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HETEROSIS, GENE EFFECT, HERITABILITY AND GENETIC ADVANCE IN TWO WHEAT CROSSES (*T. aestivum* L.)

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ABSTRACT

This study was carried out at the Agricultural Experimental Farm of Faculty of Agriculture Kafr El-Sheikh, Tanta University, through the period from 1998/1999 to 2000/2001. The main objectives of the study were: to determining heterosis, genetic effects, heritability, and expected genetic advance; for yield, and yield components, plant height and heading date in wheat. Two crosses (Sakha 61 x Dobri) in cross I and (Gemmeiza x Rigstan) in cross II were used for applying Gamble Model (1962). Data from parents, F_1, F_2, BC_1 and BC_2 were used in the analysis.

The results could be summarized as follows:

1. Significant positive heterotic effects relative to mid parent were found for most traits in both crosses, except for heading date in both crosses and spike length as well as spike weight in cross 1.
2. Significant negative heterotic effects relative to high parent were found for most traits in both crosses, except for heading date and 1000 kernels weight in cross 1 and plant height in cross II.
3. Positive values of inbreeding depression were obtained for all traits in both crosses except for heading date which showed negative value.
4. Additive gene effects were significantly exhibited in all traits in the two crosses, except spike weight in cross I. Also, dominance effects were significant for all studied traits in the two crosses except for spike length and spike weight in the first cross. Epistatic effects were found to be responsible and significant for most of the studied traits in the two crosses.
5. Heritability estimates in broad sense were high to moderate in magnitudes with values ranged between 52.34% for spike length to 93.07% for plant height.
6. Heritability estimates in narrow sense for all studied characters ranged between relatively high for plant height and number of kernels/spike in both crosses, with moderate estimates for spike length, spike weight and 1000-kernels weight and with low estimates for heading date and grain yield/plant in the two crosses.
7. The predicted genetic advance was rather moderate for spike weight in the two crosses, and low for the remaining traits.

INTRODUCTION

Wheat breeders are interested in estimating the type and magnitude of genetic variation and the relative importance of additive and non-additive gene action types in their materials, because of their implications in choosing the most effective selection and breeding procedures which increase the ability to recognize the desired genotypes in segregating populations. Accordingly, the maximum progress in improving any character would be expected in a selection program when the additive gene action was the main component of genetic variance. Whereas, the presence of non-additive gene action might suggest the use of a hybridization program. For achieving this goal, many genetic models were proposed by Mather (1949), Gamble (1962), Hayman and Mather (1955) and Mather and Jinkes (1971).

The main objectives of the present study were to estimate the type of gene action, heterosis effects, heritability percentage and expected genetic advance from selection for yield, yield components and other agronomic characters in two wheat crosses.

MATERIALS AND METHODS

The present study was carried out at the Agricultural Experimental Farm of Faculty of Agriculture Kafr El-Sheikh, Tanta University, through the period from 1998/1999 to 2000/2001. Four bread wheat (*Triticum aestivum* L.) genotypes were used, where two of them local cultivars, i.e., Gemmeiza 9 and Sakha 61 and the other two are the Russian cultivars: Rigstan and Dobri. These genotypes were chosen according to diversity in origin. In 1998/1999 two crosses, i.e., Sakha 61 x Dobri and Gemmeiza 9 x Rigstan were made to produce F_1 generation. In the second season 1999/2000, F_1 plants of each cross were self pollinated and back crossed to both parents of each cross to produce F_2 and back crosses seeds. In 2000/2001 season, seeds from the six populations of each cross i.e. P_1, P_2, F_1, F_2, BC_1 and BC_2 were sown in a randomized complete block design with three replications. Each plot consisted of 15 rows (five rows for F_2 generation and two rows for each parent, F_1 and back crosses). The rows were 3 m long spaced 30 cm apart and seeds were spaced 15 cm within the row. All the recommended agricultural practices for wheat production were applied at the proper time.

The data were recorded on ten individual plants for each of P_1, P_2, F_1, BC_1 and BC_2 and 30 plants for F_2 generation in each replicate.

The studied characters were:

Heading date (days), plant height (cm), spike length (cm), spike weight (g), number of kernels/spike, 1000-kernels weight (g) and grain yield/plant (gm).

Means and variances within each population for each cross were calculated.

Data were statistically analyzed according to Gamble's procedure (1962) to estimate the six parameters, i.e. mean (m) additive (a), dominance (d), dominance x dominance (dd), additive x dominance (ad) and additive x additive (aa), estimation of heritability values in broad and narrow sense (Mather, 1949), and predicted genetic gain from selection (Δg) (Johnson *et al.*, 1955). Heterotic effects were computed relative to mid parent (MP) and high parent (HP) for all traits.

RESULTS AND DISCUSSION

1. Mean performance:

Mean and standard error of the studied traits of the six populations for the two wheat crosses are presented in Table 1. Parental means of the first cross Dobri x Sakha 61 were higher than the second cross Reg. x Gem. in grain yield/plant and spike length. Furthermore, parents of the first cross were -earlier than those of the second cross.

Table 1: Mean ± standard error of the six population (P_1, P_2, F_1, BC_1, BC_2 and F_2) for the yield and its attributes characters in two wheat crosses.

Characters	Crosses	P_1	P_2	F_1	BC_1	BC_2	F_2
Heading date (day)	Cross I	93.16±0.05	102.16±0.05	96.06±0.05	94.00±0.15	104.04±0.14	100.80±0.14
	Cross II	102.10±0.12	104.80±0.14	101.27±0.12	101.0±0.20	102.50±0.20	102.17±0.18
Plant height (cm)	Cross I	98.12±0.09	82.62±0.13	92.1±0.15	95.29±0.31	80.8±0.34	91.12±0.38
	Cross II	88.00±0.06	110.0±0.06	114.2±0.06	89.0±0.2	113.1±0.19	106.03±0.20
Spike length (cm)	Cross I	10.52±0.08	12.06±0.08	10.83±0.08	10.2±0.11	11.76±0.11	10.76±0.12
	Cross II	9.53±0.09	10.900.14	10.87±0.15	9.78±0.16	11.94±0.18	9.88±0.16
Spike weight (g)	Cross I	3.00±0.09	2.50±0.09	2.66±0.08	2.43±0.12	2.50±0.13	2.44±0.13
	Cross II	2.02±0.08	3.000.02	2.59±0.04	2.28±0.04	2.85±0.05	2.13±0.05
No. of kernels/spike	Cross I	50.00±0.06	58.00±0.06	53.7±0.05	49.88±0.13	56.17±0.12	52.16±0.14
	Cross II	42.40±0.07	70.05±0.08	55.9±0.09	49.0±0.17	63.15±0.18	48.53±0.18
1000 kernels weight (g)	Cross I	43.02±0.24	39.12±0.19	44.01±0.19	42.30±0.40	39.50±0.39	39.46±0.41
	Cross II	40.00±0.11	44.55±0.12	44.2±0.12	39.48±0.18	44.16±0.18	41.40±0.16
Grain yield/plant (g)	Cross I	28.00±0.06	31.00±0.05	29.8±0.05	24.66±0.15	29.15±0.14	28.01±0.14
	Cross II	21.05±0.09	30.85±0.10	26.3±0.11	23.00±0.17	29.20±0.18	24.90±0.15

The F_1 mean values were generally intermediate between the two parental means for all studied traits in the two crosses except for heading date and plant height in the second cross, the F_1 means were earlier and taller than the earlier and taller parents.

The F_2 mean values were also intermediate between the two parents in the two studied crosses. F_2 reduction below F_1 performance was found in the two crosses for all studied characters, indicating that inbreeding depression has occurred. However, both BC_1 and BC_2 mean values varied according to the trait itself, it was tended toward the mean of recurrent parent for the studied characters with some exceptions.

2. Heterosis, inbreeding depression and degree of dominance:

Heterosis in wheat has been exploited by several authors who detected significant heterosis and positive inbreeding values in most crosses of wheat for yield and its attributes such as Salem and Hassan (1991); Walia *et al.* (1993); Perenzin *et al.* (1996); Hassan (1998) and Abd El-Aty (2000).

Estimates of heterosis, inbreeding depression and degree of dominance for the studied traits of the two crosses are presented in Table 2.

Significant positive heterotic effects relative to mid parent were found for most traits in both crosses except for heading date which showed significant negative heterotic values in both crosses (i.e. -1.63% and -2.11% for cross I and cross II, respectively) and spike length as well as spike weight in cross I. Insignificant heterosis effects were found for number of kernels/spike in the two crosses.

Heterotic effects in cross I ranged from -4.07% for spike length to 7.15% for 1000 kernels weight while they varied from -2.11% for heading date to 15.35% for plant height in cross II. These results are in close harmony with those recorded by Mahgoub and Hassan, 1992; Hassan and Saad, 1996 and Abd El-Aty, 2000).

With respect to heterotic effects relative to high parent, significant negative heterotic effects were found for most traits in both crosses, except for heading date and 1000 kernels weight in cross 1 and plant height in cross II. The heterotic magnitude, however, differed from cross to cross and trait to trait. Heterotic effects in cross I varied from -11.33% for spike weight to 3.11% for heading date, while varied from -20.14% for number of kernels/spike to 3.82% for plant height in cross II. These results are in close agreement with those of Hassan, 1998 and Abd El-Aty, 2000.

Heterosis effects were generally higher in cross I than cross II for most traits.

Positive values of inbreeding depression were obtained for all traits in both crosses except for heading date which was negative value. The magnitude of inbreeding depression in cross II was higher for all traits than in cross 1 except for 1000-kernels/spike and grain yield/plant. Heterosis and inbreeding depression are coincided to the same particular phenomenon, therefore it is logic to anticipate that heterosis in the F_1 will be followed by an appreciable reduction in the F_2 performance. The conficting results of heterosis and inbreeding depression might be due to the presence of linkage between genes in these materials (van der Veen, 1959).

The average degree of dominance for heading date and grain yield/plant in both crosses more than unit, indicating the presence of over dominance gene effects in the genetic control of these characters.

On the other hand the values of average degree of dominance for the remaining traits in both crosses were less than unity, indicating partial dominance. Consequently, over dominance effects were responsible for heterotic effects of grain yield and heading date in the two studied crosses.

Table 2: Estimates of heterosis (MP mid parent, H.P higher parent)., degree of dominance, inbreeding depression (I.D%) and potence ratio (P) for studied traits the two wheat crosses.

Characters	Crosses	Heterosis		I.D %	Degree of dominance
		M.P	B.P		
Heading date (day)	Cross I	-1.63*	3.11**	-4.93	1.44
	Cross II	-2.11	-0.81	-0.89	1.13
Plant height (cm)	Cross I	2.00**	-6.1**	1.10	0.47
	Cross II	15.35**	3.82**	7.15	0.69
Spike Length (cm)	Cross I	-4.07**	-10.19**	0.73	0.45
	Cross II	6.38**	-0.28	9.12	0.50
Spike Weight (g)	Cross I	-3.27**	-11.33**	7.96	0.67
	Cross II	2.88**	-13.66**	17.60	0.57
No. of Kernels/spike	Cross I	-0.43	-7.29**	3.01	0.56
	Cross II	-0.57	-20.19**	13.18	0.57
1000 kernels weight (g)	Cross I	7.15**	2.30*	10.36	0.89
	Cross II	4.66**	-0.67	6.44	0.74
Grain yield/plant (g)	Cross I	1.18*	-3.71**	6.18	1.43
	Cross II	1.54*	-14.58**	5.50	1.69

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

3. Estimation of type of gene action:

Types of gene effects for all studied traits of wheat crosses are presented in Table 3. In all traits the mean effect of parameters (m) was highly significant.

Additive gene effects were exhibited in all traits studied. These results indicated that potentiality of improving the performance of these traits by using pedigree selection program in both crosses.

The estimates of dominance effects were highly significant for all the studied traits in both crosses except spike length and spike weight in the first cross. Moreover, the dominance effect was more important and greater than the additive effect for most traits. When dominance gene action is present, it would be tended to favor the production of hybrids. While, the existing of the additive gene action in the gene pool encourages the improvement of the character by selection program.

Table 3: Value of additive (a), dominance (d), additive x additive (aa), additive x dominance (ad) and dominance x dominance (dd) effects for all studied character in two wheat crosses.

Characters	Crosses	m	a	d	aa	ad	dd
Heading date (day)	Cross I	100.80*	-6.40**	-8.74**	-7.13**	-5.56**	-1.51
	Cross II	102.17*	-1.50**	-3.86**	-1.68	-0.15	4.12**
Plant height (cm)	Cross I	91.12**	14.45**	-10.39**	-12.20**	6.65**	24.84**
	Cross II	106.03**	-24.10**	-4.72**	-19.92**	-13.10**	42.12**
Spike Length (cm)	Cross I	10.76**	-1.56**	0.44	0.89**	-0.78**	0.58
	Cross II	9.88**	-2.16**	4.57**	3.92**	-1.47**	-5.19**
Spike Weight (g)	Cross I	2.45**	-0.07*	-0.02	0.07	-0.32	0.89
	Cross II	2.13**	-0.57**	1.82**	1.74**	-0.08	-1.80**
No. of Kernels/spike	Cross I	52.16**	-6.28**	3.26**	3.49***	-2.28**	0.06
	Cross II	48.53**	-14.15**	29.85**	30.18**	-0.32	-30.23**
1000 kernels weight (g)	Cross I	39.46**	2.79**	8.72*	5.77*	0.84	0.79
	Cross II	41.90**	-4.68**	3.65**	1.68	-2.40	4.09**
Grain yield/plant (g)	Cross I	28.01**	-4.26**	2.59**	-3.94**	-2.76**	14.56**
	Cross II	24.90**	-6.20**	5.20**	4.80**	-1.30**	4.60**

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

The additive x additive epistatic type was significant for all traits except spike weight in the first cross as well as heading date and 1000 kernels weight in the second cross. Also, the additive x dominance gene effect was significant for plant height, spike length and grain yield/plant in the two crosses and heading date as well as number of kernels/spike in the first cross. Dominance x dominance effects were significant for most traits except for heading date, spike length and number of kernels/spike in the first cross.

Generally, the relative magnitude of any of the significant gene effect determines its importance in the inheritance of the respective trait. In this concern, grain yield/plant was mainly due to the dominance effect in both crosses and epistatisis (dominance x dominance) and (additive x additive) in cross II. Plant height and 1000-kernels weight were related to additive gene effect in the first cross and (dominance x dominance) in the two crosses. Number of kernels/spike and spike length were attributed to dominance gene effects and (additive x additive) in both crosses. Heading date was attributed to dominance gene effect and (dominance x dominance) epistatic effects in the second cross. This indicates that both additive and dominance played a major role in the inheritance of the studied characters. Also, epistatic effects were important source of variation. These results were in close agreement with those of Bhatt (1972), Ketata *et al.* (1976a and b), Sawant and Jain (1985), Atlae and Vitkare (1990), Menon and Sharma (1995), Al-Kaddoussi (1996) and Hagras (1999).

4. Genetic component of variance, heritability and genetic advance:

Table 4 illustrates the estimates of additive genetic variances (σ^2A) which were greater than that of dominance genetic variances (σ^2D) for plant height, spike length, spike weight, number of kernels/spike and 1000-kernel weight for the two crosses, indicating that the selection for these traits might be more effective in early generations for improving such traits in the two studied crosses. These results were in harmony with those obtained by Bhatt (1972), Edward *et al.* (1976) and El-Kaddoussi (1996).

Table 4: Estimates of additive (σ^2A), dominance (σ^2D), environmental (σ^2E) variances, heritability in broad and narrow sense as well as expected genetic advance (Δg) for the different characters of the two wheat crosses.

Characters	Crosses	σ^2A	σ^2D	σ^2E	Heritability		Δg %
					Broad sense	narrow sense	
Heading date (day)	Cross I	0.170	0.364	0.076	87.24	28.33	0.49
	Cross II	0.290	0.376	0.337	66.26	29.00	0.58
Plant height (cm)	Cross I	3.072	0.692	0.432	89.70	73.21	3.39
	Cross II	0.758	0.359	0.083	93.07	63.16	1.34
Spike length (cm)	Cross I	0.169	0.036	0.186	52.34	43.33	5.18
	Cross II	0.355	0.090	0.342	56.53	45.06	8.33
Spike weight (g)	Cross I	0.168	0.076	0.215	53.09	36.52	20.84
	Cross II	0.044	0.014	0.017	76.92	58.30	15.47
No of kernels/spike	Cross I	0.382	0.118	0.078	86.45	66.09	1.98
	Cross II	0.602	0.197	0.147	84.45	63.57	3.47
1000 kernels weight (g)	Cross I	2.144	1.705	1.190	76.37	42.54	4.99
	Cross II	0.384	0.209	0.276	68.19	44.19	3.16
Grain yield/plant (g)	Cross I	0.170	0.349	0.081	86.55	28.3	1.61
	Cross II	0.128	0.364	0.222	68.87	17.87	1.25

On the other hand, the dominance genetic variances (σ^2D) were greater than the additive genetic variances (σ^2A) for heading date and grain yield/plant. Similar results were obtained by Amaya *et al.* (1972), Hassan (1993) and El-Kaddousi (1996).

Heritability estimates in broad sense were moderate to high in magnitude with values between 52.34% for spike length in cross I to 93.07% for plant height in cross II as shown in Table 4. Similar results were obtained by Bhatt (1972), El-Shamy (1978), Menshawy (1996), Shehab El-Dein (1997) and Hagras (1999). Narrow sense heritability were relatively high for plant height and number of kernels/spike in both crosses, while they were moderate for spike length, spike weight and 1000-kernels weight.

However, low narrow sense heritability values were found for heading date and grain yield/plant. These results emphasized that dominance genetic variance had a major role in the existence of variability in these traits.

Such results agreed with those obtained by Kheiralla and Tahany (1992), May and Van Sanford (1992) and Shehab El-Dein, 1997.

The expected genetic advance as selecting the best 5% of the plants was calculated and the results are presented in Table 4 as percent of F_2. For cross 1, it is expected that mass selection for spike weight would increase the yield by 20.84 for each cycle, while this increase would be 15.47% for the second cross for each cycle.

Advance from selection for grain yield/plant, number of kernels spike, plant height, 1000 kernels/weight and spike length is expected to give an advance ranging between 1.61 to 5.18% in cross I and 1.25 to 8.33% in cross II. Selection would be ineffective for earlier plants as its genetic advance was 0.4 and 0.58 in cross I and cross II respectively.

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قوة الهجين والتأثير الجينى ومعامل التوريث والتحسين الوراثى فى قمح الخبز

محمد سعد مغازى عبد العاطى

قسم المحاصيل – كلية الزراعة بكفرالشيخ – جامعة طنطا

أجريت هذه الدراسة بمزرعة كلية الزراعة بكفرالشيخ خلال المدة من عام 1999/1998 وحتى عام 2001/2000 بهدف دراسة قوة الهجين والتأثير الجينى ومعامل التوريث والتحسين الوراثى لمحصول القمح ومكوناته وارتفاع النبات وميعاد التزهير واستخدم لذلك هجينين من القمح واستخدم فى التقدير البيانات المحسوبة من الاباء وهجين الجيل الاول والثانى والهجن الرجعية للاب الاول والثانى وذلك بتطبيق طريقة Gamble (1962).

ويمكن تلخيص النتائج كالاتى:

1- كانت تأثيرات قوة الهجين موجبة ومعنوية بالنسبة لمتوسط الابوين لمعظم الصفات فى كلا الهجينين فيما عدا صفة ميعاد التزهير فى كلا الهجينين وصفة طول السنبلة ووزن السنبلة فى الهجين الاول.
2- كانت تأثيرات قوة الهجين سالبة ومعنوية منسوبه الى الاب الاعلى لمعظم الصفات فى كلا الهجينين فيما عدا صفتى تاريخ التزهير ووزن الالف حبه بالنسبة للهجين الاول وصفة ارتفاع النبات فى الهجين الثانى.
3- بالنسبة لمعامل التربية الداخلية فقد ظهر نقصا موجبا فى جميع الصفات المدروسة فى كلا الهجينين بينما كانت القيمة سالبة بالنسبة لصفة تاريخ التزهير.
4- كانت التأثيرات المضيفة معنوية لمعظم الصفات فى كلا الهجينين فيما عدا صفة وزن السنبلة فى الهجين الاول وكذلك كانت التأثيرات السيادية معنوية لمعظم الصفات فى كلا الهجينين فيما عدا صفتى طول السنبلة ووزن السنبلة فى الهجين الاول. كما كانت للاختلافات التفوقية تأثيرات معنوية على معظم الصفات المدروسة.
5- كانت قيم معامل التوريث بمعناه الواسع عالية الى متوسطه وتراوحت من 52.34% لصفة طول السنبلة الى 93.07% بالنسبة لصفة ارتفاع النبات.
6- كانت قيمة معامل التوريث بمعناه الضيق عالية نسبيا لصفة ارتفاع النبات وعدد الحبوب فى السنبلة فى كلا الهجينين ومتوسطه بالنسبة لصفات طول السنبلة ووزن السنبلة ووزن الالف حبه بينما كانت منخفضه بالنسبه لصفتى تاريخ التزهير ومحصول النبات الفردى فى كلا الهجينين.
7- كان النسبه المئوية للتحسين الوراثى المتوقع متوسطه لصفة وزن السنبله فى كلا الهجينين وكانت منخفضه فى باقى الصفات الاخرى.