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The relative merits of pedigree selection for grain yield of bread wheat under drought stress and sensitivity to environments

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Abstract:

The present article was carried out to study the relative merits of pedigree selection for grain yield/plant under drought stress and normal irrigation environments. Three cycles of pedigree selection for high grain yield were achieved under both environments. The base population was the F_3-population of Giza 168/Sids 4. In the fourth year, selections under drought stress and selections under normal irrigation were evaluated at both environments. The phenotypic variance generally decreased from the F_3- to the F_6-generation, and was slightly larger than the genotypic variance. The realized heritability under normal irrigation was 8.27, 79.41 and 78.46% compared to 25.57, 14.06 and 37.88% under drought stress after cycles $_1$, $_2$ and $_3$; respectively. The observed gain from C_3 was nearly twice that from C_1 and C_2. Hence, these results suggest delaying selection to the F_5-genreation, till homozygosity reach acceptable level to save costs and efforts, under the condition of minimizing competition between plants from F_2 to F_5 generation to avoid loss of the best genotypes. The observed gains from the better parent of the drought selections were 20.16 and 16.58%, compared to 10.97 and 11.00% for the normal irrigation selections, when evaluation practiced under drought and normal irrigation, respectively. The results indicate that the antagonistic selection reduced sensitivity to drought stress, and synergistic selection increased it. Furthermore, selection for grain yield/plant under drought stress was better than under normal irrigation, either selections evaluated under drought or under normal irrigation.

Introduction:

Pedigree selection method has become the most popular of the plant breeding procedures. Most of the Egyptian wheat cultivars were produced through this method. It is preferred by plant breeders because it is versatile, relatively rapid and makes possible conducting of genetic studies along with the plant breeding work. Many workers indicated that pedigree selection was effective in improving grain yield (Mahdy, 1988; Pawar *et al*., 1990; Ismail, 1995 and 2001; Ismail *et al*., 1996; Mahdy *et al*., 1996 and 2012; Ahmed, 2006; El-Karamity *et al*., 2007; Eissa, 1996; Kheiralla *et al*., 1993; Khan *et al*., 2007; Hammam, 2008 and Ali, 2011). Furthermore, selection for tolerance to stress is worthwhile, in which the water is the main abiotic limiting factor in the new reclaimed soils, and at the northern sea coast of Egypt. However, selection for yield or production traits in stress and non-stress environments is a problem which continues to perplex plant breeders. 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 of the high selection, and the lower environmental sensitivity of the low selection. Ceccarelli and Grando (1989) showed that in adapted barley germplasm the use of direct selection in presence of stress increased selection efficiency for stress environments. Also,in In "1991a and b" they stated that the genotypes selected for high grain yield under low yielding conditions were less sensitive to changing environments than genotypes selected for high grain yield under high yielding conditions. Kheiralla and El-Defrawy (1994) found that antagonistic selection increased environmental sensitivity and was not fully successful in decreasing mean performance of days to heading, which does not conform with Jinks-Connolly model. The objectives of the present article were to study; 1) the relative merits of pedigree selection for grain yield/plant under normal irrigation and drought stress environments, and 2) the sensitivity of the selected lines to drought stress.

MATERIALS AND METHODS

The present article aims to study the efficiency of pedigree selection for grain yield, in a segregating population of bread wheat; *Triticum aestivum L.* and the sensitivity of the selected lines to drought stress. Three cycles of pedigree selection were achieved under optimum "normal irrigation" and drought stress conditions, and evaluated under both environments. The base population was the F_{3-} generation of a cross Giza 168 x Sids 4. The experiments were carried out during the four successive seasons, i.e. 2007/08, 2008/09, 2009/10 and 2010/11 at Fac. Agric. Exper. Farm. Assiut University.

Planting date:

Season	Date	Generation	Experimental design
2007/08	27/11/2007	F_3	Non-replicated exper.
2008/09	25/11/2008	F_4	RCBD with three replications
2009/10	21/11/2009	F_5	,,
2010/11	25/11/2010	F_6	,,

Irrigation

The experiment under normal irrigation in the four seasons received planting irrigation and five irrigations throughout the growing season. However, the experiment under drought stress received planting irrigation and only one irrigation three weeks after planting. The soil texture was clay. In all experiments, super phosphate (P_2O_5, 15.5%) was added during land preparation at a rate of 23.25 kg P_2O_5/Fed. Nitrogen fertilizer in the form of ammonium nitrate (33.5% N) was added at a rate of 80 kg N/Fed. in one dose before the first irrigation. **In season 2007/08**, the F_3-individual plants (base population) were grown in seven non-replicated plots under each of irrigated and drought stressed environment. Each plot consisted of 10 rows, 3 m long and 30 cm apart. Grains were sown and spaced 15 cm within a row. The parents were grown in separate plots at each environment. At the end of the season, the characters were recorded on 509 random guarded plants in the irrigated experiment and 540 plants in the drought stressed experiment; the highest 40 plants in grain yield were saved. **A**n equal number of grains from each plant (509 plants in the irrigated and 540 plants in the stressed experiments) were bulked to give F_4-ranodm unselected bulk sample for each environment. **In season 2008/09 (F_4-generation); a**n experiment was grown under irrigated environment, and another one under drought stressed environment. In each experiment, the 40 selected F_4-plants along with the two parents and the bulk sample were sown. A randomized complete block design of three replications was used. The experimental unit was one row 3m in long, 30 cm apart and 5 cm between grains within a row. Data were recorded on 20 guarded plants from each family. At the end of the season, the best high yielding plant from each of the best 20 high yielding families were saved. **In season 2009/10 (F_5-generation); a**n experiment was grown under each of irrigated and stressed environment as in the previous season. Each experiment included 20 selected plants (families) along with the two parents and the random bulk sample. Data were recorded on 20 guarded plants from each family. At the end of the season, the best 10 high yielding families were identified and the best plant from each was saved. **In season 2010/11 (F_6-generation); t**he 10 high yielding families selected under irrigation + the 10 high yielding families selected under stress environment + the two parents + the bulk sample were evaluated under both environments. Data were recorded on ten guarded plants for each family. The studied characters were; days to heading (DH), plant height (PH;cm), spike length (SL;cm), number of spikes /plant(NS/P),biological yield/plant (BY/P;g), grain yield/plant(GY/P;g), harvest index (HI), 100-grain weight(100GW;g) and number of grains/main spike (NG/ms). Data were subjected to proper statistical analysis according to **Steel and Torrie (1980).** Genotypes means were compared using Revised Least Significant Differences test (RLSD) according to **El-Rawi and Khalafala (1980).** The phenotypic (σ^2p), genotypic (σ^2g) variances, and heritability in broad sense (H) were calculated according to **Walker (1960).** Realized heritability (h^2) was calculated as; $h^2 = R / S$ **(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).**Drought susceptibility index (DSI) was calculated according to the method of **Fischer and Maurer (1978)**. The sensitivity and relative merits of a selected line were assessed as (Falconer, 1990).

Results and Discussion

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

Summary of the characteristics of the two parents and the F_3-genration under both of drought stress and normal irrigation environments are shown in Table 1. Sids 4 has shorter plant height, longer spike, higher grain weight, higher number of grains/spike, lower tillering ability and grain yield/plant compared to Giza 168. Plant height of the F_3-population showed partial dominance towards tallness under normal irrigation, and towards shortness under drought stress. The reduction caused by drought stress in the F_3-population was 13.68, 2.50, 6.38, 12.10, 0.74 and 5.21% for plant height, spike length, number of spikes/plant, grain yield/plant, number of grains/spike and 100 grain weight; respectively. Mahdy (2007) noted average reduction caused by drought stress of 14.21 and 6.30% for plant height and spike length; respectively, over two years of evaluation of 20 cultivars. Kazmi *et al*. (2003) found that ear length was reduced by 36% under water stress. Kheiralla *et al*. (2004) found that skipping irrigation at any stage reduced spike length.Number of spikes/plant tended to show complete dominance towards the higher parent Giza 168 under both environments. However, grain yield/plant in the F_3-population showed nearly complete dominance under normal irrigation and over-dominance than the higher yielding parent Giza 168 under drought stress. The coefficient of variability was sufficient for selection, and ranged from 12.91 to 38.77% under normal irrigation, and from 14.84 to 43.39% under drought stress; for plant height and grain yield/plant; respectively. These results are in agreement to those reported by Ismail (1995), Eissa (1996), Ismail *et al*. (1996), Mahdy *et al*. (1996), El-Karamity *et al*., (2007), Zakaria *et al*. (2008), Mahdy *et al*.(2012), El-Morshidy *et al*. (2010) and Ali (2011). Heritability in broad sense was generally higher under drought than under normal irrigation. The expected genetic advance under selection of the superior 7.86% under irrigation and 7.41% plants under drought was high and ranged from 8.83 for number of grains/spike to 30.05% for number of spikes/plant under normal irrigation, and from 18.34 to 52.71%

under drought stress for number of grains/spike and grain yield/plant; respectively. These results are in line with those reported by Khan *et al*. (2007), Cheema *et al*. (2006) and Zakaria *et al*. (2008).

2- Selection for grain yield/plant

2.1- Variability and heritability estimates:

Mean squares of grain yield/plant was significant (P<0.01) under both environments (not included). The phenotypic variance (σ^2_{ph}) generally was larger under normal irrigation than under stress conditions in C_0, C_2 and C_3 (Table 2). The genotypic variance; σ^2_g was also larger under normal irrigation than under drought stress in C_2 and C_3. The phenotypic coefficient of variability (pcv) under normal irrigation was 38.77% for grain yield/plant in the base population, and decreased to 21.71, 17.94 and 15.31% after C_1, C_2 and C_3; respectively. Likewise, the pcv% under drought stress was slightly more than that under normal irrigation and showed the same trend, this could be due to higher mean grain yield under normal irrigation than under drought stress. The gcv % was slightly less than pcv % under both environments, and decreased from C_1 to C_3. The close estimates of phenotypic and genotypic variability resulted in very high estimates of broad sense heritability in the three cycles of selection. Another cause of high estimates of broad sense heritability which calculated from the expected mean squares, was the evaluation of the selected families at one site for one season, which inflates families mean squares by the confounding effects of the interactions of families, years and locations. However, the realized heritability of grain yield/plant was 8.27, 79.41 and 78.46% under irrigation, and 25.57, 14.06 and 37.88% under drought after C_1, C_2 and C_3; respectively. These results are in agreement with those of Talbert *et al*. (2001), Ahmed (2006), Abd El-Kader (2011), Ali (2011) and Mahdy *et al*. (2012).

2.2- Means and observed gains under drought stress evaluation: The two groups of families selected for high grain yield/plant for three cycles, either under drought stress or under normal irrigation were evaluated in the F_6-generation under both environment and presented in Table 3.

The group of families selected under drought stress ranged in grain yield/plant from 17.57 for family No.161 to 30.87 for family No.301 with an average of 22.13 g/plant. The average direct observed gain from selection significantly (P<0.01) out yielded the bulk sample by 34.94% and from the better parent by 20.16%. Furthermore, all the selected families except one (family No. 161) showed significant (P<0.01) observed gain from the bulk sample ranged from 14.63 to 88.21%, six of them showed significant or highly significant observed gain from the better parent. The significant observed gain from the better parent in grain yield/plant ranged from 12.22% for family No. 85 to 67.60% for family No. 301.

The group of families selected for grain yield/plant under normal irrigation and evaluated under drought stress, ranged in grain yield from 18.10 to 24.97 with an average of 20.44 g/plant. The average observed gain significantly (P<0.01) out yielded the bulk sample by 24.61% and the better parent (P<0.05) by 10.97%. Nine selected families selected for grain yield/plant showed significant observed gain under drought stress ranged from 12.20 to 52.24%, four of them; family No. 189, No. 347, No. 436 and No. 509 gave significant observed gain of 19.82, 30.50, 35.57 and 11.86% from the better parent.

2.3- Means and observed gains under normal irrigation evaluation:

The group of families selected for high grain yield/plant for three cycles under drought stress ranged from 19.03 for family No. 108 to 31.90 for family No. 301 with an average of 25.34 g/plant (Table 3). The average observed gain was significant and reached 39.72 and 16.58% from the bulk sample and the better parent; respectively. All the selected families under drought stress except family No. 108 showed significant (P<0.01) observed gain from the bulk sample, seven of them showed also significant observed gain from the better parent, and ranged from 11.96 for family No. 85 to 46.78% for family No. 301. Means of the group of families selected under normal irrigation for high grain yield/plant for three cycles, ranged from 19.80 for family No. 275 to 28.00 for family No. 474 with an average of 24.12 g/plant. The average observed gain in grain yield/plant was significant and accounted for 33.03 and 11.00% from the bulk sample and the better parent Giza 168; respectively. Eight families showed significant (P<0.01) observed gain from the bulk sample; ranged from 19.85 for family No. 261 to 54.41% for family No. 474. Five of these families showed significant (P<0.01) observed gain from the better parent; ranged from 17.18 for family No. 347 to 28.83% for family No. 474.Generally, it could be concluded that selection for high grain yield/plant for three cycles under drought stress in these materials was better than selection under normal irrigation either evaluation practiced under drought stress or under normal irrigation. These results are in line with those reported by many investigators. **Kheiralla (1989)** noted that pedigree selection for grain yield *per se* increased grain yield by 20.81% of the bulk sample. **Kheiralla (1993)** reported that pedigree selection for grain yield was effective in increasing grain yield. **Ismail (1995)** reported genetic gains in grain yield over the bulk sample and the better parent of 8.47 and 4.86 in a population, and 6.96 and 6.41% in another population; respectively. **Eissa (1996)** noted realized gain in grain yield of 8.97% from the better parent. **Ismail *et al*. (1996) and Mahdy *et al*. (1996)** came to the same conclusion. **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. **Ali (2011)**, **Abd El-Kader (2011) and Mahdy *et al.* (2012)** are in line with our results.

2.4- Average observed gain from selection for grain yield/plant in the three cycles:

Means and observed gain from selection for high grain yield/plant are shown in Table 4.

The observed gain from selection for high grain yield/plant under drought stress was 7.04, 8.31 and 20.16% from the better parent in C_1, C_2 and C_3, respectively. The observed gain from selection for high grain yield/plant under normal irrigation in the three cycles was 12.21 and 5.08% for cycle 1, 16.12 and 10.61% for cycle 2, and 39.72 and 16.58% for cycle 3, from the unselected bulk sample and the better parent, respectively. It could be noticed from these results that selection for high grain yield/plant under both environments from the F_5-generation was more effective than selection from F_3 and F_4. This may be due to the increase of level of homozygosity in the F_5-generation, and it was easy 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 effort under the condition of minimizing competition between plants from F_2- to F_5-generations to avoid loss of the best genotypes.

The third cycle selections were evaluated under both environments. The observed gain in the drought stress group were 20.16 and 16.58% from the better parent compared to 10.97 and 11.00% for the normal irrigation group. It is obvious that selection for high grain yield plant under drought stress was better than selection under normal irrigation. In other words antagonistic selection for grain yield was better than synergistic selection.

2.5- Drought susceptibility index and sensitivity to environment of the selected families for high grain yield/plant after three cycles of selection:

The drought susceptibility index (DSI) and the sensitivity to drought stress and normal irrigation of the selected families for high grain yield/plant are shown in Table 5.The results of the selected families for three cycles under drought stress (drought group), and evaluated under both environments indicate that five families; No. 39, No. 301, No. 176, No. 290 and No. 488 showed drought susceptibility index (DSI) of 0.79, 0.36, 0.42, 0.68 and 0.54; respectively. These families could be considered less susceptible to drought. Furthermore, the family No. 108 gave negative (-0.06) drought susceptibility index, indicating maximum possible drought resistance. The drought susceptibility index of **Fischer and Maurer (1978)** of the selected families coincided with the sensitivity test of **Falconer (1990)**. The five families which gave drought susceptibility index less than one (less susceptible), gave also values less than one (less sensitive) in sensitivity test, and the family No. 108 which gave negative DSI, also gave negative value in sensitivity test. It could be noticed that four superior families; No. 301, No. 176, No. 290 and No. 488 were less susceptible and less sensitive to drought, and showed significant observed gain from the better parent Giza 168. It should be recalled that the drought susceptibility index measures susceptibility respect to the overall mean of the selected families. Therefore, the DSI is very sensitive to the extremes, and confined to a certain group of families or lines. This means that the DSI of a line within a group of lines could be changed if this line incorporated in another group of lines under the same conditions of evaluation. However, the sensitivity test of **Falconer (1990)** measures the difference in the performance of a line under two environments relative to the difference in a base population or in a contemporaneous unselected control, which give efficiency to this test.

The results of the normal irrigation group of families showed that six families, No. 189, No. 208, No. 275, No. 322, No. 347 and No. 436 gave drought susceptibility index of 0.02, 0.48, 0.11, 0.98, 0.37, and 0.36 indicating less susceptibility or great resistance to drought. Giza 168 showed average susceptibility, however, Sids 4 and the bulk sample were less susceptible. Five out of the six less susceptible families according to the DSI, were also less sensitive. Ranks of the selected families according to DSI and sensitivity test were alike to a large extent.

It is of interest to indicate that the two superior families; No. 347 and No. 436 which showed significant ($P<0.01$) observed gain from the better parent were less susceptible and less sensitive to drought stress. These results indicate that the antagonistic selection reduced sensitivity to drought stress and synergistic selection increased it. **Falconer (1990)** stated that, when selection and environment change the character in opposite direction this is antagonistic selection, i.e. selection upwards in a low environment or downwards in a high environment. Synergistic selection is the reverse; upwards in a high environment or downwards in a low environment, when selection and environment change the character in the same direction. **Rosielle and Hamblin (1981)** stated that on theoretical grounds, selection under stress condition where genetic variance is generally small, will result in a reduced mean yield in non-stress conditions, while selection for mean productivity will generally increase mean yields in both stress and non-stress conditions. **Jinks and Connolly (1973)** showed that sensitivity is reduced by selection upwards in a bad environment and by selection downwards in a good environment. This rule was restated with additional evidence by **Jinks and Pooni (1982)**. **Ceccarelli and Grando (1991a)** found that one cycle of selection in low yielding environment produced on average five times more entries out yielding the best check in low yielding than selection in high yielding environment. They concluded that selection for high yield in high yielding environment is an inefficient strategy for improving yield in low yielding environments. **Ceccarelli and Grando (1991b)** indicated that the genotypes selected for high grain yield under low yielding conditions were less sensitive to changing environments than genotypes selected for high grain yield under high yielding conditions.

The relative merits of the two types of selection in changing the mean is expressed as the ratio (**Falconer, 1990):**

$$\frac{\text{Change of mean by antagonistic selection}}{\text{Change of mean by synergistic selection}}$$

A ratio of over 1.0 means that antagonistic selection was better, and a ratio of under 1.0 means that synergistic selection was better.

In the F_6-generation after three cycles of selection for high grain yield under drought stress (drought group) and under normal irrigation (irrigation group), the two groups of families were evaluated under both environments. The relative merit were 1.418 and 1.037 when selections evaluated under drought stress and under normal irrigation; respectively. These results indicate that antagonistic selection was better than synergistic selection to increase grain yield/plant in these materials, either evaluation made under drought stress or under normal irrigation. These results are in agreement with **Jinks and Connolly (1973)** rule. **Falconer (1990)** suggested that to increase the mean performance, selection should be made upwards in a bad environment, and conversely, to decrease mean performance downwards selection should be made in a good environment. **Mohamed (2001)** found that antagonistic selection reduced sensitivity of the intermated families and synergistic increased it. **Kheiralla *et al.* (2006)** found that selection under early planting (synergistic selection) increased sensitivity of the selected families, while selection under late planting (antagonistic selection) decreased it.

Table 1. Means, phenotypic variance (σ^2 ph), coefficient of variability(CV%), heritability in broad sense (Hb) and expected genetic advance(ΔG)of the base population(F3) evaluated under normal irrigation and drought stress environments for the studied traits.

Item	Normal irrigation						Drought stress					
	PH;cm	SL;cm	NS/p	Gy/p;g	NG/ms	100GW;g	PH;cm	SL;cm	NS/p	Gy/p;g	NG/ms	100GW;g
F3-Population Mean±SE	96.29 ±0.55	14.38 ±0.09	9.71 ±0.14	29.09 ±0.50	66.41 ±0.65	4.99 ±0.05	83.04 ± 0.53	14.02 ±0.09	9.09 ± 0.12	25.57 ± 0.48	65.92 ±0.67	4.73 ± 23.1
Reduction%							13.68	2.50	6.38	12.10	0.74	5.21
CV%	12.91	15.19	33.92	38.77	22.12.	20.71	14.84	15.81	32.28	43.39	23.61	23.10
Hb%	65.76	52.20	47.46	41.16	21.40	84.63	87.62	71.28	65.97	64.13	41.01	87.60
Δ G/mean%	15.85	14.80	30.05	29.83	8.83	32.66	24.64	21.36	40.37	52.71	18.34	38.48
Giza 168												
Mean±SE	105 ± 1.2	15.1 ± 1.2	9.92 ± 1.44	30.61 ± 1.44	61.98 ± 1.81	5.31 ± 0.06	99.16 ± 0.70	14.52 ±0.19	8.46 ± 0.33	19.4 ± 1.06	48.7 ± 1.73	4.90 ± 0.1
Reduction%							5.56	3.84	14.72	36.62	21.42	7.72
CV%	8.12	9.48	31.70	33.15	20.66	7.51	4.99	9.46	27.60	38.50	25.14	8.80
Sids 4												
Mean±SE	80.4 ±0.82	16.9 ± 0.22	4.52 ± 0.13	22.77 ± 0.97	78.71 ± 1.87	5.74 ±0.06	77.66 ± 0.51	16.04 ±0.14	3.94 ± 0.09	18.9 ± 0.81	77.6 ±1.65	5.4 ± 0.1
Reduction%							3.41	5.09	12.83	16.99	1.41	5.92
CV%	7.20	9.35	20.10	30.16	16.83	7.15	4.66	6.04	16.50	30.10	15.03	6.80

Δ G = The expected genetic advance from selecting the superior 40 / 540 plants under drought and 40/509 under irrigation .

Table 2. Variability and heritability estimates of grain yield/plant as affected by three cycles of selection under normal irrigation (N) and drought stress (D).

Selection cycle	σ^2_p		σ^2_g		P.C.V. %		G.C.V. %		H %		Realized heritabil-ity%	
	N	D	N	D	N	D	N	D	N	D	N	D
F_3 families (C_0) 2007/2008	127.53	123.1	-	-	38.77	43.39	-	-	41.16	64.13	-	-
F_4 selected families (C_1) 2008/2009	9.84	11.62	9.53	10.94	21.71	25.49	21.36	24.74	98.38	94.19	8.27	25.57
F_5 selected families (C_2) 2009/2010	9.38	5.53	8.72	5.19	17.93	19.14	17.29	18.53	92.98	93.82	79.41	14.06
F_6 selected families (C_3) 2010/2011	13.49	12.31	12.82	11.85	15.31	16.96	14.93	16.64	95.02	96.25	78.46	37.88

H = Heritability in broad sense.

Table 3. 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 three cycles of selection under drought stress and normal irrigation.

Ite m	Fam. No.	Evaluation under drought			Evaluation under normal irriga-		
		Mean	OG%(Bul	OG%(B	Mean	OG%(Bul	OG%(B
Drought selections	39	22.13	34.96**	20.18**	23.83	31.43**	9.66
	301	30.87	88.21**	67.60**	31.90	75.92**	46.78**
	85	20.67	26.02**	12.22*	24.33	34.19**	11.96*
	108	19.13	16.67**	3.89	19.03	4.96	-12.42
	152	19.47	18.70**	5.70	26.27	44.85**	20.86**
	161	17.57	7.11	-4.62	28.60	57.72**	31.60**
	176	25.03	52.64**	35.93**	26.03	43.57**	19.79**
	290	24.40	48.78**	32.49**	26.00	43.38**	19.63**
	463	18.80	14.63**	2.08	22.93	26.47**	5.52
	488	23.23	41.67**	26.15**	24.43	34.74**	12.42*
	Aver-	22.13	34.94**	20.16**	25.34	39.72**	16.58*
Irrigation selections	189	22.07	34.55**	19.82**	23.47	29.41**	7.98
	208	18.40	12.20*	-0.09	19.87	9.56	-8.59
	254	18.87	15.04**	2.44	27.77	53.13**	27.76**
	261	18.10	10.37	-1.72	21.73	19.85**	0.00
	275	19.47	18.70**	5.70	19.80	9.19	-8.90
	322	18.87	15.04**	2.44	22.17	22.24**	1.99
	347	24.03	46.54**	30.50**	25.47	40.44**	17.18**
	436	24.97	52.24**	35.57**	26.43	45.77**	21.63**
	474	19.00	15.85**	3.17	28.00	54.41**	28.83**
	509	20.60	25.61**	11.86**	26.53	46.32**	22.09**
	Aver-	20.44	24.61**	10.97*	24.12	33.03**	11.00*
	Giza	18.42			21.73		
	Sids 4	15.07			17.20		
	Bulk	16.40			18.13		
$R.LSD_{0.05}$		1.76			2.22		
$R.LSD_{0.01}$		2.34			2.96		

*and ** significant at 0.05 and 0.01 levels of probability, respectively.

Table 4.Means and observed gain from selection for high grain yield/plant for the three cycles under drought stress and normal irrigation from the bulk sample and the better parent.

Cycle and means	Drought stress (D)		Normal irrigation (N)	
Cycle 1:F_4-generation				
Families mean	**13.66**		**15.72**	
Giza 168	**12.77**		**14.96**	
Sids 4	**8.31**		**14.33**	
Bulk sample	**7.32**		**14.01**	
OG% (Bulk)	**86.68****		**12.21***	
OG% (Better parent)	**6.96**		**5.08**	
R.LSD $_{0.05}$	**2.17**		**1.39**	
R.LSD $_{0.01}$	**2.86**		**1.84**	
Cycle 2:F_5-generation				
Families mean	**12.49**		**17.46**	
Giza 168	**11.53**		**15.78**	
Sids 4	**10.10**		**12.77**	
Bulk sample	**11.27**		**15.03**	
OG% (Bulk)	**10.88**		**16.12***	
OG% (Better parent)	**8.31**		**10.61**	
R.LSD $_{0.05}$	**1.62**		**2.15**	
R.LSD $_{0.01}$	**2.14**		**2.83**	
Cycle 3:F_6-generation	**D-group**	**N-group**	**D-group**	**N-group**
Families mean	**22.13**	**20.44**	**25.34**	**24.12**
Giza 168	**18.42**		**21.73**	
Sids 4	**15.07**		**17.20**	
Bulk sample	**16.40**		**18.13**	
OG% (Bulk)	**34.94****	**24.61****	**39.72****	**33.03****
OG% (Better parent)	**20.16****	**10.97***	**16.58***	**11.00***
R.LSD $_{0.05}$	**1.76**	**1.76**	**2.22**	**2.22**
R.LSD $_{0.01}$	**2.34**	**2.34**	**2.96**	**2.96**

*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 sample.

Table 5. Drought susceptibility index (DSI) and sensitivity to environments after three cycles of selection for grain yield/plant (GY/P)

Item	Fam. No.	GY/P; g under irrigation	GY/P; g under drought	DSI	Sensitivity
Drought selections	**39**	**23.83**	**22.13****	**0.79**	**0.98**
	301	**31.90****	**30.87****	**0.36**	**0.60**
	85	**24.33***	**20.67***	**1.66**	**2.12**
	108	**19.03**	**19.13**	**-0.06**	**-0.06**
	152	**26.27****	**19.47**	**2.85**	**3.93**
	161	**28.60****	**17.57**	**4.25**	**6.38**
	176	**26.03****	**25.03****	**0.42**	**0.58**
	290	**26.00****	**24.40****	**0.68**	**0.92**
	463	**22.93**	**18.80**	**1.98**	**2.39**
	488	**24.43***	**23.23****	**0.54**	**0.69**
	Average	**24.34***	**22.13***		
Irrigation selections	**189**	**23.47**	**22.07****	**0.02**	**0.81**
	208	**19.87**	**18.40**	**0.48**	**0.85**
	254	**27.77****	**18.87**	**2.10**	**5.14**
	261	**21.73**	**18.10**	**1.09**	**2.10**
	275	**19.80**	**19.47**	**0.11**	**0.19**
	322	**22.17**	**18.87**	**0.98**	**1.91**
	347	**25.47****	**24.03****	**0.37**	**0.83**
	436	**26.43****	**24.97****	**0.36**	**0.84**
	474	**28.00****	**19.00**	**2.11**	**5.20**
	509	**26.53****	**20.60***	**1.47**	**3.43**
	Average	**24.12**	**20.44**		
	G168	**21.73**	**18.42**	**1.00**	**1.91**
	Sids 4	**17.20**	**15.07**	**0.81**	**1.23**
	Bulk	**18.13**	**16.40**	**0.63**	

*** and ** ; significant observed gain from the better parent at 0.01 and 0.05 level of probability; respectively.**

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الميزة النسبية للانتخاب المنسب لمحصول الحبوب في قمح الخبز تحت ظروف الجفاف والري العادي والحساسية للبيئة

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أجري هذا البحث لدراسة الميزة النسبية للانتخاب المنسب لمحصول الحبوب / نبات تحت ظروف الجفاف والري العادي. تم تنفيذ ثلاثة دورات انتخابية في البيئتين. كانت العشيرة القاعدية عبارة عن الجيل الثالث للهجين جيزه ١٦٨ × سدس ٤. وفي السنة الرابعة تم تقييم منتخبات الجفاف والري تحت ظروف البيئتين. انخفض التباين المظهري تدريجياً من الجيل الثالث إلي الجيل السادس ، وكان أكثر قليلاً من التباين الوراثي. كان معامل التوريث المحقق تحت ظروف الري ٢٨.٢٧ ، ٧٩.٤١ ، ٧٨.٤٦% مقابل ٢٥.٥٧ ، ١٤.٠٦ ، ٣٧.٨٨% تحت ظروف الجفاف للدورة الأولي والثانية والثالثة علي الترتيب. وكانت الزيادة المحققة في المحصول من الدورة الثالثة وحدها تعادل تقريباً ضعف الزيادة المحققة من الدورتين الأولي والثانية. ولهذا فإن هذه النتائج تقترح تأخير الانتخاب حتي الجيل الخامس، وحتي تصل الأصالة الوراثية إلي درجة معقولة لتقليل الجهد والنفقات بشرط تقليل والتنافس بين النباتات من الجيل الثاني حتي الخامس لتفادي الفقد في التراكيب الوراثية الجيدة. كانت الزيادة المحققة في المحصول لمنتخبات الجفاف ٢٠.١٦ ، ١٦.٥٨% بالمقارنة بـ ١٠.٩٧ ، ١١.٠٠% لمنتخبات الري عند تقييمهما تحت ظروف الجفاف والري علي الترتيب. وتشير هذه النتائج إلي أن الانتخاب المتضاد يقلل الحساسية للجفاف أما الانتخاب المتوافق فيزيد الحساسية للجفاف. كما أن الانتخاب لمحصول الحبوب للنبات تحت ظروف الجفاف كان أفضل من الانتخاب تحت ظروف الري سواء أجري التقييم تحت ظروف الجفاف أو تحت ظروف الري.