Minufiya J. Agric. Res. Vol. 27 No. 2: 215 - 224 (2002)

GENETIC BEHAVIOUR OF YIELD AND ITS COMPONENTS IN THREE BREAD WHEAT CROSSES

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(Received: Mar., 5 , 2002)

ABSTRACT: *To determine the types of gene effects and to creating new genetic combinations, six diverse bread wheat genotypes and their F_1, F_2 and F_3 generations were grown in a field experiment at the Experimental Research Station of the National Research Center during four successive seasons .*
Significant useful heterosis in positive direction was detected for grain yield / plant in the first and second cross and 100- grain weight in the third cross, .Highly significant negative inbreeding depression was obtained for spikes / plant and grain yield / plant in the three wheat crosses under investigation .
Both scaling tests and F_2 – deviation revealed the presence of epistasis for most of the characters studied in the three crosses .Five parameter model indicated the involvement of additive , dominance and epistatic gene effects in the inheritance of plant height , spikes / plant, spike length , 100 – grain weight and grain yield / plant in the three wheat crosses . Additive X additive gene interaction contribute the major portion of gene pool .The biparental mating approach would be useful for enhancing genetic variability and creating transgressive segregates .The most promising hybrid populations that would contain superior progenies appears to be Giza 157 × Sids 7 and Gimmeza 3× Sids 8.
Key Words: *Bread wheat – Gene effects – Five parameters – Scaling test.*

INTRODUCTION

The success of any breeding program in self and cross pollinated species, depends on the amount of genetic variability present and the types of gene effects involved in the inheritance of different characters in the used materials .To form a population with genetic variability for the characters in view, hybridization between genetically diverse parents must be done .

Early generation testing is used to estimate the genetic potential of individual, lines or populations at an of early stage of inbreeding .The objective of the early generation testing is to eliminate lines or populations that do not merit consideration for further inbreeding and selection .Fehr et al. (1987) .

Therefore, the present study was carried out to obtain information on the mode of inheritance of yield and its components and to identify bulk hybrid populations that would contain superior progenies .

MATERIALS AND METHODS

The present investigation was carried out at the Experimental Research Station of the National Research Center at Shalakan , El- Kalyoubia Governorate during the four winter growing seasons ; 1997 –1998 ; 1998-1999; 1999 –2000 and 2000-2001 to ascertain the types of gene action controlling grain yield and its components in the three wheat crosses by using five parameter model . Plant materials used in this study included six bread wheat varieties i. e., Giza – 157 , Gimmeza – 3, Sids- 5 , Sids –7 Sids - 8 and Sakha- 69 .

In the first season 1997–1998 using biparental mating system , six parents were intercrossed by hand pollination to obtain F_1 hybrid grains of the three crosses; I (Giza–157 X Sids–7). II (Gimmeza- 3x Sids – 8) and III (Sskha-69 x Sids –5) . F_2 and F_3 grains of each cross were produced during the two other successive seasons 1998 / 1999 and 1999/ 2000 .

In the fourth season 2000 / 2001 the five populations (P_1, P_2, F_1, F_2 and F_3) of each cross were planted as a separate experiment in a randomized complete block design with three replicates using 3 m long rows and 20 cm apart with 10 cm between plants . Each replicate comprised two rows from each of parents and F_1 whereas eight rows of the two segregating generations F_2 and F_3 were used in this concern .

Data were recorded on ten competitive plants randomly selected from each row for the following characters ; plant height (cm), No of spikes/ plant, Main spikes length (cm), 100– grain weight (g) and grain yield/plant (g).

Statistical analysis :

The data were first subjected to the C and D scaling tests to detect the presence of non – allelic interaction by using Mathér and Jinks (1982) formulae

$$C = 4\overline{F}_2 - 2\overline{F}_1 - \overline{P}_1 - \overline{P}_2$$
$$D = 8\overline{F}_3 - 2\overline{F}_1 - 3\overline{P}_1 - 3\overline{P}_2$$

The analysis of five parameters model of Hayman (1958) was made to compute the types of gene effects involved. Also , useful heterosis and inbreeding depression were calculated as follows :

$$BPH = \frac{\overline{F}_1 - \overline{B}.P}{B.P} \times 100$$

$$I.d = \frac{\overline{F}_1 - \overline{F}_2}{\overline{F}_1} \times 100$$

RESULTS AND DISCUSSION

The observed values of all generation means in the three wheat crosses with their standard errors are given in Table (1) . Significant genetic variance within F_2 plants for all traits studied were detected in the three wheat crosses , also with the exception of 100- grain weight in cross I and grain

Table (1): Means of the five generations (P1 , P2 , F1 , F2 and F3) for all traits studied in the three bread wheat crosses

Character	Cross	P1	P2	F1	F2	F3
Plant height (cm)	I	129.40 ± 0.607	114.10 ± 0.678	116.90 ± 0.718	120.25 ± 0.963	116.88 ±1.04
	II	120.0 ± 0.843	105.8 ± 0.405	123.60 ± 0.914	113.10 ± 1.18	113.34 ± 1.15
	III	147.55 ± 1.049	112.30 ± 0.731	130.99 ± 0.932	123.75 ± 1.32	124.11 ± 1.44
No. of spikes / Plant	I	5.80 ± 0.231	3.0 ± 0.158	5.70 ± 0.183	6.31 ± 0.144	5.03 ± 0.149
	II	4.20 ± 0.205	2.40 ± 0.115	3.40 ± 0.115	5.70 ± 0.231	4.12 ± 0.095
	III	7.66 ± 0.387	3.10 ± 0.127	4.40 ± 0.240	6.10 ± 0.210	4.0 ± 0.109
Main spike length (cm)	I	16.10 ± 0.245	12.60 ± 0.173	14.98 ±0.241	15.0 ± 0.115	13.57 ± 0.134
	II	15.85 ± 0.289	10.65 ± 0.149	13.80 ± 0.254	15.70 ± 0.275	13.11 ± 0.176
	III	15.55 ± 0.200	9.05 ± 0.082	13.39 ± 0.147	14.37 ± 0.264	12.80 ±0.228
100 –grain weight (g)	I	5.67 ± 0.041	5.53 ± 0.064	5.18 ± 0.102	5.29 ± 0.032	4.91 ± 0.035
	II	6.49 ± 0.046	4.71 ± 0.097	5.32 ± 0.49	6.11 ± 0.054	5.81 ± 0.064
	III	4.65 ± 0.045	4.02 ± 0.074	5.47 ± 0.042	5.17 ± 0.056	4.75 ± 0.060
Grain yield / Plant (g)	I	15.95 ± 0.728	12.45 ± 0.593	20.63 ± 0.192	25.27 ± 0.509	19.26 ± 0.298
	II	9.39 ±0.460	8.56 ± 0.245	10.28 ± 0.261	23.04 ±1.28	13.03 ±0.465
	III	13.77 ± 0.693	9.98 ±0.367	12.73 ± 0.470	20.59 ± 0.937	10.62 ± 0.274

In each case P1 is the larger and P2 the smaller parent yield in cross II , significance parental mean differences were observed for all traits in the three crosses examined , indicating the presence of sufficient amount of genetic variability that would enabel to obtain more reliable estimates of various genetical parameters used in this concern and wide scope for improvement of the economic traits studied .So, the " t " and " F " statistical tests were firstly applied to our data (Table 2).

The estimated values of (C) and (D) scaling tests and F_2 deviation (E_1) tests for all cases are given in Table (2). Significance of any one of the three epistatic scales would indicate the presence of non – allelic interactions amongst the genes controlled of traits in view . Results of " C "and " D " parameters were significant in most cases indicated the inadequacy of the additive –dominance model to interpret the gene effects involved in the present materials (Mather and jinks1982) i.e. epistatic contributions are .important in the inheritance of these traits in the particular material investigated . Moreover , F_2 deviation (E_1) was found to be significant for all traits studied in the three crosses except main spike length and 100- grain weight in cross I , these confirm the previous results which would indicate the presence of non- allelic interactions as revealed by the two different scaling tests C and D . Pawar et al . (1988) reported that epistasis was present in tillers/ plant , 1000- grain weight and yield / plant in two wheat crosses .Also, a greater importance of epistasis was also reported in wheat by Singh and Nana (1989), Eissa (1994) and El-Sayed (2001).

F_1 –hybrids showed highly significant negative heterosis (hybrids inferior to the better parents) for main spike length in the three crosses , 100- grain weight in cross I and II and spikes/ plant in the second and third cross.However , useful heterosis was highly significant and positive for grain yield / plant in the two crosses I and II , and 100- grain weight in cross III.

These results are in agreement with those obtained by .Hendawy(1994) , Khalifa et al .(1998) , El- Hosary et al. (2000) and El-sayed (2001) .

Generally , there are major differences among the three wheat crosses examined for the amount of inbreeding depression of the most studied traits (Table 3). Estimates of the inbreeding depression were found to be highly significant and negative for spikes/ plant and grain yield/ plant in the three crosses , spike length in the two crosses II and III, 100- grain weight in cross II , and plant height in cross I. While highly significant positive estimates of inbreeding depression were found for plant height in the second and third cross and 100- grain weight in cross III .

Five parameters (m, d, h, i and l) analysis revealed the involvement of additive , dominance and epistatic types of gene effects in the inheritance of the all traits studied, which proved to be good fitness of this model to account for variation in these traits . Additive gene effects (d) were highly significant for all traits studied in the three crosses, except 100- grain weight in the first cross and grain yield in the second cross, suggesting that the selection practice of progeny from theses crosses should be more success

Table (2): Tests of the differences between parents (T- test), significance of the genetic variance within F_2 Populations (F- test) , individual scaling test (C and D) and F_2 deviation (E_1)

Character	Cross	T- test	F - test	Scaling test		F2 – deviation E1
				C	D	
Plant height (cm)	I	15.30**	* *	3.7± 4.21	-29.26**± 8.86	0.925** ± 0.123
	II	14.20**	* *	-20.60**±5.14	-17.88 ± 9.76	-5.15 ** ± 0.149
	III	35.25**	* *	-26.83** ± 5.74	-48.65 ± 12.27	-6.71** ± 0.166
No.of spikes / Plant	I	2.80**	* *	5.04** ±0.74	2.44 ± 1.50	1.26** ± 0.185
	II	1.80**	* *	9.40** ± 0.98	6.36**± 1.06	2.35 ** ± 0.246
	III	4.56**	* *	4.84** ± 1.05	-9.08**± 1.57	1.21** ± 0.263
Main spike length (cm)	I	3.50**	* *	1.34 ±0.73	-7.50**± 1.48	0.34 ± 0.183
	II	5.20**	* *	8.70** ±1.25	-2.22 ± 1.79	2.17** ± 0.314
	III	6.50**	* *	6.10** ±1.12	1.88 ± 1.96	1.52** ± 0.279
100 –grain weight (g)	I	1.40	* *	-0.40± 0.26	-4.68**± 0.50	-0.10 ± 0.067
	II	1.78**	* *	2.589** ± 0.26	2.22**± 0.61	0.65** ± 0.065
	III	0.63**	* *	1.07** ± 0.25	1.05 ± 0.55	0.27** ± 0.064
Grain yield / Plant (g)	I	3.50**	* *	31.42** ±2.28	27.62**± 3.71	7.85** ± 0.569
	II	0.83	* *	53.63** ± 5.19	29.82**± 4.07	13.41 ** ± 1.29
	III	3.79**	* *	33.13 ** ± 3.94	-11.77**± 3.35	8.29 ** ± 0.98

* and ** significant at 0.05 and 0.01 levels of probability , respectively

Table (3): High parent heterosis inbreeding depression and types of gene effects of all charaters studied in the three bread wheat crosses I (Giza – 157 X Sids – 7) , II (Gimmeza –3 X Sids – 8) and III (Sakha -69 X Sids –5).

Character	Cross	Heterosis	Inbreeding depression	Five parameters model				
				m	d	h	i	l
Plant height (cm)	I	2.45**	-2.86**	120.25**±0.963	7.65**±0.455	6.75**±3.91	-26.91**±9.67	26.89**±3.34
	II	16.82**	8.49**	113.10**±1.18	7.1**±0.468	6.36±3.41	29.28*±11.50	9.86**±3.79
	III	16.64**	5.53**	123.75**±1.32	17.62**±0.639	3.87 ±4.69	21.23±13.28	38.05**±4.45
No. of spikes / Plant	I	-1.72	-10.70**	6.31**±0.144	1.40**±0.140	3.01**±0.506	-8.045**±1.48	4.51**±0.543
	II	-19.05**	-67.65**	5.70**±0.231	1.80**±0.118	2.68**±0.533	-14.56**±1.95	4.38**±0.646
	III	-42.56**	-38.64**	7.66**±0.210	2.28**±0.204	4.46**±0.535	-15.73**±1.89	10.00**±0.728
Main spike length (cm)	I	-6.96**	-0.13	15.00**±0.115	1.75**±0.150	3.80**±0.454	-7.68**±1.33	6.67**±0.509
	II	-12.93**	-13.77**	15.70**±0.275	2.60**±0.163	5.64**±0.743	-18.88**±2.49	10.29**±0.843
	III	-13.89**	-7.32**	14.37**±0.264	3.25**±0.108	3.53**±0.812	-10.99**±2.74	8.94**±0.868
100 –grain weight (g)	I	-8.64**	-2.12	5.29**±0.032	0.07±0.059	0.94**±0.133	-2.32**±0.418	1.50**±0.173
	II	-18.03**	-14.85**	6.11**±0.054	0.891**±0.054	0.273±0.204	-3.707**±0.569	2.339**±0.363
	III	17.85**	5.48**	5.17*±0.056	0.315**±0.043	1.32**±0.445	-1.44*±0.563	0.815**±0.276
Grain yield/ Plant (g)	I	29.34**	-22.49**	25.27**±0.509	1.75**±0.469	12.93**±1.29	-44.43**±4.40	10.00**±1.62
	II	9.48*	-124.12**	23.04**±1.28	0.417±0.261	18.18**±2.86	-87.37**±10.59	-25.98**±3.31
	III	-7.55	-61.74**	20.58**±0.937	1.89**±0.392	21.35**±2.04	-74.12**±7.74	24.28**±2.51

* and ** significant at 0.05 and 0.01 levels of probability , respectively

m = F_2 means d = additive gene effect h = dominance gene effect

i= additive x additive type of epistasis l = dominance x dominance type of epistasis in improving the performance of the traits under investigation, since these combinations have a greater opportunity to fix favorable gene responsible for yield and its attributes .The dominance genes effects (h) were highly significant for spikes / plant, main spike length and grain yield/ plant and in positive direction in all cases. The estimates of dominance components found to be were higher in their magnitudes than the additive one , indicating the greater importance of dominance effect in the inheritance of these traits .

Both types of epistatic effects , additive x additive (i) and dominance x dominance (l) were found to be highly significant for all traits studied in the three crosses , except plant height in cross III .This would indicate that epistatic gene effects are important in the inheritance of these traits . Also , these results would ascertain the results previously obtained by C and D scaling tests. However , the additive x additive components were found to be greater in magnitude than dominance x dominance epistatic gene action in all cases , except plant height in the third cross .Therefore , to exploit additive and non- additive gene effects , reciprocal recurrent selection by intermitting the most desirable segregates and/or biparental mating along with selection in the advanced generation are advocated to stabilize the effect of epistasis . Similar conclusion was also reported in wheat by Chaudhary et al .(1996).

Additive , dominance and epistatic types of gene effects were previously found to play an important role in the inheritance of yield and its components by Kapoor and Luthra (1990), Luther and Bangarwa (1994), Eissa (1994) El-Sayed (2001) , Kattab et al.(2001) and Esmail (2002) using different sources of genetic materials .While Walia et al. (1994) found non of the genetic components was significant for spikes /plant .

The classification of epistatic gene effects into duplicate and complementary types which depends on the relative signs of (h) and (l) would reveal that similar signs of the two parameters indicate prevalence of complementary epistasis , while different signs indicate duplicate interaction. Complementary epistatic was detected for plant height , spikes /plant , main spike length and 100- grain weight in the three crosses and grain yield in the cross I and III ,.whereas duplicate epistasis was observed for grain yield in cross II. Hayman (1957) stated that in a complementary case the F_2 mean was nearer to the midparent and in a duplicate case nearer to the F_1 mean. This finding is clear from (Table 1). Singh and Singh (1978) , Pawar et .al (1988) concluded predominance of complementary interaction for tillers/ plant , 100- grain weight and yield /plant. Duplicate epistasis for grain yield per spike and plant height were detected by Kattab et al. (2001).

From the results obtained here , it could be concluded that a biparental mating design would be useful for enhancing genetic variability and creating of transgressive segregates . Both scaling tests and F_2- deviation indicate the presence of epistasis in the inheritance of the characters studied in the three wheat crosses. The presence of epistatic effects in such large magnitude suggest that epistasis should be included in predictive models when breeding wheat for improvement of yield characters . The most promising crosses appears to be Giza –157x Sids 7 and followed by Gimmeza 3 x Sids 8.

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السلوك الوراثى لصفة المحصول ومكوناته فى ثلاثة هجن لقمح الخبز

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الملخص العربى

اجريـت هذه الدراسة فى محطة البحوث الزراعية بشلقان التابعة للمركز القومى للبحوث بشلقان– قليوبـية خلال اربعة مواسم متتالية ٩٧ / ١٩٩٨ ، ٩٨/ ١٩٩٩ ، ٩٩/٢٠٠٠ ، ٢٠٠١/٠٠ بهدف تقديـر طبيعة التاثير الجينى باستخدام متوسطات الاجيال لصفة المحصول ومكوناته فى ثلاثة هجن من القمح و ايجاد تراكيب وراثية جديدة يمكن الانتخاب من خلالها فى الاجيال الانعزالية المبكرة للحصول على سلالات جديدة من القمح تتفوق فى صفاتها المحصولية على الاصناف التجارية المنزرعة .

اسـتخدام لتحقـيق ذلك ستة تراكيب ذات اصول وراثية متباعدة وكل من الجيل الاول والثانى والثالث للهجن الثلاثة الناتجة من التهجين بينها وهى ١–(جيزة ١٥٧ × سدس ٧) ، ٢– (جميزة ٣ × سدس ٨) ، ٣– (سخا ٦٩ × سدس ٥) .

ويمكن تلخيص اهم النتائج فيما يلى :–

كانـت قوة الهجين على اساس الاب الافضل معنوية وموجبة لصفة محصول الحبوب نبات فى كل من الهجين الاول والثانى ولصفة وزن ١٠٠ حبه فى الهجين الثالث .

اظهرت تقديرات كل من Scaling tests والـ F_2 – deviations مساهمة التأثير الجينى التفوقى epistatic effect فى وراثة معظم الصفات تحت الدراسة فى الهجن الثلاثة

اتضـح مـن الدراسـة مساهمة كل من الفعل الجينى المضيف والسيادى والتفوقى فى وراثة صـفات ارتفاع النبات ، عدد السنابل / نبات، طول سنبلة الساق الرئيسى ، وزن ١٠٠ حبه ومحصول الحبوب / نبات فى الهجن الثلاثة المختبرة .

كما كان التأثير التفوقى المضيف × المضيف Additive x additive اكثر المكونات مساهمة فى التأثير الجينى بشكل عام مما يؤكد اهمية استغلاله فى برامج التربية المستقبلية لتحسين محصول القمح وهذا يؤيد اجراء التهجين بين الاصناف والانتخاب فى الاجيال الانعزالية المبكرة للحصول على اصناف جديدة محسنة وراثيا من قمح الخبز خاصة فى الهجينين جيزة ١٥٧ × سدس ٧ ، جميزة ٣ × سدس ٨ .