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EFFECT OF SOIL MOISTURE REGIME ON YIELD AND ITS COMPONENTS AND WATER USE EFFICIENCY FOR SOME WHEAT CULTIVARS

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ABSTRACT

This research trial was conducted, during 2001/2002 and 2002/2003 seasons, at Gemmeiza Agric. Res. St., in order to investigate the influence of different irrigation regimes, i.e. irrigation as 40-45 (I_1), 60-65 (I_2) and 80-85% (I_3) of the available soil moisture depletion, on yield and its components and water use efficiency for eight wheat cultivars namely Sids 1, Gemmeiza 7, Sakha 8, Gemmeiza 9, Sakha 93, Giza 168, Gemmeiza 5and Giza 170. The results can be summarized as follows:-

Subjecting wheat plants to drought-stress resulted in a significant reduction in grain yield, while the reduction in straw yield did not reach the significance level, and this was true in the two growing seasons of study. Regardless irrigation treatments, grain and straw yields were significantly differed, due to the tested wheat cultivars; in 1st season only. Yield components i.e. number of spikes/m^2, number of grains/spike, grain weight/ spike and 1000-grain weight seemed to be increased as the irrigation regime were increased. Moreover, these traits were significantly differed due to the tested wheat cultivars. However, Gemmeiza 7 cultivar surpassed the other tested cultivars with respect the above mentioned traits except, number of spikes/ m^2 since Sids 1 cultivar was the superior. Water Consumptive Use (CU) for tested wheat cultivars under study were significantly increased as water stress increased. The highest CU value was recorded with Gemmeiza 9 cultivar. The tested wheat cultivars were significantly interacted with the adopted irrigation regimes with regard to water consumptive use. Water Use Efficiency (WUE) tends to increase significantly as irrigation regime decreased i.e, low stress condition. The highest WUE value was recorded for Gemmeiza 7 cultivar. The tested wheat cultivars were significantly interacted with the adopted irrigation regimes with regard to water use efficiency. Crop susceptibility factor (CS) indicates that the reduction in wheat yield was acceptable due to drought stress under I_2 irrigation regime. Increasing drought condition i. e. I_3 resulted in differentials higher CS values Sakha 93 proved to be the most drought- tolerant wheat cultivar , compared to other tested ones, as an average of the two seasons. To save irrigation water without great im-

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pairing in grain yield, its recommended to irrigated the wheat plants after as a depletion of 60-65% of the available soil moisture under Gemmeiza conditions because of the reduction in grain yield is acceptable under such of irrigation regime.

Key words: Wheat cultivars, Water use efficiency (WUE), Water consumptive use (CU), Crop susceptibility factor (CS), Soil moisture regime

INTRODUCTION

In Egypt, wheat (Triticum aestivum-L) is the most important cereal crop. However, the gap between the local production and consumption is continuously increased due to increasing the country population with limited cultivated area. So, increasing wheat production, either horizontal or vertical, through scientific basis is a national target. Cultivating the new reclaimed areas with drought tolerant cultivars under modern irrigation systems, will increase wheat production horizontally. Meanwhile, cultivation of high yielding cultivars and applying the proper agronomic practices mean increasing wheat production vertically.

Irrigation is the most important and limiting practice affecting wheat production in arid and semi-arid regions. So, irrigation optimizing i.e. applying the irrigation water timely and quantitatively will increase wheat yield and save water as well and will be an important mean in increasing water use efficiency and reducing the gap between wheat production and consumption.

El-Kalla *et al* (1995) found that irrigation after high soil moisture depletion significantly decreased plant height, number of tillers, number of spikes/m^2, number of grains/spike, 1000-grain weight and grain and straw yields. **Shalaby *et al* (1992)** found significant variation among 16 bread wheat genotypes, grown under three irrigation regimes i.e. 2,3 and 4, irrigations in grain yield, spike length, number of spikelets / spike and 1000-kernel weight.

Several research trials were conducted in order to increase WUE for wheat through different management. **Khater *et al* (1997)** found that WUE values were improved as irrigation was applied to refill the root zone to 100% of field capacity. Moreover, **Hefnawy and Wahba (2003)** reported that reducing the number of irrigation, through skiping the late ones, resulted in higher WUE values for wheat crop. In addition, **Yousef and Eid (1994)** found that irrigation at a depletion of 30% of available soil moisture gave the highest grain and straw yields and WUE values for Sakha 69 wheat cultivar.

The objective of the present research is to determine the effect of different irrigation regimes on yield and its components and water use efficiency for some wheat cultivars.

MATERIAL AND METHODS

In order to achieve the objectives of the herein research, two field experiments were executed at Gemmeiza Agric. Res. Station during 2001/2002 and 2002/2003 seasons. The soil of the experimental site is clayey in texture, with water table more than 150 cm and some of its water constants are shown in Table (1).

Table 1. Some soil water constants of the experimental site

Soil depth cm.	Field capacity, W/W%		Wilting point, W/W%		Bulk density, g cm^{-3}	
	2001/2002	2002/2003	2001/2002	2002/2003	2001/2002	2002/2003
0-15	45.60	44.30	24.90	24.60	1.11	1.02
15-30	40.20	39.60	21.60	21.50	1.26	1.20
30-45	38.60	38.00	20.90	20.65	1.30	1.26
45-60	37.00	36.90	19.80	24.60	1.31	1.29

The adopted experimental treatments were arranged in split-plot design with three replicates. The main plots represented irrigation regimes as follows:

1- Irrigation when 40 – 45 % of the available soil moisture was depleted (I_1)
2- Irrigation when 60 – 65 % of the available soil moisture was depleted (I_2)
3- Irrigation when 80 – 85 % of the available soil moisture was depleted (I_3)

The sub-plots were assigned to the tested 8 wheat cultivars namely Sids 1, Gemmeiza 7, Sakha 8, Gemmeiza 9, Sakha 93, Giza 168, Gemmeiza 5 and Giza 170. The size of the main and sub-plot equal to 70 and 4.2 m^2 in 1st and 2nd seasons, respectively. The two experiments were sown on the 26th of November 2001 and 21st of November 2002.

Irrigation water was delivered to the plots through a circular orifice and water quantity was measured using the formula of immersed orifice according to **James (1988)** as follows:

$$Q = 0.61 \times 0.334 A \sqrt{h}$$ where

Q =quantity of irrigation water, L/sec.
A = Area of the orifice, cm^2.
h = effective water head over the orifice center (m.).

Water consumptive use (for the different wheat cultivars under the adopted irrigation regimes) was determined by sampling the soil just before each irrigation and 48 hrs later from 0-15, 15-30, 30-45 and 45-60 cm depth of soil layers. Besides first and the next irrigation, wheat plants under I_1, I_2 and I_3 treatments received three, two and one irrigation, respectively, in 1st and 2nd seasons. Irrigation dates and quantities of applied water are shown in Table (2). Water Use Efficiency (kg grain/fed./mm water consumed) was estimated according to **Michael (1978)**. As follows:

Water Use Efficiency (W.U.E.) = Y/Cu

Where:

Y = Grain yield (kg /fed.)
Cu = Water consumed (mm).

The crop susceptibility factor(CS) was calculated on grain yield basis, using formula presented by **Hiler and Clark (1971)** as follows :-

$$CS = Ym - Yi / Ym$$

Where:

Ym = yield potential without drought
Yi = yield under drought

Table 2. Date and quantity of irrigation water and accumulated water applied (mm) under different irrigation regimes in 2001/2002 and 2002/2003 seasons

Preceding crop	Irrigation regimes		Sowing date	1 st irrigation	2 nd irrigation	3 rd irrigation	4 th irrigation	Accumulation water applied
				2001/2002 season				
Cotton	I_1	Date	26/11/2001	17/12/2001	6/2/2002	2/3/2002	18/3/2002	618.3
		Q,mm	161.8	95.5	121.2	133.8	106.0	
	I_2	Date	26/11/2001	17/12/2001	9/3/2002	10/4/2002	-	591.0
		Q,mm	161.8	95.5	188.3	145.4	-	
	I_3	Date	26/11/2001	17/12/2001	18/3/2002	-	-	502.3
		Q,mm	161.8	95.5	245.0	-	-	
				2002/2003 season				
Maize	I_1	Date	21/11/2002	11/12/2002	21/1/2003	19/2/2003	22/3/2003	534.1
		Q,mm	112.1	109.3	91.3	122.1	99.3	
	I_2	Date	21/11/2002	11/12/2002	15/2/2003	1/4/2003	-	471.8
		Q,mm	112.1	109.3	130.4	120.0	-	
	I_3	Date	21/11/2002	11/12/2002	13/4/2003	-	-	445.8
		Q,mm	112.1	109.3	224.4	-	-	

All of agronomic practices i.e. N - fertilization, pest control ...etc, were done as recommended for wheat production in the region. At harvest, the plants of each entire sub-plot area were sampled in order to determine straw (ton / fed.) and grain yields (ardab / fed.). Number of spikes/m^2 was calculated by counting all spikes per square meter selected at random from each sub-plot. Ten spikes were taken randomly from each sub-plot to estimate the following characters; number of spikes /m^2, number of grains/spike, grain weight/spike and 1000-grain weight. Data were statistically analyzed according to **Snedecor and Cocheran (1980).**

RESULTS AND DISCUSSION

Yield and yield components

1- Number of spikes /m^2

The triat of spikes/m^2in 2001/2002 and 2002/2003 seasons as affected by irrigation treatments, wheat cultivars and their interaction are presented in Table (3). The results revealed that irrigation treatments significantly affected number of spikes/m^2 in 2002/2003 season, whereas, no significant effect was detected in the first season 2001/2002. The largest number of spikes/m^2 were obtained under sufficient irrigation (I_1) as compared with (I_2) and (I_3) ones. These results are in full agreement with those of **EL-Kalla *et al* (1995), Ali (1997), Abou Khadrah *et al* (1999) and Hefnawy and Wahba (2003).** Data showed that the number of spikes/m^2 are in accordance with **Jack and Major (1994)** who concluded that number of spikes per plant was the most important yield component determining final yield. Sids 1 cultivar interacted with the adopted irrigation treatments to increase number of spikes/m^2, while Gemmeiza 7 cultivar followed an opposite trend in this respect.

2-Number of grains/spike

Regarding irrigation treatments, data in Table (3) reveal that irrigation treatments significantly affected number of grains/spike in the first season 2001/2002 only. The highest number of grains/spike (60.05 and 59.50) was obtained under sufficient irrigation (I_1), whereas the lowest values (55.38 and 55.02) resulted from (I_3) treatment. in 2001/2002 and 2002/2003 seasons, respectively, this may be due to decreasing soil moisture in the root zone. Similar results were obtained by **Moustafa *et al* (1996) and Tawfiles *et al* (1997)** who indicated that the drought reduced number of kernels/spike as the most yield components affected by drought stress. The present results are also similar to those obtained by **Ali (1997)** who found that, the kernels number/ spike were increased when irrigation frequency increased from 3 to 4 irrigations. Data in Table (3) indicated also that the number of grains / spike was highly significantly influenced by the tested wheat cultivars in the two growing seasons. Gemmeiza 7 cultivar significantly exceeded the other cultivars in both seasons, while the lowest value was given by Sakha8 cultivar. Such differences may be due to variability among the wheat cultivars under study. **Ali (1997), Abd El-Majeed *et al* (1998) and Abd El-All (1999)** detected differences in number of kernels / spike among wheat cultivars. The interaction between irrigation regimes and cultivars did not exert significant effect on grains number/spike.

Table 3. Average of number of spikes/m^2 and number of grains/spike for some wheat cultivars as affected by different irrigation regimes

Irrigation regimes (a)	Cultivars (b)	No. of spikes/m^2			No. of grains/spike		
		2001/2002	2002/2003	Average	2001/2002	2002/2003	Average
I_1	Sids 1	392.00	360.00	376.00	58.20	69.90	59.55
	Gem. 7	370.00	343.33	356.66	68.13	68.30	68.21
	Sakha 8	344.33	343.33	343.83	52.13	51.77	51.95
	Gem. 9	372.00	336.67	354.33	67.47	55.10	61.28
	Sakha 93	373.33	345.00	359.16	55.80	60.87	58.33
	Giza 168	342.67	335.00	338.83	62.87	57.00	59.93
	Gem. 5	376.67	353.33	365.00	61.67	60.43	61.05
	Giza 170	337.33	353.33	345.33	54.13	61.67	57.90
Average		363.54	346.25	354.89	60.05	59.50	59.77
I_2	Sids 1	390.00	358.33	374.16	57.20	60.40	58.80
	Gem. 7	321.33	276.67	299.00	64.87	64.53	64.65
	Sakha 8	340.67	323.33	332.00	51.27	49.07	50.17
	Gem. 9	358.00	305.00	331.50	63.20	54.97	59.08
	Sakha 93	309.33	303.33	306.33	55.27	60.30	57.78
	Giza 168	352.00	303.33	327.66	61.33	56.77	59.05
	Gem. 5	344.00	313.33	328.66	60.40	55.07	57.73
	Giza 170	332.00	351.67	341.83	53.87	59.87	56.87
Average		343.42	316.87	330.14	58.42	57.61	58.01
I_3	Sids 1	344.00	316.67	330.33	53.73	59.00	56.36
	Gem. 7	296.00	265.00	280.50	64.00	62.67	63.33
	Sakha 8	326.00	315.00	320.50	41.53	47.97	44.75
	Gem. 9	325.33	280.00	302.66	62.20	52.63	57.41
	Sakha 93	309.33	296.77	303.00	55.00	54.00	54.50
	Giza 168	319.33	303.33	311.33	58.60	53.63	56.11
	Gem. 5	319.33	300.00	309.66	56.80	51.63	54.21
	Giza 170	322.00	350.00	336.00	51.20	58.67	54.93
Average		320.17	303.33	311.75	55.38	55.02	55.20
Average for all irrigation regimes	Sids 1	375.33	345.00	360.16	56.38	60.10	58.24
	Gem. 7	329.11	295.00	312.05	65.67	65.13	65.40
	Sakha 8	337.00	327.22	332.11	48.31	49.60	48.95
	Gem. 9	351.78	307.22	329.50	64.29	54.23	59.26
	Sakha 93	330.67	315.00	322.83	55.36	58.39	56.87
	Giza 168	338.00	313.89	325.94	60.93	55.24	58.08
	Gem. 5	346.67	322.22	334.44	59.62	56.28	57.95
	Giza 170	330.44	351.67	341.05	53.07	60.07	56.57
Average		342.37	322.15	332.26	57.95	57.38	57.66
L.S.D. at 5%	Irrig.(a)	n.s	18.328	-	3.256	n.s	-
	Cultivars (b)	20.799	20.902	-	4.697	4.281	-
	Interaction (axb)	n.s	n.s	-	n.s	n.s	-

3-Grain weight / spike (g)

Data in Table (4) indicate an increase in grain weight / spike with sufficient irrigation (I_1), compared to the other two treatments (I_2 and I_3) as exposing the plants to drought stress and the effect was significant in 2001/2002 season. Grain weight / spike at full irrigation increased by 12.48 and 16.56%, compared with (I_3) treatments and by 6.01 and 4.43 % with (I_2) treatments in the first and second season, respectively. This character is linked to the other yield components. i.e. number of grains/spike and 1000-grain weight to obtained grain yield / fed Similar results were obtained by **Gharti and Lales (1990)** who reported that grain weight / spike was significantly correlated with soil moisture content. Data in Table (4) also indicated that wheat cultivars were varied significantly in grain weight /spike. Gemmeiza 7 significantly exceeded the other tested wheat cultivars in this character while Sakha 8 gave the lowest values in the two growing seasons. Such differences may be due to the variation among genotypes of cultivars (**Rayan *et al* 1999**). The interaction between irrigation regimes and cultivars was insignificant for grain weight /spike in both seasons.

4-1000- grain weight (g)

From data in Table (4) showed that 1000-grain weight was influenced significantly by irrigation treatments in both seasons. Increasing irrigation water (I_1 treatment) had significant highest values of 1000-grain weight. Grain index at full irrigation (I_1) increased by 4.18 and 10.39% as an average of the two seasons more than the plants subjected to soil moisture stress irrigations (I_2 and I_3) treatments, 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)**, who stated that increasing soil moisture depletion tended to reduced 1000- grain weight. The evaluated wheat cultivars significantly varied in 1000- grain weight where Gemmeiza 7 cultivar produced higher grain index than the other cultivars, while the lowest value was obtained by Sakha 8. The differences in grain index were previously reported by **Shalaby *et al* (1992) and Hefnawy and Wahba (2003)**. The interaction between the irrigation regimes and cultivars was insignificant for 1000-grain weight in both seasons.

5-Straw yield (ton/fed.)

Data in Table (5) show that the tested irrigation treatments insignificantly influenced straw yield / fed. in both seasons, However, full irrigation treatment (I_1) produced straw yield higher than the other treatments in which plants were subjected to drought i.e. I_2 and I_3. The percentage of reduction in straw yield, due to drought conditions under I_2 and I_3 irrigation treatments were 13.70 and 20.91% in first season and 6.65 and 13.30 in second one. **Massoud *et al* (1999)** estimated the percentage of reduction in straw yield due to late drought to be 3 %. **Abou-Khadrah *et al* (1999)** stated that 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. The interaction between irrigation regimes and cultivars was insignificant for straw yield in both seasons.

Table 4. Average of grain weight/spike and 1000-grain weight for some wheat cultivars as affected by different irrigation regimes

irrigation regimes (a)	Cultivars (b)	Grain weight/spike (g.)			1000-grain weight (g.)		
		2001/ 2002	2002/ 2003	Average	2001/ 2002	2002/ 2003	Average
I_1	Sids 1	2.797	3.627	3.212	51.23	56.57	53.90
	Gem. 7	3.483	4.423	3.953	56.60	58.30	57.45
	Sakha 8	2.497	3.237	2.867	46.07	49.93	48.00
	Gem. 9	3.390	3.767	3.578	54.47	53.37	53.92
	Sakha 93	2.863	3.450	3.156	50.93	50.90	50.91
	Giza 168	2.810	3.467	3.138	51.23	48.97	50.10
	Gem. 5	2.750	3.467	3.108	49.67	57.63	53.65
	Giza 170	2.697	3.440	3.068	49.70	50.70	50.20
Average		2.911	3.610	3.260	51.24	53.30	52.27
I_2	Sids 1	2.747	3.620	3.183	49.00	54.63	51.81
	Gem. 7	3.393	4.097	3.745	55.23	57.60	56.41
	Sakha 8	2.210	2.933	2.571	44.43	49.47	46.95
	Gem. 9	3.160	3.673	3.416	51.73	51.80	51.76
	Sakha 93	2.723	3.217	2.970	48.93	47.43	48.18
	Giza 168	2.730	3.237	2.983	48.63	48.80	48.71
	Gem. 5	2.527	3.400	2.963	45.60	54.90	50.25
	Giza 170	2.477	3.477	2.977	48.20	46.37	47.28
Average		2.746	3.457	3.101	48.97	51.37	50.17
I_3	Sids 1	2.580	3.277	2.928	44.07	52.83	48.45
	Gem. 7	3.273	3.670	3.471	54.10	53.20	53.65
	Sakha 8	1.917	2.703	2.310	41.83	47.27	44.55
	Gem. 9	2.963	3.570	3.266	50.47	51.37	50.92
	Sakha 93	2.393	3.080	2.736	41.93	44.63	43.28
	Giza 168	2.660	2.427	2.543	47.63	44.70	46.16
	Gem. 5	2.503	3.287	2.895	44.23	51.30	47.76
	Giza 170	2.417	2.760	2.588	44.33	43.83	44.08
Average		2.588	3.097	2.842	46.07	48.64	47.35
Average for all irrigation regimes	Sids 1	2.708	3.508	3.108	48.10	54.68	51.39
	Gem. 7	3.383	4.063	3.723	55.31	56.37	55.84
	Sakha 8	2.208	2.958	2.583	44.11	48.89	46.50
	Gem. 9	3.171	3.670	3.420	52.22	52.18	52.20
	Sakha 93	2.660	3.249	2.954	47.27	47.66	47.46
	Giza 168	2.733	3.043	2.888	49.17	47.49	48.33
	Gem. 5	2.593	3.384	2.988	46.50	54.61	50.55
	Giza 170	2.530	3.226	2.878	47.41	46.97	47.19
Average		2.748	3.388	3.068	48.76	51.10	49.93
L.S.D. at 5%	Irrig.(a)	0.233	n.s	-	3.068	2.519	-
	Cultivars (b)	0.452	0.463	-	3.607	2.595	-
	Interaction (axb)	n.s	n.s	-	n.s	n.s	-

6- Grain yield (ardab / fed.)

The results in Table (5) show that grain yield/fed. was significantly increased with increasing irrigation regime and this was true in the two growing seasons. Grain yield under sufficient irrigation treatment (I_1) was increased by 6.71 and 4.31%, compared to (I_2) and by 16.39 and 16.92% compared to (I_3) as the plants exposed to drought in the first and second seasons, respectively. Increasing grain yield with increasing irrigation regime is attributed to the increase in yield components values such as number of spikes/m^2, number of grains/spike, grain weight/ spike and 1000-grain weight. These results are in agreement with those obtained by **Wang *et al* (1991)** and **Abou-Khadrah *et al* (1999)** who reported that the amount of irrigation water applied was closely related with grain yield due to increased number of grains/ear and single grain weight which were greatly affected by the soil moisture condition. Data in Table (5) show that, regardless irrigation treatments, the evaluated 8 cultivars were differed significantly in their potentiality where Gemmeiza 9 and Gemmeiza 7 were the leading cultivars followed by Giza 168 and Sids1 in both seasons. It could be concluded that Gemmeiza 9 and Gemmeiza 7 are the most suitable wheat cultivars to be grown under Middle Delta conditions. The differences in the productivity of wheat cultivars were also reported by **Shalaby *ėt al* (1992), Abd El-Majeed *et al* (1998), Abd El-All (1999) and Hefnawy and Wahba (2003).** The results in Table (6) indicated that there are insignificant effect for the the interaction between irrigation and cultivars in both seasons, however Gemmeiza 9 cultivar gave the highest grain yield under the adopted irrigation treatments.

7- Seasonal water consumptive use (CU)

Water consumptive use is defined as the water lost from the plants organs, specially leaves surface, and namely transpiration besides that evaporated from the soil surface during the entire growing season. Data in Table (6) reveal that CU values, regardless wheat cultivars, were significantly increased as irrigation regime increased. The increase % in CU values under I_1 were more than those under I_2 and I_3 by 23.75 and 51.38 and 13.50 and 55.11 in 1st and 2nd seasons, respectively. These results were attributed to more available soil moisture, under I_1 treatment, which enhanced both transpiration from plants leaves and evaporation from the soil surface. Similar results were reported by **Hefnawy and Wahba (2003)** in middle Egypt (Malawy) and **Khater *et al* (1997)** in lower Egypt (Gemmeiza). Moreover, **Oweis *et al* (2000)** with wheat crop, found that evapotranspiration (ET) value was increased as supplemental irrigation increased in wheat crop, since evapotranspiration ranged from 338-382 mm at 1/3 of full supplemental irrigation and from 434 to 453 mm at full supplemental one. Moreover, the obtained data showed that the tested wheat cultivars were significantly differed with respect to CU values and the higher value was noticed with Gemmeiza 9 cultivar, as compared with the other tested cultivars in the two seasons. Data also clearout that CU values were significantly influenced in 2nd season only as interacted of irrigation regimes and wheat cultivars.

Table 5. Average of straw yield (ton/fed.) and grain yield (ardab/fed.) for some wheat cultivars as affected by different irrigation regimes

Irrigation regimes (a)	Cultivars (b)	Straw yield (ton/fed.)			Grain yield (ardab/fed.)		
		2001/2002	2002/2003	Average	2001/2002	2002/2003	Average
I_1	Sids 1	4.73	4.66	4.69	20.51	20.45	20.48
	Gem. 7	4.23	4.62	4.42	21.93	21.28	21.61
	Sakha 8	3.03	4.04	3.53	18.81	20.15	19.48
	Gem. 9	4.93	4.44	4.68	22.75	21.53	22.14
	Sakha 93	3.83	4.66	4.24	19.69	20.00	19.85
	Giza 168	3.97	4.64	4.30	21.28	21.48	21.38
	Gem. 5	4.03	4.48	4.25	20.42	20.58	20.50
	Giza 170	4.50	4.54	4.52	19.92	20.92	20.42
Average		4.16	4.51	4.33	20.66	20.80	20.73
I_2	Sids 1	4.17	4.13	4.15	19.93	19.82	19.87
	Gem. 7	3.33	4.59	3.96	20.71	.2067	20.69
	Sakha 8	3.00	3.44	3.22	18.04	17.93	17.98
	Gem. 9	4.63	4.34	4.48	20.83	21.18	21.01
	Sakha 93	3.43	4.14	3.78	18.71	19.87	19.29
	Giza 168	3.47	4.35	3.91	19.21	20.90	20.06
	Gem. 5	3.30	4.27	3.78	19.18	19.55	19.36
	Giza 170	3.37	4.46	3.91	18.27	19.58	18.92
Average		3.59	4.21	3.90	19.36	19.94	19.65
I_3	Sids 1	3.57	3.71	3.64	18.20	18.13	18.16
	Gem. 7	3.27	4.38	3.82	18.07	18.65	18.36
	Sakha 8	2.73	3.43	3.08	17.06	14.88	15.97
	Gem. 9	3.90	4.27	4.08	18.36	19.15	18.75
	Sakha 93	3.37	3.96	3.66	17.94	18.92	18.43
	Giza 168	3.27	3.51	3.61	18.13	16.13	17.13
	Gem. 5	2.97	4.14	3.55	17.19	18.37	17.78
	Giza 170	3.23	3.87	3.55	17.06	18.07	17.56
Average		3.29	3.91	3.60	17.75	17.79	17.77
Average for all irrigation regimes	Sids 1	4.16	4.17	4.16	19.55	19.47	19.51
	Gem. 7	3.61	4.53	4.07	20.24	20.20	20.22
	Sakha 8	2.92	3.64	3.28	17.97	17.65	17.81
	Gem. 9	4.49	4.35	4.42	20.65	20.62	20.63
	Sakha 93	3.54	4.25	3.89	18.78	19.60	19.19
	Giza 168	3.57	4.17	3.87	19.54	19.50	19.52
	Gem. 5	3.43	4.30	3.86	18.93	19.50	19.21
	Giza 170	3.70	4.29	3.99	18.42	19.52	18.97
Average		3.60	4.21	3.94	19.26	19.51	19.38
L.S.D. at 5%	Irrig.(a)	n.s	n.s	-	1.206	1.453	-
	Cultivars(b)	0.625	n.s	-	0.792	n.s	-
	Interaction (axb)	n.s	n.s	-	n.s	n.s	

Table 6. Average of seasonal water consumptive use and water use efficiency (kg/fed/mm) for some wheat cultivars as affected by different irrigation regimes

Irrigation regimes (a)	Cultivars (b)	Seasonal water consumptive use, mm			Water use efficiency (kg/fed/mm)		
		2001/ 2002	2002/ 2003	Average	2001/ 2002	2002/ 2003	Average
I_1	Sids 1	504.4	407.8	456.1	6.100	7.804	6.952
	Gem. 7	427.4	415.1	421.3	7.696	7.691	7.694
	Sakha 8	418.7	370.9	394.8	6.739	8.149	7.444
	Gem. 9	510.0	445.3	464.7	6.691	7.237	6.964
	Sakha 93	414.1	330.8	372.5	7.131	9.069	8.100
	Giza 168	458.7	419.4	452.0	6.960	7.702	7.331
	Gem. 5	461.1	398.9	430.0	6.644	7.740	7.192
	Giza 170	451.6	407.0	429.3	6.615	7.709	7.162
Average		455.8	399.4	427.6	6.822	7.888	7.355
I_2	Sids 1	367.3	367.8	367.6	8.141	8.340	8.241
	Gem. 7	367.2	324.3	345.7	8.508	9.559	9.034
	Sakha 8	375.0	314.7	344.8	7.217	9.416	8.317
	Gem. 9	432.7	398.7	415.7	7.181	7.863	7.522
	Sakha 93	408.0	383.6	395.8	6.878	7.769	7.324
	Giza 168	407.0	380.0	393.5	7.080	8.362	7.721
	Gem. 5	418.6	339.7	379.2	6.872	8.633	7.753
	Giza 170	413.3	306.1	359.7	6.630	9.596	8.113
Average		368.3	351.9	375.3	7.313	8.692	8.003
I_3	Sids 1	314.2	257.8	286.0	8.690	10.439	9.565
	Gem. 7	282.0	238.8	260.4	9.766	11.715	10.741
	Sakha 8	283.9	260.0	271.9	9.014	10.462	9.738
	Gem. 9	336.6	300.6	318.6	8.054	9.440	8.747
	Sakha 93	314.7	253.0	283.8	8.551	11.354	9.953
	Giza 168	309.2	225.7	267.5	8.795	10.722	9.759
	Gem. 5	302.7	271.5	287.1	8.517	10.147	9.332
	Giza 170	268.0	252.7	260.4	9.550	10.724	10.137
Average		301.1	257.5	279.4	8.867	10.625	9.746
Average for all irrigation regimes	Sids 1	395.3	344.5	369.9	7.644	8.859	8.252
	Gem. 7	358.9	326.1	342.5	8.657	9.655	9.156
	Sakha 8	359.2	315.2	337.2	7.657	9.342	8.500
	Gem. 9	426.4	381.5	403.9	7.309	8.180	7.745
	Sakha 93	378.9	322.5	350.7	7.520	9.397	8.459
	Giza 168	391.6	341.7	366.6	7.612	8.928	8.270
	Gem. 5	394.1	336.7	365.4	7.344	8.840	8.092
	Giza 170	377.6	321.9	349.8	7.598	9.343	8.471
Average		385.3	336.3	360.8	7.668	9.068	8.368
L.S.D. at 5%	Irrig.(a)	0.688	0.232	-	0.442	0.242	-
	Cultivars (b)	0.921	0.516	-	0.328	0.511	-
	Interaction (axb)	n.s	0.894	-	0.568	0.884	-

Table 7. Crop susceptibility factor (CS) for the tested wheat cultivars as affected by drought conditions in 2001/2002 and 2002/2003 seasons

Cultivars	Sids 1	Gem. 7	Sakha 8	Gem. 9	Sakha 93	Giza 168	Gem. .5	Giza 170	Average
$cs_1^{st\ season}$	0.0283	0.0556	0.0409	0.0844	0.0498	0.0973	0.0607	0.0828	0.062
$cs_2^{st\ season}$	0.1126	0.1760	0.0930	0.1930	0.0889	0.1480	0.1582	0.1436	0.139
Average	0.070	0.116	0.067	0.139	0.069	0.123	0.109	0.113	0.101
$cs_1^{ndseason}$	0.0308	0.0289	0.1102	0.0163	0.0065	0.0270	0.0500	0.0640	0.042
$cs_2^{ndseason}$	0.1134	0.1236	0.2615	0.1105	0.0540	0.2491	0.1074	0.1362	0.145
Average	0.072	0.076	0.186	0.064	0.030	0.138	0.079	0.100	0.093
Average overall	0.071	0.096	0.126	0.102	0.050	0.131	0.095	0.107	0.097

8- Water Use Efficiency (WUE)

Water use efficiency means kg of grains produced due to consumption 1 mm water depth of soil moisture per feddan. Data in Table (6) indicat that, WUE values were significantly differed under the adopted irrigation regimes, and the value was increased as irrigation moisture regime decreased. The increases in WUE value under (I_3), were more than those under (I_1) and (I_2) by 29.98 and 21.25% in first season, while the corresponding increase in second season were 34.70 and 22.24%.Other researchers indicated WUE values were increased with irrigation after higher soil moisture depletion, (**Khater *et al* 1997**). Moreover, **Hefnawy and Wahba (2003)** stated that WUE for wheat cultivars was increased due to reducing numbers of irrigations. Furthermore, **Oweis *et al* (2000)** found that the highest WUE, i.e gross yield: rain + supplemental irrigation, was achieved at 1/3 to 2/3 supplemental irrigation, comparable to full supplemental one and rainfed. Regardless irrigation regimes, the wheat cultivars were significantly differed with respect to WUE, and the highest value was recorded with Gemmeiza 7 cultivar, in the two seasons of study. Moreover, the tested wheat cultivars significantly interacted with the adopted irrigation regimes to affect WUE charcter, the highest value was recorded for Gemmeiza 7 cultivar under I_3 irrigation regime.

9-The crop susceptibility factor (CS)

Crop susceptibility factor (CS) means, in the present research trial, the reduction extent in grain yield, due to drought conditions i.e. I_2 and I_3 treatments, comparable to the yield potential under I_1 treatment. So, higher CS values indicated that more drought sensitive wheat cultivar and vice versa. Data in Table (7) clearout that CS values for the tested wheat cultivars were lower under I_2 treatment indicating acceptable yield reduction. As drought-stress arised, CS values seemed to be higher therefore, it can be concluded that Sakha 93 proved to be the most drought-tolerant wheat cultivar in 1st and 2nd seasons.

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مجلة حوليات العلوم الزراعية ، كلية الزراعة ، جامعة عين شمس ، القاهرة ، م٤٩ ، ع(٢)، ٥١٥ - ٥٣٠ ، ٢٠٠٤

تأثير الرى عند استنفاذ مستويات مختلفة من الرطوبة الأرضية على محصول القمح ومكوناته وكفاءة استخدام مياه الرى لبعض أصناف القمح

[٣٥]

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أقيم هذا البحث خلال موسمى النمو ٢٠٠١/٢٠٠٢ ، ٢٠٠٢/٢٠٠٣ وذلك لدراسة تأثير رى نباتات القمح عند استنفاذ ٤٠-٤٥ % (I ١) ، ٦٠ - ٦٥ % (I ٢) ، ٨٠ - ٨٥ % (I ٣) من الماء الميسر بالتربة على المحصول ومكوناته وكفاءة استخدام مياه الرى . لبعض أصناف القمح هى سدس١ ، جميزة ٧ ، سخا ٨ ، جميزة ٩ ، سخا ٩٣ ، جيزة ١٦٨ ، جميزة ٥ ، جيزة ١٧٠ . ويمكن تلخيص أهم النتائج فى الآتى:

أدى تعريض نباتات القمح للاجهاد الرطوبى الى نقص معنوى فى محصول الحبوب/ للفدان والى نقص غير معنوى فى محصول القش للفدان. هذا وقد كانت هناك اختلافات معنوية بين أصناف القمح المختبرة بالنسبة لمحصول الحبوب فى الموسمين ومحصول القش فى الموسم الأول فقط .

ازدادت مكونات المحصول مثل عدد السنابل/ م^2 ، عدد حبوب/ السنبلة ، وزن حبوب / السنبلة ، ووزن الألف حبة ازدادت بزيادة الرى (الرى عند فقد ٤٠ -٤٥ % من الماء الميسر بالتربة) وقد أظهرت النتائج وجود اختلافات معنوية بين أصناف القمح المختبرة فى مكونات المحصول المدروسة حيث أعطى الصنف جميزة ٧ أفضل القيم بالنسبة لهذه المكونات فيما عدا عدد السنابل/ م^2 والتى تميز فيها الصنف سدس ١ .

أدى الرى عند أقل استنفاذ للرطوبة الأرضية الى زيادة الاستهلاك المائى زيادة معنوية لجميع أصناف القمح تحت الدراسة وعموما أظهر الصنف جميزة ٩ أعلى القيم للاستهلاك المائى تحت أى من نظم الرى تحت الدراسة. هذا وقد كان التفاعل معنويا بين أصناف القمح تحت الدراسة ومستويات الرطوبة المستنفذة على قيم الاستهلاك المائى.

تحسنت كفاءة استخدام مياه الرى تحسنا معنويا بالرى بعد استنفاذ أعلى رطوبة ميسرة هذا وقد سجل الصنف جميزة ٧ أفضل القيم وكان التفاعل بين أصناف القمح تحت الدراسة ومستويات الرى معنويا على هذه الصفة .

أظهر عامل حساسية المحصول أن النقص فى محصول الحبوب للأصناف تحت الدراسة كان أقل تحت معاملة الرى(I ٢) مقارنة بالمعاملة (I ٣) . وقد أدى زيادة الإجهاد الرطوبى الى زيادة قيم عامل الحساسية . وعموما أظهر الصنف سخا ٩٣ أعلى مقاومة للأجهاد الرطوبى يلية الصنف سدس١ فى هذه الدراسة كمتوسط لموسمى الزراعة .

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