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# INHERITANCE AND SELECTION FOR EARLINESS IN SPRING WHEAT UNDER HEAT STRESS

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**Abstract:** The seven parents and their diallel crosses in the $F_2$ generations with the 21 $F_3$ selected families for earliness were sown under normal and late planting (heat stress) conditions to obtain some information on the nature of the genetic system controlling heading date and yearly changes from contemporaneous populations. The results showed that both additive and non-additive genetic variances were highly significant. The results exhibited the presence of partial dominance for earliness under all conditions. A remarkable shift in the order of dominance characterized the first season. An exceptional case was the earliest under both conditions. Heritabilities in narrow sense were similar and rather high in magnitude under favourable and stress conditions.

Highly significant differences were observed between environments, among genotypes and their interactions for all studied traits.

The response to selection measured as deviation from the means of $F_2$ populations ranged from -8.09 to -0.90% and from -8.57 to -2.49% under favourable and stressed conditions, respectively. The earliest $F_3$ selected families showed consistent earliness in the two environments, whereas some crosses indicated inconsistent responses, reflecting the presence of G x E interactions.

A correlated response in each of grain yield/plant and 1000-grain weight was decreased under both conditions, the first trait was more affected than the second. It is concluded that the direct selection for earliness under late sowing date is expected to be more effective than indirect selection.

**Key words**: inheritance, selection, heat stress, earliness, wheat.

## Introduction

Wheat is an important cereal crop not only in Egypt, but also all over the world. It plays an important role as an industrial and food crop. Throughout the growing season, it is subjected to different factor stresses (drought, heat, salinity and low soil fertility) particularly in new reclaimed area.

The use of different planting dates allow for subjecting the plant at different developmental stages to various temperature regimes (Kheiralla and sherif, 1992). However, high temperature during the grain filling period is a major environmental factor which drastically reduces wheat production in Upper Egypt (Abdelghani *et al*., 1994). Development of stress tolerant cultivars is an objective of many breeding program, but successes has been limited due to inadequate screening techniques and the lack of genotypes that show clear differences in response to well defined environmental stresses (Bruckner and Frohberg, 1987). Selection for stress tolerance (the difference in yield between non-stress and stress environment) would improve yield in the stress environment at the expense of yield in the non-stress environment.

Diallel analysis provides a powerful tool for identifying the parents and crosses of interest to the breeder. Al-Kadoussi and Hassan (1991), Attia (1998) and Ahmed (2003) reported that additive gene action was more important than non-additive one in the inheritance of heading date . Additive and non-additive gene effects were found to be controlling days to heading under normal and heat stress environments (Kheiralla and sherif, 1992). Kheiralla *et al*., (2001) indicated that additive gene effects were more important than dominance one for variation in earliness under all environments.

The present study was undertaken to: 1) investigate the inheritance of heading earliness in wheat, 2) select the best environment for earliness, 3) evaluate the correlated response in grain yield/plant and 1000-grain weight .

## Materials and Methods

In 2002/2003 growing season, seven wheat genotypes which varied in origin and widely different in agronomic traits were crossed in a half diallel fashion at Exp. Farm, Faculty of Agric., Qena, South Valley Univ., Egypt . The local names, pedigree and origin of the seven genotypes are presented in Table 1 .

**Table(1):** Pedigree and origin of the seven parents.

| Entry No. | Entry name | Pedigree | Origin |
|---|---|---|---|
| 1 | Sakha 8 ($P_1$) | Indus 66 x Norteno'S'/PK 3418-65-ISW-OS | ICARDA |
| 2 | Sahel 1 ($P_2$) | NS732/PIMA//Veery'S' | ICARDA |
| 3 | Giza 164 ($P_3$) | KVZ/Buha'S'//Kal/Bb= Veery'S' | ICARDA |
| 4 | Tokwie ($P_4$) | - | South Africa |
| 5 | Local 2052 ($P_5$) | Local 2052 | Egypt |
| 6 | GV/D6301//Ald'S' ($P_6$) | L882-lAP-0AP-2AP-lAP-0AP | ICARDA |
| 7 | Kasyon/Glennson-81 ($P_7$) | - | ICARDA |

In 2003/2004 season, the 21 $F_1$ hybrids were hand sown in the field in rows 3.00 m long, 30 cm apart and 10 cm between seeds within row, to produce of the $F_2$ generations. Twenty eight genotypes (21 $F_2$ populations and seven parents) were sown in two planting dates, on 15$^{th}$ November (Favorable or recommended planting time in the area) and 25 $^{th}$ of December (late planting date) in 2004/2005 growing season. A randomized complete block design of three replications was used for each planting date . Each plot consisted of two rows, 3m long, 30 cm apart and 10 cm between plants within rows. The cultural practices were carried out as recommended for wheat production throughout the growing season in the two planting dates. Days to heading was measured as the number of days from planting to the day when 50% of the heads were protruded from the flag leaf sheath. In the favourable condition the earliest head was labeled of each plot. The earliest plant from each of the 21 $F_2$ populations were selected at maturity.

In 2005/2006 season, the 49 genotypes (21 $F_2$ populations, the earliest 21 $F_3$ families and the seven parents) were evaluated in the two planting dates as before. At maturity, grain yield/plant was measured for each individual plant on thirty random plants from the middle portion of the each plot in the replicated experiment. 1000-grain weight was recorded on plot mean basis. The average minimum and maximum temperature in 2004/2005 and 2005/2006 seasons are shown in Table 2.

The means of the different genotypes in each plot for each trait in the experiments were first subjected to conventional analysis of variance. The genetic analysis for earliness and narrow sense heritability estimate were computed using diallel analysis according to Hayman (1954). Following the failure of the assumption of a unity slope for the Wr/Vr regression line, the test for epistasis proposed by Jinks *et al*., (1969) was used and the parents involved in the non-allelic interaction were identified and removed from the diallel table. Then the diallel analysis was performed on the remaining interaction free tables Response to selection for earliness and correlated response in grain yield/plant and 1000-grain weight were calculated as deviation of the selected families from the $F_2$ mean and from the best parent of each population. According to Falconer (1990) such selection can be considered as antagonistic selection since the favourable planting date (high) caused late flowering date estimates, while selection was in the opposite direction (towards earliness).

**Table(2):** Average minimum and maximum temperature in 2004/2005 and 2005/2006 seasons.

| Season | | 2004/2005 | | | 2005/2006 | | |
|---|---|---|---|---|---|---|---|
| Month | Day | Maximum | Minimum | Average | Maximum | Minimum | Average |
| November | 1-15 | 32.42 | 17.54 | 24.98 | 26.41 | 12.91 | 19.66 |
| | 16-30 | 24.43 | 12.01 | 18.22 | 28.97 | 13.23 | 21.10 |
| Average | | 28.43 | 14.78 | 21.60 | 27.69 | 13.07 | 20.38 |
| December | 1-15 | 24.28 | 9.01 | 16.65 | 28.90 | 14.08 | 21.49 |
| | 16-31 | 22.46 | 8.44 | 15.45 | 21.74 | 8.19 | 14.97 |
| Average | | 23.37 | 8.73 | 16.05 | 25.32 | 11.14 | 18.23 |
| January | 1-15 | 21.34 | 7.72 | 14.53 | 23.56 | 10.35 | 16.96 |
| | 16-31 | 22.28 | 7.35 | 14.82 | 23.46 | 7.53 | 15.50 |
| Average | | 21.81 | 7.54 | 14.67 | 23.51 | 8.94 | 16.23 |
| February | 1-14 | 20.70 | 7.61 | 14.16 | 24.09 | 8.46 | 16.28 |
| | 15-28 | 29.13 | 14.55 | 21.84 | 28.06 | 11.54 | 19.80 |
| Average | | 24.92 | 11.08 | 18.00 | 26.08 | 10.00 | 18.04 |
| March | 1-15 | 28.93 | 13.05 | 20.99 | 28.59 | 12.99 | 20.79 |
| | 16-31 | 29.71 | 12.71 | 21.21 | 30.21 | 14.33 | 22.27 |
| Average | | 29.32 | 12.88 | 21.10 | 29.40 | 13.66 | 21.53 |
| April | 1-15 | 33.04 | 16.39 | 24.72 | 30.77 | 15.67 | 23.22 |
| | 16-30 | 36.79 | 21.21 | 29.00 | 34.71 | 19.66 | 27.19 |
| Average | | 34.92 | 18.80 | 26.86 | 32.74 | 17.67 | 25.20 |
| May | 1-15 | 34.80 | 20.20 | 27.50 | 36.90 | 21.70 | 29.30 |
| | 16-31 | 39.10 | 23.20 | 31.15 | 38.00 | 22.20 | 30.10 |
| Average | | 36.95 | 21.70 | 29.33 | 37.45 | 21.95 | 29.70 |

*Source of Meteorology, South Valley University, Qena, of east .

## Results and Discussion

The daillel analysis of variance for heading date under favourable and stressed conditions is presented in Table (3). Both additive and non-additive genetic variances "a and b" were highly significant. The first compared to the second gave higher estimates under all conditions, indicating that the additive gene effects were the most important in the inheritance of earliness. These results show that the selection could be applied for early heading in the $F_2$ in these materials. It is noted that the mean squares of the two items "a" and "b" differed from environment to another, indicating the interaction of both, the additive and dominance components, with environments. Similar results were obtained by Avey *et al*., (1982a,b), Frederickson and Kronstad, (1985), Muhammed, (1992), Kheiralla and Sherif, (1992) and Kheiralla *et al.*,( 2001). The significance of the "$b_1$" component under all environments, suggesting that the dominance was unidirectional. Also, the significance of the "$b_2$" component was observed under stress and favourable conditions in 2004/2005 and 2005/2006 seasons, respectively, indicating unequal genes distribution of the dominant alleles among the parents. The "$b_3$" component was highly significant in both seasons, favourable and stressed conditions, showing the existence of dominance effects due to specific combinations and/or epistasis. Similar results were reported by Saakyan *et al.*, (1983), Hassaballa *et al.*, (1984), Lonc (1987), Mahdy (1988), Tammam (1989), Abdel-Karim (1991), Kheiralla and Sherif (1992) and Muhammad (1992).

**Table(3):** Diallel analysis of variance for days to heading of the 7 parents and their 21 $F_2$ populations grown under favourable (F) and heat stressed (S) conditions.

| Item | df | df $^{@}$ | Mean squares$^{+}$ | | | |
|---|---|---|---|---|---|---|
| | | | Heading date in 20042005 | | Heading date in 2005/2006 | |
| | | | F | S$^{@}$ | F | S |
| a | 6 | 5 | 129.25$^{**}$ | 133.03$^{**}$ | 324.33$^{**}$ | 273.73$^{**}$ |
| b | 21 | 15 | 14.15$^{**}$ | 11.03$^{**}$ | 21.77$^{**}$ | 28.80$^{**}$ |
| $b_1$ | 1 | 1 | 72.00$^{**}$ | 22.00$^{**}$ | 82.65$^{**}$ | 54.88$^{**}$ |
| $b_2$ | 6 | 5 | 4.55 | 12.15$^{**}$ | 8.49$^{**}$ | 5.37 |
| $b_3$ | 14 | 9 | 14.14$^{**}$ | 9.18$^{**}$ | 23.12$^{**}$ | 36.98$^{**}$ |
| Block x a | 12 | 10 | 3.47 | 2.96 | 3.11 | 4.58 |
| Block x b | 42 | 30 | 7.15 | 3.96 | 2.17 | 5.85 |
| Block x $b_1$ | 2 | 2 | 33.65 | 2.01 | 0.17 | 2.03 |
| Block x $b_2$ | 12 | 10 | 3.91 | 3.24 | 3.77 | 11.14 |
| Block x $b_3$ | 28 | 18 | 6.65 | 4.57 | 1.77 | 3.85 |
| Block interaction | 96 | 70 | 3.56 | 2.12 | 1.34 | 3.13 |

+Each item is tested against the block interaction .
*,** Significant at 0.05 and 0.01 probability levels, respectively .
@ One array omitted (6parents) .

**Table(4):** Estimates of the genetic parameters for days to heading of 7 or 6 parents and their derived $F_2$ populations grown under favourable (F) and heat stressed (S) conditions.

| Parameters | Heading date in 2004/2005 | | Heading date in 2005/2006 | |
|---|---|---|---|---|
| | F | S@ | F | S |
| D | 12.82 ± 1.70 | 12.39 ± 1.73 | 30.77 ± 1.35 | 28.25 ± 2.06 |
| $H_1$ | 36.58 ± 4.09 | 4.40 ± 4.38 | 64.09 ± 3.24 | 77.06 ± 4.96 |
| $H_2$ | 9.85 ± 3.60 | 3.23 ± 3.91 | 47.61 ± 2.85 | 52.27 ± 4.37 |
| F | 0.14 ± 4.07 | -0.40 ± 4.22 | 2.66 ± 3.23 | 4.25 ± 4.94 |
| E | 3.56 ± 0.60 | 2.12 ± 0.65 | 1.34 ± 0.48 | 3.13 ± 0.73 |
| $(H_1/4D)^{½}$ | 0.84 | 0.60 | 0.72 | 0.83 |
| $H_2/4H_1$ (UV) | 0.07 | 0.18 | 0.19 | 0.17 |
| KD/KR | 1.01 | 0.95 | 1.06 | 1.10 |
| Narrow-sense heritability | 0.70 | 0.70 | 0.80 | 0.72 |

@ Six parents .

The Wr/Vr graphs illustration (Fig. 1) indicated that epistatic effects were absent under all conditions. The regression lines intercepted the Wr axis in a positive position, showing partial dominance under all conditions, except under heat stress in the first season. So, the test of epitasis suggested by Jinks *et al.*, (1969) was used to determine the interacting parents. The Wr/Vr graphs were significantly different from zero but not from unity after omitting array No. 3 from the diallel table. Moreover, the relative position of the points representing the parents around the regression line differed between the two seasons in the two environments (Fig 1). For instance, in the first year the points representing the latest parents $P_2$ and $P_5$ occupied the position furthest of the origin point under favourable conditions, indicating that it possessed the most recessive alleles. However, it occupied a position near the point of origin for the heat stress, which indicates a high proportion of dominant alleles . Similar results were obtained by Kheiralla and Sherif (1992) and Kheiralla *et al.*, (2001).

**Genetic components**

The results presented in Table 4 showed highly significant estimates of the additive effect "D" under early and late plantings. It noticed that the second season compared to the first one, and the early planting date to late planting date conditions gave higher estimates of the additive effect (D), reflecting the effect of

differences in environments on the additive genetic effect. Also, the estimates "$H_1$" were highly significant and greater than their corresponding estimates of "D" under all conditions, except at stress condition in 2004/2005 season. However, the "F" values indicated inconsistent trend for relative frequencies of dominant and recessive genes between years. The average degree of dominance computed by $(H_1/4D)^{½}$ ratio was smaller than one under all conditions, indicating a partial dominance. The $H_2/4H_1$ (UV) values indicated asymmetry genes distribution among the parents. Heritabilities in narrow sense were rather high in all environments and their estimates were similar under favourable and stress conditions.

**b- Selection for early heading**

Highly significant differences between environments, among genotypes as well as the genotype x environment interaction (Table 5) were observed. These results indicated that wheat genotypes responded differently to the heat

**Table(5):** The analysis of variance of days to heading, grain yield/plant and 1000-grain weight of the 7 parents and their 21 $F_2$ and the earliest $F_3$ selected families grown under favourable (F) and heat stressed(S) conditions during the 2005/2006 season .

| SOV | df | Mean squares | | |
|---|---|---|---|---|
| | | Days to heading | Grain yield/plant | 1000-grain weight |
| Environments (Env.) | 1 | 1472.67** | 1927.68** | 6438.93** |
| Rep/E | 4 | 1.19 | 8.47 | 25.56 |
| Genotypes (G) | 48 | 89.87** | 22.76** | 75.03** |
| Parents (P) | 6 | 187.98** | 38.81** | 31.23** |
| $F_2$ | 20 | 81.21** | 20.27** | 35.16** |
| $F_3$ | 20 | 56.69** | 17.77** | 25.48** |
| P vs. $F_2$ | 1 | 119.10** | 18.07* | 32.81* |
| $F_2$ vs. $F_3$ | 1 | 308.84** | 80.67** | 2168.45** |
| G x Env. | 48 | 25.05** | 11.56** | 12.08** |
| Error | 192 | 2.51 | 3.69 | 7.40 |

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

stress, reflecting the assessment of genotypes under different conditions in order to identify the best genotype for a particular environment. These results are in agreement with Mahdy *et al*., (1988), Kheiralla and Sherif (1992) and Kheiralla (1994). Also, the parents, $F_2$ populations and $F_3$ selected families groups were obviously quite different reflecting the significant responses to selection. Similar results were obtained by Kheiralla (1994). May and Van Sanford, (1992) reported that a greater selection advance is expected to occur after the first cycle of selection than after the second one. Two cycles of selection for early heading exhausted the genetic variation (Kheiralla *et al*., 1993 and Ismail, 1995_). So, we confined ourselves with analyzing our data of the first cycle of selection. The effectiveness of selection was revealed by the attenuation of stress reduction in the correlated response in both grain yield/plant and 1000- grain weight.

The average days to heading of the parents, $F_2$ populations and the earliest selected $F_3$ families of the 21 crosses under favourable and heat stressed conditions as well as the selection advance (once measured as % deviation from the $F_2$ population and the other from the earliest parent ) and the mean performance are presented in Tables (6) and (7). In the second season, the average days to heading ranged from 68.33 for ($P_3$ x $P_7$) to 82.33 days for ($P_5$ x $P_6$) crosses in the $F_2$ populations and ranged from 66.67 to 75.67 days for the same populations in the $F_3$ selected families for early heading under normal sowing date. But it ranged from 66.33 to 78.33 days and from 63.00 to 73.00 for the same crosses in the $F_2$ poplations and in the $F_3$ selected families under late sowing date, respectively. It noticed that late planting reduced the number days from sowing to heading, for the average in both $F_2$ populations and $F_3$ selected families by 4 and 6 days, respectively. Similar results was obtained in wheat by Younis *et al.*, (1988), Kheiralla and Sherif (1992) and Kheiralla (1994). However, comparing the average of the $F_3$ selected families and the $F_2$ populations, it could be noticed that the $F_3$ selected families was earlier than the $F_2$ populations about 3 and 5 days in the favourable and heat stressed conditions, respectively.

The cross ($P_3$ x $P_7$) was the earliest $F_3$ selected family which exhibited the earliest mean of 66.67 and 63.00 days under favourable and stressed conditions, respectively. This indicates the exceptional carry-over effect observed after increasing earliness potential through selecting under favourable conditions. In addition, the cross ($P_4$ x $P_7$) was not significantly different from the previous cross under the favourable conditions, while it was significantly different under heat stress, reflecting the presence of G x E interactions. Contrariwise, five crosses; ($P_1$ x $P_3$),

($P_2$ x $P_5$), ($P_3$ x $P_4$), ($P_4$ x $P_6$) and ($P_6$ x $P_7$) exhibited non-significant responses to selection under favourable conditions, but it showed highly significant responses to selection under stress conditions .

**Table(6):** Mean days to heading of the 7 parents and their 21 $F_2$ populations of wheat grown under favourable (F) and heat stressed(S) conditions in the 2004/2005 and 2005/2006 seasons.

| Genotypes | Days to heading | | | |
|---|---|---|---|---|
| | 1n 2004/2005 | | In 2005/2006 | |
| | F | S | F | S |
| $P_1$ | 88.00 | 78.00 | 80.33 | 74.67 |
| $P_2$ | 87.00 | 72.67 | 75.00 | 70.00 |
| $P_3$ | 83.33 | 79.33 | 73.00 | 69.00 |
| $P_4$ | 83.33 | 72.67 | 72.67 | 71.00 |
| $P_5$ | 92.00 | 81.00 | 84.33 | 80.33 |
| $P_6$ | 88.67 | 80.67 | 84.00 | 80.00 |
| $P_7$ | 80.00 | 74.67 | 70.67 | 65.67 |
| $P_1$ x $P_2$ | 83.00 | 74.67 | 76.33 | 74.00 |
| $P_1$ x $P_3$ | 84.00 | 75.67 | 76.67 | 70.67 |
| $P_1$ x $P_4$ | 82.67 | 72.67 | 73.33 | 70.33 |
| $P_1$ x $P_5$ | 85.67 | 80.00 | 75.00 | 70.33 |
| $P_1$ x $P_6$ | 88.33 | 77.00 | 80.00 | 76.33 |
| $P_1$ x $P_7$ | 82.67 | 71.33 | 73.67 | 68.67 |
| $P_2$ x $P_3$ | 80.33 | 67.67 | 72.67 | 68.67 |
| $P_2$ x $P_4$ | 83.67 | 74.67 | 73.33 | 68.33 |
| $P_2$ x $P_5$ | 88.67 | 77.00 | 77.00 | 69.33 |
| $P_2$ x $P_6$ | 88.33 | 76.33 | 81.00 | 77.33 |
| $P_2$ x $P_7$ | 83.00 | 72.67 | 71.33 | 67.33 |
| $P_3$ x $P_4$ | 81.67 | 72.00 | 71.00 | 67.00 |
| $P_3$ x $P_5$ | 85.33 | 74.67 | 76.33 | 73.67 |
| $P_3$ x $P_6$ | 84.67 | 77.33 | 78.00 | 73.67 |
| $P_3$ x $P_7$ | 80.33 | 75.67 | 68.33 | 66.33 |
| $P_4$ x $P_5$ | 84.67 | 77.67 | 79.67 | 77.00 |
| $P_4$ x $P_6$ | 84.00 | 73.67 | 74.67 | 70.33 |
| $P_4$ x $P_7$ | 82.00 | 71.67 | 69.00 | 67.00 |
| $P_5$ x $P_6$ | 86.67 | 79.00 | 82.33 | 78.33 |
| $P_5$ x $P_7$ | 82.33 | 77.33 | 72.00 | 70.00 |
| $P_6$ x $P_7$ | 83.00 | 75.33 | 73.33 | 70.67 |
| $LSD_{0.05}$ | 2.67 | 2.07 | 1.75 | 2.67 |
| Parent mean | 86.05 | 77.00 | 77.17 | 72.95 |
| $F_2$ mean | 84.05 | 74.95 | 75.00 | 71.21 |

The response to selection (Table 7) measured as % deviation from the $F_2$ populations ranged from $-8.09^{**}$ to $-0.90^{ns}$% and from $-8.57^{**}$ to $-2.49^{ns}$% under favourable and stressed conditions, respectively. Moreover, 14 and 20 crosses showed a significant response to selection under favourable and stressed conditions, respectively. Fourteen crosses showed a significant response to selection as % deviation from the earliest parent under favourable conditions ranging from $-9.92^{**}$ to $4.44^{**}$%. While under stressed conditions 9 crosses were significantly earlier than the better parent ranging from $0.01^{ns}$ to $9.83^{**}$%. The previous results show the presence of transgressive segregation for earliness according to Poehlman (1987). Transgressive segregation for earliness was reported by Bhatt (1972) and Kheiralla (1994).

The mean and correlated response of grain yield/plant and 1000-grain weight are illustrated in Tables 8 and 9. The average grain yield/plant (Table 8) ranged from 15.59 for ($P_2$ x $P_3$) to 23.40 g for ($P_5$ x $P_6$) crosses in the $F_2$ populations and ranged from 13.09 to 20.63 g for the same crosses in the $F_3$ selections under favourable conditions. But it ranged from 10.57 to 16.37 gm and from 8.98 to 15.75 g for the same crosses in the $F_2$ populations and early $F_3$ selected families under stressed conditions, respectively. Average 1000-grain weight ranged from 42.60 for ($P_1$ x $P_3$) to 51.77 g for ($P_4$ x $P_7$) crosses in the $F_2$ populations and ranged from 38.53 for ($P_1$ x $P_3$) to 47.80 g for ($P_2$ x $P_4$) in the $F_3$ early selected families under normal sowing date, respectively. But it ranged from 34.47 for ($P_1$ x $P_5$) to 46.67 g for ($P_2$ x $P_4$) crosses and from 28.57 for ($P_1$ x $P_3$) to 38.27 g for ($P_2$ x $P_4$) crosses in the $F_2$ populations and $F_3$ early selected families under late sowing date, respectively. The previous results indicated that delaying planting date reduced both grain yield/plant and 1000-grain weight by 29.82 and 15.46 % in the $F_2$ populations and by 26.68 and 25.57% in the $F_3$ early selected families, respectively. The decrease in grain yield/plant and 1000-grain weight could be due to increasing temperature during the grain filling period under stress conditions (late planting date), since the maximum temperature during this period was (29.40$^{\circ}$C) at normal conditions and (32.74$^{\circ}$C) at stress condition. These results confirm those obtained by Bruckner and Frohberg (1987) and Abdel-Karim (1998). Randall and Moss (1990) found that grain yield was negatively correlated with increasing mean maximum temperature. Fischer and Maurer (1978) found that grain yield was reduced by 4% as a results of increasing temperature by 1$^{\circ}$C over the optimum if such rise occurred from end of tillering until the grain filling stage. These results indicated that all selected families for earliness gave lower grain yield/plant and 1000-grain.

**Table(8):** Mean grain yield/plant(g) and 1000-grain weight(g) of the 7 parents, their 21 $F_2$ and 21$F_3$ selected families for earliness under early (F) and late planting (heat stressed).

| Population | grain yield/plant (g) | | | | 1000-grain weight (g) | | | |
|---|---|---|---|---|---|---|---|---|
| | Favourable cond. | | Heat stressed cond. | | Favourable cond. | | Heat stressed cond. | |
| | $F_2$ | $F_3$ | $F_2$ | $F_3$ | $F_2$ | $F_3$ | $F_2$ | $F_3$ |
| $P_1$ x $P_2$ | 19.18 | 16.69 | 13.15 | 11.37 | 48.73 | 44.23 | 41.90 | 32.80 |
| $P_1$ x $P_3$ | 19.00 | 17.00 | 13.65 | 12.95 | 42.60 | 38.53 | 35.70 | 28.57 |
| $P_1$ x $P_4$ | 18.27 | 14.30 | 11.40 | 11.02 | 47.70 | 44.60 | 36.57 | 31.77 |
| $P_1$ x $P_5$ | 22.40 | 16.60 | 16.15 | 13.87 | 45.57 | 40.87 | 34.47 | 29.04 |
| $P_1$ x $P_6$ | 20.02 | 16.37 | 14.33 | 12.25 | 47.33 | 43.63 | 39.30 | 32.67 |
| $P_1$ x $P_7$ | 17.78 | 13.28 | 11.28 | 9.08 | 46.93 | 42.67 | 40.73 | 33.63 |
| $P_2$ x $P_3$ | 15.59 | 13.09 | 10.57 | 8.98 | 48.07 | 41.47 | 39.87 | 34.10 |
| $P_2$ x $P_4$ | 17.33 | 14.03 | 11.67 | 11.20 | 50.13 | 47.80 | 46.67 | 38.27 |
| $P_2$ x $P_5$ | 19.12 | 15.62 | 14.77 | 12.18 | 46.63 | 41.97 | 39.73 | 34.80 |
| $P_2$ x $P_6$ | 20.78 | 17.27 | 15.28 | 12.49 | 46.80 | 42.83 | 39.30 | 33.98 |
| $P_2$ x $P_7$ | 17.15 | 15.20 | 12.06 | 11.00 | 49.80 | 46.76 | 38.43 | 29.67 |
| $P_3$ x $P_4$ | 17.05 | 14.78 | 11.80 | 10.37 | 47.63 | 43.86 | 38.57 | 31.63 |
| $P_3$ x $P_5$ | 18.14 | 13.64 | 12.11 | 10.52 | 42.90 | 41.90 | 40.30 | 30.80 |
| $P_3$ x $P_6$ | 18.07 | 13.57 | 13.02 | 10.25 | 48.30 | 46.80 | 41.73 | 33.44 |
| $P_3$ x $P_7$ | 16.88 | 13.59 | 11.02 | 10.12 | 49.73 | 45.46 | 44.50 | 34.90 |
| $P_4$ x $P_5$ | 21.16 | 19.00 | 15.50 | 13.25 | 45.40 | 41.26 | 39.33 | 30.13 |
| $P_4$ x $P_6$ | 19.13 | 17.56 | 12.82 | 9.45 | 49.20 | 46.74 | 41.83 | 35.02 |
| $P_4$ x $P_7$ | 16.12 | 14.12 | 11.05 | 9.27 | 51.77 | 45.97 | 45.97 | 30.30 |
| $P_5$ x $P_6$ | 23.40 | 20.63 | 16.37 | 15.75 | 49.67 | 44.10 | 40.37 | 33.90 |
| $P_5$ x $P_7$ | 17.34 | 15.14 | 13.64 | 11.14 | 47.40 | 44.80 | 39.40 | 31.67 |
| $P_6$ x $P_7$ | 17.53 | 14.03 | 13.30 | 12.15 | 49.60 | 45.43 | 42.30 | 34.90 |
| Parents | | | | | | | | |
| $P_1$ | 21.45 | | 13.90 | | 45.57 | | 37.03 | |
| $P_2$ | 18.15 | | 13.00 | | 46.00 | | 37.43 | |
| $P_3$ | 17.52 | | 12.57 | | 50.27 | | 41.00 | |
| $P_4$ | 17.25 | | 11.75 | | 52.00 | | 39.57 | |
| $P_5$ | 24.64 | | 15.05 | | 44.50 | | 36.20 | |
| $P_6$ | 22.97 | | 16.99 | | 46.50 | | 36.57 | |
| $P_7$ | 17.08 | | 10.52 | | 50.17 | | 39.20 | |
| $L.S.D_{0.05}$ | 2.34 | | 2.37 | | 3.51 | | 3.67 | |

**Table(9):** The correlated responses in grain yield/plant and 1000-grain weight after selection for early heading in 21 $F_2$ populations of wheat plant grown under early and late (heat stress) plantings.

| Population | grain yield/plant | | | | 1000-grain weight | | | |
|---|---|---|---|---|---|---|---|---|
| | Early planting date | | Late planting date | | Early planting date | | Late planting date | |
| | % correlated response as deviation from the | | | | | | | |
| | $F_2$ | Better parent | $F_2$ | Better parent | $F_2$ | Better parent | $F_2$ | Better parent |
| $P_1$ x $P_2$ | $-12.98^{*}$ | $-22.19^{**}$ | $-13.54^{*}$ | $-18.20^{*}$ | $-9.23^{*}$ | $-3.85^{ns}$ | $-21.72^{**}$ | $-12.37^{*}$ |
| $P_1$ x $P_3$ | $-10.53^{ns}$ | $-20.75^{**}$ | $-5.13^{ns}$ | $-6.84^{ns}$ | $-9.55^{*}$ | $-23.55^{**}$ | $-19.97^{**}$ | $-30.32^{**}$ |
| $P_1$ x $P_4$ | $-21.73^{**}$ | $-33.33^{**}$ | $-3.33^{ns}$ | $-20.72^{*}$ | $-6.50^{ns}$ | $-14.23^{**}$ | $-13.12^{*}$ | $-19.71^{**}$ |
| $P_1$ x $P_5$ | $-25.89^{**}$ | $-32.63^{**}$ | $-14.12^{ns}$ | $-7.84^{ns}$ | $-10.31^{**}$ | $-10.31^{**}$ | $-15.74^{**}$ | $-21.58^{**}$ |
| $P_1$ x $P_6$ | $-18.23^{**}$ | $-28.73^{**}$ | $-14.53^{**}$ | $-27.90^{**}$ | $-7.82^{*}$ | -6.17 | $-16.87^{**}$ | $-11.77^{ns}$ |
| $P_1$ x $P_7$ | $-25.31^{**}$ | $-38.09^{**}$ | $-19.50^{**}$ | $-34.68^{**}$ | $-9.08^{*}$ | $-14.95^{**}$ | $-17.44^{**}$ | $-14.21^{**}$ |
| $P_2$ x $P_3$ | $-16.04^{*}$ | $-27.88^{**}$ | $-15.04^{*}$ | $-30.92^{**}$ | $-13.73^{**}$ | $-17.51^{**}$ | $-14.46^{**}$ | $-16.83^{**}$ |
| $P_2$ x $P_4$ | $-19.04^{**}$ | $-22.70^{**}$ | $-4.03^{ns}$ | $-13.85^{ns}$ | $-4.65^{ns}$ | $-8.08^{*}$ | $-18.00^{**}$ | $-3.29^{ns}$ |
| $P_2$ x $P_5$ | $-18.31^{**}$ | $-36.61^{**}$ | $-17.54^{**}$ | $-19.07^{*}$ | $-9.99^{**}$ | $-8.76^{*}$ | $-12.42^{**}$ | $-7.03^{ns}$ |
| $P_2$ x $P_6$ | $-16.89^{**}$ | $-24.82^{**}$ | $-18.28^{**}$ | $-26.49^{**}$ | $-8.48^{*}$ | -7.89 | $-13.54^{**}$ | $-9.22^{ns}$ |
| $P_2$ x $P_7$ | $-11.37^{ns}$ | $-16.25^{*}$ | $-8.79^{ns}$ | $-15.39^{ns}$ | $-6.10^{ns}$ | -6.79 | $-22.80^{**}$ | $-24.31^{**}$ |
| $P_3$ x $P_4$ | $-13.31^{ns}$ | $-15.64^{*}$ | $-12.12^{ns}$ | $-17.50^{*}$ | $-7.92^{*}$ | $-15.65^{**}$ | $-17.99^{**}$ | $-22.85^{**}$ |
| $P_3$ x $P_5$ | $-24.81^{**}$ | $-44.64^{**}$ | $-13.13^{*}$ | $-30.10^{**}$ | $-2.33^{ns}$ | $-16.65^{**}$ | $-23.57^{**}$ | $-24.88^{**}$ |
| $P_3$ x $P_6$ | $-24.90^{**}$ | $-40.92^{**}$ | $-21.27^{**}$ | $-39.67^{**}$ | $-3.11^{ns}$ | -6.90 | $-19.87^{**}$ | $-18.44^{**}$ |
| $P_3$ x $P_7$ | $-19.49^{**}$ | $-22.43^{**}$ | $-8.17^{ns}$ | $-19.49^{*}$ | $-8.59^{*}$ | $-9.57^{**}$ | $-21.57^{**}$ | $-14.88^{**}$ |
| $P_4$ x $P_5$ | $-10.21^{ns}$ | $-22.89^{**}$ | $-14.53^{**}$ | $-11.96^{ns}$ | $-9.12^{*}$ | $-20.65^{**}$ | $-23.40^{**}$ | $-23.86^{**}$ |
| $P_4$ x $P_6$ | $-8.21^{ns}$ | $-23.55^{**}$ | $-26.31^{**}$ | $-44.38^{**}$ | $-5.00^{ns}$ | $-10.12^{**}$ | $-16.29^{**}$ | $-11.49^{*}$ |
| $P_4$ x $P_7$ | $-12.41^{ns}$ | $-18.15^{**}$ | $-16.11^{*}$ | $-21.11^{*}$ | $-11.20^{**}$ | $-11.60^{**}$ | $-34.08^{**}$ | $-23.43^{**}$ |
| $P_5$ x $P_6$ | $-11.84^{*}$ | $-16.27^{**}$ | $-3.79^{ns}$ | $-7.30^{ns}$ | $-11.21^{**}$ | $-5.16^{ns}$ | $-16.02^{**}$ | $-7.30^{ns}$ |
| $P_5$ x $P_7$ | $-12.65^{ns}$ | $-38.56^{**}$ | $-18.33^{**}$ | $-25.98^{**}$ | $-5.49^{ns}$ | $-10.70^{**}$ | $-19.62^{**}$ | $-19.21^{**}$ |
| $P_6$ x $P_7$ | $-19.97^{**}$ | $-38.92^{**}$ | $-8.67^{ns}$ | $-28.49^{**}$ | $-8.41^{**}$ | $-9.45^{**}$ | $-17.49^{**}$ | $-10.97^{*}$ |

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

weight than the better parent under both environments, except the two crosses; ($P_2$ x $P_4$) and ($P_5$ x $P_6$) under stressed conditions. These results agree with those of Kheiralla (1994) for grain yield/plant only. In the two crosses, ($P_4$ x $P_6$) and ($P_5$ x $P_7$) both grain yield/plant and 1000-grain weight did not differ significantly from the $F_2$ mean under favourable condition, whereas these traits were significantly reduced under stress conditions (Table 9). In six crosses, a significant grain yield/plant reduction under favourable conditions was observed [($P_1$ x $P_4$), ($P_1$ x $P_5$), ($P_2$ x $P_4$), ($P_3$ x $P_7$), ( $P_5$ x $P_6$) and ($P_6$ x $P_7$)], but it benefited from earliness under stress condition. These selections were not to be selected if selection was carried out under favourable conditions with a lack of information on their performance under heat stress.

In general, selection for earliness resulted in lower grain yield/plant and 1000-grain weight under favourable conditions. However, some of these selections were good grain yielder under stress. So, selection and testing based on this limited sample of populations and environments under favourable or stress conditions alone may not be the most effective for increasing yield under heat stress . Such conclusion was reported also by Nasir Ud-Din *et al*., (1992) and Kheiralla (1994). Moreover, Ceccarelli *et al.,* (1992) indicated that screening a large number of genotypes only under high yield environment implies a high probability of discarding many potentially high yielding genotypes in low yield environments. We may conclude also that heritability estimates, which were of equal values in both environments, alone are not sufficient to identify the best environment for selection. Heritability estimates were sufficient to identify the best environment for selection (Atlin and Frey, 1989). Under the present conditions, the heritability of heading date is similar in the two environments, it is expected that direct selection under stress conditions will be more effective than indirect selection (Falconer, 1989). Support to this conclusion can be drawn from the remarkable shift in the order of dominance shown in the Wr/Vr graphical analysis (Paroda and Hayes, 1971 and Kheiralla, 1994). However, some plant breeders may want to improve the overall environments. So selection could be practiced on the base of the mean performance as well as sensitivity and the cross $P_3$ x $P_7$ is promising in this regard. Omara (1987) found such selection efficiency for early heading in barley.

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## الوراثة والانتخاب للتبكير في القمح الربيعي تحت الإجهاد الحراري

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تمت زراعة سبعة أباء وهجنها الدائرية في الجيل الثاني مع منتخبات الجيل الثالث تحت الظروف العادية وظروف الإجهاد الحراري للحصول على بعض المعلومات عن النظام الوراثى الذي يتحكم في ميعاد التزهير وكذلك التغيرات السنوية لنفس العشائر. ولقد أوضحت النتائج أن التأثيرات المضيفة وغير المضيفة تتحكم في صفة التبكير في البيئات المختلفة . وتشير النتائج إلى وجود سيادة جزئية لصفة التبكير في كل البيئات . كما ظهر تغيرا واضحا في علاقة السيادة من بيئة لأخرى في الموسم الأول . ولقد كانت درجة التوريث مرتفعة نوعا ومتساوية تحت الظروف المثلي وظروف الإجهاد . وجدت اختلافات معنوية جدا بين كل من التراكيب الو راثية والظروف البيئية والتفاعل بينهما لكل الصفات تحت الدراسة .

كما نجح الانتخاب في التبكير في التزهير لكل العشائر تحت الدراسة وتراوح مدى الاستجابة للانتخاب من - 8.09 إلى -0.9% تحت ظروف الزراعة المثلي ومن- 8.57 إلى -2.49% تحت الزراعة المتأخرة مقاسة كنسبة مئوية للانحراف عن متوسط عشائر الجيل الثاني . ظهرت حالة واحدة فقط لأحدى العشائر حيث كانت منتخباتها مبكرة في كل من البيئتين ولكن بقية العشائر الأخرى أعطت استجابات مختلفة للتبكير في كل من البيئتين وهذا يدل على وجود التفاعل الوراثى بيئي. أما بالنسبة للاستجابة المرتبطة في محصول الحبوب للنبات الفردي ووزن الألف حبة والناتجة عن الانتخاب للتبكير كان محصول الحبوب للنبات الفردي أكثر تأثرا . ويمكن الاستخلاص أن الانتخاب للتبكير تحت ظروف الزراعة المتأخرة قد يكون أكثر فاعلية من الانتخاب تحت ظروف الزراعة المثلي .