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Response of yield and yield attributes of some wheat (*Triticum aestivum L.*) cultivars to irrigation intervals and growth regulators under sandy soil conditions.

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Two field experiments were done at Abazah Village - Faqous– Sharkia Governorate, Egypt during 2016/2017 and 2017/2018 growing seasons, Egypt, to study the response of yield and yield attributes of three wheat cultivars. *i.e.* Gemmeiza 11, Misr 1 and Giza 171 to three irrigation intervals, *i.e.* irrigation every 10, 15 and 20 days and five concentration of growth regulators, *i.e.* control, cycocel at 500 and 1000 mg/L, salicylic acid at 0.05 m M/L and salicylic acid at 0.1 m M/L as foliar spray. The results obtained (combined data) showed that exposing wheat plants to drought stress at irrigation every 15 and 20 days significantly decreased each of plant height, number of spikes/m^2, spike length, number of spikelets/spike, number of grains/spikelet, number of grains/spike, 1000 grain weight and yields/fad (grain, straw and biological) compared to full irrigation treatment (irrigation every 10 days). Harvest index was significantly increased when the plants were irrigated every 20 days followed by irrigation every 15 days compared to full irrigation treatment. Application of salicylic acid at 0.05 or 0.1 mM/L gave the highest values of plant height, spike length (cm), number of spikelets and grains /spike, 1000- grain weight (gm), grain yield (ardab/fad), straw yield (ton/fad.) and biological yield (ton /fad.), while application of cycocel at rate of 1000 mg/L produced maximum number of spikes/m^2 and harvest index. Giza 171 and Gemmieza 11 cultivars were superior Misr1 in each of plant height, number of spikelets/spike and 1000-grain weight. However, Misr 1 cultivar had significant increase in each of number of spikelets/spike, number of grains/spike, grain yield ardab/fad., straw yield ton/fad. and biological yield ton/fad., while Gemmieza 11 gave the highest thousand grain weight and harvest index compared to other tested cultivars. The interaction between the three tested factors showed that the application of optimal irrigation and spraying salicylic acid by rate of 0.05 or 0.01 mM/L or cycocel by rate of 1000 mg/L to wheat cultivars namely Misr$_1$, Giza 171 and Gemmeiza 11 are useful to save water consumption without significant reduction in wheat production.

Keywords: Growth regulators, Wheat, Irrigation intervals, Cultivars, Cycocel, Salicylic acid

INTRODUCTION

Wheat is considered one of the most vital cereal crops not only in Egypt, but also in the whole world, as it is used for food and fodder. It provides around 21.0% of protein and 19.0% of the calories that are needed for daily human demand at the universal scale (Braun et al., 2010). In Egypt, the production of wheat was about 9.0Mt obtained from about 3.3M fad (faddan= 4200 m^2), however, there is a big gap between the Egyptian production (9.0Mt) of wheat and the Egyptian consumption (19.0Mt) of this crop (FAOSTAT, 2015). Increasing cultivated of wheat production of unit land area are the most important national objectives in Egypt for minimizing the gap between the production and population consumption. That could be achieved by improving agricultural practices especially in desert area such as irrigation and growth regulators…etc.

Wheat crop is responsive to the timing of a water deficit period rather than the total reduction of applied irrigation water. Exposing wheat plants to high moisture stress, depressed seasonal consumptive use and grain yield (Bukhat, N.M. (2005). Water stress can result in a negative impact on phonological growth stages, reduced biomass production and grain yield (Seleiman et al., 2011). El-Kholy et al., (2005) stated that, irrigation practices and irrigation water are factors which have always limited wheat productivity. Number of irrigations recommended at the reproductive stages and also the vegetative have to be applied suitably and timely for much better yields. Hussein et al., (2014), Yavas and Unay (2016) and Abdelghany et al., (2016) found that drought stress significantly decreased plant height, spike length, number of grains per spike , 1000 grain weight and grain yield.

Salicylic acid (SA) is a plant growth regulator known as an endogenous signaling molecule, which is involved in various physiological processes in plants, such as growth regulation, photosynthesis, stomatal conductance, nutrient uptake, plant water relations and mechanisms of plant resistance and tolerance to biotic and abiotic stresses (Hayat et al. 2010). In this context, several studies have demonstrated that exogenous SA application enhances plant growth and development. In another study Hussein et al. (2007) and Maghsoudi et al. (2019) revealed that growth traits of wheat plants were improved as a result of SA spraying on the plants. It was revealed that SA increased the abscisic acid content, leading to the accumulation of proline, which improves the drought tolerance. Also, Farooq et al., (2009) cleared that, salicylic acid regulates physiological and biochemical properties of plants under drought stress. Ahamed and Jama, (2007) found that, cycocel reduce plant size when applied at early stages and induce a reduction in water consumption in the post-spraying period. This might extend water availability to later stages essential for yield formation and therefore increase water use efficiency. Abdul AKher et al., 2018, Khalilzadeh et al. (2016) and Afkari and Ghaffari (2018) observed that, foliar spraying with salicylic acid produced the highest values of number of spikes/m^2, spike length, number of grains/spike, grains weight/spike, 1000 grain weight, grain yield, straw yield and harvest index (%), while plant height was reduced.

Several investigators reported that wheat cultivars showed significant differences in yield and yield attributes under drought stress due to differences in their genetic background (Abd El-kreem and Ahmed, 2013; Abd - ELattief (2014) and Fayed et al., 2015). Also, Kang et al. (2002) showed that reactions of grain yield and water use efficiency of wheat varieties were different significantly with respect to irrigation regimes that this is due to the amount of soil moisture and irrigation scheduling. Ahmadi and Siose Marde (2004), cleared that moisture stress created in spike emergence flowering, decreased seed yield cultivars.

Therefore, the objective of the present investigation was to study the performance of three wheat cultivars on different irrigation intervals and growth regulators treatments to determine the proper cultivar in proper irrigation interval and specific concentration of growth regulators.

MATERIALS AND METHODS

Two field experiments were conducted at Abazah,Village - Faqous– Sharkia Governorate, Egypt during 2016/2017 and 2017/2018 growing seasons, to study the response of some wheat cultivars to irrigation intervals, cycocel and salicylic acid concentrations under sandy soil conditions for yield and yield attributes of wheat (*Triticum aestivum. L*). Each experiment included 45 treatments which were the combination of three irrigation intervals, i.e. Irrigation every 10 days, Irrigation every 15 days and Irrigation every 20 days, five concentration of growth regulators, i.e. (Control), Cycocel at 500 mg/L, Cycocel at 1000 mg/L, Salicylic acid at 0.05 m M/L and Salicylic acid at 0.1 m M/L as a foliar spray and three Wheat cultivars i.e. Gemmieza 11, Misr 1 and Giza 171. Growth regulators treatments were foliar sprayed twice after 35 days from sowing (200 litre/fad.) and 15 days later. The design of the experiment was a split- split plot with three replications, where the main plots were occupied by irrigation treatments, cycocel and salicylic acid treatments in split plots, whereas wheat cultivars were allotted in the sub-plots.

Cultural practices:

Nitrogen fertilizer in form of urea (46.5%) was added at rate of 90 Kg N/fad in six equal splits. The preceding crop was maize in both seasons. The sub – sub plot area was 12 m^2 (3m. in width x 4m. in length) which included 20 rows 15 cm apart. Calcium super phosphate (15.5% P2O5) at rate of 200 kg/fed., and potassium sulphate (50% K_2O) at rate of 100 kg./fed were added during seedbed preparation. Surface irrigation using Nile water was used. Cultivars were sown at the seed rate of 70 kg/fed in the two successive seasons. Weeds were controlled manually (two times). The other culture practices were applied as recommended.

Table (1): Some physical and chemical properties of the experimental soil in the two seasons of investigation.

Soil characteristics	Soil location			
	0-15 cm		15-30 cm	
	1st season	2nd season	1st season	2nd season
Soil particles distribution				
Sand%	80.87	84.05	91.13	93.61
Silt%	12.03	10.23	7.83	4.23
Clay%	7.10	5.72	1.04	2.16
Textural class	Sandy loam	Sandy loam	Sandy	Sandy
pH *	7.98	8.11	8.32	8.49
EC,(ds/m)*	0.40	0.36	0.14	0.13
Soluble cations and anions (mmole/L)*				
Ca++	1.4	1.3	0.42	0.22
Mg++	0.7	0.6	0.13	0.23
Na+	1.55	1.38	0.64	0.55
K+	0.35	0.32	0.21	0.30
$CO3^{=}$	-	-	-	-
$HCO3^{-}$	1.32	1.19	0.56	0.37
Cl^{-}	1.29	1.16	0.43	0.51
$SO4^{=}$	1.34	1.25	0.41	0.37
Available N, (mg Kg^{-1} soil)	40.33	53.91	36.72	31.49
Available P, (mg Kg^{-1} soil)	7.26	6.24	5.11	3.95
Available K, (mg Kg^{-1} soil)	60.40	58.09	53.95	49.81

**Soil-water suspension 1:2.5

Table (2): Monthly mean minimum and maximum air temperatures, relative humidity and precipitation during the two wheat growing seasons.

Month	Temperature (°C)			Relative humidity (%)	Precipitation (mm)
	Min.	Max.	Mean		
2016/2017 season					
November	13.3	24.33	18.81	73	4.5
December	12.83	21	16.91	88	9.1
January	8.16	14.83	11.49	85	14.2
February	14.83	25.16	19.99	65	4.0
March	15	26.5	20.75	60	0.3
April	16.83	32	24.41	54	0.1
May	18.33	32.5	25.41	52	0.0
2017/2018 season					
November	13	24.33	19.66	74	4.2
December	11.83	20.5	18.08	80	9.0
January	7.66	14	10.83	73	13.5
February	13.66	24.83	19.24	68	4.2
March	14.33	26.16	20.24	70	0.5
April	14.5	29	21.75	62	0.0
May	18.5	31.83	25.16	50	0.0

The experimental soil was sandy in texture. Some physical and chemical properties of the experimental field soils in the two seasons are presented in Table (1). The temperature °C and relative humidity during periods of wheat growth were shown in Table (2).

Recorded data:

1-Plant height (cm).
2-Number of spikes/ m^2.
3-Spike length (cm).
4-Number of spikelet's/spike.
5-Number of grain/spike.
6-Thousand grain weight (gm).
7-Straw yield (ton/fad)
8-Grain yield (ardab/fad.).
9-Biological yield (ton/fad).
10-Harvest index

Harvest index is defined as a ratio of grain weight to that of the total aboveground biomass and has frequently been as an indicator of overall partitioning efficiency for dry matter (Riggs, 1982).

Statistical analysis:

The data obtained from each trial were subjected to the analysis of variance of split –split plot design using computer program MSTAT-C as described by Snedecor and Chochran (1981). Then, a combined analysis was made for data of the two seasons. The differences among treatments were compared using Duncan's multiple range test (Duncan, 1955), where means had the different letters were statistically significant, while those means followed by the same letters were statistically insignificant. In the interaction tables capital and small letters were used to compare between means in rows and columns, respectively.

RESULTS AND DISCUSSION

Plant height, Number of spikes/m^2 and spike Length

Data presented in Table (3) show the influence of irrigation intervals, growth regulators treatments and cultivars on plant height, number of spikes/m^2 and spike length of wheat during both growing seasons and their combined.

Regarding the effect of irrigation intervals, it was quite evident that increasing irrigation interval was followed by a significant decrease in each of plant height, number of spikes/m^2 and spike length compared with optimal or moderate one, respectively. Results of the combined indicated that the tallest plants (106.8 cm), maximum number of spikes/m^2 (389.0 spikes/m^2) and the longest spike length (13.0 cm) were observed at irrigation every 10 days, while the shortest plants (97.9 cm), minimum number of spikes/m^2 (348.6 spikes/m^2) and the shortest spike length (9.42 cm) were recorded by irrigation every 20 days. This finding might be because availability of well distributed soil moisture at different growth stages due to irrigation probably enhanced the growth of plant. These results are in accordance with those reported by Morsy and Abd El-Hameed(2012),Yavas and Unay (2016).

Concerning the effect of growth regulators treatments, results presented in Table 3 show that both cycocel and salicylic acid treatments had a significant effect on plant height, number of spikes/m^2 and spike length. Despite salicylic acid slightly increased plant height, the cycocel application resulted in shorter plants than the control. Results of the combined indicated that salicylic acid at 0.1 mm/L gave the tallest plants (110.5 cm) and the longest spike length (12.5 cm),while cycocel treatment at1000 mg/L gave the highest number of spikes/m^2 (382.5 spikes/m^2) and the shortest plant height (89.5 cm). These results confirm the vital role of salicylic acid and cycocel in all aviate the harmful effects of drought stress in wheat plants by altering the activities of some key metabolites. These results are in agreement with those obtained by Abd-El-Hamed et al., (2004), Irfan et al., (2006) and Zewail (2007).

Respecting varietal differences, it is clear that Giza 171 and Gemmieza 11 cultivars gave taller plants without significant differences (Table 3), while the shortest plants were recorded by Misr 1 in both seasons and combined. Misr1 and Giza 171 gave the highest number of spikes/m^2 without significant differences (combined analysis) while, Gemmieza 11 recorded the lowest ones in both growing seasons and their combined. Gemmieza 11 had the longest spike followed by Misr1 and Giza 171 without significant differences (combined analysis). It could be concluded that varietal differences among wheat cultivars may be due to genetically make up.

Furthermore, the significant interaction between growth regulators and wheat cultivars on plant height in the combined analysis (Table 3-a), revealed that the tallest plant (114.8 cm) , highest number of spikes/m^2 (385.0) and the longest spike (12.0 cm) were recorded by Giza 171 when salicylic acid at 0.1 mM/L were applied. Otherwise, the shorter plants were recorded by Misr 1 when cycocel at 500 mg/L was applied.

Table (3): Plant height, number of spikes/m^2 and spike length (cm) of wheat as affected by irrigation intervals, growth regulators and cultivars and their interactions during two successive winter seasons (2016/2017 and 2017/2018) as well as their combined.

Main effects and interactions	Plant height (cm)			Number of spikes /m2			Spike length (cm)		
	1st season	2nd season	Combined	1st season	2nd season	Combined	1st season	2nd season	Combined
Irrigation intervals (I) :									
Every 10 days	108. a	105.0 a	106.8 a	392.5 a	385.5 a	389.0 a	13.6 a	12.4 a	13.0 a
Every 15 days	104.9 b	99.5 b	102.2 b	369.4 b	366.6 b	368.0 b	11.8 ab	11.7 b	11.6 b
Every 20 days	100.9 c	94.8 c	97.9 c	348.1 c	349.1 b	348.6 c	9.0 b	9.9 c	9.4 c
F. test	**	*	**	**	*	**	**	**	*
Growth regulators (G) :									
control	108.2 b	104.6 b	106.4 a	359.1 c	352.2 c	355.7 d	9.9 c	9.31 d	9.6 c
Cy. 500 mg/L	102.0 c	97.1 d	99.5 b	373.6 b	365.6 b	369.6 b	11.2 b	10.61 c	10.9 b
Cy. 1000 mg/L	90.8 d	88.2 e	89.5 c	385.4 a	379.6 a	382.5 a	12.4 a	12.14 ab	12.3 a
S.A. 0.05 mM/L	111.0a	100.3 c	105.6 a	361.7 c	366.4 b	364.0 c	11.1 b	11.6 b	11.4 b
S.A. 0.1 mM/L	112.3 a	108.6 a	110.5 a	370.2 b	371.6 b	370.9 b	12.6 a	12.48 a	12.5 a
F. test	*	*	**	**	*	**	*	*	**
Cultivars(C):									
Giza 171	106.7 a	101.3 a	104.0 a	377.3 b	370.8 b	374.0 a	11.3 b	10.8 b	11.1 b
Misr 1	101.9 b	97.3 b	99.6 b	380.9 a	382.8 a	381.8 a	11.1 b	10.8 b	10.9 b
Gemmieza 11	105.9 a	100.8 a	103.3 a	351.8 c	347.6 c	349.7 c	12.0 a	12.1 a	12.0 a
F. test	**	*	**	**	**	**	*	*	**
Interactions									
I x G	ns	ns	ns	ns	ns	ns	*	ns	ns
I x C	ns	ns	ns	*	ns	ns	*	**	**
G x C	**	*	*	**	**	**	ns	**	**

Table (3-a): Wheat plant height (cm), number of spikes /m^2 and spike length (cm) as affected by the interaction between growth regulators and cultivars (combined data).

Growth regulators	Cultivars		
	Giza 171	Misr 1	Gemmieza 11
	Plant height (cm)		
control	A 110.0 b	C 102.4 b	B 106.9 ab
Cy. 500 mg/L	A 100.7 d	B 97.4 c	A 100.4 c
Cy. 1000 mg/L	A 88.9 d	A 88.9 d	A 90.5d
S.A. 0.05 mM/L	B 105.5 c	B 102.9 b	A 108.5 a
S.A. 0.1 mM/L	A 114.8 a	B 106.3 a	A 110.3 a
control	Number of spikes /m^2		
Cy. 500 mg/L	B 357.3 c	A 370.7 c	C 338.9 b
Cy. 1000 mg/L	B 373.0 b	A 384.5 b	C 351.3 a
S.A. 0.05 mM/L	B 381.1 a	A 415.2 a	C 351.2 a
S.A. 0.1 mM/L	A 373.8 b	A 368.3 c	B 350.0 a
control	A 385.0 a	B 370.6 c	C 357.1 a
Cy. 500 mg/L	Spike length (cm)		
Cy. 1000 mg/L	A 9.5 d	A 9.7 c	A 9.6 d
S.A. 0.05 mM/L	B 10.8c	B 10.6 b	A 11.4 c
S.A. 0.1 mM/L	B 11.8 ab	B 11.8a	A 13.3a
control	B 11.2 bc	B 10.7 b	A 12.2 b
Cy. 500 mg/L	B 12.0 a	B 11.9 a	A 13.6 a

Table (3-b): Spike length (cm) as affected by the interaction between irrigation intervals and cultivars (combined data).

Irrigation intervals	Cultivars		
	Giza 171	Misr 1	Gemmieza 11
Every 10 days	B 12.7 a	B 12.3 a	A 14.1 a
Every 15 days	B 11.0 a	AB 11.2 a	A 12.5 a
Every 20 days	B 9.5 a	B 9.3 a	B 9.5 a

Table (4): Number of spikelets /spike, number of grains /spike and1000 grain weight (gm) of wheat as affected by irrigation intervals, growth regulators and cultivars and their interactions during two successive winter seasons (2016/2017 and 2017/2018) as well as their combined.

Main effects And interactions	Number of spikelets/spike			Number of grains /spike			1000 grain weight (gm)		
	1st season	2nd Season	Combined	1st season	2nd Season	Combined	1st season	2nd Season	Combined
Irrigation intervals(I) :									
Every 10 days	18.5 a	17.7 a	18.1 a	50.5 a	48.3 a	49.4 a	42.8 a	41.6 a	42.2 a
Every 15 days	17.3 b	16.4 b	16.4 b	47.2 a	41.0 b	44.1 b	39.5 b	39.0 b	39.2 b
Every 20 days	14.2 c	13.8 c	14.0 c	37.4 b	28.7 c	33. 1 c	36.8 c	36.1 c	36.4 c
F. test	**	**	**	**	**	**	**	**	**
Growth regulators (G) :									
control	13.8 d	13.3 d	13.5 e	35.0 c	32.0 d	33.5 d	36.0 d	34.4 d	35.2 d
Cy. 500 mg/L	16.0 c	15.4 c	15.7 d	42.7 b	34.8 c	38.7 c	39.0 b	37.8 c	38.4 c
Cy. 1000 mg/L	18.2 a	17.5 b	17.8 b	50.8 a	43.7ab	47.3 a	42.0 b	42.0 a	42.04
S.A. 0.05 mM/L	16.9 b	15.6 c	16.3 c	45.0 b	44.1 a	44.5 b	39.2 a	39.4 b	39.3 b
S.A. 0.1 mM/L	18.5 a	18.0 a	18.2 a	51.5 a	42.1 b	46.8 a	42.1 a	41.0 a	41.5 a
F. test	*	*	**	**	**	**	**	**	**
Cultivars(C):									
Giza 171	17.2 a	16.1 a	16.7 a	42.8 b	37.8 b	40.3 b	41.0 a	40.3 a	40.6 a
Misr 1	15.9 b	15.6 b	15.8 b	48.9 a	41.1 a	45.0 a	37.7 c	35.3 b	36.6 b
Gemmieza 11	16.9 a	16.1 a	16.5 a	43.4 b	39.1 b	41.2 b	40.7 b	41.0 a	40.6 a
F. test	*	*	**	**	*	**	**	**	**
Interactions									
I x G	ns	**	**	ns	**	**	**	**	**
I x C	ns	**	**	*	*	*	*	**	**
G x C	*	**	**	*	**	**	**	**	**

On the other hand the lowest number of spikes/m^2 and shortest spike were recorded by Giza 171 under without application of growth regulators. These results are in accordance with those reported by Amin (2010).

Spike length (cm) was significantly affected by the interaction between irrigation intervals and cultivars in the combined analysis (Table 3-b). Gemmieza 11 has been irrigated every 10 days produced the longest spike (14.1 cm), while shortest spike (9.3 cm) was obtained when Misr 1 irrigated every 20 days. The significant interaction between cultivars and irrigation intervals shows the sensitivity of different cultivars to irrigation intervals for spike length of wheat.

Number of spikelets/spike, number of grains /spike and 1000 grain weight (gm)

Data presented in Table (4) show the influence of irrigation intervals, growth regulators treatments and cultivars on number of spikelets/spike, number of grains /spike and 1000 grain weight (gm) of wheat during both growing seasons and their combined.

Regarding the effect of irrigation intervals, it was quite evident that increasing irrigation interval up to irrigation every 20 days significantly decreased each of number of spikelets/spike, number of grains /spike and 1000 grain weight compared to optimal (irrigation every 10 days) or moderate one (irrigation every 15 days) , respectively. Results of the combined indicated that the highest number of spikelets /plant (18.1), maximum number of grains/spike (49.4) and the heaviest 1000 grain weight (42.2 gm) were observed at optimal irrigation interval (10 days), on the other hand, the lowest number of spikelets/plant (14.0), minimum number of grains/spike (33.0) and the highest 1000 grain weight (36.4 gm) were recorded by longest one (20 days). This finding might be because availability of well distributed soil moisture at different growth stages due to irrigation probably enhanced the growth of plant. These results are in accordance with those reported by. Morsy and Abd El-Hameed (2012),Yavas and Unay (2016) .

Concerning the effect of growth regulators treatments, results presented in Table 4 show that cycocel and salicylic acid treatments had highly significant effect on number of spikelets/spike, number of grains/spike and 1000 grain weight. Results of the combined indicated that salicylic acid treatment at 0.1 mM/L gave the highest number of spikelets/spike (18.2), whereas both cycocel at1000 mg/l and salicylic acid at 0.1 mm/L treatments gave the highest number of grains/spike (47.3 and 46.8) and the weightiest grains (41.8 and 41.5), respectively. These results confirm the vital role of salicylic acid and Cycocel in alleviate the harmful effects of drought stress in wheat plants by altering the activities of some key metabolites. These results are in agreement with those obtained by Abdul AKher et al., 2018 who, reported in their studies on wheat that, foliar spraying with salicylic acid produced the highest values of number of spikelets/spike, number of grains /spike and 1000 grain weight (gm) Also, Khalilzadeh et al. (2016) and Afkari and Ghaffari (2018) found that, cycocel application under drought stress significantly increased yield and yield components .

Respecting varietal differences, it is clear that wheat cultivars were differed significantly in their number of spikelets/spike, number of grains/ spike and 1000-grain weight in both seasons and their combined analysis (Table 4). According to combined analysis Giza 171 and Gemmieza 11 recorded the highest number of spikelets/ spike (16.7 and 16.5) and 1000-grain weight (40.6 and 40.6 gm), whereas Misr 1 gave the highest number of grains/spike (45.0).. The reasons for differences in number and weight of grains might be attributed to of genetic structure of the cultivars primarily affected by heredity. These results are in harmony with those obtained by Kang *et al.* (2002) who cleared that reactions of yield attributes of wheat and water use efficiency of wheat varieties were different significantly with respect to irrigation regimes, that this is due to the amount of soil moisture and irrigation scheduling**.**

Furthermore, the significant interaction between irrigation intervals and growth regulators treatments on number of spikelets/spike, number of grains/spike and 1000-grain weight (gm) in the combined analysis (Table 4-a), revealed that the highest number of spikelets/spike (20.4), number of grains/spike (57.3) and 1000-grain weight (46.8 gm) was recorded by irrigation every 10 days when salicylic acid at 0.1 mM/l was applied. While, the lowest values of number of spikelets/spike (10.5), number of grains/spike (28.6), 1000-grain weight (31.7 gm) was recorded by irrigation every 20 days when growth regulators are not added.

Regarding the significant interaction between irrigation intervals and cultivars on number of spikelets/spike, number of grains/spike and 1000-grain weight (gm) in the combined analysis (Table 4-a), the results showed that Gemmieza 11 had the highest number of spikelets/spike (18.9) followed by Misr1 (18.1) and Giza 171 (17.2) when the irrigation period was 10 days, while the lowest one recorded by Giza 171 (13.7) when irrigation period was 20 days.

Data presented in Table. 4-a show that the highest values of number of grain/spike and thousand grain weight (52.9 and 44.0 gm) belonged to Misr 1 and Giza 171 when their plants were irrigated each 10 days. On the other hand, exposing wheat plants to severe drought stress (irrigation interval each 20 days) produced the lowest values of number of grains/spike (31.3) in Gemmieza 11 and 1000 grain weight (33.7gm) in Misr 1. The differences among the tested wheat cultivars under different irrigation intervals may be referred to their genetic constitutions and their interaction with prevailing environmental conditions such as drought stress. In this respect, many researchers found significant interaction between wheat genotypes and irrigation treatments for grain number/spike and 1000 grain weight (Milad et al., 2016 and El Hag, 2017).

The interaction between growth regulators and wheat cultivars was found to be significant for number of spikelets/spike, number of grains/spike and 1000 grain weight (combined data), as shown in Table 4-b. The results showed that the three wheat cultivars had various reactions to different growth regulators. The highest values of number of spikelets/spike (18.9) belonged to Gemmieza 11, when wheat plants treated by salicylic acid at 0.1 mM/L , while the highest number of grains /spike (51.3) belonged to Misr 1, when wheat plants treated by salicylic acid at 0.1 mM/L . Also, results in Table 4-b cleared that Gemmieza 11, had heaviest grain weight (44.9 gm) when wheat plants treated by cycocel at 1000 mg/L. The lowest values of numbers of spikelets/spike (12.6) belonged to Gemmieza 11, when wheat plants did not treated by growth regulators , while the lowest number of grains /spike (31.6) belonged to Giza 171, when wheat plants did not treated by growth regulators. Misr 1 had the lightest grain weight (33.0 gm) under control. These results are in harmony with those obtained by Kareem et al., (2017) and Abdul AKher et al., (2018**)** who, reported that ,foliar spraying with salicylic acid produced the highest values of number of spikes/m^2 ، spike length , number of grains/spike, grains weight/spike ,1000 grain weight , grain yield, straw yield and harvest index (%).

Grain, straw and biological yields/fad. as well as harvest index

Data presented in Table (5) show the influence of irrigation intervals, growth regulators and cultivars on grain yield (ard./fad.) , straw yield (ton/fad) and biological yield (ton/fad.) of wheat during both growing seasons and their combined.

Regarding the effect of irrigation intervals, it was quite evident that increasing irrigation interval significantly increased harvest index in both seasons and their combined, the relative increased in harvest index due to increasing irrigation intervals from 10 to 20 days was 32.25%, 34.45% and 33.15 in 1st, 2nd seasons and combined, respectively. The results also, show that increasing irrigation interval was followed by a significant decrease in each of grain, straw and biological yield compared with optimal or moderate one, respectively. Results of the combined indicated that the highest grain yield (20.03 ard./fad.) , straw yield (5.31 ton/fad.) and biological yield (8.4 ton/fad.) were observed at optimal irrigation interval (10 days). Data of combined revealed that the relative decrease due to increasing irrigation intervals from 10 to 20 days was 58.83 %, 71.93% and 65.47% for grain yield (ardab/fad.), straw yield(ton/fad.) and biological yield(ton/fad.), respectively. These results are harmony with those obtained by El-Kholy et al., (2005) , Seleiman et al., 2011, Yavas and Unay (2016), Abdelghany et al., (2016), Yavas and Unay (2016), Abdelghany et al.,(2016), Morsy and Abd El-Hameed (2012) as well as Yavas and Unay (2016) who, reported that water stress can result in a negative impact on phonological growth stages, reduced biomass production and grain yield.

Concerning the effect of growth regulators, results presented in Table 5 show that cycocel and salicylic acid treatments had a significant effect on each of grain, straw and biological yield and harvest index. Results of the combined indicated that both cycocel (1000 mg/l) and salicylic acid (0.1 mM/L) treatments gave the highest grain yield (17.0 and 16.9 ard./fad.), respectively. Whereas, both salicylic acid treatment at 0.05 and 0.1 mM/L recorded the highest straw yield (4.0 and 4.2 ton/fad. , respectively.) in the same direction salicylic acid treatment at 0.1 mm/L gave highest biological yield (6.8 ton/fad.). Harvest index recorded highest percentage (46.1 %) when wheat plants sprayed by cycocel at 1000 mg/L. These results confirm the vital role of salicylic acid and cycocel in alleviate the harmful effects of drought stress in wheat plants by altering the activities of some key metabolites. These results are in agreement with those obtained by Abdul AKher *et al.*, 2018 who, reported that, foliar spraying with salicylic acid produced the highest values of number of spikes/m^2, spike length, number of grains/spike, grains weight/spike, 1000 grain weight, grain yield, straw yield and harvest index (%). Also, Khalilzadeh *et al.* (2016) and Afkari and Ghaffari (2018) found that, cycocel application under drought stress significantly increased yield and yield components.

Respecting varietal differences, it is clear that wheat cultivars were differed significantly in their grain yield (ardab/fad.), straw yield (ton/fad.), biological yield (ton/fad.) and harvest index (Table 5). According to combined analysis Misr 1 recorded the highest grain yield (15.8 ardab/fad.), straw yield (3.7 ton/fad), biological yield (6.1 ton/fad) whereas Gemmieza 11, gave the highest harvest index value (43.4) (Table 5).

Table (4-a) Number of spikelets /spike, number of grains /spike and 1000 grain weight (gm) of wheat as affected by the interaction between irrigation intervals and growth regulators (combined data).

Irrigation intervals	Growth regulators					Cultivars		
	Control	S.A. (0.05 mM/l)	S.A. (0.1 mM/l)	Cy. (500 mg/l)	Cy. (1000 mg/l)	Giza 171	Misr 1	Gemmieza 11
	Number of spikelets /spike					Number of spikelets /spike		
Every 10 days	D 15.7 a	C 17.3 a	B 19.2 a	C 17.8 a	A 20.4 a	B 18.1 a	C 17.2 a	A 18.9 a
Every 15 days	D 14.3 b	C 16.0 b	A 18.2 b	B 17.0 a	A 18.7 b	A 17.3 b	B 16.2 b	A 17.0 b
Every 20 days	C 10.5 c	B 13.9 c	A 16.1 c	B 14.1 b	A 15.5 c	A 14.6 c	AB 13.8 c	B 13.7 c
	Number of grains /spike					Number of grains /spike		
Every 10 days	D 37.9 a	C 46.7 a	A 54.1 a	B 50.9 a	A 57.3 a	B 46.9 a	A 52.9 a	B 49.2 a
Every 15 days	C 34.0 b	B 39.1b	A 50.5 a	A 49.5 a	A 47.2 b	c 34.0 b	A 46.0 b	A 43.1 b
Every 20 days	D 28.6 c	CD 30.4 c	A 37.2 b	BC 33.1 b	AB 35.8 c	B 31.69 b	A 36.1 c	B 31.3 c
	1000 grain weight (gm)					1000 grain weight (gm)		
Every 10 days	D 38.0 a	C 40.3 a	B 44.2 a	C 41.7 a	A 46.8 a	A 44.0 a	B 39.7 a	A 42.8 a
Every 15 days	E 36.0 b	D 38.0 b	A 42.2 b	B 40.1 a	C 39.9 b	A 41.0 b	B 36.4 b	A 40.4 b
Every 20 days	D 31.7 c	BC 37.0 b	A 39.4 c	C 36.2 b	ABC 37.9 c	B 36.9 c	C 33.7 c	A 38.7 c

Table (4-b) Number of spikelets/spike, number of grains /spike and 1000 grain weight (gm) of wheat as affected by the interaction between growth regulators and cultivars (combined data).

Growth regulators	Cultivars		
	Giza 171	Misr 1	Gemmieza 11
	Number of spikelets/spike		
control	A 14.4 c	A 13.6 c	B 12.6 d
Cy. 500 mg/L	A 16.2 b	AB 15.6 b	B 15.3 c
Cy. 1000 mg/L	A 17.9 a	B 16.9 a	A 18.7 a
S.A. 0.05 mM/L	BC 16.2 b	C 15.5 b	A 17.1 b
S.A. 0.1 mM/L	A 18.7 a	B 17.2 a	A 18.9 a
control	Number of grains /spike		
Cy. 500 mg/L	B 31.6 d	A 37.0 d	B 31.9 d
Cy. 1000 mg/L	B 38.2 c	A 41.8 c	B 36.3 c
S.A. 0.05 mM/L	B 45.7 a	A 49.0 a	AB 47.0 a
S.A. 0.1 mM/L	A 43.6 ab	A 45.9 b	A 44.1 b
control	B 42.3b	A 51.3a	A 46.8a
Cy. 500 mg/L	1000 grain weight (gm)		
Cy. 1000 mg/L	D 36.1 a	B 33.0 d	A 36.6 d
S.A. 0.05 mM/L	A 40.0 c	B 35.6 c	A 39.6 c
S.A. 0.1 mM/L	B 43.3 a	C 37.5 b	A 44.9 a
control	A 42.7 ab	C 35.1 c	B 40.1 c
Cy. 500 mg/L	A 41.0 bc	A 41.7 a	A 41.9 b

Table (5): Grain yield (ard./fad.), straw yield (ton/fad.) ,biological yield (ton/fad.) and harvest index of wheat as affected by irrigation intervals, growth regulators and cultivars and their interactions during two successive winter seasons (2016/2017 and 2017/2018) as well as their combined

Main effects and interactions	Grain yield (ardablfad.)			Straw yield (ton/fad.)			Biological yield (ton/fad.)			harvest index		
	1st season	2nd season	Comb.	1st season	2nd season	Comb.	1st season	2nd season	Comb.	1st season	2nd season	Comb.
Irrigation intervals (I) :												
Every 10 days	21.0 a	19.1 a	20.0 a	5.42 a	5.2 a	5.3 a	8.7 a	8.1 a	8.4 a	37.2 c	35.7 c	36.5 c
Every 15 days	16.3 b	14.3 b	15.3 b	3.45 b	3.26 b	3.4 b	5.9 b	5.4 b	5.7 b	42.1 b	40.7 b	41.4 b
Every 20 days	9.9 c	8.7 c	9.3 c	1.55 c	1.42 c	1.5 c	3.0 c	2.7 c	2.9 c	49.2 a	48.0 a	48.6 a
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Growth regulators (G) :												
control	12.6 c	9.6 c	11.1 d	3.0 c	2.4 c	2.7 c	4.9 c	3.8 d	4.4 e	41.6 c	40.1 c	40.9 c
Cy. 500 mg/L	14.9 b	11.9 b	13.4 c	3.0 c	2.6 c	2.8 c	5.3 c	4.4 c	4.8 d	44.7 b	43.4 b	44.1 b
Cy. 1000 mg/L	17.9 a	16.0 a	17.0 a	3.2 c	3.03 b	3.1 b	5.9 b	5.4 b	5.7 c	46.9 a	45.4 a	46.1 a
S.A. 0.05 mM/L	15.6 b	16.5 a	16.1 b	3.8 b	4.3 a	4.0 a	6.1 b	6.7 a	6.4 b	40.9 c	39.3 c	40.1 c
S.A. 0.1 mM/L	17.6 a	16.2 a	16.9 a	4.3 a	4.2 a	4.2 a	6.9 a	6.6 a	6.8 a	40.2 c	39.1 c	39.6 c
F. test	**	**	**	**	**	**	*	*	**	*	*	**
Cultivars(C):												
Giza 171	15.9 a	14.1 a	15.0 b	3.5 b	3.3 b	3.4 b	5.9 b	5.4 b	5.7 b	42.8 b	41.3 b	42.0 b
Misr 1	16.6 a	15.0 a	15.8 a	3.8 a	3.3 a	3.7 a	6.3 a	5.9 a	6.1 a	41.5 c	40.5 b	41.0 b
Gemmieza 11	14.6 b	13.0 b	13.8 b	3.1 c	2.9 c	3.0 c	5.2 c	4.8 c	5.1 c	44.2 a	42.7 a	43.4 a
F. test	*	*	**	**	**		**	**	**	**	*	*
Interactions												
I x G	*	**	**	*	**	**	ns	**	**	ns	**	ns
I x C	*	*	**	*	**	**	*	**	ns	ns	ns	ns
G x C	ns	**	**	ns	**	**	ns	**	ns	**	ns	ns

Table (5-a) Grain yield (ardab/fad.), straw and biological yield (ton/fad.) of wheat as affected by the interaction between irrigation intervals and growth regulators (combined data).

Irrigation intervals	Growth regulators				
	Control	S.A. (0.05 mM/l)	S.A. (0.1 mM/l)	Cy. (500 mg/l)	Cy. (1000 mg/l)
	Grain yield (ardablfad.)				
Every 10 days	E 14.6 a	D 18.2 a	B 22.3 a	C 20.6 a	A 24.4 a
Every 15 days	D 11.7 b	C 13.6 b	A 18.2 b	A 17.2 b	B 15.9 b
Every 20 days	C 7.0 c	B 8.3 c	A 10.4 c	A 10.4c	A 10.4 c
	Straw yield (ton/fad.)				
Every 10 days	C 4.59 a	C 4.56 a	C 4.6 a	B 5.98 a	A 6.82 a
Every 15 days	C 2.44 b	C 2.6 b	B 3.22 b	A 4.4 b	A 4.1 b
Every 20 days	C 1.15 c	BC 1.29 c	ABC 1.57 c	AB 1.66 c	A 1.75 c
	Biological yield (ton/fad.)				
Every 10 days	D 6.8 a	CD 7.3 a	C 7.9 a	B 9.1 a	A 10.5 a
Every 15 days	C 4.2 b	C 4.6 b	B 6.0 b	A 7.0 b	AB 6.5 b
Every 20 days	C 2.2 c	BC 2.5 c	AB 3.1 c	A 3.2 c	A 3.3 c

Table (5-b) Grain yield (ardab/fad.), straw and biological yield (ton/fad.) of wheat as affected by the interaction between irrigation intervals and cultivars (combined data).

Irrigation intervals	Cultivars		
	Giza 171	Misr 1	Gemmieza 11
	Grain yield (ardab/fad.)		
Every 10 days	B 20.0 a	A 21.7 a	C 18.4 a
Every 15 days	A 16.2 b	A 15.7 b	B 14.1 b
Every 20 days	B 8.8 c	A 10.0 c	AB 9.0 c
	Straw yield(ton/fad.)		
Every 10 days	B 5.26 a	A 6.06 a	C 4.62 a
Every 15 days	A 3.68 b	A 3.47 b	C 2.91 b
Every 20 days	A 1.37 c	A 1.67 c	A 1.41 c

Table (5-c) Grain yield (ardab/fad.), straw and biological yield (ton/fad.) of wheat as affected by the interaction between irrigation intervals and cultivars (combined data).

Growth regulators	Cultivars		
	Giza 171	Misr 1	Gemmieza 11
	Grain yield (ardab/fad.)		
control	AB 11.1 d	A 11.8 d	C 10.3 d
Cy. 500 mg/L	A 14.2 c	A 14.0 c	B 11.9 c
Cy. 1000 mg/L	A 17.6 a	A 17.8 a	B 15.5 a
S.A. 0.05 mM/L	A 16.6 ab	A 16.2 c	A 15.5 a
S.A. 0.1 mM/L	B 15.5 bc	A 19.2 a	B 16.0 a
control	Straw yield (ton/fad.)		
Cy. 500 mg/L	B 2.5 c	A 3.31 b	B 2.37 c
Cy. 1000 mg/L	A 3.09 b	A 3.12 c	B 2.24 c
S.A. 0.05 mM/L	A 3.22 b	A 3.57 b	B 2.57 c
S.A. 0.1 mM/L	A 4.4 a	A 4.03a	B 3.61 b
control	A 3.97 b	A 4.3a	A 4.07 a

The superiority of Misr1 in the yield component parameters may be due to the increase in its number of grains/spike (table 3) and number of spikes/m^2 (Table 5) which led to a promotion in the photosynthesis activity and consequently produced the great amount of metabolites synthesized in such cultivar plants. The variation among some Egyptian bread cultivars were previously detected by other investigators for number of spikes/m ^{2}, spike length, number of grains/spike, 1000 grain weight as well as grain weight/spike (Milad et al., 2016 and El Hag, 2017)

Regarding, the significant interaction between irrigation intervals and growth regulators treatments on grain yield (ardab/fad.), straw yield (ton/fad.) and biological yield (ton/fad.) in the combined analysis (Table 5-a), cleared that the highest values of grain yield (24.4 ardab/fad.), straw yield/fad.(6.82 ton/fad.) and biological yield (10.5 ton/fad) were recorded by irrigation every

10 days when cycocel (500 mg/l**)** was applied. While, the lowest values of grain yield (7.0 ardab/fad.), straw yield/fad (1.15 ton/fad) and biological yield (2.2 ton/fad) was recorded by irrigation every 20 days when growth regulators are not added.

The interaction effect between irrigation intervals and wheat cultivars was significantly differed for grain yield (ardab/fad.) and straw yield (ton/fad) in both seasons and their combined analysis (Table 5-b). The data of combined presented in Table 5-b show that the highest values of grain yield (21.7 ardab/fad.) belonged to Misr 1 when their plants were irrigated every 10 days (full irrigation). Also, the highest values of straw yield (6.06 ton/fad.) belonged to Misr 1 when their plants were irrigated every 10 days (full irrigation). On the other hand, exposing wheat plants to severe drought stress (irrigation every 15 days) and (irrigation every 20 days) produced the lowest values of grain yield (8.8 ardab/fad.) in Giza 171. The lowest straw yield was recorded for all cultivars when wheat plants irrigated every 20 days. The differences among the tested wheat cultivars under different irrigation regimes may be referred to their genetic constitutions and their interaction with prevailing environmental conditions such as drought stress.

The interaction between growth regulators and wheat cultivars was found to be significant for grain yield and straw yield, (combined data), as shown in Table 5-c. The results showed that the three wheat cultivars had various reactions to different growth regulators. The highest values of grain yield (19.2 17.8 ardab/fad.) belonged to Misr 1, when wheat plants treated by salicylic acid at 0.1 mM/L and cycocel 1000 (mg/l) followed by (17.6 ardab/fad.) belonged to Giza 171 cv., when wheat plants treated by cycocel 1000 (mg/l) and (15.5 ardab/fad.) belonged to Gemmieza cv., when wheat plants treated by salicylic acid: 0.05 mM/l. Also, results in Table 5-c cleared that Giza 171 had the highest value of straw yield (4.40 ton/fad.) when wheat plants treated by salicylic acid at 0.05 mM/l, followed by Misr 1 cv. (4.30 ton/fad.) and Gemmieza 11 (4.07 ton/fad.), when wheat plants treated by salicylic acid at 0.1 mM/l .The lowest values of grain yield (10.3 ardab/fad.) and straw yield (2.27 ton/fad.) belonged to Gemmieza 11 when wheat plants did not treated by growth regulators. These results are in harmony with those obtained by Abdul AKher et al., 2018 who, reported that ,foliar spraying with salicylic acid produced the highest values, grain yield, straw yield and harvest index (%),

CONCLUSION

From the abovementioned results, it can be noticed that exposing wheat plants to drought stress by increasing irrigation intervals up to 20 day caused high significant reduction in yield and yield attributes. Misr 1 cultivar was most tolerant for drought stress where it exhibited lower yield reduction with exposing to drought stress followed by Giza 171 and Gemmeiza 11, respectively. Finally, it can be concluded that irrigation every 10 days with Misr 1 cultivar is most profitable to save water consumption without significant reduction in wheat productivity under this experiment conditions. However, application with salicylic acid by rate of : 0.05 and 0.1 mM/L or cycocel by rate of 1000 mg/L. had a beneficial effect on yield of wheat under different levels of irrigation interval.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of this study.

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