.2	2.5	1.36	1.56	1.73	1.65
1000-grain weight (gm)	$\bar{X}$	23	21.93	27.23	25.47	28.67	28.3	28.5	28.01	23.01	24.22	27.99	28.85
	V	0.13	0.19	0.2	0.41	0.31	0.26	2.44	2.64	1.64	1.77	1.75	1.83
No of filled grains/panicle	$\bar{X}$	62.17	81.41	113.2	130.6	129.4	116.3	121.3	115.8	66.51	67.51	117.4	118.2
	V	96.51	101.6	106.7	122.4	145.2	163.2	793.5	815.3	674.5	715.6	666.1	697.5
Harvest index%	$\bar{X}$	39.75	34.8	41.77	37.5	42.4	36.2	46.39	45.45	37.15	39.88	41.31	40.35
	V	2.76	3.15	9.85	5.58	2.89	3.64	30.15	35.22	22.53	26.15	23.15	24.6

Table 4. Heterosis, inbreeding depression, potence ratio and the type of gene action parameters in the cross I (HR5824 x Sakha 102) for the agronomic characters studied at the nitrogen levels (L1 and L2)

Characters	N levels	heterosis	Inbreeding depression	Potence ratio	Gene action parameters							
					m	a	d	aa	ad	dd	E1	E2
Plant height (cm)	L1	19.9**	11.22**	2.57	98.1**	-19.3**	-13.7**	-32.0**	-5.05**	77.1**	-3.2**	-221.9**
	L2	14.7**	2.65**	2.72	110.8**	-18.1**	-51.1**	-65.7**	-7.39**	114.3**	4.2**	-231.3**
Heading date	L1	0.15	0.45	0.03	81.1**	-19.1**	15.3**	15.1**	-10.1**	-29.1**	-0.31	-182.0**
	L2	-0.5**	-5.21**	-0.09	87.6**	-17.9**	8.51**	10.6**	-9.64**	-34.3**	4.1**	-185.0**
Flag leaf area (cm)	L1	60.7**	17.54**	4.33	25.4**	-1.83	-10.5**	-21.4**	2.8**	42.6**	0.42	-51.8**
	L2	40.9**	21.1**	6.26	27.3**	-1.01	-8.74**	-18.8**	2.22**	46.7**	-2.2**	-60.3**
Stem diameter.mm	L1	11.6**	-15.9**	2.0	3.79**	-0.32**	-1.58**	-1.92**	0.02	1.07**	0.7**	-6.52**
	L2	29.2**	4.42**	2.19	3.89**	-0.2*	-0.04	-0.96**	0.64**	0.8	0.28**	-7.42**
Grain yield /plant	L1	-8.9**	-59.0**	-0.55	55.2**	-8.61*	-43.8**	-40.4**	3.73	5.8	18.7**	-81.4**
	L2	19.7**	-14.9**	1.3	56.7**	-4.69	-23.5*	-31.6**	7.83*	17.5	11.4**	-95.3**
No of panicle/plant	L1	15.1**	13.42**	1.17	16.7**	-5.41**	13.4**	10.9**	-1.07	-16.5**	-1.3**	-41.4**
	L2	-5.1**	5.07**	-0.58	18.5**	-4.15**	10.3**	11.3**	-0.52	-16.7**	-1.5**	-44.2**
Panicle weight (gm)	L1	30.4**	3.46**	1.93	3.35**	-0.11	-5.73**	-6.54**	0.74**	11.9**	0.29**	-6.24**
	L2	7.2**	-15.1**	0.51	2.89**	0.2	-3.67**	-3.84**	0.87**	5.82**	0.47**	-4.65**
1000-grain weight (gm)	L1	7.1**	4.48**	1.51	26.0**	-5.72**	-2.1**	-3.92**	-3.31**	9.08**	-0.3**	-58.3**
	L2	3.8**	-1.14**	0.71	25.8**	-5.38**	1.22*	0.28	-2.75**	-3.6**	0.76**	-55.4**
No of filled grains/panicle	L1	29.7**	-2.2	1.88	120.5**	-32.1**	-96.7**	-123**	-3.37	183.1**	16.1**	-240.9**
	L2	15.3**	23.45**	1.51	90.2**	-37.4**	41.6**	26.0**	-16.6**	27.1	-19**	-257.3**
Harvest index%	L1	0.81**	-0.05	0.78	40.9**	-2.3**	-6.86**	-7.2**	-1.45*	13.6**	0.19	-83.8**
	L2	-1.5**	-11.6**	-0.51	40.7**	-4.85**	-5.07**	-4.5*	-2.61**	-6.79*	3.9**	-78.3**

* and ** significant at 0.05 and 0.01 probability levels, respectively.
L1 = nitrogen level 40 kg/feddan L2 = nitrogen level 80 kg/feddan

Table 5. Heterosis, inbreeding depression, potence ratio and the type of gene action parameters in the cross II (HR5824 x Giza177) for the agronomic characters studied at the nitrogen levels (L1 and L2)

Characters	N levels	heterosis	Inbreeding depression	Potence ratio	Gene action parameters							
					m	a	d	aa	ad	dd	E1	E2
Plant height (cm)	L1	15.9**	18.9**	3.8	80.0**	-6.9**	37.3**	23.8**	0.25	-0.27	-11.8**	-190.5**
	L2	13.5**	16.7**	5.78	87.8**	-6.66**	21.7**	9.16**	-0.31**	27.0**	-11.3**	-204.9**
Heading date	L1	8.01**	4.53**	1.44	83.9**	-15.0**	-18.0**	-24.5**	-5.93**	51.9**	-0.7**	-184.3**
	L2	1.84**	3.55**	0.31	86.0**	-15.6**	-8.82**	-10.4**	-5.19**	30.3**	-2.3**	-192.3**
Flag leaf area (cm)	L1	40.9**	5.41**	3.03	27.9**	-1.96	-6.65**	-15.2**	3.7**	19.7**	2.7**	-52.5**
	L2	9.63**	-20.2**	0.86	36.4**	-1.33	-36.1**	-38.7**	4.9**	47.7**	7.4**	-59.2**
Stem diameter (mm)	L1	30.9**	-6.62**	3.08	4.51**	-0.59**	-3.82**	-4.82**	0.06	6.52**	0.78**	-8.05**
	L2	40.7**	-6.61**	3.18	4.68**	-0.4**	-3.89**	-5.16**	0.41**	6.61**	0.93**	-7.91**
Grain yield /plant	L1	-14**	-36.3**	-0.98	42.5**	-3.61	-19.5*	-14.3	7.07	-6.11	8.7**	-71.2**
	L2	23.7**	-22.1**	1.7	60.2**	-2.77	-44.7**	-54.2**	8.38*	45.9**	15.6**	-91.9**
No of panicle/plant	L1	3.96**	-8.48**	0.39	17.6**	-3.35**	-8.44**	-9.06**	-0.12	11.3**	1.69**	-35.2**
	L2	-8.5**	-12.9**	-2.04	19.1**	-3.85**	-11.9**	-10.4**	-2.31**	15.2**	1.41**	-39.2**
Panicle weight (gm)	L1	20.9**	-8.33**	1.4	3.38**	-1.2**	-2.06**	-2.6**	-0.43*	3.08**	0.53**	-6.9**
	L2	27.0**	12.6**	1.83	2.63**	-1.48**	2.12**	1.48**	-0.78**	-2.72**	-0.06	-6.86**
1000-grain weight (gm)	L1	14.1**	0.59**	3.36	28.5**	-4.98**	-8.44**	-12.0**	-2.87**	17.5**	1.61**	-58.7**
	L2	19.4**	1.02**	5.2	28.0**	-4.63**	-1.3*	-5.9**	-2.86**	3.76**	2.01**	-56.6**
No of filled grains/panicle	L1	47.6**	6.28**	3.27	121.3**	-50.8**	-75.6**	-117**	-25.3**	183.7**	12.7**	-267.9**
	L2	9.65**	0.38	0.83	115.8**	-50.7**	-81.4**	-91.7**	-26.1**	164.7**	4.68*	-273.0**
Harvest index%	L1	4.02**	-9.41**	3.25	46.4**	-4.16**	-27.0**	-28.6**	-3.15**	38.0**	4.81**	-87.3**
	L2	0.14	-25.5**	0.07	45.4**	-0.47	-21.2**	-21.3**	0.88	5.58	9.28**	-72.8**

* and ** significant at 0.05 and 0.01 probability levels, respectively.
L1 = nitrogen level 40 kg/feddan L2 = nitrogen level 80 kg/feddan

grain weight and filled grains number per panicle in the two crosses (I and II) at the two nitrogen fertilizer levels (L1 and L2). Also, significant positive useful heterotic effects was found for grain yield per plant in both crosses (I and II) at L2, panicle number per plant in both crosses (I and II) at L1 and

harvest index in the two crosses (I and II) at L1. Similar results were obtained by El-Mowafi (1988), Reddy and Chaudhary (1991), Reddy and Nekar (1991), El-Hissewy and El-Kady (1992), Lokaprakash *et al.* (1992), Wilfered and Prosad (1992), Hammoud (1996), Salem (1997), Abd El-Aty (2001) , El-Refaee (2002), Hammoud (2004) and Hammoud (2005).

As for inbreeding depression, significant positive values were obtained for plant height in the two crosses (I and II) at the two nitrogen levels (L1 and L2), heading date in the cross II at (L1 and L2), flag leaf area in the cross I at (L1 and L2) and the cross II at L1, stem diameter in the cross I at L2, panicle number per plant in the cross I at (L1 and L2), panicle weight in the cross I at L1 and in the cross II at L2, 1000-grain weight in the cross I at L1 and in the cross II at (L1 and L2) and filled grains number per panicle in the cross I at L2 and in the cross II at L1. However, significant negative value of ID was found for heading date in the cross I at L2, flag leaf area in the cross II at L2, stem diameter in the cross I at L1 and in the cross II at (L1 and L2), grain yield per plant in both crosses at (L1 and L2), panicle number per plant in the cross II at (L1 and L2), panicle weight in the cross I at L2 and the cross II at L1, 1000-grain weight in the cross I at L2 and harvest index in the cross I at L2 and in the cross II at (L1 and L2). The present results were found to be agreed with the cases that were previously obtained by Aly (1979), Reddy and Chaudhary (1991), Vivekanandan and Giridharan (1995), El-Refaee (2002), Hammoud (2004) and Hammoud (2005).

Concerning potence ratio, over dominance towards the better parent was found for flag leaf area in the cross I at L1 and L2 and in the cross II at L1, stem diameter in the two crosses at L1 and L2, grain yield per plant in the two crosses at L2, panicle number per plant in the cross I at L1, panicle weight in the cross I at L1 and in the cross II at L1 and L2, 1000-grain weight in the cross I at L1 and in the cross II at L1 and L2, filled grains number per panicle in the cross I at L1 and L2 and in the second cross at L1, and harvest index in the cross II at L1. The existence of over dominance was previously reported by Aly (1979), Reddy and Chaudhary (1991) , El-Abd (1999), El-Abd and Abdallah (2002), Hammoud (2004) and Hammoud (2005). for grain yield per plant, panicles number per plant, 1000-grain weight, filled grains per panicle and Verma *et al* (1994) for harvest index. Partial dominance towards the better parent was found for heading date in the cross I at L2, flag leaf area in the cross II at L2, panicle number per plant in the cross II at L1, panicle weight and 1000-grain weight in the cross I at L2 respectively, filled grains number per panicle in the cross II at L2 and harvest Index in the cross I and the cross II at L1 and L2, respectively. Similar results were previously obtained by Abd El-Aty *et al* (2002), El-Abd and Abdallah (2002), Hammoud (2004) and Hammoud (2005).

The nature of gene action was studied according to Gamble (1962). The estimated values of the various types of gene effects are illustrated in Table (4 and 5). In all traits the mean effect of parameters (m) was highly significant. The additive gene effects (a) were found to be highly significant for all traits in the two crosses at the two nitrogen fertilizer levels except flag leaf area in the two crosses at both fertilizer levels, grain yield per plant in the cross I at L2 and in the cross II at L1 and L2, panicle weight in the cross I at L1 and L2 and harvest index in the cross II at L2. Therefore, it could be concluded that the traits which exhibited highly significant estimates of the additive gene effects (a) would give the potential for obtaining further improvements.

The estimates of dominance effects were highly significant for all traits studied except for stem diameter in the cross I at L2.

Significant additive x additive epistatic types were detected for all traits except grain yield per plant in the cross II at L1 and 1000-grain weight in the cross I at L2, the estimated values of additive x dominance types of digeneic epistasis were found to be significant for all traits except plant height in the cross II at L1, stem diameter and grain yield per plant in the cross I and cross II at L1, panicle number per plant in the cross I at L1 and L2 and the cross II at L1, filled grains number per panicle in the cross I at L1 and harvest index in the cross II at L2. Dominance x dominance types of gene action were found to be significant for all traits studied except plant height in the cross II at L1, stem diameter in the cross I at L2, grain yield per plant in the cross I at L1 and L2 and the cross II at L1, and harvest index in the cross II at L2. The same results were previously reported by Tripathi *et al* (1999), Hammoud (2004) and Hammoud (2005).

Heritability values are important to the breeder since it quantifies the expected improvement upon selection. To achieve genetic improvement through selection, heritability must be high. Heritability in both broad and narrow sense and genetic advance under selection were computed and the obtained results are presented in Table (6). High heritability estimates in broad sense were detected for all traits studied in the two crosses at L1 and L2. Similar results were previously reported by Aly (1979), Kato (1990), Peng (1991), Marwat *et al* (1994), Sawant and Patil (1995), Choudhury and Das (1997), Singh *et al.* (1998), El-Refaee (2002), Hammoud (2004) and Hammoud (2005).

High estimates of narrow sense heritability were found for heading date in the cross I at L1 and L2 and in the cross II at L2, flag leaf area in the cross I at L1 and L2 and in the cross II at L1, panicle number per plant in the cross II at L2, panicle weight in the cross I at L1 and in the cross II at L1 and L2, 1000 grain weight in the cross I at L2 and in the cross II at L1 and L2, and harvest index in the cross I at L1 and L2 and in the cross II at L2. Moderate estimates of narrow sense heritability were observed for plant height in the cross I at L1 and L2, stem diameter in cross I at L2 and in the cross II at L1, panicle number per plant in both crosses at L1, filled grains number per panicle in the cross I at L1 and harvest index in the cross II at L1. Low heritability values in narrow sense were found for the remaining characters studied

Table (6): Heritability estimates, genetic advance (ΔG) and genetic advance expressed as a percentage of the F2 mean in the Cross I (HR5824 x Sakha102) and cross II (HR5824 x Giza177) for all agronomic characters studied.

Characters	Crosses	Heritability %				Genetic advance			
		Broad sense		Narrow sense		ΔG		ΔG %	
		L1	L2	L1	L2	L1	L2	L1	L2
Plant height (cm)	Cross I	68.0	67.0	50.0	54.0	5.17	6.02	5.0	5.0
	Cross II	59.0	64.0	23.0	41.0	2.0	4.07	2.0	5.0
Heading date (days)	Cross I	89.0	89.0	58.0	58.0	3.47	3.58	4.0	4.0
	Cross II	81.0	85.0	38.0	58.0	2.15	3.58	3.0	4.0
Flag leaf area (cm)	Cross I	92.0	93.0	60.0	61.0	8.63	9.12	34.0	33.0
	Cross II	89.0	89.0	56.0	43.0	7.7	6. 1	28.0	17.0
Stem diameter (mm)	Cross I	78.0	80.0	44.0	51.0	0.60	0.74	16.0	19.0
	Cross II	82.0	86.0	47.0	42.0	0.66	0.66	15.0	14.0
Grain yield per plant (gm)	Cross I	90.0	87.0	35.0	30.0	19.07	16.5	35.0	29.0
	Cross II	89.0	84.0	35.0	39.0	17.59	20.25	41.0	34.0
Panicle number per plant	Cross I	67.0	69.0	54.0	38.0	5.25	4.13	31.0	22.0
	Cross II	53.0	67.0	46.0	55.0	4.61	6.19	26.0	32.0
Panicle weight (gm)	Cross I	90.0	87.0	85.0	41.0	2.94	1.18	88.0	41.0
	Cross II	92.0	91.0	60.0	72.0	1.82	2.33	54.0	89.0
1000-grain weight (gm)	Cross I	92.0	91.0	24.0	68.0	0.71	2.3	3.0	9.0
	Cross II	91.0	89.0	61.0	64.0	1.96	2.13	7.0	8.0
Filled grains No./panicle	Cross I	77.0	76.0	47.0	44.0	23.38	22.45	20.0	25.0
	Cross II	85.0	84.0	31.0	27.0	18.02	15.69	15.0	14.0
Harvest index %	Cross I	84.0	84.0	63.0	58.0	6.74	6.23	16.0	15.0
	Cross II	83.0	88.0	48.0	56.0	5.48	6.83	12.0	15.0

Table (6). Similar results were previously reported by Tripathi *et al.* (1999), Abd El-Aty *et al.* (2002), El-Abd and Abdallah (2002), El-Refaee (2002), Hammoud (2004) and Hammoud (2005). The differences in magnitudes of both broad and narrow sense heritabillty estimates were found for most traits under investigation would indicate and ascertained the presence of both additive and non-additive genetic variance in the inheritance of most traits in the two crosses under investigation as previously obtained from gene action parameters studied Table (6). The same conclusion was previously reached by Aly *et al.* (1979), Loknathanl *et al.* (1991), Reddy and Chaudhary (1991), Marwat *et al* (1994), Sawant and Patil (1995), Choudhury and Das (1997), Regbell and Subborman (1997), Singh *et al.* (1998), Tripath *et al.* (1999), Abd El-Aty *et al.* (2002), El-Abd and Abdallah (2002), El-Refaee (2002), Hammoud (2004) and Hammoud (2005).

The genetic advance under selection in Table (6) depends on the amount of genetic variability and show the possible gain as percent increase in the F3 generation over the F2 mean when the most desirable 5% of the F2 plants are selected. The expected genetic advance under selection (ΔG %) for all characters studied was derived by using heritability in narrow sense. Genetic advance under selection was found to be high in magnitudes for flag leaf area in the cross I at L1 and L2 and in the cross II at L1, grain yield per plant, panicle number per plant and panicle weight in both crosses at L1 and L2, and filled grains number per panicle in the cross I at L1 and L2. Relatively moderate genetic gains were obtained for flag leaf area in the cross II at L2, stem diameter in both crosses at L1 and L2, filled grains number per panicle in the cross II at L1 and L2 and harvest index in both crosses at L1 and L2. Low genetic gains were detected for plant height, heading date and 1000-grain weight in both crosses at L1 and L2.

Johanson *et al.* (1955) reported that heritability estimates along with genetic gain are usually more useful in predicting the effect of selection than heritability values alone. On the other hand, Dixit *et al.* (1970) pointed out that high heritability is not always associated with high genetic gain, but in order to make effective selection, high heritability should be associated with high genetic gain. In this investigation, high genetic gain was found to be associated with high narrow sense heritability estimates for flag leaf area and panicle weight in both crosses. Consequently, selection for these traits should be effective and satisfactory for successful breeding purposes. Moderate estimates of both narrow sense heritability and genetic advance were obtained for stem diameter in both crosses and harvest index in the cross II . Therefore, selection for these traits in these populations will be effective, but probably of less success than in the former characters. Low genetic gain was associated with low narrow sense heritability values for the other of the characters studied. Hence, selection for these traits would be of less effectiveness.

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التركيب الوراثى لبعض الصفات الكمية فى الأرز

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الملخص العربى

أجرى هذا البحث بمركز البحوث والتدريب في الأرز بسخا- كفر الشيخ- مصر خلال مواسم ٢٠٠٤, ٢٠٠٥, ٢٠٠٦ على هجينين من الأرز الأول (اتش آر ٥٨٢٤- ب-٣-٢-٣X سخا١٠٢) والثانى (اتش آر ٥٨٢٤- ب-٣-٢-٣X سخا١٧٧) تحت مستويين من التسميد الآزوتى (٤٠, ٨٠ وحدة آزوت) وشملت الدراسة في كل منهما الأبوين والجيل الأول والثانى وجيلى الهجينين الرجعيين الأول والثانى بهدف دراسة تأثير الفعل الجينى - درجة التوريث بمعناها العام والضيق وكذلك التحسين الوراثى المتوقع لصفات طول النبات, ميعاد التزهير, قطر الساق, مساحة الورقة, محصول النبات الفردى, عدد السنابل بالنبات, وزن السنبلة, وزن ١٠٠٠ حبة, عدد الحبوب الممتلئة بالسنبلة ودليل الحصاد.

ويمكن تلخيص النتائج كالآتى:-

* كانت قوة الهجين معنوية وسالبة لكل من ميعاد التزهير في الهجين الأول تحت مستوى التسميد النيتروجينى (٨٠ وحدة آزوت) ومحصول النبات الفردى في الهجينين تحت المستوى النيتروجينى الأول (٤٠ وحدة آزوت) وعدد السنابل بالنبات في الهجينين تحت المستوى النيتروجينى الثانى (٨٠ وحدة آزوت) ومعامل الحصاد في الهجين الأول تحت المستوى النيتروجينى الأول (٤٠ وحدة آزوت). وكانت قوة الهجين معنوية وموجبة لباقى الصفات.
* أظهر معامل التربية الداخلية نقصا موجبا لصفات ميعاد التزهير في الهجين الأول ومساحة الورقة في الهجين الثانى تحت المستوى النيتروجينى الثانى وقطر الساق في الهجين الأول تحت المستوى النيتروجينى الأول في الهجين الثانى تحت المستوى النيتروجينى الثانى و محصول النبات الفردى في الهجينين تحت مستويي النيتروجين الأول و الثانى و عدد

السنابل بالنبات في الهجين الثانى تحت مستويي النيتروجين الأول و الثانى و وزن السنبلة في الهجينين الأول و الثانى تحت مستويي النيتروجين الثانى والأول علـى الترتيب, وزن ١٠٠٠ حبة في الهجين الأول تحت المستوى النيتروجينى الثانى ودليل الحصاد في الهجين الأول تحت المستوى النيتروجينى الثانى و في الهجين الثانى تحت المستوى النيتروجينى الأول والثانى. بينما أظهر زيادة معنوية في بقية الصفات عدا صفات ميعاد التزهير في الهجين الأول تحت المستوى النيتروجينى الأول و عدد الحبوب الممتلئة بالسنبلة في الهجين الثانى تحت المستوى النيتروجينى الثانى.

* كانت درجة السيادة فائقة في اتجاه الأب الأعلى وذلك لصفات مساحة الورقة في الهجين الأول تحت المستوى النيتروجينى الأول والثانى و في الهجين الثانى تحت مستويي النيتروجين الأول وقطر الساق في الهجينين تحت مستويي النيتروجين الأول و الثانى و محصول النبات الفردى في الهجينين تحت مستوى النيتروجين الثانى و عدد السنابل بالنبات في الهجين الأول تحت المستوى النيتروجينى الأول و وزن السنبلة في الهجين الأول تحت المستوى النيتروجينى الأول وفى الهجين الثانى تحت مستوى النيتروجين الأول والثانى ووزن ١٠٠٠ حبه في الهجين الأول تحت المستوى النيتروجينى الأول وفى الهجين الثانى تحت مستوى النيتروجين الاول والثانى وعدد الحبوب الممتلئة بالسنبلة في الهجين الأول تحت مستوى النيتروجين الأول والثانى وفى الهجين الثانى تحت المستوى النيتروجينى الثانى ومعامل الحصاد في الهجين الثانى تحت المستوى النيتروجينى الاول .
* كانت قيمة الانحراف الراجع الى التفاعل الجينى E2, E1 معنوى لمعظم الصفات . وبالنسبة لطبيعة فعل الجينات كان أثر فعل الجينات من النوع المضيف معنوى لكل الصفات في الهجين تحت مستوى النيتروجينى الأول والثانى عدا مساحة الورقة في الهجينين تحت مستوى النيتروجينى الاول والثانى ومحصول النبات الفردى في الهجين الاول تحت المستوى النيتروجينى الثانى وفى الهجين الثانى تحت مستوى النيتروجين الاول والثانى ووزن السنبلة في الهجين الاول تحت مستوى النيتروجينى الاول والثانى ومعامل الحصاد في الهجين الثانى تحت المستوى النيتروجينى الثانى . وكان تأثير فعل الجين السيادى معنوياً لكل الصفات تحت الدراسة عدا قطر الساق في الهجين الاول تحت المستوى النيتروجينى الثانى .

* كان فعل الجين التفوقى (المضيف × المضيف) معنوياً لكل الصفات المدرسة ما عدا محصول النبات الفردى في الهجين الثانى تحت المستوى النيتروجينى الاول ووزن ١٠٠٠ حبه في الهجين الاول تحت المستوى النيتروجيني الثانى ، كذلك كان الفعل الجينى (المضيف × السيادى) و (السيادى × السيادى) معنوياً لمعظم الصفات .
* كانت قيمة معامل التوريث بمعناه الواسع عالية وتراوحت من ٥٩% لصفة طول النبات في الهجين الثانى تحت المستوى النيتروجينى الاول الى ٩٣% مساحة الورقة في الهجين الاول تحت المستوى النيتروجينى الثانى . بينما كانت قيمة معامل التوريث بمعناه الضيق عالية الى متوسطة في معظم الصفات.

كانت القيم العالية للتحسين الوراثى المتوقع بالانتخاب مرتبطة بالقيم العالية لمعامل التوريث بالمعنى الضيق لكل من مساحة الورقة ووزن السنبلة في كلا الهجين .