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# GENE ACTION CONTROLLING EARLINESS AND GRAIN YIELD IN BREAD WHEAT (*Triticum aestivum* L.)

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**ABSTRACT: Diallel cross among six bread wheat genotypes were used to study the genetic behaviour of earliness, grain yield and protein content. The parents included two early (Sids 4 and Line 28), two moderate (Sakha 93 and Giza 168) and two late genotypes (Gemmeiza 9 and Gemmeiza 10) . This investigation was carried out during 2005/2006 and 2006/2007 seasons at Kafer El-Hamam Agricultural Research Station. The obtained 15 $F_1$'s together with the six parents were evaluated during 2006/2007 season in a randomized complete block design with three replicates under two sowing dates, viz early sowing on 9$^{th}$ of November and the late sowing was on 9$^{th}$ of December.**

**The results indicated that additive and dominance gene effects were significant and involved in the inheritance of all the studied characters. Additive component played the major role in the inheritance of days to heading, anthesis and maturity. Thus, phenotypic selection would be an effective procedure for improving these characters. Whereas, the dominance genetic variance was the main component controlling the inheritance of grain filling period, grain filling rate, grain yield/plant and protein content, under the early sowing date. The F value coupled with KD/KR ratio, indicated an excess of dominant increasing alleles for all characters, except days to maturity under the early sowing date and protein content under the late sowing one. Heritability estimates in narrow sense were high for earliness characters, relatively high for grain filling**

**period and protein content and low for grain filling rate and grain yield/plant.**

**Key words: Wheat, earliness, diallel crosses, gene action, heritability, (*Triticum aestivum* L.).**

## INTRODUCTION

Wheat is the most important grain crop in Egypt as a source of human food. Increasing production per unit area appears to be one of the important factors for narrowing the gap between wheat production and consumption. In this respect, plant breeders need continuous knowledge about nature of gene action and genetic system controlling the inheritance of wheat traits.

Breeding early maturing wheat (*Triticum aestivum* L.) cultivars is an important objective in most wheat improvement programs. Information about the inheritance of earliness components and productivity are important to wheat breeders for developing short duration cultivars with high yield. Early sowing has increased since the mid- nineties when high- yielding late flowering cultivars become commercially available. Therefore, knowledge of the effect of sowing date on development is also necessary to improve wheat cultivars adapted to early sowing. In Egypt, earliness has several advantages, for instance early maturing cultivars are highly needed to fit in new crop intensive rotations like planting cotton after wheat and planting wheat after harvesting short duration vegetable crops. Early-maturing cultivars are also preferable to escape diseases, pests, drought, heat and other stress injuries that occur at the end of growing season.

Informations about the genetics of earliness components, grain yield and protein content are prerequsite for increasing the selection efficiency. Tawafelis (2006) found significant variation in yield and its components among wheat genotypes under normal and late planting. He also reported that delaying sowing date reduced significantly grain yield/plant.

Additive and dominance gene effects with great importance of additive were found to control earliness characters (Menshawy 2004 and 2005 and Al-Naggar *et al.*, 2007). On the other hand , Awaad (2001), Menshawy (2004) and Al-Naggar *et al.*, (2007) reported that additive and dominance gene effects with great importance to dominance were operating in controlling grain filling period, grain filling rate and grain yield/plant. Moreover, Hamada and El- Beially (2003) reported that additive gene effect was the main type controlling grain protein content with moderate to high narrow sense heritability.

The objective of the present investigation was to study the genetic behaviour of earliness, grian yield and protein content of bread wheat.

## MATERIALS AND METHODS

The present investigation was conducted at Kafer El-Hamam Agricultural Research Station, Agricultural Research Center, Egypt, during the two wheat growing seasons 2005/2006 and 2006/2007. Six diverse bread wheat genotypes were selected and crossed in all possible combinations, excluding reciprocals, in 2005/2006 season to produce their $F_1$ crosses. Name and pedigree of the parental wheat genotypes are shown in Table (1).

In 2006/2007 season, the 15 $F_1$'s and the six parental genotypes were evaluated under two sowing dates, i.e. 9th of November (early sowing date) and 9th of December (late sowing date) in two adjacent experiments in a randomized complete block design with three replications. Each cross was planted in a plot of five rows (2 rows for each parent and 1 row for the $F_1$ cross). The row length was 2m, row to row and plant to plant spaces were 20 and 10cm, respectively.

Ten guarded plants were chosen randomly from each parental genotype and $F_1$ and labeled to collect data on the following characters: days to heading, days to anthesis, days to maturity, grain filling period (days), grain filling rate (gm/day) and grain yield/plant (g). Grain protein content (%) was estimated using micro-kjeldahl method to determine the total nitrogen in the grain and multiplied by 5.75 to obtain the percentage of protein according to A.O.A.C. (1980).

Analysis of variance was conducted to test the differences among various genotypes according to Snedecor and Cochran (1989). The diallel cross analysis adopted by Hayman (1954 a and b) was applied.

**Table 1. Pedigree and origin of the six parental bread wheat genotypes used in this study**

| Name | Pedigree | Origin | Earliness |
|---|---|---|---|
| Sids 4 | MAYA "s" / Mon"s"// CMH 74A – 592/5/ GIZA 157*2 | Egypt | Early |
| Gemmeiza 10 | Maya 74 "s"/ON // 1160-147/3/BB/G11/4/ CHAT "s"/S/ Crow "S" | Egypt | Late |
| Gemmeiza 9 | ALD "s" / HYAC "s" / CMH74A. 630/SX: CGM4583-5 GM | Egypt | Late |
| Sakha 93 | Saka92/LTR 810328 s 8871-15-25-15-05 | Egypt | Moderate |
| Line 28 | SARA// JUP/ BJY /3/ KAUZ /4/ BABX / 5FRTL. | Mex. | Early |
| Giza 168 | MRL/BUC //Seri | Egypt | Moderate |

## RESULTS AND DISCUSSION

Separating out the total genetic variance into its main components i.e. additive and dominance ($H_1$ and $H_2$) gene effects using the diallel analysis method was performed for earliness characters, grain yield and protein content in order to provide detailed genetic information for the breeder to choose the most efficient breeding methodology. Therefore, in the present study, the diallel analysis according to Hayman (1954 a and b) was used to identify the type of gene action controlling the studied characters for each sowing date, separately.

### Earliness Characters

Data presented in Table 2 indicated that both additive (D) and dominance ($H_1$ and $H_2$) genetic components were highly significant for earliness characters under both sowing dates. The additive genetic component was higher in its magnitude than the dominance one, resulting in an average degree of dominance $(H_1/D)^{0.5}$ less than unity, suggesting that the fixable gene type could be exploited efficiently through phenotypic selection. In this respect, additive and non-additive gene effects were found to be significant with the preponderance of additive gene action in controlling earliness characters (Menshawy 2004 and 2005 and Al-Naggar *et al.* 2007).

The covariance of additive and dominance gene effects in the parents (F value) was positive and highly significant for days to heading and days to anthesis under both sowing dates as well as days to maturity under late sowing date, indicating more frequent of the increasing dominant alleles than the recessive ones in the parental genotypes. Otherwise, F value was found to be negative and did not reach the level of significance for days to maturity under early sowing date.

**Table 2. Additive (D), dominance (H) genetic variances and their derived parameters for days to heading, days to anthesis and days to maturity under two sowing dates**

| Genetic parameters | Days to heading | | Days to anthesis | | Days to maturity | |
|---|---|---|---|---|---|---|
| | $D_1$ | $D_2$ | $D_1$ | $D_2$ | $D_1$ | $D_2$ |
| D | 122.67** ± 2.81 | 83.12** ± 0.84 | 106.60** ± 1.96 | 75.73** ± 0.64 | 71.04** ± 2.90 | 55.53** ± 2.67 |
| $H_1$ | 19.42** ± 7.14 | 9.56** ± 2.13 | 15.04** ± 4.94 | 9.19** ± 1.68 | 22.58** ± 7.35 | 27.80** ± 6.78 |
| $H_2$ | 15.86** ± 6.38 | 6.43** ± 1.90 | 121.17** ± 4.41** | 6.55** ± 1.46** | 21.57** ± 6.57** | 25.66** ± 6.06 |
| F | 17.75** ± 6.87 | 17.94** ± 2.05 | 17.26 ± 4.75 | 16.27** 1.57 | -2.48 ± 7.08 | 21.56** ± 6.53 |
| $h^2$ | 7.57 ± 1.06 | 0.283 ± 032 | 2.47 ± 0.73 | -0.075 ± 0.24 | 0.45 ± 1.09 | 11.40** ± 1.01 |
| E | 0.441 ± 1.06 | 0.38 ±0.32 | 0.29 ±0.73 | 0.32 ±0.24 | 0.55 ±1.09 | 0.53 ±1.01 |
| **Derived parameters** | | | | | | |
| $(H_1 / D)^{0.5}$ | 0.398 | 0.339 | 0.375 | 0.348 | 0.563 | 0.707 |
| $H_2 / 4H_1$ | 0.204 | 0.168 | 0.202 | 0.178 | 0.238 | 0.230 |
| KD /KR | 1.445 | 1.933 | 1.549 | 1.892 | 0.939 | 1.753 |
| $h^2$ (ns) | 92.4 | 94.5 | 93.2 | 94.40 | 86.2 | 72.2 |

$D_1$= The early sowing date (9th Nov.).
$D_2$ = The late sowing date (9th Dec.) .

It is interesting to note that, the components of genetic variance differed in their magnitude from early to late sowing date, revealing that allelic expression was affected by sowing date.

The environmental variance was insignificant for earliness characters under both sowing dates. The proportion of genes with positive and negative effects in the parents as indicated by ($H_2$ / $4H_1$) was less than its maximum value (0.25) for days to heading and days to anthesis under both sowing dates, suggesting asymmetrical distribution of positive and negative alleles among the parental genotypes. On the other hand, it was near to its maximum value (0.25) for days to maturity under both sowing dates, suggesting equal distribution of positive and negative alleles among the parental genotypes. Symmetrical distribution of positive and negative alleles among the parents was recorded for days to heading by Awaad (1996). On the contrary, asymmetrical distribution of positive and negative alleles was revealed for days to heading and days to maturity by Hamada (2003).

The proportion of dominance to recessive genes in the parents was more than unity [KD/ KR>1] for days to heading and days to anthesis under both sowing dates and days to maturity under late sowing one, indicating an excess of dominant alleles in the genetic make up of the parental genotypes and *Vise versa* for days to maturity under early sowing one, suggesting an excess of recessive alleles than the dominant ones in the parents.

Narrow sense heritability was high 92.4 and 94.5% for days to heading; 93.2 and 94.40% for days to anthesis and 86.2 and 72.2% for days to maturity under the early and late sowing dates, respectively. Thus, selection in segregating generations based on phenotype may be effective to isolate early wheat genotypes. In this respect, high narrow sense heritability was detected for earliness characters by Awaad (1996) and 2001), Manshawy (2004), Koumber and El-Beially (2005) and AL-Naggar *et al.*, (2007).

**Grain Filling Characters**

Data presented in Table 3, show that both additive and dominance genetic components were highly significant under both sowing dates for grain filling period. Whereas, the dominance component $H_1$ and $H_2$ under late sowing date and the component $H_2$ only under early sowing one were significant and involved in the inheritance of grain filling rate. Therefore, average degree of dominance was more than unity for both grain filling period and rate.

The overall dominance effects of heterozygous loci ($h^2$) were positive and highly significant for grain filling period under both sowing dates and for grain filling rate under the early sowing one, hereby, dominance was mainly attributable to heterozygous loci and seemed to be acting in positive direction. The environmental variance was insignificant for grain filling characters under the two sowing dates.

The proportion of genes with positive and negative effects in the parents as indicated by $H_2$ / $4H_1$ was less than its maximum value (0.25) for grain filling characters, suggesting asymmetrical distribution of positive and negative alleles among the parental genotypes. The proportion of dominance to recessive genes (KD/KR) in the parents was more than unity, indicating an excess of dominant alleles for grain filling traits in the genetic make up of the parental genotypes.

Narrow sense heritability was relatively high for grain filling period 51.8 and 53.4% under early and late sowing dates, respectively. Whereas, it was low for grain filling rate 20.4 and 20.0 % in the same respective order. In this connection, high values of narrow sense heritability for grain filling period and rate were recorded by Menshawy (2005) and Al-Naggar *et al.,* (2007), whereas, low estimate of narrow sense heritability was recorded by Awaad (2001) .

**Grain Yield/plant and Protein Content**

Data given in Table 4. show genetic components of variance and their derived parameters for both grain yield/plant and protein content. For grain yield/plant, the results indicated that dominance genetic component was found to be highly significant for grain yield/plant under both sowing dates. The dominance component ($H_1$ and $H_2$) was higher in magnitude than the corresponding additive one, resulting in an average degree of dominance ($H_1/D^{0.5}$) more than unity, confirming the important role of overdominance gene effects in the genetic control of wheat grain yield. This result provides an evidence that grain yield/plant was mainly controlled by non-additive gene effects. Such non-fixable type of gene action could be exploited through a hybrid breeding program, if hybrid vigor in wheat becomes feasible.

Table 3. Additive (D), dominance, (H) genetic variances and their derived parameters for grain filling period and grain filling rate under two sowing dates

| Genetic parameters | Grain filling period | | Grain filling rate | |
|---|---|---|---|---|
| | $D_1$ | $D_2$ | $D_1$ | $D_2$ |
| D | 7.90** ± 0.97 | 12.71** ± 1.99 | 0.009 ± 0.05 | 0.010 ± 0.007 |
| $H_1$ | 9.11** ± 2.47 | 16.65** ± 5.02 | 0.050 ± 0.130 | 0.052** ± 0.017 |
| $H_2$ | 7.89** ± 2.21 | 14.49** ± 4.48 | 0.034** ± 0.011 | 0.040** ± 0.014 |
| F | 3.61 ± 2.38 | 5.12 ± 4.82 | 0.19 ± 0.013 | 0.021 0.016 |
| $h^2$ | 3.78** ± 1.48 | 10.37** ± 3.02 | 0.037** ± 0.007 | 0.017 ± 0.010 |
| E | 0.584 ± 0.37 | 0.619 ± 0.75 | 0.001 ± 0.002 | 0.001 ± 0.002 |
| Derived parameters $(H_1 / D)^{0.5}$ | 1.074 | 1.414 | 2.361 | 2.261 |
| $H_2 / 4H_1$ | 0.216 | 0.217 | 0.172 | 0.193 |
| KD /KR | 1.540 | 1.427 | 2.756 | 2.755 |
| $h^2$ (ns) | 51.8 | 53.4 | 20.4 | 20.0 |

D1 = The early sowing date (9th Nov.).
$D_2$ = The late sowing date (9th Dec.).

It is interesting to note that the magnitude and significance of genetic components for grain yield differed from early to late sowing date and tended to decrease with late sowing date. Similar findings were reported by Hamada (2003), Al-Naggar *et al.*, (2007) anel Ahmed and Mohamed (2009).

The overall dominance effects of heterozygous loci ($h^2$) were positive and highly significant under both sowing dates, indicating that dominance was mainly due to heterozygous loci and seemed to be acting in a positive direction. The proportion of genes with positive and negative effects in the parents as indicated by $H_2/4H_1$ was less than its maximum value (0.25), suggesting unequal distribution of positive and negative alleles of grain yield among the parental genotypes. The proportion of dominance to recessive genes in the parents was more than unity (KD/KR>1) under both sowing dates, reinforcing an excess of dominant alleles of grain yield in the genetic make up of the parental genotypes.

Heritability estimates in narrow sense for grain yield were found to be low with values of 28.7 and 19.0 % under early and late sowing dates, respectively. In this respect, low values of narrow sense heritability were recorded for grain yield by many investigators,( Salem *et al.*, 2000; Awaad 2002; Hamada and EL-Beially 2003 and Ahmed and Mohamed 2009).

For protein content, the results indicated that both types of gene action, additive and dominance appeared to be significant under the two sowing dates. The dominance component made up the most part of the total genetic variance as it was larger in its magnitude than the corresponding additive one under the early sowing date, resulting in an average degree of dominance $(H_1/D)^{0.5}$ more than unity and the opposite was true under the late sowing one. Abd El Aty and Katta (2002) and Hamada and El Beially (2003) indicated that additive genetic variance was the main type of gene action controlling grain protein content. On the contrary, El-Marakby *et al.*, (1993) detected over dominance mode of inheritance for grain protein content in wheat.

The environmental variance had a significant effect on grain protein content, indicating that this character was influenced by the environmental conditions.

The value of ($H_2/4H_1$) for grain protein was less than its maximum (0.25) under the early sowing date. Whereas, it was equal to 0.25 under the late sowing one. The ratio of KD/KR for grain protein was more than unity under the early sowing date, whereas, it was less than unity under late sowing, indicating the significant role of environmental effect on the gene expression of grain protein.

Narrow sense heritability values for grain protein were high 50.3 and 68.5% under the early and late sowing dates, respectively, suggesting that selection could be effective to improve grain protein content. High and moderate values of heritability in narrow sense were also obtained by Abd El-Aty and Katta (2002) and Hamada and El-Beially (2003).

**Table 4. Additive (D), dominance (H), genetic variances and their derived parameters for grain yield/plant and protein content under two sowing dates**

| Genetic parameters | Grain yield/plant | | Protein content | |
|---|---|---|---|---|
| | $D_1$ | $D_2$ | $D_1$ | $D_2$ |
| D | 32.52** ±11.60 | ±27.22 14.72 | 0.43** ±0.08 | 0.37** ±0.04 |
| $H_1$ | 132.57** ±24.45 | 104.88** ±37.37 | 0.64** ±0.20 | 0.19** ±0.09 |
| $H_2$ | 98.49** ±26.31 | 74.57** 33.38 | 0.56** ±0.18 | 0.19** ±0.09 |
| F | 45.97 ±28.34 | 48.38 ±35.96 | 0.08 ±0.19 | -0.10 ±0.09 |
| $h^2$ | 132.47** ±17.71 | 65.01** ±22.46 | -0.04 ±0.12 | 0.13** ±0.05 |
| E | 0.915 ±4.38 | 0.79 ±5.56 | 0.07** ±0.03 | 0.06** ±0.01 |
| **Derived parameters:** | | | | |
| $(H_1/D)^{0.5}$ | 2.019 | 1.962 | 1.229 | 0.712 |
| $H_2/4H_1$ | 0.185 | 0.177 | 0.125 | 0.25 |
| KD/KR | 2.077 | 2.654 | 1.177 | 0.673 |
| $h^2$(ns) | 28.7 | 19.0 | 50.3 | 68.5 |

$D_1$ = The early sowing date (9th Nov.).

$D_2$ = The late sowing date (9th Dec.).

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## الفعل الجينى المتحكم فى التبكير ومحصول الحبوب فى قمح الخبز

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أجريت هذه الدراسه بمحطة بحوث كفر الحمام – مركزالبحـوث الزراعيــة خــلال موسمى ٢٠٠٥/٢٠٠٦ و ٢٠٠٦/٢٠٠٧ بهدف دراسة الفعل الجينى المتحكم فى التبكيــر ومحصول الحبوب فى قمح الخبز وذلك باستخدام الجيل الأول الناتج من تهجين ستة أصناف من قمح الخبز متباينه فى صفات التبكير والمحصول بطريقــة الــدياليل مــستبعداً الهجــن

العكسية أثنين منهما مبكرين وهما (سدس٤، سلاله ٢٨)، وأثنين متوسطى التبكير وهمـا (سخا٩٣، جيزة ١٦٨) وأثنين متأخرين و هما (جميزة ٩، جميزة ١٠) وذلك تحت ميعادين للزراعة الأول مبكر (٩ نوفمبر) ، والثانى متأخر(٩ ديسمبر).

أشارت النتائج إلى معنوية كل من الفعل الجينى المضيف والسيادى لـصفات التبكيـر تحت ميعادى الزراعة مع وجود دور أكبر للفعل الجينى المضيف مشيراً إلى فعالية الإنتخاب المظهرى فى تحسين هذه الصفات. وقد دلت النتائج على زيادة تكـرار الألـيلات الـسائدة المتحكمة فى وراثة صفتى عدد الأيام من الزراعه حتى طرد السنابل وعـدد الأيـام حتـى التزهير تحت ميعادى الزراعة وصفة عدد الأيام حتى النضج تحت الميعاد المتأخر.

أشار انحراف النسبة ($H_2/4H_1$) عن قيمتها النظرية (٠,٢٥) إلـي التوزيـع غيـر المتماثل للأليلات الموجبة والسالبة بين الآباء لصفتى عدد الأيام من الزراعه حتـى طـرد السنابل وعدد الأيام حتى التزهير، فى حين كان قريب جداً من قيمتها (٠,٢٥) لصفة عـدد الأيام حتى النضج مشيراً إلي التوزيع المتماثل للأليلات الموجبة والسالبة بين الآباء لهـذه الصفة . كانت قيم كفاءة التوريث بالمعنى الضيق مرتفعة لصفات التبكيـر تحـت ميعـادي الزراعه المبكر والمتأخر.

كان المكون السيادى هو الأكثر أهمية فى وراثة فترة ومعدل امـتلاء الحبـوب فـى الميعادين. أظهرت نتائج التوزيع التكراري للآليلات السائدة فى الآباء ($H_2/4H_1$) انحراف النسبة عن قيمتها (٠,٢٥) لصفتي امتلاء الحبوب تحت الميعادين مشيراً إلي التوزيع غير المتماثل للاليلات السالبة والموجبة فى الآباء. و كانت قيم معامل التوريث بالمعنى الـضيق مرتفعة نسبياً (٥١,٨ ، ٥٣,٤%) لصفة فترة امتلاء الحبوب فى حـين كانـت منخفـضة (٢٠,٤، ٢٠%) لصفة معدل امتلاء الحبوب تحت الميعادين المبكر والمتأخر، على الترتيب

أوضحت النتائج أهمية كلاً من الفعل الجيني المضيف والسيادى فى وراثـة محـصول الحبوب/النبات ونسبة البروتين مع وجود دور اكبر للفعل الجيني السيادى. أوضحت النسبة ($H_2/4H_1$) أن هناك توزيع غير متماثل لكل من الجينات السالبة والموجبة بين الأباء لصفة محصول الحبوب تحت الميعادين ولصفة نسبة البروتين تحت الميعاد المبكر. كانت قيم كفاءة التوريث بالمعنى الضيق منخفضة لصفة محصول الحبوب (٢٨,٧ ، ١٩%) ، بينما كانـت مرتفعة نسبياً لنسبة البروتين (٥٠,٣ ، ٦٨,٥%) تحت ميعادي الزراعة المبكر والمتـأخر، على الترتيب.