GENETIC BEHAVIOR OF YIELD AND ITS COMPONENTS IN THREE BREAD WHEAT CROSSES.

EL-BORHAMY,H. S., M. A. EL-MAGHRABY AND A. M. GADALLAH

The National Wheat Res. Program, Field Crops Res. Institute, ARC, Giza

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Abstract

Three crosses were made among four bread wheat cultivars, Sahka 93 x Gemmeiza 7, Sakha 94 x Gemmeiza 7 and Sakha 94 x Giza 168. The five populations i.e P1, P2, F1, F2 and F3 of each cross were used to estimate genetic variance, gene action and heritability for grain yield and its components. The experiment was conducted at Sakha Agricultural Research Station from 2003/2004 through 2006 / 2007 season. Significant positive heterotic effects were obtained relative to the better parents for plant height, spike length and 100-kernel weight in some crosses. Meanwhile, for maturity date, significant negative (favorable) heterosis relative to the earlier parent was detected in the first cross. Overdominance towards the higher parent was detected for days to heading and to maturity in the first cross, and plant height and spike length in the second and third crosses, respectively. While, overdominance towards the lower parent was detected for spike length only in the first cross. Partial dominance towards the higher parent was obtained for days to maturity in the second and third crosses , spike length in the second cross, and grain yield plant-1 in the first and second crosses. On the other hand, partial dominance towards the lower parent was observed for plant height in the first and third crosses, days to heading in the second and third crosses, number of kernel spike-1, 100 - kernel weight in the three crosses, and grain yield plant-1 in the third one. Significant positive estimates of inbreeding depression were detected for all studied characters except for days to heading in the first and second cross and days to maturity in the third one. The additive gene effect was significant for all characters in all crosses. In addition, dominance and epistasis effects were significant for most of the studied attributes. Estimates of heritability in broad sense were high to moderate for all studied characters in the three crosses. Moreover, moderate estimates of narrow sense heritability were detected for most studied characters. These results indicated that selection for the studied characters could be used in the early generations but would be more effective if postponed to late generations.

Keywords: Wheat crosses, Heterosis, Heritability, Inbreeding depression, Gene action.

INTRODUCTION

Increasing bread wheat (*Triticum aestivum* L.) production to narrow down the gap between production and consumption is considered a main target in Egypt as in most developing countries. Two approaches can be followed to fulfill this target, increasing the cultivated area to wheat (horizontal expansion) and/or increasing the yield of unit area (vertical expansion) using high-yielding cultivars and applying proper cultural practices (Shehab El-Din, 1993).Wheat breeders are always looking for means and sources of genetic improvement of grain yield and its components and other characteristics. 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 characteristics in such materials.

In many studies, additive, dominance and additive x additive gene effects epistasis were found to control most of characteristics such as days to maturity (Menshawy, 2000 and Mahgoub and Hamad, 2006), plant height, 100-kernel weight and grain yield plant^{-1} (Abul-Naas *et al.*, 1991, Al-Kaddoussi *et al.*, 1994 and El-Borhamy, 2000). Also, additive x dominance gene effects were important in the inheritance of plant height, spike length and 100-kernel weight (Awaad, 2002 and Hamad, 2003). On the other hand, El-Hosary *et al.* (2000) found that grain yield and its components in a diallel cross among eight wheat parents, were controlled by both additive and non-additive gene effects.

The present work was conducted to study the genetic variance, gene action, and heritability and to compare between actual and expected genetic gain from selection in three bread wheat crosses derived from four bread wheat genotypes using five populations in each cross. The ultimate goal of this study was to elucidate the breeding value of the crosses that could be utilized in breeding program to improve wheat productivity.

MATERIALS AND METHODS

The present investigation was carried out at Sakha Agricultural Research Station from 2003/2004 to 2006/ 2007. Four bread wheat cultivars were chosen to form three crosses, viz. Sakha 93 x Gemmeiza 7, Sakha 94 x Gemmeiza 7 and Sakha 94 x Giza 168.Names and pedigrees of these cultivars are presented in Table (1).

Table 1. Name and pedigree of the four parental bread wheat cultivars.

Name	Pedigree
Sakha 93	Sakha 92 / Tr 810328 S.8871-1S-2S-1S-0S
Sakha 94	Opata/Rayon//kauz CMBW 90 Y 3180-0TOPM-3Y-010M- 010M-010Y-10M-015Y-0Y-0AP-0S
Giza 168	Mrl/buc//seri CM 93046-8M-0Y-0M-2Y-0B
Gemmeiza 7	CMH74A.630/sx//seri 82/ Agent CGM 4611-2GM-3GM -1GM-0GM

In 2003 /2004 season, the parental genotypes were sown at three dates and crosses were made to secure enough F_1 hybrid seeds among the parents. In 2004/2005 season, a part of the F_1 seeds were planted and the rest were left to produce the F_2 seeds of the three crosses. In 2005/2006 season, 20 and 60 seeds from F_1 and F_2, respectively for each cross were cultivated to obtain F_2 and F_3, respectively seeds. Moreover, the four parents were planted in the same season , the same crosses were again made to obtain additional and /or fresh F_1 seeds.

In the fourth season 2006/2007, the seeds of the five populations (P_1, P_2, F_1, F_2 and F_3) for each cross were planted together at the 21st of November, in a randomized complete block design with three replications. Each replicate consisted of 50 rows for each cross (one row for each parent and F_1, 6 rows for F_2 generation and 41 rows for F_3 families). Each row was 3 m long and 30 cm apart. seeds within rows were 20 cm apart, each row included 15 plants.

Data of the following characteristics were recorded:

Heading date,. Maturity date,. Plant height (cm), measured. Spike length (cm), number of kernels spike^{-1}, 100-kernel weight and grain yield plant^{-1} were recorded on samples of 10 individual guarded plants from each row.

Biometrical parameters were calculated for the characteristics where the F_2 genetic variances were significant. The amounts of heterosis were expressed as the performance of F_1's over better parent values. Meanwhile, inbreeding depression was calculated as the difference between F_1 and F_2 means in terms of percentage from the F_1 mean. The T- test was used to determine the significance of these deviations and also potence ratio (P) was calculated according to Peter and Frey (1966). The population means and the variances were used to compute the scaling tests C and D to estimate the type of gene effects according to Hayman and Mather (1955) and Mather and Jinks (1971). The five parameters model proposed by Hayman (1958) and

Jinks and Jones (1958) was used to estimate the different gene effects. Partitioning of variance was calculated according to Mather (1949) and Mather and Jinks (1971). Heritability estimates were calculated in broad sense (h^2b) and narrow sense (h^2n) according to Mather (1949).

RESULTS AND DISCUSSION

Analysis of variance (not presented) showed that parental differences in response to their genetic background were significant in most characters under investigation. Parental mean differences and genetic variance among F_2 populations were calculated and tested for statistical significance. The means and variances for the five populations (P_1, P_2, F_1, F_2 and F_3) for the studied characters in the three crosses are presented in Table (2). All studied characters showed significant genetic variance in the three crosses, indicating the presence of genetic variability for these characters in these materials and therefore, detailed analysis of gene action was made. Data of heterosis percentage over better parent (BP), potence ratio (P) and inbreeding depression for the three crosses are presented in Table (3). Moreover, F_1 hybrids showed highly significant negative heterosis effects (hybrids inferior to the better parents) for maturity date in the first cross (would be very useful from the breeder's point of view). Meanwhile, the second and first crosses revealed positive heterotic effects for plant height and spike length.

The potence ratio indicated overdominance towards the higher parent for days to heading and maturity in the first cross, and for plant height and spike length in the second and third crosses, respectively. On the other hand, over dominance towards the lower parent was detected for spike length in the first cross. Meanwhile, partial dominance towards the lower parent was observed for plant height in the first and third crosses, and days to heading in the second and third crosses and number of kernels spike^{-1}, kernel weight in the three crosses and grain yield plant^{-1} in the third one. On the other hand, partial dominance towards the higher parent was observed for days to maturity in the second and third crosses and for spike length in the second cross and for grain yield plant^{-1} in the first and second ones.

Significant positive estimates of inbreeding depression were detected in all studied characters except for days to heading in the first and second crosses and days to maturity in the third cross for which significant negative estimates were evident (Table 3).

Significant positive F_2 deviation (E_1) was detected for days to heading in the third cross, plant height and grain yield plant^{-1} in all crosses, spike length and number of kernels $^{-1}$spike in the first cross and 100-kernel weight in the first and second crosses. Meanwhile, significant (E_1) negative estimates were obtained for days to heading in the first cross and days to maturity in all crosses. These results may refer to the contribution of epistatic gene effects in the performance of these characters. F_3 deviation (E_2)was significantly positive for plant height, spike length, number of kernels spike $^{-1}$, 100-kernel weight and grain yield plant^{-1} for all crosses except the third cross for spike length and 100-kernel weight in the first cross. Meanwhile, significant negative E_2 values were detected for days to heading in the first and second crosses and days to maturity in the third cross. These results proved the magnitude of epistasis that warrants great deal of attention in breeding programs.

Heritability estimates in both broad and narrow senses are presented in Table (3). In general, high to moderate (more than 50%) heritability estimates in broad sense were detected for all studied characters in all crosses except for spike length in the first cross. On the other hand, moderate estimates of narrow sense heritability were detected for all studied characters except for days to heading in the first two crosses , plant high and number. of kernels spike $^{-1}$ in the second cross, kernel weight in the first and third crosses and spike length in the three crosses .

Narrow sense heritability reflects the importance of the proportion of variation due to additive gene effects in the inheritance of these characters. Therefore, selection for the desirable characters could be useful in early generations but would be more effective if delayed to later ones (Shehab El-Din *et al.*,1996, El-Seidy and Hamada, 1997, and El-Borhamy, 2004).

Nature of gene action calculated according to Hayman (1958) are presented in Table (4). The estimated mean effect of F_2 (m), which reflects the contribution due to the overall mean plus the locus effect and interaction of the fixed loci, was highly significant .The additive gene effect (d) was significant and positive for days to heading and maturity in the second crosses, plant height and spike length in the second and third crosses, respectively, and for grain yield plant^{-1} in the first and second crosses. Meanwhile, it was significant and negative for days to heading and maturity and plant height in the first and third cross, for spike length in the first and second ones, number of kernels spike^{-1} and 100- kernel weight in all crosses, and for grain yield/plant in the third cross. These results suggest the possibility of further improvement for the characters in which d values were positive. They also prove that using pedigree selection program would be more effective. Similar results were obtained by Amaya *et al*. (1972), Hendawy (1998), El-Hosary *et al.* (2000), Moustafa (2002), El-Borhamy (2004), El-Borhamy (2005) and Abdel-Nour *et al.* (2006). Dominance gene effect (h) was significant for days to heading and spike length in the second cross, days to maturity in the first and third crosses, plant height in all crosses, number of kernels spike^{-1} in the first and second crosses, and for kernel weight in the first cross. The significance of these components indicated that both additive and dominance gene effects are important in the inheritance of these characters. Therefore, selection of desired characters could be practiced in the early generations but would be more effective in late ones.

Estimates of epistatic gene effects, i.e., dominance x dominance (I), and additive x additive (i) are presented in Table (4). Dominance x dominance gene effects were significant for all studied traits except for days to maturity, spike length and 100-kernel weight in the third cross, No.of kernels spike^{-1} in the first and third cross and for grain yield plant^{-1} in the second and third crosses.

A significant additive x additive type of epistasis (i) was detected for most of the studied traits except for days to heading in the first and second cross, and for days to maturity in the first cross, spike length in the second and third crosses and number of kernels spike^{-1} in the second cross. These results are in agreement with those of EL-Seidy and Hamada (1997), and Kheiralla *et al.* (2001). The important role of both additive and non-additive gene actions indicated that selection procedures based on the accumulation of additive effects would be very successful in improving these characters. This conclusion was also reported by Gouda *et al.* (1993), Al-Kaddoussi *et al.* (1994), El-Hosary *et al.* (2000), Moustafa (2002), El-Borhamy (2004), and Abdel-Nour *et al.* (2006).

Table 2. Means and variances (S2) for studied characters in the five populations (P1,P2,F1,F2, and F3 families) of three bread wheat crosses.

Character	Cross	Parameter	P_1	P_2	F_1	F_2	F_3
Days to heading	1	Mean	92.7	97	91.2	94.4	92.8
		S^2	0.128	0.152	0.139	0.34	0.293
	2	Mean	102.0	97	98.6	99.1	101.1
		S^2	0.142	0.152	0.157	0.33	0.274
	3	Mean	95.0	102.0	98.9	97.3	98.2
		S^2	0.15	0.142	0.133	0.3	0.20
Days to maturity	1	Mean	135.9	142.6	133.9	135.8	134.4
		S^2	0.139	0.13	0.135	0.336	0.254
	2	Mean	147.0	142.6	145.0	146.0	145.3
		S^2	0.148	0.13	0.148	0.321	0.287
	3	Mean	140.1	147.0	141.0	143.0	143.3
		S^2	0.154	0.148	0.144	0.315	0.239
Plant height (cm)	1	Mean	105.2	115.1	114.3	108.4	112.6
		S^2	0.145	0.145	0.138	0.419	0.306
	2	Mean	122.3	155.2	128.0	123.8	120.1
		S^2	0.143	0.145	0.162	0.415	0.3
	3	Mean	106.8	122.3	118.8	114.5	117.4
		S^2	0.124	0.143	0.167	0.343	0.218
Spike length (cm)	1	Mean	11.1	12.2	12.4	11.8	12.0
		S^2	0.106	0.118	0.104	0.18	0.154
	2	Mean	10.0	12.2	11.1	11.0	10.3
		S^2	0.064	0.118	0.159	0.194	0.171
	3	Mean	10.4	10.0	10.5	10.3	10.3
		S^2	0.073	0.064	0.048	0.172	0.103
No. of kernels spike^{-1}	1	Mean	80.1	89.4	87.1	85.1	84.1
		S^2	0.154	0.159	0.15	0.301	0.249
	2	Mean	84.4	89.8	87.1	86.9	85.1
		S^2	0.133	0.159	0.142	0.28	0.15
	3	Mean	71.1	84.4	80.7	79.89	80.0
		S^2	0.121	0.133	0.154	0.409	0.154
100-kernel weight	1	Mean	47.0	53.1	51.3	49.11	51.0
		S^2	0.148	0.151	0.145	0.323	0.258
	2	Mean	44.3	53.1	50.2	47.96	48.2
		S^2	0.145	0.151	0.148	0.297	0.214
	3	Mean	41.9	44.3	43.2	43.04	42.8
		S^2	0.154	0.145	0.149	0.215	0.189
Grain yield plant^{-1}	1	Mean	39.7	30.1	37.1	35.52	35.6
		S^2	0.145	0.151	0.157	0.345	0.264
	2	Mean	45.4	30.1	40.3	38.33	37.9
		S^2	0.113	0.124	0.13	0.336	0.271
	3	Mean	36.03	45.4	42.0	41.04	40.8
		S^2	0.131	0.113	0.144	0.227	0.181

Table 3. Heterosis, potence ratio, inbreeding depression F2 and F3 deviation and heritability for studied characters of three bread wheat crosses.

Character	cross	Heterosis % over B.P	Potence ratio (p)	Inbreeding depression	F_2 E_1	F_3 E_2	Heritability	
							Broad	Narrow
Days to heading	1	-1.618**	1.697	-4.002**	-3.464**	-1.743**	73.1	49.9
	2	1.721**	-0.336	-0.856**	-0.445	-2.472**	79.9	37.7
	3	4.051**	-0.099	0.352*	1.648**	0.707**	78.0	65.1
Days to maturity	1	-1.449**	1.582	-3.997	-1.358**	-0.373	80.7	60 2
	2	1.654**	0.082	0.124	-0.668**	-0.200	68.4	54.0
	3	0.642**	0.740	-1.819**	-1.390**	-1.624**	77.5	58. 9
Plant height	1	-0.726**	-0.832	3.641**	5.221**	1.478**	87.7	50.3
	2	4.719**	2.625	7.279**	3.288**	6.162**	87.9	31.7
	3	-2.813**	-0.556	3.627**	3.677**	1.211**	88.9	67.6
Spike length	1	2.186*	-1.540	6.096**	5.010**	3.402*	43.4	38.8
	2	-9.040**	0.023	-0.225	0.424	6.749**	70.1	37.2
	3	-0.009	1.277	2.630**	2.283	1.998	52.2	44.1
No. of kernels spike^{-1}	1	-2.897**	-0.460	2.542**	2.318**	3.431**	82.6	58.7
	2	-2.919**	-0.011	0.034	0.275	2.261**	80.0	42.1
	3	-4.453**	-0.435	3.601**	0.966	0.830**	85.8	84.4
100-kernel weight	1	-3.329**	-0.414	2.436**	4.269**	0.584	79.3	49.8
	2	-5.371**	-0.349	3.047**	4.481**	3.983**	78.5	71.7
	3	-3.071**	-0.108	0.300	0.439	1.110*	55.1	40.1
Grain yield Plant^{-1}	1	-6.466**	0.463	5.969**	4.343**	4.101**	76.0	69.9
	2	-11.343**	0.325	6.173	4.770**	5.764**	90.7	78.7
	3	-7.489**	-0.274	3.059**	2.285**	2.881**	84.0	73.8

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

Table 4. Gene action parameters for studied characters in the three crosses of bread wheat.

Character	cross	m	d	h	l	i	C	D
Days to heading	1	94.36**	-2.150**	2.080	-16.80**	1.430	5.34**	-7.26**
	2	99.11**	2.515**	-5.626**	9.493**	0.248	0.07	7.19**
	3	97.25**	-3.498**	-1.393	9.306**	-8.738**	-5.823**	1.157
Days to maturity	1	135.75**	-3.383**	2.306*	-11.893**	0.893	-3.427*	-12.347**
	2	146.0**	2.180**	1.166	-6.213**	5.346**	4.24**	-0.42
	3	142.96**	-3.465**	-2.186*	-3.466	-6.551**	2.71*	0.11
Plant height	1	108.36**	-5.000**	-7.433**	38.746**	-12.596**	-15.554**	13.506**
	2	123.82**	3.550**	12.620**	-8.400**	10.400**	1.8	-4.5**
	3	114.46**	-7.750**	-4.900**	27.280**	-24.710**	-8.86**	11.6**
Spike length	1	11.81**	-0.492**	-0.118	2.728*	-1.860**	-0.976	1.07
	2	11.02**	-1.075**	1.898**	-3.608**	-0.227	-0.238	-2.944**
	3	10.27**	0.216**	0.080	0.800	0.236	-0.407	0.193
No. Kernels spike^{-1}	1	85.11**	-4.815**	3.933**	0.213	-7.911**	-3.65**	-3.49**
	2	86.87**	-2.650**	4.773**	-8.586**	-0.556	-0.9	-7.34**
	3	79.89**	-6.665**	0.226	2.666	-16.008**	2.69	4.69**
100.kernel weight	1	49.11**	-3.017**	-3.580**	15.920**	-10.864**	-6.26**	5.68**
	2	47.96**	-4.380**	0.833	7.333**	-9.456**	-5.94**	-0.44
	3	43.04**	-1.200**	0.900	-1.040	-1.630**	-0.5	-1.28
Grain yield plant^{-1}	1	35.52**	4.783**	0.835	4.781*	8.185**	-2.019	1.567
	2	38.33**	7.635**	2.346*	2.986	15.131**	-2.71*	-0.47
	3	41.04**	-4.685**	1.306*	1.226	-9.348**	-1.27	-0.35

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

m = Mean effect h = dominance effect d = additive effect l = dominance x dominance i = additive x additive

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السلوك الوراثي للمحصول ومكوناته فى ثلاث هجن من قمح الخبز

هانى سعد البرهامى، ماهر عبدالمنعم المغربى ، أحمد محمد جادالله

قسم بحوث القمح – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

اجرى هذا البحث فى محطة البحوث الزراعيــة بســخا فــى أربعــة مواســم متتاليــة مــن ٢٠٠٣/٢٠٠٤ إلى ٢٠٠٦/٢٠٠٧ على ثلاثة هجن من قمح الخبز بين أربعة أباء هــى ســخا ٩٣ ، سخا ٩٤ ، جيزة ١٦٨ و جميزة ٧ وذلك لدراسة التباين الوراثى والفعل الجينى ومعامــل التوريــث للمحصول ومكوناته ، حيث زرعت الآباء والأجيال الأول و الثانى و الثالث لكل هجين فى تجربــة بتصميم القطاعات الكاملة العشوائية (RC BD) فى ثلاث مكررات. كانت تأثيرات قوة الهجين موجبة ومعنوية بالنسبة للأب الأفضل لصفات طول النبات،طول السنبلة،وزن ١٠٠ حبة فى بعض الهجــن . كذلك كانت قوة الهجين سالبة ومعنوية للأب الأفضل لصفة النضج الفسيولوجى فى الهجين الأول.كما أوضحت النتائج أن السيادة كانت فائقة تجاه الأب الأعلى لصفتى ميعاد طرد السنابل وميعاد النضــج فى الهجين الأول وصفتى طول النبات وطول السنبلة فى الهجينين الثانى والثالث على التوالى . فــى حين كانت هناك سيادة فائقة تجاه الأب الأقل لصفة طول السنبلة فى الهجين الأول بينما كانت هنــاك سيادة جزئية تجاه الأب الأعلى لصفة ميعاد النضج فى الهجين الثانى والهجين الثالث وصــفة طــول السنبلة فى الهجين الثانى وصفة محصول الحبوب / نبات فى الهجين الأول والهجين الثانى فى حين كانت هناك سيادة جزئية تجاه الأب الأقل لصفة طول النبات فى الهجين الأول والهجين الثالث ولصفة ميعاد الطرد فى الهجينين الثانى والثالث و صفتى عدد حبوب السنبلة ووزن ١٠٠ حبه فــى الهجــن الثلاثة ومحصول الحبوب / نبات فى الهجين الثالث.

أكدت النتائج أن تأثير التربية الداخلية فى الجيل الثانى F2 كان موجباً ومعنوياً لمعظم الصــفات المدروسة ماعدا ميعاد طرد السنابل فى الهجين الأول والثانى بينما أظهرت صفة ميعاد النضج قيمــاً معنوية سالبة فى الهجين الثالث.أظهرت التأثيرات الوراثية المضيفة معنويــة فــى وراثــة الصــفات المدروسة فى الهجن الثالث وكان التأثير السيادي والتفوقى معنويّا فى معظم الصفات المدروســة.

أظهرت درجة التوريث بمعناها الواسع قيماً عالية إلى متوسطة بينما أظهرت درجة التوريــث بمعناها الضيق قيماً متوسطة لجميع الصفات المدروسة فى الهجن الثلاثة. كما كانت قــيم التحســين الوراثى الفعلى فى الجيل التالى المتحصل عليها بصفة عامه متطابقة مع القيم المتنبــأ بهــا لتحســين المحصول ومكوناته من خلال الانتخاب ومن ثم يمكن للمربى الاعتماد على القيم المتنبــأ بهــا فــى الانتخاب لتحسين الصفات المحصولية .

من النتائج المتحصل عليها يستنتج أن الانتخاب فى الأجيال الانعزالية المبكرة قد يكون مفيــداً ولكن سوف يكون أكثر كفاءة إذا تم تأجيله إلى الأجيال الانعزالية المتأخرة .