*Assiut J. Agric. Sci., (45) No. (2) 2014 (1-18) (Special Issue)*
*(The 7th Conference of Young Scientists) Fac. of Agric. Assiut University April, 28, 2014.*

# Selection for Grain Yield in Bread Wheat (*Triticum aestivum* L.) Under Normal and Heat Stress Conditions

**Salous, M.SH. [1] ; M.A. El-Morshidy[2]; K.A. Kheiralla[2] and M.Kh. Moshref[1]**
[1]Wheat Research Section, Field Crops Inst, Agric. Res. Center.
[2]Dept. of Agron., Fac. of Agric., Assiut University.

**Abstract:**

The objective of the present work is to study the efficiency of pedigree selection in improving grain yield under normal and late planting dates. Two cycles of selection were completed under each date on the $F_3$ and $F_4$-generations. The $F_5$ selected families under normal and late planting were evaluated under both conditions. The genotypic variance was slightly less than the phenotypic variance under both dates and generally decreased from the base population ($F_3$) to the $F_5$-generation. Broad sense heritability estimates for grain yield/plant under normal and heat stress conditions were 81.76 and 75.04% after two cycle's selection, respectively. The realized heritability under normal date was 49.47 and 70.98% compared to 40.90 and 53.92% under heat stress after $C_1$ and $C_2$ respectively. The average observed gain from selection under normal and late planting groups, evaluated under normal planting date showed significant difference in grain yield from the bulk sample by 13.08 and 3.36%, and from the better parent by 25.04 and 15.04%, respectively. Under late planting date, the observed gain showed significant difference ($P<0.01$) of 6.73 and 7.78%, from the bulk sample and 16.05 and 22.10% from the better parent, respectively. Selection for grain yield under normal planting date evaluated under both dates, increased sensitivity of the selected families, while selection at late planting date, decreased the sensitivity.

**Received on:** 9/3/2013 **Accepted for publication on:** 31/3/2013
**Referees:** Prof. Abd-Elazeem A. Ismail Prof. Mohammed A. Radwan

## Introduction:

Wheat is the world's most important and most widely grown cereal crop. Its importance is derived from the many properties and uses of its kernels, which make it a staple food for more than one third of the world's population (Poehlman, 1979). Many of the world's wheat areas are exposed to short periods of very high temperature during wheat grain filling period. Heat stress is one of the major constraints of wheat (*Triticum aestivum* L.) production in many areas around the world. Late heat stress is a problem in 40% of the temperate environments (Reynolds *et al*., 2001). Terminal heat stress is a common abiotic factor responsible for reducing yield of wheat in Upper Egypt (Abdel-Shafi *et al*., 1999). Heat stress affects at least 5 million ha of spring wheat in the developing world and over 7 million ha are affected continual heat stress, where mean daily temperatures are greater than 17.5°C in the coolest month (Fischer and Byerlee, 1991). The average wheat yield loss from moderately high temperature is estimated as 10-15% was mainly due to reduced kernel weight (Wardlaw and Wrigley, 1994). The pedigree selection method has become the most popular wheat breeding procedure. Most of the Egyptian wheat cultivars were produced through this method. This method is preferred by wheat breeders because it is versatile, relatively rapid and enables conducting genetic studies along with the wheat breeding work. Several workers indicated that pedigree selection is effective in improving grain yield (Abdel-Karim, 1991; Kheiralla *et al.,* 2001; Omara *et al.,* 2004; Ahmed, 2006; El-Karamity *et al*., 2007 and El-Morshidy *et al*., 2010). Kheiralla (1993) showed that direct selection for spike length, 1000-kernel weight, grains/spike and spikes/plant was accompanied by an increase in grain yield which accounted 5.63, 5.90, 6.93 and 7.50%, respectively, after two cycles of selection calculated as a deviation from the best parent mean. Jinks and Connolly (1973 and 1975), Jinks and Pooni (1982) and Falconer (1990) indicated that the better the selection environment the higher the environmental sensitivity and the bad environment, the low environmental sensitivity. The objectives of this study were to estimate: (1) the relative merits of pedigree selection for grain yield/plant under normal and heat stress conditions, (2) Phenotypic (pcv%) and genotypic (gcv%) coefficients of variability and heritability under both conditions and (3) heat susceptibility index and sensitivity to environmental conditions.

## Materials and Methods:

This investigation was carried out at El-Mattana Agric. Res. Stn., (ARC), Ministry of Agric, Egypt, during the 2007/2008 through 2010/2011 growing seasons. The base population was the $F_3$-generation of the cross Giza 168 x Anza. Two cycles of pedigree selection were achieved under normal and late planting dates and evaluated under both environments in $F_5$-generation.

2007/2008 season, ($F_2$ generation): 1000 $F_2$-individual plants were grown in non-replicated plots under normal planting date (20$^{th}$ November) and late planting date (25$^{th}$ December). Each plot consisted of 12 rows 3 m long, 30 cm apart. Grains were sown in hills spaced 15 cm within rows. The parents were grown in a separate plots at each environment.

The data were recorded on 400 random guarded plants in the two experiments.

2008/2009 season, ($F_3$ generation): Two field experiments were conducted to evaluate the $F_3$ families selected from the population in a randomized complete block design with three replicates. The first experiment was seeded at normal date, while the other experiment was seeded in late planting date. Each experiment comprised 100 $F_3$ families, the parents, $F_3$ bulked random sample comprised of a mixture of equal number of seeds from each plant to represent the each generation for each date. Data were recorded on ten guarded plants from each family for; days to heading, plant height, number of spikes/plant, number of kernels/spike, 100-kernel weight, spike length and grain yield/plant.

2009/2010 season, ($F_4$ generation): the 20-$F_4$-families selected for grain yield with the parents and $F_3$ bulk sample were grown in, a randomized complete block design of three replications. Each family was represented by a single row 3 m long, 30 cm apart and 10 cm between grains within row between plants. Data were recorded on 10 guarded plants from each family in each replicate at both planting dates. At the end of the season, the best high yielding plants from each of the best 10 high yielding families were saved to give the $F_5$ families.

2010/2011 season, ($F_5$ generation): The ten highest yielding families selected under each of normal, and late planting, the parents and the bulk sample were evaluated under both sowing dates in two separate experiments. Data were recorded for the aforementioned characters on ten guarded plants from each family.

**Statistical Analysis:**

Data were subjected to proper statistical analysis according to Steel and Torrie (1980). Genotypes means were compared using by the Revised Least Significant Differences (RLSD) according to Gomez and Gomez (1984). The phenotypic ($^{\sigma 2}$ph), genotypic ($^{\sigma 2}$g) variances, and broad sense heritability (H) were calculated according to Walker (1960). Realized heritability ($h^2$ = R / S) was calculated according to Falconer (1989); where R = response to selection and S = selection differential.

The phenotypic (pcv %) and genotypic (gcv %) coefficients of variability were calculated as outlined by Burton (1952). Heat susceptibility index (HSI) was calculated according to the method of Fischer and Maurer (1978). The sensitivity and relative merits of a selected line were assessed as described by Falconer (1990).

**Results and Discussion:**

**1- Description of the base population; season 2007/2008**

The base population used in this study was the $F_2$-generation of the cross between (Giza 168 × Anza) were completed using 400 $F_2$ plants under normal and heat stress conditions. Data in Table 1 show the average, range and phenotypic variance for studied traits of $F_2$ plants under normal and heat stress conditions.

Under normal planting date, the average number of days to heading (84.33 days), plant height (113.19 cm), number of spikes/plant (12.18 spike/plant), number of kernels/spike (55.90 kernel/spike), 100-kernel weight (2.29 gm), spike length (12.34 cm) and grain yield/plant (22.39 gm). Whereas, in late planting date, the average was 73.73 day, 102.56 cm, 9.83 spikes/plant 48.34 kernels/spike, 2.21 gm, 11.22 cm and 19.61 gm for the same traits, respectively.

**2- Mean, variance, phenotypic (pcv) and genotypic (gcv) coefficients of variability and heritability of traits in $F_3$-generation:**

The analysis of variance revealed highly significant differences among $F_3$ families under normal and late planting dates, (Table 2). The average of characters was 84.05 and 74.22 days to heading, 106.98 and 101.48 cm for plant height, 13.13 and 10.95 for number of spikes/plant, 69.23 and 67.97 for number of kernels/spike, 3.98 and 3.80 gm for 100-kernel weight, 12.83 and 11.99 cm for spike length and 33.06 and 30.09 gm for grain yield/plant under normal and late planting, respectively.

The results indicated that the phenotypic and genotypic coefficients of variability were 1.87 and 1.81% for days to heading, plant height 8.89 and 8.48%, 10.51 and 10.11% for number of spikes/plant, 11.85 and 11.57% for number of kernel/spike, 15.12 and 14.75% for 100-kernel weight, 6.65 and 6.37% for spike length and 18.50 and 18.00% for grain yield/plant under normal planting date. Under heat stress these values were 2.66 and 2.60%, 10.86 and 10.29%; 10.44 and 10.03%; 9.27 and 8.91%; 16.35 and 16.10%; 6.97 and 6.70%; and 17.32 and 16.76% for the above mentioned traits, respectively. The estimates of the phenotypic and genotypic coefficients of variation indicated the presence of sufficient variability for grain yield, indicating that selection among the $F_3$ families could be effective. These findings are in line with those reported by Zakaria (2004) who found that phenotypic and genotypic coefficients of variability for grain yield /plant were 14.32 and 13.22%, 6.85 and 5.28% and 1.47 and 1.08% for the $F_3$ families, first cycle and second cycle of selection, respectively. These results indicate that $C_0$ and $C_1$ possessed considerable amount of genetic variation more than that exist in the $C_2$ cycle for grain yield/plant.

Heritability estimates in broad sense were 94.06 and 95.67% for days to heading, 90.93 and 89.89% for plant height, 92.59 and 92.42% for number of spikes/plant, 95.23 and 92.41% for number of kernels/spike, 95.12 and 98.75% for 100-kernel weight, 91.67 and 92.28% for spike length and 94.72 and 93.63% for grain yield/plant under normal and late planting dates, respectively, (Table 2). Similar results were found by Chander *et al.* (1993) who showed that broad sense heritability varied from 79 to 88% for grain yield/plant. Also, Kherialla *et al.* (1993) showed that broad sense heritability was 0.73 for grain yield/plant in the $F_3$ families. Zakaria (2004) reported that heritability values in broad sense were 85.2%, 59.4% and 54.5% for the $F_3$ families ($C_0$), first cycle ($C_1$) and second cycle ($C_2$), respectively. Kherialla *et al.* (2001) found that broad sense heritability was 0.82 and 0.75 for grain yield under early and late planting conditions, respectively.

**Table (1): The range, mean values and phenotypic variance ($\sigma^2$ ph) in the $F_2$ plants for studied traits under normal planting date and heat stress conditions; Season 2007/2008**

| Trait | Normal date | | | Heat stress | | |
|---|---|---|---|---|---|---|
| | Range | Mean± S.E | Phenotypic Variance | Range | Mean± S.E | Phenotypic Variance |
| **Heading date** | 75.00 – 92.00 | 84.33 ± 0.12 | 6.19 | 68.00 – 80.00 | 73.73 ± 0.09 | 3.70 |
| **Plant height, cm** | 80.00 – 145.00 | 113.19 ± 0.79 | 250.15 | 65.00 – 135 | 102.56 ± 0.60 | 144.62 |
| **No. of spikes/plant** | 6.00 – 15.00 | 12.18 ± 0.11 | 5.10 | 4.00 – 11.00 | 9.83 ± 0.10 | 4.64 |
| **No. of kernels/spike** | 20.00 – 95.00 | 55.90 ± 0.55 | 120.61 | 15.00 – 75.00 | 48.34 ± 0.54 | 119.00 |
| **100-kernel weight, gm** | 1.15 – 4.45 | 2.29 ± 0.03 | 0.37 | 0.82 – 3.75 | 2.21 ± 0.02 | 0.35 |
| **Spike length, cm** | 10.00 – 15.00 | 12.34 ± 0.05 | 1.11 | 8.00 – 13.00 | 11.22 ± 0.4 | 0.58 |
| **Grain yield /plant, gm** | 6.60 – 37.00 | 22.39 ± 0.45 | 80.21 | 5.11 – 28.00 | 19.61 ± 0.39 | 61.01 |

**Table (2): Means, mean squares, phenotypic (P.C.V %) and genotypic (G.C.V %) coefficients of variability and heritability values in the $F_3$ Families under normal and late planting date.**

| Date | Item | Heading date | Plant height | No. of spikes/ plant | No. of kernels/ spike | 100-kernel weight | Spike length | Grain yield/ plant |
|---|---|---|---|---|---|---|---|---|
| Normal planting date | $P_1$ | 84.05 | 111.67 | 12.67 | 66.00 | 3.76 | 11.00 | 23.12 |
| | $P_2$ | 82.33 | 100.00 | 12.33 | 67.00 | 3.58 | 12.33 | 26.53 |
| | $F_3$ selected families | 84.05 | 106.98 | 13.13 | 69.23 | 3.98 | 12.83 | 33.06 |
| | Rep. | 1.10 | 86.58 | 1.26 | 1.86 | 0.018 | 1.32 | 8.55 |
| | Families | 7.41** | 271.66** | 5.71** | 201.95** | 1.08** | 2.18** | 114.21** |
| | Error | 0.44 | 24.63 | 0.42 | 9.62 | 0.05 | 0.18 | 4.26 |
| | PCV% | 1.87 | 8.89 | 10.51 | 11.85 | 15.12 | 6.65 | 18.50 |
| | GCV% | 1.81 | 8.48 | 10.11 | 11.57 | 14.75 | 6.37 | 18.00 |
| | Broad-sense heritability% | 94.06 | 90.93 | 92.59 | 95.23 | 95.12 | 91.67 | 94.72 |
| Late planting date (heat stress) | $P_1$ | 76.67 | 105.00 | 9.33 | 65.33 | 3.75 | 10.33 | 22.36 |
| | $P_2$ | 77.67 | 98.33 | 8.33 | 67.00 | 3.67 | 11.67 | 23.61 |
| | $F_3$ selected families | 74.22 | 101.48 | 10.95 | 67.97 | 3.80 | 11.99 | 30.09 |
| | Rep. | 0.96 | 78.52 | 0.14 | 5.11 | 0.01 | 0.97 | 14.23 |
| | Families | 11.67** | 364.19** | 3.92** | 119.03** | 1.16** | 2.20** | 83.58** |
| | Error | 0.51 | 36.80 | 0.30 | 9.03 | 0.01 | 0.20 | 4.30 |
| | PCV% | 2.66 | 10.86 | 10.44 | 9.27 | 16.35 | 6.97 | 17.32 |
| | GCV% | 2.60 | 10.29 | 10.03 | 8.91 | 16.10 | 6.70 | 16.76 |
| | Broad-sense heritability% | 95.67 | 89.89 | 92.42 | 92.41 | 98.75 | 92.28 | 93.63 |
| | % Reduction | **11.69** | **5.14** | **16.60** | **1.82** | **4.52** | **6.78** | **8.98** |

Heat stress reduced days to heading by 11.69% days, plant height by 5.14% cm, no. of spikes/plant by 16.60% spikes/plant, no. of kernels/spike by 1.82% kernels/spike, 100-kernel weight by 4.52% gm, spike length by 6.78% cm and grain yield/plant by 8.98% gm, compared with the normal planting date (Table 2). Similar results were found by El-Morshidy *et al.* (2001) found that high temperature during grain filling reduced dry matter, 1000-kernel weight and grain yield by 10.97, 10.67 and 16.52%, respectively, when compared with the normal temperature prevailing during grain filling period in the optimal planting date. Poonam *et al.* (2006) indicated that all tested cultivars showed 30-40% a decrease in yield due to late sowing and the loss was estimated compared with normal sowing. Tawfelis *et al.* (2010) estimated the reduction by 36.2 %.

**3- Response to direct selection for grain yield/plant**

**3-1-Phenotypic, genotypic coefficients of variability and heritability estimate:**

The analysis of variance of the selected families for the seven studied traits in cycle1 ($F_4$ generation) and cycle 2 ($F_5$ generation) under the two dates are shown in Table 3. Mean squares for grain yield/plant, and the other selected traits were highly significant under normal and heat stress conditions. This indicated the presence of genetic variability for further of selection for grain yield/plant.

The effect of selection for two cycles on the variability and heritability estimates of grain yield/plant are shown in Table 4. The phenotypic ($\sigma^2$ph) and genotypic ($\sigma^2$g) variances were generally larger under normal planting date than under heat stress condition in $C_0$, $C_1$ and $C_2$. The phenotypic coefficient of variability (pcv) under normal planting date was 18.50% for grain yield/plant in the base population, and decreased to 8.43 and 4.19% after $C_0$ and $C_1$; respectively. Likewise, the pcv % under heat stress was slightly more than that under normal planting and showed the same trend. This could be due to higher mean grain yield under normal planting than under heat stress. The gcv % was slightly less than the pcv % under both environments, and decreased from $C_0$ to $C_2$.

The high estimates of phenotypic and genotypic variability resulted in very high estimates of broad sense heritability in the two cycles of selection. The high estimates of broad sense heritability calculated from the expected mean squares resulted from the evaluation of the selected families at one site in one season, which inflates the families' mean squares by the confounding effects of the interactions of families with years and sowing dates. The realized heritability for grain yield/plant was 49.47 and 70.98% under normal, and 44.90 and 53.92% under heat stress after $C_1$ and $C_2$; respectively. These results are in agreement with those of Ahmed (2006), Ali (2011) and Mahdy *et al*. (2012). Talbert *et al*. (2001) reported intermediate heritability estimates (mean= 0.59) for grain yield, while Khan *et al*. (2003) reported a range of 65.58 to 90.01% for heritability of the same trait.

**Table (3): Mean squares for all studied traits in $F_4$ and $F_5$ generations for grain yield/plant under normal and heat stress conditions.**

| Generation | Dates | S.O.V | Mean Squares | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Grain yield /plant | Days to heading | Plant height | No. of spikes/plant | No. of kernels/spike | 100-kernel weight | Spike length |
| $F_4$ | N | Rep | 17.24 | 2.21 | 5.41 | 1.55 | 6.02 | 0.03 | 0.95 |
| | | Families | 28.57** | 2.94** | 128.86** | 2.91* | 27.88** | 0.22** | 1.52** |
| | | Error | 4.82 | 0.48 | 16.82 | 1.06 | 3.31 | 0.02 | 0.11 |
| | S | Rep | 1.92 | 0.72 | 0.42 | 1.05 | 0.32 | 0.01 | 0.87 |
| | | Families | 16.60** | 2.73** | 67.96** | 2.51** | 31.42** | 0.06* | 0.70** |
| | | Error | 3.16 | 0.56 | 10.07 | 0.40 | 6.51 | 0.02 | 0.20 |
| $F_5$ | N | Rep | 6.16 | 0.40 | 10.50 | 0.030 | 1.23 | 0.05 | 0.23 |
| | | Families | 7.96** | 1.99** | 27.87** | 0.89** | 12.36** | 0.18** | 0.70** |
| | | Error | 1.45 | 0.36 | 4.98 | 0.11 | 1.90 | 0.02 | 0.12 |
| | S | Rep | 2.39 | 0.03 | 15.83 | 0.03 | 8.53 | 0.04 | 0.04 |
| | | Families | 8.76** | 2.16** | 43.06** | 1.00** | 24.16** | 0.09** | 0.80** |
| | | Error | 2.19 | 0.33 | 7.50 | 0.11 | 4.27 | 0.01 | 0.14 |

*, ** Significant at 5% and 1% respectively.

**Table (4): Phenotypic ($\sigma^2$ p), Genotypic ($\sigma^2$ g) variance and corresponding coefficients of variability for grain yield in $F_3$ before and after two cycles of selection under normal (N) and heat stress (S) conditions.**

| Selection cycle | $\sigma^2$ p | | $\sigma^2$ g | | P.C.V | | G.C.V | | H% | | Realized heritability | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | S | N | S | N | S | N | S | N | S | N | S |
| $F_3$ Families ($C_0$) | 37.41 | 27.16 | 35.43 | 25.43 | 18.50 | 17.32 | 18.00 | 16.76 | 94.72 | 93.63 | - | - |
| $F_4$ selected families ($C_1$) | 9.52 | 5.53 | 7.92 | 4.48 | 8.43 | 7.88 | 7.69 | 7.09 | 83.15 | 80.98 | 49.47 | 40.90 |
| $F_5$ selected families ($C_2$) | 2.65 | 2.91 | 2.17 | 2.19 | 4.19 | 5.52 | 3.79 | 4.78 | 81.76 | 75.04 | 70.98 | 53.92 |

H = Heritability in broad sense

**3-2- Means and observed gain from selection under normal planting date:**

Means of the two groups of families selected for high grain yield/plant through two cycles, either under normal or heat stress conditions were evaluated in the $F_5$-generation under both environments are presented in Table 5.

Grain yield/plant of the group of families selected under normal planting date and evaluated under normal planting date, ranged from 36.18 to 41.00 with an average of 38.80 g/plant. The average observed gain from selection significantly (P<0.01) outyielded the bulk sample by 13.08% and the better parent by 25.04%. All the selected families showed highly significant gain from the bulk sample and the better parent which ranged from 5.45 to 19.50% and from 16.60 to 32.13%, respectively. The five selected families which significantly surpassed both the bulk sample and the better parent were no. 38, 41, 51, 63 and 74.

Grain yield of the group of families selected for grain yield/plant under heat stress and evaluated under normal planting date, ranged from 30.76 to 38.00 with an average of 35.03 g/plant. The average observed gain significantly (P<0.01) outyielded the bulk sample by 3.36% and the better parent by 15.04%. The three selected families no. 29, 44 and 78 significantly surpassed both the bulk sample and the better parent.

**3.3- Means and observed gains under late planting date evaluation:**

The two groups of families selected for high grain yield/plant for two cycles either under normal or under heat stress were evaluated in the $F_5$-generation under both environments and presented in Table 5.

The group of families selected under normal planting date and evaluated under the late planting date, ranged in grain yield/plant from 29.56 to 32.23 with an average of 31.00 g/plant. The average observed gain was significant and reached 6.73 and 16.05% compared to the bulk sample and the better parent; respectively. All the selected families under normal planting, except family no. 70, showed significant (P<0.01) observed gain from the bulk sample, while, all selected families showed significant observed gain from the better parent, which ranged from 10.67 to 20.67%.

The average grain yield of families selected under heat stress and evaluated under late planting date after two cycles, ranged from 28.77 to 33.07 with an average of 30.60 g/plant. The average observed gain in grain yield/plant was significant and accounted for 7.78 and 22.10% from the bulk sample and the better parent; respectively. Six families showed highly significant observed gain compared to the bulk sample, while all the selected families showed highly significant observed gain from the better parent. The three families no. 29, 44 and 66 gave the highest grain yield when compared to both the bulk sample or the better parent. These results are in line with those reported by many investigators (Ismail (1995), Amin (2003), Ahmed (2006) and El-Morshidy *et al*. (2010). Kheiralla (1989) noted that pedigree selection for grain yield *per se* increased grain yield by 20.81% of the bulk sample. Ismail (1995) reported genetic gains in grain yield over the bulk sample and the better parent of 8.47 and 4.86 % in one population, and 6.96 and 6.41% in another population; respectively. Kheiralla *et al.* (2006), after two cycles of selection for grain yield/plant, achieved genetic gain of 20.21 and 7.62% from the bulk sample and the better parent, respectively.

**Table (5): Mean grain yield/plant and observed gain from the bulk sample (OG%"Bulk") and from the better parent (OG%"BP") for the selected families after two cycles of selection under normal planting date and heat stress.**

| Item | Fam. No. | Evaluation under normal planting date | | | Evaluation under late planting date | | |
|---|---|---|---|---|---|---|---|
| | | Mean GY/P;g. | OG%(Bulk) | OG%(Bp) | Mean GY/P;g. | OG%(Bulk) | OG%(Bp) |
| Normal selections | **4** | 37.05 | 7.99** | 19.40** | 31.93 | 9.95** | 19.54** |
| | **36** | 37.47 | 9.21** | 20.75** | 32.23 | 10.98** | 20.67** |
| | **38** | 39.67 | 15.62** | 27.84** | 30.39 | 4.65** | 13.78** |
| | **41** | 41.00 | 19.50** | 32.13** | 30.03 | 3.41* | 12.43** |
| | **51** | 39.23 | 14.34** | 26.43** | 31.26 | 7.64** | 17.03** |
| | **63** | 41.00 | 19.50** | 32.13** | 30.48 | 4.96** | 14.11** |
| | **70** | 36.18 | 5.45** | 16.60** | 29.56 | 1.79 | 10.67** |
| | **74** | 39.80 | 16.00** | 28.26** | 30.97 | 6.65** | 15.95** |
| | **75** | 38.17 | 11.25** | 23.01** | 31.55 | 8.64** | 18.12** |
| | **81** | 38.44 | 12.04** | 23.88** | 31.57 | 8.71** | 18.20** |
| | **Average** | 38.80 | 13.08** | 25.04** | 31.00 | 6.73** | 16.05** |
| Heat selections | **3** | 31.59 | -6.79* | 3.74 | 28.77 | 1.34 | 14.80** |
| | **4** | 32.94 | -2.80 | 8.18* | 29.15 | 2.68 | 16.32** |
| | **17** | 30.76 | -9.24** | 1.02 | 29.22 | 2.92* | 16.60** |
| | **25** | 38.00 | 12.13** | 24.79** | 30.20 | 6.38** | 20.51** |
| | **29** | 36.83 | 8.68** | 20.95** | 32.62 | 14.90** | 30.17** |
| | **44** | 37.58 | 10.89** | 23.42** | 32.63 | 14.93** | 30.21** |
| | **66** | 35.76 | 5.52 | 17.44** | 33.07 | 16.48** | 31.96** |
| | **72** | 32.91 | -2.89 | 8.08** | 29.76 | 4.83** | 18.75** |
| | **75** | 36.22 | 6.88* | 18.95** | 31.31 | 10.29** | 24.94** |
| | **78** | 37.72 | 11.30** | 23.88** | 29.26 | 3.06* | 16.76** |
| | **Average** | 35.03 | 3.36** | 15.04** | 30.60 | 7.78** | 22.10** |
| **R.LSD$_{0.05}$** | | 2.11 | -- | -- | 0.80 | -- | -- |
| **R.LSD$_{0.01}$** | | 2.90 | -- | -- | 1.09 | -- | -- |

Also, Mahdy *et al* (2012) observed that gains from two cycles of selection for grain yield accounted for 45.00 and 61.53% from the bulk sample and the better parent, respectively. These results indicated that the selected families under normal or heat stress conditions must be evaluated under the same conditions. It is will known that genes responsible for grain yield are completely different from those affecting stability. So, the families selected for high grain yield under normal conditions and those selected under heat stress must be involved in a breeding program.

**3.4-Average observed gain from selection for grain yield/plant in the two cycles:**

Means and observed gain from selection for high grain yield/plant are shown in Table 6. The observed gain from selection for high grain yield/plant under normal planting date was 24.61 and 34.54%, while under heat stress was 27.44 and 12.98% from the better parent in $C_0$ and $C_1$, respectively. It may be noticed from these results that selection for grain yield/plant under late planting in the $F_5$-generation was more effective. This may be due to the increased level of homozygosity in the $F_5$-generation, and which made it possible to identify the genetically superior genotypes. Therefore, as mentioned above, the results of these materials suggest delaying selection for grain yield/plant to the $F_5$-generation to save costs and efforts.

The observed gain in grain yield of families selected under normal and evaluated under both normal and heat stress was 25.04 and 14.94% from the better parent, respectively. On the other hand, these gains were 16.06 and 22.11% for families selected under heat stress and evaluated under normal and heat stress, respectively.

**Table (6): Mean and observed gain from selection for grain yield/plant under normal and heat stress from the bulk sample and the best parent.**

| Cycle and means | Normal planting date (N) | | Heat stress (S) | |
|---|---|---|---|---|
| **Base Pop.($C_0$):2008/2009** **Families mean** | 33.06 | | 30.09 | |
| **Giza 168** | 23.12 | | 22.63 | |
| **Anza** | 26.53 | | 23.61 | |
| **Bulk sample** | 28.00 | | 28.55 | |
| **OG % (Bulk)** | 18.07** | | 5.39** | |
| **OG %(Better parent)** | 24.61** | | 27.44** | |
| **Cycle 1: 2009/2010** **Families mean** | 36.61 | | 29.85 | |
| **Giza 168** | 27.21 | | 26.42 | |
| **Anza** | 24.39 | | 24.12 | |
| **Bulk sample** | 33.37 | | 27.92 | |
| **OG % (Bulk)** | 9.70** | | 6.91** | |
| **OG %(Better parent)** | 34.54** | | 12.98** | |
| **Cycle 2: 2010/2011** | **Normal date** | **Heat stress** | **Normal date** | **Heat stress** |
| **Families mean** | 38.80 | 35.00 | 31.00 | 30.60 |
| **Giza 168** | 31.03 | 29.04 | 26.71 | 25.06 |
| **Anza** | 25.08 | 30.45 | 24.74 | 23.34 |
| **Bulk sample** | 34.31 | 33.89 | 29.08 | 28.39 |
| **OG % (Bulk)** | 13.08** | 3.27** | 6.60** | 7.78** |
| **OG %(Better parent)** | 25.04** | 14.94** | 16.06** | 22.11** |

* and **; Significant at 0.05 and 0.01 levels of probability, respectively.
OG% (Bulk) = observed gain in percentage from the bulk sample.
OG% (Bp)= observed gain in percentage from the better parent.

**3-5-Heat susceptibility index, sensitivity to environment and correlation coefficients:**

Heat susceptibility index, sensitivity to environment and correlation coefficients in $F_5$-generation are presented in Table 7.

The results of the selected families for two cycles under normal planting date, and evaluated under both environments indicated that five families no. 4, 36, 70, 75 and 81 showed heat susceptibility index (HSI) values less than one. Likewise, under late planting date, and evaluation under both environments indicated that the six families no. 3, 4, 17, 29, 66 and 72 gave heat susceptibility index (HSI) values less than one. These families could be considered less susceptible to heat. The results obtained by Khanna-Chopra and Viswanathan (1999) suggested that the yield under heat stress relative to control or optimum conditions is widely accepted as an indication of heat-tolerance in wheat. Genotypes having HSI ≤ 0.500 were considered to be highly tolerant, HSI > 0.500 to ≤ 1.000 moderately tolerant and those having HSI > 1.000 were susceptible. Salous (2007) found that values of heat susceptibility index (HSI) for the parents ranged from 0.37 for Sids 4 to 0.95 for Debeira, and ranged from 0.10 to 1.46 for the $F_1$ hybrids

Two cycles of pedigree selection for grain yield/plant indicated that selection at normal date (synergistic selection) increased the sensitivity in eight families and decreased sensitivity in two families. Likewise, selection at late planting (antagonistic selection) increased the sensitivity in two out of the ten families and decreased sensitivity in only eight families. Jinks and Connolly (1973 and 1975) concluded that environmental sensitivity was reduced if selection and environmental effects were in opposite direction but sensitivity was increased if selection and environment effects were in the same direction. Kheiralla *et al*. (2006) found that antagonistic selection reduced sensitivity of the families and increased synergistic effects.

A highly significant and positive correlation was established between mean grain yield/plant under normal planting and the heat susceptibility index (HSI) (r = 0.88**), Table 7. On the other hand, correlation coefficients between HSI and each of days to heading and grain yield under heat stress were negative and significant, i.e. r = – 0.66* and r = – 0.71*, respectively. Under late sowing results showed highly significant and positive correlation between the mean grain yield/plant under normal and HSI (r = 0.75**). Likewise, negative but insignificant correlations between HSI and each days to heading and grain yield under heat stress were r = -0.08 and r = -0.11, respectively. This may indicate that about 50% of the variation in heat susceptibility in this set of genotypes could be ascribed to variation in yield potential. Therefore, a stress tolerant genotype, as defined by (HSI), need not to have a high yield since (HSI) provides a measure of tolerance based on minimization of yield loss under stress, rather than no stress yield *per se* as pointed out by Bruckner and Frohberg (1987). These results are in harmony with the results of Kheiralla (1994) who found a low negative correlation between grain yield under favourable and (DSI) was reported as (r= -0.22).

**Table (7): Mean of grain yield/plant, days to heading, heat susceptibility index (HSI) and sensitivity two dates after two cycles of selection in the $F_5$-generations and correlations between them.**

| Item | Fam. No. | under normal date | | under heat stress | | HSI | Sensitivity |
|---|---|---|---|---|---|---|---|
| | | Gy/P (N) | HD(N) | Gy/P (S) | HD(S) | | |
| Normal planting date | 4 | 37.05 | 83.33 | 31.93 | 77.67 | 0.69 | 0.97 |
| | 36 | 37.47 | 84.67 | 32.23 | 77.33 | 0.70 | 0.99 |
| | 38 | 39.67 | 83.00 | 30.39 | 76.33 | 1.16 | 1.76 |
| | 41 | 41.00 | 83.00 | 30.03 | 75.33 | 1.33 | 2.08 |
| | 51 | 39.23 | 83.33 | 31.26 | 76.00 | 1.01 | 1.51 |
| | 63 | 41.00 | 84.67 | 30.48 | 75.00 | 1.28 | 2.00 |
| | 70 | 36.18 | 83.33 | 29.56 | 76.67 | 0.91 | 1.26 |
| | 74 | 39.80 | 84.67 | 30.97 | 77.33 | 1.10 | 1.68 |
| | 75 | 38.17 | 83.33 | 31.55 | 75.33 | 0.86 | 1.26 |
| | 81 | 38.44 | 84.00 | 31.57 | 76.67 | 0.89 | 1.30 |
| | Average | 38.80 | 83.73 | 31.00 | 76.37 | -- | 1.48 |
| Correlation | Gy/P(N) | -- | 0.12 | – 0.29 | – 0.61 | 0.88** | |
| | HD(N) | -- | -- | 0.34 | 0.22 | – 0.07 | |
| | Gy/P(S) | -- | -- | -- | 0.44 | – 0.71* | |
| | HD(S) | -- | -- | -- | -- | – 0.66* | |
| | HSI | -- | -- | -- | -- | -- | |
| Late planting date ( heat stress) | 3 | 31.59 | 75.33 | 28.77 | 73.33 | 0.71 | 0.51 |
| | 4 | 32.94 | 76.67 | 29.15 | 75.00 | 0.91 | 0.69 |
| | 17 | 30.76 | 77.67 | 29.22 | 73.33 | 0.40 | 0.28 |
| | 25 | 38.00 | 75.33 | 30.20 | 72.33 | 1.62 | 1.42 |
| | 29 | 36.83 | 75.00 | 32.62 | 72.67 | 0.90 | 0.77 |
| | 44 | 37.58 | 78.67 | 32.63 | 74.33 | 1.04 | 0.90 |
| | 66 | 35.76 | 79.00 | 33.07 | 74.00 | 0.59 | 0.49 |
| | 72 | 32.91 | 79.67 | 29.76 | 72.67 | 0.76 | 0.57 |
| | 75 | 36.22 | 77.67 | 31.31 | 73.00 | 1.07 | 0.89 |
| | 78 | 37.72 | 79.33 | 29.26 | 74.00 | 1.77 | 1.54 |
| | Average | 35.03 | 77.43 | 30.60 | 73.47 | -- | 0.81 |
| Correlation | Gy/P(N) | -- | 0.05 | 0.58 | – 0.09 | 0.75** | |
| | HD(N) | -- | -- | 0.11 | 0.33 | – 0.03 | |
| | Gy/P(S) | -- | -- | -- | – 0.02 | – 0.11 | |
| | HD(S) | -- | -- | -- | -- | – 0.08 | |
| | HSI | -- | -- | -- | -- | -- | |

**References:**

Abdel-Shafi, A.M.; A.M. Abdel-ghani; M.B. Tawfelis; M.G. Mossaad and M.KH. Moshref. 1999. Screening of wheat germplasm for heat tolerance in Upper Egypt. Egypt. J. Plant Breed., 3: 77-87.

Abdel-Karim, A.A. 1991. Evaluation of some wheat germplasm under stresses. M.Sc. Thesis, Fac. of Agric., Assiut Univ., Egypt.

Ahmad, T.A. 2006. Efficiency of late and early selection for grain yield under different selection criteria and DNA marker polymorphism in wheat (*Triticum aestivum* L). Assiut J. of Agric. Sci., 37 (2): 3-16.

Ali, M.A. 2011. Response to pedigree selection for earliness and grain yield in spring wheat under heat stress. Asian J. Crop Sci., 3: 118-129.

Amin, I.A 2003 Selection for drought tolerance in wheat. Ph.D. Thesis, Agron. Dep. Fac. Agric., Minia Univ., Egypt.

Bruckner, P.L. and R.C. Frohberg. 1987. Stress tolerance and adaptation in spring wheat. Crop Science, 27(1): 31-36.

Burton, G.W. 1952. Quantitative inheritance in grasses. 6th Int. Grassland Cong. Proc., 1: 227-283.

Chander, S.; R.B. Srivastava and M.D. Yunus. 1993. Impact of intermating on population mean and genetic advance in wheat (*Triticum aestivium* L. em Thell). Cereal Res. Commun., 21(2-3): 201-206.

El-Karamity, A.E., M.A. Salem, A.M. Tammam and M.Y.G. Mobarek. 2007. Efficiency of some breeding methodologies on some bread wheat populations under new valley conditions. Ph.D. Thesis, El-Minia Univ., Egypt.

El-Morshidy, M.A.; K.A.A. Kheiralla and M.M. Zakaria. 2001. Studies on grain filling under different planting dates in wheat. The second Pl. Breed. Conf. Assiut Univ., October (2): 241-263.

El-Morshidy, M.A.; K.A.A. Kheiralla, M.A. Ali A.A. Said. 2010. Response to selection for earliness and grain yield in wheat (*Triticum aestivum* L.) under normal and water stress conditions. Assiut J. of Agric. Sci., 41: 1-23.

Falconer, D.S. 1989. Introduction to quantitative Genetics. 3rd ed. Longman, Hong Kong, pp 438.

Falconer, D.S. 1990. Selection in different environments: effects on environmental sensitivity (reaction norm) and performance. Genet. Res. Comb. 56: 57 - 70.

Fischer, R.A. and D.R. Byerlee. 1991. Trends of wheat production in the warmer areas: major issues and economic considerations. In: D. A. Saunders (ed). Wheat for Nontraditional warm areas. Mexico, D. E. CYMMYT, PP. 3-27.

Fischer, R.A. and R. Maurer. 1978. Drought resistance in spring wheat cultivars. I. Grain yield response Aust. J. Agric. Res. 29: 897-912

Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons. Inc. New York, USA.

Ismail, A.A. 1995. Pedigree selection for grain yield, grain weight and earliness in two segregating populations of spring wheat.

Assiut J. of Agric. Sci., 26(4): 59-72.

Jinks, J.L. and H.S. Pooni. 1982. Determination of the environmental sensitivity of selection lines of *Nicotiana rustica* by selection environment. Heredity, 49:291-294.

Jinks, J.L. and V. Connolly. 1973. Selection for specific and general response to environmental differences. Heredity, 30:33-40.

Jinks, J.L. and V. Connolly. 1975. Determination of environmental sensitivity of selection lines by the selection environment. Heredity, 34:401-406.

Khan, A.S., I. Salim and Z. Ali. 2003. Heritability of various morphological traits in wheat. Int. J. Agric. Biol., 5:138-140.

Khanna-Chopra, R. and C. Viswanathan. 1999. Evaluation of heat stress tolerance in irrigated environment of *T.aestivum* L. and related species. I- Stability in yield and yield components. Euphytica, 106: 169-180.

Kheiralla, K.A. 1989. Predicted gain from single and multiple traits selection in a segregating population of wheat, *Triticum aestivum*. Assiut J. Agric. Sci., 20(2): 345-355.

Kheiralla, K.A.; E.E. Mahdy and R.A. Dawood. 1993. Selection for early and correlated response in grain yield and its components of spring wheat. Assiut J. of Agric. Sci., 24(4): 95-106.

Kheiralla, K.A., M.A. El-Morshidy and M.M. Zakaria. 2001. Inheritance of earliness and yield in bread wheat under favourable and late sowing dates. The second Pl. Breed. Conf. October 2, 2001. Assiut University, 219-239.

Kheiralla, K.A., M.A. El-Morshidy, A.M. Tammam and M.M. Zakaria. 2006. The efficiency of selection and environmental sensitivity for grain yield in wheat. Symposium: Status and Improvement Horizons of Field Crops in the Arab World. 30-31 October, 2006, Alepo Univ., Syria.

Kheiralla, K.A. 1993. Selection response for grain yield and its components in as segregating population of spring wheat. Assiut J. of Agric. Sci., 24(3): 87-98.

Kheiralla, K.A. 1994. Inheritance of earliness and its relation with yield and drought tolerance in spring wheat. Assiut J. of Agric. Sci., 25(5): 129-139.

Mahdy, Rasha, E. 2012. Response to selection for earliness and yield in bread wheat under normal and drought conditions. Ph.D. Thesis, Fac. Agric. Assiut Univ. Agron. Dept. Egypt.

Mahdy, E.E.; A.E. El-Karamity; S.A. Mokadem and H.M. Fouad. 2012. Selection for yield and its components in two segregating populations of bread wheat (*Triticum aestivum* L.). Minia Int. Conf. Agric. Irrig. in the Nile Basin Coun., 26th -29th March 2012,p. 595-604.

Omara, M.K., M.M. El-Defrawy, A.M. Tammam and A.A.F. Kassam. 2004. Genetic control of pre-anthesis attributes of wheat plant and their associations with yield under heat stress. Assiut J. Agric. Sci. Vol. 35(4): 97-115.

Poehlman, J.M. (1979). Breeding Field Crops, 2nd edition. AVI Publishing Company Inc. Wastport, Comm. U.S.A. pp. 483.

Poonam, S.N.; K.V. Sumesh; V.D. Lohot and M.C. Ghildiyal. 2006. High temperature effect on grain growth in wheat cultivars: an evaluation of response. Indian Journal of plant physiology, 11 (3): 239-245.

Reynolds, M.P.; Nagarajan, S.; Razzaque, M.A. and O.A.A Ageeb. 2001. Heat stress. In: Reynolds MP, Ortiz-Monasterio JI and McNab A (eds) Application of physiology in wheat breeding. Mexico, D.F CIMMYT.

Salous, M.SH. 2007. Studies on combining ability and heterosis in some bread wheat crosses under high temperature conditions in Upper Egypt. M.Sc. Agron. Dep., Fac. Agric., Assiut Univ., Egypt.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. Mc Grow-Hill Book Co., Inc., New York.

Talbert, L.E., S.P. Lanning, R.L. Murphy and J.M. Martin. 2001. Grain fill duration in twelve hard red spring wheat crosses: Genetic variation. Crop Sci., 41: 1390-1395.

Tawfelis, M.B.; M.A. El-Morshidy; K.A.A. Kheiralla and Y.M. Feltaous. 2010. Performance and stability parameters of some bread wheat genotypes (*Triticum aestivum* L.) under different environments in Upper Egypt. Egypt. J. Agric. Res., 88 (1): 135-158.

Walker, T.T. 1960. The use of a selection index technique in the analysis of progeny row data. Emp. Cott. Rev., 37: 81-107.

Wardlaw, I.F. and C.W. Wrigley. 1994. Heat tolerance in temperature cereals; an overview. Austr. J. Plant Physiol., 21: 698-703.

Zakaria, M.M. 2004. Selection for earliness and grain yield in bread wheat (*Triticum aestivum* L.) under different environmental conditions. Ph.D. Thesis, Fac. of Agric., Assiut Univ., Egypt .

**الإنتخاب لمحصول الحبوب فى قمح الخبز( تريتيكم أسيتيفم ل.) تحت الظروف المثلي وظروف الاجهاد الحرارى**

**موسى شوقى سلوس[١] ، محمد عبد المنعم المرشدى[٢]، كمال عبده خيرالله[٢]، محمد خلف مشرف[١]**
[١] قسم بحوث القمح ، معهد المحاصيل الحقلية ـ مركز البحوث الزراعية.
[٢] قسم المحاصيل – كلية الزراعة – جامعة أسيوط.

**الملخص:**

يهدف هذا البحث إلى دراسة كفاءة الانتخاب المنسب في تحسين محصول الحبوب/للنبات تحت ظروف ميعادى الزراعة الأمثل والمتأخر. بعد دورتين من الانتخاب تحت ميعادي الزراعة الأمثل والمتأخر للعشيرة القاعدية والجيل الرابع للهجين (جيزة ١٦٨ × أنزا). وفى السنة الثالثة تم تقييم منتخبات الميعاد الأمثل والمتأخر تحت ظروف البيئتين. وكان مقدار التباين الوراثى أقل قليلا من التباين المظهرى تحت ظروف البيئتين، وانخفض تدريجيا من الجيل الثالث الى الجيل الخامس. وكانت كفاءة التوريث بالمعنى الواسع لصفة محصول النبات تحت ميعاد الزراعة الأمثل ٨١,٧٦ و٧٥,٠٤ % ، على الترتيب. كما كانت كفاءة التوريث الفعلية تحت ميعاد الزراعة الأمثل ٤٩,٤٧ و ٧٠,٩٨% مقابل ٤٠,٩٠ و ٥٣,٩٢% تحت تاثير الحرارة للدورة الأولي والثانية علي الترتيب. وقد أظهرت التراكيب الوراثية المنتخبة ضمن المجموعة الاولى (الميعاد الأمثل) والمجموعة الثانية ( الميعاد المتأخر) والتى جرى تقييمها تحت ميعاد الزراعة الأمثل زيادة معنوية جدا بالنسبة للعينه العشوائية بمقدار ١٣,٠٨ و ٣,٣٦% و بمقدار ٢٥,٠٤ و ١٥,٠٤% بالنسبة للاب الامثل على الترتيب. وعند تقييم المنتخبات تحت ميعاد الزراعة المتأخر أظهرت منتخبات المجموعة الأولى (الميعاد الأمثل) والمجموعة الثانية (الميعاد المتأخر) زيادة معنويه لمحصول الحبوب بمقدار ٦,٧٣% و ٧,٧٨% بالنسبة للعينة العشوائية و بمقدار ١٦,٠٥ و ٢٢,١٠ % بالنسبة للاب الافضل على الترتيب. وتشير النتائج إلي أن الانتخاب لمحصول الحبوب فى ميعاد الزراعة الأمثل أدى الى زيادة حساسية العائلات المنتخبة، بينما كانت العائلات المنتخبة اقل حساسية للظروف البيئية فى نهاية الموسم.