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Evaluation of Some Bread Wheat Cultivars under Irrigation Intervals 2: Studies on Morphophysiological Traits

Al-Farouk, M. O.[1]; K. A. Elfky[2*] and Basma E. M. Elsmahy[3]

[1] Wheat Res Dep. Field Crops Res. Inst, Agric., Res. Center, Giza, Egypt
[2] Crops physiology Res Dep. Field Crops Res. Inst, Agric., Res.Center, Giza, Egypt
[3]Seed Tech Res Dep. Field Crops Res. Inst. Agric., Res. Center, Giza, Egypt

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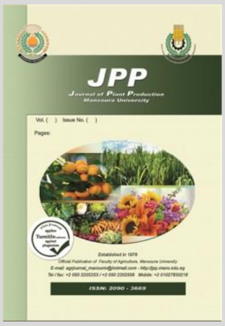

ABSTRACT

The study was carried out at El-Gemmeiza Agricultural Research Station (ARC), El- Gharbia Governorate, Egypt, during 2019/2020 and 2020/2021 growing seasons to study the effect of three irrigation intervals on morphological and physiological characters of ten bread wheat cultivars. A split - plot design with four replications was performed, the main plots included the three irrigation intervals *i.e.*, irrigation every 20, 30 and 40 days and the ten bread wheat cultivars (Giza171, Sakha 95, Giza 168, Sids14, Misr 3, Misr 2, Sakha 94, Gemmeiza 11, Shandweel 1 and Gemmeiza 12) were placed in sub-plots. Irrigation intervals every 40 days caused a decrease in all of the studied characters (days to maturity, days to heading, grain filling rate, grain filling period, leaf area index, plant height, crop growth rate, relative growth rate, transpiration rate and relative water content) except for total chlorophyll content, stomatal resistance, leaf temperature and proline content in both seasons. The highest value of stomatal resistance was detected in Sakha 95 and that of total chlorophyll content and proline content were found in Misr 3 at irrigation intervals every 40. Thus, Misr 3 and Sakha 95 are suitable cultivars for conditions of water stress.

Keywords: bread wheat, cultivars, morpho-physiological traits, irrigation intervals.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major grain crop in Egypt and many countries. Wheat straw is also an essential nutrition source for animals. However, wheat accounts for around 20% of the food required for human consumption.

In Egypt, we produce less wheat than we consume. So, priority to achieve wheat self-sufficiency has been placed on enhancing production by increasing the wheat cultivated area (horizontal expansion) and/or raising the yield per unit area (vertical expansion). Wheat productivity varies by year and region due to different factors as nutritional inadequacy, illnesses, pests, climate change, soil fertility, and water resource limitations.

In Egypt, water shortage is a major environmental problem owing to limited and fixed sharing of Nile water. Reducing water use is the biggest environmental stress in agriculture globally, and one of plant breeding's main objectives is to increase output in drought-prone areas (Cattivelli *et al*., 2008).

Salinity, nutrient deficiencies, and water limitation are main constraints on wheat production, globally. (Mujeeb-Kazi *et al*., 2019).

Water deficit stress results from infrequent rains, poor irrigation and water scarcity in irrigated agriculture (Ouda *et al*., 2020).

The stress of water deficit is associated with reduction in number of maturity days, grain and biological yield and yield components in wheat (Farhat 2015, Hamza *et al*., 2018, Seleiman and Abdel-Aal 2018, Thanaa *et al*., 2019, Abd El-Hamid *et al*., 2019 and 2020 and Raghib *et al*., 2020).

Plants under water stress undergo detrimental morphological, physiological, biochemical, anatomical, and molecular alterations. Under conditions of water stress, declining morphological and agronomic traits were generally noted.(Shalaby *et al*., 2020; Shehab-Eldeen and Farhat, 2020; Mu *et al*., 2021; Nehe *et al.*, 2021; Wasaya *et al.*, 2021 and Morsy *et al.*, 2022).Reduction in relative water and chlorophyll content were also reported in water stress at physiological level. (Wasaya *et al.*, 2021). On the other hand, proline and leaf temperature increased in water stress. (El-Gammaal, 2018, Din *et al*., 2020 and Mu *et al*., 2021).

Thus, this research aimed to assess water deficit effects on the morpho-physiological traits of some bread wheat cultivars and to identify the most tolerant cultivars for water deficit.

MATERIALS AND METHODS

The current study was conducted at El-Gemmeiza Agric. Res. Stat., A.R.C., El- Gharbia Governorate, Egypt.

During the two growing successive seasons of 2019/2020 and 2020/2021 to study the effect of three irrigation intervals on growth and morphophysiological attributes of ten bread wheat cultivars (*Triticum aestivum* L.).

A split-plot design with four replications was the experimental design, three irrigation intervals (every 20, 30 and 40 days) were allocated for the main-plots and the sub-plots were assigned for the ten bread wheat cultivars *i.e.*,

[*] **Corresponding author.**
E-mail address: www.yasenkamal@gmail.com

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Giza171, Sakha 95, Giza 168, Sids14, Misr 3, Misr 2, Sakha 94, Gemmeiza 11, Shandweel 1 and Gemmeiza 12.

Sowing dates in the first and second season were 17th and 20th November respectively. The experimental unit area measured 8.4 m^2 which was 2.4 m width and 3.5 m length. Maize was the previous crop in both seasons.

Table 1 shows the mechanical and chemical parameters of the experimental field soil.

All other agricultural methods were followed as recommendation for wheat agriculture in the Meddle Delta Region.

Accumulation water and total rainfall applied in the two seasons are listed in Table 2.

Table 1. Mechanical and chemical soil properties of the experimental sites during 2019/20 and 2020/21.

Variable	Seasons 2019/20	2020/21
Mechanical analysis		
Fine sand (%)	19.90	17.50
Silt (%)	31.60	34.60
Clay (%)	48.50	47.90
Soil texture class	Clay	Clay
Chemical analysis		
Available N (ppm)	34.15	32.19
Available P (ppm)	7.10	7.22
Available K (ppm)	347	332
Organic matter %	1.95	1.83
PH*	8.16	7.90
EC**	1.67	1.64

Table 2. Total applied water with plus rainfall water (m^3/fed) under different irrigation regimens during the two seasons, 2019/20 and 2020/21.

Irrigation Treatment	Seasons					
	2019/20			2020/21		
	I_1 (20 days)	I_2 (30 days)	I_3 (40 days)	I_1 (20 days)	I_2 (30 days)	I_3 (40 days)
Irrigation water (m^3/fed)	1865.2	1639.6	762.4	1830.6	1551.9	635.3
Total rainfall (m^3/fed)		434.17			312.59	
Seasonal water applied	2299.37	2073.77	1196.57	2143.19	1864.49	947.89

Studied characters:

A- Morphological characters:

Heading date (HD,day) is calculated as the number of days between the sowing date and the day when 50% of the main spikes/plot emerge entirely from the flag leaves. Maturity date (MD,day) refers to the number of days between the sowing date and the day when 50% of the main peduncles in the plot turn yellow. Grain filling period (GFP, day) equals the number of days between anthesis and maturity. Grain filling rate (GFR, kg fed^{-1} day^{-1}) is calculated as grain yield (kg) per feddan divided by GFP. Plant height (PH,cm) is the length of plant from soil surface to top of the main spike excluding awns as average of ten plants and Flag leaf area (cm^2) was measured as length × maximum width × 0.75 (Daughtry and Hollinger 1984).

B- Physiological characters:

Crop growth rate (CGR, g/m^2/day) was estimated according to (Hunt ,1990) and relative growth rate (RGR, mg/g^{-1}/day) according to (Watson,1952). Total chlorophyll content (TCC) was measured using the spectro-photometric method according to (Moran,1982). Stomatal resistance (SR), transpiration rate (TR) and leaf temperature (LT) were assessed using a portable steady-state promoter (LI- COR model LI- 1600). During measurement period, Air temperature ranged from 18.0 to 22.0 ^{O}C. Rate of water loss (RWL) was determined using (Yang *et al.*, 1991),Relative water content (RWC) was assessed by (Ritchie *et al.*, 1990) and proline content (PC) according to (Bates *et al,* .1973).

Statistical analysis:

All gathered data were enrolled in a statistical analysis of variance as indicated by Snedecor and Chochran(1981), and the different averages were compared using the least significant difference (LSD) at the 5% level of probability.

RESULTS AND DISCUSSION

A- Morphological characters:

1. Effect of irrigation treatments (I)

Wheat, the main daily diet plant in 35% of world population, provides energy from carbohydrates and proteins. The most critical phases of wheat development are stem elongation, heading, flowering and grain filling. Drought is regarded as a main factor affecting plant growth and production.

Data presented in Tables 3 and 4 referred to the significant effects of the tested irrigation intervals on the studied traits of wheat in both seasons. Whereas, irrigation intervals every 20 days (I_1) increased morphological characters *i.e.* days to heading (day) by 6.3 % and 4.1 % , days to maturity (day) by 5.4 % and 6.0 %, grain filling period (day) by 3.9 % and 9.8 %, grain filling rate (kg/fed/day) by 55.3 % and 33.0 % , plant height (cm) by 7.0 % and 10.1 % and flag leaf area (cm^2) by 13.7 % and 24.9 % in both seasons respectively as compared to irrigation intervals every 40 days (I_3).

While, irrigation intervals every 40 days (I_3) recorded the lowest values of these characters in comparison with both irrigation intervals (every 20 and 30 days). Water stress can negatively affect plants and induce physiological and morphological changes. These findings align with the findings of Ghanem and Al-Farouk (2024) who stated that drought can lower the morphological traits and productivity of wheat plants owing to the reduction in life span of leaves and accelerated senescence. This may be the result of greater growth and greater duration for spike production. (Iqbal *et al*., 2016) also reported that irrigation regimens significantly affect the number of DTH and DTM.

In general, lower agronomic and morphological traits were noticed by water deficit conditions (Shalaby *et al*., 2020 and Shehab-Eldeen and Farhat, 2020). Mubeen *et al.* (2013) delineated that higher irrigation may result in higher leaf area and other characters.

The leaf area index of wheat gradually and rapidly increases and after emergence, reaching its peak 2-3 weeks before flowering and gradually decreases owing to leaf loss by maturity (Koc and Barutcular, 2000). These findings support (Lehari *et al*., 2019) who considered the growth decline is an adaptive mechanism that can help plants to resist drought since sequester energy and assimilates aid in leaf growth and shooting into molecules that resist the drying process.

Wheat height has been found to be variably declined according to drought period and severity (Shamsi *et al*., 2010). Early- heading is a main drought escaping mechanism, mainly in terminal stresses, allowing plants to complete their cycle before deeper water deficits (Levitt, 1980). Early-heading genotype has greatly time for assimilates accumulation in the grain. The reduction in leaf size is another adaptive mechanism by lowering transpiring area. (Tardieu, 2005).

2. Wheat cultivars performance (V)

The data in Tables 3 and 4 demonstrated that the tested cultivars were significantly varied in all studied morphological traits in both seasons.

Table 3. Effects of irrigation intervals, 10 wheat cultivars and their interaction on heading date (day), maturity date (day) and grain filling period (day) in 2019/20 and 2020/21 growing seasons.

Characters	Heading date (day)		Maturity date (day)		Grain filling period (day)	
Factor	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation (I)						
I_1(20 days)	102	102	155	158	53	56
I_2(30 days)	100	101	153	155	52	54
I_3(40 days)	96	98	147	149	51	51
LSD 0.05	0.8	0.8	1.4	1.5	1.1	1.2
Wheat cultivars (V)						
Giza171	99	100	152	153	53	53
Sakha 95	102	103	155	157	53	53
Giza 168	96	95	146	150	50	54
Sids14	101	101	153	155	52	54
Misr 3	101	100	153	157	52	57
Misr 2	102	103	154	155	52	52
Sakha 94	102	105	157	159	54	54
Gemmeiza 11	97	98	147	148	50	51
Shandweel 1	98	98	151	155	52	57
Gemmeiza 12	98	99	150	152	51	53
LSD 0.05	1.3	1.3	1.6	1.7	2.2	2.0
LSD 0.05(I×V)	NS	2.3	2.8	2.8	NS	3.4

Table 4. Effects of irrigation intervals, 10 bread wheat cultivars and their interaction on grain filling rate (g/fed/day), plant height (cm) and flag leaf area (cm^2) in 2019/20 and 2020/21 growing seasons.

Characters	Grain filling rate(kg/fed/day)		Plant height (cm)		Flag leaf area (cm^2)	
Factor	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation (I)						
I_1(20 days)	14.6	12.1	107.9	110.0	12.26	12.17
I_2(30 days)	13.3	11.9	105.9	107.4	10.90	10.19
I_3(40 days)	9.4	9.1	100.8	99.9	10.78	9.74
LSD 0.05	0.82	0.34	2.22	3.20	0.29	0.30
Wheat cultivars (V)						
Giza171	14.7	13.2	109.4	107.5	14.26	10.67
Sakha 95	15.3	13.7	114.9	112.5	14.78	13.67
Giza 168	14.1	11.7	104.0	104.8	12.00	12.59
Sids14	9.5	8.6	111.8	109.3	8.90	7.84
Misr 3	16.3	13.2	97.2	103.2	15.48	14.19
Misr 2	14.1	12.8	95.0	99.7	12.72	12.05
Sakha 94	11.3	10.3	108.2	106.2	9.58	10.01
Gemmeiza 11	8.7	8.4	105.3	108.6	8.04	8.86
Shandweel 1	7.0	6.7	102.9	102.0	7.01	7.21
Gemmeiza 12	13.3	11.6	100.4	103.9	10.37	9.92
LSD 0.05	1.28	1.02	3.23	2.97	1.51	1.43
LSD 0.05(I×V)	NS	1.69	NS	NS	NS	NS

Sakha 94 wheat cultivar recorded the highest values of number of days to heading and days to maturity in both seasons and GFP in the first season. While, Shandweel 1 and Misr3 wheat cultivars recorded the highest value of grain filling period in the second season only. Sakha 95 wheat cultivar recorded the highest value of plant height in both seasons and the highest value of grain filling rate in the second season only. Misr 3 showed the highest value of LAI in both seasons and the highest value of GFR in the first season only.

These findings coincide with those of Ghanem and Gebrel (2024). Therefore, differences between wheat cultivars may be due to the cultivar's genetic makeup. This finding suggests that there is a discernible level of genetic variation that might be most important for flexibility and adaptation to a range of environmental circumstances. Furthermore, these results in consistent with Poudel *et al.* (2020), who demonstrated that reduction in number of days due to drought was significantly correlated to wheat cultivars. Additionally, early flowering, especially during late developmental stages, is a drought escaping mechanism, as reported by Blum (2010).

3. The interaction effect

The interaction between irrigation treatments and cultivars was highly significant as demonstrated in Tables 5 and 6.

Table 5. Effects of the interactions between irrigation intervals and wheat cultivars on heading date (day) and maturity date (day) in both growing seasons.

Characters	Heading date (day)			Maturity date (day)					
Wheat cultivars (V)	Irrigation intervals (I)			Irrigation intervals (I)					
	2020/21			2019/20			2020/21		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
Giza171	103	100	97	155	153	149	157	154	149
Sakha 95	105	104	101	159	155	151	161	156	153
Giza 168	96	97	94	151	148	138	156	151	142
Sids14	104	102	98	155	153	150	158	155	152
Misr 3	101	101	99	156	153	150	162	157	153
Misr 2	107	104	100	158	154	151	159	155	152
Sakha 94	108	105	102	160	157	153	163	159	155
Gemmeiza 11	98	99	96	153	149	140	154	150	140
Shandweel 1	99	99	96	154	152	147	158	155	151
Gemmeiza 12	102	100	97	154	151	144	157	153	146
LSD0.05		2.3			2.8			2.8	

Table 6. Effects of the interactions between irrigation intervals and wheat cultivars on grain filling period (day), grain filling rate (kg/fed/day) and crop growth rate ($g/m^2/day$) in growing seasons.

Characters	Grain filling period (day)			Grain filling rate (kg/fed/day)			Crop growth rate ($g/m^2/day$)		
Wheat cultivars (V)	Irrigation intervals (I)			Irrigation intervals (I)			Irrigation intervals (I)		
	2020/21			2020/21			2019/20		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
Giza171	54	54	52	14.6	13.8	11.3	31.92	29.38	23.44
Sakha 95	56	52	52	14.4	14.8	11.8	33.48	29.67	24.67
Giza 168	60	55	49	12.3	13.3	9.5	29.00	26.00	20.66
Sids14	54	54	54	9.9	8.8	7.1	25.70	25.33	19.00
Misr 3	61	56	54	13.5	14.3	11.7	35.66	31.01	26.00
Misr 2	52	51	52	14.8	14.4	9.3	30.67	26.44	22.33
Sakha 94	54	54	53	12.0	11.4	7.4	26.00	23.70	19.69
Gemmeiza 11	57	51	44	8.5	8.3	8.4	24.42	25.42	22.67
Shandweel 1	58	56	55	7.5	6.9	5.6	23.33	22.32	21.02
Gemmeiza 12	55	53	49	13.3	12.9	8.7	27.55	23.00	23.33
LSD0.05		3.4			1.69			3.06	

These results may indicate the different response of wheat cultivars to watering intervals. In this concern, the combination of Sakha 94 wheat cultivar and the irrigation interval every 20 days produced the highest values of number of days to heading and maturity in the second season and in both seasons respectively. As well as, Misr 3 recorded the highest value of grain filling period (day) with irrigation interval every 20 days and Misr 2 wheat cultivar recorded the highest value of grain filling rate (kg/fed/day) only in the second season.

B- Physiological characters:

1. Effect of irrigation treatments (I)

The data presented in Table 7 revealed that the highest values of crop growth rate and relative growth rate were recorded by application of irrigation intervals every 20 days (I_1) in both seasons. While, the highest total chlorophyll content was obtained by application of irrigation intervals every 40 days (I_3) in both seasons. Results in Table 8 indicated that the application of irrigation intervals every 40 days (I_3) was associated with the highest values of stomatal resistance and leaf temperature in both seasons. While, irrigation every 20 days (I_1) had the highest transpiration rate in both seasons. Irrigation every 20 days (I_1) was also associated with the highest values of RWC and rate of water loss, as delineated in Table 9 in both seasons. Regarding proline, the highest content was detected by irrigation intervals every 40 days (I_3) in both seasons.

These findings are in line with Ghanem and Al-Farouk (2024), who found that drought, resulted in a significant reduction in total chlorophyll content, RWC, and the rate of water loss in wheat plant. Reactive oxygen species formed by water deficit may damage chloroplasts resulting in reduction in chlorophyll contents (Shalaby *et al*., 2020 and Khayatnezhad and Gholamin, 2021). Drought stress actually is one of the most common environmental stresses affecting up to 26% of the earth usable areas especially with continuous transpiration and evaporation by atmospheric conditions (Blum,1986 and Kramer,1980). Levels of the accumulated proline under water regime reflect the dynamic plants' response at the biochemical level to that stress (Zandalinas *et al*., 2017).

Drought can inhibit photosynthesis by damaging its system, breaking down the equipment which produces chlorophyll, and limiting nutrients intake from soil and their translocation inside plants. (Sikuku *et al.,* 2010) besides damaging the thylakoid membranes (Rana *et al.,* 2021), that negatively affect the chlorophyll synthesis and photo-assimilates distribution and accumulation (Medrano *et al.,* 2002).

Degradation of chlorophyll by stress conditions is thought to be caused by chlorophyllase enzyme activation under that stress (Saleem *et al*., 2016a). According to Outoukarte *et al.,* (2019), the decrease in growth and yield attributes may be resulted from water deficit in the grain filling stage, and the decrease in yield may be due to the photosynthetic efficiency suppression.

Furthermore, water deficit during plant life can induce stomatal closure and the reduction of transpiration with subsequent rising of the plant temperature and more stress hazardous (Haworth *et al*., 2018). Wheat genotypes are reported to be different in stomatal conductance especially under moderate drought. Similar trend was reported in CO_2 assimilation and stomatal resistance by drought stress (Gupta *et al*., 2001).

2. Wheat cultivars performance (V)

Data in Tables 7, 8 and 9 showed that the tested cultivars were significantly varied in all studied physiological traits in both seasons. Whereas, the highest values of crop growth rate, relative growth rate and total chlorophyll were recorded by wheat cultivars Misr 3, Sakha 95 respectively in both seasons as presented in Table 7.

Table 7. Effects of irrigation intervals, 10 wheat cultivars and their interaction on crop growth rate (g/m^2/day), relative growth rate (mg/day) and total chlorophyll content in 2019/20and 2020/21growing seasons.

Characters Factor	Crop growth rate (g/m^2/day)		Relative growth rate (mg/day)		Total chlorophyll content	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation (I)						
I_1(20 days)	28.77	26.03	21.78	20.58	41.60	40.97
I_2(30 days)	26.23	23.13	21.45	19.21	42.08	42.16
I_3(40 days)	22.28	19.98	16.31	15.18	50.92	49.10
LSD 0.05	0.94	0.87	0.12	0.15	0.35	0.40
Wheat cultivars (V)						
Giza171	28.25	24.41	21.60	18.20	47.77	44.13
Sakha 95	29.27	27.33	22.69	21.01	48.16	48.07
Giza 168	25.22	26.40	19.25	19.85	44.89	47.08
Sids14	23.34	20.04	18.01	16.26	42.64	42.48
Misr 3	30.89	29.00	24.72	22.83	50.69	50.20
Misr 2	26.48	22.89	20.80	19.74	44.70	44.97
Sakha 94	23.13	21.58	19.13	17.44	43.33	43.20
Gemmeiza 11	24.17	19.33	17.28	16.26	42.89	40.23
Shandweel 1	22.23	18.23	15.78	14.45	41.18	39.26
Gemmeiza 12	24.63	21.24	19.20	17.22	42.44	41.12
LSD 0.05	1.82	1.80	1.56	1.58	1.76	1.85
LSD 0.05(I×V)	3.06	NS	2.57	NS	2.91	NS

Table 8. Effects of irrigation intervals, 10 wheat cultivars and their interaction on stomatal resistance (S.cm^{-1}) transpiration rate (mg/H_2O.cm^{-2}.S^{-1}) and leaf temperature (°C) in 2019/20 and 2020/21 growing seasons.

Characters Factor	Stomatal resistance (S.cm^{-1}) 120 DAS		Transpiration rate (mg/H_2O.cm^{-2}.S^{-1}) 120 DAS		Leaf temperature (°C) 120 DAS	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation (I)						
I_1(20 days)	9.34	10.25	3.92	3.52	24.32	25.37
I_2(30 days)	11.25	11.05	3.57	2.46	25.29	26.36
I_3(40 days)	13.21	13.85	2.21	1.75	25.46	26.58
LSD 0.05	0.11	0.14	0.45	0.49	0.18	0.10
Wheat cultivars (V)						
Giza171	12.74	11.98	2.75	2.17	25.13	26.46
Sakha 95	14.36	13.40	2.46	1.85	23.42	25.16
Giza 168	12.21	12.39	2.58	2.12	26.46	27.76
Sids14	11.21	9.80	3.80	3.54	24.71	25.39
Misr 3	13.57	14.04	2.18	1.63	22.79	24.12
Misr 2	11.60	13.03	2.68	1.93	25.46	26.13
Sakha 94	10.39	11.06	3.09	2.65	24.11	24.61
Gemmeiza 11	8.74	10.67	3.30	2.47	27.03	28.25
Shandweel 1	7.91	9.24	5.05	4.28	26.76	27.46
Gemmeiza 12	9.92	11.54	4.43	3.14	24.37	25.71
LSD 0.05	1.47	1.49	0.74	0.75	1.52	1.60
LSD 0.05(I×V)	NS	NS	NS	NS	NS	NS

Table 9. Effects of irrigation intervals, 10 wheat cultivars and their interaction on relative water content (%),rate of water loss and proline content (mg Fwt^{-1}) in 2019/20 and 2020/21 growing seasons.

Characters Factor	Relative water content (%)		Rate of water loss (RWL)		Proline content (mg Fwt^{-1})	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation (I)						
I_1(20 days)	80.67	80.49	78.98	74.39	0.56	0.52
I_2(30 days)	78.89	75.19	75.85	71.43	0.63	0.69
I_3(40 days)	77.09	73.59	70.71	68.50	1.01	0.87
LSD 0.05	0.90	0.31	0.13	0.29	0.03	0.01
Wheat cultivars (V)						
Giza171	82.40	80.02	72.36	67.62	0.84	0.76
Sakha 95	84.84	80.68	72.07	68.69	0.86	0.79
Giza 168	78.46	74.91	73.33	70.38	0.77	0.68
Sids14	72.92	74.46	81.44	78.11	0.64	0.62
Misr 3	86.69	82.04	71.91	66.28	0.94	0.82
Misr 2	80.15	75.91	73.72	70.00	0.70	0.73
Sakha 94	77.50	74.36	75.89	71.56	0.66	0.64
Gemmeiza 11	74.14	72.04	76.95	75.80	0.63	0.63
Shandweel 1	75.03	74.31	79.14	73.61	0.61	0.60
Gemmeiza 12	76.73	75.48	75.00	72.33	0.65	0.64
LSD at 0.05	3.32	3.08	1.93	1.89	0.04	0.03
LSD 0.05(I×V)	5.49	5.07	NS	NS	NS	NS

As well as, the highest values of stomatal resistance, transpiration rate and leaf temperature were obtained by wheat cultivars Sakha 95, Shandweel 1 and Gemmeiza 11 respectively in both seasons as shown in Table 8. Also, the highest values of relative water content, rate of water loss and proline content were recorded by Misr 3, Sids 14 and Misr 3 respectively in both seasons as presented in Table 9. Relative water content is an essential indication of leaf water stresses (Merah, 2001) because it is directly related to cell volume and accurately reflects the balance between leaf water supply and transpiration rate (Farquhar *et al*., 1989). It also aids plant recovery from stress affecting grain yield and stability.

As well as, the highest values of stomatal resistance, transpiration rate and leaf temperature were obtained by wheat cultivars Sakha 95, Shandweel 1 and Gemmeiza 11 respectively in both seasons as shown in Table 8. The chlorophyll content actually corresponds to photosynthesis and can be used to determine stress tolerance of different genotypes (Shabala and Munns, 2017). These results are in line with Ghanem and Al-Farouk (2024) who reported that drought-tolerant wheat genotypes had higher pigment content than non-tolerant genotypes. Furthermore, a more significant drop is noted in wheat genotypes prone to drought (Lv *et al.*, 2019). On the other point of view, the rate of proline accumulation was substantially higher in the tolerant genotype, indicating that proline synthesis rate can be far more reliable than proline accumulation (Bayoumi *et al*., 2008).

3. The interaction effect

The data in Table (10) showed that the interaction between wheat cultivars and irrigation intervals has significant effect on relative growth rate whereas, the maximum values of this trait was recorded by wheat cultivar Misr 3 under the irrigation interval every 30 days in the first season only. As well as, the maximum values of total chlorophyll content was produced by wheat cultivar Misr 3 under the irrigation interval every 40 days in the first season only. Also, the highest values of this relative water content were recorded by wheat cultivars Misr 3 and Sakha 95 under the irrigation interval every 20 days in the first and the second season respectively.

Table 10. Effects of interactions between irrigation intervals and wheat cultivars on relative growth rate (mg/day), total chlorophyll content and relative water content (%) in growing seasons.

Characters	Relative growth rate (mg/day)			Total chlorophyll content			Relative water content (%)					
Wheat cultivars (V)	Irrigation intervals (I)			Irrigation intervals (I)			Irrigation intervals (I)					
	2019/20			2019/20			2019/20			2020/21		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
Giza171	22.67	24.67	17.47	43.33	44.59	55.39	85.15	84.05	78.00	84.05	80.00	76.00
Sakha 95	23.70	25.68	18.67	43.54	46.06	54.89	88.77	87.74	78.00	87.74	84.36	74.00
Giza 168	20.62	20.62	16.50	41.00	41.09	52.59	79.36	78.33	77.68	78.33	75.68	70.71
Sids14	20.35	18.30	15.33	39.41	42.55	45.95	72.74	70.68	75.33	77.68	66.35	79.36
Misr 3	25.39	28.37	20.37	45.74	47.40	58.93	91.01	89.68	79.36	85.68	82.64	73.68
Misr 2	21.52	23.50	17.36	42.00	42.17	49.92	84.00	78.70	77.76	78.70	76.00	73.04
Sakha 94	23.67	19.33	14.40	40.37	40.11	49.51	78.40	77.38	76.70	77.40	74.33	71.35
Gemmeiza 11	20.42	17.39	14.00	40.67	39.52	48.49	74.33	72.37	75.71	76.37	68.04	71.70
Shandweel 1	18.00	16.00	13.34	39.47	38.08	45.99	75.00	74.04	76.04	79.89	70.71	72.33
Gemmeiza 12	21.46	20.44	15.69	40.51	39.27	47.55	77.95	75.89	76.35	79.04	73.70	73.70
LSD0.05		2.57			2.91			5.49			5.07	

CONCLUSION

Under the conditions of EL-Gemmeiza region in the old land in middle delta, Soil water deficit resulted from irrigation intervals every 40 days caused a decrease in most of the studied wheat characters except for total chlorophyll content stomatal resistance, leaf temperature and proline content. Sakha 95 recorded the highest value of stomatal resistance while Misr 3 recorded the highest values of total chlorophyll content and proline content at irrigation intervals every 40. Thus, Misr 3 and Sakha 95 can be suitable cultivars for cultivation in water-stress conditions.

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تقييم بعض أصناف قمح الخبز تحت تأثير فترات الرى ٢ : دراسة بعض الصفات المورفوفسيولوجية

محمدعمرالفاروق[١] ، كمال الدين على الفقى[٢] وبسمه السيد محمد السماحي[٣]

[١] قسم بحوث القمح - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية- الجيزه - مصر
[٢] قسم فسيولوجيا المحاصيل- معهد بحوث المحاصيل الحقلية -مركز البحوث الزراعية- مصر
[٣] قسم بحوث تكنولوجيا البذور- معهد بحوث المحاصيل الحقلية- مركز البحوث الزراعية- مصر

الملخص

تم إجراء تجربة حقلية خلال موسمي الزراعة ٢٠١٩ / ٢٠٢٠، ٢٠٢١/٢٠٢٠ في المزرعة البحثية بمحطة البحوث الزراعية بالجميزة، محافظة الغربية، مركز البحوث الزراعية- الجيزة - مصر- لدراسة تأثير ثلاث فترات ري على الصفات المورفولوجية و الفسيولوجية لعشرة أصناف من قمح الخبز. وكان التصميم المستخدم هو القطع المنشقة في أربع مكررات حيث إحتوت القطع الرئيسية على فترات ري وهي الري كل ٢٠- ٣٠-٤٠ يوم وتضمنت القطع الشقية على أصناف القمح (جيزة ٧١- سخا ٩٥ - جيزة ١٦٨- سدس ١٤- مصر٣- مصر٢- سخا ٩٤- جميزة ١١- شندويل ١- جميزة ١٢). وأظهرت النتائج أن الري كل ٤٠ يوم (الإجهاد المائي) أدى الى نقص كل الصفات المدروسة (عدد الأيام حتى الطرد، عدد الأيام حتى النضج، فترة إمتلاء الحبوب، معدل إمتلاء الحبوب، طول النبات، دليل مساحة الاوراق، معدل النموالمحصولى، معدل النمو النسبي، معدل النتح ومحتوى الماء النسبي بالأوراق) بإستثناء محتوى الكلوروفيل الكلى، مقاومة الثغور للنتح، درجة حرارة الورقة ونسبة البرولين في كلا الموسمين. سجل الصنف سخا٩٥ أعلى القيم لصفة مقاومة الثغور للنتح ، بينما الصنف مصر٣ كان له أعلى القيم لمحتوى الكلوروفيل الكلى ومحتوي البرولين عند الري كل ٤٠ يوم. ويعتبر الصنفان مصر٣ و سخا٩٥ أكثر الأصناف المدروسة تحملا للإجهاد المائي وبالتالي تكون مناسبة لظروف نقص المياه.