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Evaluation of some Bread Wheat Cultivars Productivity as Affected by Sowing Dates and Water Stress in Semi-arid Region

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ABSTRACT

Agriculture is inherently sensitive to weather and climate especially water supply and heat changes. Adaptation of an appropriate economic management strategy is one of the likely decisions to cope with the impacts of climate changes. The effect of the potential impact of three sowing dates; first sowing date (16th November, FSD), second sowing date (1st December, SSD) and third sowing date (16th December, TSD) on two wheat cultivars (Giza 168 and Sakha 93) under three levels of water stress (irrigation every: 10; 15 and 20 days) was studied at the Farm of Environmental Agricultural Sciences Faculty, El-Arish, during two winter seasons (2009/2010; 2010/2011). Results showed that the Second Sowing Date (SSD) gave superiority of wheat grain yield and most of its components, in response to increasing heat temperature at anthesis stage. Most of growth characters, grain yield and its components of Sakha 93 cultivar were greater than Giza 168 under both stressed and non-stressed conditions; this cultivar could be adapted to heat and water stress more than the other one in relation to its genetic stability under unfavorable conditions and its positive response to late sowing date. Water Consumptive Use (WCU) means by Sakha 93 was higher than those of Giza 168 under all water stress levels; superiority was recorded for 10 day interval.

Key words: Wheat cultivars, sowing dates, water stress, grain yield, relative water content, water consumptive use, grain protein content

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major cereal crop in many parts of the world and it is commonly known as king of cereals. In Egypt, its cultivated area reached about 2.7-2.9 million feddan in the winter season of 2007/2008 produced an average of 18.1-18.2 ardab per feddan of grain (FAO, 2008). Planting date is one of the most important agronomic factors involved in producing high yielding small grain cereal crops, which affects the timing and duration of the vegetative and reproductive stages. Mahfouz (1992), Ouda *et al.* (2005), Qasim *et al.* (2008) and Hozayn and Abd El-Monem (2010) found that the highest values of some vegetative characters, yield attributes and grain yield as well as enhancement in biological and economic yield were occurred when wheat was planted earlier. The reduction in wheat grain yield and its attributes with delaying sowing date was as a result of exposure plants to high temperature, which reduces season length (Naceur *et al.*, 1999; Abd El-Monem, 2007; Mostafa *et al.*, 2009). Yield reduction in wheat under heat stress could be caused by accelerating phase's development, accelerated senescence, increased respiration, reduced photosynthesis and inhibition of starch synthesis in developing kernels (Hamam and Khaled, 2009). Water deficiency affects physiological and biochemical processes in plants (Osborne *et al.*, 2002). During wheat vegetative growth, under water stress, leaves became smaller, which results in low leaf area index (Gardner *et al.*, 1985), low tillers per plant, as well as low shoot dry weight (Mosaad *et al.*, 1995; McMaster, 1997). Also, early grain development stage is more vulnerable to water stress than latter grain development stage (El-Kholy *et al.*, 2005). Applying highest irrigation water levels to wheat genotypes produced lowest wheat yield (Ouda *et al.*, 2010). In contrast, Saleh (2011) found that drought caused great reduction in grain yield, yield attributes and relative water content.

To meet up the increasing demand for food grains, efforts are being made to develop modern wheat cultivars with high yield potential. In this respect, Ashmawy and Abo-Warda (2002) showed that Giza-168 wheat cv., significantly surpassed Sids-1 and Gemmeiza-9 cvs., in grain yield and number of grains/spike. While, Nouri-Ganbalani *et al.* (2009) reported that under normal irrigation, no significant correlation was observed between the grain yield and other morphological characters but under drought stress conditions, there were positive highly significant correlations between grain yield and 1000 grain weight. Also, Abd El-Hmeed (2005) and Zeidan *et al.* (2009) concluded that Giza-168 wheat cv., gave higher values of most of yield attributes, grain and straw yields as compared to Sakha-93 but under water stress (Abd El-Kareem and El-Saidy, 2011) found that Sakha 93 may be considered the best parents for drought recovering ability and can be crossed to produce new crosses with desirable characters related to drought tolerance.

Therefore, the aims of this study are to assess the varietal differences between the two studied cultivars; To investigate the impact of sowing dates on Water Consumptive Use (WCU), yield and its components of wheat and to evaluate economically the used wheat cultivar under water and heat stress in semi-arid regions and similar areas.

MATERIALS AND METHODS

Two field experiments were carried out at the Experimental Farm of Faculty of Environmental Agricultural Science, El-Arish, North Sinai Governorate, Egypt, during two successive winter seasons of 2008/2009 and 2009/2010 on bread wheat. Soil texture was sandy loam with pH 7.66 and EC 6.87 m mhos cm^{-1} 1:5 as average over the two seasons. Monthly Relative humidity (%), maximum and minimum temperature (C°) and precipitation rate (mm) were obtained from El-Arish climatic station, ARC, at 2009, 2010 and 2011 seasons are presented in respective (Fig. 1-4).

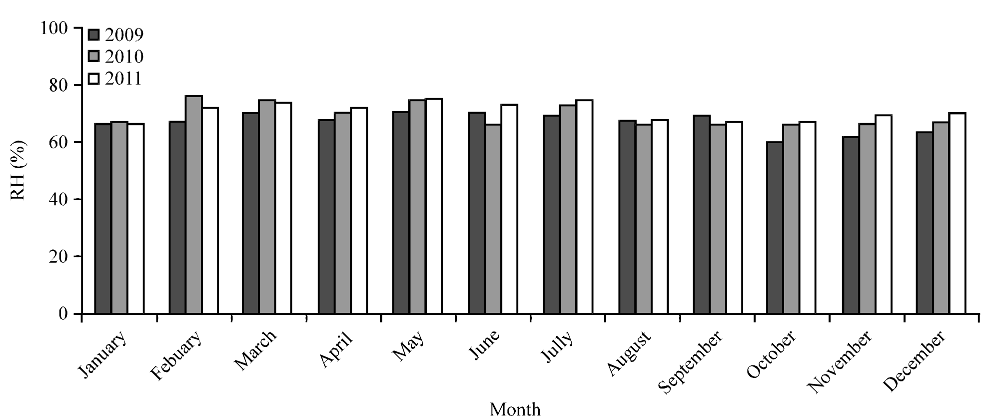

Fig. 1: Means of relative humidity (RH) at 2009-2011 seasons

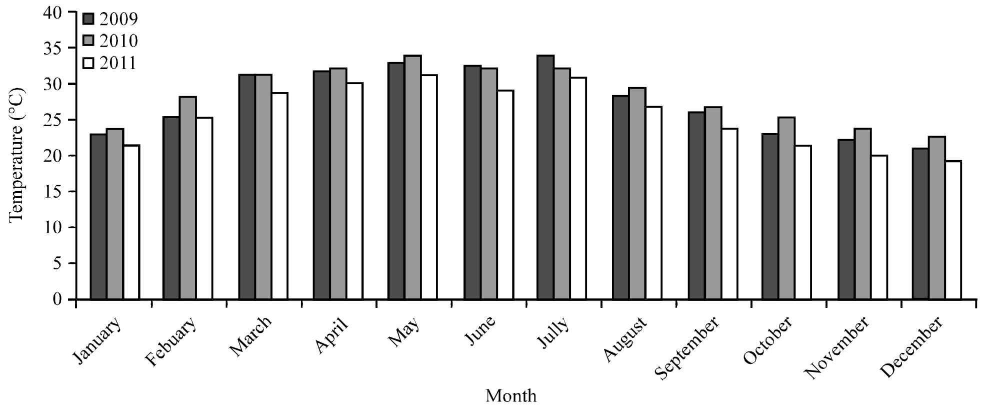

Fig. 2: Maximum temperature at 2009-2011 seasons

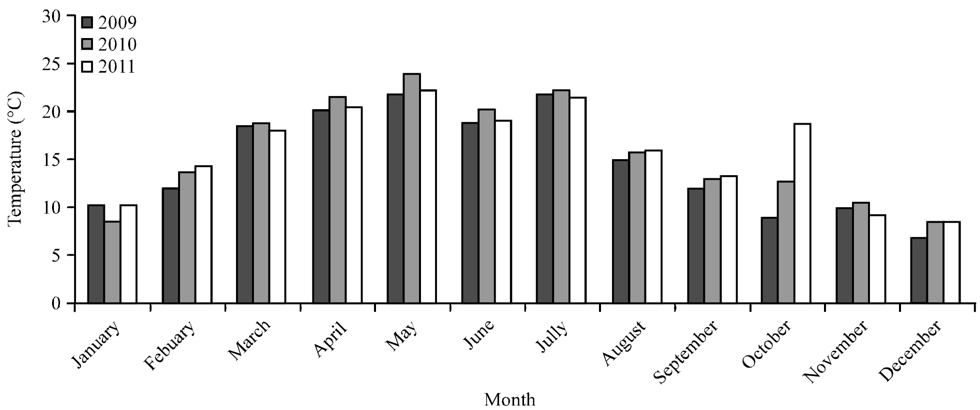

Fig. 3: Minimum temperature at 2009-2011 seasons

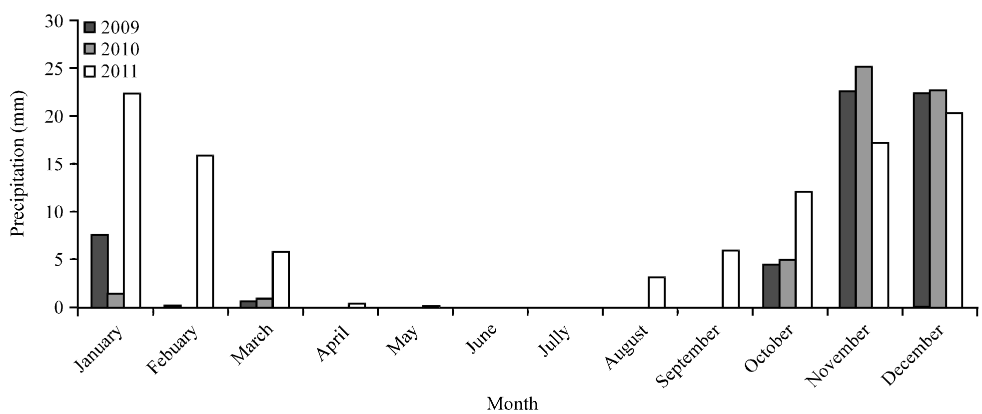

Fig. 4: Means of precipitation rate (mm) at 2009-2011 seasons

Each experiment included 18 treatments; three planting dates (16^{th} November, 1st December and 16^{th} December), three water stress levels (irrigation every 10, 15 and 20 days; as total irrigation numbers of 18, 12 and 9, respectively) and two bread wheat cultivars (Sakha 93 and

Giza 168) with three replicates in a split-split plot design and the sub-sub plot area was 12 m^2 (3×4 m = 1/350 feddan). Seeding rate was 60 kg $fed.^{-1}$ Surface irrigation was used with water salinity ranked 3800 and 4200 ppm. Organic fertilizer (20 $m^3 fed.^{-1}$) and mono supper phosphate (31 kg $fed.^{-1}$, 15% P_2O_5) were added at land preparation. Nitrogen fertilizer (Urea, 75 kg $fed.^{-1}$, 46%N) was separated in two equal doses and was added prior to the first and second irrigation in both seasons but potassium sulfate (50 kg $fed.^{-1}$, 48% K_2O) was applied at booting stage. After 120 days from sowing (after heading stage) plant height (cm) and flag leaf area (cm^2) were estimated as vegetative characters. The Relative Water Content (RWC %) was estimated of fully expanded flag leaves according to Barrs (1986) using the following formula:

$$\text{RWC (\%)} = \frac{\text{FW-DW}}{\text{SW-DW}} \times 100$$

where, F, D and S weights referred to leaves fresh, dry and saturated weights, respectively.

Soil moisture sampling was collected before irrigation to calculate water consumptive use according to Israelsen and Hansen (1962) using the following equation:

$$\text{CU} = (\theta 2\text{-}\theta 1) \times \text{Bd} \times \text{ERZD}$$

where, CU is amount of water consumptive use (mm) $\theta 2$ and $\theta 1$ is soil moisture percentage after irrigation and before the following irrigation, respectively, Bd is bulk density (g cm^{-3}) and ERZD is effective root zone depth (cm).

At harvest time (ripening stage, Zadoks *et al*., 1974), one meter square was randomly selected from each experimental plot to estimate: spike length (cm), number of spikes/plant, number of spikes/m^2, number of grains/spike, grains weight/plant (g) and 1000 grain weight (g). Wheat plants were manually harvested on the second week of May in both seasons from all area of each experimental plot (3×4 m) and left on air to dry (13% moisture) then grain, straw and biological yield in kg per plot were determined and converted to ton per feddan. Grain protein content (GPC, %) was determined according to AACC (2000) on dry weight basis.

All data were subjected to statistical analysis according to Snedecor and Cochran (1990). The combined analysis was conducted for the data of both seasons according to Steel and Torrie (1980). The Least Significant Difference (LSD at 5%) was used to compare the treatments means.

RESULTS AND DISCUSSION

Effect of sowing date: Results presented in Table 1 show significant effects ($p<0.05$) of different sowing dates on all the studied characters except 1000 grain weight and grain protein content (GPC, %) of bread wheat. The highest values of plant height (93.37 cm), flag leaf area (26.02 cm^2), spike length (9.87 cm), No. spikes/plant (3.11), No. grains/spike (63.12), grain weight/plant (5.88 g), relative water content (92.55%), grain yield (2.033 ton fed.) and straw yield (1.914 ton $fed.^{-1}$) were obtained when wheat cultivars planted in the 1st December. While, delaying wheat cultivation to 30th December gave the lowest values for all the previous characters compared with the other sowing dates. Wheat plants sown at 1st December could reserve more water content in their flag leaves (92.55%) and manifested highest water consumptive use value (328.23 mm) than those planted at 16th November and 30th December.

At the second sowing date (1st December), wheat plants out yielded more than those of the other two sowing dates by 13.97 and 8.16% for grain yield, 7.16 and 23.01% for straw yield and

Table 1: Effect of wheat sowing dates on the studied characters in combined analysis (2009/2010 and 2010/2011 growing seasons)

	Sowing dates			
Parameter	16th November	1st December	16th December	LSD at 5% level
Plant height (cm)	91.080	93.370	89.250	2.64
Flag leaf area (cm^2)	22.660	26.020	20.110	2.32
Spike length (cm)	8.050	9.870	6.080	1.11
No. of spikes/plant	2.920	3.110	2.120	0.26
No. of grains/spike	58.860	63.120	57.660	1.65
Grains weight/plant (g)	4.910	5.880	4.380	1.72
No. of spikes/m^2	282.600	281.200	280.600	1.30
1000 grain weight (g)	28.340	28.810	31.880	ns
RWC (%)	90.220	92.550	90.020	1.60
CU (mm)	318.660	328.230	300.680	6.12
Grain yield (ton $fed.^{-1}$)	1.786	2.035	1.882	0.06
Straw yield (ton $fed.^{-1}$)	1.784	1.914	1.556	0.083
Biological yield (ton $fed.^{-1}$)	4.460	4.858	4.155	0.150
GPC (%)	11.780	11.880	11.110	ns

RWC: Relative water content, CU: Consumptive use, GPC: Grain protein content, LSD: Least significant difference, ns: Not significant

8.92 and 16.91% for biological yield than those sown in respective mid-November and mid-December. These results could be attributed to the appropriate weather conditions prevailing during growth and development of SSD plants whom received adequate amounts of rainfall at blooming stage and appropriate temperature at anthesis stage (Fig. 2, 4) and this in turn increased net assimilation rate, growth and productivity of wheat. These results were in agreement with those obtained by Ouda *et al.* (2005) whom reported that planting wheat in early December increased season length through increasing number of days to anthesis and consequently number of days to physiological maturity. Recently, Hamam and Khaled (2009) and Hozayn and Abd El-Monem (2010) concluded that, sowing at favorable date where heat units and metabolites stored in favorable sowing date caused taller plants, vigorous growth and taller spikes. These results are in harmony with those obtained by Mahfouz (1992), Witt (1996) and El-Gizawy (2009).

Effect of water stress levels: Significant effect ($p<0.05$) of water stress levels; i.e. irrigation every 10, 15 and 20 days, on bread wheat vegetative growth, water relations, yield and its attributes as well as Grain Protein Content (GPC%) in combined analysis over the two studied seasons are presented in Table 2. Results showed that irrigation of wheat plants at short intervals every 10 days (18 irrigation till harvest) led to the tallest plants and spikes, largest flag leaf area and highest values of the numbers of; spike/plant, grains/spike, spikes/m^2 and grains weight/plant as well as 1000 grain weight than those irrigated at medium and long intervals; i.e., every 15 and 20 days (12 and 9 irrigations, respectively). Non-stressed plants (10 days irrigation interval) gave superiority of relative water content and water consumptive use (93.8% and 321.64 mm, respectively), while the lowest values (89.2% and 318.87 mm, respectively) were obtained from the highest stressed plants (20 day interval). Increasing irrigation intervals from 10 up to 15 and 20 days decreased grain yield from 2.162 to 1.815 and 1.680 ton $fed.^{-1}$, respectively. Meanwhile, the highest value of straw yield (2.044 ton $fed.^{-1}$) was gained when plants irrigated every 10 days but the lowest value (1.669 ton $fed.^{-1}$) was obtained when plants received 12 irrigations (15 day interval). An opposite trend was found for GPC %, since plants grown under water stress conditions (irrigation every 20 days) accumulate more protein in their grains (12.3%) when compared with

Table 2: Effect of water stress levels on the studied characters in combined analysis (2009/2010 and 2010/2011 growing seasons)

	Irrigation interval (day)			
Parameter	10	15	20	LSD at 5% level
Plant height (cm)	94.300	91.100	89.200	2.300
Flag leaf area (cm^2)	27.820	23.560	20.110	3.530
Spike length (cm)	8.500	8.100	7.600	0.330
No. of spikes/plant	3.500	3.100	2.700	0.300
No. of grains/spike	62.600	59.800	56.600	0.760
Grains weight/plant (g)	6.110	4.640	4.020	0.880
No. of spikes/m^2	281.400	281.600	277.400	4.600
1000 grain weight (g)	31.210	28.350	26.720	3.220
RWC (%)	93.800	91.300	89.200	2.600
CU (mm)	321.640	319.910	318.830	2.440
Grain yield (ton $fed.^{-1}$)	2.162	1.815	1.680	0.101
Straw yield (ton $fed.^{-1}$)	2.044	1.669	1.703	0.066
Biological yield (ton $fed.^{-1}$)	4.535	4.881	4.365	0.121
GPC (%)	11.130	12.240	12.360	0.080

RWC: Relative water content, CU: Consumptive use, GPC: Grain protein content, LSD: Least significant difference

the other treatments (11.1 and 12.2%, for 15 and 10 day intervals, respectively). Positive impact of 10 day interval treatment on growth and yield traits could be due to the sufficient soil moisture in the root zone which increased the capacity of wheat plant in photosynthesis and consequently increased spikes number, grain weight (g) and flag leaf area as well as relative water content which have indirect contribution in carbohydrates transfer from source to sink. This result is in agreement with those obtained by Siddique *et al.* (1999) and El-Abady *et al.* (2009). They reported that the reduction in growth and yield components due to water stress during grain filling might have been due to the inhibition in photosynthesis efficiency under insufficient water conditions. Similar results have been reported by Gupta *et al.* (2001) and Zeidan *et al.* (2009).

Cultivar differences: Data presented in Table 3 show that Sakha 93 and Giza 168 cultivars are differed significantly at 0.05 probability levels in all the studied characters except the plant height. It was evident, from the combined analysis, that Giza 168 wheat cultivar had surpassed in flag leaf area (25.61 cm^2), number of spikes/plant (3.1), number of grains/spike (65.2) and grains weight/plant (5.34 g) than Sakha 93. Meanwhile, Sakha 93 gave more number of spikes/m^2 and weighed more grams of 1000 grain and its superiority was by 8.85 and 14.78% for the above respective yield attributes as compared with Giza 168 cultivar. Water Consumptive Use (WCU) value was higher for Sakha 93 than Giza 168 by 10.21%, while the relative water content was greater (93.8%) for Giza 168 than that of Sakha 93(90.3%). The superiority of Sakha 93 wheat cultivar over Giza 168 is confirmed for wheat yields and grain protein content. Sakha 93 cultivar out yielded more grain, straw and biological yields than Giza 168 cultivar (Table 3) by 4.82, 6.98 and 17.94%, respectively, as compared with Giza 168 cv. This finding was expected since it ranked the top in number of spikes per square meter and 1000-grain weight. The varietal differences were reported by many investigators; among them Hassan *et al.* (2002), Allam (2005), and Zeidan *et al.* (2009).

Table 3: Varietal differences of wheat cultivars (Sakha 93 and Giza 168) on the studied characters in combined analysis (2009/2010 and 2010/2011 growing seasons)

	Cultivars		
Parameter	Sakha 93	Giza 168	LSD at 5% level
Plant height (cm)	92.400	93.200	ns
Flag leaf area (cm^2)	22.110	25.610	2.33
Spike length (cm)	8.600	9.600	0.20
No. of spikes/plant	2.800	3.100	0.20
No. of grains/spike	54.400	65.200	1.10
Grains weight/plant (g)	4.620	5.340	0.41
No. of spikes/m^2	291.300	267.600	7.30
1000 grain weight (g)	30.360	26.450	2.03
RWC (%)	90.300	93.800	1.60
CU (mm)	336.800	305.600	8.30
Grain yield (ton $fed.^{-1}$)	1.924	1.845	0.06
Straw yield (ton $fed.^{-1}$)	1.885	1.752	0.008
Biological yield (ton $fed.^{-1}$)	4.113	4.851	0.113
GPC (%)	12.130	11.210	0.120

RWC: Relative water content, CU: Consumptive use, GPC: Grain protein content, LSD: Least significant difference

Table 4: Effect of sowing date, water stress levels and varietal differences between wheat cultivars in some studied characters in combined analysis (2009/10 and 2010/11)

Treatments	Irrigation interval (day)	Cultivar	Plant height (cm)	Flag leaf area (cm^2)	Spike length (cm)	No. of spikes ($plant^{-1}$)	No. of grains ($spike^{-1}$)
FSD	10	Sakha 93	93.30	25.42	7.70	3.30	57.80
		Giza 168	95.50	29.68	10.80	3.40	68.40
	15	Sakha 93	91.40	23.64	7.30	2.90	54.30
		Giza 168	93.40	24.33	9.60	3.20	65.30
	20	Sakha 93	88.60	18.66	7.10	2.40	51.60
		Giza 168	90.30	21.87	8.20	2.80	61.50
LSD at 5% level			2.20	1.66	0.77	0.09	2.10
Mean			92.06	23.89	8.45	3.10	59.78
SSD	10	Sakha 93	95.40	28.62	9.70	3.60	61.80
		Giza 168	97.60	32.83	11.80	3.80	72.40
	15	Sakha 93	93.60	26.33	9.50	3.30	58.10
		Giza 168	95.80	27.25	11.70	3.50	69.80
	20	Sakha 93	91.20	21.81	9.20	2.80	55.30
		Giza 168	92.60	24.66	10.30	3.10	65.80
LSD at 5% level			1.70	1.82	0.76	0.11	2.80
Mean			94.33	26.86	10.35	3.33	63.78
ThSD	10	Sakha 93	91.20	23.22	5.30	2.90	56.30
		Giza 168	94.30	27.12	8.60	2.80	67.20
	15	Sakha 93	89.30	21.34	5.10	2.30	53.10
		Giza 168	91.60	22.13	7.70	2.70	64.40
	20	Sakha 93	86.30	16.36	4.80	2.10	50.30
		Giza 168	89.10	18.88	6.80	2.30	60.60
LSD at 5% level			1.60	1.13	1.30	0.04	1.88
Mean			90.20	21.51	6.36	2.49	58.57

FSD: 1st sowing date, 16th November, SSD: 2nd sowing date, 1st December, ThSD: 3rd sowing date, 16th December

Table 5: Effect of sowing date, water stress levels and varietal differences between wheat cultivars in some studied characters in combined analysis (2009/10 and 2010/11)

Treatments	Irrigation interval (day)	Cultivar	Grain weight plant^{-1} (g)	No. of spikes (m^{-2})	1000 grain weight (g)	RWC (%)	CU (mm)
FSD	10	Sakha 93	5.61	295.80	32.11	92.30	337.80
		Giza 168	6.65	288.60	30.34	95.80	305.20
	15	Sakha 93	4.38	292.60	31.65	90.80	336.60
		Giza 168	4.97	267.40	25.13	93.20	302.60
	20	Sakha 93	3.83	289.10	30.42	88.40	334.10
		Giza 168	4.29	265.10	23.16	89.20	298.10
LSD at 5% level			0.12	9.90	2.06	1.90	7.11
Mean			4.88	283.00	28.81	91.56	319.10
SSD	10	Sakha 93	7.26	296.30	35.22	94.50	348.10
		Giza 168	7.51	271.40	28.33	97.60	316.50
	15	Sakha 93	6.12	294.20	33.08	92.30	345.60
		Giza 168	5.58	269.80	24.62	94.80	312.80
	20	Sakha 93	4.99	290.30	31.11	90.80	344.30
		Giza 168	4.62	266.50	22.81	91.40	310.10
LSD at 5% level			0.17	6.60	2.14	3.10	8.16
Mean			6.03	280.67	29.08	93.46	329.50
ThSD	10	Sakha 93	5.13	293.40	35.22	90.50	325.60
		Giza 168	6.27	286.70	36.33	94.20	288.90
	15	Sakha 93	3.88	290.80	34.13	88.90	324.30
		Giza 168	4.52	265.50	28.79	91.60	278.80
	20	Sakha 93	3.58	285.80	34.28	86.70	322.70
		Giza 168	3.55	264.80	25.71	88.60	270.40
LSD at 5% level			0.09	4.30	1.46	1.10	4.50
Mean			4.78	281.2	32.36	90.07	301.70

FSD: 1st sowing date, 16th November, SSD: 2nd sowing date, 1st December, ThSD: 3rd sowing date, 16th December; RWC: Relative water content, CU: Consumptive nse

Effect of interaction: Data presented in Table 4 show significant effects ($p<0.05$) of sowing dates×irrigation intervals×wheat cultivars for all the studied characters. Combined analysis data clear that the highest values of plant height (97.6 cm), spike length (11.8 cm) and flag leaf area (32.83 cm^2) were obtained when Giza 168 wheat cultivar planted in the 2nd sowing date and irrigated every 10 days. Also, superiority in numbers of spikes/plant and grains/spike (3.8 and 72.4) were obtained from the previous interaction treatment of SSD×10 day interval×Giza 168 CV.

Significant effect at $p<0.05$ level of sowing dates×irrigation intervals×wheat cultivars was found for all the studied characters (Table 5). Planted Sakha 93 wheat cultivar at 1st December and irrigated every 10 days gave superiorities in number of spikes/m^2 (296.0) and water consumptive use (348.11 mm). Meanwhile, the highest 1000 grain weight (36.33 g) was obtained when Giza 168 wheat planted at mid-December and irrigated every 10 days. Furthermore, Interaction of sowing date of 1st December×Sakha 93×irrigation every 10 days gave most grain, straw and biological yields (2.485, 2.202, 5.662 ton fed.$^{-1}$, respectively, Table 6). However, sowing Sakha 93 cultivar at 1st December and irrigated every 20 days gave the maximum grain protein content (12.9%) as compared with the all other interaction treatments.

Table 6: Effect of sowing date, water stress levels and varietal differences between wheat cultivars in some studied characters in combined analysis (2009/10 and 2010/11)

			Yield (ton fed.$^{-1}$)			
Treatments	Irrigation interval (day)	Cultivar	Grain	Straw	Biological yield	GPC (%)
FSD	10	Sakha 93	2.116	2.118	5.006	11.60
		Giza 168	1.197	2.004	4.462	11.20
	15	Sakha 93	1.926	2.001	4.881	12.40
		Giza 168	1.712	1.581	4.866	11.10
	20	Sakha 93	1.746	1.723	4.662	12.80
		Giza 168	1.618	1.566	3.605	11.80
LSD at 5% level			0.103	0.062	0.101	0.03
Mean			1.721	1.826	4.578	11.70
SSD	10	Sakha 93	2.485	2.202	5.662	11.80
		Giza 168	2.041	2.068	5.436	11.40
	15	Sakha 93	2.282	2.012	5.055	12.60
		Giza 168	2.112	1.785	5.002	11.50
	20	Sakha 93	2.013	1.811	4.806	12.90
		Giza 168	1.523	1.695	4.998	12.10
LSD at 5% level			0.106	0.088	0.041	0.06
Mean			2.075	1.927	5.157	12.10
ThSD	10	Sakha 93	2.279	2.003	4.865	11.30
		Giza 168	2.181	1.884	4.068	11.10
	15	Sakha 93	2.177	1.798	4.521	12.10
		Giza 168	1.661	1.385	4.435	10.80
	20	Sakha 93	2.076	1.572	4.311	12.40
		Giza 168	1.325	1.319	3.276	11.30
LSD at 5% level			0.006	0.012	0.007	0.04
Mean			1.948	1.661	4.245	11.50

FSD: 1st sowing date, 16th November, SSD: 2nd sowing date, 1st December, ThSD: 3rd sowing date, 16th December, GPC: Grain protein content

Economic evaluation for the field trails results

Net income and pound invested return: According to the previous field results of sowing the two wheat cultivars (Giza 168 and Sakha 93), at the first of December and taking 18 irrigations long the growing season, the economic evaluation was done at the local cost of the two seasons. Table 7 show the economic efficiency of sowing the two investigated wheat cultivars under semi-arid conditions of northern Sinai. It is clear that the feddan net return has reached about 3052 Egyptian pounds of Sakha 93 as compared to 2383 Egyptian pounds of Giza 168. Considering the cost of production, which came closer with rising productivity per feddan for the Sakha 93 wheat cultivar and the output of grain which reached 14.3 ardab as compared with 12.8 ardab

Table 7: Net income and pound invested return for the two wheat cultivars under semi-arid region conditions in northern Sinai in 2011

Indicators	Giza 168	Sakha 93
Grain productivity (ardab/fed.)	12.80	14.30
Straw productivity (heml/fed.)	8.50	9.60
Production costs (LE)	3064	3075
Revenues (LE)	5447	6109
Net return (LE/fed.)	2383	3052
Invested pound return	0.78	0.99

Table 8: Economic evaluation criteria for the cultivation of the two wheat cultivars under semi-arid conditions within the territory of the North Sinai during the year 2011

Economic evaluation criteria	Giza 168	Sakha 93
Net present value (NPV)	-452.3	3679.1
Benefit/cost (B/C)	0.99	1.09
Internal rate of return (IRR)	10	14
Capital pay back period (CPBP)	10	7

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Table 9: Economic evaluation criteria for the cultivation of the two wheat cultivars under high temperature conditions within North Sinai in 2011

Indicators	Giza 168	Sakha 93
Net present value (NPV)	1701	6184
Benefit/cost (B/C)	1.04	1.15
Internal rate of return (IRR)	10	14
Capital pay back period (CPBP)	10	7

of Giza 168 cv. (ardab = 150 kg). Also, results indicate high productivity per feddan of the by-product of Sakha 93 cultivar, where the return of the invested pound has reached 0.99 but it decreased to 0.78 for the Giza 168 cv., each 1000 pounds paid on the production process achieved a return of 999 pounds fed.$^{-1}$.

Economic evaluation criteria: Table 8 shows the results of economic assessment of the studied two wheat cultivars under semi-arid conditions of northern Sinai, when the discount factor is 10%, which the results confirms superiority of Sakha 93 cv. as compared with Giza 168 cv. as well as the results indicate that the internal return rate has reached 14% of Sakha 93 cv. as compared with 10% to Giza 168 cv. The percentage of return cost of 1.09 of Sakha 93 wheat cultivar as compared to 0.99 for Giza 168 cv. also, gave a positive value equal to 3679.1 for Sakha 93 wheat cultivar. Results show that the Capital Pay Back Period (CPBP) had reached 7 years for Sakha 93 cv. as compared to 10 years for Giza 168 wheat cultivar, which indicates the feasibility of expansion in Sakha 93 cv. cultivation at the optimum sowing date as recommended in the field experiment results under high temperature conditions in North Sinai.

Meanwhile, results in Table 9 show standards of economic implementation to grow wheat cultivars under water and heat stress conditions within the territory of North Sinai in 2011 when the discount factor reached 8% per year. Also, results confirm that the internal return rate had reached 14% for Sakha 93 wheat cv. as compared to 10% to Giza 168 cv. while, the percentage of return cost was 1.15 for Sakha 93 cv. as compared to 1.04 for Giza 168 cv. The results indicated that NPV for Giza 168 had reached about 1701 LE as compared to 6184 for Sakha 93 cv. and CPBP has reached 7 years for Sakha 93 cv. as compared to 10 years for Giza 168 cv. This indicates the feasibility of expansion in the cultivation of Sakha 93 wheat cultivar under semi-arid conditions in North Sinai and similar area.

CONCLUSION

It can be recommended from the previous field and economic evaluation for growing wheat cultivars under semi-arid regions conditions that sowing Sakha 93 wheat cultivar at the first of December and irrigated using surface irrigation every 10 days gave superiorities for grain, straw and biological yields, which return more benefit for the growers in this areas, which suffer from water and heat stress and similar conditions.

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