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(Original Article)

Evaluation of Grain Yield and its Attributes in Bread Wheat Cultivars Under Heat Stress Conditions

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Abstract

This study was conducted at Al-Ghuraira Village, Esna Center, Luxor Governorate, Egypt to evaluate the performance of twelve bread wheat cultivars under heat stress (late planting dates) in newly reclaimed soil during 2017/2018 and 2018/2019. Twelve bread wheat cultivars (Giza 168, Giza 171, Sids 1, Sids 12, Sids 14, Gemmeiza 9, Gemmeiza 11, Misr 1, Misr 2, Misr 3, Shandwell 1 and Sakh 94) were grown at three planting dates (November 20, December10 and December 30). Each planting date in each season was considered as a separate experiment. The experimental design for each sowing date was a randomized complete block design (RCBD) with three replications. The obtained result show that the tested sowing dates, bread wheat cultivars and their interaction had a highly significant effect on height of height and spike length, spikes number m^{-2}, number of kernels $spike^{-1}$, 1000-kernel weight and grain yield $fed.^{-1}$ in both seasons. Moreover, sowing Sids 12 bread wheat cultivar on 20 November recorded the high average values of grain yield (3.03 and 3.11 ton/fed. in the two respective seasons). As for the heat sensitivity index (H.S.I), 6 out of 12 cultivars showed H.S.I values less than unity for the second planting date and 5 cultivars for the late planting date in both seasons, which indicates that these varieties were more tolerant to heat stress. Moreover, it appears that the Misr 1 cultivar was more tolerant to heat stress, as it showed heat sensitivity index values less than unity at the two late planting dates.

Keywords: *Bread wheat cultivars, Grain yield and its attributes, Sowing dates.*

Introduction

Wheat (*Triticum spp*. L.) is considered one of the most important cereal crops in the world. In Egypt, wheat is the main winter cereal crop, and it ranks first in terms of area. The cultivated area of wheat in 2021/2022 season reached about 1,394,558 produced about 9 million tons with an average of 6.454 t/ha. While the consumption reached about 19 million tons yearly so the gap between production and consumption overrides 10 million ton year-1 (FAO, 2022).

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To reduce the gap between production and consumption, high-yielding varieties must be selected, planted at the appropriate time, supplied with their nutritional needs in sufficient quantity and at the appropriate time, all other growth factors must be provided, and losses during harvesting and storage must be reduced.

Planting date decides the growth habit of the crop as climatic conditions vary from optimum conditions. Cereals respond significantly to varying environmental features as their growth and grain development is highly temperature and moisture dependent. Late planting dates represent a sort of heat stress on the wheat crop, which causes the plant to obtain its thermal needs in a short time, which leads to the plant shortening each stage of growth, but this effect varies depending on the variety grown and the extent of its resistance to the heat stress prevailing at the time of late planting. In addition, the timing of sowing has a significant influence on phenophases, grain production, and wheat components (Mohamed *et al*., 2022). Livelong vegetative development phase, as a result of sowing at the suitable sowing date, to improve radiation use efficiency and dry matter accumulation and thus the optimum values for grain yield and its components.

Therefore, it is very important to the choice a suitable sowing date and there are enough possibilities to increase wheat yields through developing new high yielding cultivars and by adopting proper sowing date. Thus, the sowing date and genotype are the most important factors that affect wheat grain yield and quality. El hag (2012) & El- Sayed *et al*. (2018) stated significant variation in yield and its components among wheat genotypes under normal and late planting. They also reported that delaying sowing date reduced number of kernels spike^{-1}, 1000-kernel weight and grain yield. Mohamed *et al*. (2022) studied the effect of two sowing dates (November 25th and December 25th) on the phenology, grain yield, and grain component composition of four Egyptian bread wheat cultivars (Sids 14, Shandwell 1, Giza 171, and Gemmeiza 12) the obtained results indicated that seeding late (25 December) considerably reduced all characters in both seasons when compared to the optimum sowing date (25 November), except for 1000-grain weight, which remained the same. Also, Sids 14 cultivar outperformed the other cultivars in all evaluated traits including grain yield.

The objectives of this study were to evaluate bread wheat planting timing affecting yield and determine the better bread wheat cultivar under different studied planting dates.

Material and Methods

This study was conducted at Al-Ghuraira Village, Esna Center, Luxor Governorate, Egypt to evaluate the performance of twelve bread wheat cultivars under heat stress (late planting dates) in newly reclaimed soil during 2017/2018 and 2018/2019 seasons. The structure of the experimental soil site is loamy sand, comprising of 11.30 % clay, 3.82 % silt and 84.88 % sand with pH of 7.40 and EC 1.78 dsm^{-1}. Twelve bread wheat cultivars (Giza 168, Giza 171, Sids 1, Sids 12, Sids 14, Gemmeiza 9, Gemmeiza 11, Misr 1, Misr 2, Misr 3, Shandwell 1 and Sakh 94) were grown at three planting dates (November 20, December10 and December 30). Each planting date was considered as a separate experiment. The experimental design for each sowing date was a randomized complete block design (RCBD) with three replications consisting of twelve bread wheat cultivars. The area of the experimental plot was 3 × 3.5 m^2. The previous summer crop was corn during both seasons. All wheat recommendations packages have been implemented in Upper Egypt.

The prevailing temperatures and relative humidity during the experiment

Data presented in Table 1 shows the monthly means of the maximum and minimum temperatures (C^o) as well as relative humidity (%) for the experiment site during the growing seasons 2017/2018 and 2018/2019 (Central Laboratory for Agricultural Climate, Giza, Egypt).

Table 1 Means of monthly maximum and minimum temperatures as well as relative humidity during the 2019/20 and 2020 /2021 seasons

Weather factors	Season	Month						
		November	December	January	February	March	April	May
Maximum temperature	2017/2018	27.93	26.13	22.32	28.07	33.84	35.38	39.90
	2018/2019	28.07	22.35	20.97	23.39	26.87	32.53	40.02
Minimum temperature	2017/2018	13.07	11.26	7.03	11.11	15.87	19.21	25.10
	2018/2019	13.77	9.00	6.35	9.96	12.03	16.67	24.19
Relative humidity (%)	2017/2018	41.17	46.26	45.19	32.82	27.81	18.29	18.55
	2018/2019	39.70	50.58	41.74	36.96	27.90	29.26	23.84

Studied traits

1-Plant height (cm): as average height of ten guarded stems chosen randomly from each plot.

2- Spike length (cm): as average length of ten guarded spikes chosen randomly from each experimental unit.

3- Number of spikes m^{-2}: determined by counting the number of fertile spikes / m^2 from each plot.

4 -Number of kernels $spike^{-1}$: measured counted as an average number of grains collected per spike of ten spikes in each plot.

5-1000 kernel weight (g): recorded in grams (g) by the mean weight of random 1000-kernel samples.

6 -Grain yield/fed. (tons/fed.): Average grain weight for each experimental plot is weighted in kg and converted to tons/ fed.

Statistical analysis

Separate analysis of variance was done according to Snedecor and Cochran (1980) then homogeneity of errors using Bartlett's test (1937 was done and combined analysis for planting dates (ANOVA) was performed using the MSTATC statistic. Means of planting dates and genotypes were obtained and differences were estimated using LSD at the 5% probability level.

Heat sensitivity index

It was used as a measure of heat tolerance in terms of minimization of the reduction in yield caused by unfavorable versus favorable environments. H.S.I was calculated for each cultivar according to the formulae of Fisher and Maurer (1978):

$$\mathbf{HSI = [1- (Ys/Yp)] / [1- (\bar{Y}s/\bar{Y}p)]}$$

Ys, Yp, $\bar{Y}s$ & $\bar{Y}p$ represent grain yield for each cultivar under stress conditions, grain yield for each cultivar under optimum condition, mean of grain yield in all cultivars in stress and optimum conditions, respectively.

Heat susceptibility index (HSI) which its numerical low amounts (less than unity) indicated high tolerance of genotype to stress (Choukan, *et al*. 2006).

Results and discussion

1-Plant height (cm)

The results presented in Table 2 indicate that there is a highly significant effect of the studied planting dates on the height of plants characteristic of the wheat crop during the two seasons of the study. There were gradual decreases in plant height by delaying the planting date from the 20 of November to the 30 of December. The planting date 20 of November recorded the highest average values for plant height, which reached 94.1 & 106.9 cm in both respective seasons. The rate of increase in plant height at the first planting date over the other two planting dates was approximately 4.44 and 32.35%, respectively in the first season being, 4.92 and 29.65% in the second season in the same order, this shows that delaying the planting date from November 20 to December 10 led to a slight decrease in plant height, but increasing the delay to December 30 led to a sharp decrease in plant height. These differences in the height of plants between different planting dates is due to the differences in environmental conditions prevailing at the time of growth in the different planting dates, in which temperatures and humidity varied between them, as shown in Table 1, which led to obtaining the previous results. Similar trend was observed by Mohamed *et al*. (2022).

Moreover, the illustrated data in Table 2 reveal that the tested bread wheat cultivars had a highly significant ($P \leq 0.01$) influence on the plant height in the two growing seasons. Thus, the cultivar Giza 171 was significantly superior to most of the cultivars under study during the two growing seasons and gave the highest average values for plant height, reaching 92.6 & 97.1 cm for the first and second seasons, respectively. The difference between the cultivars in plant height is due to the genetic differences between the studied cultivars and the interaction with the prevailing environmental conditions, which favored the superiority of the Giza 171 cultivar due to the suitability of the weather conditions and its genetic makeup more than the rest of the cultivars under study. These results are similar to those reported by Mohamed *et al*. (2022), Saad *et al*. (2022), Alhabbar *et al*. (2023) and Tesfaye & Diriba-Shiferaw (2023).

Table 2. Means of plant height (cm) as affected by bread wheat cultivars, sowing dates and their interaction in 2017/18 and 2018/19 seasons

Seasons	2017/2018			Mean	2028/2019			Mean
Cultivars (C)	Sowing dates (D)				Sowing dates (D)			
	D1	D2	D3		D1	D2	D3	
Giza 168	81.0	85.4	66.5	77.6	92.3	90.3	62.0	81.6
Giza 171	99.7	102.0	76.1	92.6	103.3	98.3	89.7	97.1
Gemmeiza 9	90.6	94.1	68.5	84.4	103.1	103.7	79.3	95.4
Gemmeiza 11	95.2	95.0	78.3	89.5	97.3	98.7	73.0	89.7
Sids 1	92.2	94.6	69.1	85.3	103.0	104.0	83.3	96.8
Sids 12	94.1	91.8	82.5	89.5	103.7	97.3	80.0	93.7
Sids 14	84.7	86.7	68.7	80.0	88.7	88.0	62.7	79.8
Misr 1	90.0	93.8	69.5	84.4	99.3	93.3	70.7	87.8
Misr 2	92.9	101.1	82.8	92.2	104.7	98.0	82.7	95.1
Misr 3	91.3	91.4	72.8	85.2	97.7	93.0	81.3	90.7
Shandwell 1	89.9	87.2	72.5	83.2	102.0	93.0	69.3	88.1
Sakha 94	94.1	90.1	71.1	----	106.7	101.7	82.3	----
F test and L.S.D 0.05	**F test**		**L.S.D 0.05**		**F test**		**L.S.D 0.05**	
D	**		1.82		**		1.22	
C	**		1.98		**		2.46	
D × C	**		3.43		**		4.26	

Where D1 sowing at 20/11, D2 sowing at 10/12 and D3 sowing at 30/12
** mean significant at 1 % level of probability.

Furthermore, the exhibited data in Table 2 show that the plant height trait was affected significantly by the interaction between planting dates and bread wheat cultivars in the two growing seasons. The maximum mean values of plant height (102.0 and 104.7 cm in the two respective seasons) were recorded from Giza 171 cultivar which sown on 10 December in the first season and from Misr 2 cultivar which was sown on 20 November in the second one. These findings are in agreement with those obtained by Refay (2011), Hefny and Naheif (2018) and Mohamed *et al*. (2022).

2-Spike length (cm)

Results illustrated in Table 3 show that there is a highly significant effect of the planting dates under study on spike length in the two growing seasons. The first planting date on the 20 of February gave the highest values for spike length, reaching 13.0 and 12.2 cm in the first and second seasons, respectively, while the spike length decreased linearly by delaying the planting date to December 10 or December 30. These differences in the spike length between different planting dates is due to the differences in environmental conditions prevailing at the time of growth in the different planting dates, in which temperatures and humidity varied between them, as shown in Table 1 and resulting in differences between them in plant height and spike length. These results were confirmed with that confirmed by Mohamed *et al*. (2022).

Also, the presented data in Table 3 reveal that the tested bread wheat cultivars had a highly significant influence on spike length in the two growing seasons. Gemmeiza Gemmeiza 11 cultivar superior the other tested cultivars in this respect and produced the maximum mean values (12.8 and 13.0 cm in the two respective seasons). This may cause by the difference between the cultivars in genetic makeup and its interaction with environmental conditions, which was more suitable for the Gemmeiza 11 cultivar than the rest of the cultivars, so the previous result was achieved. These results are detected with those reported by Mohamed *et al*. (2022), Saad *et al*. (2022), Alhabbar *et al*. (2023) and Tesfaye & Diriba-Shiferaw (2023).

In addition, the illustrated data in Table 3 reveal that the interaction between planting dates and cultivars had a highly significant effect on the spike length in the first season only while the effect in the second season failed to be significant at 5 % level of probability. Sowing Gemmeiza 11 cultivar on 20 November produced the maximum mean value of spike length (13.4 cm) in the 2017/18 season. These results are confirmed with those obtained by Refay (2011), Hefny and Naheif (2018) and Mohamed *et al*. (2022).

Table 3. Means of spike length (cm) as affected by bread wheat cultivars, sowing dates and their interaction in 2017/18 and 2018/19 seasons

Seasons	**2017/2018**			**Mean**	**2028/2019**			**Mean**
Cultivars (C)	**Sowing dates (D)**				**Sowing dates (D)**			
	D1	**D2**	**D3**		**D1**	**D2**	**D3**	
Giza 168	12.1	12.2	11.0	11.8	11.5	11.5	10.0	11.0
Giza 171	12.3	12.2	11.2	11.9	12.6	11.9	10.9	11.8
Gemmeiza 9	12.8	12.2	10.1	11.7	12.1	12.1	10.3	11.5
Gemmeiza 11	13.4	12.6	12.3	12.8	13.9	13.5	11.7	13.0
Sids 1	12.5	12.4	11.1	12.0	12.8	11.5	10.6	11.6
Sids 12	12.2	12.6	11.5	12.1	12.1	11.8	10.7	11.6
Sids 14	11.8	11.7	10.4	11.3	11.9	11.6	9.5	11.0
Misr 1	11.6	11.0	10.1	10.9	11.4	10.6	9.9	10.7
Misr 2	11.6	10.9	10.6	11.0	11.6	10.4	9.8	10.6
Misr 3	11.4	11.0	10.9	11.1	11.3	11.0	10.5	11.0
Shandwell 1	11.9	11.9	10.8	11.6	12.4	11.9	10.1	11.5
Sakha 94	13.0	12.0	10.8	12.0	12.2	10.9	10.5	11.2
F test and L.S.D 0.05	**F test**		**L.S.D 0.05**		**F test**		**L.S.D 0.05**	
D	**		0.36		**		0.51	
C	**		0.45		**		0.45	
D × C	**		0.78		NS		NS	

Where D1 sowing at 20/11, D2 sowing at 10/12 and D3 sowing at 30/12
Ns and ** means non-significant and significant at 1 % level of probability, respectively.

3-Number of spikes per m^2

The exhibited data in Table 4 reveal that the tested sowing date had a highly significant effect on the number of spikes m-2 in the two growing seasons. Thus, sowing wheat on 20 November gained the maximum average values of spikes number m-2 (399.27 and 458.29 in the two respective seasons). Otherwise, delaying sowing date from 20 November to 10 or to 30 December decrease number of spikes per m^2 by the rate of 10.39 and 42.74 % in the 2017/18 season, respectively being 2.23 and 28.98 % in the 2018/19 season. These aforementioned results may be attributed to the effect of the low temperature accompanying the planting dates in December (Table 1), which make an decrease in the activity of cell division and elongation and the process of photosynthesis, which had a type of inhibitory effect on the growth of basal buds and the formation tillers, and thus led to a decrease in the number of ears per square meter for those dates compared to planting in November. Sasani *et al*. (2020) stated that the negative effects of late sowing date on bread wheat performance via poor germination, which causes a decrease in growth of individual plants and reduces number of spikes per plant under low temperatures when compared to recommend sowing date. These findings are in good line with those obtained by EL-Sayed *et al*. (2018) and Mohamed *et al*. (2022).

Furthermore, the illustrated data in Table 4 show that the studied bread wheat cultivars had a highly significant ($P \leq 0.01$) influence on spikes number m-2 in both seasons. Misr 1 bread wheat cultivar surpassed the other studied cultivars in this respect and recorded the highest average value of spikes number m-2 in the first season which was 413.3 spike /m^2, while Sids 1 one recorded the maximum mean value in the second season (470.4 spike/ m^2). These results could be attributed through presence of a clear degree of genetic variation that may contribute the adaptation and flexibility to diverse environmental conditions. Gomaa *et al*. (2018) who confirmed that such significant main effects of the genotypes and their interactions with environments like sowing dates show that these genotypes carry genes with different additives and additives by additives effects which seemed unstable and tended to rank differently from the environment to another. Also, the variations among studied bread wheat cultivars might be attributed to the genetic constitution of the cultivar. These results are harmony with those stated by Tahir *et al*. (2009); Hasina *et al*. (2012); Hassanein *et al*. (2012); Lak *et al*. (2013); Upadhyay *et al*. (2015) and Mohamed *et al*. (2022).

Moreover, the data presented in Table 4 focus that the interaction between sowing date and cultivars had a highly significant impact on the spikes number m-2 in the two growing seasons. Sowing Misr 2 cultivar on 10 December recorded the highest mean value of spikes number /m^2 in the first season (480.0 spike/m^2) while, sowing Misr 2 at the same previous sowing date in the second season produced the maximum mean value in this respect (503.3 spike/m^2). On the contrary, sowing Gemmeiza 11 in the first season or Giza 171 in the second one at 30 December (late sowing) recorded the lowest average values of spikes number in this respect which were 236.7 and 226.7 spike /m^2, respectively. Similar observations were detected by Mohamed *et al*. (2022).

Table 4: Means of spikes number/m^2 as affected by bread wheat cultivars, sowing dates and their interaction in 2017/18 and 2018/19 seasons

Seasons	2017/2018			Mean	2028/2019			Mean
Cultivars (C)	Sowing dates (D)				Sowing dates (D)			
	D1	D2	D3		D1	D2	D3	
Giza 168	407.7	316.7	273.3	332.6	494.3	398.0	404.0	432.1
Giza 171	308.7	280.0	246.7	278.4	391.7	483.3	226.7	367.2
Gemmeiza 9	362.0	380.0	320.0	354.0	491.0	463.3	393.3	449.2
Gemmeiza 11	372.7	260.0	236.7	289.8	411.0	343.3	340.0	364.8
Sids 1	425.7	410.0	263.3	366.3	482.3	493.3	435.7	470.4
Sids 12	409.0	400.0	303.3	370.8	464.3	466.7	340.0	423.7
Sids 14	414.7	413.3	246.7	358.2	417.7	403.3	346.7	389.2
Misr 1	403.3	343.3	303.3	350.0	461.0	503.3	353.3	439.2
Misr 2	436.7	480.0	323.3	413.3	455.0	477.3	346.7	426.3
Misr 3	400.7	340.0	266.7	335.8	481.0	436.7	330.0	415.9
Shandwell 1	453.3	320.3	290.0	354.6	481.0	439.3	390.0	436.8
Sakha 94	396.7	396.7	283.3	358.9	481.0	483.3	366.7	443.7
Mean	399.27	361.69	279.72	-----	459.28	449.26	356.09	-----
F test and L.S.D 0.05	**F test**		**L.S.D 0.05**		**F test**		**L.S.D 0.05**	
D	**		6.72		**		12.30	
C	**		13.60		**		17.63	
D × C	**		23.56		**		30.53	

Where D1 sowing at 20/11, D2 sowing at 10/12 and D3 sowing at 30/12
** mean significant at 1 % level of probability.

4-Number of kernels spike^{-1}:

It is clear from the data presented in Table 5 that the studied sowing date had a highly significant (P≤ 0.01) effect on the kernels number /spike in the two growing seasons. Wherein, sowing wheat on 20 November surpassed the others two studied sowing date (late sowing) in this respect and gained the maximum mean values of kernels number spike-1 which were 59.8 and 53.9 kernel/spike in the two studied seasons, respectively. The superiority of the planting date of November 20 over the planting dates on December 10 and December 30 in the number of grains per spike is due to the prevailing environmental conditions during growth and the processes of pollination and fertilization, such as appropriate temperatures and relative humidity, which accompany the first planting date and its suitability to increase the set rate, which gained an increase in the number of grains in the spike. On the contrary, high temperatures at late dates during the period during which the processes of pollination and fertilization occur, as is clear in Table 1, led to a decrease in the vitality of the pollen grains and thus a decrease in the number of grains per spike. These findings are in harmony with those obtained by Ren *et al*. (2019); Sayed *et al*. (2021) and Mohamed *et al*. (2022).

Here too, the exhibited data in Table 5 show that the kernels number spike-1 affected significantly by the tested bread wheat cultivars in both seasons. Thus, it is clear from the data obtained that there are highly significant differences among the studied cultivars under study in this trait, as the differences varied within one season and during the two seasons, where the variety Sids 14 recorded the highest average number of spike grains in the first season, amounting to 59.6. On the other hand, the Sakha 94 cultivar recorded the highest average number of spike grains in the second season, amounting to 55.3, while the Sids 12 cultivar recorded the lowest number of spike grains, amounting to 46.0, for the same season. These differences between the bread wheat cultivars under study in the number of spike grains are attributed to the genetic differences between those cultivars and their interactions with the prevailing environmental conditions at the time of planting and the occurrence of the processes of pollination and fertilization, which led to some cultivars being superior to others and their variation from one season to another, as they were more suitable for some cultivars than others which led to its superiority. The previous results are confirmed with those stated by Tahir et al. (2009), Hasina et al. (2012), Hassanein *et al.* (2012), Lak *et al*., (2013), Upadhyay *et al.* (2015) and Mohamed *et al*. (2022).

Table 5: Average number of kernels/spike of some bread wheat cultivars under different sowing dates and their interaction in 2017/18 and 2018/19 seasons

Seasons	2017/2018				2028/2019			
Cultivars (C)	Sowing dates (D)			Mean	Sowing dates (D)			Mean
	D1	D2	D3		D1	D2	D3	
Giza 168	62.3	55.7	52.7	56.9	55.3	47.0	38.3	46.9
Giza 171	57.0	60.3	47.7	55.0	46.7	55.3	48.0	50.0
Gemmeiza 9	56.7	59.3	46.0	54.0	57.7	46.0	43.7	49.1
Gemmeiza 11	60.7	52.3	42.7	51.9	52.7	59.7	46.7	53.0
Sids 1	56.3	45.3	43.3	48.3	56.7	50.0	44.7	50.4
Sids 12	61.3	53.3	49.3	54.7	48.7	49.0	40.3	46.0
Sidis 14	68.0	65.0	45.7	59.6	49.0	68.7	45.3	54.3
Misr 1	59.0	50.3	48.0	52.4	53.3	56.0	43.7	51.0
Misr 2	60.7	53.0	41.7	51.8	59.0	48.7	47.3	51.7
Misr 3	53.0	47.7	42.3	47.7	51.7	50.7	50.7	51.0
Shandwell 1	65.3	56.0	47.3	56.2	52.0	54.3	46.7	51.0
Sakha 94	56.7	57.3	48.3	54.1	64.0	56.0	46.0	55.3
Mean	59.8	54.6	46.3	-----	53.9	53.5	45.1	----
F test and L.S.D 0.05	**F test**		**L.S.D 0.05**		**F test**		**L.S.D 0.05**	
D	**		1.61		**		1.02	
C	**		2.25		**		2.72	
D × C	**		3.89		**		4.71	

Where D1 sowing at 20/11, D2 sowing at 10/12 and D3 sowing at 30/12
** mean significant at 1 % level of probability.

Also, the illustrated data in Table 5 denote that the interaction between sowing dates and cultivars had a highly significant (P≤ 0.01) influence on the kernels number spike-1 in the two growing seasons. Sowing Sids 14 bread wheat cultivar on 20 November in the first season or 10 December in the second one produced the maximum mean values of kernels number spike-1 which were 68.0 and 68.7 kernel/spike, respectively. The superiority of the Sids 14 cultivar when planted on November 20 in the first season or December 10 in the second season is due to the number of grains per spike being suitable for the prevailing weather conditions during the two planting seasons greater rate than the rest of the cultivars under the same conditions, which showed its superiority over the rest of the cultivars under the same dates of sowing. Similar results were confirmed with those recorded by Mohamed *et al*. (2022).

5-Thousand kernel weight (g)

Data exhibited in Table 6 reveals that seed index trait was affected significantly by the tested sowing date in the two growing seasons. Planting on November 20 led to an increase in the weight of 1000 kernels compared to the others studied planting dates. The weight of 1000 kernel was recorded 43.9, 42.8 and 42.9 g for the first season during the planting dates on 20 November, 10 December and 30 December, respectively, while the weight of 1000 kernel was recorded 48.8, 43.4 and 43.3 g for the second season during the same planting dates mentioned above, in the same order. These findings are attributes to the fact that wheat sowing later subjected the crop to low soil temperatures, which resulted in poor emergence, as well as high temperatures during the grain filling stage, which may harm reproductive growth phases. According to Upadhyay *et al*., (2015); El- Sayed *et al*., (2018) and Mohamed *et al*. (2022), earlier wheat sowing at the optimal date resulted in greater growth of wheat plants, biomass accumulation and translocation to grains. These results are in good line with those pointed by Ren *et al*., (2019); Sayed *et al*., (2021) and Sasani *et al*. (2020).

Moreover, the illustrated data in Table 6 show that the tested bread wheat cultivars had a highly significant effect on the 1000- kernel weight in both seasons. Thus, Sids 12 cultivar superior the others tested cultivars in this respect and recorded the highest mean values of 1000- kernel weight which were 52.6 and 52.0 g in the two respective seasons. On the contrary, the lowest mean values of 1000-kernel weight (37.9 and 42.1 g in the first and second seasons, respectively) were recorded from Misr 2 cultivar in the first season and from Shandwell 1 cultivar in the second one. The difference between the cultivars in the weight of a thousand grains is due to the differences in genetic composition among them and its interaction with environmental conditions, which was more suitable for the Gemmeiza 11 cultivar more than the other varieties. These results are confirmed with those detected by Hasina *et al*. (2012), Hassanein *et al*. (2012); Lak *et al*. (2013), Upadhyay *et al*. (2015) and Mohamed *et al*. (2022).

Table 6. Means of 1000 grain weight (gm) of some bread wheat cultivars under different sowing dates and their interaction in 2017/18 and 2018/19 seasons

Seasons	2017/2018			Mean	2028/2019			Mean
Cultivars (C)	Sowing dates (D)				Sowing dates (D)			
	D1	D2	D3		D1	D2	D3	
Giza 168	40.7	38.0	39.0	39.2	48.2	41.7	39.1	43.0
Giza 171	51.7	47.7	48.3	49.2	55.2	42.2	47.1	48.2
Gemmeiza 9	42.3	41.3	42.3	42.0	46.9	48.6	40.7	45.4
Gemmeiza 11	47.0	42.7	42.7	44.1	49.4	41.8	47.7	46.3
Sids 1	44.0	40.7	41.3	42.0	47.0	42.6	42.8	44.1
Sids 12	53.7	53.3	50.7	52.6	54.5	47.9	53.6	52.0
Sidis 14	36.3	44.3	42.3	41.0	58.1	41.1	40.5	46.5
Misr 1	41.7	45.3	47.0	44.7	49.5	41.2	47.3	46.0
Misr 2	38.3	34.3	41.0	37.9	40.2	51.6	38.1	43.3
Misr 3	49.0	42.7	40.0	43.9	47.4	38.4	36.7	40.8
Shandwell 1	40.0	39.7	39.3	39.7	44.3	41.2	40.7	42.1
Sakha 94	42.0	43.0	41.0	42.0	45.4	40.7	44.9	43.7
Mean	43.9	42.8	42.9	-----------	48.8	43.4	43.3	------

F test and L.S.D 0.05	F test	L.S.D 0.05	F test	L.S.D 0.05
D	**	1.00	**	2.46
C	**	1.92	**	2.41
D × C	**	3.33	**	4.17

Where D1 sowing at 20/11, D2 sowing at 10/12 and D3 sowing at 30/12
** mean significant at 1 % level of probability.

Furthermore, the obtained data in Table 6 notice that the interaction between sowing dates and cultivars had a highly significant (P≤ 0.01) effect on seed index trait in both seasons. Wherein, the maximum average values of thousand kernels weight (53.7 and 58.1 g in the two respective seasons) were recorded from Gemmeiza 11 and Sids 14 cultivars in the first and second seasons, respectively when sowing was done on 20 November in both seasons. The previous findings are in good line with those obtained by El-Sayed *et al.* (2018).

6- Grain yield (ton fed.$^{-1}$)

The illustrated data in Table 7 reveal that the studied sowing date had a highly significant (P≤ 0.01) impacts on grain yield/fed. in the two growing seasons. The planting date of November 20 was superior to the planting dates of December 10 and December 30 and gave the highest average values for the grain yield per fed., which reached 2.79 and 2. 91 tons per fed. for the two respective seasons. In addition, planting wheat on December 30 (late planting) led to a significant decrease in grain yield per fed., and recorded the lowest average values for this trait, amounting to 1.25 and 1.63 tons per fed. for both studied seasons, respectively with an average decrease from planting on November 20 of 123.2 and 78.53 % in the first and second seasons, respectively. This is to be expected since the same trend was observed with regard all studied yield components traits. These results are in agreement with those obtained by

Seleiman *et al*. (2011), Haroun *et al*. (2012), EL-Sayed *et al*. (2018), Sasani *et al*. (2020), Al-Jayashi *et al*. (2021) and Mohamed *et al*. (2022).

Here too, the presented data in Table 7 show that the tested bread wheat cultivars had a highly significant influence on the wheat grain yield fed. in the 2017/18 and 2018/19 growing seasons. The bread wheat cultivar Sids 12 outperformed the rest of the cultivars under study and gave the highest average grain yield values per fed., which reached 2.45 and 2. 71 tons per fed. for the two respective seasons, while the lowest average values for this trait reached 2.00 and 2. 22 tons /fed. were obtained, from the Giza 171 cultivar. The superiority of the Sids 12 cultivar in grain yield per fed. over the rest of the cultivars is due to its superiority in the thousand grains weight as mentioned before. Similar trend was recorded by EL-Sayed *et al*. (2018), AL-Ghumaiz *et al*. (2019), Shaalan *et al*. (2019), Al-Zahy *et al*. (2020), Said *et al*. (2020), Nada *et al*. (2021), Makarem *et al*. (2022) and Mohamed *et al.* (2022).

Table 7: Means of grain yield (ton fed.$^{-1}$) of some bread wheat cultivars under different sowing dates and their interaction in 2017/18 and 2018/19 seasons.

Seasons	2017/2018			Mean	2028/2019			Mean
Cultivars (C)	Sowing dates (D)				Sowing dates (D)			
	D1	D2	D3		D1	D2	D3	
Giza 168	2.80	2.79	1.42	2.34	2.87	2.81	1.61	2.43
Giza 171	2.50	2.43	1.07	2.00	2.73	2.67	1.27	2.22
Gemmeiza 9	2.89	2.66	1.28	2.28	3.09	2.73	2.15	2.66
Gemmeiza 11	2.62	2.52	1.11	2.08	2.71	2.58	1.53	2.27
Sids 1	2.80	2.51	1.25	2.19	2.91	2.68	1.84	2.48
Sids 12	3.03	2.88	1.44	2.45	3.11	2.89	2.17	2.72
Sidis 14	2.73	2.66	1.06	2.15	2.77	2.69	1.37	2.28
Misr 1	2.75	2.72	1.27	2.24	2.82	2.73	1.59	2.38
Misr 2	2.89	2.59	1.35	2.28	3.02	2.84	1.59	2.48
Misr 3	2.75	2.72	1.04	2.17	2.78	2.77	1.44	2.33
Shandwell 1	2.96	2.78	1.28	2.34	3.08	2.91	1.59	2.53
Sakha 94	2.77	2.52	1.41	2.23	3.01	2.85	1.42	2.43
Mean	2.79	2.65	1.25	----	2.91	2.76	1.63	-----
F test and L.S.D 0.05	**F test**		**L.S.D 0.05**		**F test**		**L.S.D 0.05**	
D	**		0.07		**		0.12	
C	**		0.14		**		0.19	
D × C	**		0.25		**		0.33	

Where D1 sowing at 20/11, D2 sowing at 10/12 and D3 sowing at 30/12
** mean significant at 1 % level of probability.

Concerning the interaction involved in this respect, the exhibited data in Table 7 denote that the grain yield fed.-1 trait was affected significantly by the interaction between sowing date and cultivars in the two growing seasons. Sowing of Sids 12 bread wheat cultivar on 20 November recorded the highest mean values of grain yield fed.-1 (3.03 and 3.11 ton/fed. in the two respective seasons). Similar results were recorded by Gomaa *et al*. (2018); Hefny and Naheif (2018) Mohamed *et al*. (2022).

7-Heat sensitivity index (H.S.I.)

Table 8 shows the heat sensitivity index of the cultivars for grain yield, whose low numerical magnitudes (less than one) indicate a high stress tolerance of the variety Choukan, *et al*. (2006).

It is interest to mention, 6 wheat varieties out of 12 showed heat sensitivity index values less than unity for the second planting date and 5 cultivars for the late planting date in both seasons, which indicates that these cultivars were more tolerant to heat stress. Moreover, it appears that the Misr 1 cultivar was more tolerant to heat stress, as it showed heat sensitivity index values less than unity for the two late planting dates in both seasons.

Table 8: Heat sensitivity index for wheat grain yield (ton./fad.) of twelve bread wheat genotypes during both growing seasons (2017/2018 and 2018/2019)

Genotypes	Season 2017/2018		Season 2018/2019	
	HSI12	HSI13	HSI12	HSI13
Giza 168	0.05	0.89	0.41	1.00
Giza 171	0.59	1.04	0.44	1.22
Gemmeiza 9	1.59	1.01	2.31	0.69
Gemmeiza 11	0.75	1.05	0.95	0.99
Sids 1	2.06	1.00	1.57	0.84
Sids 12	0.95	0.95	1.22	0.68
Sides 14	0.48	1.11	0.54	1.15
Misr 1	0.19	0.98	0.67	0.99
Misr 2	2.04	0.96	1.18	1.08
Misr 3	0.19	1.12	0.04	1.10
Shandwell 1	1.20	1.03	1.30	1.11
Sakha 94	1.75	0.88	1.12	1.21

H.S.I1.2: between normal sowing date and second planting date. H.S.I1.3: between normal sowing date and late sowing

The variations in mean performance of the previous varieties could be due to differential response of varieties to environmental changes. Similar trends were obtained by Menshawy (2007), Al-Otayk (2010), Ud-Din *et al*. (2010), Sikder and Paul (2010) and El-Ameen (2012).

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تقيم محصول الحبوب ومساماته في اصناف قمح الخبز تحت ظروف الاجهاد الحراري

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الملخص

أجريت هذه الدراسة بقرية الغريرة بمركز إسنا، محافظة الأقصر، مصر لتقييم أداء اثني عشر صنفاً من قمح الخبز تحت الإجهاد الحراري (مواعيد الزراعة المتأخرة) في التربة المستصلحة حديثاً والتي تم تنفيذها خلال موسمي 2018/2017، 2019/2018. تمت زراعة اثنا عشر صنفاً من قمح الخبز (جيزة 168، جيزة 171، سدس 1، سدس 12، سدس 14، جميزة 9، جميزة 11، مصر 1، مصر 2، مصر 3، شندويل 1، سخا 94) في ثلاثة مواعيد زراعة (20 نوفمبر، 10 ديسمبر ، 30 ديسمبر). تم اعتبار كل موعد زراعة في كل موسم بمثابة تجربة منفصلة. كان التصميم التجريبي لكل موعد للزراعة هو تصميم القطاعات كاملة العشوائية بثلاث مكررات. أظهرت النتائج المتحصل عليها أن مواعيد الزراعة المختبرة وأصناف قمح الخبز والتفاعل بينهما كان لها تأثير عالي المعنوية على ارتفاع النبات وطول السنبلة وعدد السنابل للمتر المربع وعدد الحبوب للسنبلة ووزن الالف حبة وحاصل الحبوب للفدان لكلا الموسمين عدا تأثير التفاعل على طول السنبلة في الموسم الثاني. علاوة على ذلك، سجلت زراعة صنف قمح الخبز سدس 12 في 20 نوفمبر أعلى متوسط قيم لإنتاج الحبوب والذي بلغ 3.03، 3.11 طن/فدان في الموسمين على التوالي. أما بالنسبة لمؤشر الحساسية للحرارة فقد أظهرت 6 أصناف من أصل 12 صنفاً من قمح الخبز قيم أقل من الوحدة لموعد الزراعة الثاني و5 أصناف لموعد الزراعة المتأخر في كلا الموسمين مما يدل على أن هذه الأصناف كانت أكثر تحملاً للحرارة علاوة على ذلك يبدو أن الصنف مصر 1 كان أكثر تحملاً للإجهاد الحراري حيث أظهر قيم أقل من الوحدة في موعدي الزراعة المتأخرين.