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Physiological Characteristics, Yield and Yield Attributes of Some New Bread Wheat (*Triticum aestivum* L.) Cultivars as Affected by Irrigation Regimes under Sprinkler Irrigation System

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TWO FIELD experiments were carried out in the Experimental Farm at Ismailia Agricultural Research Station, El-Ismailia Governorate, Egypt during two successive winter seasons (2009/2010 – 2010/2011). The experiments determined the effect of three irrigation regimes (I_1, I_2 and I_3) on some new bread wheat cultivars (Giza 168, Sakha 94, Sids 12 and Gemmeiza 11) under sprinkler irrigation system in sandy soils.

Severe water stress was induced by irrigation every three weeks throughout the season (I_3) using a sprinkler irrigation system in sandy soil conditions. This treatment significantly decreased plant height (55.71 cm), days to 50% heading (84.5 day) and maturity (115.65 day), relative water content (41.09%), transpiration rate (105.65 mg H_2O/g FW/h), number of spikes/m^2 (220.06), number of grains/ spike (24.57), 1000-grain weight (26.83 g) and grain yield (3.69 ardab/fed) but increased proline content. Lesser reductions were observed for treatments with irrigation every two weeks (I_2) relative to irrigation every week (I_1) throughout the season. These effects were present for both seasons and in a combined analysis.

Gemmeiza 11 had the highest plant height (66.66 cm), relative water content (55.38%), and 1000-grain weight (35.2 g). It had a transpiration rate of 132.23 mg H_2O/g FW/h. Giza 168 had the highest number of spikes/m^2 (263.5) and number of grains/spike (41.03), as well as transpiration rate (134.23 mg H_2O/g FW/h). Sids 12 had the highest number of spikes/m^2(263.15) and grain yield (6.33 ardab/fed). Meanwhile, Sakha 94 was latest in heading and maturity, gave the highest proline content (18.53µ moles proline/g FW) and the lowest transpiration rate (121.3 mg H_2O/g FW/h). Gemmeiza 11 and Giza 168 followed by Sids 12 were tolerant to water stress and Sakha 94 was the most sensitive. Physiological characters, *i.e.,* relative water content (RWC), transpiration rate and proline content may be playing a role in the tolerance of wheat plants to water deficit. It is suggested that breeders can use these characters as selection criteria for drought tolerance.

Keywords: Wheat, Cultivars, Irrigation, RWC%, Transpiration rate, Physiological, Phonological characteristics, Sprinkler irrigation, Sandy soils.

Bread wheat (*Triticum aestivum* L.) is considered to be one of the most important cereal crops in the world as well as in Egypt (FAO, 2007). In Egypt, the national production of cereals is less than consumption. Raising wheat production through increasing the productivity per unit area is thus an important national target. Improving productivity could be achieved by cultivating high yielding cultivars coupled with improved agronomic practices such as irrigation treatments. It is thus important to understand the drought response of new Egyptian wheat cultivars and some work has already been carried out to this effect. Ashmawy & Abo-Warda (2002) showed that wheat cv. Giza-168 significantly surpassed Sids-1 and Gemmeiza-9 cultivars in grain yield per hectare, number of grains per spike and 1000-grain weight . Moreover, Abd El–Hameed (2005) concluded that, wheat cultivar Giza-168 gave higher number of spikelets per spike, number of grains per spike, 1000-grain weight and grain yield per hectare than Sakha-93. Gafar (2007), Ramadan & Awaad (2008) and El- Murshedy (2008) found varietal differences for plant height, number of spikelets and grains per spike, grain weight per spike and grain yield per hectare Zeidan *et al*. (2009) showed that, for three wheat cultivars Sids 1 was superior and gave the highest values for grains per spike, 1000- grain weight and grain yield per hectare. This was followed by Giza 168 while Sakha 93 produced the lowest values in all studied characters. However, Amin *et al*. (2010) reported that wheat cultivar Gemmeiza 9 gave the highest number and heaviest grains per spike and grain yield followed by Sakha 93 and Giza 168. On the basis of these data the above 4 cultivars have been selected for further evaluation.

Water stress affects physiological processes, growth and yield of wheat plants. El-Far & Teama (1999) studied the effect of irrigation intervals (21, 31 and 41 days) on the productivity of some bread and durum wheat cultivars. The results revealed that, the highest number of spikes/m^2 (514.17) 1000- grain weight (54.059 g) and grain yield (27.64 ardab/fed) were obtained from irrigation every 31 days. Sharaan *et al.* (2000) using five wheat cultivars (Sids-1, Sakha-8, Sakha-69, Giza-164 and Giza-167) grown under three water regimes found that skipping one irrigation either at heading or at dough-ripe stage decreased all studied traits except biological and straw yields/fed. Full irrigation produced the highest averages for the different traits followed by skipping one irrigation at dough ripe stage. The lowest values were obtained from skipping one irrigation at heading stage. Siddique *et al.* (2000) reported that exposure of wheat plants to drought led to a noticeable decrease in leaf water potential and relative water content with a concurrent increase in leaf temperature. Higher leaf water potential and relative water content as well as, lower leaf temperature were associated with a higher photosynthetic rate. Haikel & El-Melegy (2005) stated that, at the El-Bustan area under a sprinkler irrigation system the maximum grain yield of Giza 164 was obtained at a seeding rate of 100 kg/fed using 120 kg mineral nitrogen with biofertilizer (Syrialin at a rate of 400 g/fed) and irrigated with recommended requirement +25%. Pal *et al.* (2006) reported that, comprised nine schedules of sprinkler irrigation: (i) Six irrigations (25, 45, 65, 85, 110 and 115 days after swing) with 5, 6 and 7 operating hours; (ii) Seven irrigations (20, 40, 60, 75, 90, 105 and 115 days after swing) with 4, 5 and 6 operating hours; and eight irrigations (20, 35, 50, 65, 80, 95, 105 and 115 days after swing) with 4, 5 and 6 operating hours. These schedules were compared with check basin method of recommended six irrigations corresponding to irrigation water depth of 425 mm. The best schedule of irrigation was found to be 8-irrigation through sprinkler for 6 h at 12 m spacing of nozzle in sandy loam soils at 20, 35, 50, 65, 80, 95, 105 and 115 days after swing operating the sprinkler system at 2.5 kg/cm2 pressure. This schedule resulted in 312 mm water depth, over traditional check basin method. (Huang GuanHua *et al.* 2008) a quota of 75% pan evaporation is recommended for sprinkler irrigation of winter wheat in Beijing area, China. Zeidan *et al*. (2009) stated that, irrigation intervals every 15 days gave the highest values for number of spikes / m^2, number of grains/spike, spike weight, grain weight/spike, spike index, 1000 - grain weight and grain yield (ton/fed). Liu HaiJun *et al.* (2011) stated that, dry biomass, 1000-grains weight and yield were negatively affected by water stress for those treatments with irrigation depth less than 0.50E, where E is the net evaporation (which includes rainfall) from the 20-cm diameter pan. While irrigation with a depth over 1.0E also had negative effect on 1000-grains weight and yield. Ibrahim, *et al.* (2012) found that, irrigating wheat grown in sandy soil with an amount of either 1.0 or 0.8 of ETc with fertigation application in 80% of application time is recommended to enhance growth and yield, and to reduce wheat's damage caused by extreme climate change.

The present investigation studied the effect of three irrigation treatments (I_1, I_2 and I_3) on physiological characteristics, yield and yield attributes of some new bread wheat cultivars (Giza 168, Sakha 94, Sids 12 and Gemmeiza 11) under sprinkler irrigation system in sandy soils.

Materials and Methods

Two field experiments were carried out in the Experimental Farm at Ismailia Agricultural Research Station, El-Ismailia Governorat, Egypt during two winter successive seasons (2009/2010 – 2010/2011). The experiment aimed to study the effect of three irrigation treatments (I_1; I_2; and I_3) on physiological characters, yield and yield attributes of some new bread wheat cultivars (Giza 168, Sakha 94, Sids 12 and Gemmeiza 11). The pedigree of the studied wheat cultivars are given in Table 1 . The experimental field soil was sandy in texture and very poor in fertility (Table 2). Each experiment included 12 treatments which were the combination of four bread wheat cultivars (Giza 168, Sakha 94, Sids 12 and Gemmeiza 11) and three levels of irrigation (I_1; I_2; and I_3) were as follow:

I_1: Irrigation by sprinkler system every week throughout the season (control).

I_2: Irrigation by sprinkler system every two weeks throughout the season (moderate stress by skipping one irrigation).

I_3: Irrigation by sprinkler system every three weeks throughout the season (severe stress by skipping two irrigations).

TABLE 1. Pedigree of the studied wheat cultivars .

Cultivars	Pedigree	Years of release
Giza 168	MRL/BUC//SERI. CM93046-8M-0Y-2Y-0B-0GZ.	1999
Sakha 94	OPATA/RAYON//KAUZ. CMBW90Y3180-0TOPM-3Y-010M-01M-010Y-10M-015Y-0Y-0AP-0S.	2004
Sidis 12	BUC//7C/ALD/5/MAYA74/ON//1160-147/3/BB/GLL/4/CHAT"S"/6/MAYA/VUL//CMH74A.630/4*SX. SD7096-4SD-1SD-1SD-0SD.	2007
Gemmeiza 11	BOW"S"/KVZ"S"//7C/SERI82/3/GIZA168/SAKHA61. GM7892-2GM-1GM-2GM-0GM.	2011

TABLE 2. Initial physical and chemical properties of the investigated soil before conducted the experiment.

Site No	*Depth (cm)*	*Partical size distrbution*			*Soil Texture*	*$CaCO_3$ %*	*OM %*	*pH*	*Total N*	*NH_4-N*	*NO_3-N*	*P Olsen*	*K-DTPA*
		Sandy %	*Silt %*	*Clay %*					*mg kg^{-1}*	*mg kg^{-1}*	*mg kg^{-1}*	*mgkg^{-1}*	*mg kg^{-1}*
1	0-30	96.7	1.3	2.0	Sandy	0.60	0.22	7.93	8.65	5.01	3.42	8.52	30.50
2	0-30	97.0	1.2	1.8	Sandy	0.72	0.23	7.88	9.07	4.32	2.75	10.37	29.37
3	0-30	95.5	1.5	3.0	Sandy	0.65	0.23	7.91	8.75	4.42	3.34	8.91	30.01
4	0-30	96.0	2.0	2.0	Sandy	0.71	0.18	7.93	8.65	4.71	3.38	9.01	30.20

A split- plot design with four replicates was followed, irrigation regimes were assigned to the main plots, whereas, cultivars were allocated in the sub plots. The area of plot was 3.6 m^2 (3 m in length and 1.2 m in width) included 6 rows, 20 cm apart. Seeds (350 grains per m^2) were hand drilled on November 17^{th} and 22^{nd} in the first and second seasons, respectively. Phosphorous fertilizer was applied during soil preparation in the form of calcium super phosphate (15.5% P_2O_5) with 31.0 kg P_2O_5 per fed . Nitrogen in form of ammonium sulfate (20.5% N) was supplied in seven equal doses at 10, 20, 30, 40, 50, 60 and 70 days after sowing. A fixed rate of 50 kg K_2O per fed. of potassium sulphate (48% K_2O) was given in equal portions at sowing and heading. Other normal cultural practices of wheat were applied properly as recommended for the region.

The studied cultivars used were: Giza 168, Sakha 94, Sids 12 and Gemmeiza11. Wheat was sown after a fallow in the two seasons. Sprinkler irrigation was scheduled at an almost one week interval during winter and this period was shortened to four or five days from the beginning of spring up to fifteen days before harvest.

Collected data

A- Phonological characteristics were recorded on plot basis as follows:

1- Days to heading (day), it was computed as number of days observed from sowing until the upper most spikes appeared beyond the auricles of the flag leaf sheath (50% heading on plant basis).
2- Days to maturity (day), it was computed as number of days from sowing to 50% yellow of peduncle of spike.

B-Physiological characters: for studying physiological characters, one sample was taken after 75 days from planting to estimate:

1- Relative water content% (RWC%): 30 discs of leaf were undertaken flag leaf , the discs were immediately weighed to obtain their fresh weight (FW), then the discs were floated on distillated water for 16 hr, after that the turgid leaf discs were rapidly blotted dry and weighted to obtain the turgid weight (TW). Leaf discs were then dried in a microwave oven and weighted until a constant weight to obtain dry weight (DW). Leaf RWC was calculated by the following formula given by Schonfeld *et al.* (1988):

$$RWC\% = \frac{(FW - DW)}{(TW - DW)} \times 100.$$

2- Transpiration rate (mg H_2O/g fresh weight/hour): the rapid weighting method (Stocker, 1956 and Gosev, 1960) was adopted using a torsion balance of 10 mg per division. Flag leaf in different irrigation treatments was used; the leaf was immediately covered with a thin layer of Vaseline at the place of cutting. Rapidly weighted on the torsion balance sheltered from wind, they were then exposed in the open air under natural conditions for five minutes and re-weighted. The decrease in weight was estimated. Transpiration rate was determined as total water output in grams/on hour/gram of fresh weight of leaf.
3- Proline content: the proline concentration was determined according to the method given by Bates *et al.* (1973)from a standard curve and calculated on a fresh weight basis as follows: µ moles proline / g of fresh weight material.

C- Yield and yield attributes: At harvest time (was done during the last week of April in the first and second seasons). Sample of ten guarded plants were taken from each plot to measure:

1- Plant height (cm) of wheat plant was measured from the base of the culms to the tip of the spikes excluding awns. Ten spikes were randomly selected from each treatment to measure:
2- Number of spikes/m^2.
3- Number of grains per spike.
4- Thousand grain weight (g).
5- The inner four rows of each sub- plot by a long of 3 m (2.40 m^2) were harvested to determine grain yield (ardab/ fed).

Statistical analysis of each experiment was performed as the methods outlined by Steel &Torrie (1980). Significancy of differences between the various means of different characters under study was compared with the help of Duncan's multiple range test (Duncan, 1955). In the interaction tables, capital and small letters were used for the comparison among rows and columns means, respectively.

Results and Discussion

Physiological characteristics

Relative water content (RWC %), transpiration rate and proline content:

Irrigation regimes effect

Effect of irrigation regimes on relative water content (RWC %), transpiration rate and proline content. Relative water content, was proposed as a better indicator of water status. RWC through its relation to cell volume may more closely reflect the balance between water supply to the leaf and transpiration rate. The highest values of relative water content indicate that, plants are tolerant, while, the low values reveal that plants are sensitive to drought. In this respect, the higher relative water content (RWC) was determined to be a drought-resistant rather than drought-escape mechanism (Schonfeld *et al.*,1988). Transpiration rate was measured as total water out put / one hour in grams divided on gram fresh weight of leaf. Rate of transpiration tended to decrease as the soil moisture stress was increased, where the low values of transpiration rate reveal that plants are tolerant, while the high values indicate more sensitivity to drought. Based on combined data the results presented in Table 3 indicate that, decreasing irrigation water quantity from I_1, I_2 and up to I_3, resulted in a significant decrease of relative water content and transpiration rate from 60.09%, 50.51% and 41.09% and from 157.73, 127.17and 105.65 mg H_2O/g F.W./h., respectively. Transpiration rate tended to decrease with increasing the level of soil moisture stress. It could be detected that, exposing wheat plants to water stress tended to close the stomata apparatus and this in turn caused a reduction in transpiration rate. These results confirm the finding of Gupta *et al.* (2001), Rane *et al.* (2001) and Yaday *et al.* (2001) who reported that, relative water content (RWC) and transpiration rate were significantly decreased under water stress conditions compared to normally irrigated control conditions. While, the obtained results revealed that, proline concentration in leaves was increased with decreasing soil moisture level. It is interesting to mentione that, decreasing quantity of irrigation water increased proline content. It was 22.23, 16.96 and 10.55 µ moles proline / gm F.W. for I_1, I_2 and I_3, respectively. Generally, proline content was increased as affected by drought stress. Stewart (1977) reported that, proline oxidation could be function as a control mechanism for maintaining low cellular levels of proline in turgid tissue and in water stressed tissue, proline oxidation is reduced to negligible rates. It seems likely that inhabitation of proline oxidation is necessary in maintaining the high levels of proline found in stressed leaves. In this connection, many investigators reported that, free proline content was increased under unirrigated conditions (Deora *et al.*, 2001 and Hamada, 2001).

TABLE 3. Relative water content (RWC%) , transpiration rate (mg H_2O/ g F.W./h.) and proline content (µ moles/g F.W.) as affected by irrigation treatments and cultivars during the two successive seasons (2009/2010- 2010/2011) and their combined analysis.

Main effects and interaction	Relative water content(RWC%)			Transpiration rate (mg H_2O/ g F.W./h.)			proline content (µ moles/g F.W.)		
	2009/2010	2010/2011	Comb.	2009/2010	2010/2011	Comb.	2009/2010	2010/2011	Comb.
Irrigation treatments (I)									
I_1	61.62a	58.54a	60.09a	157.53a	157.93a	157.73a	10.13c	11.02c	10.55c
I_2	51.59b	49.43b	50.51b	130.26b	124.70b	127.17b	16.84b	17.09b	16.96b
I_3	42.63c	39.16c	41.09c	106.69c	104.66c	105.65c	22.40a	22.07a	22.23a
F-test	**	**	**	**	**	**	**	**	**
$LSD_{0.5}$	1.37	0.92	0.86	4.78	5.43	3.75	1.04	0.69	0.40
Cultivars (c)									
Giza 168	45.81d	43.19d	44.51d	134.59a	135.39a	134.99a	13.45d	14.23d	13.81d
Sids 12	51.33c	48.09c	49.84c	134.08a	130.39a	132.24a	15.89c	16.17c	16.04c
Gemmeiza 11	56.33a	54.44a	55.38a	133.4a	131.15a	132.23a	17.50b	17.68b	17.59b
Sakha 94	54.33b	50.45b	52.52b	123.9b	119.48b	121.28b	19.00a	18.80a	18.53a
F-test	**	**	**	**	**	**	**	**	**
$LSD_{0.5}$	1.58	1.06	1.04	5.53	6.27	4.34	1.19	0.79	0.46
Interaction									
I . C	**	**	**	**	**	**	NS	**	**

NS, * and **: indicate Not significant, significant and highly significant at 0.05 and 0.01 level, respectively.
Comb =combined, C: cultivars and I:irrigation water quantity.
I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

Cultivar differences effect

Effect of cultivars on relative water content (RWC %), transpiration rate and proline content: Results presented in Table 3 show that, relative water content (RWC), transpiration rate and proline content of bread wheat cultivars in both seasons and their combined were affected by cultivars. It was evident (from the-combined analysis) that, relative water content and transpiration rate were significantly varied from 55.38% and 132.23 mg H_2O/ g F.W./ h. (Gemmeiza 11) to 52.52% and 121.28 mg H_2O/ g F.W./ h. (Sakha 94) to 49.84% and 132.24 mg H_2O/ g F.W./ h. (Sids 12) and to 44.51% and 134.99mg H_2O/ g F.W./ h. (Giza 168), respectively. It is worthily to mention that, the wheat cultivar Gemmeiza 11 exhibited the highest mean value of relative water content (55.38%) and indicating that, this cultivar was more tolerant to stress conditions. Whereas, wheat cultivar Giza 168 was the lowest one(44.51% and 134.99 mg H_2O/g F.W./ h.), respectively among the studied wheat cultivars in this concern which expressed as sensitive one. Meanwhile , wheat cv. Sakha 94 give the lowest value in the transpiration rate (121.3 mg H_2O / g F.W. / h) . Similar result was found by Sairam & Saxena (2000). On the other hand, insignificant differences among bread and durum wheat genotypes for relative water content transpiration rate were detected by Masterangele *et al.* (2000). Concerning the effect of cultivars on proline content: in combined data, the values of proline content ranged from 13.81 µ moles proline / gm F.W.(Giza 168) to 16.04 µ moles proline / gm F.W. (Sids 12) to 17.59 µ moles proline / gm F.W. (Gemmeiza 11) and to 18.53 µ moles proline / gm F.W. (Sakha 94). In this respect, Narayan & Misra (1989) observed varietal differences in free proline accumulation at 75 and 90 days after sowing in both irrigated and unirrigated conditions. Meanwhile, insignificant differences between six bread wheat cultivars (Abd El-Gawad *et al.*,1998) and two durum wheat genotypes (Mastrangele *et al.,* 2000) in proline content were recorded under normal and stress conditions.

Interaction effect

As shown in the combined analysis, the significant interaction effect between the four bread wheat cultivars and irrigation water quantities on relative water content (RWC), transpiration rate and proline content of bread wheat cultivars were significant (Tables 3, 3-a, 3-b and 3-c). The data indicate that, Gemmeiza 11 by irrigation of wheat plants by sprinkler system every week throughout the season (control) gave increase values of relative water content (RWC) and transpiration rate as well as decreased values of proline content while, the lowest values were obtained in Giza-168 irrigated by severe water stress condition .

TABLE 3-a . Relative water content (RWC%) of wheat as affected by the interaction between irrigation regimes and cultivars (combined analysis) .

Cultivar / Irrigation Regimes	Giza-168	Sids 12	Gemmeiza 11	Sakha 94
I_1	D 52.72a	C 58.70a	A 65.87a	B 63.05a
I_2	C 44.21b	B 49.64b	A 57.41b	B 50.78b
I_3	C 36.58c	B 41.17c	BA 42.88c	A 43.72c

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

TABLE 3-b . Transpiration rate(mg H_2O /g F.W./h.) as affected by the interaction between irrigation regimes and cultivars (combined analysis) .

Cultivar / Irrigation regimes	Giza-168	Sids 12	Gemmeiza 11	Sakha 94
I_1	D 148.16a	B 159.41a	A 171.75a	C 151.76a
I_2	A 137.40b	B 130.18b	B 126.26b	C 114.84b
I_3	A 119.47c	B 107.13c	C 98.68c	C 97.31c

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

TABLE 3-c . Proline content (μ moles proline/ gm F.W.) as affected by the interaction between irrigation regimes and cultivars (combined analysis) .

Irrigation regimes \ Cultivar	Giza-168	Sids 12	Gemmeiza 11	Sakha 94
I_1	C 8.37c	AB 10.43c	A 11.50c	A 12.02c
I_2	D 13.13b	C 15.92b	B 18.56b	A 20.26b
I_3	B 20.03a	AB 21.77a	A 22.73a	A 23.31a

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

Days to 50% heading and maturity "day":

Irrigation regimes effect

Results presented in Table 4 show that, irrigation of wheat plants every three weeks throughout the season (I_3) led to significant decrease in number of days to 50% heading (84.5 day) and maturity (115.65), in both seasons and their combined than those of wheat plants irrigated every two weeks throughout the season (I_2) (85.68 day to heading and 117.96 day to maturity) and irrigated every week throughout the season (I_1), as normal treatments (88.06 day to heading and 121.03 day to maturity), respectively. Earliness in days to 50% heading and maturity may play an important role for drought escape in wheat plants under stress conditions . The previous results are in full agreement with those reported by Bayoumi *et al.* (2002). They indicated that water stress decreased number of days from sowing to 50% heading.

Cultivar differences effect

Results presented in Table 4 show that, days to heading and maturity "day" of four bread wheat cultivars in both seasons and their combined significantly differed .It was evident that the earliest wheat cultivar was Giza 168, followed by Gemmeiza 11, Sids 12 and Sakha 94 with an average 84.2, 85.41, 86.58 and 88.12 for days to 50% heading and 115.45, 116.75, 120.25 and 120.41 for days to 50% maturity, respectively. In general, wheat cultivar Giza 168 was earlier in days to 50% heading and wheat cultivar Gemmeiza 11 was earlier in days to 50% maturity and could be used in breeding program for developing early mature wheat genotypes. These results are in harmony with those obtained by Abd El-Gawad *et al.* (1998) that they indicted varietal differences with respect to days to 50% heading . Moreover , Ludlow & Muchow (1990) reported that genotypes which flowered earlier tend to give higher and greater yield stability than later flowering ones , if rain dose not occur during the latter half of the growing season . Meanwhile , it enables a cultivars to escape drought during the critical reproductive stages .

TABLE 4. Heading date (day) and maturity date (day) as affected by cultivars and irrigation treatments during the two successive seasons (2009/2010 and 2010/2011) and their combined analysis.

Main effects and interaction	Heading date(day)			maturity date(day)		
	2009/2010	2010/2011	Comb.	2009/2010	2010/2011	Comb.
Irrigation treatments (I)						
I_1	87.43a	88.68a	88.06a	120.5a	121.6a	121.03a
I_2	85.37b	86.0b	85.68b	117.3b	118.6b	117.9b
I_3	84.06c	84.62c	84.50c	115.1c	116.2c	115.7c
F-test	**	**	**	**	**	**
$LSD_{0.5}$	0.55	0.46	0.39	0.63	0.56	0.38
Cultivars (C)						
Giza 168	83.75d	84.66d	84.20d	116.4b	117.1c	116.8b
Sids 12	85.91b	87.25b	86.58b	119.8a	120.7b	120.3a
Gemmeiza 11	85.16c	85.83c	85.41c	114.8c	116.1d	115.5c
Sakha 94	87.66a	88.00a	88.12a	119.5a	121.3a	120.4a
F-test	**	**	**	**	**	**
$LSD_{0.5}$	0.63	0.53	0.45	0.72	0.56	0.44
Interaction						
I.C.	NS	**	**	**	NS	**

NS, * and **: indicate Not significant, significant and highly significant at 0.05 and 0.01 level, respectively.

Comb = combined, C: cultivars and I; irrigation treatments

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

Interaction effect

As shown in the combined analysis, the significant interaction effect between the four bread wheat cultivars and irrigation water quantities on days to heading and maturity "day" of bread wheat cultivars were significant (Tables 4, 4-a and 4-b). The data indicate that, Giza 168 that was earlier by irrigation of wheat plants (I_3) has significant decreased in number of days to 50% heading (82.5 day) . While, wheat cultivar Sakha 94 was later by irrigation by (I_1) has significant increased in number of days to 50% heading and maturity (90.87 and 124 day), respectively. While, wheat cultivar Gemmeiza 11 was earlier in days to 50% maturity (113.87 day).

TABLE 4-a . Number of days to 50% heading of wheat as affected by the interaction between irrigation regimes and cultivars (combined analysis).

Irrigation regimes \ Cultivar	Giza-168	Sids 12	Gemmeiza 11	Sakha 94
I_1	D 85.87a	B 88.62a	C 86.87a	A 90.87a
I_2	C 84.25b	B 86.25b	C 84.87b	A 87.37b
I_3	C 82.5c	B 84.87c	B 84.5b	A 86.12c

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

TABLE 4-b. Number of days to 50% maturity of wheat plants as affected by the interaction between irrigation regimes and cultivars (combined analysis) .

Irrigation regimes \ Cultivar	Giza-168	Sids 12	Gemmeiza 11	Sakha 94
I_1	C 119.5a	B 122.87a	D 117.75a	A 124..00a
I_2	C 116.75b	A 120.75b	D 114.75b	B 119.62b
I_3	B 114.00c	A 117.12c	C 113.87c	A 117.62c

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

Plant height (cm) and number of spikes/m^2

Irrigation regimes effect

The results given in Table 5 show that, plant height (cm) and number of spikes /m^2 in both seasons and their combined, water stress (irrigation of wheat plants by sprinkler system every three weeks throughout the season I_3 severe stress) led to significant decrease in plant height (55.71cm) and number of spikes/m^2 (220.06), followed by irrigation with I_2 (moderate stress) which gave 65.25 cm and 254.93 spike/m^2. While, the highest values (68.18 cm and 279.86 spike/m^2) were obtained with irrigation of wheat plants with I_1 (control) as a normal irrigation. The decrease in that traits due to water deficits compared to the other quantities of irrigation water (I_1 and I_2) could be discussed on the basis growth stages which are highly sensitive to the shortage in water supply which was reflected in decreasing length of the internodes , tillering and number of tillers/plant. The previous results are in full agreement with those reported by Abd El-Gawad *et al.* (1998) and El Far & Teama (1999). They indicated that, water stress decreased plant height and number of spikes/m^2.

TABLE 5. Plant height (cm) and number of spikes / m^2 of wheat as affected by cultivars and irrigation treatments during the two successive seasons (2009/2010 and 2010/2011) and their combined analysis.

Main effects and interaction	Plant height(cm)			Number of spikes/m^2		
	2009/2010	2010/2011	Comb.	2009/2010	2010/2011	Comb.
Irrigation treatments (I)						
I_1	68.06a	68.81a	68.18a	265.18a	294.56a	279.86a
I_2	64.56b	65.93b	65.25b	244.87b	264.62b	254.93b
I_3	54.68c	56.12c	55.71.c	205.50c	232.87c	220.06c
F-test	**	**	**	**	**	**
$LSD_{0.5}$	0.89	0.81	1.03	7.10	5.04	5.28
Cultivars (C)						
Giza 168	60.50c	62.00c	61.41c	241.16b	286.33a	263.50a
Sids 12	60.91c	59.75d	59.83d	254.41a	271.91b	263.15a
Gemmeiza 11	65.00a	67.50a	66.66a	237.83b	261.33c	251.25b
Sakha 94	63.30b	65.25b	64.29b	220.66c	236.50d	228.58c
F-test	**	**	**	**	**	**
$LSD_{0.5}$	1.03	0.93	1.19	8.20	5.82	6.09
Interaction						
I.C.	**	**	**	**	**	**

NS, * and **: indicate Not significant, significant and highly significant at 0.05 and 0.01 level, respectively.

Comb. =combined, C: cultivars and I: irrigation treatments .

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

Cultivar differences effect

The results given in Table 5 show that, plant height (cm) and number of spikes / m^2 of four bread wheat cultivars in both seasons and their combined significantly differed. It was evident that, combined analysis, Gemmeiza 11 was the tallest wheat genotypes (66.66 cm) followed by Sakha 94 (64.29 cm) and Giza 168 (61.41cm) , while, wheat cultivar Sids 12 was the shortest one (59.83 cm), respectively. Significant varietal differences regarding that traits were reported by Hassan *et al.* (2002) and Zeidan *et al.* (2005). Concerning number of spikes/m^2, combined analysis in Table 5, revealed significant differences among wheat cultivars,where, the highest value for that trait was obtained by wheat cultivar Giza 168 or Sids 12 (263.5 or 263.15 spike/m^2), respectively followed by Gemmeiza 11 (251.25 spike/m^2), while, Sakha 94 attained the lowest mean value (228.58 spike/m^2). These results confirm the findings of El Hawary (2000) who found that, significant differences among wheat cultivars in number of spikes/m^2.

Interaction effect

As shown in the combined analysis, the interaction effect between the four bread wheat cultivars and irrigation water quantities on plant height and number of spikes/m^2 of bread wheat cultivars was significant (Tables 5, 5-a and 5-b). The data indicate that, Giza 168 was the shortest, irrigation of wheat plants in I_3 significantly decreased plant height (51 cm) while, wheat cultivar Gemmeiza 11 was the tallest by irrigation with I_1. Plant height significantly increased (73.25 cm), respectively, while, Giza 168 gave the highest value for number of spikes/m^2 with I_1 (normal irrigation).While, Sakha 94 gave the lowest mean for that trait under water stress (I_3).

TABLE 5-a. Plant height (cm) of wheat as affected by the interaction between irrigation regimes and cultivars (combined analysis) .

Irrigation regimes \ Cultivar	Giza-168	Sids 12	Gemmeiza 11	Sakha 94
I_1	B	D	A	C
	68.50a	64.12a	73.25a	66.87a
I_2	B	B	A	AB
	64.75b	64.37a	66.37b	65.5a
I_3	B	B	A	A
	51.00c	51.00b	60.37c	60.50b

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

TABLE 5-b . Number of spikes/m^2 of wheat plants as affected by the interaction between irrigation regimes and cultivars (combined analysis) .

Irrigation regimes \ Cultivar	Giza-168	Sids 12	Gemmeiza 11	Sakha 94
I_1	A 297.62a	B 288.22a	C 277.87a	D 255.75a
I_2	A 271.50b	B 267.37b	C 247.25b	D 233.62b
I_3	C 221.37c	A 233.87c	B 228.62c	D 196.37c

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

Number of grains/spike, 1000-grain weight (g) and grain yield (ardab per fed)

Irrigation regimes effect The results given in Table 6 show that, number of grains/spike, 1000-grain weight (g) and grain yield (ardab / fed) in both seasons and their combined, were significantly affected by irrigation water treatment severe stress (irrigation every three weeks throughout the season I_3) it led to significant decrease in number of grains/ spike (24.57), 1000-grain weight (26.83 g) and grain yield (3.69 ardab per fed) followed by irrigation with moderate stress (I_2) which gave 35.5 grain/spike,31.62 g and 5.25 ardab/fed. While, the highest values (45.64 grain/spike,36.74 g and 7.58 ardab/fed) were obtained with irrigation of wheat plants every week throughout the season (I_1) as a normal irrigation. These results indicating that, water stress (I_3) had more adverse effect on relative water content, transpiration rate, plant height, number of spikes/m^2, number of grains/spike, its may be due to the effect of water deficit on pollinated and fertilization processes, then caused decreasing that traits and then decreased 1000- grain weight and grain yield. The previous results are in full agreement with those reported by Abd El-Gawad *et al.* (1998) and El Far & Teama (1999), Siddique *et al.* (2000) , El-Sayed (2003, Hefnawy & Wahba (2003), Huang GuanHua *et al.* (2008), Lui HaiJun *et al.* (2011), Sayed &Bedaiwy (2011) and Ibrahim *et al.* (2012)

TABLE 6. Number of grains/spike, 1000-grain weight (g) and grain yield (ardab/fed) of wheat as affected by irrigation treatments and cultivars during the two successive seasons (2009/2010- 2010/2011) and their combined analysis.

Main effects and interaction	Number of grains/spike			1000-grain weight(g)			grain yield (ardab/fed.)		
	2009/2010	2010/2011	Comb.	2009/2010	2010/2011	Comb.	2009/2010	2010/2011	Comb.
Irrigation treatments (I)									
I_1	43.56a	47.66a	45.64a	35.85a	37.45a	36.74a	7.41a	7.72a	7.58a
I_2	34.10b	36.86b	35.50b	30.11b	33.40b	31.62b	4.14b	6.39b	5.25b
I_3	23.33c	25.86c	24.57c	26.31c	27.29c	26.83c	2.71c	4.67c	3.69c
F-test	**	**	**	**	**	**	**	**	**
$LSD_{0.5}$	1.09	1.23	0.79	0.78	0.88	0.69	0.15	0.19	0.13
Cultivars (C)									
Giza 168	39.32a	42.72a	41.03a	30.72b	33.81b	32.28b	4.96b	6.30b	5.62b
Sids 12	37.80b	40.36b	39.11b	29.03c	31.84c	30.55c	5.52a	7.13a	6.33a
Gemmeiza 11	30.26c	34.41c	32.37c	35.03a	35.67a	35.20a	4.65c	6.00c	5.32c
Sakha 94	27.27d	29.68d	28.43d	28.25c	29.53d	28.90d	3.88d	5.62d	4.74d
F-test	**	**	**	**	**	**	**	**	**
$LSD_{0.5}$	1.26	1.42	0.91	0.98	1.02	0.81	0.18	0.23	0.15
Interaction									
I.C	**	**	**	**	**	**	**	**	**

NS, * and **: indicate Not significant, significant and highly significant at 0.05 and 0.01 level, respectively.

Comb.=combined, C: cultivars and I:irrigation water quantity.

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

Cultivar differences effect

Data given in Table 6 clearly indicate the significant differences among wheat cultivars respecting number of grains/spike, 1000-grain weight(g) and grain yield ardab/fed in the two seasons and their combined. The highest value of number of grains/spike in combined data was obtained by Giza 168 (41.03) followed by Sids 12 (39.11) and Gemmeiza 11 (32.77), whereas, Sakha 94 showed lowest value (28.43). Concerning 1000-grain weight (g), based on combined data, wheat cultivar Gemmeiza 11 produced, the heaviest grains expressed as 1000-grain weight (35.20 gram) followed by Giza 168 (32.28 g) and Sids 12 (30.55 g), whereas, Sakha 94 was the lightest (28.9 g) one in this respesct. Similar results were obtained by Kandil *et al.* (2001) who reported significant differences between wheat cultivars regarding 1000-grain weight in their response to water stress. Regarding grain yield ardab/fed based on combined analysis, the highest grain yield (6.33 ardab per fed) was recorded by using Sids 12 followed by Giza 168 (5.62 ardab/fed) and Gemmeiza 11 (5.32 ardab/fed). Whereas, Sakha 94 gave the lowest grain yield (4.74 ardab/fed), respectively. The differences in 1000-grain weight (g) and grain yield (ardab per feddan) among the evaluated four wheat cultivars might be attributed to the genetic variations. Similar observations were found by Ashmawy & Abo-Warda (2002), Hassan *et al.* (2002), Abd El–Hameed (2005), Zeidan *et al*. (2005), Gafar (2007); El-Murshedy (2008), Ramadan & Awaad (2008), Ahmed *et al*. (2009), Amin *et al*. (2010) and Sayed & Bedaiwy (2011). While, Saleh (2003) did not find any effect of varieties on grain yield per feddan.

Interaction effect

As shown in the combined analysis, the significant interaction effect between the four bread wheat cultivars and irrigation water quantities on number of grains/spike, 1000-grain weight (g) and grain yield ardab/fed of bread wheat cultivars were significant (Tables 6, 6-a, 6-b and 6-c). the data indicate that, Sakha 94 gave the values of number of grains/spike (19.85), 1000-grain weight (22.35 g) and grain yield ardab/fed (3.161) by irrigation of wheat plants every three weeks throughout the season while, Giza 168, Gemmmeiza 11 and Sids 12 gave the highest values from aforementioned traits by irrigation every week throughout rhe season, respectively.

Conclusion

Water stress (severe stress by irrigation every three weeks throughout the season I_3) under sprinkler irrigation in sandy soil conditions decreased plant height, days to 50% heading and maturity, relative water content, transpiration rate, number of spikes/ m^2, number of grains/ spike, 1000-grain weight and grain yield but increased proline content, followed by irrigation every two weeks and irrigation every week throughout the season. In this respect, in combined analysis, wheat cultivars Gemmeiza 11 surpassed in plant height (66.66 cm), relative water content (55.38%), transpiration rate (132.23 mg H_2O/g F.W./h.) and 1000-grain weight (35.2 g), Giza 168 surpassed in transpiration rate (134.99 mg H_2O/g F.W./h.), number of spikes/m^2 (263.5) and number of grains/spike (41.03), Sids 12 surpassed in number of spikes/m^2 (263.15) and grain yield (6.33 ardab/fed), whereas, Sakha 94 was later in heading and maturity, gave the highest level from proline content (18.53 µ moles proline/ g F.W.). It can be concluded that, wheat cultivars Gemmeiza II and Giza 168 followed by Sids 12 were tolerant to water stress but wheat cultivars Sakha 94 was sensitive one. Physiological characters *i.e.,* RWC, transpiration rate and proline content may be playing a role in the tolerant of wheat plants to water deficit. The breeder can use these characters as selection criteria for drought tolerance.

TABLE 6-a . Number of grains/spike of wheat as affected by the interaction between irrigation regimes and cultivars (combined analysis) .

Irrigation regimes \ Cultivar	Giza-168	Sids 12	Gemmeiza 11	Sakha 94
I_1	A 51.87a	B 49.38a	C 42.97a	D 38.32a
I_2	A 42.80b	A 41.32b	B 30.75b	C 27.12b
I_3	A 28.42c	B 26.62c	C 23.4c	D 19.85c

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

TABLE 6-b. 1000-grain weight (g) of wheat plants as affected by the interaction between irrigation regimes and cultivars (combined analysis) .

Irrigation regimes \ Cultivar	Giza-168	Sids 12	Gemmeiza 11	Sakha 94
I_1	B 36.62a	C 35.32a	A 39.65a	C 35.37a
I_2	B 31.97b	BC 30.52b	A 35.02b	C 28.97b
I_3	B 28.25c	C 25.82c	A 30.92c	D 22.35c

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

TABLE 6-c. Grain yield ardab/fed of wheat plants as affected by the interaction between irrigation regimes and cultivars (combined analysis).

Irrigation regimes \ Cultivar	Giza-168	Sids 12	Gemmeiza 11	Sakha 94
I_1	B 7.658a	A 8.997a	C 7.374a	D 6.314a
I_2	B 5.442b	A 5.678b	C 5.121b	D 4.762b
I_3	B 3.787c	A 4.331c	B 3.491c	C 3.161c

I_1 : Control
I_2 : Moderate water stress
I_3 : Severe water stress

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تأثير معاملات الري على الصفات الفسيولوجية والمحصول ومساهماته لبعض أصناف حديثة من قمح الخبز تحت نظام الري بالرش

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أقيمت تجربتان حقليتان خلال موسمي ٢٠١٠/٢٠٠٩ و ٢٠١١/٢٠١٠ بالمزرعة التجريبية بمحطة بحوث الإسماعيلية ، لدراسة تأثير ثلاث معاملات للري (I_1 و I_2 و I_3) على الصفات الفسيولوجية وعلى صفات المحصول ومساهمات لأربعة أصناف حديثة من قمح الخبز (جيزة ١٦٨ – سخا ٩٤ – سدس ١٢ و جميزة ١١) تحت نظام الري بالرش بالأ راضى الرملية .

ويمكن تلخيص اهم النتائج التى تم التحصل عليهاعلى النحو التالى:
١-أدى استخدام المستوى الثالث لمياه الري (الري كل ثلاث اسابيع طوال الموسم I_3) تحت نظام الري بالرش بالا راضى الرملية إلى حدوث نقص معنوي لكل من الصفات التالية: ارتفاع النبات(٧١,٥٥ سم)، عد الأيام من الزراعة حتى طرد ٥٠% من السنابل (٨٤,٥ يوم)، عدد الأيام من الزراعة حتى النضج (١١٥,٦٥ يوم)، محتوى الأوراق النسبي (٤١,٠٩%)، نسبة النتح (١٠٥,٦٥ مجم مياه/ جرام وزن طازج/ الساعة)، عدد السنابل/م٢ (٢٢٠,٠٦)، عدد الحبوب بالسنبلة (٢٤,٥٧)، وزن الألف حبة (٢٦,٨٣ جم) و محصول الحبوب (٣,٦٩ اردب للفدان). بينما أدى لزيادة محتوى أوراق النباتات من البرولين. بالمقارنة بالمستويين الآخرين (الري كل أسبوعيين طوال الموسم I_2 و الري كل أسبوع طوال الموسم I_1 فيما يتعلق بالصفات السابق ذكرها وذلك خلال موسمي الدراسة والتحليل المشترك.

٢-أدى استخدام الصنف جميزة ١١ لأعلى القيم في صفات ارتفاع النبات (٦٦,٦٦ سم)، محتوى الأوراق النسبي للمياه(٥٥,٣٨%) نسبة النتح (١٣٢,٢٣ مجم مياه/ جرام وزن طازج/الساعة) ووزن الألف حبة(٣٢,٥ جم). جيزة ١٦٨ أعطى أعلى القيم في صفات نسبة النتح (١٣٤,٩٩ مجم مياه/ جرام وزن طازج/ الساعة)، عدد السنابل بالم٢ (٢٦٣,٥) و عدد الحبوب بالسنبلة (٤١,٠٣). سدس ١٢ أعطى أعلى القيم في صفات عدد السنابل (٢٦٣,١٥/م٢) ومحصول الحبوب

(٦,٣٣ اردب/ الفدان). بينما الصنف سخا ٩٤ كان متأخرا في عدد الأيام من الزراعة حتى ظهور ٥٠% من السنابل وحتى النضج وأعطى أعلى القيم لمحتوى الأوراق من البرولين (١٨,٥٣ ميكرو مول برولين /جرام وزن طازج) وأقل القيم في معدل النتح (١٢١,٣ مج ماء / جرام وزن طازج / ساعة) وذلك خلال موسمي الدراسة والتحليل المشترك .

٣-أوضحت نتائج التحليل التجميعي للموسمين التأثير المعنوى لتداخل الفعل بين الأصناف و معاملات الري على جميع الصفات السابق ذكرها هذا وقد تبين من نتائج البحث أن أصناف القمح جميزة ١١ و جيزة ١٦٨ تلاهما سدس ١٢ كانت متحملة للإجهاد المائي . أما الصنف سخا ٩٤ فقط كان أكثر حساسية للإجهاد المائي . كما أن الصفات الفسيولوجية وهي المحتوي النسبي للماء ومعدل النتح ومحتوي الأوراق من البرولين تلعب دوراً في تحمل نباتات القمح لنقص المياه هذا ويمكن لمربي النبات أن يتخذ هذه الصفات كدلائل انتخابية لتحمل الجفاف .