East African Scholars Journal of Agriculture and Life Sciences
Abbreviated Key Title: East African Scholars J Agri Life Sci
ISSN 2617-4472 (Print) | ISSN 2617-7277 (Online) |
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-2 | Issue-5 | May-2019 |

Research Article

Evaluation of four wheat cultivars under water deficit stress conditions

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Abstract: Two field experiments were conducted at El-Gemmeiza Agric. Res. Station, ARC during 2015/2016 and 2016/2017 seasons to study the response of four wheat cultivars (Gemmeiza 12, Misr 1, Giza 168 and Sids 13) under four irrigation treatments (normal irrigation as control, withholding irrigation at tillering stage, withholding irrigation at heading stage and withholding irrigation at grain filling stage) in relation to vegetative and physiological growth characters, water relation characters and yield components. Results detected significant differences among the four tested wheat cultivars, whereas wheat Gemmeiza 12 cultivar surpassed significantly the other three tested cultivars (Misr 1, Giza 168 and Sids 12) for all the studied traits in both seasons. Meanwhile Sids 13 cultivar gave the lowest values of all the studied traits in both seasons. It can be concluded that Gemmeiza 12 cultivar with receiving its plants with full water irrigation resulted in increases growth analysis and growth attributes, saving water irrigation as well as increase yield and yield components of wheat crop for the abovementioned cultivar under such conditions. Our results recommend growing wheat cultivar (Gemmeiza 12) with normal irrigation gave the highest values of vegetative and physiological growth characters, and yield components. However, growing the same cultivar with holding irrigation at grain filling stage caused slight reduction in all studied traits under such condition.
Keywords: El-Gemmeiza Agric. Res. Station, vegetative and physiological growth characters.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most essential cereal crops cultivated all over the world belongs to Poaceae family and plays critical role in the diet of the Egyptian people (Abdelaal *et al.*, 2014, Hafez and Abdelaal, 2015, Abdelaal *et al.*, 2018a). In Egypt, it has a special importance because the local production is not sufficient to meet the annual demands that because of many stresses such as water deficit, salinity and temperatures which, significantly reduce photosynthesis and biochemical processes related to plant growth and yield of maize (Abdelaal *et al.*, 2017) and barley plants (Abdelaal *et al.*, 2018b).

One of the main definitions in the crop production is water deficit which used to describe the plant production under few water requirements. Water deficit is the most harmful abiotic stress limiting plant production (Saleem *et al.*, 2016). Under water stress, one of the major factors responsible for decreasing plant growth and productivity is the production of reactive oxygen species (ROS) in organelles including chloroplasts, mitochondria and peroxisomes. The reactive oxygen species are responsible for cellular membrane lipids, enzyme proteins and nucleic acids degradation (Farooq *et al.*, 2009). In faba bean plants chlorophyll concentrations were decreased, however electrolyte leakage was increased under water deficit conditions (Abdelaal, 2015). Also in flax plants, water deficit led to decrease chlorophyll a and b concentrations (Rashwan and Abdelaal, 2019).

These reserves improve yield stability in grain crops by providing an alternative source when photosynthetic capacity is reduced during the later phases of grain filling, or during periods of environmental and abiotic stresses. Chlorophyll content, membrane stability index MSI and relative water content (RWC) are good physiological indices of drought tolerance can be used for improvement drought tolerance in wheat (Almeselmani *et al.*, 2011). So, the present investigation aims to evaluate four wheat cultivars grown under water deficit stress in different growth stages at Gemmeiza, El-Gharbia Governorate

Quick Response Code

Journal homepage:
http://www.easpublisher.com/easjals/

Article History
Received: 15.04.2019
Accepted: 30.04.2019
Published: 14.05.2019

DOI: 10.36349/easjals.2019.v02i05.007

conditions and study the growth and physiological characters as well as yield components.

MATERIAL AND METHODS

Two field experiments were conducted at EL-Gemmeiza Agricultural Research Station during 2015/2016 and 2016/2017 winter seasons to study the effect of water deficit at different growth stages on four wheat cultivars in relation to some growth, physiological and yield characters as well as some water relation parameters.

The characteristics of experimental soil are presented in Table (1).

Table (1): Some soil-water constant properties and bulk density of the experimental soil sites in 2015/16 and 2016/17 seasons.

Soil layer depth (cm)	Field capacity (w/w,%)		Wilting point (w/w,%)		Available water (mm)		Bulk density (gcm^{-3})	
	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17
00 - 20	43.20	42.95	23.50	23.23	19.61	19.73	1.11	1.12
20 – 40	40.35	40.05	21.79	21.67	18.56	18.38	1.26	1.29
40 - 60	37.80	37.55	20.47	19.76	17.33	17.79	1.31	1.33

Table (2): Meteorological records of the Central Laboratory for Agriculture Climate (Source: The Agriculture Research Center, El-Giza)

Seasons	2015 / 2016					2016 / 2017				
Month	Temperature °C			Relative Humidity %	Range	Temperature °C			Relative Humidity %	Range
	Max	Min	Mean	Mean	Mean	Max	Min	Mean	Mean	Mean
Nov.	26.36	15.73	21.04	63.92	0.66	26.91	14.87	20.89	57.55	1.30
Dec.	21.49	11.21	16.35	64.61	0.27	19.24	9	24.12	67.82	1.21
Jan.	18.72	7.91	13.31	63.15	0.61	18.38	6.67	12.52	67.11	0.10
Feb.	24.45	9.79	17.12	56.53	0.08	20.95	7.64	14.29	63.04	0.19
Mar.	26.57	11.58	19.07	48.47	0.26	25.22	10.88	18.05	53.15	0.00
Apr.	33.79	14.96	24.37	39.26	0.07	29.00	12.52	20.76	49.30	1.39

The experimental treatments:

Irrigation regime treatments:

Four water deficit irrigation treatments were as follows:

I_1- Control treatment (full irrigation) at all growth stage.
I_2- Withholding irrigation at tillering stage.
I_3- Withholding irrigation at heading stage.
I_4- Withholding irrigation at grain filling stage.

Wheat Cultivars:

Four tested wheat cultivars were as follows:
CV1= Gemmeiza 12, **CV2**= Misr 1, **CV3**= Giza 168, **CV4**= Sids 13.

Studied Characteristics:

Physiological Growth Characters:

At each growth stages five plants were taken randomly from each plot to measure the following physiological growth characters.

1. Chlorophyll content

Chlorophyll a, b and total chlorophyll were extracted and determined according to Moran (1982). Three discs of fresh flag leaf were taken and extracted using known volume of (5 m1) of N-N dimethyl formamide. The absorbance of the extracted color was measured spectrophotometrically at 664 and 647 nm.Chlorophyll a and b were calculated using the following, formula:

Chlorophyll a = $12.64 \times A664 - 2.99 \times A647$ = mg g^{-1} fw

Chlorophyll b =$23.26 \times A647 - 5.6 \times A664$ = mg g^{-1} fw

Total chlorophyll =$7.04 \times A664 + 20.27 \times A664$= mg g^{-1} fw

2. Growth characters

2.1. Total Dry Matter (TDM)

Plant samples from the two outer ridges of each plot were fresh weighted then oven dried at 70 ^{0}C to constant weight, then the plant materials were grinded and kept for chemical analysis.

2.2. Crop Growth Rate (CGR)

Crop growth rate (CGR) is the rate of dry matter accumulation per unit of ground per day (Watson, 1952).

The increase of plant dry material per unit ground area per unit of time. CGR = $(W2 - W_1) / (T2 - T_1)$ = g^{-1} m^{-2} day^{-1}

Leaf area index, net assimilation rate and crop growth rates were computed according to Watson (1952).

3. Yield and Yield Components

At harvesting time i.e. 12th and 15th April in the first and the second seasons, respectively, the data of yield and yield components from the other three ridges of every plot as the following:

1-Number of grains/spike, 2- Number of spikes/m^2, 3- 1000 grain weight, 4- Grain yield per feddan (ton/fed), 5- Harvest index.

The collected data, except Cu, were statistically analyzed according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

The investigation was performed during the two successive winter seasons 2015/16 and 2016/17 using irrigation regime treatments i.e holding irrigation at tillering, heading and grain filling stages, along with the conventional irrigation treatment (control) as well as four commercial wheat cultivars (Gemmiza 12, Misr 1, Giza 168 and Sids 13).

1. Chlorophyll Content

Generally, cholorophyll a, b and total chlorophyll gradually decreased in the plants grew under water deficit conditions in the two seasons.

1. A. Effect of Irrigation Treatments

Our results indicated that chlorophyll content of wheat leaves as affected by irrigation regime treatments under three studied growth stages i.e. tillering, heading and grain filling stages are presented in Table (3). At tillering stage the reduction in chlorophyll a, b and total chlorophyll were [(13.38, 10.38, 12.46%) (4, 7.59, 5.16%)] in the first and second season respectively. At heading stage the reduction in chlorophyll a, b and total chlorophyll were [(12.25, 15.38%) (15.73, 13.70%) (13.37, 14.84%)] in the first and second season respectively. Whereas at grain filling stage the reduction in chlorophyll a, b and total chlorophyll were [(4.72, 29.72, 33.10%) (17.64, 21.56, 26.14%) (2.16, 15.62, 22.83%)] as compared with the control (conventional or full irrigation) in the first and second season, respectively. The reduction in chlorophyll content could be due to the harmful effect of water deficit on chloroplast resulting in disorganization of thylakoid membranes and degradation of chlorophyll (Siddiqui *et al.*, 2015 and Abdelaal *et al.*, 2018b). These results are in accordance with those achieved by Abdalla and El-Khoshiban (2007).

1. B. Effect of Wheat Cultivars

Gemmeiza 12 significantly surpassed all the other cultivars in all growth stages at tillering, heading and grain filling stages in both seasons and gave the highest values of chlorophyll a, b and total chlorophyll content. In this respect, wheat cultivar Gemmeiza12 exceeded Sids13 by [(20.99, 30.07, 23.98%) (28.64, 28.14, 28.48%)] at tillering stage, [(28.92, 34.57, 30.75%)(16.25, 16.97, 16.64%)] at heading stage and [(31.20, 27.63, 30%) (29.10, 25.15, 27.77%)] at grain filling stage in the first and second seasons, respectively for chlorophyll a,b and total chlorophyll content in Table (3). These results may be due to the good growth of Gemmeiza12 compared with the other cultivars. These results are in agreement with those obtained by Abdalla and El-Khoshiban (2007), Keyvan (2010), Wu and Bao (2011), Abu-Grab and Morad (2010).

1. C. Effect of Interaction

The interaction between the two studied factors i.e. irrigation regime treatments and wheat cultivars showed significant effect on chlorophyll a, b and total chlorophyll content at the three growth stages i.e. tillering, heading and grain filling stages in both seasons (Table 4).

Table (4): Chlorophyll a & b and total chlorophyll content as affected by irrigation regime treatments and the four tested wheat cultivars during 2015/2016 and 2016/2017 seasons:

	Chl.amg^{-1} g fw						Chl.b mg^{-1} g fw						Total Chl.mg^{-1} g fw					
	2015/16			2016/17			2015/16			2016/17			2015/16			2016/17		
	Till	Head	Gf	Till	Head	Gf	Till	Head	Gf	Till	Head	Gf	Till	Head	Gf	Till	Head	Gf
Irrigation Regime Treatments *(I)																		
I_1	5.23	4.16	2.96	4.99	4.56	3.19	2.31	1.97	1.53	2.37	2.13	1.78	7.54	6.13	4.16	7.36	6.69	4.52
I_2	4.53	3.65	2.82	4.79	4.08	2.92	2.07	1.66	1.26	2.19	1.95	1.33	6.60	5.31	4.07	6.98	6.03	4.19
I_3		3.52	2.08		3.87	2.37		1.70	1.20		1.85	1.27		5.22	3.51		5.73	4.15
I_4			1.98			2.29			1.13			1.19			3.21			3.48
LSD 5%	0.23	0.20	0.20	0.14	0.15	0.11	0.08	0.06	0.04	0.08	0.07	0.04	0.23	0.17	0.20	0.14	0.17	0.12
Reduction%	13.38	12.25	4.72	4.00	10.52	8.46	10.38	15.73	17.64	7.59	8.45	25.28	12.46	13.37	2.16	5.16	9.86	7.30
		15.38	29.72		15.13	25.70		13.70	21.56		13.14	28.65		14.84	15.62		14.34	8.18
			33.10			28.21			26.14			33.14			22.83			23.00
Wheat cultivars																		
Gemmiza12	5.43	4.46	2.98	5.90	4.49	3.23	2.66	2.14	1.52	2.70	2.18	1.63	8.09	6.60	4.50	8.60	6.67	4.86
Misr1	5.03	3.78	2.48	4.76	4.40	2.73	2.21	1.84	1.29	2.34	2.06	1.41	7.24	5.62	3.77	7.10	6.46	4.13
Giza168	4.77	3.71	2.33	4.68	4.03	2.52	2.04	1.71	1.21	2.16	1.87	1.31	6.81	5.42	3.54	6.84	5.90	3.84
Sids13	4.29	3.17	2.05	4.21	3.76	2.29	1.86	1.40	1.10	1.94	1.81	1.22	6.15	4.57	3.15	6.15	5.56	3.51
LSD 5%	0.33	0.23	0.20	0.19	0.18	0.11	0.11	0.07	0.04	0.11	0.08	0.04	0.33	0.20	0.20	0.20	0.20	0.12
Reduction%	20.99	28.92	31.20	28.64	16.25	29.10	30.07	34.57	27.63	28.14	16.97	25.15	23.98	30.75	30.00	28.48	16.64	27.77

Where:* Irrigation regime treatments (I) were as follows: I_1= control treatment (conventional or full irrigation). I_2= with holding irrigation at tillering stage. I_3= with holding irrigation at heading stage. I_4= with holding irrigation at grain filling stage.

Table (5): Chlorophyll a & b and total chlorophyll contents content as affected by the interaction between irrigation regime and tested wheat cultivars during 2015/2016 and 2016/2017 seasons:

Irrig*wheat cultivars Interaction	Chl. a mg^{-1} g fw						Chl.bmg^{-1} g fw						Total Chl. mg^{-1} g fw					
	2015/16			2016/17			2015/16			2016/17			2015/16			2016/17		
	Tell	Head	Gf	Tell	Head	Gf	Tell	Head	Gf	Tell	Head	Gf	Tell	Head	Gf	Tell	Head	Gf
I_1Gemmiza12	5.83	5.10	3.24	5.91	5.15	4.02	2.96	2.52	1.40	2.90	2.45	1.48	8.80	7.62	4.63	8.81	7.59	5.49
I_1Misr1	5.12	3.98	2.87	4.90	4.75	3.34	2.27	1.96	1.30	2.41	2.29	1.37	7.39	5.95	4.17	7.30	7.04	4.71
I_1Giza168	5.37	4.01	2.80	4.93	4.28	2.75	2.11	1.82	1.23	2.23	1.94	1.30	7.48	5.83	4.03	7.16	6.22	4.04
I_1Sids13	4.61	3.54	2.36	4.21	4.05	2.64	1.90	1.57	1.10	1.94	1.86	1.18	6.51	5.11	3.46	6.16	5.91	3.83
I_2Gemmiza12	5.02	4.33	3.89	5.90	3.92	3.74	2.35	2.03	1.40	2.49	2.13	1.50	7.37	6.36	5.29	8.39	6.05	5.23
I_2Misr1	4.94	3.76	2.90	4.62	4.52	2.73	2.14	1.82	1.21	2.27	1.99	1.29	7.08	5.59	4.11	6.89	6.51	4.02
I_2Giza168	4.17	3.60	2.57	4.42	4.12	2.74	1.97	1.70	1.15	2.09	1.86	1.21	6.14	5.30	3.72	6.51	5.98	3.95
I_2Sids13	3.97	2.91	2.48	4.21	3.77	2.48	1.82	1.09	1.05	1.93	1.81	1.09	5.79	4.00	3.53	6.14	5.57	3.58
I_3Gemmiza12		3.94	2.44		4.41	2.65		1.88	1.91		1.96	2.09		5.82	4.35		6.36	4.74
I_3Misr1		3.59	2.09		3.94	2.36		1.74	1.49		1.90	1.77		5.34	3.58		5.84	4.13
I_3Giza168		3.51	1.95		3.69	2.21		1.62	1.41		1.81	1.67		5.13	3.36		5.50	3.89
I_3Sids13		3.06	1.45		3.46	2.24		1.54	1.30		1.75	1.58		4.60	2.75		5.21	3.83
I_4Gemmiza12			2.36			2.51			1.37			1.45			3.73			3.97
I_4Misr1			2.07			2.48			1.15			1.19			3.22			3.68
I_4Giza168			1.98			2.39			1.06			1.07			3.04			3.46
I_4Sids13			1.91			1.79			0.94			1.04			2.85			2.83
LSD 5%	0.46	N.S	0.40	0.28	0.31	0.22	0.16	0.12	0.07	0.15	0.14	0.08	0.47	0.35	0.40	0.29	0.34	0.23

Where:* Irrigation regime treatments (I) were as follows: I_1= control treatment (conventional or full irrigation). I_2= with holding irrigation at tillering stage. I_3= with holding irrigation at heading stage. I_4= with holding irrigation at grain filling stage.

2. PLANT GROWTH

2.1. Total Dry Matter (TDM)

2.1. A. Effect of irrigation treatments

Data presented in Table (6) revealed that the four irrigation treatments differed significantly in their effects on total dry matter (TDM). The reduction in dry matter accumulation due to water stressed at telliring stage was (11.44, 12.07%), [(13.03, 14.54%) (7.26, 12.01%)] at heading stage and [(7.92, 11.55, 16.50%) (4.94, 10.46, 10.86%)] at grain filling stage in the first and second season, respectively. This reduction in dry matter could be due to the reduction in fresh and dry weight of plants due to the harmful effect of water deficit on stimulating the photosynthetic enzymes (Abdalla and El-Khoshiban 2007). The obtained results are in harmony with those of Abu-Grab and Morad (2010) concluded that water deficit reduced dry matter accumulation in wheat plant. Also Boutraa *et al.*, (2010) mentioned that dry weights of roots, shoots and whole wheat plant were decreased under severe stress conditions.

2.1. B. Effect of Wheat Cultivars

Analysis of variance revealed significant differences among the means of four wheat cultivars for total dry matter (Table 6). In this respect Gemmeiza 12 exceeded Sids 13 By (16.93, 16.79%) at tillering stage, (24.63, 18.13%) at heading stage and (17.66, 17.73%) at grain filling stage for total dry matter (TDM) in the first and second seasons, respectively. These results are in accordance with those obtained by Boutraa *et al.*, (2010), Abu-Grab and Morad (2010), Abu-Grab and Elshaarawy (2013) and Getent *et al.*, (2015).

2.1. C. Effect of Interaction

Irrigation treatments and wheat cultivars interaction affected total dry matter (TDM) significantly at tillering and heading stages in the first season and heading, grain filling stages in the second season. On the hand the results were not significant at grain filling stage in the first season and at tillering stage in the second one (Table 6).

2.2. Crop Growth Rate (CGR)

2.2. A. Effect of Irrigation Treatments

As shown from table (6), the highest values of CGR were obtained under I_1 treatment (control or conventional irrigation treatment). The reduction in CGR trait were [(4.55, 6.74, 15.69%) (0.58, 4.56, 11.53%)] at tillering to heading stage whereas the reduction at heading to grain filling stage were [(11.20, 15.75, 22.44) (0.64, 4.28, 11.37)] at the two periods of growth in the first and second season respectively The results of water stress on wheat plants were reported by Rafiq *et al.*, (2005), Abu-Grab and El-shaarawy (2013) and Abu-Grab *et al.*, (2015) who indicated that irrigation at 65 and 80% AVSMD comparable with 50% AVSMD decreased crop growth rate.

2.2. B. Effect of Wheat Cultivars

Gemmeiza 12 exceeded all the other wheat cultivars, and produced the highest values of CGR at the two growth periods in both seasons and Sids 13 gave the lowest values of this trait. The reduction between the highest values that recorded with Gemmiza 12 and the lowest one that recorded with Sids 13 were (26.93, 17.45%) at tillering to heading stage and (24.32, 11.37%) at heading to grain filling stage in the first and second season, respectively. The differences in studied traits among wheat cultivars may be due to genetic constitution which seriously affected by environmental conditions. These results were reported by Abu-Grab and Morad (2010), Abu-Grab and El-Shaarawy (2013), Abu-Grab *et al.*, (2015) and Getnet *et al.*, (2015).

2.2. C. Effect of Interaction

Results in Table (7) revealed that wheat plants Gemmiza 12 grown in plots received normal irrigation showed significant increase in crop growth rate (CGR) at the two growth periods in both seasons.

Table (6): Total dry matter and Crop growth rate as affected by irrigation regime treatments and tested wheat cultivars during 2015/2016 and 2016/2017 seasons

	TDM (kg/m^2)						CGR (g/m^2/d)			
	2015/16			2016/17			Tillering to heading stage.		Heading to grain filling stage.	
	Till	Head	Gf	Till	Head	Gf	2015/16	2016/17	2015/16	2016/17
Irrigation Regime Treatments *(I)										
I_1	2.36	3.30	3.03	2.65	3.58	3.44	37.53	42.75	21.96	21.72
I_2	2.09	2.87	2.79	2.33	3.32	3.27	35.82	42.50	19.50	21.58
I_3		2.82	2.68		3.15	3.08	35.00	40.80	18.50	20.79
I_4			2.53			2.86	31.64	37.82	17.03	19.25
LSD 5%	0.06	0.15	0.08	0.11	0.11	0.09	1.53	1.91	1.32	1.18
Reduction%	11.44	13.03	7.92	12.07	7.26	4.94	4.55	0.58	11.20	0.64
		14.54	11.55		12.01	10.46	6.74	15.75	15.75	4.28
			16.50			16.86	15.69	22.44	22.44	11.37
Wheat cultivars										
Gemmiza12	2.48	3.45	3.00	2.68	3.64	3.44	39.84	44.64	22.16	21.80
Misr1	2.22	3.04	2.86	2.59	3.45	3.29	36.80	42.58	19.75	21.57
Giza168	2.13	2.90	2.69	2.47	3.32	3.09	34.22	39.80	18.29	20.66
Sids13	2.06	2.60	2.47	2.23	2.98	2.83	29.11	36.85	16.77	19.32
LSD 5%	0.09	0.17	0.08	0.16	0.13	0.09	1.53	1.91	1.32	1.18
Reduction%	16.93	24.63	17.66	16.79	18.13	17.73	26.93	17.45	24.32	11.37

Where:* Irrigation regime treatments (I) were as follows: I_1= control treatment (conventional or full irrigation). I_2= with holding irrigation at tillering stage. I_3= with holding irrigation at heading stage. I_4= with holding irrigation at grain filling stage.

Table (7): Total dry matter (TDM) and Crop growth rate (CGR) as affected by the interaction between irrigation regime treatments and tested wheat cultivars during 2015/2016 and 2016/2017 seasons

Irrig*wheat cultivars Interaction	TDM						CGR			
	2015/16			2016/17			2015/162016/17		2015/162016/17	
	Till	Head	Gf	Till	Head	Gf	Tillering to heading stage.		Heading to grain filling stage.	
I_1Gemmiza12	2.75	3.99	3.06	2.81	3.85	3.52	42.44	46.66	28.11	22.88
I_1Misr1	2.33	3.24	2.91	2.75	3.64	3.35	39.55	44.44	21.66	21.77
I_1Giza168	2.20	3.04	2.63	2.56	3.48	3.16	35.55	39.00	20.74	20.29
I_1Sids13	2.15	2.93	2.55	2.48	3.35	3.05	32.55	40.89	17.33	21.39
I_2Gemmiza12	2.22	3.23	2.78	2.55	3.53	3.20	38.22	42.66	20.55	21.11
I_2Misr1	2.12	2.95	2.64	2.43	3.35	3.04	33.78	40.44	19.33	20.66
I_2Giza168	2.05	2.79	2.55	2.37	3.24	2.94	32.89	38.66	17.33	20.00
I_2Sids13	1.97	2.32	2.14	1.98	2.48	2.27	21.66	29.51	16.77	15.22
I_3Gemmiza12		3.13	2.86		3.55	3.29	39.33	45.33	19.11	22.00
I_3Misr1		2.91	2.71		3.36	3.12	35.77	41.99	17.33	20.72
I_3Giza168		2.88	2.62		3.25	3.01	33.77	38.44	16.44	20.78
I_3Sids13		2.55	2.51		3.11	2.89	31.11	37.44	15.22	19.67
I_4Gemmiza12			3.30			3.75	39.39	43.89	20.89	21.22
I_4Misr1			3.17			3.65	38.11	43.44	20.66	23.11
I_4Giza168			2.96			3.24	34.66	43.11	18.66	21.55
I_4Sids13			2.70			3.12	31.11	39.55	17.77	21.00
LSD 5%	0.13	0.29	N.S	N.S	0.23	0.17	3.06	3.82	2.63	2.37

Where:* Irrigation regime treatments (I) were as follows: I_1= control treatment (conventional or full irrigation). I_2= with holding irrigation at tillering stage. I_3= with holding irrigation at heading stage. I_4= with holding irrigation at grain filling stage.

3. Yield And Yield Components:

The statistical analysis of variance revealed that different irrigation regime treatments and the tested wheat cultivars had a significant effect on yield and yield components traits i.e. number of grains/spike, number of spike/m^2, grain weight/spike, 1000 grain weight, yields of grains, straw and biological/feddan as well as harvest index are presented in Table (8).

3.1. Number of Grains/Spike:

3.1. A. Effect of irrigation treatments

According to our results in Table (8) a significant effect of irrigation treatments on number of grains/spike in both seasons was recorded. I_1 treatments (control or conventional irrigation) gave the highest number of grains/spike in both seasons. However I_4 treatments (withholding irrigation at grain filling stage) ranked the second. Meanwhile, I_2 treatments (withholding irrigation at tillering stage) gave the lowest number of grains/spike. The reduction in number of grains/spike were (13.37, 18.57, 6.77%) and (10.42, 18.61, 6.64%) in the first and second seasons, respectively. This result may be due to the damaging effect of water deficit on fresh and dry weight of wheat plants as well as chlorophyll concentration. These results are in accordance with those recorded by These results are in harmony with those obtained by Atta and Swelam (2006), Abu-Grab and Morad (2010), Abu-Grab and EL-Shaarawy (2013) and Abu-Grab *et al.,* (2015).

3.1. B. Effect of wheat cultivars

As shown in Table (8), the results detected significant differences among the four tested wheat cultivars in both seasons. It clearly evident that Gemmeiza 12, followed by Misr 1 produced the highest number of grains/spike. While Sids 13 cultivar gave the lowest number of grains/spike. Gemmeiza 12 outnumbered Sids 13 wheat cultivar by 23.02 and 2.98% for this trait in the first and second seasons, respectively. These present results are in harmony with those reported by Atta and Swelam (2006), Salem Nagwa *et al.,* (2006), Zaki Nabila *et al.,* (2007).

3.1. C. Effect of interaction

The interaction between irrigation regime treatments and wheat cultivars was significant for grains number/spike in both seasons. As shown in Table (8).

3.2. Number of spikes/m^2

3.2. A. Effect of irrigation

Data presented in Table (8) showed that the effect of irrigation treatments had significant effect on number of spikes/m^2 in both seasons. I_4 treatment (withholding irrigation at grain filling stage) produced the highest number of spikes/m^2. The reduction in number of spikes/m^2 were (18.57, 23.04, 13.13%) and (14.19, 18.72, 13.10%) in the first and second seasons, respectively. These results are in accordance with those obtained by Zhang *et al.*, (2008), Abu-Grab and Morad (2010), Abu-Grab and EL-Shaarawy (2013).

3.2. B. Effect of Wheat Cultivars

The effect of wheat cultivars on number of spikes/m^2 was significant in both seasons. As shown in Table (8) the different among the four tested wheat cultivar reached the level of significant in both seasons. Gemmeiza 12 outnumbered Sids 13 by 34.82 and 29.30% for number of spikes/m^2 in the first and second season respectively. These results are in agreement with those found by Atta and Swelam (2006), Mobarak Zainab (2006), Abu-Grab and EL-Shaarawy (2013).

3.2. C. Effect of interaction

The interaction between irrigation regime treatment and wheat cultivars was significant for number of spikes/m^2 in both seasons.

3.3. 1000 Grain Weight

3.3. A. Effect of Irrigation Treatment

According to our results the maximum value of 1000 grain weight were obtained from watering wheat plant with normal or conventional irrigation treatment (I_1), whereas this treatment ranked first in this respect. It is followed by I_4 treatment (withholding irrigation at grain filling stage). The reduction in 1000 grain weight were (16.60, 30.02, 12.34%) and (6.56, 22.54, 3.37%) at tillering, heading, grain filling stage in the first and second season, respectively. The reduction in 1000 grain weight may be due to the adverse effect of water deficit in reducing the plant growth and photosynthetic rate in the stressed plants. These results are in harmony with those obtained by Atta and swelam (2006), Mobarak Zainab (2009), Abu-Grab and Mourad (2010), Abu-Grab and EL-Shaarawy (2013), Abu-Grab *et al.*, (2015).

3.3. B. Effect of Wheat Cultivars

Respecting 1000 grain weight as affected by wheat cultivar, it is clear from Table (7) that the four tested wheat cultivars were differed significantly in their effects on thousand grain weights in the two seasons of study. The superiority ratios between the highest cultivar Gemmeiza 12 and the lowest one Sids 13 were 22.66 and 22.53% for the above mentioned trait in the first and second season, respectively. These findings are in the same line with those found by Atta and Swelam (2006), Zainab Mobarak (2009), Abu-Grab and Mourad (2010), Abo-Grab and EL-Shaarawy (2013) and Abu-Grab *et al.*, (2015).

3.3. C. Effect of Interaction

As shown in Table (8) significant interaction effect between irrigation treatments and wheat cultivars was detected for 1000 grain weight trait in both seasons of study. The heaviest grains were obtained from wheat Gemmeiza 12 when growing under control treatment (normal irrigation). Meanwhile the lightest grains were given from wheat cultivar Sids 13 growing under water stress condition at tillering stage.

3.4. Grain Yield (Ton/Fed)

3.4. A. Effect of Irrigation Treatment

With respect to grains yield/fed under the effect of irrigation regime treatment data presented in Table (8) revealed that the highest grain yield/fed was performed under I_1 treatment (control or normal irrigation), followed by escaping irrigation during the grain filling stage. The reduction in grain yield/fed were (35.77, 46.29, 12.64%) and (38.73, 45.23, 30.18%) at tillering, heading and grain filling stage in the first and second seasons, respectively. The reduction in grains yield under water deficit stress might be due to the decrease of fresh and dry weight of plants as well as 1000 grain weight. Atta and Swelam (2006) concluded that growing wheat plants under five irrigations gave the highest values of grains yield, while wheat plants received three irrigation gave the lowest grain yield/fed. Similar results trend were reported by obtained by Abu-Grab *et al.,* (2015).

3.4. B. Effect of Wheat Cultivars

Gemmeiza 12 passed all the other cultivars under study and produced the highest values of grain yield/fed in both seasons. Meanwhile the lowest values of this trait were obtained from Sids 13. As shown in Table (7) Gemmeiza 12 exceeded Sids 13 by 30.41% and 29.27% for grain yield trait in the first and second seasons respectively. Those results are in agreement with results reported by Atta and Swelam (2006), Reiad *et al.*, (2007), Zhang *et al.*, (2008), Mobarak Zainab (2009), Abu-Grab and Mourad (2010), Abu-Grab and EL-Shaarawy (2013) and Abu-Grab *et al.*, (2015).

3.4. C. Effect of Interaction

The interaction between irrigation regime treatments and wheat cultivars was significant for grain yield/fed in both seasons. As shown in Table (8), wheat Gemmeiza 12 cultivar produced the highest values of grain yield/fed in both seasons. However, wheat Sids 13 cultivar gave the lowest grains yield under water stressed at tillering stage in both seasons of study.

3.5. Harvest Index

3.5. A. Effect of irrigation treatments

As shown in table (8), results showed that the response of harvest index to irrigation treatments was similar to each of grain, straw and biological yield traits in the two seasons of study. The reduction in harvest index were (16.54, 18.26, 2.08%) and (20.45, 22.16, 11.53%) at tillering, heading and grain filling stages in the first and second seasons, respectively. This result might be due to the adverse impact of water stress on gains yield in wheat plants. Similar results trend were reported by Mobarak Zainab (2009).

3.5. B. Effect of Wheat Cultivars

As shown in Table (8) results revealed that Gemmeiza 12 cultivar surpassed significantly the other tested wheat cultivars, which did not differ significantly from each other in this respect. Gemmiza 12 exceded Sids 13 by 4.42% and 3.89% for harvest index trait in the first and second season, respectively. Also the differences among the four tested wheat cultivars could be attributed to their genetic constitutions as well as their response to the prevailing environmental conditions. The results of harvest index as affected by wheat cultivars were obtained by Mobarak Zinab (2009).

3.5. C. Effect of Interaction

As shown in Table (8) the interaction between irrigation treatments and wheat cultivars had significant effect on harvest index trait in both seasons.

Finally the significant interaction between irrigation treatments and wheat cultivars mean that each one of the two studied factors acted yield and yield component traits dependently.

Table (7): Yield and yield components as affected by irrigation regime and grown cultivars through 2015/2016 and 2016/2017 seasons:

	No.of grains/spike		No.of spikes/m^2		Grains weight/spike		1000 grain (g) weight		Grain yield (ton fedan^{-1})		Harvest index	
	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17
Irrigation Regime Treatments *(I)												
I_1	68.54	74.60	385.61	423.68	2.77	2.90	58.98	61.55	2.83	3.22	33.25	33.21
I_2	59.38	66.83	313.99	363.54	1.66	1.78	49.19	57.51	1.82	1.97	27.75	26.42
I_3	55.82	60.72	296.78	344.38	1.49	1.68	41.28	47.67	1.52	1.76	27.18	25.85
I_4	63.90	69.65	334.99	368.18	2.34	2.62	51.70	59.48	2.47	2.25	32.56	29.38
LSD 5%	1.79	2.41	18.29	17.59	0.11	0.05	2.55	2.16	0.14	0.24	2.68	2.36
Reduction	13.37	10.42	18.57	14.19	40.17	38.71	16.60	6.56	35.77	38.73	16.54	20.45
	18.57	18.61	23.04	18.72	46.12	42.10	30.02	22.54	46.29	45.23	18.26	22.16
	6.77	6.64	13.13	13.10	15.47	9.44	12.34	3.37	12.64	30.18	2.08	11.53
Wheat cultivars												
Gemmiza12	69.80	78.69	395.95	442.87	2.35	2.53	57.01	63.59	2.56	2.83	31.92	29.39
Misr1	63.71	69.14	366.85	383.76	2.13	2.27	51.63	57.72	2.20	2.19	29.57	29.15
Giza168	60.39	65.71	310.48	360.07	1.96	2.14	48.42	55.64	2.09	2.17	30.19	28.70
Sids13	53.73	58.25	258.09	313.09	1.84	2.03	44.09	49.26	1.78	2.00	30.51	28.26
LSD 5%	1.79	2.41	18.29	17.59	0.11	0.05	2.55	2.16	0.14	0.24	1.35	1.12
Reduction	23.02	25.98	34.82	29.30	21.71	19.85	22.66	22.53	30.41	29.27	4.42	3.84

Where:* Irrigation regime treatments (I) were as follows: I_1= control treatment (conventional or full irrigation).I_2= with holding irrigation at tillering stage. I_3= with holding irrigation at heading stage. I_4= with holding irrigation at grain filling stage.

Table (8): Yield and yield components as affected by the interaction between Irrigation regime and grown cultivars through 2015/2016 and 2016/2017 seasons:

Irrig*wheat cultivars Interaction	No.of grains/spike		No.of spikes/m2		Grains weight/spike		1000 grain weight		Grain yield		Harvest index	
	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17	2015/16	2016/17
I_1Gemmiza12	81.13	88.10	490.27	520.73	3.44	3.57	63.63	68.15	3.77	4.48	30.72	30.50
I_1Misr1	68.30	73.23	390.07	414.63	2.79	2.84	58.89	61.96	2.67	2.78	30.09	30.25
I_1Giza168	65.93	70.30	358.40	386.80	2.52	2.68	56.73	60.05	2.53	2.92	31.04	29.78
I_1Sids13	58.80	66.77	303.70	372.57	2.35	2.50	56.68	56.03	2.34	2.69	32.48	29.33
I_2Gemmiza12	65.27	75.40	366.23	418.43	1.79	1.90	58.60	63.84	1.93	2.24	26.18	24.26
I_2Misr1	61.77	67.53	344.57	377.07	1.70	1.81	52.85	57.22	1.86	2.01	25.65	24.07
I_2Giza168	57.47	64.80	290.40	353.17	1.60	1.73	47.93	55.35	1.81	1.89	26.46	23.69
I_2Sids13	53.00	59.57	254.77	305.50	1.55	1.65	47.41	53.64	1.66	1.74	27.68	23.33
I_3Gemmiza12	62.57	72.53	336.20	390.57	1.67	1.78	50.15	55.95	1.78	1.97	25.64	23.74
I_3Misr1	59.83	64.40	359.37	354.37	1.54	1.73	44.56	50.07	1.71	1.78	25.12	23.55
I_3Giza168	55.03	60.40	287.53	332.47	1.43	1.62	42.01	49.92	1.58	1.68	27.11	23.18
I_3Sids13	45.83	45.53	204.03	300.10	1.34	1.57	28.39	34.76	1.01	1.61	26.18	22.83
I_4Gemmiza12	70.23	78.73	391.10	441.73	2.48	2.88	55.66	66.42	2.77	2.64	31.37	26.98
I_4Misr1	64.93	71.40	373.40	388.97	2.51	2.70	50.21	61.63	2.54	2.20	30.72	26.74
I_4Giza168	63.13	67.33	305.60	367.83	2.28	2.52	47.00	57.25	2.45	2.17	31.70	26.35
I_4Sids13	57.30	61.13	269.87	274.20	2.11	2.39	43.89	52.62	2.12	1.97	33.17	25.95
LSD 5%	3.59	4.83	36.58	35.17	0.22	0.11	5.11	4.32	0.28	0.48	2.83	2.46

Where:* Irrigation regime treatments (I) were as follows: I_1= control treatment (conventional or full irrigation). I_2= with holding irrigation at tillering stage. I_3= with holding irrigation at heading stage. I_4= with holding irrigation at grain filling stage.

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