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# دراسات وراثية على بعض هجن قمح الخبز

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**قسم بحوث القمح- معهد بحوث المحاصيل الحقلية- مركز البحوث الزراعية**

## الملخص العربي

**أجريت هذه الدراسة بالمزرعة البحثية لمحطة البحوث الزراعية بالجميزة – مركز البحوث الزراعية خلال ثلاثة مواسم زراعية ٢٠٠٧/٢٠٠٨ ، ٢٠٠٨/٢٠٠٩ و ٢٠٠/٢٠١٠ بغرض دراسة كل من قوة الهجين والسلوك الوراثي ودرجة التوريث والتحسين الوراثي المتوقع بالانتخاب وذلك لسبع صفات هي عدد الأيام حتى طرد السنابل، تاريخ النضج، طول النبات، عدد السنابل في النبات، عدد حبوب السنبلة، وزن الحبوب ومحصول الحبوب للنبات وذلك في ثلاثة هجن من قمح الخبز هي الأول IRINA X P3 والثاني PBW343 xP4 والثالث P3 XP4 ويمكن تلخيص النتائج المتحصل عليها كما يلي:**

- **أوضحت النتائج المتحصل عليها من تحليل التباين وجود اختلافات معنوية بين العشائر الوراثية تحت الدراسة لجميع الصفات في جميع الهجن الثلاثة كما لوحظ وجود تباين غير أليلي لمعظم الحالات حيث كانت قيم الفعل الجيني المضيف وكذلك السيادي معنوية لمعظم القيم ماعدا بعض الحالات القليلة.**
- **كان التفاعل الجيني من نوع المضيفx المضيف معنويا لجميع القيم ماعدا صفة وزن الحبوب فى الهجين الثالث. كما لوحظ أن التفاعل الجيني من نوع المضيفx السيادي كان معنويا لكل الصفات المدروسة في هجن الدراسة ماعدا صفة عدد الأيام حتى طرد السنابل فى الهجين الأول وصفة عدد السنابل فى النبات فى الهجن الثلاثة وصفة وزن الحبوب فى الهجين الثالث. وأظهرت النتائج أيضا أن التفاعل الجيني التفوقى من النوع السياديx السيادي كان معنويا لجميع القيم ماعدا صفة النضج فى الهجين الثانى.**
- **أوضحت النتائج وجود قوة هجين معنوية منسوبة للأب الأفضل في الهجن الثلاثة لكل الصفات ماعدا صفة عدد الأيام حتى طرد السنابل فى الهجينين الأول والثالث وصفة النضج فى الهجن**

الثلاثة وطول النبات فى الهجينين الأول والثالث وصفة عدد السنابل فى النبات فى الهجين الأول.

- كان تأثير التربية الداخلية معنويا لمعظم الصفات تحت الدراسة.
- كانت قيم الكفاءة الوراثية بمعناها العام والدقيق عالية المعنوية لمعظم الصفات المدروسة في العشائر الثلاثة تحت الدراسة وكانت القيم العالية للتحسين الوراثي المتوقع بالانتخاب مرتبطة مع التقديرات العالية لدرجة التوريث بمعناها الدقيق وذلك في صفة طول النبات فى الهجين الثالث وصفة وزن الحبوب فى الهجينين الثاني والثالث وصفة محصول النبات فى الهجن الثلاثة.

# GENETIC STUDIES ON SOME BREAD WHEAT CROSSES

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**ABSTRACT:** ***Six- populations i.e, Parents ($P_1$&$P_2$), $F_1$,$F_2$ $Bc_1$ and $Bc_2$ of three bread wheat (Triticum aestivum, L.) crosses namely, IRENA x p3, PBW 343 x P4 and P3 x P4 were grown during the three seasons, 2007/2008, 2008/2009 and 2009/2010 at the experimental farm of El-Gemmeiza Agric. Res. Station, ARC, Egypt. The non-allelic interaction, scaling tests (A,B,C and D) coupled with six types of gene actions were estimated in addition to determining the adequacy of genetic model controlling the genetic system of the inheritance of some economic traits. Heading date, maturity date, plant height, number of spikes/plant, number of kernels/spike, kernel weight and grain yield/plant were studied. The obtained results can be summarized as follows:***

***Analysis of variance indicated significant differences among the studied generations for all studied characters. The results indicated the presence of non-allelic interaction in all studied characters and crosses except for few casses in which the values did not reach the significant levels. In the six parameters model, additive component (a) as well as dominance component (d) were significant in most casses. Additive x additive (aa) was significant in all casses except for kernel weight in the third cross. Additive x dominance (ad) component was significant in all casses except for heading date in the first cross, number of spikes / plant at the three crosses and kernel weight in the third cross. Also, dominance x dominance (dd) was significant for all characters in all crosses except for maturity date in the second cross. Significant positive or negative heterosis values comparing to better parent values were obtained for all crosses and characters except for heading date for the first and third crosses, maturity date for the three crosses, plant height of first and third crosses and number of spikes/plant for the first cross. Inbreeding depression values were highly significant for most characters studied in the three crosses except for heading date at the third cross , maturity date at the three crosses and plant height at the first cross. Heritability estimates in both broad and narrow senses were high in***

***magnitude for most characters studied in the three populations under investigation. High genetic advance under selection was associated with high narrow sense heritability estimates for; plant height, kernel weight and grain yield/plant in the three crosses.***

***Key words:*** ***Gene action- heterosis- wheat- heritabilty -genetic advance under selection- six generation model***

# INTRODUCTION

**Wheat (*Triticum aestivum* L.) is the most important cereal crop in Egypt and world wide. In Egypt, increasing grain yield of cereal crops is considered one of the main national goals to face the growing needs of the populations. Therefore, it has become necessary to develop genotypes which are consistent by showing superior performance.**

**The plant breeder is interested in the estimation of gene effects in order to formulate the most advantageous breeding procedures for improving his breeding program. Therefore, breeders need information about nature of gene action, heterosis, inbreeding depression, heritability and predicted genetic gain from selection for earliness, agronomic traits, as well as yield and its components. Since decision making about effective breeding system to be used is mainly dictated by type of gene action controlling the genetic variation, such information is helpful for the breeders to predict in early generation the effective breeding program. The potential of new recombination lines that could be derived of a lowing series of selfing generations. Since, genetic information obtained from multi populations ($P_1$, $P_2$, $F_1$, $F_2$, $Bc_1$ and $Bc_2$) are considered the one which may give detailed genetic information of the employed genotypes.**

**Many investigators studied the type of gene effect in wheat genotypes and reported that partial dominance was relatively more important than additive in the inheritance of grain yield, while additive genetic effects were predominated in the expression of plant height and heading date Amaya *et al.*(1972). Moreover, partial dominance of genes were important in expression of heading date, plant height and kernel weight. Also, high values of heritability and no significant epistatic effect were detected in the inheritance of these traits Singh *et al.* (1985). Meanwhile, Khalifa *et al.* (1997) and El-Sayed *et al.* (2000), found that additive-dominance model were adequate for revealing the inheritance of grain yield and its components. On the other hand, Amawate and Behl (1995) revealed that dominance gene effect were more important than additive ones in most traits which showed presence of both types of gene effects. Results of Sharma *et al.* (1998) and Yadav and Nersinghani (1999) indicated that additive gene effects were predominant for yield and yield components, though non-additive gene effects were also important. Hamada (2003), Tammam (2005) and Abd El-**

**Majeed (2005) revealed that additive and dominance components were significant for most traits studied.**

**The present work was undertaken to study the behavior of gene action and other genetic parameters of seven traits in three wheat crosses by using their six populations ($P_1$, $P_2$, $F_1$, $F_2$, $Bc_1$ and $Bc_2$ ).**

## MATERIALS AND METHODS

**The present study was carried out at El-Gemmeiza Agric. Res. Station A.R.C., Egypt, during three seasons from 2007/2008 to 2009/2010. This study aimed to estimate heterosis, heritability and type of gene action of some quantitative characters in three bread wheat crosses. Four bread wheat genotypes were chosen for this study on the basis of their diversity in origin (Table 1). In 2007/2008 season, three crosses were made, $P_1$ x $P_3$, $P_2$ x $P_4$ and $P_3$ x $P_4$ to produce $F_1$ hybrids. In 2008/2009 season some $F_1$ plants of each cross were backcrossed to each of the two parents to produce the backcrosses ($Bc_1$ and $Bc_2$ ). The rest of the $F_1$ plants were selfed to produce $F_2$ generations. In 2009/2010 season, the six populations, $P_1$, $P_2$, $F_1$, $F_2$, $Bc_1$ and $Bc_2$ of three crosses were sown in a randomized complete block design with four replications. Each replicate for every cross was planted with 40 grains in two rows for each of the two parents and $F_1$, 100 grains in five rows of each of the two backcrosses and 160 grains in eight rows for the $F_2$ population. Plants were sown in rows, 2.0 m long and 30 cm apart and 10 cm within rows. Recommended field practices for wheat production were adopted in all growing seasons.**

**Table (1): The name, pedigree and origin of the four parental bread wheat genotypes.**

| Parents | Pedigree | Origin |
|---|---|---|
| $P_1$ | IRENA= BUC/FLK//MYNA/VUL<br>CM 91575-28Y-OM-OY-1M-OY | Mexico |
| $P_2$ | PBW 343= ND/VG9144//KAL/BB/3/YACO/4/VEE#5<br>CM 5836-4Y-OM-OY-8MOY-01ND | Mexico |
| $P_3$ | Sids.7/4 BLOUDAN/3BB/7C* 211Y50E/KAL* 3<br>S. 13545- 1S-1S- 3S- OS | Egypt |
| $P_4$ | D6301/HEINEV11/ERA/3/BUC/4/LIRA/5/SPB/61GIZA144//PIN"s" /BOW"s"<br>S.13582- 8S- 1S- OS- YR- 1S- OS | Egypt |

**Data were recorded on 30, 30, 180 and 90 plants for both parents, $F_1$, $F_2$ and backcrosses of each cross for every replicate, respectively. Data were recorded on individual guarded plants for heading date, maturity date, plant height, number of spikes/plant, number of kernels/spike, 1000- kernel weight (g) and grain yield/plant (g).**

## Statistical and genetic analysis:-

**To determine the presence or absence of non-allalic interactions, scaling test as outlined by Mather (1949) was used. The t-test was used to examine the existence of genetic variance between parental means. Statistical procedures used herein would only be computed if the $F_2$ genetic variance was significant. A one tail (F) ratio was used to examine the existence of genetic variance within the $F_2$ population. The degrees of freedom for this test were considered as infinity. If calculated (F) ratio was equal to or larger than the tabulated ones, various biometrical parameters needed in this investigation would be computed. Heterosis (H),was expressed as percent increase of the $F_1$ mean performance above the respective better parent, i.e ( $\overline{F1}$ – $\overline{BP}$ )/ $\overline{BP}$ X 100.**

**Inbreeding depression (I.d) was measured as the average percent decrease of the $F_2$ from the $F_1$ . $F_2$ deviation ($E_1$), was calculated as the deviation of the $F_2$ mean performance from the average of $F_1$ and mid-parent value. Backcrosses deviation ($E_2$), was computed as the deviation of the two backcrosses performance from their $F_1$ and mid-parent performances. The validity of some estimates were examined by t-test. Nature of gene action was studied according to the relationships illustrated by Gamble (1962). In this procedure the means of the six populations of each cross were used to estimate six parameters of gene action. A test of significance of these parameters was conducted by the t-test. Heritability was estimated in both broad and narrow senses for $F_2$ generation, according to Mather's procedure (1949). The predicted genetic advance under selection ($\Delta$G) was computed according to Johnson *et al.* (1955). This genetic gain represented as percentage of the $F_2$ mean performance was also obtained following (Miller *et al.,* 1958).**

# RESULTS AND DISCUSSION

## Mean performance :-

**Significant genetic variance was detected for all studies characters in the three crosses , therefore other genetical parameters were estimated (Table, 2). Also, differences between the two parents in each cross were significant**

**for all studies characters. The existence of significant genetic variability in spite of the significant differences between the parents, obtained herein in most traits, may suggest that the genes of like effects were not completely associated in the parents, i.e., these genes are dispersed Mather and Jinks (1971).**

**In general, the mean performance of $P_2$ , $F_2$ and $Bc_2$ in cross (1) and $P_2$ , $F_2$, $Bc_1$ and $Bc_2$ in cross (2) were the earliest in heading date. The best maturing were $P_1$ , $F_1$ , $F_2$ and $Bc_2$ in cross (1), $P_2$ , $F_1$ , $F_2$ and $Bc_1$ in cross (2) and $F_2$ , $Bc_1$ and $Bc_2$ in cross (3). For plant height P2,F1,F2 and Bc1 in cross(1), F1**

**TABLE 2**

**and Bc1 in cross (2) and P1,F2 and Bc2 in cross (3) were the highest values. For number of spikes/plant (P1,F1,F2 and Bc1) in cross1, (P2, F1,F2 and Bc2) in cross2 and (P2, F1 and Bc2) in cross 3 have the highest values. On the other hand, (P1,P2,F1,F2,Bc1 and Bc2), (P2,F1 and Bc2) and (F2,bc1and Bc2) were the best in number of kernels/spike for the crosses 1, 2 and 3, respectively. The heaviest kernel weight for cross1 are (P1,P2 and Bc1), for cross 2 are(F1 and Bc1) and in cross 3 are (P2, F1,F2, Bc1 and Bc2). Meanwhile, F2 and Bc2 in cross1 and 2 and F1, Bc1 and Bc2 in cross3 recorded the highest grain yield /plant.**

## Gene action :-

**Nature of gene action was also studied according to relationships illustrated by Gamble (1962). All traits under study were significant for scaling tests A,B,C and D in the three crosses except scaling test A for heading date in the third cross and for number of spikes/plant and kernel weight in the first cross. Scaling test B for number of spikes/plant in the first cross and for 1000-kernel weight in the third cross. Scaling test D for kernel weight in the third cross. These results assumed the contribution of epistatic gene effect in the performance of these traits. The estimates of the various types of gene effects contributing to the genetic variability are presented in Table (3). In all studied characters , the mean effects parameters (m) which reflect the contribution due to the overall mean plus the locus effects and interactions of the fixed loci was highly significant, the additive genetic estimates were significant. These results indicate the potentiality of improving the performance of these traits by using pedigree selection program. Similar results were obtained by Mosaad et al (1990),Sirvestava *et* (1992) , Abul-Nass *et al* (1993), Khalifa *et al* (1997), El- Siedy and Hamada (1997) , Hamada (2003) , El-Sayed and El-Shaarawy (2006) and El-Shaarawy (2008). Also, the major contribution by dominance gene effects to variation in these crosses for all traits indicated by the relative magnitude of the parameter dominance (d) to the parameter (m). In addition, the estimates of dominance effects were significant, indicating the importance of dominance gene effects in the inheritance of all traits. Significant additive (a) and**

**dominance (d) components indicated that both additive and dominance effects were important for these traits. Similar conclusion was obtained by Mosaad *et al* (1990), Khalifa *et al* (1997), El- Siedy and Hamada (1997) , Hamada (2003) and El-Sayed and El-Shaarawy (2006).**

**Significant estimates for epistatic gene effects for one or more of the three epistasis types were exhibited in the three crosses for all studied traits, except additive x additive in the third cross for 1000- kernel weight, additive x dominance in the first and third crosses for heading date, number of spikes /plant and 1000-kernel weight, respectively, dominance x dominance in the second cross for maturity date. Generally, the absolute magnitudes of**

**TABLE 3**

**the epistatic effects were larger than the additive or dominance gene effects in most cases. Therefore, it could be concluded that epistatic effect was important as a major contributor in the performance of these cases. These results agree with the idea that the inheritance of a quantitative characters is generally more complex than single quantitative characters. Similar results were obtained by Ronga *et al* (1995), Awaad (2001), El- Morshidy *et al* (2001), Kheiralla *et al* (2001), Moustafa (2002) and Tammam (2005).**

## Heterosis :-

**Highly significant positive heterotic effects relative to better parent values were obtained for plant height in the second cross, number of kernels/ spike in the third cross, number of spikes/ plant and kernels weight in the second and the third crosses and grain yield /plant in the three crosses. Significant negative heterotic effects relative to better parent were detected for heading date in the second cross. Also, significant negative heterotic effects relative to better parent for number of kernels/ spike and kernel weight in the first and the second crosses. Earliness, if found in wheat is favorable for escaping destructive injuries caused by terminal stress conditions. Both first and second crosses, as previously mentioned, expressed negative heterosis for heading and maturity date. Hence, it could be concluded that both populations are valuable in breading for earliness. Similar results were previously reported by Abd- El-Aty (2000), El- Sayed *et al* (2000), Ashoush *et al* (2001), Awaad (2001), Hamada *et al* (2002), Hamada (2003), Hendawy (2003), Moussa (2005) , El-Sayed and El-Shaarawy (2006) and El-Shaarawy (2008).**

**Significant and positive better parent heterosis effects for grain yield / plant were detected in the three crosses, therefore, it could be concluded that the three crosses exhibited a great potential for commercial hybrid wheat production. Similar results were reported by El- Morshidy *et al* (2001), Hamada (2003), Abd- El- Majeed (2005) , El-Sayed and El-Shaarawy (2006) and Moussa A.M (2010).**

## Inbreeding depression:-

**Inbreeding depression measured the reduction in performance of the $F_2$ generation due to inbreeding. Significant positive values were obtained for inbreeding depression of kernel weight and grain yield /plant in the three crosses. Significant positive results showed for heading date in the first and second crosses, maturity date and number of spikes/ plant in the third cross. Also, significant positive values were detected for number of kernels / spike in the second and third crosses and for plant height in the second cross. On the other hand, significant negative inbreeding depression values were detected for plant height in the third cross, number of spikes / plant in the first and second crosses and for number of kernels/ spike in the first cross. Significant effects for both heterosis and inbreeding depression seems logic since the expression of heterosis in $F_1$ followed by considerable reduction in the $F_2$ performance. The contribution between sings for dominance and epistatic of most parameters may lead to the observed absence of heterosis effect El- Hosary *et al* (2000) . Also, reduction in values of non- additive genetic components is logically caused by means of inbreeding depression . These results were in agreement with those obtained by Abul- Naas *et al* (1993), Hendawy (2003), El-Sayed and El-Shaarawy (2006) and El-Shaarawy (2008).**

## Heritability estimates:-

**Heritability estimate indicated the progress from selection for plant height character is relatively easy or difficult to make in breeding program. Plant breeders, through experience, can perhaps rate a series of characters based on their response to selection. Heritability gave a numerical description of this concept. Assessment of heritability of various traits is of considerable importance in crop improvement program, for example, to predict response to selection, Nyguist (1991) and to identify optimum environments for selection, Allen *et al* (1978). Heritability has been estimated in several experimental situations in literature. Standard errors of the estimates or the confidence intervals of heritability are reported for parent-offspring data by Falconer (1982) and others. Exact confidence intervals for heritability were obtained by Knapp *et al* (1985) when the data were collected. On progeny mean basis from several environments. The standard errors and confidence interval of response to selection have given by Bridges *et al* (1991), Singh *et al* (1993) and Singh and Ceccarelli (1995). For the standard errors of the estimates heritability from the data generated in a randomized complete block design or incomplete blocks conducted in an environment ( or single trail ) and in several environments ( or multi- location trails ). Using a simulation technique, Singh *et al* (1993) found that, the distribution of heritability estimated to normal distribution in their cases.**

**Heritability estimates depending on magnitudes of its genetic variance components of additive and dominance are presented in Table (4). The highest broad sense heritability was obtained for heading and maturity date in second cross ( 96.96% and 93.71% ), respectively. Meanwhile, the lowest estimate was resultant for number of kernels/ spike, 1000- kernel weight and grain yield /plant in the first cross with value (33.76%, 37.22% and 38.36%) respectively. Heritability in narrow sense as estimated by using $F_2$ and back crosses data, were low for plant height and grain yield /plant in the first cross (15.78% and 15.22% ) respectively, and high in the second cross for heading and maturity date (71.53% and 73.38%) , respectively.**

**The results revealed also that the genetic variance was mostly attributed to the additive effects of genes for the other studied traits. This confirmed**

**TABLE 4**

**the previous results found by means of gene action estimates of additive genetic portion, which was mostly predominant. These results were in harmony with those obtained by El- Sayed *et al* (2000), El- Hosary et al (2000), Hamada *et al* (2002), Hendawy (2003) , El-Sayed and El-Shaarawy (2006) and Moussa A.M (2010).**

## Genetic advance:-

**The genetic advance as percentage of the $F_2$ mean for the studied characters are presented in Table (4). Moderate to high genetic advance (∆g%) was detected for plant height, 1000- kernel weight, number of kernels/ spike, number of spikes/ plant and grain yield/ plant for the three crosses, and low genetic advance was obtained for the other cases. In the present work, high genetic advance was found to be associated with high heritability estimates for plant height, 1000- kernel weight and grain yield/ plant in the three crosses. Therefore, selection in those particular population should be effective and satisfactory for successful breeding purposes. Also, moderate and low genetic advance was found to be associated with moderate or low heritability estimates.**

**As it is well known, expected improvement via selection is directly proportional to heritability. Also, the expected response to selection varies with the phenotypic standard deviation of population means. This figure is a measure of low total variability in these traits and therefore reflects the total response that could be realized by breading techniques. It is possible to visualize a situation where the heritability is high by little response can be expected,( El- Hosary *et al* (1997) , El-Sayed and El-Shaarawy (2006) and Moussa A.M (2010).**

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# دراسات وراثية على بعض هجن قمح الخبز

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

**الملخص العربي**

**أجريت هذه الدراسة بالمزرعة البحثية لمحطة البحوث الزراعية بالجميزة – مركز البحوث الزراعية خلال ثلاثة مواسم زراعية ٢٠٠٧/٢٠٠٨ ، ٢٠٠٨/٢٠٠٩ و ٢٠٠/٢٠١٠ بغرض دراسة كل من قوة الهجين والسلوك الوراثي ودرجة التوريث والتحسين الوراثي المتوقع بالانتخاب وذلك لسبع صفات هي عدد الأيام حتى طرد السنابل، تاريخ النضج، طول النبات، عدد السنابل في النبات، عدد حبوب السنبلة، وزن الحبوب ومحصول الحبوب للنبات وذلك في ثلاثة هجن من قمح الخبز هي الأول IRINA X P3 والثاني PBW343 xP4 والثالث P3 XP4 ويمكن تلخيص النتائج المتحصل عليها كما يلي:**

- **أوضحت النتائج المتحصل عليها من تحليل التباين وجود اختلافات معنوية بين العشائر الوراثية تحت الدراسة لجميع الصفات في جميع الهجن الثلاثة كما لوحظ وجود تباين غير أليلي لمعظم الحالات حيث كانت قيم الفعل الجيني المضيف وكذلك السيادي معنوية لمعظم القيم ماعدا بعض الحالات القليلة.**
- **كان التفاعل الجيني من نوع المضيفx المضيف معنويا لجميع القيم ماعدا صفة وزن الحبوب فى الهجين الثالث. كما لوحظ أن التفاعل الجيني من نوع المضيفx السيادي كان**

معنويا لكل الصفات المدروسة في هجن الدراسة ماعدا صفة عدد الأيام حتى طرد السنابل فى الهجين الأول وصفة عدد السنابل فى النبات فى الهجن الثلاثة وصفة وزن الحبوب فى الهجين الثالث. وأظهرت النتائج أيضا أن التفاعل الجيني التفوقى من النوع السياديx السيادي كان معنويا لجميع القيم ماعدا صفة النضج فى الهجين الثانى.

- أوضحت النتائج وجود قوة هجين معنوية منسوبة للأب الأفضل في الهجن الثلاثة لكل الصفات ماعدا صفة عدد الأيام حتى طرد السنابل فى الهجينين الأول والثالث وصفة النضج فى الهجن الثلاثة وطول النبات فى الهجينين الأول والثالث وصفة عدد السنابل فى النبات فى الهجين الأول.
- كان تأثير التربية الداخلية معنويا لمعظم الصفات تحت الدراسة.
- كانت قيم الكفاءة الوراثية بمعناها العام والدقيق عالية المعنوية لمعظم الصفات المدروسة في العشائر الثلاثة تحت الدراسة وكانت القيم العالية للتحسين الوراثي المتوقع بالانتخاب مرتبطة مع التقديرات العالية لدرجة التوريث بمعناها الدقيق وذلك في صفة طول النبات فى الهجين الثالث وصفة وزن الحبوب فى الهجينين الثاني والثالث وصفة محصول النبات فى الهجن الثلاثة.

**Table (2) :- Means ( $\bar{X}$ ) and variances ($S^2$) of $P_1$ , $P_2$ , $F_1$ , $F_2$ , $Bc_1$ and $Bc_2$ populations of the three wheat crosses for the traits studied.**

| Traits | | Cross I ($P_1$ x $P_3$) | | | | | | Cross II ($P_2$ x $P_4$) | | | | | | Cross III ($P_3$ x $P_4$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $P_1$ | $P_2$ | $F_1$ | $F_2$ | $Bc_1$ | $Bc_2$ | $P_1$ | $P_2$ | $F_1$ | $F_2$ | $Bc_1$ | $Bc_2$ | $P_1$ | $P_2$ | $F_1$ | $F_2$ | $Bc_1$ | $Bc_2$ |
| Heading date (cm) | $\bar{X}$ | 91.77 | 87.93 | 90.47 | 86.97 | 90.53 | 87.63 | 100.53 | 82.00 | 90.00 | 83.10 | 88.49 | 88.00 | 90.93 | 99.97 | 92.10 | 92.30 | 91.40 | 92.08 |
| | $S^2$ | 0.26 | 0.25 | 0.69 | 2.11 | 1.92 | 0.81 | 0.26 | 0.25 | 0.25 | 8.29 | 5.69 | 4.96 | 1.99 | 0.87 | 0.46 | 2.16 | 2.20 | 1.60 |
| Maturity date (days) | $\bar{X}$ | 149.90 | 150.00 | 149.53 | 148.25 | 150.53 | 148.47 | 151.97 | 144.53 | 149.50 | 146.71 | 146.49 | 149.51 | 150.07 | 151.40 | 151.40 | 146.60 | 149.78 | 149.33 |
| | $S^2$ | 0.25 | 0.25 | 0.60 | 2.30 | 1.23 | 2.30 | 0.25 | 025 | 0.26 | 4.02 | 2.65 | 2.44 | 1.09 | 1.14 | 1.28 | 2.05 | 1.99 | 1.60 |
| Plant height (cm) | $\bar{X}$ | 102.37 | 117.33 | 115.00 | 115.40 | 111.00 | 110.00 | 101.50 | 104.33 | 114.00 | 109.70 | 112.38 | 98.80 | 110.70 | 108.47 | 106.57 | 113.80 | 106.00 | 112.00 |
| | $S^2$ | 35.34 | 37.47 | 49.24 | 204.10 | 203.00 | 173.00 | 79.20 | 59.11 | 81.29 | 146.20 | 118.29 | 115.06 | 41.66 | 30.95 | 25.36 | 223.50 | 197.00 | 148.00 |
| No. of spikes/plant | $\bar{X}$ | 9.50 | 7.78 | 9.77 | 10.30 | 9.57 | 8.97 | 9.23 | 12.33 | 11.07 | 14.00 | 7.70 | 9.36 | 10.13 | 11.60 | 13.73 | 8.93 | 9.17 | 10.20 |
| | $S^2$ | 8.88 | 8.59 | 9.22 | 19.75 | 20.30 | 14.60 | 8.98 | 11.15 | 12.23 | 28.40 | 20.49 | 22.62 | 10.30 | 7.50 | 7.30 | 16.30 | 13.20 | 13.50 |
| No. of kernels/spike | $\bar{X}$ | 61.63 | 69.56 | 64.23 | 67.09 | 68.49 | 74.00 | 56.50 | 75.67 | 61.00 | 59.48 | 57.27 | 73.81 | 59.47 | 59.53 | 70.97 | 63.40 | 69.69 | 65.88 |
| | $S^2$ | 214.72 | 171.22 | 228.30 | 309.10 | 279.36 | 269.80 | 159.31 | 136.10 | 205.57 | 332.60 | 297.50 | 244.70 | 138.90 | 110.60 | 84.26 | 196.60 | 175.60 | 156.40 |
| 1000–kernel weight(gm) | $\bar{X}$ | 49.21 | 51.28 | 48.21 | 45.78 | 48.95 | 46.91 | 45.50 | 42.50 | 47.10 | 44.92 | 46.92 | 44.21 | 48.39 | 53.76 | 57.07 | 54.36 | 53.57 | 55.45 |
| | $S^2$ | 17.60 | 15.69 | 18.05 | 27.26 | 26.14 | 19.67 | 12.98 | 7.98 | 14.79 | 45.70 | 36.20 | 30.80 | 24.60 | 25.09 | 37.83 | 96.16 | 61.70 | 98.60 |
| Grain yield/ plant(gm) | $\bar{X}$ | 20.94 | 22.22 | 30.59 | 24.97 | 22.82 | 29.36 | 14.10 | 19.98 | 18.88 | 27.59 | 15.29 | 35.93 | 21.40 | 23.61 | 34.41 | 20.20 | 22.61 | 22.09 |
| | $S^2$ | 99.11 | 99.97 | 134.44 | 180.35 | 176.21 | 157.04 | 59.96 | 58.20 | 100.47 | 169.40 | 168.35 | 119.49 | 62.80 | 75.60 | 84.60 | 246.53 | 156.05 | 203.60 |

**Table (3) :- Scaling test and gene action parameters of the traits studied in the three wheat crosses.**

| Traits | Crosses | Scaling test | | | | *Gene action parameter | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | m | a | d | aa | ad | dd |
| Heading date | I | -1.18** | -3.14** | -12.75** | -4.22** | 86.97** | 2.90** | 9.40** | 8.43** | 0.98 | -4.11** |
| | II | -13.55** | 4.00** | -30.13** | -10.29** | 83.10** | 0.49 | 19.32** | 20.58** | -8.78** | -11.03** |
| | III | -0.23 | -7.91** | -5.90** | 1.12** | 92.30** | -0.68 | -5.59** | -2.24** | 3.84** | 10.38** |
| Maturity date | I | 1.63** | -2.59** | -5.97** | -2.50** | 148.25** | 2.06** | 4.58** | 5.00** | 2.11** | -4.03** |
| | II | -8.49** | 4.99** | -8.66** | -2.58** | 146.71** | -3.02** | 6.41** | 5.16** | -6.74** | -1.66 |
| | III | -1.91** | -4.14** | -17.87** | -5.91** | 146.60** | 0.45 | 12.94** | 11.82** | 1.12** | -5.77** |
| Plant height | I | 4.63** | -12.33** | 11.90** | 9.80** | 115.40** | 1.00* | -14.45** | -19.60** | 8.48** | 27.30** |
| | II | 9.26** | -20.73** | 4.97** | 8.22** | 109.70** | 13.58** | -5.36** | -16.44** | 15.00** | 27.91** |
| | III | -5.27** | 8.96** | 22.89** | 9.60** | 113.80** | -6.00** | -22.22** | -19.20** | -7.12** | 15.51** |
| No. of spikes/plant | I | -0.13 | 0.31 | 4.30** | 2.06** | 10.30** | 0.60 | -3.04** | -4.12** | -0.22 | 3.94** |
| | II | -4.90** | -4.68** | 12.30** | 10.94** | 14.00** | -1.66** | -21.60** | -21.88** | -0.11 | 31.64** |
| | III | -5.52** | -4.93** | -13.47** | -1.51** | 8.93** | -1.03* | 5.89** | 3.02** | -0.30 | 7.43** |
| No. of kernels/spike | I | 11.11** | 14.21** | 8.70** | -8.31** | 67.09** | -5.51** | 15.26** | 16.62** | -1.55** | -41.94** |
| | II | -2.96** | 10.95** | -16.25** | -12.12** | 59.48** | -16.54** | 19.16** | 24.24** | -6.96** | -32.23** |
| | III | 9.48** | 1.26** | -7.34** | -9.04** | 63.40** | 4.08** | 29.55** | 18.08** | 4.11** | -28.82** |
| 1000–kernel weight | I | 0.49 | -5.67** | -13.79** | -4.30** | 45.78** | 2.04** | 6.57** | 8.61** | 3.08** | -3.43** |
| | II | 1.24** | -1.18** | -2.52** | -1.29** | 44.92** | 2.71** | 5.68** | 2.58** | 1.21** | -2.65** |
| | III | 1.68** | 0.07 | 1.15** | -0.30 | 54.36** | -1.88** | 6.60** | 0.60 | 0.80 | -2.35** |
| Grain yield/ plant | I | -5.89** | 5.91** | -4.45** | -2.24** | 24.79** | -6.55** | 13.48** | 4.47** | -5.90** | -4.49** |
| | II | -2.40** | 33.00** | 38.51** | 3.96** | 27.59** | -20.64** | -6.07** | -7.90** | -17.70** | -22.70** |
| | III | -10.59** | -13.84** | -33.03** | -4.30** | 20.20** | 0.52 | 20.51** | 8.60** | 1.63** | 15.83** |

*, ** significant at 5% and 1% probability levels, respectively.

Table (4) :- Heterosis (BP), inbreeding depression , heritability ( Bs&Ns ), genetic advance upon selection and genetic advance as percentage for the traits studied in the three wheat crosses.

| Traits | Crosses | Heterosis $\overline{BP}$ % | Inbreeding depression % | Heritability % | | Δg | Δg % |
|---|---|---|---|---|---|---|---|
| | | | | Broad | Narrow | | |
| Heading date | I | -1.42 | 3.86** | 81.07 | 70.80 | 2.12 | 2.44 |
| | II | -10.47** | 7.67** | 96.96 | 71.35 | 4.24 | 5.11 |
| | III | 1.29 | -0.22 | 48.77 | 24.07 | 0.73 | 0.79 |
| Maturity date | I | -0.24 | 0.86 | 84.06 | 46.52 | 1.45 | 0.98 |
| | II | -1.62 | 1.87 | 93.71 | 73.38 | 3.03 | 2.07 |
| | III | 0.89 | 3.17** | 42.93 | 24.88 | 0.73 | 0.50 |
| Plant height | I | -1.99 | -0.35 | 80.07 | 15.78 | 4.64 | 4.02 |
| | II | 9.27** | 3.77** | 49.89 | 40.39 | 10.06 | 9.17 |
| | III | -1.75 | -6.78** | 85.39 | 45.64 | 14.05 | 12.35 |
| No. of spikes/ plant | I | 2.81 | -5.46** | 54.95 | 23.29 | 2.13 | 20.70 |
| | II | 19.86** | -26.50** | 62.02 | 48.20 | 5.29 | 37.80 |
| | III | 35.54** | 34.96** | 48.67 | 36.20 | 3.01 | 33.71 |
| No. of kernels /spike | I | -7.66** | -4.45** | 33.76 | 22.34 | 8.09 | 12.06 |
| | II | -19.38** | 2.49** | 49.79 | 36.98 | 13.89 | 23.36 |
| | III | 19.22** | 10.67** | 43.41 | 31.13 | 8.99 | 14.18 |
| 1000 – kernel weight | I | -5.99** | 5.04** | 37.22 | 31.95 | 3.44 | 7.51 |
| | II | 10.82** | 4.63** | 73.92 | 53.39 | 7.44 | 16.55 |
| | III | 6.16** | 4.75** | 69.66 | 33.30 | 6.73 | 12.37 |
| Grain yield/ plant | I | 46.21** | 18.36** | 38.36 | 15.22 | 4.21 | 16.86 |
| | II | 33.93** | 46.12** | 56.98 | 30.08 | 8.07 | 29.24 |
| | III | 60.79** | 41.30** | 69.85 | 54.12 | 17.50 | 36.65 |