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Effect of number of irrigations on productivity of some new bread wheat cultivars

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TO DETERMINE the best cultivar which exhibits strong performance under both normal irrigation and water stress conditions, a field experiment was conducted in two locations (Bani-Sweif governorate and Sohag governorate) and four irrigation treatments {Irr 1, Irr 2, Irr 3 and Irr 4 which are (2, 3, 4 and 5 irrigations after sowing one, respectively)} to examine the new bread wheat cultivars (Misr 3, Misr 4 and Sakha 95) throughout the two consecutive growing seasons of 2021-2022 and 2022-2023. The findings indicated that the influence of seasons was highly significant on all the examined characters except number of spikes m^{-2} and number of kernels spike^{-1} in both seasons, the locations influence was greatly significant on all the examined characters except days to heading and maturity in the second season, the effect of irrigation treatments was significant on all the examined traits except number of spikes m^{-2} in the 1st season and days to heading and plant height in the 2nd season. The differences between wheat cultivars were significant for all the examined characters except number of spikes m^{-2} and 1000-kernel weight in both seasons and number of kernels spike^{-1} in the 2nd season. According to the interaction between irrigation treatments and wheat cultivars, the three cultivars have a high yield potential under normal irrigation and also have a good performance under water stress conditions with some preference to the new cultivar Misr 4 which significantly surpassed the other two cultivars in the 2nd season.

Keywords: Bread wheat, Irrigation, Water stress.

Introduction

Wheat (*Triticum aestivum* L.) ranks as one of the leading cereal crops, both worldwide and within Egypt. Two billion people, or 36 percent of the global population, dependedon wheat as their primary way of eating, it is the source of 20% of the caloric intake for 55% of the world's population (Kumar *et al*., 2024). In Egypt, on the last season (2023-24) the planted area of wheat is around 3.254 million feddan, and the production is around 9.431 million metric tons, (Economic Affairs, Annual report, 2024). One of the key non-living stressors in semi-arid zones is the limited availability of water (Hassan *et al*., 2023). Drought represents a significant limitation to wheat cultivation and is increasingly emerging as a critical issue across many wheat-producing regions globally. It leads to substantial declines in both the growth and yield of wheat crops. Adequate water availability is essential for photosynthesis process and overall plant development. Inherently, arid and semi-arid zones experience insufficient rainfall throughout the year, while even typically humid areas may encounter dry spells with minimal precipitation. During these periods, the moisture retained in the soil is often inadequate to satisfy the crop’s water needs. However, it is not always essential to supply water continuously throughout every stage of the growing season (Ya-Xu *et al*., 2016). Water stress during crucial growth phases—such as tillering, flowering, and grain filling—leads to substantial yield losses in the season (Sharma *et al*., 2022). The height of the plant, no. of spikes m^{-2}, number of kernels spike^{-1}, 1000-kernel weight and other yield-attributing attributes are influenced by moisture deficiency. Water scarcity leads to decreased grain yield, with the extent of the loss according to the genotype, crop growth stage, and various soil, plant, and environmental factors (Rawtiya and Kasal, 2021). While sufficient irrigation is crucial for optimal crop production, during water shortages, it becomes necessary to identify the crop's critical growth stages where skipping irrigation would not significantly reduce grain yields (Sharma and Solanki, 2022). Effective irrigation scheduling is crucial for optimizing water, energy, and resource efficiency. Three key factors that determine irrigation timing are the crop's water requirements, the availability of irrigation water, and the water-holding capacity of the root zone (Baloch *et al*., 2014). Inadequate irrigation is the primary factor contributing to the decline in wheat yield, with water scarcity during

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the crop's critical growth phases being the most limiting condition for attaining optimal wheat production (Wei *et al*., 2018). Full irrigations resulted in maximum grain yield, although the lowest grain yields were recorded with two irrigations, and irrigation at both booting and flowering are crucial for minimizing grain yield losses (Abd El-Rady *et al*., 2020). The current research sought to identify the critical periods which wheat crops needs water irrigation to produce high grain yield, and the other periods which we can skip irrigation without significant lose in grain yield.

Materials and Methods

Sixteen field experiments (four experiment in each location at each season) were took place during 2021/2022 and 2022/2023 growing seasons on the experimental farm of Sids Agric. Res. Sta., Bani-sweif governorate (longitude of 29°3´ and the latitude of 31°5´N and height of 32.2 m above the sea level), and Shandaweel Agric. Res. Sta., Sohag governorate, (longitude of 31°42´E and the latitude of 26°33´N, and height of 61 m above the sea level), Agric. Res. Cen, Egypt. The experimental design was randomized complete block design (RCBD) with four replications for each irrigation treatment, and the wheat cultivars randomly allocated. Soil samples from the experimental soil in both seasons and locations were gathered from 0-30 depth, analyzed and presented in Table 1. The study used three bread wheat cultivars exhibiting a broad spectrum of morphological and agronomic traits; Misr 3, Misr 4 and Sakha 95. Table 2 provides information on the genetic origin and development history of the cultivars. Minimum, maximum and average temperature degrees in the two seasons and in the two locations are presented in Table 3.

Table1. Mechanical and chemical characteristics of the test soil through both seasons.

Loc.	Cations mg l^{-1}				Anions mg l^{-1}		
	Mg^{++}	Ca^{++}	K^{+}	Na^{+}	$So4^{--}$	Cl^{-}	$Hco3^{-}$
1	3.83	5.18	1.62	14.63	10.55	11.70	3.00
2	1.99	2.69	1.20	7.61	4.90	6.08	2.50
	N	P	K	SAR	EC ds m^{-1}	PH	SP%
1	25	9	311	6.89	2.25	7.91	81
2	15	7	320	4.97	1.17	7.88	75

Table 2. Name, pedigree and chosen history of the three wheat cultivars.

No	Name	Pedigree and selection history
1	Misr 3	Rohf 07*2/Kiriti CGSS 05 B00123T-099T-0PY-099M-099NJ-6WGY-0B-0BGY-0GZ
2	Misr 4	NS732/HER/3/PRL/ SARA// TSI/VEE 5/6/FRET 2/5/WHEAR/SOKOLL CM SA09Y007125-050Y- 050ZTM-0NJ-099NJ-0B-0EG
3	Sakha 95	PASTOR//SITE/MO/3/CHEN/AEGILOPS SQUARROSA (TAUS)// BCN/4/ WBLL1 CMSA01Y00158S-040P0Y-040M-030ZTM-040SY-26M-0Y-0SY-0S

Table 3. minimum, maximum and average temperature degrees in seasons 21-22 and 22-23 of first and second locations.

Season	Loc.		Nov.	Dec.	Jan.	Feb.	March	April	May
21/22	Sids Loc.	Min	10.8	7.7	4.4	5.3	6.2	12.3	14.9
		Max	25.3	20.1	17.8	19.6	21.1	31.0	31.4
		Mean	17.3	13.6	10.6	12.3	13.6	21.5	23.5
	Shand. Loc.	Min	11.6	8.0	4.9	6.9	8.7	16.7	18.6
		Max	27.7	20.1	16.7	19.9	22.5	34.1	33.3
		Mean	19.2	13.8	10.6	13.3	15.5	25.6	25.8
22/23	Sids Loc.	Min	10.5	8.7	6.3	4.9	9.3	11.3	13.5
		Max	23.3	22.2	20.4	18.8	25.3	29.0	30.0
		Mean	16.4	15.1	13.0	11.7	17.1	20.3	22.0
	Shand. Loc.	Min	12.0	9.9	7.4	6.3	12.4	15.5	18.6
		Max	23.8	22.1	20.5	19.2	27.0	30.5	33.3
		Mean	17.7	15.6	13.6	12.7	19.8	23.3	24.7

The wheat cultivars were grown under four irrigation regimes; Irr 1, Irr 2, Irr 3 and Irr 4 (2, 3, 4 and 5 irrigation after sowing irrigation, respectively), the mean of the amount of the used irrigation water for each irrigation over both seasons and the total irrigation water amount for each irrigation treatment under the two location are presented in Table 4. All suggested farming techniques were implemented. To prevent the impact of sideways water flow during flooding, every treatment was separated by ditches. The planting day was 25th November in both seasons. The plot size was 8.4 m^2 (12 rows × 20 cm apart × 3.5 m long). Pesticides were administered as necessary to maintain the field free of insect and For each irrigation treatment, an analysis of variance was executed on the plot means. Additionally, a combined analysis of variance was conducted across irrigation treatments and locations for both seasons, as well as over the two seasons and irrigation treatments using GenStat computer program according to Gomez and Gomez (1984), pest infestations, while approved herbicides were used to manage weed growth.

The studied characters: number of days to 50% heading (days), number of days to 50% maturity (days), plant height (cm), number of spikes m^{-2}(spikes), number of kernels $spike^{-1}$(kernels), 1000-kernel weight (gm) and grain yield (ardab $feddan^{-1}$) following testing the homogeneity of errors utilizing Bartlett (1937). Mean comparisons were performed employing the Least Significant Difference (LSD) test at a 5% significance level, following the method proposed by Waller and Duncan (1969).

Table 4. Mean of the amount of the used irrigation water for each irrigation over both seasons and the total irrigation water for each irrigation treatment under the two locations.

Location	Irrigation Treatment	Amount of irrigation water (m^3 $feddan^{-1}$)						
		Sowing Irrigation	1st Irrigation	2nd Irrigation	3rd Irrigation	4th Irrigation	5th Irrigation	Total
Sids Loc.	Irr 1	403	283	285				971
	Irr 2	403	283	287	302			1275
	Irr 3	403	285	286	303	325		1602
	Irr 4	403	282	285	302	328	354	1954
Shand. Loc.	Irr 1	450	280	300				1030
	Irr 2	450	283	301	318			1352
	Irr 3	450	284	298	315	350		1697
	Irr 4	450	281	302	316	352	360	2061

Results and discussions

1- Effect of Seasons

Data of the effect of seasons on the examined characters are displayed in Table 5. There were extremely substantial differences among two seasons for all the examined characters except count of spikes m^{-2} and count of kernels $spike^{-1}$ which were insignificant. The 2nd season was earlier in each of days to heading with a mean of 96.95 days and days to maturity with a mean of 147.55 days, shorter plant height with an average of 109.45 cm, heavier 1000-kernel weight with an average of 46.12 gm and higher grain yield with a mean of 30.73 ardab/feddan compared to the 1st season (averages were 98.87 days, 149.24 days, 112.75 cm, 44.65 gm and 25.92 ardab for the previous traits, respectively). Mollasadeghi *et al*. (2013) demonstrated that the grain yield trait exhibited a significant seasonal effect during both normal irrigation and drought stress conditions. Abd El-Rady *et al*. (2020) noted that the effect of seasons was highly significant on heading time, maturity period, plant height, number of spikes m^{-2}, 1000-kernel weight, number of kernels $spike^{-1}$ and grain yield. Sareen *et al*. (2023) reported that the pooled ANOVA for years demonstrated notable variation ($p < 0.05$) across the genotypes for time to heading, maturity period, plant height, 1000-kernel weight, number of kernels $spike^{-1}$ and grain yield.

2- Effect of locations:

The means of the examined traits for the two locations in both seasons are displayed in table 5. In the 1st season, there were greatly significant differences between the two locations for all the examined characters: Sids location was earlier in time to heading (96 days), latest in number of days to maturity with an average of 153.2 days, taller in plant height with an average of 117.4 cm, fewer in number of spikes m^{-2} with a mean of 421.1 spikes, lighter in 1000-kernel weight with an average of 42.03 g, higher in number of kernels $spike^{-1}$ with a mean of 62.26 kernels and higher in grain yield with a mean of 33.51 ardab/feddan compared to Shandaweel location with an averages of (96.69 days, 145.2 days, 108.1 cm, 466.8 spikes, 47.28 g, 34.56 kernels and 18.33 ardab/feddan, respectively). Conversely, in the 2nd season greatly substantial variances were found for all the examined characters except each of number of days to heading and number of days to maturity, Sids location was taller in plant height with a mean of (112.0 cm), fewer in number of spikes m^{-2} with an average of (415.7 spikes), heavier in 1000-kernel weight with an average of (49.17 g), higher in number of kernels $spike^{-1}$ with an average of (59.89 kernels) and higher in grain yield with an average of (33.97 ardab/feddan) compared to Shandaweel location with an averages of (106.9 cm, 471.5 spikes, 43.06 g, 36.48 kernels and 27.49 ardab/feddan, the mean values for these traits, respectively). Grain yield was higher in Sids location in both seasons compared to Shandaweel location, if we liked this data with the soil analysis which presented in table 1 and monthly air temperature means which presented in table 2, we found that the soil in Sids location was higher in all the nutrients except potassium. According to monthly air temperature means, Sids location was lower in monthly air temperature means with values ranged from 0^oc on January 2022 to 4.1^oc on April 2022 with an average of 1.67^oc, these results cleared that Sids location was favorable to wheat production than Shandaweel location which resulted in high grain yield. Readings of air temperatures (Min., Max. and Means) which presented in Table 3 cleared that air temperatures at Sids location were less than it in Shandaweel location contributed to greater grain yield and its components in Sids location relative to Shandaweel location. Moisture deficiency negatively impacts plant height, no. of spikes m^{-2}, number of kernels $spike^{-1}$, 1000-kernel weight, ultimately reducing grain yield. The extent of yield loss depends on soil and environmental factors (Rawtiya and Kasal, 2021). Sareen *et al*. (2023) reported that the pooled ANOVA for locations displayed substantial variation ($p < 0.05$) across the genotypes for time to heading, time to maturity, plant height, 1000-kernel weight, number of kernels $spike^{-1}$ and grain yield

Table 5. Means of the examined characters of wheat cultivars as influenced by Seasons, irrigation levels, compost and gypsum treatments in 2021/2022 and 2022/2023 seasons.

Item		Days to Heading	Days to maturity	Plant height cm.	No. of spikes m^{-2}	1000-kernel weight	No. of kernels $spike^{-1}$	Grain yield (ard/fed)
Seasons								
Season 1		98.87	149.24	112.75	443.9	44.65	48.41	25.92
Season 2		96.95	147.55	109.45	443.6	46.12	48.19	30.73
F test		**	**	**	Ns	**	Ns	**
Locations								
1st Season	L_1	101.04	153.2	117.4	421.1	42.03	62.26	33.51
	L_2	96.69	145.2	108.1	466.8	47.28	34.56	18.33
	F test	**	**	**	**	**	**	**
2nd Season	L_1	96.81	147.5	112.0	415.7	49.17	59.89	33.97
	L_2	97.08	147.6	106.9	471.5	43.06	36.48	27.49
	F test	Ns	Ns	**	**	**	**	**
Irrigation Treatments								
1st Season	I_1	97.46	144.00	108.92	443.8	42.97	44.57	22.48
	I_2	98.88	149.04	111.67	443.6	43.97	45.96	24.88
	I_3	99.08	149.33	114.33	439.4	44.88	49.76	26.65
	I_4	100.04	154.58	116.08	449.0	46.79	53.37	29.69
L.S.D 0.05		0.60	1.64	1.94	Ns	1.24	1.7	0.478
2nd Season	I_1	96.29	144.63	108.29	403.83	41.70	43.63	27.83
	I_2	97.00	148.88	107.96	439.17	44.65	46.08	30.12
	I_3	96.75	149.83	111.25	455.71	48.22	48.93	31.91
	I_4	97.75	146.88	110.29	475.75	49.91	54.10	33.08
L.S.D 0.05		Ns	1.38	Ns	9.16	1.086	3.982	1.192
Cultivars								
1st Season	Misr 3	97.41	149.47	108.72	438.9	44.21	49.78	26.57
	Misr 4	100.75	150.94	111.09	444.6	44.76	47.56	25.77
	Sakha	98.42	147.31	118.44	448.3	44.98	47.89	25.43
L.S.D 0.05		0.448	0.917	1.384	Ns	Ns	1.6	0.703
2nd Season	Misr 3	94.43	146.87	106.57	441.13	46.11	47.75	29.98
	Misr 4	97.39	147.97	106.13	444.39	46.99	48.35	31.85
	Sakha 95	99.06	147.81	115.22	447.09	45.56	48.33	30.29
L.S.D 0.05		0.715	0.818	2.071	Ns	Ns	Ns	0.643

ns: non-significant. * and **: significant at 0.05 and 0.01 levels of probability, correspondingly.

3- Effect of irrigation treatments:

Date of the examined characters means in the two growing seasons over both sites are shown in Table 5. For all traits studied, significant differences were observed in both seasons, except for the count of spikes m^{-2} in the first season and both days to heading and plant height in the second season. The full irrigation (Irr 4 treatment) resulted in the longest duration to heading, with an average of 100.04 days, latest number of days to maturity with an average of 154.58 days, maximum plant height, with a mean of 116.08 cm, heaviest 1000-kernel weight with a mean of 46.79 g, higher in number of kernels spike^{-1} with a mean of 53.37 kernels and higher in grain yield with a mean of 29.69 ardab/feddan compared to other irrigation regimes treatments in the 1st season. Conversely, in 'the 2nd season, the full irrigation (Irr 4 treatment) resulted in the highest mean values for grain yield and its component: the maximum number of spikes m^{-2} with an average of 475.75 spikes, the heaviest 1000-kernel weight with an average of 49.91 g, higher in number of kernels spike^{-1} with a mean of 54.10 kernels and higher in grain yield with a mean of 33.08 ardab/feddan compared to other irrigation regimes treatments, while Irr 3 (non-irrigated after flowering stage gave the latest number of days to maturity with a mean of 149.83 days compared to other irrigation regimes treatments. Khakwani *et al*. (2012) identified a statistically significant difference ($p<0.05$) among the two irrigation treatments was observed regarding number of tillers, plant height, number of kernels spike^{-1} and grain yield. Noreldin and Mahmoud (2017) observed that the implemented irrigation treatments had a notable influence on all the assessed traits. Wei *et al*. (2018) stated that deficit irrigation had a notable impact on spike number, 1000-kernel weight and grain yield. The minimum 1000-kernel weight resulted from omitting irrigation during the milk, grain yield decreased as a result of water stress throughout various growth stages in the experiment, relative to optimal irrigation conditions. Seleiman and Abdel-Aal (2018) found that exposing wheat plants to drought stress by skipping two irrigations significantly decreased plant height, days from sowing to heading as well as maturity, no. of spikes m^{-2}, no. of kernels spike^{-1}, 1000 kernel weight and grain yield. Abd El-Rady *et al*. (2020) reported that reducing both the frequency of irrigations and the volume of water applied during various growth stages led to a significant reduction in the number of days until heading, time to maturity, plant height, count of spikes m^{-2}, number of kernels spike^{-1}, 1000- kernel weight and grain yield, irrigation during both the booting and flowering stages is crucial for minimizing grain yield loss. Morsy *et al* (2020) stated that the irrigation regimes had a significant influence on plant height, number of kernels spike^{-1}, 1000-kernel weight, number of spikes m^{-2} and grain yield. Mahdy and Farghali (2021) found that the water stress caused a significant decrease in plant height, no. of spikes, 100-kernel weight and grain yield. Khan *et al*. (2022) recorded that water stress significantly influences wheat's growth and yield characteristics, with the preanthesis stage being the most sensitive to water scarcity. Ghallab *et al*. (2024) indicated a considerable effect of skipping irrigations on grain yield, with the highest reduction observed when irrigation at the heading stage was skipped. Lal *et al*. (2024) cleared that drought stress significantly affected yield and its related attributes.

4- Effect of wheat cultivars:

Data for the examined characters mean values of the three wheat cultivars over both locations are presented in Table 5. Wheat cultivars varied among themselves in the mean values of the examined characters in both seasons. Significant differences were obtained across wheat cultivars for all the examined characters in both seasons, except each of number of spikes m^{-2} and 1000-kernel weight in the 1st season, and each of number of spikes m^{-2}, 1000-kernel weight and number of kernels spike^{-1} in the 2nd season. Misr 3 cultivar gave the earliest number of days to heading with an average of 97.41 days, greatest count of kernels spike^{-1} with a mean of 49.78 kernels and the highest grain yield with a mean of 26.57 ardab/feddan, relative to the other wheat cultivars, while Sakha 95 gave the earliest number of days to maturity with a mean of 147.31 days and the tallest plant height with a mean of 118.44 cm, relative to the other wheat cultivars, in the 1st season. On the other hand, Misr 3 cultivar gave the earliest number of days to heading with a mean of 94.43 days and the earliest time to maturity with a mean of 146.87 days, relative to the other wheat cultivars, whereas Sakha 95 exhibited the greatest plant height, averaging 11.22 cm, relative to the other wheat cultivars and Misr 4 cultivar recorded the highest grain yield, averaging 31.85 ardab/feddan, compared to the other wheat cultivars, in the 2nd season. Khakwani *et al*. (2012) identified a significant difference ($p<0.05$) among the six varieties was observed regarding number of tillers, plant height, number of kernels spike^{-1} and grain yield. Noreldin and Mahmoud (2017) reported that all the assessed traits showed significant responses to the genotypes. Arab *et al*. (2021) stated that substantial genotypes mean squares were identified for 1000-kernel weight and grain yield demonstrating that wheat genotypes responded differently to water stress. Hassaan *et al*. (2023) confirmed that the examined traits significantly influenced the tested genotypes, demonstrating notable variability among them. Abd El-Aty *et al*. (2024) found that highly notable variations were detected within the wheat genotypes for days to heading, number of kernels spike^{-1}, 1000-kernel weight and grain yield. Ghallab *et al*. (2024) reported that considerable variations for grain yield among wheat cultivars, Misr-3," followed by Sakha-95," are the top-performing cultivars in terms of drought tolerance during the flowering stages.

5- Impact of the 1st order of the interaction:

5-1- Impact of interaction between locations and irrigation treatments:

Data in Table 6 represent the interaction among sites and irrigation treatments. The examined traits exhibited significant variations in both seasons. In the 1st season, (Irr 1) gave earliest time to heading with a mean of 96.25 days and the earliest time to maturity with an average of (142.92 days), in the 2nd location, relative to the other irrigation treatments, Irr 4 resulted in the greatest plant height with a mean 120.00 cm, the greatest number of kernels spike^{-1} with a mean of 65.48 kernels and the extreme grain yield with a mean of 35.58 ardab, in the 1st location, relative to the other irrigation treatments, (Irr 2) yielded the greatest count of spikes m^{-2} with an average of (474.67 spikes), in the 2nd location, relative to the other irrigation treatments and (Irr 4) produced the greatest 1000-kernel weight with an average of (50.64 g), in the 2nd location, relative to the other irrigation treatments. Conversely, in the 2nd season, (Irr 2) gave earliest time to heading with a mean of (96.25 days), in the 1st location, relative to the other irrigation treatments, (Irr 1) gave the earliest time to maturity with an average of (141.00 days), in the 2nd location and the tallest plant height with an average of (115.83 cm), in the 1st location, relative to the other irrigation treatments, (Irr 4) resulted in the greatest count of kernels spike^{-1} with an average of (63.53 kernels), in the 1st location, the maximum number of spikes m^{-2} with an average of (552.75 spikes), the heaviest 1000-kernel weight with an average of (52.39 g) and the highest grain yield

Table 6. Impct of the interaction among locations and each of irrigation levels and wheat cultivars for the examined characters in 2021/2022 and 2022/2023 seasons.

Season	Item		Days to heading	Days to maturity	Plant height (cm)	No. of spikes m^{-2}	1000-kernel weight (g)	No. of kernels spike^{-1}	Grain yield (ard fed^{-1})
Interaction between locations and irrigation levels									
2021-2022	L_1	I1	98.67	145.08	112.50	415.83	42.30	59.97	30.98
		I2	100.58	153.17	117.92	412.50	41.04	60.00	33.01
		I3	101.75	153.75	119.17	421.58	41.84	63.60	34.47
		I4	103.17	160.92	120.00	434.58	42.94	65.48	35.58
	L_2	I1	96.25	142.92	105.33	471.83	43.63	29.17	13.99
		I2	97.17	144.92	105.42	474.67	46.91	31.92	16.74
		I3	96.42	144.92	109.50	457.17	47.93	35.92	18.82
		I4	96.92	148.25	112.17	463.33	50.64	41.25	23.79
L.S.D 0.05			0.85	2.32	2.74	17.73	1.75	2.4	0.676
2022-2023	L_1	I1	96.50	148.25	115.83	405.00	47.42	58.42	29.79
		I2	95.50	149.92	112.08	432.08	48.29	56.99	34.66
		I3	97.00	148.83	111.67	427.08	50.80	60.60	35.69
		I4	98.25	142.92	108.33	398.75	50.18	63.53	35.75
	L_2	I1	96.08	141.00	100.75	402.67	33.21	28.83	19.90
		I2	98.50	147.83	103.83	446.25	38.50	35.17	24.54
		I3	96.50	150.83	110.83	484.33	48.15	37.25	29.17
		I4	97.25	150.83	112.25	552.75	52.39	44.67	36.37
L.S.D 0.05			1.58	1.95	3.78	12.96	1.54	3.1	1.69
Interaction between locations and wheat cultivars									
2021-2022	L_1	Misr 3	100.25	154.25	111.56	420.50	41.67	63.19	34.23
		Misr 4	103.06	154.75	114.69	425.19	42.14	60.94	33.48
		Sakha 95	99.81	150.69	125.94	417.69	42.28	62.66	32.82
	L_2	Misr 3	94.56	144.69	105.88	457.25	46.76	36.38	18.91
		Misr 4	98.44	147.13	107.50	464.00	47.38	34.19	18.06
		Sakha 95	97.06	143.94	110.94	479.00	47.68	33.13	18.03
L.S.D 0.05			0.66	1.54	2.07	Ns	ns	Ns	Ns
2022-2023	L_1	Misr 3	95.00	146.43	108.57	410.36	50.00	60.26	34.16
		Misr 4	98.13	148.56	108.75	420.31	50.53	59.13	34.74
		Sakha 95	97.56	147.50	117.81	417.19	47.46	60.48	32.90
	L_2	Misr 3	93.94	147.25	104.81	468.06	42.71	36.81	26.33
		Misr 4	96.60	147.33	103.33	470.07	43.20	36.87	28.77
		Sakha 95	100.56	148.13	112.63	477.00	43.65	36.19	27.67
L.S.D 0.05			1.12	1.33	ns	Ns	1.47	Ns	1.10

ns: mean non-significant at 5% level of probability.

with an average of (36.37 ardab), in the 2nd location, compared to the other irrigation treatments. Rawtiya and Kasal, (2021) found that plant height, no. of spikes m^{-2}, no. of kernels $spike^{-1}$, 1000-kernel weight and other yield-related traits are all influenced by moisture deficiency, leading to a decline in grain yield, the degree of yield loss varies by variety of soil and environmental conditions.

5-2- Impact of the interaction among locations and wheat cultivars:

Table 6 represents the interaction among locations and wheat cultivars .In the 1st season, there were significant differences to the interaction between locations and wheat cultivars for the studied traits: time to heading, time to maturity and plant height. Misr 3 was the earlier cultivar for days to heading trait with a mean of 94.56 day in the 2nd location, while Sakha 95 was the earlier cultivar for days to maturity trait with an average of 143.94 day in the 2nd location and also it was the tallest cultivar with an average of 125.94 cm under the 1st location. Conversely, in the 2nd season, there were notable differences to the interaction among locations and wheat cultivars for the examined characters: duration to heading, duration to maturity, 1000-kernel weight and grain yield. Misr 3 was the earlier cultivar for days to heading trait with a mean of 93.94 day in the 2nd location, also, it was the earlier cultivar for days to maturity trait with an average of 146.43 day in the 1st location. 1000-kernel weight of the cultivar Misr 4 was the heaviest with an average of 50.53 g and its grain yield was the highest with a mean of 34.74 ardab/feddan in the 1st location. The height of the plant, no. of spikes m^{-2}, no. of kernels $spike^{-1}$, 1000-kernel weight and other yield-attributing characters under water stress, are all affected by genotype and crop development stage, variety of soil, and environmental conditions, leading to a decline in grain yield (Rawtiya and Kasal, 2021).

5-3- Impact of the interaction among irrigation treatments and wheat cultivars:

Table 7 presents the data on the interaction among wheat cultivars and irrigation treatments. There were significant differences only for 100-kernel weight trait in the 1st season, 1000- kernel weight of the cultivar Sakha 95 was the heaviest with an average of 47.57 g under the 4th irrigation treatment. Conversely, in the 2nd season, there were significant differences for the traits: duration to heading, count of spikes m^{-2}, count of kernels $spike^{-1}$ and grain yield. The cultivar Misr 3 was the first to reach heading with a mean of 93.25 days under the 1st and 3rd irrigation treatments. Also this cultivar has the greatest count of spikes m^{-2} with a mean of 485.25 spikes and the greatest count of kernels $spike^{-1}$ with a mean of 55.29 kernels under the 4th irrigation treatment. While the cultivar Misr 4 has the highest grain yield with a mean of 34.58 ardab/feddan under the 4th irrigation treatment. Noreldin and Mahmoud (2017) demonstrated that all assessed traits showed significant responses to the interactions between the implemented irrigation methods and wheat genotypes. Wei *et al*. (2018) found that the inter action between deficit irrigation and wheat cultivars led to a notable variation in spike count, 1000-kernel weight and grain yield. Abd El-Rady *et al*. (2020) reported that the interaction among irrigation treatment and wheat cultivars were notable for count of spikes m^{-2}, 1000-kernel weight and grain yield. According to Lal *et al*. (2024), the interaction between genotypes and treatments had a notable impact on yield and related traits in water stress conditions.

6- Impact of the 2nd degree of interaction among locations, irrigation treatments and wheat cultivar:

The data of the interaction among locations, irrigation treatments and wheat cultivar in both seasons are presented in Table 8 for the 1st season and Table 9 for the 2nd season. There were significant differences for the number of days to heading and plant height in the 1st season and for the number of days to heading and grain yield in the 2nd season. The cultivar Misr 3 exhibited the earliest heading date with an average of 94.50 days under the 1st, the 3rd and the 4th irrigation treatments in the 1st season, and with an average of 93.00 days under the 3rd irrigation treatment in the 2nd season. The cultivar Sakha 95 was the tallest with an average of 128.75 cm under the 4th irrigation treatment in the 1st season. The cultivar Misr 4 yielded the highest grain production, averaging 38.92 ardab/feddan with the 4th irrigation treatment in the 2nd season.

Table 7. Impact of the interaction among Irrigation levels and wheat cultivars for the examined characters in 2021/2022 and 2022/2023 seasons.

Season	Item		Days to heading	Days to maturity	Plant height cm.	No. of spikes/ m^2	1000-kernel weight	No. of kernels/ spike	Grain yield (ard/fed)
2021-2022	I1	Misr 3	96.25	144.63	105.50	440.38	42.46	44.70	22.96
		Misr 4	99.25	144.50	108.38	444.25	43.61	44.23	22.67
		Sakha 95	96.88	142.88	112.88	446.88	42.82	44.78	21.81
	I2	Misr 3	97.13	149.00	107.13	430.38	43.71	48.53	25.33
		Misr 4	101.13	150.88	110.88	453.63	43.56	43.45	24.35
		Sakha 95	98.38	147.25	117.00	446.75	44.65	45.90	24.94
	I3	Misr 3	97.63	150.00	110.25	443.63	43.67	50.83	27.40
		Misr 4	101.00	151.50	112.38	430.38	46.09	49.33	26.58
		Sakha 95	98.63	146.50	120.38	444.13	44.89	49.13	25.96
	I4	Misr 3	98.63	154.25	112.00	441.13	47.02	55.08	30.58
		Misr 4	101.63	156.88	112.75	450.13	45.79	53.25	29.48
		Sakha 95	99.88	152.63	123.50	455.63	47.57	51.78	29.00
L.S.D 0.05			Ns	Ns	Ns	Ns	1.82	Ns	Ns
2022-2023	I1	Misr 3	93.25	144.00	105.25	394.50	41.12	42.13	27.16
		Misr 4	96.13	145.00	103.25	413.38	42.73	45.60	28.59
		Sakha 95	99.50	144.88	116.38	403.63	41.25	43.15	27.72
	I2	Misr 3	95.00	148.38	104.38	427.50	45.10	48.83	29.89
		Misr 4	98.38	149.75	104.50	451.88	44.89	44.93	29.89
		Sakha 95	97.63	148.50	115.00	438.13	43.95	44.49	30.57
	I3	Misr 3	93.25	148.75	110.13	448.25	48.59	47.50	31.42
		Misr 4	97.50	150.13	107.88	453.13	48.92	47.78	33.38
		Sakha 95	99.50	150.63	115.75	465.75	47.15	51.50	30.95
	I4	Misr 3	95.88	146.13	108.63	485.25	49.68	55.29	32.75
		Misr 4	97.75	147.25	108.50	461.13	50.17	52.83	34.58
		Sakha 95	99.63	147.25	113.75	480.88	49.88	54.19	31.90
L.S.D 0.05			1.58	Ns	Ns	17.62	Ns	3.50	1.56

ns: mean non-significant at 5% level of probability.

Table 8. Influence of the interaction across Locations, irrigation levels and the three wheat cultivars for the examined characters in 2021/2022 season.

Item			Days to heading	Days to maturity	Plant height cm.	No. of spikes/ m^2	1000-kernel weight (g)	No. of kernels/ spike	Grain yield (ard/fed)
L1	I1	Misr 3	98.00	146.75	106.25	416.25	40.97	59.15	31.38
		Misr 4	100.00	144.25	110.00	422.50	43.24	58.95	31.22
		Sakha 95	98.00	144.25	121.25	408.75	42.70	61.80	30.33
	I2	Misr 3	99.50	153.75	111.25	396.25	41.47	63.55	33.63
		Misr 4	103.25	154.50	116.25	433.75	40.22	55.65	32.33
		Sakha 95	99.00	151.25	126.25	407.50	41.43	60.80	33.08
	I3	Misr 3	100.75	155.25	115.00	433.25	40.81	63.90	35.54
		Misr 4	104.00	156.50	115.00	418.25	43.24	62.40	34.33
		Sakha 95	100.50	149.50	127.50	413.25	41.48	64.50	33.54
	I4	Misr 3	102.75	161.25	113.75	436.25	43.42	66.15	36.38
		Misr 4	105.00	163.75	117.50	426.25	41.87	66.75	36.04
		Sakha 95	101.75	157.75	128.75	441.25	43.53	63.55	34.33
L2	I1	Misr 3	94.50	142.50	104.75	464.50	43.95	30.25	14.54
		Misr 4	99.25	144.50	108.38	444.25	43.61	44.23	22.67
		Sakha 95	95.75	141.50	104.50	485.00	42.95	27.75	13.29
	I2	Misr 3	94.75	144.25	103.00	464.50	45.95	33.50	17.04
		Misr 4	99.00	147.25	105.50	473.50	46.90	31.25	16.38
		Sakha 95	97.75	143.25	107.75	486.00	47.88	31.00	16.79
	I3	Misr 3	94.50	144.75	105.50	454.00	46.53	37.75	19.25
		Misr 4	98.00	146.50	109.75	442.50	48.95	36.25	18.83
		Sakha 95	96.75	143.50	113.25	475.00	48.30	33.75	18.38
	I4	Misr 3	94.50	147.25	110.25	446.00	50.63	44.00	24.79
		Misr 4	98.25	150.00	108.00	474.00	49.70	39.75	22.92
		Sakha 95	98.00	147.50	118.25	470.00	51.60	40.00	23.67
L.S.D 0.05			1.32	Ns	4.13	ns	Ns	ns	Ns

ns: mean non-significant at 5% level of probability.

Table 9. Effect of the interaction amng Locations, irrigation levels and the three wheat cultivars for the examined characters in 2022/2023 season.

Item			Days to heading	Days to maturity	Plant height cm.	No. of spikes/ m^2	1000-kernel weight (g)	No. of kernels/ spike	Grain yield (ard/fed)
L1	I1	Misr 3	93.25	143.50	111.25	393.75	46.81	57.00	28.58
		Misr 4	97.75	144.50	111.25	423.75	47.88	59.95	30.25
		Sakha 95	98.50	140.75	125.00	397.50	47.59	58.30	30.54
	I2	Misr 3	95.00	148.50	104.38	427.50	44,62	48.83	32.79
		Misr 4	97.00	150.25	108.75	446.25	50.54	56.35	35.79
		Sakha 95	95.00	147.75	118.75	432.50	49.73	55.48	35.41
	I3	Misr 3	93.50	149.75	111.25	426.25	49.36	60.50	35.25
		Misr 4	98.75	150.50	108.75	420.00	51.85	57.30	35.37
		Sakha 95	98.75	148.38	115.00	435.00	45.10	64.00	29.89
	I4	Misr 3	97.75	148.25	106.25	401.25	49.05	63.58	34.98
		Misr 4	99.00	149.00	106.25	391.25	51.86	62.90	37.54
		Sakha 95	98.00	147.50	112.50	403.75	49.62	64.13	34.74
L2	I1	Misr 3	93.25	140.50	99.25	395.25	32.61	27.25	19.60
		Misr 4	94.50	141.00	95.25	403.00	33.59	31.25	19.65
		Sakha 95	100.50	141.50	107.75	409.75	33.44	28.00	20.46
	I2	Misr 3	95.50	147.25	100.00	437.50	39.02	38.50	23.32
		Misr 4	99.75	149.00	100.25	457.50	37.93	33.50	24.40
		Sakha 95	100.25	147.25	111.25	443.75	38.54	33.50	25.90
	I3	Misr 3	93.00	149.75	109.00	470.25	47.45	34.50	27.42
		Misr 4	96.25	150.00	107.00	486.25	47.31	38.25	30.97
		Sakha 95	100.25	152.75	116.50	496.50	49.68	39.00	29.11
	I4	Misr 3	94.00	151.50	111.00	569.25	51.77	47.00	34.96
		Misr 4	96.50	150.00	110.75	531.00	52.45	42.75	38.92
		Sakha 95	101.25	151.00	115.00	558.00	52.95	44.25	35.22
L.S.D 0.05			2.24	Ns	ns	ns	Ns	ns	2.20

ns: mean non-significant at 5% level of probability.

Conclusion

The effect of locations was highly significant, because the soil in the 1st location (Sids location) was richer in its content of the nutrients which the wheat plants need it, also, the climate in the Sids location was better than Shandaweel location which lead to the grain yield in Sids location was higher than Shandaweel location. For irrigation treatments, the findings demonstrated that the best irrigation treatment was Irr 4 (5 irrigations after sowing irrigation) leading to the highest grain yield among all irrigation treatments, but it consume more water (1954 and 2061 m^3 of irrigation water, in the 1st and the 2nd location, correspondingly), so, if the irrigation water was available, it's better to use this treatment, but when the irrigation water was determined, the 3rd irrigation was good which produce good grain yield compared to the consumption irrigation water (it save about 354 and 360 m^3 of irrigation water, in the 1st and the 2nd location, correspondingly).

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تأثير عدد الريات على الإنتاجية لبعض أصناف القمح الجديدة

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لتحديد أفضل الأصناف والذي يتميز بأداء جيد تحت ظروف الري العادي والإجهاد المائي، تم تنفيذ تجربة حقلية في موقعين (محطة البحوث الزراعية في سدس بمحافظة بني سويف ومحطة البحوث الزراعية في شندويل بمحافظة سوهاج) تحت أربعة معاملات ري {1، 2 ، 3 و 4 (2 ، 3 ، 4 و 5 ريات بخلاف رية الزراعة، على الترتيب)} وذلك لتقييم ثلاثة أصناف جديدة من قمح الخبز (مصر 3، مصر 4 و سخا 95) خلال الموسمين الزراعيين (2021–2022 و 2022–2023). بينت النتائج أن تأثير المواسم كان عالي المعنوية على كل الصفات المدروسة عدا عدد السنابل للمتر المربع وعدد حبوب السنبلة ، كان تأثير المواقع عالي المعنوية على كل الصفات المدروسة عدا عدد الأيام لكل من طرد السنابل والنضج في الموسم الثاني، كان تأثير معاملات الري معنوي على كل الصفات المدروسة عدا عدد السنابل للمتر المربع في الموسم الأول وعدد الأيام حتى طرد السنابل وطول النبات في الموسم الثاني، كان الإختلاف بين أصناف القمح معنوي في كل الصفات المدروسة عدا عدد السنابل للمتر المربع ووزن الـ 1000 حبة خلال الموسمين وعدد حبوب السنبلة في الموسم الثاني. طبقاً للتفاعل بين معاملات الري وأصناف القمح، من الواضح أن الثلاثة أصناف لها قدرة محصولية عالية تحت الري العادي كما لها أيضاً أداء جيد تحت ظروف الإجهاد المائي مع بعض الأفضلية للصنف مصر 4والذي تفوق معنوياً على الصنفين الآخرين خلال الموسم الثاني.