Evaluation of some Wheat Genotypes under Drought Conditions in Nubaria Region

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ABSTRACT

Twelve wheat bread (*Triticum aestivum*, L.) genotypes evaluated for their yielding ability under water stress and well watered conditions in the new reclaimed lands among two growing seasons 1997/98 and 1998/99. The results could be summarized as follow : (1) spike numbers/m^2 decreased significantly by water deficit from 15.70 to 16.93%; (2) significant reduction was found in grain yield ranged from 11.63 to 12.57%; (3) lines 1,3,4,7 and Nesser cultivars produced the highest number of spikes/m^2; (4) genotypes were different significantly in number of grains/spike in both seasons; (5) line3, Sahel 1, Sids 1 and Nesser cultivars gave the highest number of grain/spike; and (6) drought stress significantly decreased 1000 grain weight by 4.04 to 6.56%, whereas line 3,6,8 and Sakha 8 produced the heaviest kernels as an average of the two seasons.

INTRODUCTION

Wheat (*Triticum aestivum*, L.) is the most important cereal crop all over the world, and in Egypt. Wheat production in Egypt had been increased from 2.06 million tons in 1983 to 6.56 million tons in 1999/2000 season (328% increase)*. This sharp increase in grain yield in the last two decades was achieved not only by increases in cultivated wheat area (from 1.32 million feddans in 1983 to 2.46 million feddans in 2000), but also by continuous increases in grain yield per feddan (from 1.51 ton/fed. In 1983 to 2.67 ton/fed. in 2000), , as a result of planting high yield potentiality.

In the newly reclaimed lands, the problem of water stress is increasing with the time because of the nature of sandy soil in some areas and shortage of water in the lands located at the tails of irrigation canals. Therefore, there is a need of developing new wheat genotypes tolerant to water stress and adapted to newly reclaimed lands.

Wheat breeders are always looking for genetic diversity in which drought tolerance and yield potential can be combined. At the same time, breeders are looking for such criteria that play a role in the plant water relations of wheat under stressed conditions which could be used to screen germplasm for drought tolerance.

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* Statistical Data for Wheat Production in Egypt 2000, issued by Agric. Res. Cent., Giza, on 9/10/2000. Arabic).

The objectives of this study are :

a) To evaluate some bread wheat genotypes for their yielding ability under water stress and well watered conditions in the new reclaimed lands.

b) To compare the response of some wheat lines to water stress developed under drought conditions with other lines derived from well watered breeding program.

c) To investigate the response to water stress could be related to plant water potential and possibility of using it as a selection criterion under drought conditions.

MATERIALS AND METHODS

This investigation was carried out on Research Farm of Nubaria Agricultural Research Station in the two growing seasons of 1997/98 and 1998/99. The experimental site in North Tahrir calcareous soil (21.5% $CaCO_3$) with a sandy loam texture, low organic matter content (0.895%) and pH value of 8.15 under surface irrigation.

The study involved twelve bread wheat (*Triticum aestivum*, L.) lines and cultivars under two irrigation treatments. The tested wheat genotypes are presented in (Table 1) and involved eight lines derived from wheat breeding program of Nubaria Research Station, three Egyptian wheat cultivars, and a Syrian wheat cultivar. Wheat lines 1, 3, 5 and 7 were selected from well irrigated breeding program while lines 2, 4, 6 and 8 were selected from wheat breeding program under water stress conditions.

Water treatments included two regimes :

a) Irrigation treatment: recommended water requirements of wheat at calcareous soil of North Tahrir according to Ministry of Agriculture (6 irrigations).

b) Water stress treatment of two irrigations,:the first at sowing and the second irrigations at 30 days after planting then the trial was under rainfall conditions. The amount of percepitation (Table 2) was obtained from the meterological data of Nubaria Agricultural Research Station.

The experimental design was a split plot, with four replications. Where experiment irrigation treatments were allocated to the main plots while the twelve wheat genotypes were randomly assigned to the sub plots. Each sub plot consisted of six rows (3.5 m long and 20 cm apart). Sowing dates were 16 and 20 November in the first and second seasons, respectively. Seeding rate was 60 kg/fed in the two seasons. Chemical fertilizers were applied at the recommended levels for North Tahrir site, i.e., 150 kg/Fad of superphosphate fertilizer (15.5% P_2O_5) was applied before sowing, 50 kg/Fad potassium sulfate (48% K_2O) was applied before sowing and 100 kg/Fad of nitrogen fertilizer in the form of ammonium nitrate (33.5% N) was added in two equal doses at planting and before the first irrigation.

Collected data for this investigation involved yield and its components, some agronomic traits, and some physiological measurements as follows :

1- Grain yield (ton/Fad) measured from the four middle guarded rows.
2- Number of spikes/m^2 (fertile spikes).
3- Number of grains/spike (average of 10 random spikes/plot).
4- 1000-kernel weight (gm) of three samples for each plot.
5- Plant height (cm) was measured as an average of five random plants from each sub-plot before harvesting.
6- Number of days from sowing to 50% heading (complete emergence of 50% of spike from the leaf sheath).

1) Flag leaf area (cm^2) : was estimated at anthesis growth stage as the average of five flag leaves taken randomly from each sub-plot. It was measured using electrical apparatus (LI-3000 Portable Area Meter, LI-3050 A Belt Conveyer).
2) Plant water potential (Bar) : it was determined using a pressure pump (Soil Moisture Equipment Corp. plant water status console model 3005, at three times during the growing season:

(a) at tillering stage, (b) at heading stage, (c) at anthesis stage, in the two seasons.

3) Drought susceptibility index (SI) : was calculated for the grain yield and yield components according to Fischer and Maurer (1978) as the following :

Table 1. Names, cross and pedigree of the twelve bread wheat genotypes evaluated in the two growing seasons 1997/1998 and 1998/1999.

No.	Line / cultivar	Cross and pedigree
1	Line 1 (L_1)	(I)Giza 155 / OR 5821 Nub. 101-1-54-0
2	Line 2 (L_2)	(D) Giza 155 / OR 5821 Nub. 101-2-8-7-0
3	Line 3 (L_3)	(I) Gemmiza 1 / OR 8519 Nub. 102-1-6-2-0
4	Line 4 (L_4)	(D) Gemmiza 1 / OR 8519 Nub. 102-2-6-5-0
5	Line 5 (L_5)	(I) Gemmiza 1 / ABA 55 Nub. 103-1-5-8-0
6	Line 6 (L_6)	(D) Gemmiza 1 / ABA 55 Nub. 103-5-8-4-0
7	Line 7 (L_7)	(I) Gemmiza 1 / Stephens Nub. 104-3-1-1-0
8	Line 8 (L_8)	(D) Gemmiza 1 / Stephens Nub. 104-10-1-2-0
9	Sakha 8 (Sk_8)	Cno 67 Sn 64 / KLRE /3/8156 PK 3418-65-15-OS
10	Sahel 1 (Sh_1)	NS 732 / PIMA / Veery "S" SD 735-4SD-1SD-OSD
11	Sids 1 (Sd_1)	HD 2172 / Pavon "S" // 1158.57/Maya 74 "S" SD 46-4SD-2SD-1SD-OSD
12	Nesser (Ns)	ICW 85-0658-300 L-300 AP-300 L-3AP.OL.1AP

$$SI = (1 - Y_D / Y_I) / D$$

Where, Y_D = grain yield of the i^{th} genotype in the drought treatment.
Y_I = grain yield of the same genotype in the control treatment.
D = drought intensity = 1- [mean Y_D of all genotypes] / [mean Y_I of all genotypes].

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

Table 2. Air temperature means (C°) and total precipitation (mm) for the experimental sites in the two growing seasons 1997/1998 and 1998/1999.

Month	Air temperature (C°)		Precipitation (mm)	
	1997/1998	1998/1999	1997/1998	1998/1999
November	15.4	20.2	17.0	0.0
December	13.7	15.8	50.0	3.0
January	13.1	14.7	12.0	6.0
February	13.8	14.5	4.0	12.0
March	14.0	16.4	2.0	1.4
April	21.4	22.2	0.0	0.0
May	22.1	23.4	1.0	0.0
Total			86.0	22.4
Average	16.2	18.		

RESULTS AND DISCUSSION

1. Yield and yield components :

Analysis of variance for grain yield, yield components, and harvest index (HI) is presented in Table (3). The results showed highly significant differences among wheat genotypes in grain yield, number of spikes/m^2, number of grains/spike and 1000-grain weight, in the two growing seasons except number of spikes/m^2 and number of grains/spike in 1998/99 season where the differences among genotypes in these two characters were only significant. The results of analysis of variance indicated the different responses of these genotypes to Nubaria conditions because of genetic diversity among the genetic material where cultivars Giza 155 and Gemmiza 1 were Egyptian materials crossed with OR 5821, OR 8519, ABA 55 and Stephens which were introduced from USA. Cultivars Sakha 8, Sahel 1 and Sids 1 are also Egyptian cultivars with different genetic backgrounds while Nesser is a Syrian cultivar selected from ICARDA's material (Table 1).

Results in Table (3) showed significant differences between the two irrigation treatments in grain yield and 1000-grain weight, while highly significant differences were detected between the two irrigation treatments in number of spikes/m^2 in the two seasons. However, insignificant differences in number of grains/spike were detected in the two growing seasons.

Genotypes x irrigation treatments interactions, as indicator to (G x E) interaction, were highly significant or only significant in one season and insignificant in the other season for grain yield, number of spikes/m^2, and number of grains/spike (Table 3). However, 1000-grain weight showed insignificant differences in genotype x irrigation treatments interactions. These results might be interpreted by differences in amounts and distribution of preciptation in the two growing seasons (Table 2). Data in Table (4) showed that average wheat grain yields were 1.89 ton/Fad and 2.73 ton/Fad in well irrigated treatment and 1.67 ton/Fad and 2.39 ton/Fad in drought treatment in first and second seasons, respectively. This means that moisture stress reduced grain yield by 11.64 and 12.45% in 1997/98 and 1998/99 seasons, respectively.

Grain yield differed significantly among wheat genotypes as affected by irrigation treatments (Table 4). The highest grain were detected by Nesser, line 3, and line 8 in the two growing seasons in addition to Sakha 8, Sahel 1, and Sids 1 in the second season. Reduction in grain yield due to water stress ranged from 2.88% in Sahel 1 to 21.15% in line 4 in 1997/98 while it ranged from 0.54% in Sakha 8 to 21.93% in line 4 (Table 5). These results indicated that Sahel 1 and Sakha 8 showed the least percentages of grain yield reduction in the two growing seasons. Sahel 1 was selected under water stress conditions and recommended to rainfed areas and Sakha 8 is well known for its tolerance to salinity. Abd El-Gawad *et al.* (1993) reported that Sakha 8 showed relatively high tolerance to water stress. Reduction caused by drought was discussed by Rawson and Evans (1971) who reported that wheat grain yield reduction, as a result of drought stress, might be due to that part of dry matter loss could be attributed to respiration and remobilization of assimilates to the grain during grain filling. Bidinger *et al.* (1977) also reported that remobilization of assimilates contributed to 13% of final yield in irrigated wheat compared to 27% in drought stressed wheat. Similar conclusions were obtained by Sayed and Mashhady (1983) and Bayoumi (1999).

Drought susceptibility index (SI) was used as a parameter to provide a measure of stress resistance based on minimization of yield loss under stress as compared to the optimum conditions rather than on yield level under non stress per se. Tables 5 and 6 present reductions in grain yield and susceptibility indices of the twelve wheat genotypes under study. Results in these two tables indicate that line 6, line 7, Sakha 8, Sahel 1, Sids 1 and Nesser could be categorized in one group because these genotypes were not significantly affected by irrigation treatments (low reduction percentage) and had "SI" lower than the unity in 1997/98 season. In the second season (1998/99) line 7, line 8, Sakha 8, Sahel 1, Sids 1 and Nesser showed the lowest reduction percentage in grain yield and less than unity "SI" values. These results of the two seasons confirm the drought tolerance of wheat cultivars Sahel 1, Sakha 8, Sids 1, and Nesser.

One of the most important yield components in wheat is number of spikes/m^2 which is highly affected by environmental conditions especially soil fertility and water stress. Data in Table (4) showed that drought had significantly decreased average number of spikes/m^2 compared to well watered treatment in the two growing seasons. Drought treatment had decreased number of spikes/m^2 (from 622.29 to 529.17) by 14.96 and (from 616.42 to 519.63) 15.70% in the two growing seasons 1997/98 and 1998/99, respectively. These results agree with those obtained by Srivastave and Bansal (1975), Ehdaic *et al.* (1988), and Abdel-Gawad *et al.* (1993). Although studied genotypes exhibited different responses to irrigation treatments in the two seasons for this trait, the genotype x irrigation treatment interaction reached the significance level in the second season only (Table 3). From the data in Tables (5 and 6), lines 4,5,6,7,8 and Nesser cultivars showed the least reduction percentages in number of spikes/m^2 (3.28%, 0.72%, 11.49%, 10.67% and 15.56%, respectively) and the least susceptibility indices (SI) also of 0.21, 0.05, 0.73, 0.50, 0.68 and 0.99 in the same trait, respectively, in 1998/99 season. Although, genotype x irrigation treatment interaction did not the significance level in 1997/98 the studied genotypes varied in their response to water treatments. Lines 2,5,7,8, Sakha 8, Sids1 and Nesser showed lower values in reduction percentages (SI) values (Tables 5 and 6).

Table 3. Mean squares of the analysis of variance for the yield and its components in 1997/98 and 1998/99 seasons.

S.O.V.	d.f.	Grain yield (ton/fed.)		Number of spikes/m^2		Number of grains/spike		1000 grain weight (g)	
		1997/98	1998/99	1997/98	1998/99	1997/98	1998/99	1997/98	1998/99
Replication	3	1.118	0.124	56338.465	22477.041	283.070	49.184	15.560	50.018
Irrigation treatments (A)	1	0.944*	1.101*	35026.040**	51987.040**	8.000$^{n.s}$	70.727$^{n.s}$	63.970*	95.775*
E (a)	3	0.092	0.101	768.152	647.042	55.139	51.405	5.999	9.335
Genotypes (B)	11	0.745**	1.485**	26435.132**	10.396.567*	129.564**	90.100*	328.079**	202.567**
A x B	11	0.758**	0.360	12841.962	23119.769**	71.022*	37.440	3.930	24.325
E (b)	66	0.003	0.189	7209.500	466.042	33.513	44.156	7.100	19.703

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

Table 4. Grain yield (ton/fed) and yield components of the twelve wheat genotypes under irrigation and drought treatments at Nubaria region in 1997/98 and 1998/99 seasons.

Treatments	Grain yield (ton/fed)		Number of spikes/m^2		Number of grains/spike		1000 grain yield weight (g)	
	1997/98	1998/99	1997/98	1998/99	1997/98	1998/99	1997/98	1998/99
Irrigation (I)								
Irrigated	1.89 a	2.73 a	622.29 a	616.42 a	52.60 a	47.31 a	40.14 a	46.63 a
Drought	1.67 b	2.39 b	529.17 b	519.63 b	48.19 a	43.38 a	38.52 b	43.76 b
Genotypes (G)								
Line 1 (L_1)	1.76 e	2.40 b	638.75 a	562.50 ab	49.88 b	44.01 b	38.11 c	41.87 c
Line 2 (L_2)	1.77 e	1.81 c	541.25 d	596.75 a	48.63 b	44.07 b	42.83 b	44.36 bc
Line 3 (L_3)	2.12 a	3.01 a	572.50 c	576.75 ab	57.50 a	42.62 b	43.06 b	50.22 ab
Line 4 (L_4)	1.25 f	2.50 b	551.23 cd	600.00 a	46.38 b	46.33 b	27.03 d	36.31 d
Line 5 (L_5)	1.12 g	1.92 c	416.25 e	483.75 b	47.06 b	47.33 b	26.06 d	36.64 d
Line 6 (L_6)	1.80 d	2.33 bc	555.00 cd	553.75 ab	45.88 b	43.08 b	44.76 ab	49.27 ab
Line 7 (L_7)	1.83 d	2.21 bc	657.50 a	610.00 a	48.13 b	43.67 b	40.12 c	44.98 bc
Line 8 (L_8)	2.08 b	3.09 a	560.00 cd	568.00 ab	49.63 b	43.42 b	45.75 a	52.70 a
Sakha 8 (Sk 8)	1.74 e	2.77 ab	523.75 d	592.50 ab	45.88 b	43.39 b	44.40 ab	45.44 bc
Sahel 1 (Sh 1)	1.88 c	2.94 a	603.75 b	542.25 ab	56.38 a	54.93 a	41.39 bc	47.97 b
Sids 1 (Sd 1)	1.92 c	2.84 ab	587.50 bc	529.75 b	55.13 ab	46.48 b	39.00 c	48.09 b
Nesser (Ns)	2.13 a	2.88 ab	656.25 a	592.50 ab	52.38 ab	44.62 b	39.41 c	45.73 bc
Interaction								
I x G	**	n.s.	n.s.	**	*	n.s.	n.s.	n.s.

Means designated by the same letter (s) in the same column are not significantly different at 0.05 level.

Number of grains/spike is one of the grain yield components which is highly affected by water deficit. The average number of grains/spike was 52.60 and 47.31 under irrigation treatment while it was 48.19 and 43.38 under drought treatment in the first and second seasons, respectively, (Table 4). Drought treatment reduced the number of grains/spike by 8.38% and 8.31% in 1997/98 and 1998/99 seasons, respectively, but these reductions were insignificant. These results might be attributed to the fact of drought at heading and grain development was not severe enough to impose a decisive effect on number of grains/spike.

The studied genotypes differed significantly in both seasons in number of grains/spike (Table 4). The Egyptian cultivar Sahel 1 produced the highest grain number/spike in the two seasons. Only line 3 exceeded Sahel 1 in the first season. Genotypes also showed different responses to drought in number of grains/spike and genotype x irrigation interaction reached the significance level in 1997/98 only (Tables 3 and 4). Reduction percentages and susceptibility index values (SI) of number of grains/spike in 1997/98 and 1998/99 seasons are presented in Tables 5 and 6. Lines 1,3,6,7,8, Sahel 1, Sids 1 and Nesser showed low reduction percentages and lower SI values than one indicating that these genotypes are able to produce higher number of grains/spike under water stress conditions. Dabtez and Bole (1973) and Ehdaie *et al.* (1988) reported that drought had no significant effect on number of grains/spike. However, many researches found that water deficit decreased number of grains/spike as Fischer (1980), Moursi *et al.* (1983), Islam (1990) and El-Monoudi and Harb (1994).

Grain weight is an important component which has big contribution in wheat grain yield. This trait is highly affected by environmental conditions especially soil moisture and temperature during grain filling stage. In the present investigation 1000-grain weight of the twelve wheat genotypes was significantly affected by water treatments in both seasons (Table 4). Well watered genotypes produced heavier grains than those produced under drought treatment in the two seasons of investigation (Table 4) while water stress treatment was found to reduce 1000-grain weight by 4.04 and 6.56% in 1997/98 and 1998/99 seasons, respectively. The twelve wheat genotypes differed significantly in 1000-grain weight in the two seasons of the study. Lines 6 and 8 produced the highest 1000-grain weight in the two seasons, Sakha 8 also produced high 1000-grain weight in the first season. Genotype x irrigation interaction was insignificant in the two seasons which means that the genotypes under study showed similar response to the irrigation treatments in the two seasons of 1997/98 and 1998/99. Drought treatment reduced kernel weight significantly and reduction percentage differed from genotype to another. In 1997/98, lines 2,4,6 and 8, Sakha 8 and Sids 1 showed the least reduction percentages and the lowest susceptibility index (SI) values (less than one).

Table 5. Reduction and reduction percentages due to drought for the grain yield (ton/fed) and yield components of the twelve wheat genotypes at Nubaria region in 1997/98 and 1998/99 seasons.

Genotypes	Grain yield (ton/fed)				Number of spikes/m^2				Number of grains/spike				1000 grain weight (gm)			
	Reduction		Reduction (%)		Reduction		Reduction (%)		Reduction		Reduction (%)		Reduction		Reduction (%)	
	97/98	98/99	97/98	98/99	97/98	98/99	97/98	98/99	97/98	98/99	97/98	98/99	97/98	98/99	97/98	98/99
Line 1 (L_1)	0.30*	0.36*	15.49	13.95	177.50**	195.00**	24.40	29.55	4.25	0.65	6.17	1.47	1.85	3.73	4.74	8.53
Line 2 (L_2)	0.28*	0.80**	14.70	36.05	72.50	102.50*	12.55	15.77	14.75*	4.53	26.34	9.78	1.30	5.35*	2.99	11.38
Line 3 (L_3)	0.36**	0.53*	15.69	16.06	120.00*	147.50*	18.97	22.61		1.73	2.58	3.96	2.15	1.57	4.87	3.06
Line 4 (L_4)	0.30*	0.62*	21.15	21.33	172.50**	20.00	27.06	3.28	1.50	0.35	8.42	0.75	0.40	5.55*	1.47	14.20
Line 5 (L_5)	0.25*	0.39*	19.68	18.44	2.50	3.50	0.54	0.72	4.25	6.90*	14.78	13.59	1.75	0.28	6.49	0.76
Line 6 (L_6)	0.19	0.41*	10.05	15.98	60.00	67.50	10.26	11.49	7.50*	3.40	5.82	7.59	1.15	2.17	2.54	4.31
Line 7 (L_7)	0.15	0.24	7.61	10.32	105.00*	50.00	14.79	7.67	2.75	2.67	2.56	5.93	1.67	7.80**	4.08	15.96
Line 8 (L_8)	0.35**	0.09	15.56	2.89	80.00	64.00	13.33	10.67	1.25	5.17	8.21	11.24	0.68	2.50	1.48	4.63
Sakha 8 (Sk 8)	0.19	0.02	10.35	0.54	42.50	105.00*	7.80	16.28	4.25	7.12*	12.76	15.17	0.90	1.78	2.01	3.84
Sahel 1 (Sh 1)	0.06	0.03	2.88	1.02	157.50*	192.00**	23.08	29.68	6.25*	4.55	3.06	7.96	4.02**	1.13	9.26	2.33
Sids 1 (Sd 1)	0.12	0.29	5.81	9.55	75.00	114.50*	12.00	19.51	1.75	4.05	2.24	8.35	1.40	1.42	3.53	2.91
Nesser (Ns)	0.12	0.36*	5.48	11.77	52.50	100.00	7.69	15.56	1.25	6.03	6.02	12.66	2.17	3.50	5.36	7.37
									3.25							

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

Table 6. Susceptibility index (SI) of grain yield (ton/fed) and yield components for the twelve wheat genotypes irrigation and drought treatments at Nubaria region in 1997/98 and 1998/99 seasons.

Genotypes	Grain yield (ton/fed)		Number of spikes/m^2		Number of grains/spike		1000 grain yield weight (gm)	
	1997/98	1998/99	1997/98	1998/99	1997/98	1998/99	1997/98	1998/99
Line 1 (L_1)	1.33	1.11	1.63	1.88	0.98	0.18	1.18	1.30
Line 2 (L_2)	1.26	2.87	0.84	1.00	3.14	1.18	0.74	1.74
Line 3 (L_3)	1.35	1.28	1.27	1.44	0.31	0.48	1.21	0.47
Line 4 (L_4)	1.82	1.74	1.81	0.21	1.00	0.09	0.36	2.17
Line 5 (L_5)	1.69	1.47	0.04	0.05	1.76	1.64	1.61	0.12
Line 6 (L_6)	0.87	1.27	0.69	0.73	0.69	0.91	0.63	0.66
Line 7 (L_7)	0.66	0.82	0.99	0.50	0.31	0.71	1.01	2.43
Line 8 (L_8)	1.34	0.23	0.89	0.68	0.98	1.35	0.37	0.71
Sakha 8 (Sk 8)	0.89	0.04	0.52	1.04	1.52	1.83	0.50	0.59
Sahel 1 (Sh 1)	0.25	0.08	1.54	1.91	0.37	0.96	2.30	0.36
Sids 1 (Sd 1)	0.50	0.76	0.80	1.84	0.27	1.01	0.87	0.44
Nesser (Ns)	0.47	0.94	0.51	0.99	0.72	1.52	1.33	1.13

Similarly, in 1998/99 season, lines 3,5,6 and 8, Sakha 8, Sahel 1, and Sids 1 showed least values for reduction percentages and drought susceptibility indices were less (Tables 5 and 6). Other genotypes showed higher reduction percentages in 1000-grain weight and higher SI values. These results are in agreement with Fischer and Wood (1979), Bhardwaj *et al.* (1987), Islam (1990) and Bayoumi (1999) who pointed out that occurrence of drought at flowering and ripe stages significantly reduced 1000-grain weight.

Previous results of yield and yield components indicated that line 3, line 6, line 7, line 8, Sakha 8, Sahel 1, Sids 1, and Nesser had the least reduction in grain yield, number of spikes/m^2, number of grains/spike, and 1000-kernel weight, moreover, the results showed lower values of SI than units hence they might be used as drought tolerant genotypes under water stress environments.

2. Some agronomic characters :

2.1. Plant height (cm) :

Variations in plant height due to irrigation treatment were highly significant in the second season only (Table 7). However, differences among genotypes were highly significant in the two seasons of the study while irrigation x genotype interactions were not significant in both seasons. Well watered treatment produced taller wheat plants than those in drought treatment. Plant height reduction reached about 14% in the second season. Line 6 and Sids 1 produced the tallest plants while Nesser produced the shortest plants in the first season (Table 8). The data showed that line 3 and Sids 1 had the tallest plants while line 4 and Nesser were the shortest genotypes in the second season of the study. The highest reduction percentages in plant height were detected by line 6, line 7, Sakha 8, Sahel 1 and Sids 1 in 1998/99 season. Blum and Pnuel (1990) concluded that taller wheat cultivars had a greater capacity to support grain filling from stem reserves under drought because of their greater storage. the previous results were in agreement with Srivastava and Bansal (1975), Islam (1990), and Abd El-Gawad *et al.* (1993).

2.2. Number of days to heading (days) :

Analysis of variance of days to heading (Table 7) indicated that variations due to irrigation treatments were significant in the second season only, while highly significant differences were found among the studied genotypes in the two seasons. Genotype x irrigation interaction was highly significant in the second season only.

Data in Table 9 showed that drought treatment caused earlier heading than recommended irrigation. Drought conditions decreased number of days to heading by 0.76 and 2.47% in 97/98 and 98/99 seasons, respectively. The latest material in heading under irrigation treatment were line 1, line 2, line 4 and line 5 while line 3,line 8, Sakha 8 and Sahel 1 were the earliest genotypes. On the other hand, under drought conditions, Sakha 8, Sids 1 and Nesser cultivars became significantly earlier than under irrigated condition (Table 9).

Table 7. Means squares of the analysis of variance for the agronomic characters in 1997/98 and 1998/99 seasons.

S.O.V.	d.f.	Plant height (cm.)		Days to heading (day)		Flag leaf area (cm^2)	
		1997/98	1998/99	1997/98	1998/99	1997/98	1998/99
Replication	3	128.063	39.132	18.344	5.472	27.025	15.822
Irrigation treatments (A)	1	4.860	2158.407**	15.844	155.041*	188.468*	298.803*
E (a)	3	29.968	12.692	2.399	14.903	8.273	16.306
Genotypes (B)	11	268.085**	308.550**	2951.101**	235.394**	126.767**	26.118**
A x B	11	25.565	38.852	1.980	12.815**	21.593*	10.100
E (b)	66	24.930	35.951	5.409	4.748	8.255	5.714

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

Table 8. Means of some agronomic characters of the twelve wheat genotypes under irrigation and drought treatments at Nubaria region in 1997/98 and 1998/99 seasons.

Treatments	Plant height (cm)		Days to heading (day)		Flag leaf area (cm^2)	
	1997/98	1998/99	1997/98	1998/99	1997/98	1998/99
			Irrigation (I)			
Irrigated	113.33 a	120.96 a	107.08 a	102.73 a	18.70 a	13.27 a
Drought	112.97 a	104.05 b	106.27 a	100.19 b	15.90 b	9.75 b
			Genotypes (G)			
Line 1 (L_1)	115.83 ab	116.70 b	132.13 b	108.63 a	22.22 ab	14.57 a
Line 2 (L_2)	114.83 ab	116.05 b	127.38 c	108.63 a	20.54 b	14.07 ab
Line 3 (L_3)	115.10 ab	123.03 a	90.00 f	97.00 c	16.51 de	10.22 bc
Line 4 (L_4)	109.00 b	106.39 c	134.75 a	107.88 a	18.99 c	9.73 bc
Line 5 (L_5)	116.08 ab	119.80 ab	135.50 a	109.00 a	23.61 a	12.64 ab
Line 6 (L_6)	118.05 a	121.35 ab	94.13 e	97.75 c	11.70 g	10.36 bc
Line 7 (L_7)	115.60 ab	114.85 b	94.25 e	96.63 c	21.13 b	8.51 c
Line 8 (L_8)	115.70 ab	118.95 ab	91.75 f	95.63 c	12.20 g	11.55 b
Sakha 8 (Sk 8)	110.25 b	115.42 b	93.75 ef	97.63 c	15.37 e	10.85 bc
Sahel 1 (Sh 1)	111.40 b	115.28 b	93.25 ef	97.50 c	14.63 ef	11.82 b
Sids 1 (Sd 1)	118.60 a	123.65 a	96.13 de	100.38 b	17.00 d	10.73 bc
Nesser (Ns)	97.53 c	103.08 c	97.13 d	100.88 b	13.67 f	13.08 ab
			Interaction			
I x G	n.s.	n.s.	n.s.	**	*	n.s.

Means designated by the same letter (s) in the same column are not significantly different at 0.05 level.

Table 9. Reduction and reduction percentages for the agronomic characters of the twelve wheat genotypes at Nubaria region in 1997/98 and 1998/99 seasons.

Genotypes	Plant height (cm)				Days to heading (day)				Flag leaf area (cm^2)			
	Reduction		Reduction (%)		Reduction		Reduction (%)		Reduction		Reduction (%)	
	97/98	98/99	97/98	98/99	97/98	98/99	97/98	98/99	97/98	98/99	97/98	98/99
Line 1 (L_1)	1.15	7.40	0.99	6.15	2.25*	-0.75	1.69	-0.69	7.70**	4.93*	29.54	28.95
Line 2 (L_2)	0.75	6.40	0.65	5.37	0.75	-0.75	0.59	-0.69	5.04*	4.87*	21.86	29.52
Line 3 (L_3)	-3.50*	6.85	-3.09	5.42	0.00	3.00	0.00	3.05	6.39**	0.94	32.44	8.79
Line 4 (L_4)	-0.50	3.98	-0.46	3.67	-0.50	1.75	-1.75	1.61	-0.82	0.40	-4.41	4.03
Line 5 (L_5)	-6.85**	1.90	-6.08	1.57	0.50	0.50	0.37	0.46	-1.98	6.14*	-8.75	39.08
Line 6 (L_6)	3.20*	14.10**	2.67	10.98	1.25	6.50*	1.32	6.44	-0.27	3.31	-2.34	27.56
Line 7 (L_7)	-0.80	12.20*	-0.69	10.09	2.50*	0.25	2.62	0.26	3.01	4.88*	13.30	44.57
Line 8 (L_8)	1.80	9.90*	1.54	7.99	0.50	2.75	0.54	2.84	0.19	1.19	1.55	9.80
Sakha 8 (Sk 8)	5.90*	13.63*	4.79	11.15	0.50	5.25**	0.53	5.24	3.47	4.61*	20.29	35.06
Sahel 1 (Sh 1)	1.30	14.05**	1.16	11.49	1.50	2.50	1.60	2.53	2.41	1.38	15.22	11.03
Sids 1 (Sd 1)	-3.01*	14.60**	-2.57	11.15	1.25	4.25*	1.29	4.15	1.10	2.39	6.26	20.05
Nesser (Ns)	5.65**	8.75*	5.63	8.14	-0.75	5.75**	-0.78	5.54	7.40**	7.26**	42.60	43.45

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

Many researchers as Levitt (1972) and Beg and Turner (1976) emphasized the importance of earliness in ensuring a good yield performance of wheat under water stress conditions. They stated that development of faster maturity types was considered to be basic drought escape mechanism for better match of water demand to water supply. In the present study, the genotypic differences in heading and earliness of some genotype is a good escape mechanism which may help in determining drought avoidance in the studied genotype. Wheat cultivars Sakha 8, Sids 1 and Nesser showed significant earliness under drought treatment.

2.3. Flag leaf area :

Analysis of variance of flag leaf area (Table 7) showed that variations in flag leaf area due to irrigation treatments were significant in the two seasons. Highly significant differences were also detected among the twelve wheat genotypes in the two seasons. Genotype x irrigation treatments interaction was significant in the first season only. Data in Table (8) show that irrigation treatment produced larger flag leaf area than drought treatment in the two seasons. Flag leaf areas were 18.70 and 13.27 cm^2 under irrigation while they were 15.90 and 9.75 cm^2 under drought conditions resulting 14.97% and 26.53% reductions in flag leaf area in 1997/98 and 1998/99 seasons, respectively. Lines 1, 2, 3 and Nesser cultivars showed significant reduction in flag leaf area as a result of drought, the reduction percentages here in were 29.54%, 21.86%, 32.44% and 42.60%, respectively.

Richards (1983) reported that leaf area reduction was a common drought avoidance mechanism. Wery *et al.* (1994) also pointed out that reduction of leaf area was an important adaptive mechanism for drought stress. In addition, reduced leaf growth rate and accelerated leaf senescence are common response to water deficit and both reduced leaf area.

3. Plant water potential :

Data in (Table 10) indicated that variations in plant water potential due to irrigation treatments were significant at heading and anthesis while at tillering they were not significant in the two seasons. Similarly, variations among wheat genotypes were also significant at heading and anthesis stages in the two seasons. Genotypes x irrigation treatments interaction did not reach significance level in the three growth stages except at anthesis in the first season. From data in Table (11) drought treatment had significantly reduced plant water potential at heading by 30.00% and 37.33% in 1997/98 and 1998/99 seasons, respectively. At anthesis, drought treatment reduced plant water potential by 13.24% in 1997/98 and by 27.04% in 1998/99 season.

Bayoumi (1999) pointed out that water deficit decreased leaf water potential compared to well-watered condition. Moustafa *et al.* (1996) stated that early drought stress during tillering stage had no significant effect on leaf water potential, but after that (during heading stage), drought had significantly decreased leaf water potential.

Table 10. Means squares of the analysis of variances for the plant water potential in bar during 1997/98 and 1998/99 growing seasons.

S.O.V.	d.f.	Tillering stage		Heading stage		Anthesis stage	
		1997/98	1998/99	1997/98	1998/99	1997/98	1998/99
Replication	3	11.910	15.379	8.407	5.608	3.264	12.100
Irrigation treatments (A)	1	147.513	9.690	198.662*	20.825*	48.878*	58.954*
E (a)	3	24.475	10.778	7.296	0.959	1.438	2.878
Genotypes (B)	11	10.888	10.432	10.171*	13.424*	12.139**	17.430*
A x B	11	3.666	6.951	7.870	2.534	7.976*	4.713
E (b)	66	16.072	18.962	3.394	4.066	3.815	5.788

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

Table 11. Plant water potential (bar) of the twelve genotypes under irrigation and drought treatments at tillering, heading and anthesis growth stages at Nubaria region in 1997/98 and 1998/99 seasons.

Treatments	Plant water potential at tillering stage (bar)		Plant water potential at heading stage (bar)		Plant water potential at anthesis stage (bar)	
	1997/98	1998/99	1997/98	1998/99	1997/98	1998/99
				Irrigation (I)		
Irrigated	3.06 a	2.87 a	8.97 b	3.75 b	15.64 b	10.76 b
Drought	4.41 a	3.71 a	11.66 a	5.15 a	17.71 a	13.67 a
				Genotypes (G)		
Line 1 (L_1)	3.80 a	2.49 a	7.89 c	2.88 c	15.85 b	12.60 ab
Line 2 (L_2)	3.45 a	2.07 a	9.55 b	4.39 bc	17.09 ab	13.25 ab
Line 3 (L_3)	5.74 a	4.18 a	10.54 ab	5.49 ab	17.75 ab	12.10 ab
Line 4 (L_4)	4.38 a	2.74 a	9.92 b	3.74 bc	15.48 b	10.88 b
Line 5 (L_5)	3.38 a	2.20 a	9.94 b	3.69 bc	15.93 b	12.20 ab
Line 6 (L_6)	3.73 a	4.08 a	10.72 ab	3.29 bc	17.53 ab	12.15 ab
Line 7 (L_7)	4.43 a	3.14 a	10.78 ab	2.75 c	14.50 b	12.50 ab
Line 8 (L_8)	2.90 a	4.88 a	11.69 a	7.14 a	18.67 a	13.33 a
Sakha 8 (Sk 8)	1.44 a	3.20 a	10.61 ab	3.88 bc	17.95 ab	12.62 ab
Sahel 1 (Sh 1)	3.68 a	3.84 a	11.01 ab	4.15 b	16.39 b	12.00 ab
Sids 1 (Sd 1)	2.76 a	2.86 a	11.54 a	5.08 b	17.85 ab	10.83 b
Nesser (Ns)	4.54 a	3.85 a	9.63 b	6.85 ab	16.15 b	11.73 ab
			Interaction			
I x G	n.s.	n.s.	n.s.	n.s.	*	n.s.

Means designated by the same letter (s) in the same column are not significantly different at 0.05 level.

Data of plant water potential at heading stage in Table (11) showed that line 8 and Sids 1 had the lowest plant water potential values while line 1 scored the highest plant water potential in the first season. In the second season (1998/99), line 5, line 8 and Nesser gave the lowest plant water potential values while line 1 and line 7 gave the highest plant water potentials.

Data in Table (11) also showed that at anthesis stage, line 8 had the lowest plant water potential while lines 1, 4, 5, 7, Sahel 1 and Nesser showed the highest values of plant water potential in 1997/98, however, in 1998/99 season, line 8 also showed the lowest value of plant water potential while line 4 and Sids 1 had the highest values of plant water potential.

Previous results indicated that plant water potential values for the studied wheat genotypes differed from one season to another during the two seasons of the study. Kaul (1969) found genetic differences in leaf asmotic potential when samples were taken during grain filling in cultivars under moisture stress. Moutafa *et al.* (1996) pointed out that differences in leaf potential may be explained by differences in rate of water use during irrigation and soil water content at the time measurements were made.

Comparison between selected lines under well watered conditions and selected lines under drought conditions showed significant differences between the two groups in plant water potential at tillering and heading however, such differences were insignificant at anthesis. Average values of reduction over the two seasons were 42.65%, 45.53% and 20.45% for genotypes selected under favorable conditions compared to 28.01%, 34.83% and 21.37% for genotypes selected under drought conditions at tillering, heading and anthesis stages, respectively. These results indicated that genotypes selected under irrigation conditions were sensitive to drought conditions.

Previous results of this study demonstrate that all characters of the studied wheat genotypes suffered from drought stress conditions in the two seasons except line 3, line 8, and Nesser cultivars which were slightly affected by drought treatment. The previous genotypes had the highest grain yield confirmed by Abayomi and Wright (1999) and almost yield components, shorter stature, earlier heading, larger flag leaf area and less plant water potential values than the other studied genotypes. Since wheat breeder is searching for the genetic diversity in which drought tolerance and yield potential may be combined, those three genotypes could be evaluated in enlarged yield traits to confirm their yielding potentiality in combination with drought tolerance and could be used in breeding programs for drought tolerance.

Table 12. Reduction and reduction percentages for plant water potential of the twelve wheat genotypes at tillering, heading and anthesis growth stages at Nubaria region in 1997/98 and 1998/99 seasons.

Genotypes	Plant water potential at tillering stage				Plant water potential at heading stage				Plant water potential at anthesis stage			
	Reduction		Reduction (%)		Reduction		Reduction (%)		Reduction		Reduction (%)	
	97/98	98/99	97/98	98/99	97/98	98/99	97/98	98/99	97/98	98/99	97/98	98/99
Line 1 (L_1)	0.20	0.82	5.41	39.42	3.02*	1.65	47.34	25.49	0.60	1.90	3.86	16.31
Line 2 (L_2)	0.70	0.23	22.58	11.79	2.70*	0.22	32.93	5.14	0.48	1.10	2.85	8.66
Line 3 (L_3)	3.48*	2.95*	87.00	109.26	1.28	3.22**	12.93	82.99	0.90	4.80*	5.20	49.49
Line 4 (L_4)	0.55	0.12	13.41	4.48	1.87	1.58	20.82	53.56	1.45	3.35*	9.83	36.41
Line 5 (L_5)	1.15	0.50	41.07	25.64	4.42**	0.78	57.18	23.64	0.95	1.30	6.15	11.26
Line 6 (L_6)	0.05	0.45	1.35	11.69	2.53	1.18	26.77	43.70	6.45*	5.10*	48.50	53.13
Line 7 (L_7)	0.95	0.28	24.05	9.33	4.50**	1.30	52.75	61.91	1.30	6.10**	9.39	61.93
Line 8 (L_8)	1.60*	2.85*	76.19	82.61	2.62*	3.72**	25.24	70.46	1.73	0.25	9.70	1.89
Sakha 8 (Sk 8)	1.60*	0.70	128.00	24.56	0.35	1.25	3.36	38.46	5.00**	1.73	32.36	14.72
Sahel 1 (Sh 1)	2.75*	0.42	119.57	11.57	2.85	0.30	29.75	7.50	0.62	3.20*	3.86	30.77
Sids 1 (Sd 1)	1.25	0.35	58.14	13.06	3.08*	1.85	30.80	44.58	2.70*	4.85*	16.36	57.74
Nesser (Ns)	1.88*	0.40	52.22	10.96	3.20*	0.90	39.85	14.06	2.70*	1.35	17.51	12.22

All data of water potential in the three stages traits were negative values.
*,** Significant reduction at 0.05 and 0.01 probability levels, respectively.

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الملخص العربي

تقييم بعض التراكيب الوراثية للقمح تحت ظروف الجفاف فى منطقة النوبارية

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أجريت الدراسة خلال موسمى ١٩٩٨/٩٧ ، ١٩٩٩/٩٨ بمحطة البحوث الزراعية بالنوباريـــة لتقييـم القدرة المحصولية لإثنا عشر تركيباً وراثياً بقمح الخبز *Triticum aestivum*, L. تحت نظامين للرى هما:

١-الرى Irrigation تحت ظروف الرى العادية ٦ ريات خلال موسم النمو.

٢-الإجهاد الجفافى Drought إعطاء ريتين الأولى عند الزراعة والثانية بعد ٣٠ يوم من الزراعة مع بقـــاء النباتات تحت ظروف الأمطار المتساقطة خلال موسم النمو.

وأستخدم تصميم القطع المنشقة A split-plot design فى أربع مكررات ، وكانت معاملات الـــرى تمثل القطع الرئيسية Main plot والإثنى عشر تركيباً وراثياً عامل القطع المنشقة Sub-plot وهـــى أربـــع سلالات منتخبة تحت ظروف الرى العادية بالنوبارية وأربعة سلالات منتخبة تحت ظـــروف الجفـــاف وأربعـــة أصناف ثلاثة منها محلية (سخا ٨، ساحل ١، سدس١) وصنف (نسر) مســـتورد مـــن الإيكـــاردا ICARDA بسوريا. وتتلخص بعض النتائج فيما يلى :

١-إنخفض عدد السنابل/م^2 إنخفاضاً معنوياً بالإجهاد المائى من ١٥,٧ إلى ١٦,٨٣%.

٢-كان الإنخفاض معنوياً فى محصول الحبوب بنسبة ١١,٦٣-١٢,٥٧%.

٣-السلالات ١، ٣، ٤، ٧ وصنف نسر أنتجت أعلى عدد من السنابل/م^2.

٤-إختلفت التراكيب الوراثية الإثنى عشر فى عدد الحبوب/سنبلة فى كلا الموسمين.

٥-السلالة ٥ والأصناف ساحل ١، سدس ١، نسر أعطت أعلى عدد من الحبوب/سنبلة.

٦-الإجهاد الجفافى خفض وزن الـــ ١٠٠٠ حبة بنسبة تتراوح من ٤,٠٤ إلى ٦,٥٦% ، بينما الســـلالات ٣، ٦، ٨، والصنف ساحل ١ أنتجت الأثقل فى وزن الألف حبة فى الموسمين.