

Response to Selection for Earliness and Grain Yield in Wheat (*Triticum aestivum* L.) Under Normal and Water Stress Conditions.*

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Abstract:

This study was carried out during the period from 2004/05 to 2006/07 growing seasons, at Faculty of Agriculture, Sohag University, Egypt to estimate observed and expected response to selection and other genetic parameters and calculate drought susceptibility index. Results revealed highly significant differences between F₃ and F₄ families under normal and drought conditions for days to heading, spike length, no. of spikes/plant, no. of kernels/spike, 100-kernel weight and grain yield/plant.

Observed direct response to selection for days to heading was negative and highly significant compared with bulk and the check cultivar in F₄ with values of -5.58 and -13.88 % and -6.13 and -13.88 % under normal and drought conditions, respectively. The expected response to selection was 3.15 and 3.68% under normal and drought conditions, respectively. Observed direct

response to selection for grain yield/plant was positive and highly significant compared with bulk, better parent and the check in F₄ with values of 28.19, 18.59 and 26.09 % and 27.49, 16.67 and 21.20 % under normal and water stress conditions, respectively. On the other hand, the expected response to selection was 11.98 and 9.06% under normal and drought conditions, respectively.

Phenotypic and genotypic coefficients of variation under normal conditions for days to heading of the early families were 4.75 and 4.26% in F₃ and 5.17 and 4.84% in F₄ generation, respectively. While under drought stress conditions those values were 4.26 and 4.05% in F₃ and 4.84 and 4.78% in F₄ generation, respectively. Phenotypic coefficient of variation for grain yield of the highest yielding families under favourable conditions was 14.57 and 13.40 % in F₃ and F₄ generations, respectively, while, it was 13.32 and 12.43 % in the same generations, respectively under water stress conditions.

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Likewise the genotypic coefficient of variability under normal conditions was 12.48 and 11.96 % in F₃ and F₄ generations, respectively. Meanwhile, it was 10.82 and 10.89 % under drought stress conditions in the two generations, respectively.

High broad sense heritability values for days to heading of the early families was obtained under normal and drought stress in F₃ and F₄ generations. While narrow sense heritability was 34.34 and 39.40 % in F₄ generation under normal and drought stress, respectively. The broad sense heritability for grain yield/plant of the highest yielding families was high under normal and water stress in F₃ and F₄ generation, while, the narrow sense heritability was 53.34 and 43.43 % in F₄ generation under the two studied conditions, respectively. These results showed that the pedigree method of selection was effective to produce new lines tolerant to drought stress with high grain yield.

Drought susceptibility index showed that the nine families, i.e., no. 19, 22, 24, 25, 33, 35, 37, 38 and 39 produced relatively high grain yield under drought stress environments due to high yield potential, rather than having low susceptibility to stress environments. These genotypes could be used as source of drought tolerance/or factors contributing to general adaptation.

Introduction:

Wheat is considered the most important cereal crop in terms of

area and production. In Egypt, wheat production is far below to meet the local consumption of the growing population of the country which resulted in increasing wheat imports. The total wheat production in 2008 season was 8 million metric tons obtained from 3 million feddans and the annual consumption of wheat was about 14 million metric tons so the imported wheat was about 6 million tons (F.A.O. Statistic Year Book, 2009). Increasing wheat production vertically and horizontally became an important target to reduce the amount of wheat imports, save hard currency and provide enough quantity to meet the increase in internal demands. These targets could be realized through expanding wheat cultivated area in the new reclaimed areas as well as rainfed area with using drought tolerant wheat cultivars. Such cultivars could help increasing land use efficiency.

In Egypt, earliness has several advantages, for instance, early cultivars are highly needed to fit in new crop intensive rotation as planting cotton after wheat and planting wheat after harvesting short duration vegetable crops, ect. Also, early cultivars are also preferred to escape drought, heat, diseases, pests and other stress injuries that occur at the end of growing season (Menshawy, 2007).

The efficiency of a breeding program for drought tolerance depends largely on the efficiency of selection criteria and the selec-

tion method used to achieve genetic improvement through selection. In addition to the complexity of drought itself (Passioura, 1996, 2007), plant response to drought is complex and different mechanisms are adopted by plants when they encounter drought (Levitt 1980, Jones et al. 1981, Jones 2004). The most important mechanism is drought escape by rapid development which allows plants to finish their cycle before severe drought stress occur, so the selection for earliness is very beneficial to drought tolerance. Nasr and Ghoshe (1977) found 92% heritability estimate for heading date in segregated wheat population grown under rainfed conditions in semi-arid region of the Middle East in Iran. Broad and narrow sense heritabilities for heading date were 0.87 and 0.85 (Calzolari *et al.*, 1980). The broad sense heritabilities for heading date ranged from 82.4 to 90.8 % in seven crosses (Das and Razaque, 1983)

The increase in wheat grain yield is considered the final goal for breeding programs under drought conditions to face the growing population requirements (Tammam et al., 2004a and b), thereby it has been advocated to develop genotypes, which consistently show superior yields. In the breeding programs the first step is to identify the superior tolerant genotypes to be used. Heritability estimates of developmental traits in spring wheat were inter-

mediate to high (Mou and Kronstad, 1994 and Menshawy, 2007). Heritability of days to heading and grain yield has been studied under drought conditions by many investigators. Broad sense heritability for days to heading and grain yield were high (Calzolari *et al.*, 1980, Kheiralla *et al.*, 1993, Wiersma *et al.*, 2001 and Shamroukh, 2006) On the other hand, narrow sense heritability values were moderate for days to heading and grain yield/plant (Attia, 2003 and Shamroukh, 2006). Information about association of earliness and grain yield and its components can help breeders for increasing the selection efficiency (Menshawy, 2007).

The objective of this study was to estimate the selection response for earliness and grain yield under normal and drought stress conditions.

Material and methods

The present study was carried out during the period from 2004/2005 to 2006/2007 growing seasons, at Faculty of Agriculture, Sohag University, Egypt, to estimate the response to selection (i. e. pedigree selection) under normal and water stress conditions, in early generations of a bread wheat (*Triticum aestivum* L. em. Thel) population originated from the cross between Sids 4 and Tokwie. The genetic parameters were estimated in F3 and F4 generations. The pedigree and origin of the two parents and the check (Sahel 1) is presented in table 10

Table (1): The pedigree and origin of the parents and the check (Sahel 1) used in this study.

Parental name	Pedigree	Origin
Sids 4(P1)	May'S/Mon'S//CMH74A.592/ 3/Giza 157*2	Egypt
Tokwie (P2)	-----	South Africa
Sahel 1	NS 732/PIMA//Veery'S'	ICARDA

In the 2004 / 05 season, 1000 plants of F₂ generation were grown in four non-replicated plots. Each plot consisted of 12 rows 3 m long, 20 cm apart and grain spaced 10 cm within row (average 30 individual plant/row). Also, the parents and the local check (Sahel 1, drought tolerant) were grown alongside each a row. The cultural practices were carried out as recommended for wheat production. Data were collected on 600 harvested plants. Data were recorded on number of days to heading, No of spikes/plant, 100 kernels weight and grain yield/plant for each individual plant. The 60 highest yielding plants and 60 earliest plants were selected. An equal number of grains from each plant (600 plants) were bulked to give F₃ random bulk sample.

In the 2005/06 season, two field experiments were conducted each in a randomised complete block design of four replications. The first experiment did not receive any irrigation after jointing stage (drought stress "D"), while the other one was grown in supplemental water applied regularly as recommended (Normal "N"). Each selected plant from the F₂ generation was planted in the two

experiments. Each experiment comprised 120 F₃ families (60 high yielding and 60 early families). At the end of the season, the 15 earliest and 16 high yielding families were identified from both experiments after the statistical analysis. The best plant from each of these families was saved (31 plants; 15 for earliness and 16 high yielding).

In 2006/07 season (F₄ generation), two field experiments were conducted as in the previous season. The selected plants from the F₃ generation (31 plants) were evaluated under stressed and normal irrigated conditions; along with the two parents, bulk sample and the check cultivar Sahel 1. Days to 50% heading, spike length, no. of spike/plant, no. of kernel/spike, 100-kernel weight and grain yield/plant were recorded.

The analysis of variance for randomized complete block design was carried out according to Snedecor and Cochran (1980).

1- The observed and expected response to selection were calculated using the following formula :

Observed response: the difference between the mean of the

selected families and the mean of bulk population, best parent and check cultivar.

Expected response = $i H_n \sigma_p$
 where σ_p = is the phenotypic standard division, H = narrow

sense heritability and i = selection intensity.

The degrees of freedom and expected mean squares are present in Table (2).

Table (2): the analysis of variance and expected means of squares:

Source of variance	D.F	M . S	E . M . S
Replication	r - 1	M ₃	$\sigma^2_e + g \sigma^2_r$
Genotypes	g - 1	M ₂	$\sigma^2_e + r \sigma^2_g$
Error	(r - 1) (g - 1)	M ₁	σ^2_e

2 - The genotypic variance $\sigma^2_g = M_2 - M_1/r$

3 - The phenotypic variance $\sigma^2_p = \sigma^2_g + \sigma^2_e$

4 - The genotypic (G.C.V%) and phenotypic (P.C.V%) coefficient of variability were calculated as σ_g / \bar{x} and σ_p / \bar{x} respectively .

5 - Heritability in the broad sense (H) was estimated as the ratio of genotypic (σ^2_g) to the phenotypic ($\sigma^2_g + \sigma^2_e$) variance according to Walker (1960).

6 - Heritability in the narrow sense was estimated using the correlation and offspring regression according to Smith and Kinman (1965) as follow:-

Parent - offspring generation

$$r_{xy} \quad h = b/2r_{xy}$$

$$F_2, F_3 \quad 3/4 \quad 2/3 \quad b \quad F_3, F_2$$

$$F_3, F_4 \quad 7/8 \quad 4/7 \quad b \quad F_4, F_3$$

7 - The genetic parameters were estimated as outlined by Mather and Jinks (1977) and Falconer (1989).

8 - Comparisons among means were calculated by using revised L.S.D where, L.S.D = least sig-

nificant difference, and was calculated as:

$$R L S D_\alpha = (t)_\alpha * \sqrt{(2MSE / r)}$$

(El Rawi and Khalafalla 1980)

Where t is the t value from "minimum-average-risk t-table" at F-value of treatments, treatment df and experimental error df.

9 - The significance of observed direct and correlated response to selection was measured as deviation percentage of families mean from the bulk or the better parent or the check using L. S. D. where, L.S.D = least significant differences between the bulk or the better parent or the check values and mean of the selected families, and was calculated as:

$$L.S.D = \sqrt{(MSE / r + MS_E/fr)} * t_\alpha$$

Where f: number of families r: number of replicates

Drought susceptibility Index (S): was calculated according to the method of Fischer and Maurer (1978).

Results and discussion

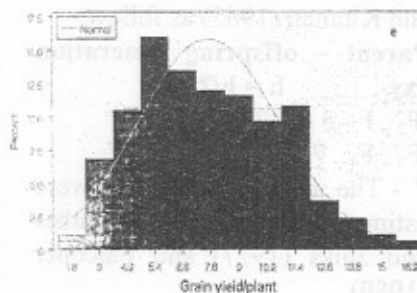
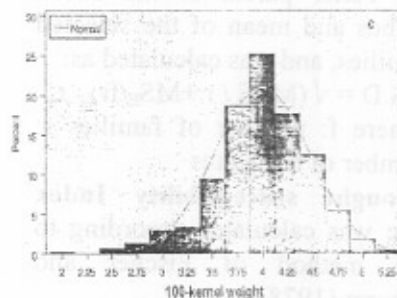
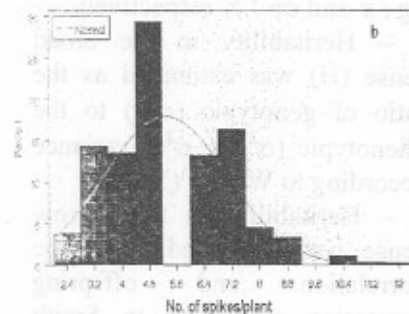
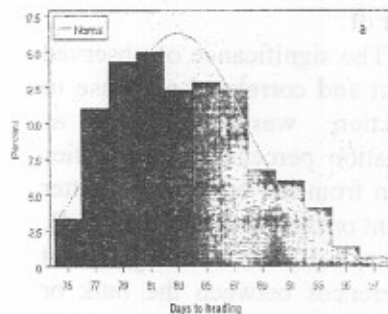
I- Evaluation of the base population (F₂ -generation).

The results in Table (3) indicated that number of days to 50 % heading ranged from 74.00 to 97.00 with an average of 82.98 days and variation coefficient was 5.91 in F₂ generation under normal conditions (see histogram a). The average number of spikes/plant was 5.28 with a range from 2.00 to 11.00 and variation coefficient was 33.84 in F₂ under normal conditions, as

shown histogram (b). The average 100-kernel weight ranged from 2.00 to 5.26 with an average of 3.99 and coefficient of variation was 11.89 in F₂ (histogram c). The average grain yield/plant ranged from 1.36 to 16.62 with an average of 7.70 and coefficient of variation was 39.29 in F₂ generation (see histogram d).

Table (3): Range, mean and coefficient of variation in F₂ plants for days to heading, no. of spikes/plant, 100-kernel weight and grain yield/plant under normal conditions.

Trait	Range	Means±S.E	C.V. %
1-Days to heading	74.00 – 97.00	82.98±0.20	5.91
2-No. of spikes / plant	2.00 – 11.00	5.28±0.07	33.84
3-100 kernel weight (gm)	2.00 – 5.26	3.99±0.02	11.89
4-Grain yield / plant (gm)	1.36 – 16.62	7.70±0.12	39.29



Histograms (a, b, c and d) shows the normal distribution of days to heading , no. of spikes/plant, 100 kernel weight and grain yield/plant as traits on the F₂ plants under normal conditions

Selection for earliness.

1-Response to direct selection for early heading under normal and water stress conditions.

The analysis of variance for all studied traits (Table 4) showed highly significant differences among F₃ and F₄ families under normal and water stress conditions.

Data presented in Table (5) showed that number of days to 50 % heading in the F₄ generation ranged from 68.50 to 82.50 with an average of 71.05 days and from 68.00 to 73.00 with an average of 70.46 days under normal and water stress conditions, respectively. The four families, i.e., no. 35, 37, 56 and 89 from earliness selection were significantly earlier than the earlier parent in days to heading under normal and water stress conditions. Meanwhile, all selected families were significantly earlier than check (Sahel 1) under the two conditions. These results refer to that the pedigree selection was more effective in isolating early genotypes in heading date. These results were in agreement with those obtained by Knott, 1979, Pawar *et al.*, 1986 and Tammam *et al.*, 2004a.

The observed response to selection for earliness (Table 6) compared with bulk, better parent and check were (-5.58, -0.98 and -13.88 %) and (-6.13, -1.19 and -13.88 %) in F₄ families under normal and drought conditions, respectively. On the other hand, the expected response to selection was 2.24 and 2.59 days un-

der normal and drought conditions, respectively. These results are in line with those reported by Kheiralla *et al.*, 1993, Tammam *et al.*, 2004a and Shamroukh, 2006.

Values of phenotypic (P.C.V.%) and genotypic (G.C.V.%) coefficients of variation in F₃ and F₄ generations under normal conditions (Table 7) cleared that PCV and GCV were 4.75 and 4.26% in F₃ and 5.17 and 4.84% in F₄ generation, respectively. Under drought stress condition those values were 4.55 and 4.05% in F₃ and 5.26 and 4.78% in F₄ generation, respectively. Many investigators obtained PCV values ranged from 3.82 to 6.15% and GCV values ranged from 3.61 to 5.81% (Amin *et al.*, 1992, Kheiralla *et al.*, 1993, Tammam, 1995 and Tammam *et al.*, 2004a).

The broad sense heritability for days to heading (Table 7) was 80.33 and 79.52 % in F₃ generation under normal and water stress, respectively, while, it was 87.57 and 82.59 % in F₄ generation under normal and water stress, respectively. Narrow sense heritability was 34.34 and 39.40 % in F₄ generation under normal and drought stress, respectively. These results are in line with those reached by Wiersma *et al.*, 2001, Tammam *et al.*, 2004a and Shamroukh, 2006.

III-2-Effects of selection for earliness under normal and water stress conditions on correlated traits.

Data in Table (5) presented the range and average of F_4 generation under normal and water stress conditions for the studied traits. The average spike length ranged from 11.03 to 15.93 with an average of 13.23 cm and from 9.28 to 14.23 with an average of 11.70 cm under the two environments, respectively. However, the eight families, i.e., no. 3, 12, 35, 52, 56, 75, 100 and 105 in F_4 were significantly longer than the check under drought conditions.

The range of no. of spikes/plant varied from 4.50 to 10.60 with an average of 6.96 spikes/plant and from 4.40 to 9.00 with an average of 6.15 spikes/plant in F_4 generation under the two environments, respectively. The two families, i.e., no. 37 and 56 of the earliness selection surpassed the check in no. of spikes/plant under normal and water stress conditions.

Mean 100-kernel weight ranged from 4.14 to 5.72 with an average of 5.21 and from 3.74 to 5.22 with an average of 4.65 gm under the two conditions, respectively. The six families, i.e., no. 12, 35, 37, 52, 53 and 56 were significantly higher than the better parent under drought condition. While, all selected families surpassed the check except no. 57 and 75 under water stress conditions.

The average no. of kernels/spike ranged from 34.01 to 64.12 with an average of 49.99 and from 27.96 to 54.11 with an average of 43.14 under the two environments, respectively. The

two families, i.e., no. 56 and 105 were significantly higher than the better parent under normal condition. While, they surpassed the check under drought conditions.

The average grain yield/plant ranged from 13.82 to 22.02 with an average of 16.65 g/plant and from 9.47 to 15.59 with an average of 12.67 g/plant under the two environments, respectively. The three families in the early families, i.e., no. 35, 37 and 56 were significantly out-yielded the better parent and the check under normal and water stress conditions.

II-4- Drought susceptibility index (DSI).

The values of drought susceptibility index for families selected for earliness (Table 8) ranged from 0.72 to 1.50 and from 0.66 to 1.31 in F_3 and F_4 generations, respectively. Data indicated that six families in F_3 and seven families in F_4 gave low values of drought susceptibility index ($DSI < 1$), but the five families, i.e., no 3, 35, 52, 85 and 103 produced the low values of susceptibility index in F_3 and F_4 generation, (0.73 and 0.72), (0.98 and 0.91), (0.72 and 0.67), (0.73 and 0.66), (0.72 and 0.72), respectively. Superior genotypes for drought tolerance of the selected families gave the low values of drought susceptibility index and the highest grain yield under drought. These families were no. 35 in F_3 and F_4 generations and no. 37 in F_4 generation.

III-Selection for grain yield.

III-1-Response to direct selection for grain yield under normal and water stress conditions.

The analysis of variance in Table (4) revealed highly significant differences among F₃ and F₄ families for all studied traits under normal and water stress conditions.

The results in Table (9) showed that the range of F₄ generation varied from 19.21 to 26.55 with an average of 21.54 g/plant under normal condition and was from 14.28 to 19.37 with an average of 16.22 g/plant under drought condition. All selected families under normal condition significantly exceeded the better parent except (no. 1, 24 and 35), also all selected families under drought stress significantly out-yielded the high yielding parent except (no.1, 13, 28, 42 and 56). Meanwhile, all selected families under normal condition and all selected families under drought stress except (no. 1 and 42) significantly exceeded the check.

The observed response to selection for high yielding families (Table 10) compared with bulk, better parent and check were (28.19, 18.59 and 26.09 %) and (27.49, 16.67 and 21.20 %) in F₄ families under normal and drought conditions, respectively. On the other hand, the expected responses to selection were 2.58 and 1.47 gm under normal and drought conditions, respectively. These results are in agreement with many studies, Kheiralla,

1993, Tammam, 1995 and Tammam *et al.*, 2004a.

The phenotypic coefficient of variation for grain yield/plant under favourable conditions (Table 7) was 14.57 and 13.40 % in F₃ and F₄ generations, respectively. While, it was 13.32 and 12.43 % in the same generations, respectively under water stress conditions. Likewise the genotypic coefficient of variability under normal condition was 12.48 and 11.96 % in F₃ and F₄ generations, respectively. Meanwhile, it was 10.82 and 10.89 % under drought stress conditions in the two generations, respectively.

The broad sense heritability for grain yield/plant (Table 7) was 73.36 and 65.96 % in F₃ generation under normal and water stress, respectively as well as 79.66 and 76.76 % in F₄ generation under normal and drought stress conditions, respectively. While, the narrow sense heritability was 53.34 and 43.43 % in F₄ generation under the two studied conditions, respectively. These results are in agreement with those obtained by Tammam, 1995, Wiersma *et al.*, 2001 and Tammam *et al.*, 2004a.

III-3-Effects of selection for grain yield under normal and water stress conditions on correlated traits.

The range of days to heading in F₄ under normal condition (Table 9) varied from 68.50 to 85.25 with an average of 77.72 days and was from 68.00 to 84.50 with an average of 77.02

under water stress conditions. The two families, i.e., no. 35 and 56 of high yielding families were significantly earlier than the earlier parent under normal and drought conditions. Meanwhile, all selected families under normal condition except (no. 1, 19 and 39) and all selected families under water stress condition except (no. 1, 19, 39 and 43) were significantly earlier than the check.

The average spike length in F_4 generation (Table 9) ranged from 12.38 to 16.95 with an average of 14.07 cm and from 11.40 to 14.75 with an average of 12.82 cm under the two environments, respectively. One family, i.e., no. 19 under normal conditions was significantly longer than the better parent. While, all selected families except (no. 45) under normal conditions and all selected families except (no. 13, 25 and 45) under drought condition were significantly longer than the check.

The range of no. of spikes/plant in F_4 (Table 9) varied from 6.00 to 11.40 with an average of 8.92 spikes/plant and from 5.00 to 10.55 with an average of 8.04 spikes/plant under the two environments, respectively. The two families, i.e., no. 6 and 25 under normal conditions and three families, i.e., no. 6, 25 and 45 under drought condition were significantly higher than the better parent. While, the nine families, i.e., no. 6, 13, 19, 25, 39, 42, 43, 45 and 56 under normal and

drought stress conditions surpassed the check.

Mean 100-kernel weight in F_4 (Table 9) ranged from 4.95 to 5.98 with an average of 5.45 and from 4.41 to 5.35 with an average of 4.88 gm under the two conditions, respectively. Moreover, the nine families, i.e., no. 6, 22, 24, 25, 28, 33, 35, 39 and 45 under water stress conditions were significantly higher than the better parent. Meanwhile, all selected families under water stress condition surpassed the check.

The average no. of kernels/spike in F_4 (Table 9) ranged from 40.56 to 63.38 with an average of 48.60 and from 32.29 to 54.11 with an average of 40.78 under the two conditions, respectively. One family, i.e., no. 56 surpassed the better parent and the check under normal conditions and one family, i.e., no. 56 significantly exceeded the check under water stress conditions.

These results showed that the selection for high yield under water stress condition was more effective in improving grain yield/plant in the dry land through earliness and some major yield components. These results are in agreement with those obtained by Kheiralla, 1993, Tammam, 1995, Tammam *et al.*, 2004a and Shamroukh, 2006.

III-4- Drought susceptibility index (DSI).

The values of drought susceptibility index for the highest yielding families (Table 8) ranged from 0.69 to 1.34 and from 0.60 to 1.53 in F_3 and F_4

generations, respectively. Seven families in F₃ generation and nine families in F₄ gave low values of drought susceptibility index (DSI < 1), but the seven families, i.e., no 19, 22, 24, 25, 33, 35 and 38 have tolerance for drought stress in both generations. Meanwhile, the four families, i.e., no. 24, 25, 33 and 38 and the six families, i.e., no. 19, 22, 24, 25, 33 and 38 were superior for drought tolerance and had high grain yield under drought in F₃ and F₄ generations, respectively. Moreover, superior families for drought tolerance of the selected families gave the low value of drought susceptibility index and high grain yield under drought. These families were no. 24, 25, 33 and 38 in two generations.

A significant and negative correlation (Table 11) was established between the mean grain yield under normal and DSI ($r=-0.56^*$) and between the mean grain yield under water stress and DSI ($r=-0.48^*$). This would indicate that about 50% of variation

in drought susceptibility in this set of genotypes could be ascribed to variation in yield potential, as defined by DSI, need not be have a high yield since DSI provides a measure of tolerance based on minimization of yield loss under stress, rather than no stress yield as pointed by Bruckner and Frohberg (1987). These results are in accordance with those reported by Bidinger *et al.*, 1987, Kheiralla, 1994 and Shamroukh, 2006.

Finally it could be concluded that drought susceptibility index indicated that drought tolerance could be due to high yield potential and / or low susceptibility to stress (DSI < 1). The nine families, i.e., no. 19, 22, 24, 25, 33, 35, 37, 38 and 39 produced relatively high grain yield under drought stress and low drought susceptibility index (tolerance for drought). These genotypes could be used as source of drought tolerance or factors contributing to general

Table (4): Mean squares for all studied traits of the selected families, parents, bulk sample and the check cultivar on the basis of earliness and grain yield in F₃ and F₄ generations under normal (N) and drought stress (D).

Generation	Treatments	S.o.v	Mean Squares						
			D.F	Direct selection	Correlated traits				
				Days to heading	Spike length	Number of spikes / plant	100 kernel weight	Number of kernels / spike	Grain yield / plant
Selection for early families									
F ₃	N	Reps	3	13.69	0.36	0.16	0.38	10.23	0.50
		Families	63	48.55**	7.50**	6.34**	1.76**	175.87**	25.42**
		Error	189	2.80	0.13	0.13	0.04	9.65	0.64
	D	Reps	3	3.41	0.33	0.24	0.21	14.32	2.34
		Families	63	42.65**	6.97**	5.63**	1.88**	179.63**	13.19**
		Error	189	2.58	0.10	0.11	0.03	7.54	0.54
F ₄	N	Reps	3	9.63	0.05	0.11	0.07	7.91	1.12
		Families	18	0.73**	8.68**	11.94**	0.85**	294.32**	18.09**
		Error	54	1.74	0.28	0.16	0.03	7.09	0.75
	D	Reps	3	1.21	0.26	0.13	0.02	9.58	0.45
		Families	18	49.56**	8.60**	8.75**	0.78**	215.77**	11.97**
		Error	54	2.48	0.37	0.22	0.03	11.50	0.46
Selection for high yield families									
F ₃	N	Reps	3	2.91	25.64	0.32	0.04	0.27	5.52
		Families	63	14.90**	115.43**	11.08**	7.42**	1.35**	123.87**
		Error	189	1.24	3.36	0.13	0.23	0.04	7.25
	D	Reps	3	10.13	2.09	0.32	0.98	0.05	23.96
		Families	63	6.21**	95.80**	9.87**	6.61**	2.12**	153.91**
		Error	189	0.71	3.63	0.10	0.23	0.04	5.81
F ₄	N	Reps	3	1.68	0.10	0.35	0.04	0.43	3.86
		Families	19	26.02**	76.30**	9.70**	12.71**	0.62**	152.54**
		Error	57	1.56	1.90	0.22	0.37	0.07	7.80
	D	Reps	3	0.85	4.81	0.44	0.14	0.03	1.65
		Families	19	12.42**	72.83**	6.84**	12.84**	0.47**	165.35**
		Error	57	0.87	2.23	0.38	0.31	0.04	7.41

• & **Significant at 5 % and 1 % levels of probability, respectively.

Table (5): Mean grain yield and other traits of early families in F₄ generation under normal (N) and drought (D) conditions.

Earliness families	Selection criteria		Correlated traits									
	Days to heading		Spike length		No. of spikes / plant		100 kernel weight		No. of kernels/spike		Grain yield/ plant	
	N	D	N	D	N	D	N	D	N	D	N	D
3	71.75	72.25	13.73	12.70	7.50	6.10	5.16	4.78	46.34	45.40	15.96	13.22
12	72.00	70.75	14.10	12.28	7.10	6.15	5.72	5.22	38.56	32.52	17.46	12.15
35	68.50	68.00	13.15	11.95	6.80	5.90	5.53	4.99	51.64	46.29	19.44	15.18
37	69.00	68.00	12.50	11.55	10.60	9.00	5.61	5.06	34.01	27.96	19.72	15.59
52	73.00	71.00	13.13	11.98	6.75	6.05	5.59	5.05	48.33	42.22	16.33	13.72
53	71.00	70.75	12.13	10.48	7.40	6.30	5.41	5.09	54.51	44.27	17.79	12.87
56	69.50	69.00	14.98	13.63	8.95	8.40	5.31	5.00	63.38	54.11	22.02	15.09
57	71.25	72.25	12.15	10.70	7.80	7.00	4.71	3.74	50.07	46.39	16.16	11.82
75	71.50	71.00	13.55	12.10	5.10	4.40	4.14	3.76	52.48	47.50	13.94	10.85
85	72.50	73.00	12.45	10.50	6.95	6.05	5.58	4.76	50.94	41.46	16.79	14.12
89	69.00	68.25	11.03	9.48	6.15	5.75	4.54	4.21	58.91	46.05	14.39	10.94
100	70.00	69.50	15.28	13.45	5.10	4.45	5.04	4.22	52.51	48.12	14.57	10.90
103	71.00	70.00	12.78	11.25	7.80	6.95	5.46	4.73	41.62	37.91	16.94	13.99
105	72.75	71.25	15.93	14.23	4.50	4.45	5.32	4.61	64.12	53.87	14.38	10.10
106	73.00	71.00	11.43	9.28	5.90	5.25	5.11	4.60	42.42	33.06	13.82	9.47
Average	71.05	70.40	13.23	11.70	6.96	6.15	5.21	4.65	49.99	43.14	16.65	12.67
P1	71.75	71.25	15.75	14.15	4.05	3.60	5.60	4.62	58.38	53.02	17.46	13.11
P2	80.00	79.50	11.53	9.95	10.15	9.10	5.26	4.50	40.09	35.48	18.16	13.90
Bulk	75.25	75.00	12.78	11.60	7.70	6.30	5.20	4.36	38.57	33.13	16.80	12.72
Sahel 1	82.50	81.75	11.82	10.97	7.85	6.95	4.29	3.98	52.48	46.32	17.08	13.38
RLSD _{0.05}	1.63	2.06	0.65	0.80	0.49	0.58	0.22	0.22	3.29	4.44	1.10	0.86
RLSD _{0.01}	2.14	2.71	0.86	1.05	0.65	0.76	0.29	0.29	4.31	5.83	1.49	1.12

Table (6): The observed and expected response to selection in F₄ generation for all studied traits of early families under normal (N) and drought stress (D) conditions.

Trait	Condition	Response to selection as deviation from							
		Bulk		Best patent		Check (Sahel 1)		Expected response	
		unit	%	unit	%	unit	%	unit	%(from families mean)
Days to heading	N	Direct response						2.24	3.15
	D	-4.20**	-5.58**	-0.70	-0.98	-11.45**	-13.88**	2.59	3.68
Spike length	N	Correlated response in						1.11	8.39
	D	0.45	3.52**	-2.52**	-16.00**	1.41**	11.93**	0.99	8.46
No. of spikes / plant	N	-0.74**	-9.61**	-3.19**	-31.43**	-0.89**	-11.34**	1.89	27.16
	D	-0.15	-2.43**	-2.95**	-32.45**	-0.80**	-11.56**	1.27	20.65
100 kernel weight	N	0.01	0.28**	-0.39**	-6.89**	0.92**	21.55**	0.48	9.21
	D	0.29**	6.71**	0.03	0.70**	0.67**	16.90**	0.39	8.39
No. of kernels/spike	N	22.42**	29.61**	-8.39**	-14.37**	-2.49*	-4.74**	9.22	18.63
	D	10.01**	30.22**	-9.88**	-18.63**	-3.18	-6.86**	7.66	17.76
Grain yield / plant	N	-0.15	-0.92*	-1.51**	-8.34**	-0.43	-2.54**	1.91	11.47
	D	-0.05	-0.42	-1.23**	-8.88**	-0.71*	-5.33**	1.67	13.18

* & **Significant at 5 % and 1 % levels of probability, respectively.

Table (7): Genetic parameters for days to heading of the early families and grain yield/plant of the highest yielding families in the F₃ and F₄ generations under normal and drought conditions.

Items	Selection for earliness				Selection for high yield			
	Days to heading				Grain yield/plant			
	Normal		Drought		Normal		Drought	
	F ₃	F ₄	F ₃	F ₄	F ₃	F ₄	F ₃	F ₄
Pheno. Var.	14.24	13.99	12.60	14.25	4.66	7.68	2.09	3.76
Geno. Var	11.44	12.25	10.02	11.77	3.42	6.12	1.38	2.89
P.C.V. %	4.75	5.17	4.55	5.26	14.57	13.40	13.32	12.43
G.C.V. %	4.26	4.84	4.05	4.78	12.48	11.96	10.82	10.89
Heritability								
Broad – sense	80.33	87.57	79.52	82.59	73.36	79.66	65.96	76.76
Narrow – sense	--	34.34	--	39.40	--	53.34	--	43.43

Table (8): Drought susceptibility index (DSI), grain yield (G.Y) of early and the highest yielding families in F₃ and F₄ generations under normal and drought stress conditions.

Selection for earliness							Selection for grain yield						
No.	F ₃ generation			F ₄ generation			No.	F ₃ generation			F ₄ generation		
	G.Y		DSI	G.Y		DSI		G.Y		DSI	G.Y		DSI
	N	D		N	D			N	D		N	D	
3	12.97	10.51	0.73	15.96	13.22	0.72	1	15.61	11.08	1.00	19.21	14.51	0.98
12	14.76	10.66	1.07	17.46	12.15	1.27	6	19.55	12.83	1.19	26.32	16.28	1.53
35	15.29	11.39	0.98	19.44	15.18	0.91	13	18.11	12.82	1.01	21.44	14.91	1.22
37	15.64	10.78	1.19	19.72	15.59	0.87	19	14.42	11.45	0.71	20.69	17.23	0.67
52	12.70	10.32	0.72	16.33	13.72	0.67	22	14.97	11.99	0.69	20.51	17.43	0.60
53	14.04	10.23	1.04	17.79	12.87	1.15	24	16.40	12.83	0.75	19.35	16.37	0.62
56	17.64	10.77	1.50	22.02	15.09	1.31	25	17.85	13.93	0.76	21.50	17.39	0.76
57	13.42	9.99	0.98	16.16	11.82	1.12	28	17.44	10.94	1.29	21.24	15.11	1.15
75	9.98	7.27	1.05	13.94	10.85	0.92	33	16.26	12.89	0.71	21.32	17.70	0.68
85	9.11	7.39	0.73	16.79	14.12	0.66	35	15.29	11.39	0.88	19.44	15.18	0.88
89	12.16	8.98	1.00	14.39	10.94	1.00	38	15.74	12.29	0.76	21.31	17.45	0.73
100	10.01	7.50	0.97	14.57	10.90	1.05	39	16.82	10.84	1.23	20.18	15.17	0.99
103	12.44	10.11	0.72	16.94	13.99	0.72	42	19.44	12.50	1.23	21.30	14.28	1.32
105	10.14	7.35	1.06	14.38	10.10	1.24	43	17.59	10.91	1.31	22.21	16.01	1.12
106	10.97	7.69	1.15	13.82	9.47	1.31	45	18.90	13.12	1.05	26.55	19.37	1.08
							56	17.64	10.77	1.34	22.02	15.09	1.26

Table (9): Mean grain yield and other traits of the highest yielding families in F₄ generation under normal (N) and drought (D) conditions.

Selected families	Selection criteria		Correlated traits									
	Grain yield/plant		Days to heading		Spike length		No. of spikes / plant		100 kernel weight		No. of kernels/ spike	
	N	D	N	D	N	D	N	D	N	D	N	D
1	19.21	14.51	83.50	82.75	13.53	12.63	8.45	6.35	5.09	4.72	50.34	41.66
6	26.32	16.28	79.00	78.25	13.35	12.30	11.40	10.35	5.98	5.24	44.90	34.51
13	21.44	14.91	75.75	75.00	12.63	11.55	10.70	9.75	4.95	4.41	48.97	38.52
19	20.69	17.23	82.50	81.25	16.95	14.70	9.05	8.70	5.33	4.83	41.05	36.52
22	20.51	17.43	76.00	75.75	13.45	12.00	7.60	7.00	5.78	5.03	52.70	47.61
24	19.35	16.37	77.25	76.50	16.20	14.75	6.00	5.00	5.43	5.18	40.56	34.09
25	21.50	17.39	78.25	77.25	12.65	11.73	11.20	10.55	5.44	4.93	43.15	38.92
28	21.24	15.11	76.00	75.00	12.73	12.18	8.05	7.03	5.76	5.06	50.38	41.30
33	21.32	17.70	75.75	75.25	13.03	11.98	8.35	7.75	5.91	5.35	46.17	40.72
35	19.44	15.18	68.50	68.00	13.15	11.95	6.80	5.90	5.53	4.99	51.64	46.29
38	21.31	17.45	78.75	78.00	16.03	14.23	8.05	7.50	5.11	4.60	50.28	43.10
39	20.18	15.17	85.25	84.50	14.40	13.53	9.00	8.00	5.33	4.89	46.27	34.04
42	21.30	14.28	78.75	78.25	14.50	13.23	9.65	8.00	5.22	4.48	46.60	32.29
43	22.21	16.01	80.75	80.25	15.20	13.43	9.05	8.50	5.14	4.55	50.88	43.13
45	26.55	19.37	78.00	77.25	12.38	11.40	10.45	9.88	5.87	4.88	50.26	45.74
56	22.02	15.09	69.50	69.00	14.98	13.63	8.95	8.40	5.31	4.65	63.38	54.11
Average	21.54	16.22	77.72	77.02	14.07	12.82	8.92	8.04	5.45	4.86	48.60	40.78
P1	17.46	13.11	71.75	71.25	15.75	14.15	4.05	3.60	5.60	4.62	58.38	53.02
P2	18.16	13.90	80.00	79.50	11.53	9.95	10.15	9.10	5.26	4.50	40.09	35.48
Bulk	16.80	12.72	75.25	75.00	12.78	11.60	7.70	6.30	5.20	4.36	38.57	33.13
Sahel 1	17.08	13.38	82.50	81.75	11.82	10.97	7.85	6.95	4.29	3.98	52.48	46.32
RLSD_{0.05}	1.63	1.22	1.71	1.85	0.58	0.78	0.75	0.69	0.36	0.26	3.65	3.56
RLSD_{0.01}	2.15	1.60	2.23	2.42	0.76	1.06	0.98	0.90	0.48	0.34	4.80	4.68

Table (10): Observed and expected response to selection in F₄ generation for all studied traits of the highest yielding families under normal (N) and drought stress (D) conditions.

Trait	Condition	Response to selection as deviation from							
		Bulk		Best patent		Check (Sahel I)		Expected response	
		Unit	%	Unit	%	Unit	%	Unit	%(from families mean)
Direct response									
Grain yield / plant	N	4.74**	28.19**	3.38**	18.59**	4.46**	26.09**	2.58	11.98
	D	3.50**	27.49**	2.32**	16.67**	2.84**	21.20**	1.47	9.06
Correlated response in									
Days to heading	N	2.47**	3.28**	5.97**	8.32**	-4.78**	-5.80**	2.79	3.59
	D	2.02**	2.69**	5.77**	8.09**	-4.73**	-5.79**	2.75	3.57
Spike length	N	1.29**	10.10**	-1.68**	-10.66**	2.25**	19.04**	1.62	11.51
	D	1.22**	10.55**	-1.33**	-9.38**	1.85**	16.90**	1.27	9.91
No. of spikes / plant	N	1.22**	15.87**	-1.23**	-12.10**	1.07**	13.65**	1.86	20.85
	D	1.74**	27.63**	-1.06**	-11.64**	1.09**	15.69**	1.63	20.27
100 kernel weight	N	0.25	4.79**	-0.15	-2.79**	1.16**	27.02**	0.39	7.16
	D	0.54**	11.98**	0.26**	5.68**	0.90**	22.68**	0.23	4.73
No. of kernels/spike	N	10.03**	26.00**	-9.78**	-16.76**	-3.88**	-7.40**	5.54	11.40
	D	7.65**	23.10**	-12.24**	-23.08**	-5.54**	-11.95**	6.63	16.26

* & **Significant at 5 % and 1 % levels of probability, respectively.

Table (11): Mean days to heading, grain yield/plant under normal and water stress conditions and drought susceptibility index and correlations between them of the highest yielding families in F₄ generation.

Selected families	DSI	DHn	DHs	GYn	GYs
1	0.98	83.50	82.75	19.21	14.51
6	1.53	79.00	78.25	26.32	16.28
13	1.22	75.75	75.00	21.44	14.91
19	0.67	82.50	81.25	20.69	17.23
22	0.60	76.00	75.75	20.51	17.43
24	0.62	77.25	76.50	19.35	16.37
25	0.76	78.25	77.25	21.50	17.39
28	1.15	76.00	75.00	21.24	15.11
33	0.68	75.75	75.25	21.32	17.70
35	0.88	68.50	68.00	19.44	15.18
38	0.73	78.75	78.00	21.31	17.45
39	0.99	85.25	84.50	20.18	15.17
42	1.32	78.75	78.25	21.30	14.28
43	1.12	80.75	80.25	22.21	16.01
45	1.08	78.00	77.25	26.55	19.37
56	1.26	69.50	69.00	22.02	15.09
r		-0.05	-0.05	0.56*	-0.48*
r			1.00**	0.005	0.06
r				0.003	0.05
r					0.46

adaptation and can be used in breeding programs to produce lines or cultivars having high grain yield ability and high tolerance for drought stress. These results are in agreement with those obtained by Kheiralla, 1993, Farshadfar *et al.*, 2001 and Tammam *et al.*, 2004b.

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"الاستجابة للإنتخاب للتبكير و محصول الحبوب فى القمح (ترتيم استيفم ل.) تحت ظروف الري العادي والإجهاد المائي"

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أجرى هذا البحث بكلية الزراعة - جامعة سوهاج - مصر خلال الثلاث
مواسم الشتوية من ٢٠٠٤ / ٢٠٠٥ إلى ٢٠٠٦ / ٢٠٠٧ م لتقدير الاستجابة
الفعلية و المتوقعة للإنتخاب تحت الظروف العادية وظروف الجفاف و تقدير
المكونات الوراثية الأخرى وحساب معامل الحساسية للجفاف لصفة
محصول الحبوب. أظهر تحليل التباين وجود اختلافات معنوية بين عائلات
الجيل الثالث و الرابع تحت الظروف العادية وظروف الجفاف لعدد الأيام
حتى طرد السنابل ، طول السنبل ، عدد السنابل بالنبات ، عدد الحبوب
بالسنبل ، وزن ١٠٠ حبة ، محصول الحبوب للنبات.

الاستجابة الفعلية لعدد الأيام حتى طرد السنابل للإنتخاب لعائلات
التبكير كان سالب و عالي المعنوية مقارنة بالعشيرة المجمع و صنف
المقارنة (ساحل ١) فى الجيل الرابع حيث كانت -٥,٥٨ و -١٣,٨٨%
تحت الظروف العادية وكانت -٦,١٣ و -١٣,٨٨% تحت ظروف الجفاف.
ومن ناحية أخرى كانت الاستجابة المتوقعة ٣,١٥ و ٣,٦٨% تحت
الظروف العادية وظروف الجفاف على التوالي. الاستجابة الفعلية لمحصول
الحبوب للنبات للإنتخاب لعائلات المحصول العالي كان موجب و عالي
المعنوية مقارنة بالعشيرة المجمع والاب الأفضل و صنف المقارنة فى
الجيل الرابع حيث كانت ٢٨,١٩ و ١٨,٥٩ و ٢٦,٠٩% تحت الظروف
العادية على التوالي وكانت ٢٧,٤٩ و ١٦,٦٧ و ٢١,٢٠% تحت ظروف
الجفاف على التوالي. ومن ناحية أخرى كانت الاستجابة المتوقعة ١١,٩٨ و
٩,٠٦% تحت الظروف العادية وظروف الجفاف على التوالي.

معامل الاختلاف المظهري و الوراثي تحت الظروف العادية لعدد الأيام
حتى طرد السنابل كان ٤,٧٥ و ٤,٢٦% فى الجيل الثالث وكان ٥,١٧ و
٤,٨٤% فى الجيل الرابع بينما تحت ظروف الجفاف كان ٤,٢٦ و
٤,٠٥% فى الجيل الثالث وكان ٤,٨٤ و ٤,٧٤% فى الجيل الرابع. معامل
الاختلاف المظهري تحت الظروف العادية لمحصول الحبوب للنبات كان
١٤,٥٧ و ١٣,٤٠% فى الجيل الثالث و الرابع على التوالي بينما تحت
ظروف الجفاف كان ١٣,٣٢ و ١٢,٤٣% فى نفس الاجيال على التوالي .
كذلك معامل الاختلاف الوراثي تحت الظروف العادية لمحصول الحبوب
للنبات كان ١٣,٤٨ و ١١,٩٦% فى الجيل الثالث و الرابع على التوالي
بينما تحت ظروف الجفاف كان ١٠,٨٢ و ١٠,٨٩% فى نفس الاجيال

على التوالي.

أرتفاع قيم درجة التوريبث المقدره بالمعنى العريض لعدد الأيام حتى طرد السنابل للانتخاب للتبكير تحت الظروف العادية وظروف الجفاف في الجيل الثالث و الرابع. بينما درجة التوريبث بالمعنى الضيق كانت ٣٤,٣٤ و ٣٩,٤٠% في الجيل الرابع تحت الظروف العادية وظروف الجفاف على التوالي. كذلك أرتفاع قيم درجة التوريبث المقدره بالمعنى العريض لمحصول الحبوب للنبات للانتخاب للمحصول العالي تحت الظروف العادية وظروف الجفاف في نفس الاجيال. بينما درجة التوريبث بالمعنى الضيق كانت ٥٣,٣٤ و ٤٣,٤٣% في الجيل الرابع تحت الظروف العادية وظروف الجفاف على التوالي.

والنتائج المتحصل عليها من الدراسة تشير إلى أنه يمكن الحصول على سلالات تتحمل الجفاف ذات محصول حبوب عالي باستخدام طريقة تسجيل النسب.

أظهرت نتائج معامل الحساسية المنخفض للجفاف الى أن تسعة تراكيب وراثية رقم ١٩ ، ٢٢ ، ٢٤ ، ٢٥ ، ٣٣ ، ٣٥ ، ٣٧ ، ٣٧ ، ٣٩ أعطت معدل عالي من محصول الحبوب تحت ظروف الجفاف بجانب معامل الحساسية المنخفض للجفاف (التحمل للجفاف) . هذه التراكيب الوراثية يمكن أن تستخدم كمصدر لتحمل الجفاف والأقلمة العامة .