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EFFECT OF WATER STRESS IN LATE GROWTH STAGES OF SOME WHEAT CULTIVARS

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ABSTRACT

Two field experiments were carried out at Mallawi Agricultural Research Station, El-Menya governorate, to study the effect of drought conditions (holding irrigation after 3 and 4 irriagations) at late growth stages comparing to full irrigation treatment (six irrigations) on grain yield and its components during the two successive growing seasons 2000/2001 and 2001/2002.

. Water consumptive use WCU and water use efficiency WUE were calculated for the five bread wheat cultivars (Giza 164, Giza 168, Sids 1, Gemmiza 9 and Sakha 93) were also calculated. The most important findings could be summarized as follows:

- Water stress at late growth stages reduced grain yield by 6.96 and 15.04 % and biological yield by 8.5 and 8.5 % compared with non stressed plants similary some traits of wheat.
- Exposing wheat to drought at late growth stages reduced the total water consumed WCU from 2291 to 1741 and 1312 m^3 1.40 and 1.71 to 2.08 kg /m^3. Sids 1 followed by Giza 168 gave the highest WUE followed by Gemmiza 9 and Giza 164 at the same time the lowest value was obtained form Sakha 93.
- The results indicated that Giza 164 followed by Sakha 93 and Gemmiza 9 cultivars were drought resistance more than Sids 1 and Giza 168 cultivars under Middle Egypt conditions.

INTRODUCTION

Egypt is in a vital need for sustained agricultural development in order to cope with the social and economic obligations that are normal consequences of the continued high rates of population increase. This urgent development requires continuous scientifically based implementation of both vertical and horizontal schemes under more efficient irrigation water management and more effective agricultural practices. It is time to use the limited cultivable land area for obtaining maximum yield per unit of irrigation water. Increasing the production of wheat (*Triticum aestivum, L*), the most important cereal crop in Egypt, is essential national target to fill the gab between production and consumption. In 2001/2002 the cultivated area of wheat was about 2.45 million feddan, produced an overall average 18.57 ardabs/ /fed. in addition to 470000 feddans out of valley with average productivity of 13.61 ardabs/fed. Accordingly, that total yield reached 6.625 million tons to achieve more than 55% of self sufficiency of local needs (Statistics Management, Department of Agricultural Economy, Ministry of Agriculture, A.R.E, 2002).

Wheat production could be increased through cultivation of high yielding cultivars and application of appropriate agronomic practices. Among the most important practices is water management. The increased emphasis on plant – water relationship can be attributed to its role as a controlling factor in wheat production and optimization of water use. Water stress is the most important limitation on wheat productivity in semi-arid regions of the world. Therefore, developing wheat cultivars that use available water more efficiently and are able to tolerate drought is a major goal for increasing grain productivity in drought zones as in Egypt. However, growing wheat in new lands will consume additional amounts of irrigation water. Shehab El- Din and Esmail (1997) reported that in regions distinguished by low rainfall and limited water resources, irrigation water applied to plants becomes the limiting factor. Shalaby *et al.* (1992) found significant variations among 16 bread wheat genotypes grown under three irrigation regimes (2,3 and 4 irrigations) in grain yield, spike length, number of spikelets / spike and 1000 kernel weight. They detected reduction in different traits with less irrigation. However, some genotype had better potential performance under drought stress. Moreover, Iman Sadek (2000) indicated that irrigation every seven days resulted in the highest grain yield in sandy soils. Meanwhile, Hayam Mahgoub and Sayed (2001) reported that increasing irrigation amount from 760 to 2400 m^3 resulted in corresponding significant increases in wheat grain yield and its components as well as in plant height in sandy soils.

The present investigation aimed to study the effect of drought conditions at late growth stages on wheat yield and some related traits of five bread wheat cultivars namely; Giza 164, Giza 168, Sids 1, Gemmiza 9 and Sakha 93.

MATERIALS AND METHODS

Two field experiments were carried out at Mallawi Agricultural Research Station, El-Menya governorate to study the effect of both full irrigation (six irrigations) and late drought stress (4 and 3 irrigations) on yield, some yield components, water consumptive use (WCU) and water use efficiency (WUE) of five bread wheat cultivars namely; Giza 164, Giza 168, Sids 1, Gemmiza 9 and Sakha 93, during 2000/2001 and 2001/2002 growing seasons.

The stripe plot design was adopted with three replicates. The main plots were occupied by irrigation regimes meanwhile sub – plots were devoted to wheat cultivars as follow as:

1-Main plots for water regimes:

W_1 – Non stressed at all growth stages (six irrigations)
W_2 – water stress after heading stage (4 irrigations)
W_3 – water stress after booting stage (3 irrigations)

2-Sub plots for wheat cultivars:

V_1: Giza 164, V_2: Giza 168, V_3: Sids I, V_4: Gemmiza 9 and V_5: Sakha 93 plot size was 5 m long and 4.2 m width (21 m^2) for each treatment with three replicates, soil moisture samples were taken with soil auger at planting time, before each irrigation, 48 hours after irrigation and at harvest time to determine consumptive use.

The quantities of consumptive use WCU were calculated for the upper 60 cm of the soil.

Water consumptive use WCU can be obtained by the following equation as described by Israelson and Hanson (1962).

$Cu = [(Q_2 - Q_1) /100] \times Bd \times 60/100 \times 4200$

Where:

Cu = The amount of consumptive use in m^3

Q_2 = soil moisture percentage after irrigation.

Q_1 = soil moisture percentage after next irrigation

Bd = Bulk density in gm / Cm^3

Water use efficiency WUE was calculated as kilograms / cu in m^3 (Vites, 1965).

The drought susceptibility index (s) was calculated for yield data using formula presented by Fischer and Maurer (1978).

$S = (1 - yD / yp) / D$

Where:

yD = yield under drought

yp = yield potential without drought

D = Drought intensity

1- mean yD of all genotypes / mean yp of all genotypes.

The two experiments were sown on the 17th of November 2001 and 20th of November 2001. All plots were similarly treated in every respect concerning agronomic practices except that for irrigation. Nitrogenous and phosphate fertilizers were added according to the recommended doses. For determine grain and total yields central area in each plot was kept for that purpose to eliminate any border affect: Harvesting took place on the 11th and 19th of May in 2001 and 2002 seasons, respectively. Data collected were grain yield (ton / fed), biological yield (ton / fed), harvest index %, Number of spike / m^2, 1000 kernel weight (gm), number of grains /spike, and weight of grains/spike (gm). Data were statistically analyzed according to Snedecor and Cocheran (1980).

RESULTS AND DISCUSSION

A - Yield and some yield traits:

1- Number of spikes / m^2.

The mean of spike/m^2 in 2000/2001 and 2001/2002 seasons as affected by irrigation treatments, wheat cultivars and their interaction are presented in Table 1,2. The results revealed that irrigation treatments significantly affected number of spikes/m^2 in 2001/2002 season, whereas no significant effect was detected in the first season. The largest number of spikes/m^2 were obtained from control treatment which received 6 irrigations. The reduction number of spikes/m^2 under drought condition at late stages might be due to subjecting the growing plants to a water stress that negatively affected wheat plants. These results are in full agreement with those of Mourad *et al.* (1993), El-Kalla *et al.* (1995), Ali (1997) and Abou-Khadrah *et al.* (1999) who indicated that water deficit and drought markedly reduced this traits. Data in Table 1,2 showed that the tested cultivars

Table 1: Mean of no. of spike / m^2 and 1000 kernel weight as affected by irrigation treatments and wheat cultivars in 2000/2001 and 2001/2002 growing seasons.

Treatments	No. spikes / m^2			1000 Kernel weight (g)		
	2000/2001	2001/2002	Means	2000/2001	2001/2002	Means
Irrigation :						
6 irrigation	397	407	402	44.08	46.31	45.20
4 irrigation	385	387	386	42.11	43.52	42.82
3 irrigation	378	356	367	38.72	39.74	39.23
L. S. D. 5%	N.S	18	15	1.47	1.07	0.82
Cultivars:						
Giza 164	377	384	381	39.04	40.88	39.96
Giza 168	390	380	385	41.73	43.49	42.61
Sids 1	392	428	411	44.85	46.41	45.63
Gemmiza 9	389	370	380	41.37	43.80	42.58
Sakha 93	385	354	370	41.19	41.36	41.27
L. S. D. 5%	N.S	21	16	1.42	1.22	0.59

Table 2: The interaction between irrigation and wheat cultivars in no. of spike / m^2 and 1000 kernel weight at 2000/2001 and 2001/2002 growing seasons.

Treatments		No. spikes /m^2			1000 Kernel weight (g)		
Var.	irri.	2000/2001	2001/2002	Means	2000/2001	2001/2002	Means
Giza 164	6 irri.	392	400	396	42.39	44.54	43.47
	4 irri.	368	407	388	40.38	43.03	41.71
	3 irri.	371	346	359	33.83	35.08	34.46
Giza 168	6 irri.	395	413	404	45.34	47.27	46.31
	4 irri.	386	379	383	41.69	43.85	42.77
	3 irri.	388	347	368	38.17	39.35	38.76
Sids 1	6 irri.	402	453	428	46.86	49.26	48.06
	4 irri.	398	433	416	45.08	46.21	45.65
	3 irri.	377	400	389	42.62	43.77	43.20
Gemmiza 9	6 irri.	398	411	405	42.65	46.75	44.70
	4 irri.	381	366	374	41.58	43.07	42.33
	3 irri.	387	333	360	39.87	41.58	40.73
Sakha 93	6 irri.	398	357	378	42.65	43.74	43.20
	4 irri.	390	353	372	41.82	41.41	41.62
	3 irri.	368	353	361	39.09	38.92	39.00
L. S. D. 5%		3.24	N.S.	N.S.	1.90	1.68	1.33

markedly varied in number of spikes/m^2 in both seasons. In 2001/2002 season Sids 1 significantly surpassed to Giza 164 followed Giza 168 and Gemmiza 9 while Sakha 93 gave the lowest number of spikes/m^2. In 2000/2001 season Sids 1 produced also higher number of spikes/m^2. However these increases were not significant. In both seasons Sids 1 was significantly superior to Giza 168 followed by Giza 164 and Gemmiza 9 while Sakha 93 gave the lowest number of spikes/m^2, such superiority of Sids 1 might explain the significant higher grain yield by this cultivars as well be indicated there after Sids 1 produced largest number of productive tillers.

Consequently, the number of spikes/m^2 could be considered as an important component of grain yield. Jack and Major (1994) concluded that number of spikes per plant was the most important yield component determining final yield. Irrigation regimes X cultivars interaction showed that wheat cultivars showed different response to irrigation treatments. The highest number of spikes/m^2 was recorded at full irrigations and under drought conditions with Sids 1 while Sakha 93 gave the lowest number of spikes/m^2. The significant interaction between irrigation regimes and varieties was reported by Shalaby *et al.* (1992), Ali (1997) and Abou- Khadrah *et al.* (1999).

2- 1000 kernel weight (g).

It is obvious in Table 1,2 that 1000-kernel weight was influenced significantly by irrigation treatments in both seasons, increasing water irrigation to full irrigation had significantly increased values of 1000 kernel weight. Grain index at full irrigation increased by 5.56 - 15.22% in the two seasons when plants subjected to stress at late growth stages (after 4 and 3 irrigations) respectively. These results are in agreement with those obtained by El- Kalla *et al.* (1995), Sonia *et al.* (1996) and El- Marsafawy *et al.* (1998). They showed that increasing soil moisture depletion tended to reduced 1000 kernel weight. The five evaluation cultivars significantly varied in the first and second seasons. In both seasons, it could be concluded, that Sids1 cultivars produced higher grain index than Giza 168 and Gemmiza 9, the lowest value of this trait was obtained by Sakha 93 and Giza 164. The present results indicate marked differences in the genetical make up of the tested cultivars. The differences in grain index were reported by Shalaby *et al.* (1992). The significant interaction between irrigation regimes and cultivars as showen in Table 1,2 for both seasons revealed that, the largest grain index was recorded at full irrigation and under drought conditions with Sids 1 while Giza 164 gave the lowest value under drought conditions.

3- Number of kernels per spike.

Regarding irrigation treatments, the data in Table 3,4 revealed that irrigation treatments resulted in significantly larger number of kernels per spike. The highest number of kernels per spike was obtained from control treatment which received 6 irrigation. Whereas the lowest number of kernels per spike resulted from W3 under drought conditions at late stages. The overall mean values of number of kernel per spike were higher (55.39 and 59.82) at full irrigation followed by 4 irrigations treatment (53.42 and 56.93) but at W3 treatment number of kernels / spike were low 49.53 and 51.67 in 2000/2001 and 2001/2002 respectively.

Results clear that number of kernels / spike was decreased significantly under drought conditions at late stages, this may be due to decreasing water quantity in the root zone. Similar results were obtained by Moustafa *et al.* (1996) and Tawfiles *et al.* (1996) who indicated that drought reduced number of kernels / spike as the most yield components affected by drought stress. Also, the present results are identical with those obtained by Ali (1997) who found that in Upper Egypt, the kernels number/ spike increased when irrigation frequency increased from 3 to 4 irrigations. The difference in number. Data in Table 3,4 indicated that the number of kernels / spike was high significantly influenced by wheat cultivars in the two growing seasons. The number of kernels per spike of Sids 1 significantly exceeded than that of Giza 168 in the second season and average of two seasons while the lowest value was gave by Giza 164. The overall mean values were 58.96, 56.06, 54.84, 52.11 and 50.33 for Sids 1, Giza 168, Gemmiza 9, Sakha 93 and Giza 164 respectively. Such differences might by due to variability among wheat cultivars genotype (Essam *et al.* 1993, also Abo- Warda (1997), Ali (1997), Abd El- Majeed *et al.* (1998) and Abd El- All (1999) reported that the differences in number of kernels / spike among wheat cultivars Sids 1 produced the maximum spike grain number under stress regime. The interaction between irrigation regimes and cultivars indicated that the 5 cultivars showed different response to water regimes. In 2000/2001 season Sids 1 and Gemmiza 9 followed by Giza 168 showed significant differences due to irrigation regimes in kernels / spike. On the other hand, Giza 164 produced about 41 kernels / spike at drought conditions when plant received 3 irrigations only. The greatest number of kernels was 62 in both seasons which was recorded when Sids 1 received 6 irrigation and 55.50 at drought condition (3 irrigations). The results reported by El- Kalla *et al.* (1995) and Ali (1997) showed also significant interaction effect between irrigation regimes and varieties on kernels / spike.

4- Spike grain weight (gm).

There was a significant increase in grain weight / spike with full irrigation treatment which received 6 irrigations compared to the other two treatments when plants exposed to drought at late stages. Grain weight / spike at full irrigation increased by 17.87 and 24.35% compared with W3 treatments(3 irrigations) and by 10.74 and 13.56% with W2 treatment(4 irrigations) in the first and second season respectively. This character is linked to the other yield components to obtained grain yield / fed. (i. e. spike grain number and 1000 kernel weight). Similar results were obtained by Gharti and Lales (1990) who reported that grain weight was significantly correlated with soil moisture content. The analysis of variance in Table 3,4 indicated that wheat cultivars varied significantly in weight of grain / spike, Sids 1 significantly exceeded Giza 168 and Gemmiza 9 in this character in the first and second seasons, Giza 164 and Sakha 93 gave the lowest values in two growing seasons. Such differences might be due to variation among genotypes of cultivars (Rayan *et al.* 1999).The highest weight of grains / spike at full irrigation and under late drought were given by Sids 1 followed by Giza 168 Gemmiza 9 significantly in the first season and markedly increases the second season while Giza 164 gave the lowest values under drought conditions.

Table 3: Mean of no. of kernels / spike and spike grain weight as affected by irrigation treatments and wheat cultivars in 2000/2001 and 2001/2002 growing seasons.

Treatments	Number of kernels / spike			Spike grain weight (g)		
	2000/2001	2001/2002	Means	2000/2001	2001/2002	Means
Irrigation :						
6 irrigation	55.39	59.82	57.60	2.586	2.788	2.687
4 irrigation	53.42	56.93	55.17	2.335	2.455	2.395
3 irrigation	49.53	51.67	50.60	2.194	2.242	2.218
L. S. D. 5%	1.79	2.66	1.87	0.032	0.077	0.050
Cultivars:						
Giza 164	47.78	52.89	50.33	2.194	2.248	2.221
Giza 168	54.22	57.89	56.06	2.410	2.538	2.474
Sids 1	55.22	62.70	58.96	2.636	2.866	2.751
Gemmiza 9	56.34	53.33	54.84	2.342	2.463	2.403
Sakha 93	50.33	53.89	52.11	2.276	2.359	2.318
L. S. D. 5%	3.07	3.91	1.65	0.048	0.116	0.047

Table 4: The interaction between irrigation and wheat cultivars in no. of kernels/spike and spike grain weight at 2000/2001 and 2001/2002 growing seasons.

Treatments		Number of kernels / spike			Spike grain weight (gm)		
Var.	irri.	2000/2001	2001/2002	Means	2000/2001	2001/2002	Means
Giza 164	6 irri.	52.00	55.00	53.50	2.364	2.442	2.403
	4 irri.	50.00	53.00	51.50	2.174	2.295	2.235
	3 irri.	41.33	50.67	46.00	2.045	2.008	2.027
Giza 168	6 irri.	56.67	61.67	59.17	2.581	2.874	2 728
	4 irri.	54.99	60.67	57.83	2.396	2.449	2.423
	3 irri.	51.01	51.33	51.17	2.252	2.293	2.273
Sids 1	6 irri.	57.24	66.76	62.00	3.075	3.265	3.170
	4 irri.	55.43	63.33	59.38	2.482	2.827	2.655
	3 irri.	53.00	58.00	55.50	2.351	2.504	2.428
Gemmiza 9	6 irri.	57.01	57.33	57.17	2.466	2.766	2.616
	4 irri.	56.33	52.33	54.33	2.351	2.376	2.364
	3 irri.	55.67	50.33	53.00	2.210	2.246	2.228
Sakha 93	6 irri.	54.01	58.33	56.17	2.425	2.590	2.518
	4 irri.	50.33	55.33	52.83	2.272	2.329	2.301
	3 irri.	46.66	48.00	47.33	2.112	2.159	2.135
L. S. D. 5%		3.24	N.S.	3.68	0.122	N.S.	0.104

5- Grain yield (ton/fed.)

The results in Table 5,6 showed that yield/fed., was significantly increase with increasing irrigation number in the first and second growing seasons. Grain yield at full irrigation treatment increased by 17.63 and 17.7% compared with W3 when plants exposed to drought at late growth stages (after 3 irrigations) and by 5.25 and 8.98% after 4 irrigations in the first and second season respectively. Grain yield was increased with increasing irrigation number may be attributed to the increase in number of spikes/m^2, number of kernels / spike, weight of kernels / spike and 1000 kernel weight. The previous results are in agreement with those obtained by Abd El- Rahim *et al* (1989), Wang *et al* (1991) and Abou- Khadrah *et al.* (1999) who reported that the amount of irrigation applied was closely related with grain yield due to increased number of grains / ear and single grain weight which were greatly affected by the moisture condition. The analysis of variance in Table 5,6 showed that the 5 evaluated cultivars differed significantly in their potentiality. Sids 1 was the leading cultivars followed by Giza 168 in both seasons and Sakha 93 produced the lowest yield where as Gemmiza 9 and Giza 164 were in-between. It could be concluded that Sids 1 and Giza 168 are the most suitable wheat cultivars under Middle Egypt condition. The superiority of grain yield of Sids 1 is mainly due to its superiority in number of spikes / m^2, number of kernel / spike, spike grain weight and 1000 kernel weight. The differences in the productivity of wheat cultivars were also reported by Shalaby *et al.* (1992), Ghanem *et al.* (1994), Abd El- Majeed *et al.* (1998) and Abd El- All (1999). The results in Table 5,6 indicated significant effect of the interaction between irrigation X cultivars (in both seasons). Both Sids 1 and Giza 168 preformed will at full irrigation treatment and at drought conditions at late stages and produced the highest yields where as Sakha 93 and Giza 164 produced the lowest values of yield / fed. (in both seasons). Significant interaction between irrigation regimes and cultivars was also reported Shalaby *et al.* (1992), Mourad *et al.* (1993), El- Kalla *et al.* (1995) and Moustafa *et al.* (1996).

6- Straw yield (ton/fed).

Data in Table 5,6 showed that irrigation treatments significantly influenced straw yield / fed. In both seasons in which full irrigation treatment resulted in significantly higher straw yield than the other two treatments when plants were subjected to late drought after 4 and 3 irrigation. The percentage of reduction in straw yield due to late drought were 13.81 and 22.83% when plants subjects to late drought in the first season and 5.90 and 17.82% in second. Massoud *et al.* (1999) calculated the percentage of reduction in straw yield due to late drought was 31%, the increase in straw yield as amount of irrigation increased might be due to the increase of yield components such as number of productive tillers and growth attributes (Abou-Khadrah *et al*, 1999). Table 5,6 indicated that the differences were significant among the studied cultivars in straw yield (ton/fed.)in two seasons. Straw yield was significantly higher in Sids 1 compared to Gemmiza 9 and Giza 168 followed by Giza 164 whereas the lowest straw yield was obtained from Sakha 93 in the first and second seasons. This it might be attributed to reduced tiller abortion (Mc Master *et al.*, 1994 and Abou- Khadrah *et al.*, 1999). The interaction between cultivars and irrigation (Table 5,6) showed significant effects on straw yield in both seasons, the highest straw yield was obtained from Sids 1 with full irrigation and also under late drought followed by Gemmiza 9, Giza 168 and Giza 164 the lowest straw yield was from Sakha 93 in full irrigation and under late drought in the first season and under drought conditions in second season. According of these results it could be recommended to plant these wheat cultivars in regions which suffer from lake of water at late growth stages.

Table 5: Mean of grain yield (ton/fed) and straw yield (ton/fed) as affected by irrigation treatments and wheat cultivars in 2000/2001 and 2001/2002 growing seasons.

Treatments	Grain yield (ton/fed)			Straw yield (ton/fed)		
	2000/2001	2001/2002	Means	2000/2001	2001/2002	Means
Irrigation :						
6 irrigation	3.109	3.301	3.205	6.084	7.406	6.745
4 irrigation	2.954	3.029	2.982	5.244	6.969	6.107
3 irrigation	2.643	2.803	2.723	4.695	6.086	5.391
L. S. D. 5%	0.160	0.175	0.118	0.229	0.347	0.235
Cultivars:						
Giza 164	2.708	2.914	2.811	5.204	6.661	5.933
Giza 168	3.029	3.123	3.076	5.411	6.769	6.090
Sids 1	3.269	3.348	3.309	5.903	7.451	6.677
Gemmiza 9	2.857	3.051	2.954	5.536	6.999	6.268
Sakha 93	2.614	2.785	2.700	4.650	6.222	5.436
L. S. D. 5%	0.188	0.124	0.075	0.217	0.330	0.119

Table 6: The interaction between irrigation and wheat cultivars in grain yield (ton/fed) and straw yield (ton/fed) at 2000/2001 and 2001/2002 growing seasons.

Treatments		Number of kernels / spike			Spike grain weight (gm)		
Var.	irri.	2000/2001	2001/2002	Means	2000/2001	2001/2002	Means
Giza 164	6 irri.	2.777	3.074	2.926	5.695	7.029	6.362
	4 irri.	2.742	2.952	2.847	5.322	6.771	6.047
	3 irri.	2.605	2.717	2.661	4.543	6.182	5.388
Giza 168	6 irri.	3.251	3.430	3.341	6.213	7.368	6.791
	4 irri.	3.079	3.119	3.099	5.274	7.053	6.164
	3 irri.	2.756	2.819	2.789	4.746	5.888	5.317
Sids 1	6 irri.	3.653	3.703	3.678	6.793	8.002	7.398
	4 irri.	3.241	3.334	3.288	5.604	7.347	6.476
	3 irri.	2.914	3.008	2.961	5.311	7.003	6.157
Gemmiza 9	6 irri.	3.083	3.334	3.209	6.551	7.400	6.976
	4 irri.	2.982	2.964	2.973	5.224	7.243	6.234
	3 irri.	2.506	2.855	2.681	4.834	6.354	5.594
Sakha 93	6 irri.	2.780	2.964	2.872	5.166	7.231	6.199
	4 irri.	2.627	2.777	2.702	4.795	6.432	5.614
	3 irri.	2.436	2.615	2.526	3.989	5.003	4.496
L. S. D. 5%		0.205	0.134	0.128	0.324	0.464	0.266

7- Biological yield (ton/fed).

The biological yield (ton/fed.) presented in Table 7,8 show that biological yield of wheat cultivars was significantly affected by withholding irrigation at late growth stages in both seasons. The highest yield was obtained by treatment at full irrigation (6 irrigations). The lowest value of the trait was detected when the plants were subjected to late drought. The percentage of reduction in biological yield due to late drought were 10.82 and 20.18% in the first season and 6.62 and 16.98% in second season in 4 and 3 irrigations treatments, respectively, compared to 6 irrigations treatment. These findings are similar to these obtained by El- Refaie and Hamada (1994). The analysis of variance of two studied seasons presented in Table 7,8 indicated that the differences among the five cultivars highly significant in both seasons. Biological yield (ton/fed.) was significantly higher in Sids 1 followed by Giza 168 in the first season and Gemmiza 9 in second season while the lowest values were given by Sakha 93 in both seasons. Such differences might be due too the variability among wheat cultivars genotype (Essam *et al.*, 1993). The interaction of irrigation X cultivars in Table 7 indicated that Sids 1 and Giza 168 followed by Gemmiza 9 produced the maximum dry matter in full and under stress regime in the first season. In second season Sids 1 and Gemmiza 9 followed by Giza 168 produced the maximum biological yield. While Sakha 93 gave the minimum in this trait under late drought conditions.

8- Harvest index %.

The analysis of variance in Table 7,8 indicated that irrigation regimes significantly affected harvest index in the first season and over the two seasons, it was observed that increasing drought conditions were associated with the increase of harvest index. The results in Table 7,8 indicated that the mean harvest index of the two seasons was increased from 32.21 with full irrigations to 32.81 and 33.56% when plants were subjected to late drought at 4 and 3 irrigation respectively due to a market increase in total yield with full irrigation. These results are in agreement with those obtained by Thompson and Chase (1992), Mourad *et al.* (1993), Semaika (1994), Frederick and Camberato (1995) and Tawfiles *et al.* (1992) who showed that harvest index was negatively affected by drought stress, also Ali (1997) found that the increase in irrigation frequency from 3 to 5 reduced harvest index of wheat. Harvest index differed significantly among wheat cultivars in the first season and mean of the two seasons (Table 7,8) Sids 1 and Giza 168 gave significantly higher index than Gemmiza 9 and Giza 164. The highest of Sids 1 and Giza 168 in harvest index is certainly expected as it produced the higher grain yield (ton/fed.). As for the highest of Sakha 93 in harvest index is mainly due to the lowest value of biological and straw yield produced by this cultivars. The results reported by Chowdhury (1990) Ehdaie *et al.* (1991), Mourad *et al.* (1993), Ali (1997) and Salem (1999) showed marked differences in harvest index among wheat cultivars. The significant interaction between irrigation regimes and cultivars in the first season and over two seasons indicated that cultivars produced highly biological gave lowest harvest index at full irrigation when plant subjected to drought condition produce lowest straw yield and highest of harvest index. Sakha 93 gave highest harvest index due to the reduction of total yield with drought condition.

Table 7: Mean of biological yield (ton/fed) and harvest index % as affected by irrigation treatments and wheat cultivars in 2000/2001 and 2001/2002 growing seasons.

Treatments	Biological yield (ton/fed)			Harvest index %		
	2000/2001	2001/2002	Means	2000/2001	2001/2002	Means
Irrigation :						
6 irrigation	9.193	10.707	9.950	33.82	30.83	32.21
4 irrigation	8.198	9.998	9.089	36.03	30.30	32.81
3 irrigation	7.338	8.889	8.114	36.02	31.53	33.56
L. S. D. 5%	0.246	0.383	0.296	1.72	N. S.	0.98
Cultivars:						
Giza 164	7.912	9.575	8.744	34.23	30.43	32.15
Giza 168	8.440	9.892	9.166	35.89	31.57	33.55
Sids 1	9.172	10.799	9.986	35.64	31.00	33.14
Gemmiza 9	8.393	10.050	9.222	34.04	30.36	32.03
Sakha 93	6.264	9.007	8.136	35.96	30.92	33.19
L. S. D. 5%	0.517	0.261	0.127	1.33	N. S.	0.66

Table 8: The interaction between irrigation and wheat cultivars in biological yield (ton/fed) and harvest index % at 2000/2001 and 2001/2002 growing seasons.

Treatments		Biological yield (ton/fed)			Harvest index %		
Var.	irri.	2000/2001	2001/2002	Means	2000/2001	2001/2002	Means
Giza 164	6 irri.	8.472	10.103	9.288	32.78	30.43	31.50
	4 irri.	8.064	9.723	8.894	34.00	30.36	32.01
	3 irri.	7.198	8.899	8.049	36.19	30.53	33.06
Giza 168	6 irri.	9.464	10.798	10.132	34.35	31.77	32.98
	4 irri.	8.353	10.172	9.263	36.87	30.66	33.46
	3 irri.	7.502	8.707	8.106	36.74	32.38	34.41
Sids 1	6 irri.	10.446	11.705	11.076	34.97	31.64	33.21
	4 irri.	8.845	10.681	9.764	36.64	31.21	33.67
	3 irri.	8.225	10.011	9.118	35.43	30.05	32.47
Gemmiza 9	6 irri.	9.634	10.734	10.185	32.00	31.06	31.51
	4 irri.	8.206	10.207	9.207	36.34	29.04	32.29
	3 irri.	7.340	9.209	8.275	34.14	31.00	32.40
Sakha 93	6 irri.	7.946	10.195	9.071	34.99	29.07	31.66
	4 irri.	7.422	9.209	8.316	35.40	30.16	32.49
	3 irri.	6.425	7.518	7.022	37.91	34.33	35.97
L. S. D. 5%		0.359	0.471	0.283	2.36	N. S.	1.48

1 - Water consumptive use (WCU).

Water consumptive use or evapo-transpiration (ET) is defined as the combined processed by which water is transferred from earth surface to the atmosphere. It includes evaporation of liquid water from soil and plants surfaces plus transpiration of liquid water through plant tissues expressed as depth of water per unit area. Table 9 shows the data obtained for water consumptive use of wheat cultivars as influenced by irrigation regime.

Values for all cultivars tested were the same under the three watering regime. Results clearly show that decreased from 2291 m^3/ fed to 1741 and 1312m^3/ fed. when irrigation was skipped at late growth stages of wheat (4 and 3 irrigation) respectively. This trend is mainly due to the availability of soil moisture to the plants as well as at the soil surface provided by frequent irrigation. When the soil moisture was kept wet by irrigation, higher values of water use was obtained. Mean seasonal water consumptive use by the control treatment which received 6 irrigations at the different physiological stages of wheat growth namely, crown root initiation, tillering, jointing, flowering, milk and dough stages was 2291 m^3 / fed, while skipping two irrigations at milk and dough stages gave 1741 m^3/fed. The lowest value of ET (1312 m^3/fed) was given when plants subjected to stress after 3 irrigations. Reducing irrigaton by exposing plants to late drought caused a clear reduction in ET by 24% and 43 % comparing to the full irrigation was in agreement with the result reported by Agrawal (1977), Ehdaie and Waines (1993) and Massoud *et al.* (1999).

2 - Monthly water consumptive use.

Monthly water consumptive use values under full and late drought values started low at the beginning of plant growing season and increased gradually to reach its maximum rate through February as a result to the increase investigative growth and maximum leaf area index (high water consumption by plants) then it declined again at maturity (Table 9). These results are in agreement with those obtained by Rayan *et al.* (1999).

Table 9: Monthly (cm) and seasonal water use (m^3/fed.) of wheat plant as influenced by irrigation regime in the two growing seasons.

Irri. Treat.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	W. C. m^3/fed
6 irrigation	2.6	8.37	9.31	10.95	10.23	9.12	3.96	2291
4 irrigation	2.6	8.37	9.31	8.84	7.21	3.65	1.48	1741
3 irrigation	2.6	8.37	6.62	6.02	4.21	2.11	1.30	1312

3- Water use efficiency (WUE).

The advantage of calculating water use efficiency (WUE) is that, it puts that emphasis on the water that we wish to consume or put to better use values of (WUE) expressed as kilogram grains per m^3 water consumed in complete evapotrans- piration under the various water regimes which are presented in Table 10. The results indicated that (WUE) was significantly reacted to wheat cultivars and irrigation regimes and their interaction. Sids 1 gave the highest value of WUE followed by Giza 168 and Gemmiza 9 while Sakha 93 gave the lowest WUE value. Ranking the five wheat cultivars for the values of their WUE were as follows Sids 1 > Giza 168 > Gemmiza 9 > Giza 164 > Sakha 93. This trend could be explained by high yielding ability of Sids 1 and Giza 168 from one side and less water consumed by these cultivars from the other side which in turn increased its WUE. Similar results were reported by Ali (1997), Rayan *et al.* (1999) and Massoud *et al.* (1999), who found that varieties varied widely in WUE. The data in Table 10 revealed that the plants exposed to water stress at late stages gave the highest values of WUE compared to full irrigation treatment which received 6 irrigation. This trend could be due to that more available soil moisture through increasing the irrigation water applied give a chance for more consumption of water which ultimately resulted in increasing transpiration, in addition to high water evaporation from the soil surface. These results are in agreement with those obtained by El Refaie and Hamada (1994), Massoud *et al.* (1999).

Table 10: Water use efficiency (kg/m^2) of wheat cultivars as affected by irrigation regime in the two growing seasons.

Treatments	Giza 164	Giza 168	Sids 1	Gemmiza 9	Sakha 93	Average
6 irrigation	1.28	1.46	1.60	1.40	1.25	1.40
4 irrigation	1.63	1.78	1.89	1.71	1.25	1.71
3 irrigation	2.03	2.13	2.26	2.04	1.92	2.08
Average of cultivars	1.65	1.78	1.92	1.72	1.57	

4 - Drought susceptibility index (S).

Water use efficiency (WUE) usually refers to parameter of yield per unit of water consumped and stress susceptibility index was used as measurement of relative drought resistance.

Data presented in Table 11 showed that drought susceptibility index (S) values. Giza 164 and Sakha 93 cultivars were considered as drought resistance according to Ceccarelli (1987) who reported that genotype which has a low (s) value indicates to drought resistance, while Sids 1 followed by Giza 168 and Gemmiza 9 cultivars were considered as drought susceptibility.

Table 11: Drought susceptibility index (S) for wheat cultivars as affected by drought conditions in the two growing seasons 2000/2001 and 2001/2002.

Cultivars	Giza 164	Giza 168	Sids 1	Gemmiza 9	Sakha 93
Susceptibility index (S)	0.602	1.100	1.297	1.090	0.804

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تأثير الإجهاد المائى فى مراحل النمو المتأخرة على بعض أصناف القمح

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الهدف من هذا البحث هو دراسة الإجهاد الرطوبى فى أطوار النمو المتأخر (ايقاف الـرى بعد ٣،٤ ريات) بالمقارنة بالرى الأمثل (٦ ريات) على خمسة أصناف قمح خبز هـى (جـيزة ١٦٤ ، جيزة ١٦٨ ، سدس ١ ، جميزة ٩ ، سخا ٩٣) وذلك لمعرفة تأثير الإجهاد فى الأطـوار المتأخرة والتى تتعرض لها النباتات بمنطقة مصر الوسطى خاصة بسبب قلة المياه فـى نـهايات الترع فى موسمى ٢٠٠٠/٢٠٠١ ، ٢٠٠١/٢٠٠٢ بمحطة البحوث الزراعية بملوى .

أثبتت النتائج أن تعرض القمح للإجهاد الرطوبى فى نهاية الموسم قد أدى لنقص محصـول الحبوب بنسبة ٦,٩٦ % ، ١٥,٠٤ % بالمقارنة بالرى الأمثل والمحصول الكلـى بنسـبة ٨,٥% ، ١٨,٥% (عند توقف الرى بعد ٤ ، ٣ ريات على الترتيب) .

كان أعلى محصول تحت الإجهاد والرى الأمثل من صنف سدس ١ يليه صنف جيزة ١٦٨ وجميزة ٩ ثم جيزة ١٦٤ بينما كان أقل محصول من صنف سخا ٩٣ .

كما وجد أن التعرض للإجهاد الرطوبى قلل الاستهلاك المائى من ٢٢٩١ م^3 / للفدان فـى الرى الأمثل (٦ ريات) إلى ١٧٤١ سم^3 لكل فدان و ١٣١٢ م^3 /للفدان عند توقف الرى بعـد ٤،٣ ريات على الترتيب . بينما زادت كفاءة الاستهلاك من ١,٤ إلى ١,٧١ (بعد ٤،٣ ريات بالمقارنـة بالرى الأمثل ٦ ريات) وسجل الصنف سدس ١ يليه الصنف ١٦٨ وجميزة ٩ ثم جيزة ١٦٤ أعلى كفاءة استهلاك مائى بينما كان الصنف سخا ٩٣ اقلهم كما أوضحت النتائج أن الصنف جـيزة ١٦٤ أكثر مقاومة للجفاف يليه سخا ٩٣ ثم جميزة ٩ ثم جيزة ١٦٨ بينما كان الصنف سـدس ١ أكـثر الأصناف حساسية للجفاف تحت ظروف مصر الوسطى .