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ESTIMATION OF GENE EFFECT TYPES FOR EARLINESS, YIELD AND ITS ATTRIBUTES IN SIX BREAD WHEAT POPULATION

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ABSTRACT: Six populations of three wheat crosses were grown during three consecutive seasons, at Fac. of Agric., Zagazig Univ., Egypt to estimate the adequacy of genetic model of gene action for the evaluated characters. Scaling tests data indicated that non-allelic interaction controlled most of the studies traits in all crosses, except days to heading in t 3rd one. The genetic model recorded that all genetic types were significant for plant height in the 3rd cross. Dominance (h) gene effect was negative and significant for days to heading and plant height in 2nd cross, whereas it was positive and significant for spikes/plant in 2nd cross and grains/spike, weight of 1000 grain and grain yield/plant in all crosses. Heritability was high (>50%) for days to heading in 1st and 2nd crosses, plant height in 1st cross and spikes/plant number, weight of 1000 grain and grain yield /plant in the 2nd one. Dominance ratio was less than unity in 1st and 2nd crosses for days to heading, 3rd cross for spikes/plant and the 2nd cross for weight of 1000 grain. Days to heading recorded a moderate genetic advance in the 1st and 2nd crosses, whereas a low values of this parameter were recorded in the 2nd and 3rd crosses for plant height and in all crosses for spikes/plant, grains/spike, weight of 1000 grain and grain yield/plant.

Key words: Wheat, grain yield, Six population, Gene action, heritability.

INTRODUCTION

Bread wheat is the main common food of Egyptian people and it constitutes a prominent status in the agricultural system. The Egyption consumption of wheat grains is 18 million tons in a year, whereas the local production is 9.7 million tons **(FAOSTAT, 2024).** To fix the inability of production, wheat grain yield will be improved due to using the best technics and improvement promising cultivars with high yield as a national goal in Egypt.

Generation mean analysis (GMA) follows the quantitative biometrical methods depending on assessments of phenotypic behaviors of quantitative characters. According to **Kearsey and Pooni (1996),** GMA is a beneficial method in plant improvement for determining dominance and additive gene effects and digenetic interactions controlling the expression of quantitative characters. It supports in comprehension the behavior of parents which are used in crossing and the feasibility of using crosses in heterosis utilization and pedigree selection **(Sharma *et al.* 2003).** As a polygenic trait, grain yield is conducted from the interrelation between the inheritance and the environment. Adequate information about the genetic effects of quantitative characters and grain yield heritability and its attributes is necessary to obtain a suitable program of breeding.

Many studies revealed the great role of non-allelic interactions in the expression of quantitative characters in wheat **(Said, 2014; Hassan and El-Said, 2016; Heena *et al.*, 2021). Hamam (2014), Haridy *et al.* (2021) and Sandhu *et al.* (2023)** showed the superiority of dominance gene effects for yield and its components in wheat. **Al-Naggar *et al.* (2022), Swelam *et al.* (2022) and Al-Mfarji *et al*. (2023)** reported epistatic gene actions for several traits including grain yield. **Koubisy (2019) and Amiri *et al.***

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(2024) showed that additive and dominance effects were important for grain yield, with a more pronounced effect of dominance**. Sharshar and Genedy (2020) and Mohamed and Eissa (2022)** also showed over-dominance effects for grain yield/plant and plant height. The additive gene action was significant for earliness characters; however, the dominance genetic variances were significant for grain yield **(Sheera *et al.*, 2024). Duppala *et al.* (2023)** revealed that dominance and additive gene were significant, with a higher magnitude of dominance for all studied characters.

The present study was conducted to estimate the various types of gene effects in three wheat crosses using generation mean analysis.

MATERIALS AND METHODS

The present search was laid out during 2021-2022, 2022-2023 and 2023-2024 seasons at Fac. of Agric., Zagazig Univ. Four wheat genotypes (Misr 2, Sakha 95, Giza 171 and Gemmeiza 12) were used as parents which were differed in earliness and yield components.

The genotypes were crossed in such a way to produce three crosses *i.e.* cross I (Misr 2 x Sakha 95), cross II (Giza 171 x Gemmeiza 12) and cross III (Misr 2 x Giza 171).

The three F_1's grains were cultivated to obtain F_1 plants and then back crossed to its relative parents to obtain backcrosses. The self-pollination was made to F_1 plants to obtain F_2 grains.

The produced grains of P_1, P_2, F_1, F_2, BC_1 and BC_2 populations of the three crosses were cultivated in a randomized complete block design with three replicates. Recorded data of the studied characters were done on 20, 30 and 40 plants per replicate for parents and F_1 crosses, back crosses and F_2 population, respectively. Days to heading, plant height, spikes/plant number, grains/spike number, weight of 1000- grain and grain yield/plant were recorded.

The collected data were analyzed due to two-way analysis of variance by **Steel and Torrie (1980).** The A, B, C, and D scaling tests were determined as conducted by **Mather (1949)** and **Hayman and Mather (1955).** In the existence of non-allelic model, the six parameters were computed, whereas in the non-attendance of non-allelic, the genetic three parameters were computed according to **Jinks and Jones (1958)**. Degree of dominance and Heritability in narrow sense "T_n" was estimated according to **Mather and Jinks (1982)**. Genetic advance (GA) was calculated as stated by **(IPGRIE, 2001).**

RESULTS AND DISCUSSIONS

Mean Performance

Table 2 shows mean and standard error of the six populations of wheat crosses for days to heading, plant height, number of spikes/plant, number of grains/spike, 1000 grain weight and grain yield/plant are shown in Table 2. The F1's means tended towards the earlier and the shorter parent in all crosses. These results confirm the evidence of partial dominance in the genetic makeup of these characters.

The F_1's means were near to the earlier parent for days to heading in 2nd and 3rd crosses, the shorter parent for plant height in 1st and 2nd crosses and the heaver parent in 1000 grain weight in the 3rd cross, revealing complete dominance in the inheritance of this character in those cases. On other side, the over-dominance type of inheritance as well as negative heterotic effect were shown in the 1st cross for days to heading, in 2nd cross for 1000 grain weight and in 3rd cross for grans/spike number where the F_1 mean was lower than the best parent. Similar findings were recorded for yield components by **Said, 2014; Hassan and El-Said, 2016**.

The F1's surpassed the high performing parent for grain yield/plant and number of spikes/plant in all crosses, grains/spike in 1st and 2nd crosses and 1000-grain weight in 1st cross. These results confirm the existence of over dominance, and the raising alleles were more recurrent than decrescent alleles in the parental genotypes.

The F_2 means were higher than the F_1 means for plant height and days to heading in all crosses, proposing the accumulation of increasing alleles for earliness and plant height.

Table 1. Pedigree of the studied genotypes

No.	Genotypes	Pedigree
1	**Misr 2**	Skauz/Bav92.CMSS96M0361S-1M-010SY-010M-010SY-8M-0Y-0S
2	**Sakha 95**	CMA01Y00158S-040POY-040M-030ZTM-040SY-26M-0Y-0SY-0S.
3	**Giza 171**	SAKHA 93 / GEMMIEZA 9 S.6-1GZ-4GZ-1GZ-2GZ-0S N.S.732/Pim/Vee"S"
4	**Gemmeiza12**	OTUS/3/SARA/THB//VEE.CCMSS97Y00227S-5Y-010M-010Y-010M-2Y-1M-0Y-0GM

Table 2. Mean performance of the studied six populations of the three wheat crosses for the studied characters

Populations	Days to heading			Plant height (cm)		
	Cross I	Cross II	Cross III	Cross I	Cross II	Cross III
P_1	**99.00±0.65**	97.67±0.66	97.67±0.66	101.87±0.58	109.47±0.94	101.87±0.5
F_1	**95.83±0.89**	95.37±**0.66**	97.03±0.61	94.37±0.83	105.47±**1.06**	106.27±1.06
F_2	**99.93±1.12**	99.24±1.15	99.73±1.15	107.56±1.51	109.20±1.23	107.98±1.53
BC_1	**99.67±0.93**	96.30±0.78	98.33±0.86	98.53±1.35	106.50±1.22	106.57±1.31
BC_2	**98.30±0.96**	95.60±0.71	99.63±1.09	95.43±1.23	104.87±1.18	98.17±1.44
P2	**98.00±0.44**	95.87±0.42	98.13±0.17	93.33±0.91	105.27±0.89	109.47±0.94
	Number of spikes/plant			**Number of grains/spike**		
P1	8.60±**0.25**	10.80±0.37	8.60±**0.25**	59.67±0.64	53.73±0.69	59.67±0.64
F1	11.63±0.47	11.07±**0.39**	11.00±0.43	60.20±0.69	59.37±0.70	56.80±0.63
F2	11.96±0.64	10.22±0.46	10.090.84	50.11±1.07	50.87±1.10	49.69±0.99
BC1	11.93±0.59	10.63±0.52	11.200.61	52.97±1.0	52.37±0.92	51.87±0.92
BC2	13.40±0.55	9.87±0.41	11.670.59	51.63±0.97	53.57±1.04	52.93±0.94
P2	9.47±0.24	8.40±0.25	10.80±0.37	55.00±0.45	57.60±0.31	53.73±0.31
	1000 grain weight (g)			**Grain yield /plant**		
P1	38.60±0.39	40.93±0.57	38.60±0.57	19.83±0.67	22.31±0.64	20.95±0.60
F1	39.93±**0.65**	42.77±0.8	40.90±0.63	26.83±**0.75**	26.89±1.09	26.75±1.21
F2	33.20±0.75	37.31±1.01	34.11±0.86	20.21±1.42	15.99±1.27	18.78±1.59
BC1	35.60±0.65	38.73±0.82	39.30±0.77	22.46±1.18	21.66±1.06	22.75±1.56
BC2	34.90±0.72	40.97±0.71	36.80±0.75	24.13±1.14	21.35±0.97	25.02±1.29
P2	37.93±0.64	43.93±0.43	40.93±0.39	19.70±0.53	19.78±0.64	25.52±0.96

On the other hand, it was lower than the F1 means for spikes/plant number, grains/spike number, 1000-grain weight and grain yield/plant in the all crosses, except 1st cross for spikes/ plant number, confirming the existence of inbreeding depression.

The back crosses were diverged from the mid of parents and their relative F_1 for spikes/plant number, grains/spike number and grain yield/plant in all crosses, therefore polygenic and non-mendelain inheritance are more clear.

The means of backcrosses were in the mid between the F1 and the tow parents for plant height, days to heading, and 1000 grain weight, revealing the non-attendance of dominance and genes governing these characters are independently separated.simillar results were found by **Hamam (2014), Haridy *et al.* (2021) and Sandhu *et al.* (2023)**.

Gene Effects

Scaling test and gene action for days to heading, plant height, spikes/plant number, grains/ spike number, 1000 grain weight and grain yield/ plant in three wheat crosses are shown in Tables 3, 4 and 5. The results show significant non-allelic interactions in all crosses for all characters, except days to heading in 3rd one. These results obtained the existence of epistasis and the digenic type was suitable for describing the genetic of these traits in those crosses. **Haridy *et al.* (2021) and Sandhu *et al.* (2023)** explained the genetic variation for days to heading and yield.

Insignificant non-allelic interaction was shown for days to heading in the 3rd cross. This result indicated that the simple genetic type manifests to be acceptable in describing the genetic of this character.

The adequacy of genetic model showed that all gene action types were significant for plant height in the 3rd cross. Similar results were founded by **Al Naggar *et al.* (2022), Swelam *et al.* (2022) and Al-Mfarji *et al*. (2023).**

Moreover, the additive (d) gene effect was significant and positive for days to heading in the 1st cross. In this connection, positive and significant additive (d) gene action was reported in the genetic of days to heading **Al-Mfarji *et al*. (2023)**.

Significant dominance and dominance x dominance gene actions were recorded for spikes/plant number in 2nd cross. Also, Al **Naggar *et al.* (2022)** found significant dominance and dominance x dominance gene actions for yield and its components.

Furthermore dominance (h) gene effect was negative and significant for plant height and days to heading in 2nd cross, while it was positive and significant for spikes/plant in 2nd cross and grains/spike, 1000 grain weight as well as grain yield/plant in the all crosses. The large amount of dominance gene action shown by these traits in the identical crosses may propose that breeding these traits could be conducted due to hybrid programe. In this connection, dominance gene effect was detected for yield and its attributes by **Duppala *et al.* (2023) and Sheera *et al.* (2024).**

Meanwhile, the additive x dominance (j) type of interaction was negative and significant for plant height in 1st cross and in 2nd cross for number of spikes/plant. Whereas it was significant and positive for 1000 grain weight in 3rd cross as well as the additive (d) and dominance (h) were significant for 1000 grain weight in 3rd cross.

It is interesting to mention that the dominance and dominance x dominance were significant and have different signs in 3rd cross for plant heigh and in 2nd cross for of spikes/plant, indicating that duplicate type of interaction is predominantly.

The additive x additive (i) type of interaction was significant for days to heading and spikes/ plant in 2nd cross, plant height in the 1st and 2nd crosses, grains/spike in 3rd cross, 1000 grain weight in the all crosses and grain yield /plant in 2nd and 3rd crosses.

Days to heading in the 1st and 2nd crosses, plant height in 1st cross and spikes/plant, 1000 grain weight as well as grain yield /plant in the 2nd cross recorded high narrow sense heritability "T_n", indicating great advance from selection. Whereas it was moderate for days to heading and plant height in 3rd cross and spikes/plant as well as grain yield/plant in the 1st cross. On the other hand, it was low for plant height in the 2nd cross, grains/spike in the all crosses, 1000 grain weight in the 1st and 3rd crosses and grain yield/ plant in the 3rd cross. In this concern, the moderate to high "T_n" value have been detected by **Duppala *et al.* (2023) and Sheera *et al.* (2024)** for days to heading and most of yield components.

Table 3. Scaling test and gene effects for days to heading and plant height using six populations in three wheat crosses

Crosses	Days to heading			Plant height (cm)		
Scaling test	**Cross I**	**Cross II**	**Cross III**	**Cross I**	**Cross II**	**Cross III**
A	6.90**±2.3	-0.43±1.8	1.97±1.9	0.83±2.9	-1.93±2.8	5.00±2.9
B	3.57±1.8	-0.03±1.6	4.10±2.3	3.17±2.7	-1.00±2.7	-19.40**±3.2
C	16.40**±5.4	12.71**±4.8	9.07±4.8	46.29**±6.4	11.13**±5.5	8.04±6.6
D	2.97±2.9	6.59±**2.5	1.50±2.7	21.14**±3.5	7.03**±3.0	11.22**±3.6
Six-Parameters Model						
M	101.07**±1.3	99.24**±1.5	100.9±5.4	107.56**±1.5	109.20**±1.2	107.98**±1.5
D	2.57*±1.3	0.70±1.1	-0.2±0.34	3.10±1.8	1.63±1.7	8.40**±2.0
H	-8.20±5.8	-14.6**±5.1	-0.8±12.5	-45.52±7.1	-15.97**±6.1	-21.84**±7.4
I	-5.93±5.7	-13.2**±5.1		-42.29**±7.0	-14.07**±6.0	-22.44**±7.3
J	3.33±2.7	-0.40±2.2		-2.33**±3.8	-0.93±3.6	24.40**±4.04
L	-4.53±7.5	13.64*±6.4		38.29**±9.7	17.00±8.7	36.84**±10.2
$T_{(n)}$	61.0	68.41	45.13	50.97	28.99	39.05
$(H/D)^{1/2}$	0.93	0.73	1.4	1.19	1.67	1.52
GA	10.15	10.23	6.75	10.6	4.64	7.78

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

Table 4. Scaling test and gene action for number of spikes/plant and number of grains/spike using six populations in three wheat crosses.

Crosses	Number of spikes/plant			Number of grains/spike		
Scaling test	**Cross I**	**Cross II**	**Cross III**	**Cross I**	**Cross II**	**Cross III**
A	3.63**±1.3	-0.60±1.2	2.80*±1.3	-13.9**±2.2	-8.37**±2.1	-12.73**±2.1
B	5.70**±1.2	2.40**±1.1	1.53±1.31	-11.9**±2.1	-9.83**±2.2	-4.67*±2.0
C	6.49**±2.7	-4.44±2.8	-1.04±3.5	-34.6**±4.6	-26.60**±4.7	-28.24**±4.2
D	-1.42±1.5	-3.1**±1.5	-2.69±1.9	-4.38±2.6	-4.20±2.6	-5.42*±2.4
Six-Parameters Model						
M	11.96**±0.64	9.22**±0.7	10.09**±0.84	50.11**±1.1	50.87**±1.1	49.69**±0.99
D	-1.47±0.8	-0.30±0.71	-0.47±0.85	1.33±1.4	-1.20±1.4	-1.07±1.3
H	5.44±3.1	7.71**±3.0	6.68±3.8	11.62**±5.2	12.10*±5.3	10.94*±4.8
I	2.84±3.0	6.24*±2.96	5.38±3.7	8.76±5.1	8.40±5.2	10.84*±4.76
J	-2.07±1.6	-3.00*±1.5	1.27±1.8	-2.00±2.9	1.47±2.9	-8.07**±2.7
L	-12.18**±4.2	-8.04*±3.95	-9.71*±4.9	17.11±7.2	9.80±7.3	6.56±6.8
$T_{(n)}$	40.17	55.89	61.54	36.46	39.93	33.87
$(H/D)^{1/2}$	1.51	1.04	0.98	1.62	1.51	1.73
GA	3.33	4.75	6.7	5.08	5.72	4.38

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

Table 5. Scaling test and gene action for 1000 grain weight and Grain yield /plant using six populations in three wheat crosses

Crosses	1000 grain weight (g)			Grain yield /plant (g)		
Scaling test	**Cross I**	**Cross II**	**Cross III**	**Cross I**	**Cross II**	**Cross III**
A	-7.33**±1.5	-6.23**±1.9	-0.90±1.8	-1.74±2.6	-5.88*±2.5	-2.20±3.4
B	-8.07**±1.7	-4.77**±1.7	-8.23**±1.7	1.72±2.5	-3.97±3.3	-2.23±3.0
C	-23.6**±3.4	-21.2**±4.4	-24.89**±3.7	-12.35*±5.9	-31.92**±5.6	-24.9**±6.9
D	-4.10*±1.8	-5.08*±2.3	-7.88**±2.0	-6.17±3.3	-11.04**±2.9	-10.2**±3.8
Six-Parameters Model						
M	33.20**±0.8	37.31**±1.0	34.11**±0.9	20.21**±1.4	15.99**±1.3	18.78**±1.6
D	0.70±1.0	-2.23*±1.1	2.50*±1.1	-1.67±1.6	0.31±1.4	-2.27±2.0
H	9.87**±3.7	10.49*±4.7	16.89**±4.12	19.40**±6.61	27.92**±6.00	23.94**±7.6
I	8.20*±3.6	10.16*±4.6	15.76**±4.06	12.33±6.55	22.07**±5.8	20.42**±7.5
J	0.73±2.1	-1.47±2.3	7.33**±2.3	-3.47±3.39	-1.92±3.0	0.03±4.2
L	7.20±5.1	0.84±6.2	-6.62±5.7	-12.32±8.8	-12.22±8.0	-15.99±10.6
$T_{(n)}$	37.4	56.5	41.84	49.91	52.20	39.27
$(H/D)^{1/2}$	1.33	0.94	1.36	1.26	1.02	1.47
GA	3.66	7.41	4.7	9.22	8.65	8.13

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

Over dominance ratio was less than unity in 1st and 2nd crosses for days to heading, 3rd cross for spikes/plant number and 2nd cross for 1000 grain weight, proposing the efficiency of phenotypic selection for improving the previous traits in the relative crosses. On the other side, it was over than unity in the all crosses for plant height, grains/spike and grain yield/plant; the 1st and 2nd crosses for spikes/plant, 1st and 3rd crosses for 1000 grain weight and the 3rd cross for days to heading. **Sharshar and Genedy (2020), Mohamed and Eissa (2022)** also showed over-dominance effects for plant height and grain yield/plant

Heritability alone does not reveal the degree of genetic progress that would produced from the selection of a single genotype, and the efficiency of selection depends on heritability and genetic advance. So, information of heritability with genetic advance is more important. In addition, GA is important in anticipating the expected genetic gain from a selection cycle. In the present study, a moderate genetic advance was detected in 1st and 2nd crosses for days to heading, whereas it was low for days to heading in 3rd cross, plant height in the 2nd and 3rd crosses and all crosses for spikes/ plant, grains/spike, 1000 grain weight and grain yield/plant. these results are consistent with the findings by **Hassan and El-Said (2016) and Heena *et al.* (2021).**

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تقييم طرز الفعل الجينى للتبكير والمحصول ومساهماته في ثلاث هجن من قمح الخبز

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تم زراعة العشائر الستة خلال ثلاثة مواسم زراعية في مزرعة كلية الزراعة ، جامعة الزقازيق ، مصر لتقدير تأثيرات الفعل الجينى للتبكير والمحصول ومساهماته. أظهرت نتائج تحليل المقياس تحكم التفاعل غير الأليلى في معظم الصفات تحت الدراسة في جميع الهجن، ما عدا عدد الأيام حتى الطرد في الهجين الثالث. كانت جميع طرز الفعل الجينى معنوية لصفة ارتفاع النبات في الهجين الثالث. كان الفعل الجينى السيادى سالب ومعنوى لصفة عدد الأيام حتى الطرد وارتفاع النبات في الهجين الثانى، بينما كان موجبا ومعنويا لصفات عدد السنابل/النبات في الهجين الثانى وعدد الحبوب/السنبلة، وزن 1000 حبة ومحصول الحبوب/النبات في الهجن الثلاثة. كانت قيم كفاءة التوريث مرتفعة لصفات عدد الأيام حتى الطرد في الهجينين الأول والثانى، ارتفاع النبات في الهجين الأول وعدد السنابل/النبات، وزن 1000 حبة و محصول الحبوب/النبات في الهجين الثانى. كانت درجة السيادة أقل من الوحدة في الهجينين الأول والثانى لصفة عدد الأيام حتى الطرد، الهجين الثالث لصفة عدد السنابل/النبات والهجين الثانى لوزن 1000 حبة. أظهرت النتائج أن قيم التحسين الوراثى كانت متوسطة لصفة عدد الأيام حتى الطرد في الهجينين الأول والثانى، في حين كانت منخفضة لصفات عدد الأيام حتى الطرد في الهجين الثالث، ارتفاع النبات في الهجينين الثانى والثالث وعدد السنابل/النبات، عدد الحبوب/السنبلة، وزن 1000 حبة ومحصول الحبوب/النبات في الهجن الثلاثة.

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