Heterosis and combining ability in some wheat crosses(*Triticum aestivum, L*) under water stress condition

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ABSTRACT

The present research was carried out at the Experimental Farm of Nubaria Agricultural Research Station, North Tahrir, Egypt during the two consecutive seasons of 2009 / 2010 and 2010 / 2011. The obtained data e.g. yield and its components, agronomic traits and plant water potential were summarized as follows: 1- The six wheat parents and their fifteen crosses significantly differed in all studied characters. 2- Crosses of wheat genotypes recorded heterosis percentage as positive and negative values ranged from (-18.03to 70.93 %) for grain yield, (-24.24to 26.47%)or no. of spikes/ plant, (-32.63to 8.42 %) for no. of grains / spike, (-11.98to 32.57 %) for 100 - grain weight, (-49.50to 8.25 %) for straw yield, (-10.44 to 1.17 %) for biological yield, (-5.72to 2.42%) for harvest index,(-7.17 to 25.29 %) for grain protein content and finally (-4.85to 10.64 %) for plant water potential. 3- Most of the crosses revealed significant general combining ability (G.C.A) for all studied characters. As well as in specific combining ability (S.C.A) showed significant differences for most studied traits except biological yield. 4- G.C.A/S.C.A ratio was increased than the unit for four traits which revealed the importance of additive variance controlling these traits.

5- The parent Cham 8 (P_1) revealed negative highly significant G.C.A values for 100- grain weight, grain protein content, and plant water potential. Whereas G.C.A positive Kauz/Altar84/Aos (P_2) recorded highly significant of values for grain yield, 100 grains weight and plant water potential. Also, the parent Freetz/Tukuru (P_3) gave positive significant G.C.A values and was considered as good combiner for 100- grain weight and grain protein content.6-The parent WBLL 1*2/4/YACO/PBW65/3 (P_4) was considered as good combiner for traits where showed significant and positive G.C.A values with respect to grain yield , 100- grains weight, straw yield, biological yield and grain protein content. Whereas, the parent Bow/Gen//Dern/3/TUNU (P_5) showed a highly significant G.C.A for plant water potential7- . The parent TUMU/3/ALD/COC//URES (P_6) recorded a positive and significant values for no. of spikes/ plant, biological yield, harvest index, and plant water potential. 8-All crosses showed dominant effect for number of studied characters as the cross ($P_2 \times P_3$) for 100 – grain weight, no. of spikes/ plant, straw yield biological yield and grain protein content, the cross ($P_2 \times P_4$) for grain yield, 100- grains weight, grain protein content, plant water potential, the cross ($P_2 \times P_5$) for 100 -grains weight the cross ($P_4 \times P_5$) for grain yield, no. of spikes/ plant, biological yield, grain protein content and plant water potential.

INTRODUCTION

Wheat is one of the most important cereal crops in Egypt as in most countries of the world, wheat also is a major crop in winter crop rotation in Egypt. Wheat production in Egypt had increased from 2.08 to 7.37 million tons (1983 – 2008) by increasing wheat area from 1.83 to 2.71 million fed/year and grain yield from 1.50 to 2.71 ton/fed, in the same period. **(FAO, 2008).**

However, over population created a gap between wheat production and consumption solutions of this problem is limited either to increase unit area productivity (which is greatly achieved) or the expansion of wheat cultivated area which is limited to the valley. Therefore, wheat cultivation was extended to the newly reclaimed lands. The rapid increase in wheat production had been achieved through the use of high. Yielding cultivars developed by Wheat Research Department, Agricultural Research Center (A.R.C) Ministry of Agriculture, Egypt.

The aim of this investigation was to study the performance of six different genotypes of bread wheat *(Triticum aestivum, L)* and their possible crosses excluding reciprocals and to determine heterosis in the F1 as well as general and specific combing of ability the parents.

MATERIALS AND METHODS

The experiment of the present study was carried out at the Experimental Farm of the Agricultural Research Station of Nubaria, North Tahrir during the two growing seasons 2009 / 2010 and 2010 / 2011. The study involved six bread wheat (Triticum *aestivum,* L) genotypes as parents derived from wheat breeding program of Nubaria Research Station (Table 1). All possible crosses between them excluding reciprocal were used. At the first season, parents were planted on November 2009 water ordinary practical in the region under 6 irrigations in order to make the possible crosses for obtaining the seeds of F_1 plants. In the second season, seeds of F_1 plants were planted on 20 November 2010 under two irrigations only, the first irrigation at sowing and the second one was at 30 days after planting then the trail was under normal rainfall conditions. Plot size for parent and crosses was 10.5 m^2 where consists of 10 rows with 3.5 m length and the width was 30 cm. each of parent and cross was planted in 3 rows and the cross in 4 rows at 15 cm distance between plants within the rows. Heterosis percentage in the F1 was calculated according to the two formulas **(Mather and Jinks, 1971).**

Heterosis (H) as percent deviation from the mid parent

$$\overline{H}\ (M.P), \% = \frac{\overline{F1} - Mid\ parent}{Mid\ parent} \times 100$$

Heterosis (H) as percent deviation from the better parent

$$\overline{H}\ (B.P),\% = \frac{F1 - Better\ parent}{Better\ parent} \times 100$$

The parents were carried out to techniques prescribed by **Downey *et al.*(1980)**. Randomized complete block design was used. The data obtained were analyzed according to Griffing (1956) method- 2 and model-1 (One set of parents and F_1 off spring excluding resperocal).

The following characteristics were studied in the parents and their F1 crosses:

A- Yield and yield components:-

1- Grain yield (kg / fed)

2- No. of spikes/plant

3- No. of grains / spike

4- 100 – grain weight (g)

5- Straw yield (ton/fed)

6- Harvest index (H.I.)

7- Biological yield (ton/fed)

B- Agronomic Characters

8- Grain protein content (%)

C- Plant Water Potential:

9- Plant water potential (Bar).

It was determined using a pressure pump (soil moisture Equipment crop. Plant water status censole modal 3005, at three times during the growing season: a) at tillering stage b)at heading stage c) at anthesis stage , in the two seasons according to Fisher and Maurer(1978).

Data were statistically analyzed according to **Snedecor and Cochran (1971)**. Least significant differences (LSD) were used to test the differences between means of the studied treatments.

Table (1) Pedigree of the six wheat genotypes and origin which were grown in the two seasons of 2009/2010 and 2010/2011.

No	Pedigree	Origin
P_1	CHAM 8	CB - 9/10 # 47
P_2	Kauz/Altar84/Aos	CB – 9/10 # 52
P_3	Freetz/Tukuru	CB – 9/10 # 57
P_4	WBLL 1*2/4/YACO/PBW65/3	CB – 9/10 # 58
P_5	Bow/Gen//Dern/3/TUNU	CB – 9/10 # 68
P_6	TUMU/3/ALD/COC//URES	CB – 9/10 # 72

RESULTS AND DISCUSSION

1- Grain yield (kg/fed):-

Data in (Table2). showed that the differences among the six wheat parents for grain yield (kg/fed) where were differed significantly during 2010 / 2011 season as affected by parent genotypes indicating wide diversity between the parental genotypes for this trait of this study. The two parents Kauz/Altar84/Aos (P_2) and WBLL 1*2/4/YACO/PBW65/3 (P4) recorded the highest values for grain yield (1291.50 kg/fed) and (1268.73 kg/fed), respectively. However the parent genotype CHAM 8 (P_1) recorded the lowest value (1013.93 kg /fed) for normal irrigation. However the parent WBLL 1*2/4/YACO/PBW65/3 (P_4) recorded highest values for grain yield under water stress (1000 kg/fed),indicating this parent more drought tolerance whereas the parent Freetz/Tukuru (P_3) gave the lowest value of 890 kg/fed.

Data of (F_1) crosses between six parents of wheat genotypes are presented in (Table 3). Significant differences were found for grain yield (kg /fed) in (F_1) crosses. Where the cross (P_2 x P_6) differed significantly than the rest crosses where it recorded the highest grain yield (2176.66 kg/fed). Whereas the cross (P_3 x P_4) gave the lowest one was (941.00 kg/fed).

Regarding, heterosis percentages relative to mid-parent are presented in (Table 4). It is obvious that both crosses (P2 x P_6) and (P3 x P_4) revealed positive and negative hetaeristic effects for grain yield (kg/fed), their values were(-18.03 %) and (70.93%) respectively.

On partitioning of entries sum of squares to the components, .i.e. parents , genotypes, crosses (C) and parents versus crosses (P) vs. (C), the results showed that the variations due to them were significant for grain yield (kg /fed) except P vs. F_1as shown in (Table 5).

The analysis of variance for combining ability using Griffing (1956) method – 2, model-1 as well as G.C.A / S.C.A ratio for the studied characters are shown in (Table 6). On partitioning the entries sum of squares to both components i.e., general and specific combining abilities, it could be observed that significant variations were detected in G.C.A and S.C.A for the grain yield (kg /fed).With respect to GCA/SCA ratio, it was equal to 663.90 owing to additive effect is very important effect for grain yield (kg /fed).

The results in (Table 7) indicated that general combining ability effects GCA were positive or negative and highly significant, it could be said that the parent Kauz/Altar84/Aos (P_2) recorded positive and highly significant of G.C.A effect (158.46) there for that parent could be considered a good combiner for grain yield/fed among the six parental genotypes. Whereas the parent Bow/Gen//Dern/3/TUNU (P_5) gave significant and negative values (-123.40) decreasing grain yield value.

It is worth to state that there were some negative and significant S.C.A effects in the crosses. However, the remaining S.C.A effects did not reach the level of significance as shown in (Table 8). These results are in agreement with those stated by **Khalil *et al.* (2006), Mahrous and Abdel-Hady (2006), Menshawy *et al.* (2006), Muhammad *et al.* (2007), Badr *et al.* (2009), Johari and Maralian (2011) and Keyvan and Soheil (2011).**

2- No. of spikes/plant:

Data presented in (Table 2) showed that some parents differed significantly inthe numberof spikes/ plant during 2010 / 2011 season, where WBLL 1*2/4/YACO/PBW65/3 (P4) recorded the highest value of no. of spikes/ plant (4.00) comparing by the remain parents. However the Kauz/Altar84/Aos (P_2) was decreased in no. of spikes/ plant its value was (2.80) in the normal irrigation. However, the parent WBLL 1*2/4/YACO/PBW65/3 (P4) gave highest value of no. of spikes/ plant under water stress (3.62). Whereas the parent Kauz/Altar84/Aos (P_2) gave lowest value (2.42).On the other side, (F_1) crosses revealed significant differences for no. of spikes/ plant in (Table 3). The cross (P2 x P_4) differed significantly than the rest crosses where recorded the maximum no. of spikes/ plant (4.30), mean while the cross (P_2 x P_6) gave the lowest one (2.50).

Concerning heterosis percentage in relation to mid-parents value are presented in (Table 4). It is obvious that both the crosses (P_2 x P_4) and (P_2 x P_6) revealed positive and negative heterosis effects for no. of spikes/ plant, their values were (26.47%) and (-24.24 %). On partitioning of entries sum of squares to their components, .i.e. parents (P), crosses (C) and parents versus crosses (P) vs. (C), the results showed that the variations due to parents, crosses and parent's vs. crosses were highly significant for this trait as shown in (Table 5).

The analysis of variance for combining ability using Griffing (1956) method – 2, Model –1 as well as GCA / SCA ratio for the studied characters are shown in (Table 6). It could be observed that significant variations were detected in G.C.A and S.C.A for no. of spikes/ plant. Concerning GCA/SCA ratio, it was equal to (0.14) due to dominance effect in very important effect for this trait.

The results in (Table 7) indicated that general combining ability effects were positive or negative significant except for the parent (P_5) only, it could be said that the parent Cham 8 (P_1) recorded highest significant and positive of G.C.A (0.42) whereas the parent Freetz/Tukuru (P_3) gave significant and negative value (-0.20) for no. of spikes/ plant. It is worth to state that there were negative and significant S.C.A effects for 15 crosses. However, there were three of S.C.A effects did not reach the level of significance, as shown in (Table 8). In this connection, similar results were recorded by

Mohamed *et al.* (2005), Abdel-Nour and Nadya (2006) and Abdel-Rahman and Magda (2007).

3- Number of grains / spike:

Concerning (Table2) showed that parent genotypes differed significantly in no. of grains / spike, where both parents CHAM 8 (P_1) and WBLL 1*2/4/YACO/PBW65/3 (P_4) recorded the highest values of no. of grains / spike 52.59 and 52.40, respectively, comparing by the remain parents. However, the parent Freetz/Tukuru (P_3) decreased in no. of grains / spike, its value was (44.45). Under normal irrigation. However, the parent CHAM 8 (P1) gave the highest value for no. of grains / spike under water stress was (39). Mean while, both parents WBLL 1*2/4/YACO/PBW65/3 (P4) and TUMU/3/ALD/COC//URES (P_6) recorded the same lowest value (34). On the other side, most crosses revealed significant differences for no. of grains / spike in (Table 3), where the crosses (P5 x P_6) differed significantly than the rest crosses and recorded the maximum no. of grains / spike (51.46). Whereas the (P3 x P_6) gave the lowest one (32.33). Presented data of heterosis percentages relative to mid-parents are presented in (Table 4). It is obvious that both crosses (P_5 x P_6) and (P_4 x P_6)revealed negative heterotic effects for no. of grains / spike, their values were (8.42) and (-32.63) respectively. On partitioning of entries sum of squares to their components, .i.e. parents (P), crosses (C) and parents versus crosses (P) vs. (C), the results showed that the variations due to parents, crosses and (P) vs. (C) were highly significant for this trait. as showed in (Table 5).

The analysis of variance for G.C.A and S.C.A combining abilities as well as GCA / SCA ratio for the studied characters are shown in (Table 6).

It could be observed that significant variations were detected in G.C.A and S.C.A for the no. of grains / spike. Concerning, GCA/SCA ratio it was equal to (0.17) due to the importance of dominant effect for no. of grains / spike.

The results in (Table 7) indicated that general combining ability effects were positive or negative and significant, it could be said that the parent Cham 8 (P_1) recorded the highest significant and positive of G.C.A (1.69). Hence, this parent could be considered a good combiner for number of grains/ spike among the six parental genotypes, mean while, the parent Freetz/Tukuru (P_3) gave significant and negative value (-1.35) of no. of grains / spike values.. It is worth to mention that there were negative and significant S.C.A effects for six crosses. However, the remaining S.C.A effects did not reach the level of significance as shown in (Table 8). The results are in agreement with those recorded by **Mohamed *et al.* (2005), Abdel-Nour and Nadya (2006) and Abdel-Rahman and Magda (2007).**

4- 100- Grain weight:-

Analysis of variance data in (Table 2) showed that parents genotypes were differed significantly for 100 – grains weight (g) during 2010 / 2011 season. It could be noticed that the parent Freetz/Tukuru (P_3) gave the highest value (5.50 g) of 100- grains weight with comparing the remain parents. However, the parent CHAM 8 (P1) decreased in 100- Grain weight (4.23 g) under normal irrigation. Mean while, the parent Kauz/Altar84/Aos (P_2) gave the highest value of 100- Grain weight under water stress (3.75g) comparing with the other parents. Whereas the parents CHAM 8 ($P1_)$ recorded the lowest are (3.00g). Mean performance of 15 (F_1) crosses among six parents of wheat are presented in (Table3). On the other side, (F_1) crosses revealed significant differences for 100- Grain weight (g), where the cross (P2x P_5) differed significantly than the other crosses it recorded the maximum value of 100-Grain weight (5.93 g), whereas the cross (P_2 x P_6) gave the lowest one (4.21 g).

Its obvious that heterosis percentages relative to mid-parents were shown in (Table 4). It could be noticed that both crosses (P_1 x P_6) and (P_3 x P_6) revealed positive and negative heterotic effects for 100 – grains weight (g), their values were (32.57 % and -11.98 %), respectively.

On partitioning of entries sum of squares to their components, .i.e. parents (P), crosses (C) and parents versus crosses (P) vs. (C), the results showed that the variations for all entries were highly significant for 100- Grain weight (g), as shown in (Table 5).

The analysis of variance for combining abilities GCA/SCA ratio for the studied characters is shown in (Table 6).

It could be observed that highly significant variations were detected in G.C.A and S.C.A for 100- Grain weight (g). With respect to GCA ,SCA and GCA /SCA ratio, it was equal to (0.44) it is worth to mention that dominant effect is very important heritance of 100- Grain weight (g).

The results in (Table 7) indicated that general combining ability (GCA) effects were positive or negative and significant except the parent (P_5) it could be noticed that the parent Kauz/Altar84/Aos (P_2) recorded highly significant and positive of G.C.A effect (0.16) indicating that it was the best combiner for that trait, whereas the parent CHAM 8 (P_1) gave highly significant and negative value (-0.21) decreasing in 100- Grains weight value. From (Table 8) it could be to noiced that there were positive and significant S.C.A effects in the crossesof (P_1 x P_6), (P_2 x P_3), (P_2 x P_4), (P_2 x P_5) and (P_4 x P_6). However, the six crosses for S.C.A effects did not reach the level of significance. These results confirmed by those reported by **Mohamed *et al.* (2005), Abdel-Rahman and Magda (2007), Muhammad *et al.* (2007)as well as Johari and Maralian (2011).**

5- Straw yield (ton/fed):-

As presented in (Table 2) highly significant differences were detected in straw yield (ton/fed) during growing season. The parent genotype WBLL 1*2/4/YACO/PBW65/3 (P_4) recorded the highest value of straw yield (2.53 ton/fed) under normal irrigation, comparing with the other parents. Mean while, the parent Freetz/Tukuru (P_3) recorded the highest value of straw yield(1.78 ton/fed) under water stress. Whereas the parent Kauz/Altar84/Aos (P_2) gave the lowest value (0.63 ton/fed) under water stress. On the other side, significant differences among (F_1) crosses were obtained for straw yield (ton/fed) (Table 3), where the cross (P_5 x P_6) differed significantly than the other crosses, where it the maximum straw yield (2.36 ton/fed), whereas the (P_1 x P_3) gave the lowest one (1.12 ton/fed). Regarding heterosis percentages relative to mid-parent values are presented in (Table 4). It is obvious that both crosses (P_5 x P_6) and (

$P_1 \times P_3$) revealed positive and negative heterosis effects for straw yield, their values were (8.25 and – 49.50), respectively.

On partitioning of entries sum of squares to their components, .i.e. parents (P). crosses (C) and parents versus crosses (P) vs. (C), the data showed that the variations due to parents, crosses and parents vs. crosses were highly significant for straw yield (ton/fed) as shown in (Table 5).

The analysis of variance for combining ability using Griffing method – 2, model- 1 (1956) as well as G.C.A / S.C.A ratio for the studied characters is shown in (Table 6). It could be observed that highly significant variations were detected in G.C.A and S.C.A for the straw yield (ton/fed). With respect to GCA/SCA ratio, it was equal to (0.66), it mean that dominant type of gene action was important role in the inheritance of that trait. The results in (Table 7) indicated that general combining ability G.C.A effects were positive or negative and insignificant for P_1, P_3 and P_6.

The parent gene type (P_4) was the best combiner for straw yield /fed. Whereas the parent (P_2) gave highly significant but negative value (-0.28) decreasing straw yield value. It is worth to state that there were negative and significant S.C.A affects in most the crosses. However, four crosses did not reach the level of significance as shown in (Table 8). These results are in agreement with those reported by **Hefnawy and Wahba (2003), Ali *et al.*(2004), Mekail *et al.* (2005) Menshawy *et al.* (2006), Menshawy (2007).**

6- Biological yield (ton/fed) :

Table (2) revealed highly significant differences were detected among four parent genotypes in biological yield (ton/fed). Mean while, the parent (P_4) recorded the best value of biological yield (3.80 ton/fed) under normal irrigation comparing with the other parents. In the contrary the parent (P_2) was the lowest one in biological yield and gave (3.06 ton/fed) . The parent (P_4) recorded the best value of biological yield (ton/fed)under water stress was (2.92 ton/fed) comparing with the remain parents. Whereas the parent (P_2) recorded the lowest one (2.58 ton/fed). From (Table 3) it could noticed that the cross (P_4 x P_5) differed significantly than the rest crosses where recorded the best biological yield (3.53 ton/fed), whereas the cross (P_2 x P_5) gave the lowest one (2.83 ton/fed). Regarding, heterosis percentage relative to mid-parent values are presented in (Table 4). It is obvious that both crosses (P_5 x P_6) and (P_2 x P_5) revealed positive or negative heterosic effects for biological yield, their values were (1.17and–10.44%),respectively. As shown in (Table 5), the variations due to parents, crosses and parents vs crosses were highly significant for biological yield. The G.C.A , S.C.A and G.C.A / S.C.A ratio for the studied characters are shown in (Table 6). it could be observed that highly significant variations were detected in these entries for biological yield. Regarding GCA/SCA ratio it exceeded the unity (6.52) for biological yield, such result indicated that additive and additive by additive type of gene action were important role in inheritance of this trait..

The results in (Table 7) indicated that general combining ability (GCA) effects were positive or negative and highly significant for four parents. It could be observed that the parent (P_4) recorded the best combiner for biological yield (0.19), whereas the parent (P_3) gave highly significant and negative value (-0.14) decreasing biological yield value. It is worth to mention that all crosses were positive or negative and significant S.C.A effects, as shown in (Table 8). Such results are generally in agreement with

Those stated by.**Ali *et al.* (2004) and Badr *et al.* (2009).7- Harvest index (%):**

In the concern (Table 2) showed that four parent genotypes differed significantly in harvest index during growing season. The parent genotype (P_2) recorded the maximum harvest index (35.93) comparing with the other genotypes. However the minimum harvest index (32.00) was obtained from the parent (P_4) under normal irrigation. However, the parent (P_2) gave the highest one for harvest indexunder water stress (36.00 %) comparing by the remain parents. Whereas the parent (P_3) recorded the lowest value (32.00 %). Analysis of variance of 15 (F_1) crosses showed that crosses significant differed in harvest index, where the cross (P5x p_6) recorded highest value (34.80 %). However, the cross (P1 x P_2) recorded the lowest one (32.80 %). Heterosis percentages relative to mid-parents are tabulated in (Table 4). It is obvious that the cross (P3 x P_4) gave the highest heterotic effect (2.42 %) followed by the cross (P5x P_6) (2.23 %).

Components of entries were partitioned .i.e. parents (P). Crosses (C) and parents versus crosses (P) vs (C), the results showed that the variations due to them were highly significant for harvest index, as shown in (Table 5).

The analysis of variance for combining abilities of G.C.A, S.C.A and G.C.A / S.C.A ratio for the studied characters is shown in (Table 6). It could be observed that highly significant variations were detected in G.C.A and S.C.A for the harvest index. Concerning, GCA/SCA ratio it was equal to (3.73) due to additive effect so it is very important for controlling the inheritance of harvest index.

The results in (Table 7) indicated that general combining ability effects were positive or negative and significant, it could be said that the parent (P_6) recorded significant and positive of G.C.A effect (0.56) it means that this parent could be considered a good combiner for this trait. Mean while (P_4) gave highly significant and negative value (-0.69) decreasing harvest index value. Regarding S.C.A effects. That there were positive and significant S.C.A effects .The crosses of (P_1 x P_5), (P1 x P_6), (P_3 x P_4), (P_3 x P_5) and (P_5 x P_6) recorded significant and positive G.C.A effects for that trait. However the seven crosses did not reach the level of significance for S.C.A effects, as shown in (Table 8). In this connection, similar results were recorded by **Mekail *et al.* (2005), Abdel-Nour and Nadya (2006), Boulos (2006) and Badr *et al.* (2009).**

8 -Grain protein content (%)

Means of six wheat parents for grain protein contents are presented in (Table 2). Data revealed that six genotypes significantly differed in grain protein content (%) during growing season. The parent Freetz/Tukuru (P_3) had the highest grain protein content (13.31 and 10.32 %) comparing by the remain parents under both normal irrigation and water stress, respectively. Mean while, both parents (P_4) and (P_6) passed the lowest one

(11.66 and 6.88 %)under both normal irrigation and water stress, respectively. On the other side, nine (F_1) crosses revealed significant differences in grain protein content (%) where the cross (P_2 x P_3) recorded the maximum grain protein content value (14.83 %). On contrary, the cross (P_1 x P_2) gave the lowest one (11.79) in (Table 3).

Concerning heterosis percentages relative to mid-parents values are presented in (Table 4). It is obvious that both crosses (P_2 x P_4) and (P_5 x P_6) revealed positive and negative heterosic effects for grain protein content, their values were (25.29%) and (- 7.17 %), respectively.

On partitioning sum squares of entries to their components. The results showed that the variations due to parents, crosses, and parent's vs crosses were significant or highly significant for protein content. As shown in (Table 5). The analysis of variance for combining abilities of G.C.A, S.C.A and G.C.A / S.C.A ratio for the grain protein content is shown in (Table 6). It could be observed that highly significant variations were detected in G.C.A and S.C.A for the grain protein content. with respect to, GCA/SCA ratio, it was equal to (0.76) due to both additive and dominant effects is very important effect for the inheritance of grain protein content. The results in (Table 7) indicated that general combining ability effects were positive or negative and highly significant it could be said that the parent (P_3) recorded highly significant and positive of G.C.A effect (0.33). Whereas the parent (P_1) gave highly significant and negative values (-0.63) decreasing grain protein content values. It is worth to state that there were positive and significant S.C.A effects in the crosses of (P_1 x P_6), (P_2 x P_3), (P_2 x P_4) and (P_4 x P_5).

However the remaining S.C.A effects did not reach the level of significance as shown in (Table 8). These results are generally in agreement with those reported by **Sabry *et al.* (1999), El- Sayed (2004), Mahrous and Abdel-Hady (2006)and Menshawy *et al.* (2006).**

9 - Plant water potential (bar) :-

Data in (Table 2) indicated that six parent genotypes were significantly differed in plant water potential. The parent (P_2) had the highest value of plant water potential (20 bar) comparing with the other parents. On contrary, the parent (P_4) had the lowest one for plant water potential its value (15.86 bar) So the parent (P_2) was the best genotype for tolerance the drought conditions under normal irrigation.Also, the parent (P_2) recorded the highest value of plant water potential under water stress (14.77 bar). On contrary, the parent (P_4) had the one lowest value (10.67 bar) under water stress. Analysis of variance of 15 (F_1) crosses showed significant difference in most crosses, as presented in (Table 3). It is interesting to mention that the cross passed the (P_2 x P_5) the maximum plant water potential (20.17 bar), whereas the cross (P_1 x P_4) gave the lowest one (15.92 bar). Regarding, heterosis percentages relative to mid-parent values are shown in (Table 4). It is obvious that both crosses (P_4 x P_5) and (P_1 x P_5) revealed positive heterotic effects (10.64 and 10.34 bar)for plant water potential. On the other hand, the cross (P2 x P_6) had negative and significant heterotic effect (- 4.85 bar).

On partitioning sum squares of entries sum squares to their components, .i.e. parents (P). Crosses (C) and parents versus crosses (P) vs (C), the results showed that the variations were highly significant for plant water potential. As shown in (Table 5). The analysis of variance for combining abilities G.C.A ,S.C.A and G.C.A / S.C.A ratio for the studied characters is shown in (Table 6). Highly significant variations were detected in G.C.A and S.C.A for the plant water potential, Regarding, GCA/SCA ratio; it was equal to (10.91) indicating that to additive type of gene action was important role in inheritance this trait. The results in (Table 7) indicated that general combining ability effects were positive or negative and significant. It could be noticed that the parent (P_2) and (P_5) recorded highly significant and positive of G.C.A effect (0.83) indicating that both these parents are considered good combiners for this trait. Mean while the parent (P_3) gave significant and negative values (-1.13) decreasing plant water potential value. It is worth to record that there were positive and significant S.C.A effects in the crosses of ($P_1 \times P_5$), (P1 $\times$ P_6), ($P_2 \times P_4$), ($P_3 \times P_5$), ($P_4 \times P_5$) and ($P_4 \times P_6$). However, the other S.C.A effects did not reach the level of significance, as shown in (Table 8). In this connection, these results are in agreement with those reported by **Mishra *et al.* (1998), Bayoumi (1999), Spiertz *et al.* (2006) and Alireza *et al.* (2011).**

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Table (2) Mean performance of six wheat parents for the studied characters

Characters / Entries	Grain yield (kg/fed)		No. of spikes/plant		No .of grains/Spike		100-Grain weight (g)	
	Normal irrigation	Under water stress	Normal Irrigation	Under water stress	Normal Irrigation	Under water stress	Normal irrigation	Under water stress
P1	1013.93b	910bc	3.40ab	2.86b	52.59a	39a	4.23 c	3.00 c
P2	1291.50a	930b	2.80b	2.42c	44.55 b	38a	4.95b	3.75a
P3	1029.00b	890c	3.40ab	2.70b	44.45b	37a	5.50a	3.11 bc
P4	1268.73a	1000a	4.00a	3.62a	52.40a	34 b	4.89b	3.10 bc
P5	1137.50ab	920bc	3.90a	2.82b	45.36 b	37a	4.81b	3.17 bc
P6	1255.45a	900b	3.80ab	2.82b	49.52a	34c	4.59bc	3.35b
LSD 0.05	171.56	33.8	0.62	0.29	3.69	1.8	0.39	0.33
LSD 0.01	238.10	48.4	0.86	0.51	5.13	2.4	0.55	0.70

P_1= CHAM 8 , P_2 = Kauz/Altar84/Aos , P_3 = Freetz/Tukuru , P_4 = WBLL 1*2/4/YACO/PBW65/3,
P_5 = Bow/Gen//Dern/3/TUNU , P_6 = TUMU/3/ALD/COC//URES

Means with the same letters within each column are not significant differences at 0.05 level of probability

Table (2) Cont. Mean performance of six wheat parents for the studied characters

Characters	Straw yield (ton/fed)		Biological yield (ton/fed)		Harvest index (%)		Grain protein content (%)		Plant water potential (bar)	
Entries	Normal irrigation	Under water stress	Normal irrigation	Under water stress	Normal irrigation	Under water stress	Normal irrigation	Under water stress	Normal irrigation	Under water stress
P1	2.35ab	1.23b	3.36bc	2.70b	33.66b	33bc	11.73b	8.43a	16.66b	10.68c
P2	1.77c	0.63c	3.06c	2.58c	35.93a	36a	11.82b	9.25a	20.00a	14.77a
P3	2.10b	1.78a	3.13bc	2.72b	32.83c	32c	13.31a	10.32a	15.93b	11.23c
P4	2.53a	1.34b	3.80a	2.92a	32.00c	34b	11.66b	7.65b	15.86b	10.67c
P5	2.12b	1.24b	3.26bc	2.73b	33.63b	33bc	13.10a	8.26bc	18.53a	12.43b
P6	2.24b	1.46ab	3.53ab	2.67bc	34.46ab	33bc	12.54ab	6.88c	19.53a	14.65ab
LSD 0.05	0.26	0.37	0.34	0.12	1.56	1.54	1.36	2.01	1.69	2.46
LSD 0.01	0.37	0.62	0.47	0.30	2.17	2.93	1.91	3.2	2.35	3.60

P_1= CHAM 8, P2 = Kauz/Altar84/Aos , P3 = Freetz/Tukuru , P_4 = WBLL 1*2/4/YACO/PBW65/3 ,

P_5 = Bow/Gen//Dern/3/TUNU , P_6 = TUMU/3/ALD/COC//URES.

Means with the same letters within each column are not significant differences at 0.05 level of probability.

Table (3) Mean performance of 15 wheat crosses for the studied characters.

Characters / Crosses	Grain yield (kg/fed)	No .of spikes/ plant	No .of grains/ spike	100-Grain weight (g)	Straw yield (ton/fed)	Biological yield (ton/fed)	Harvest index (%)	Grain protein content (%)	Plant water potential (bar)
$P_{1}x\ P_{2}$	1781.00*	3.40**	40.76**	4.47	1.41*	3.20*	32.80	11.79	18.58**
$P_{1}x\ P_{3}$	1370.33	2.90	41.66**	4.64	1.12	3.10	33.50*	11.86	16.60
$P_{1}x\ P_{4}$	1389.33	3.60**	38.23**	4.98**	1.91**	3.30**	33.16	12.56	15.92
$P_{1}x\ P_{5}$	1571.00	3.20*	43.06**	4.68*	1.69**	3.26**	33.86**	12.42	19.41**
$P_{1}x\ P_{6}$	944.66	2.80	36.33	5.86**	2.22**	3.16	34.53**	14.05**	19.49**
$P_{2}x\ P_{3}$	1280.66	2.60	41.63**	5.71**	1.58**	3.03	33.90**	14.83**	17.17**
$P_{2}x\ P_{4}$	1827.66**	4.30**	38.33**	5.90**	1.43*	3.26**	33.30	14.71**	19.32**
$P_{2}x\ P_{5}$	1056.66	4.10**	37.66*	5.93**	1.77**	2.83	33.00	13.96**	20.17**
$P_{2}x\ P_{6}$	2176.66**	2.50	40.36**	4.21	1.15	3.30**	34.10**	12.03	18.80**
$P_{3}x\ P_{4}$	941.00	3.60**	41.26**	4.73*	2.22**	3.16	33.23	14.40**	16.02
$P_{3}x\ P_{5}$	1070.66	3.50**	35.00	4.79*	1.86**	2.93	33.76**	12.80*	18.50**
$P_{3}x\ P_{6}$	1147.66	4.00**	32.33	4.44	1.91**	3.06	34.30**	13.40**	18.13**
$P_{4}x\ P_{5}$	1413.66	4.00**	33.66	4.71*	2.11**	3.53**	32.90	14.76**	19.02**
$P_{4}x\ P_{6}$	1683.00*	4.00**	34.33	5.42**	1.78**	3.46**	33.60*	14.06**	18.58**
$P_{5}x\ P_{6}$	1063.66	3.40**	51.46**	4.94**	2.36**	3.43**	34.80**	11.99	19.87**
LSD 0.05	630.74	0.64	4.28	0.47	0.24	0.24	0.66	0.93	1.01
LSD 0.01	843.06	0.87	5.72	0.63	0.35	0.33	0.88	1.24	1.35

*,** Significant differences at 0.05 and 0.01 level of probability

Table (4) Heterosis percentage of 15 crosses between six wheat genotypes according to mid parent values

Characters / Crosses	Grain yield (kg/fed)	No .of spikes/ plant	No .of grains/spike	100-grain weight (g)	Straw yield (ton/fed)	Biological yield (ton/fed)	Harvest index (%)	Grain protein content (%)	Plant water potential (bar)
$P_{1}x P_{2}$	**0 54.6	9.67	-16.00*	-2.61	-31.50**	-0.31	- 5.72**	0.12	1.36
$P_{1}x P_{3}$	34.14**	- 14.70*	-14.13*	-4.52	-49.50**	- 4.46	0.76	-5.27	1.87
$P_{1}x P_{4}$	21.78*	- 2.70	-27.16**	9.21	-21.70*	- 7.82	1.00	7.39	-2.09
$P_{1}x P_{5}$	46.13**	-12.32*	-12.10*	3.53	-24.20*	-1.51	0.65	0.04	10.34**
$P_{1}x P_{6}$	-16.75	- 22.22**	-28.83**	32.57**	-3.05	- 8.13	1.37	15.78*	7.73
$P_{2}x P_{3}$	10.37	- 16.12*	-6.44	9.38	-18.10	- 2.10	- 0.46	18.02*	-4.42
$P_{2}x P_{4}$	42.79**	26.47**	-20.92*	19.91*	-33.40	- 4.95	- 1.95	25.29**	7.75*
$P_{2}x P_{5}$	-13.01	22.38	-16.25*	21.51*	-8.76	- 10.44*	- 5.11*	12.03	4.72
$P_{2}x P_{6}$	70.93**	- 24.24	14.18*	11.71*	-42.50**	0.30	- 3.09*	-1.23	-4.85*
$P_{3}x P_{4}$	-18.03*	- 2.70	-14.78*	-8.86	-3.89	- 8.67	2.42*	15.33*	0.78
$P_{3}x P_{5}$	-1.15	- 4.10	-22.08*	-6.99	-11.84	- 8.13	1.41	-3.06	7.38*
$P_{3}x P_{6}$	0.48	11.11*	-31.18**	-11.98**	-11.98	-810	1.96	3.71	2.21
$P_{4}x P_{5}$	17.50*	1.26	-31.16**	-2.88	-9.05	- 0.28	0.27	19.22*	10.64**
$P_{4}x P_{6}$	33.41**	2.56	-32.63**	14.00*	-25.21*	- 5.46	1.11	16.19*	5.03*
$P_{5}x P_{6}$	-11.12	-11.68*	8.42	4.88	8.25	1.17	2.23*	-7.17	4.41
LSD 0.05	7.57	6.37	4.91	0.59	0.85	0.31	0.83	1.17	1.28

*,** : Significant differences at 0.05 and 0.01 level of probability.

Table (5) Analysis of variance for all studied characters of parents (P), crosses (C), and (P. VS. C).

Characters / S.O.V	d.f	Grain yield (kg/fed)	No .of spikes/ plant	No .of grains/ spike	100-grain weight (g)	Straw yield (ton/fed)	Biological yield (ton/fed)	Harvest index (%)	Grain protein content (%)	Plant water potential (bar)
Replications	2	13609.1	23.62	46.75	0.11	13.60	0.0030	0.58	0.19	0.10
Genotypes	21-1=20	382630.6**	94.73**	111.51**	0.86**	382.48**	0.15**	2.15**	3.74**	6.61**
Parents	6-1=5	46206.7**	19.41**	44.46**	0.52**	4.38**	0.22**	5.52**	1.58*	10.12**
Crosses	14	3484484**	1237.20**	2346.51**	38.77**	3469.05**	15.4373**	1691.02**	268.3**	509.3**
P vs F_1	1	-0.000004n.s	- 10527. 1**	-30843.2**	528.23**	-214.22**	-214.22**	-23658.9**	-3689.5**	-7048**
Error	40	202042.1	6.14	11.24	0.12	201.99	0.04	0.50	0.65	0.85
Total	62	—	—	—	—	—	—	—	—	—

N. S : Not significant .

*,** : Significant differences at 0.05 and 0.01 level of probability.

Table (6) General and specific combining abilities analysis for the studied characters using Griffings method 2, model 1.

Characters / S.O.V	d. f	Grain yield (kg/fed)	No .of spikes/ plant	No .of grains/ spike	100-grain weight (g)	Straw yield (ton/fed)	Harvest index (%)	Biological yield (ton/fed)	Grain protein content (%)	Plant water potential (bar)
Genotypes	20	382630.60**	94.37**	111.51**	0.86**	382.48**	2.15**	0.15**	3.74**	6.61**
G. C.A	5	92898.21**	4.03**	8.06**	0.14**	92.76**	1.59**	0.13**	1.01**	6.91**
S. C. A	15	139092.00**	28.64**	46.87**	0.33**	139.07**	0.42**	0.02 n.s	1.32**	0.63**
Error[a]	40	67347.38	1.53	3.74	0.04	67.33	0.16	0.01	0.21	0.28
GCA / SCA	–	663.90	0.14	0.17	0.44	0.66	3.73	6.52	0.76	10.91

N .S : Not significant .

E[a] = Error variance

*,** : Significant differences at 0.05 and 0.01 level of probability.

Table (7) General combining ability of six wheat parents for studied characters

Characters / Parent	Grain yield (kg/fed)	No .of spikes/ plant	No .of grains/ spike	100-grain weight (g)	Straw yield (ton/fed)	Biological yield (ton/fed)	Harvest index (%)	Grain protein content (%)	Plant water potential (bar)
P1	30.78**	0.42**	1.69*	0.21**-	-0.02	0.03	-0.07	-0.63**	-0.50**
P2	158.46**	-0.18**	0.47-	0.16**	-0.28**	-0.12**	0.40*	-0.036**	0.83**
P3	-121.19**	-0.20**	-1.35*	0.06*	-0.02	-0.14**	-0.17	0.33**	-1.13**
P4	44.27**	-0.11*	-0.12	0.08*	0.15**	0.19**	-0.69**	0.31**	-0.84**
P5	-123.40**	-0.06	-0.01	-0.01	0.09*	-0.02	-0.02	0.107*	0.83**
P6	11.07	0.13**	-0.01	-0.09**	0.08	0.09**	0.56*	-0.08*	0.82**
S.E gi	83.75	0.11	0.62	0.06	0.04	0.04	0.13	0.15	0.17
C.D 0.05	-11.54	0.09	-0.97	-0.04	0.09	0.02	0.29	-0.07	0.15
C.D 0.01	-23.09	0.12	-1.94	-0.09	0.11	0.05	0.58	-0.15	0.31

*,** : Significant differences at 0.05 and 0.01 level of probability

Table (8) Specific combining ability of six wheat parents for studied characters

Characters Crosses	Grain yield (kg/fed)	No .of spikes/ plant	No .of grains/ Spike	100-grainweight (g)	Straw yield (ton/fed)	Biological yield (ton/fed)	Harvest index (%)	Grain protein content (%)	Plant water potential (bar)
$P_1 \times P_2$	243.47	0.23	-2.12	-0.45	-0.17**	0.07**	-1.21**	-0.57	0.05
$P_1 \times P_3$	712.47**	-1.12**	-0.33	-0.17	-0.71**	-0.05**	0.06	-0.86	0.04
$P_1 \times P_4$	-34.00	0.72**	-5.00*	0.13	-0.11*	-0.15**	0.25	-0.15	-0.92*
$P_1 \times P_5$	315.34**	0.41*	-0.28	-0.01	-0.27**	0.04**	'0.27	-0.08	0.88*
$P_1 \times P_6$	-445.47**	-0.34	-7.30**	1.19**	0.26**	-0.17**	0.36*	1.73*	0.98*
$P_2 \times P_3$	-104.87**	0.83**	1.79	0.50*	0.15**	0.05**	-0.01	1.49*	-0.72*
$P_2 \times P_4$	276.64**	-1.67**	-2.73	0.67*	-0.33**	-0.05**	-0.08	1.39*	1.13*
$P_2 \times P_5$	-326.66**	-1.02**	-3.51	0.80*	-0.05	-0.26**	-1.06**	0.85	0.31
$P_2 \times P_6$	658.84**	0.19	-1.10	-0.82*	-0.58**	0.07**	-0.54*	-0.89	-1.05*
$P_3 \times P_4$	-330.35**	-0.77**	1.08	-0.39*	0.19**	-0.13**	0.42*	0.71	-0.19
$P_3 \times P_5$	-33.00	0.51*	-5.29*	-0.22	-0.10	-0.14**	0.28*	-0.67	0.60*
$P_3 \times P_6$	-90.48	1.09**	-8.25**	-0.50*	-0.03	-0.12**	0.23	0.11	0.25
$P_4 \times P_5$	144.52**	0.83**	-7.86**	-0.33**	-0.03	0.11**	-0.06	1.29*	0.83*
$P_4 \times P_6$	279.36**	0.91**	-7.48**	0.45*	-0.35*	-0.07**	0.05	0.78	0.41*
$P_5 \times P_6$	-172.28**	0.75**	9.53	0.08	0.28**	0.11**	0.57*	-1.07	0.018
S.E g i	230.03	0.32	1.71	0.18	0.10	0.11	0.36	0.41	0.47
C.D 0.05	71.74	0.41	4.31	0.29	0.07	0.01	0.25	1.10	0.35
C.D 0.01	18.69	0.63	7.25	1.16	0.11	0.02	1.03	4.43	1.40

*,** : Significant differences at 0.05 and 0.01 level of probability

الملخص العربي

قوة الهجين والمقدرة علي التآلف في بعض هجن القمح تحت ظروف الاجهاد المائي

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اجري هذا البحث في المزرعة البحثية لمحطة بحوث النوبارية شمال التحرير ك 46.5 طريق مصر إسكندرية الصحراوي خلال موسمي النمو 2009 / 2010 ، 2010 / 2011 . بهدف دراسة 6 تراكيب وراثية للقمح (*Triticum aestivum. L*) والهجن الممكنة بينها .ولقد زرعت الإباء الستة في الموسم 2010/2009 تحت نظام الري العادي (6 ريات) وأجريت بينها كل التهجينات المتبادلة الممكنة بدون أجراء التهجينات العكسية لإنتاج بذور الجيل الأول (F_1) لعدد 15 هجين .

وفى موسم 2011/2010 زرعت تلك الإباء الستة والهجن الناتجة عنها 15 هجين تحت نظام (ريتين فقط) الأولي عند الزراعة والثانية بعد 30 يوم من الزراعة وتترك النباتات للجفاف أو سقوط الأمطار بالمنطقة وكان التصميم المستخدم هو القطاعات العشوائية الكاملة بعدد 3 مكررات وتمت الزراعة في 17 ، 20 نوفمبر خلال موسمي النمو بالترتيب. وقد تم تحليل النباتات المتحصل عليها وفقا Griffing (1956) Method- 2, Model -1 ويمكن تلخيص أهم النتائج للمحصول ومكوناته والصفات المحصولية في الأتي :-

1- أظهرت التراكيب الوراثية للإباء الستة وال 15 هجينا اختلافا معنويا في كل الصفات تحت الدراسة.
2- أظهرت قوة الهجين قيما معنوية موجبة وسالبة للصفات المدروسة كما يلي :-

(- 18.03 : 70.93 %) لمحصول الحبوب/ فدان ، (- 24.24 : 26.47) عدد السنابل / النبات (- 32.63 : 8.42 %) عدد الحبوب / السنبلة ، (- 11.98: 32.57 %) لوزن 100 حبة، (- 49.50: 8.25 %) لمحصول القش (طن / فدان) ،(- 10.44 : 1.17) للمحصول البيولوجي ،(- 5.72 : 2.42 %) لمعامل الحصاد (- 7.17 : 25.29 %) محتوي البروتين / الحبوب ،(- 4.85 : 10.64 %) معامل الاجهاد المائي.

3- ظهرت اختلافات معنوية بالنسبة لقدرة الائتلاف العامة (GCA) في التراكيب الوراثية للآباء في كل الصفات المدروسة و في قدرة الائتلاف الخاصة (S.C.A) عدا المحصول البيولوجي.

4- زادت قيم نسبة (GCA/SCA) عن الوحدة لمعظم الصفات مما يوضح أهمية التأثير الجيني المضيف لهذه الصفات عدا عدد السنابل / النبات، عدد الحبوب / السنبلة ، وزن 100 حبة ، محصول القش (طن للفدان) ومحتوي البروتين بالحبوب .

5- سجل الأب (P_1) Cham 8 قيما G.C.A عالية المعنوية سالبة لوزن 100 حبة ، ومحتوي البروتين بالبذور ، معامل الاجهاد المائي. بينما سجل الأب (P_2) Kauz/Altar84/Aos قيما G.C.A عالية المعنوية وموجبة لكل محصول الحبوب ، ووزن 100 حبة – معامل الاجهاد المائي . كما سجل (P_3) Freetz/Tukuru قيما GCA معنوية موجبة لكل من وزن 100 حبة ، محتوي البروتين بالحبوب.

6- تفوق الأب (P_4) WBLL 1*2/4/YACO/PBW65/3 في إعطاء قيما عالية المعنوية موجبة القدرة الائتلاف العامة (G.C.A) لعدد 4 صفات هي محصول الحبوب ، محصول القش ، المحصول البيولوجي ، محتوي البروتين بالحبوب. ويعد هذا الأب Good combiner لهذه الصفات بينما لم يظهر الأب (P_5) Bow/Gen//Dem/3/TUNU سوي (قيم معنوية موجبة G.C.A) كل من محصول القش ، ومحتوي البروتين بالحبوب ، معامل الاجهاد المائي.

7- اظهر الأب (P_6) TUMU/3/ALD/COC//URES قيما معنوية موجبة G.C.A لعدد السنابل علي النبات ، محصول البيولوجي ، معامل الحصاد ، معامل الاجهاد المائي وأخري سالبة لكل من وزن 100 حبة ،محتوي البروتين بالحبوب.

8- أعطت بعض الهجن تأثيرات سيادية لعدد من الصفات مثل الهجين ($P_2 \times P_3$) في عدد السنابل للنبات، وزن 100 حبة، محصول القش ، الحصول البيولوجي ، محتوي البروتين بالحبوب والهجين ($P_2 \times P_4$) في محصول الحبوب ، وزن 100 حبة ، محتوي البروتين بالحبوب ، معامل الاجهاد المائي والهجين($P_2 \times P_5$) لوزن 100 حبة والهجين ($P_4 \times P_5$) لصفات محصول الحبوب ، عدد السنابل للنبات ، المحصول البيولوجي ونسبة البروتين بالحبوب ومعامل الإجهاد المائي.