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Effect of Heat Stress on Yield and Its Components of some Egyptian Wheat Cultivars

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ABSTRACT

Two field experiments were conducted during (2019/2020 and 2020/2021) seasons in Abu El Matamir region, Beheira Governorate, Egypt to study the effect of heat stress on yield and its components of four Egyptian wheat cultivars (Gemmeiza-11, Giza-168, Sids-12 and Bani Sweif-5). Plant phenology and grain development traits including (days to anthesis, days to maturity, plant height and grain filling duration) and grain yield and its components traits (spikes number /m^2, grains number /spikes, grain weight, grain yield, straw yield, biological yield and harvest index) were studied. The analysis of variance indicated that there were highly significant differences between cultivars for most of these traits in both seasons under both normal and heat-stressed conditions. Related to plant phenology and grain development traits, the highest cultivar under heat-stressed conditions at most of these traits was Giza 168 whereas Bani Sweif 5 was the lowest. Concerning grain yield and its components traits, the highest cultivar under heat-stressed conditions for spikes number /m^2, grain yield, straw yield and biological yield was Bani Sweif 5. Giza 168 was the lowest for grain weight, grain yield, straw yield and biological yield. These results revealed that Bani Sweif 5 cultivar can be used for heat stress programs in wheat.

Keywords: Wheat, heat stress, yield components.

INTRODUCTION

Wheat is an essential human food crop all over the world. Wheat represents about 26% of the world's cereal production and 44% of the overall consumption of cereal (McGuire, 2015). Almost wheat represented 30.0% of the world's cereal region (Cossani and Reynolds, 2012). It is the largest nutrition crop covering the surface of the planet (218.54 million ha in 2017) and also has the second highest crop productivity (771.71 million tons in 2017) after maize all over the world (Pocketbook, 2017). Wheat is a considerable source of starch and energy, wheat as well supplies a large amount of some fundamental or profitable components for health such as especially vitamins (especially B vitamins), phytochemicals and dietary fiber (Shewry and Hey, 2015).

For Egypt, wheat is the most paramount crop as it is one of the world's largest wheat importers. Egypt's wheat production in 2021 was roughly nine million metric tons, representing a 1.12 percent increase over the previous year. Between 2010 and 2020, Egyptian wheat output ranged between 7.2 and nine million metric tons. An overall positive trend was observed with an inclusive increase of about 23.6 percent during these 10 years (Breisinger et al., 2021). A shortage of wheat production presents common constraints on the food supply for a fast-growing population in Egypt.

It is predicted that global warming has a generally negative impact on plant growth because the high temperatures have a damaging effect on plant development (Badr et al., 2018). The growing threat of climatological extremes including high temperatures may cause a tragic loss of crop productivity and lead to widespread starvation (Liu et al., 2014). Wheat is a highly heat-sensitive crop (Gupta et al., 2013). The majority of investigations on the impact of heat shocks during grain maturity and filling have focused on grain yield and yield components (Yang et al., 2002). Thirty wheat crop cultivars were evaluated by Asseng et al. (2015) where the temperatures average in the growing season was from 15 to 32°C with artificial heating. The results showed that high temperatures decreased grain yield at most of the wheat-sowing locations.

The main goal of this paper was to investigate the impact of heat stress on phenological development, grain yield and its components of four bread wheat cultivars.

MATERIALS AND METHODS

This study was conducted in Abu El Matamir region, Beheira Governorate, Egypt. Abu El Matamir region is becoming an important agricultural region in Al-Beheira Governorate. The experiments included four Egyptian wheat cultivars: namely, Gemmeiza 11, Giza 168, Sids 12 and Bani Swif 5. Two field experiments were conducted in the two successive winter seasons of 2019 / 2020 and 2020 / 2021. The experiment included two sowing dates: namely, Nov. 23rd and Jan. 26th, in 2019/ 2020 season, and Nov. 23rd and Jan. 28th in 2020 / 2021 season. Sowing dates of November are recommended for wheat, while such dates of January expose wheat to heat stress, especially during the grain filling period. The other agricultural activities were carried out following the recommendations for the experimentation site. In both seasons, fertilizers such as mono-super phosphate (15.5% P_2O_5), potassium sulfate (48% K_2O), and ammonium sulfate (20.5% N) were applied as directed at the rate of 22.5 kg P_2O_5 / fed, 24 kg K_2O / fed and 100 kg N/fed, respectively. Each plot has six rows, 2 m long, 30 cm apart, with a seeding rate of 65 kg/fed.

Studied traits:

1 –Plant phenology and grain development traits:

1-Number of days to anthesis (DA):

Anthesis date was recorded as the days' number from seeding to 50% anthesis on a plot basis.

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2-Number of days to physiological maturity (DM):

The maturity date was recorded as the number of days from sowing to the date of the physiological yellow stage of maturity. The complete loss of green color from all spike parts was considered a reliable indicator of physiological maturity (Donnelly 1983).

3- Grain filling duration (GFD):

Grain filling duration was recorded as the days' number from anthesis to the date of physiological maturity.

4- Plant height (PH, cm):

Plant height was measured at harvest time on a random sample of five plants from each plot as the distance between the soil's surface and the spike's tip.

2- Grain yield and its components:

These traits were measured at harvest time:

1- Number of spikes /m^2 (NS/m^2):

The spikes number /m2 (tillering capacity) was measured at harvest as the spikes number per meter of a guarded row for each plot and was expressed as the number of spikes per square meter.

2-Number of grains/spike (NG/S):

A sample of ten spikes was randomly collected from each plot and the average of grains number per spike for each plot was counted.

3-Grain weight (GW, mg):

Grain weight was reported as the mean of two hundred-grain samples. Random Samples from each plot at harvest were collected and grain weight was expressed as mg/grain.

4- Grain yield (GY, ton/ha):

The grain yield was calculated from the central four rows of each plot and given in tons per hectare.

5- Straw yield (ton/ha).

6- Biological yield (ton/ha) = {grain yield+ Straw yield}.

7- Harvest index = grain yield/ biological yield × 100

Statistical analysis

The phenotypic data analysis was performed using SAS v9.1. A randomized complete block design (RCBD) with three replications for each sowing date (normal and heat stress), in the two seasons of the study, was used. The differences among treatment means were compared using LSD at a 0.05 probability level of significance, according to Duncan (1955). The correlation coefficient between different traits was calculated using R v3.5.1.

RESULTS AND DISCUSSION

1 –Plant phenology and grain development traits:

Results in Table 1 showed that there were highly significant differences between genotypes for the number of days to anthesis, the number of days to maturity, plant height and grain filling duration traits in both seasons under both normal and stressed conditions except for days to anthesis and plant height traits in the first season under heat-stressed condition and days to anthesis in the second season under normal conditions.

Table 1. Analysis of variance for days to anthesis (DA), days to maturity (DM) and plant height (PH) of four wheat genotypes under normal conditions and heat-stresses (H-S) environments in 2019/2020and 2020/2021 seasons.

S.O.V.	df	Days to anthesis (DA)				Days to maturity (DM				Plant height (PH)				Grain fill duration (GFD)			
		2019/2020		2020/2021		2019/2020		2020/2021		2019/2020		2020/2021		2019/2020		2020/2021	
		Normal	H-S	Normal	H-S	Normal	H-S	Normal	H-S	Normal	H-S	Normal	H-S	Normal	H-S	Normal	H-S
Rep	2	1.58	3.25	0.083	1.08	0.25	0.58	0.083	1.33	18.083	3	1.58	8.083	2.58	2.08	0.75	1.08
Genotypes	3	54.56**	8.55^{ns}	35.63^{ns}	14**	47.33**	56.11**	41.42**	96.22**	171.64**	44.88^{ns}	35.42**	279.63**	16.55**	27.42**	29.63**	43.64**
Error	6	0.47	3.47	0.97	0.75	1.58	2.36	1.42	0.88	1.97	23.22	6.58	2.30	3.47	2.42**	1.638	2.64

ns: Not significant.* Significant at the 0.05 level of probability. Significant at the 0.05 level of probability.**

Related to days to anthesis trait in 2019/2020 under normal conditions, the highest genotype was Giza 168 where it recorded 82.67 whereas the lowest cultivar was Bani Sweif 5 (73.33) (fig. 1A).

In 2020/2021 season under heat stressed conditions, the highest cultivar was also Giza 168 (75.66) whereas the lowest cultivar was also Bani Sweif 5 (70.66) (fig 1B). These results are consistent with Schittenhelm *et al.* (2020) as they found a variation between cultivars in days to anthesis trait. Many studies determined that heat stress hurts wheat growth and development (Akter and Islam 2017; Poudel and Poudel 2020). Mondini *et al.* (2014) found that there was a significant reduction of days to anthesis due to heat stress conditions. It may be happened fundamentally because of life cycle became short on account of too high temperature related to late planting.

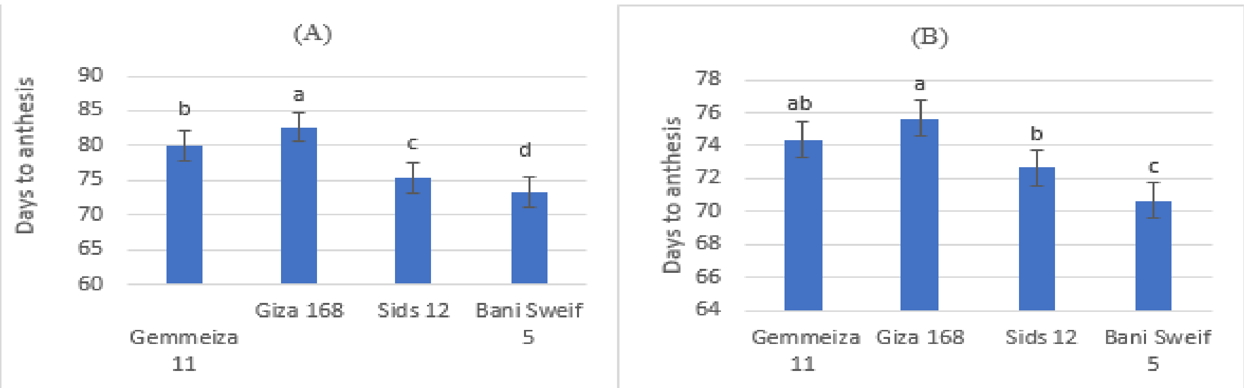

Fig 1. Days to anthesis (DA) of four wheat genotypes. A: under normal conditions in 2019/2020 season. B: under heat-stressed conditions in 2020/2021.

Concerning days to maturity in 2019\2020 season, the highest genotype was Gemmeiza (126.67) whereas the earliest cultivar in maturity was Bani Sweif 5 (120) under normal conditions (fig. 2A). Under heat stressed conditions, the highest cultivar in days to maturity trait was Giza 168 whereas the earliest cultivar in maturity was Sids 12 as they recorded 93 and 83.66 days, respectively (fig. 2B). In 2020\2021 season, Gemmeiza 11 was the latest in maturity under both normal conditions and heat-stressed conditions (131 and 108.33 respectively) whereas Sids 12 was the earliest under normal conditions and Bani Sweif 5 was the earliest under heat stressed conditions (fig 2C and 2D). Poudel *et al*. (2020) also found that there was a highly significant difference in days to maturity traits for the genotypes under heat-stressed conditions. The selection of early maturing genotypes became an efficient strategy to decrease the yield lack from heat-stressed crops in which the crop development period has been shortened.

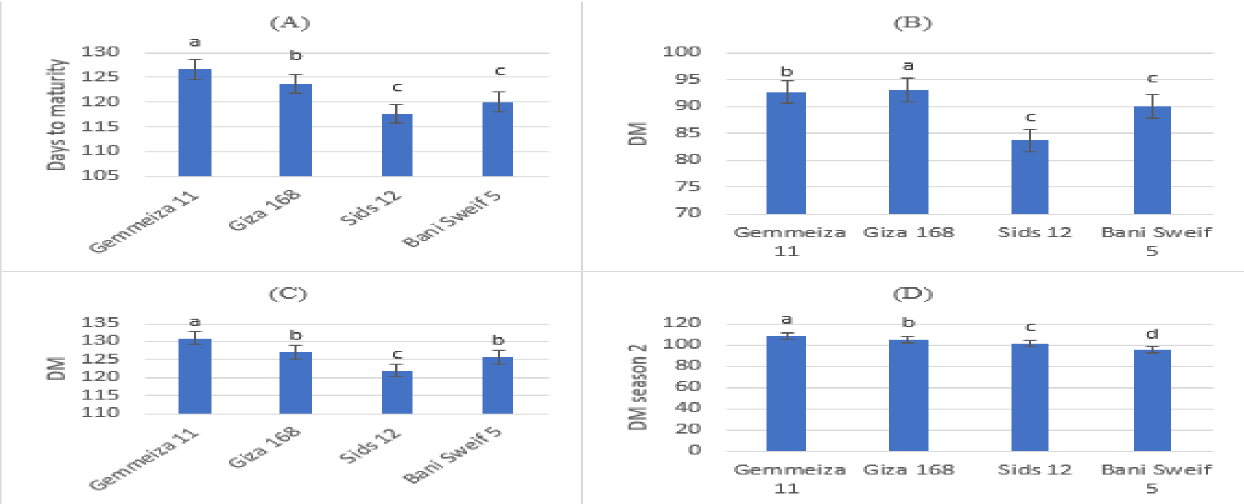

Fig 2. Days to maturity (DM) of four wheat genotypes. A: under normal conditions in 2019/2020 season. B: under heat-stressed conditions in 2019/2020 season. C: under normal conditions in 2020/2021. D: under heat-stressed conditions in 2020/2021.

Related to plant height under normal conditions, Gemmeiza 11, was the tallest cultivar in the first season (fig 3A) and the second season (fig 3B) where it recorded 102.33 and 100.33 cm respectively, on the other hand, the shortest genotype was Bani Sweif 5 in the two seasons where it recorded 84.66 and 93.33 cm respectively. Under heat-stressed conditions, Giza 168 was the tallest (73.33 cm) whereas Bani Sweif 5 was the shortest (51 cm) in the second season (Fig 3C).

Similar genotypic differences in plant height were obtained by Johari-Pireivatlou and Maralian (2011). El-Daim *et al.* (2014) studied the morphological and yield-related traits under heat-stressed conditions. They found that the wheat morphology also changed because of heat stress by reducing plant height, grain filling duration, etc.

Mean values of GFD for the four wheat genotypes, in the two seasons, showed that Gemmeiza 11, was the highest genotype for GFD except in the second season under heat-stressed conditions as Giza 168 was the highest. On the other hand, in the first season, the lowest genotype was Giza 168 under normal conditions and Sids 12 was the lowest under heat-stressed conditions (Fig 4A and 4B) whereas in the second season Bani Sweif 5 was the lowest under both normal and heat-stressed conditions (Fig 4C and 4D). These findings are consistent with those of Schittenhelm *et al.* (2020), who detected different responses of the GFD of cultivars, resulting in different numbers of GFD among different cultivars. Castro *et al.* (2007) studied the effect of heat stress on wheat grains traits. Their results revealed that high temperatures affect the grain filling duration. Mohammadi *et al.* (2006) investigated the impact of heat stress on the yield parameters such as grain filling duration. They found that there was a reduction in grain filling duration because of the high temperature.

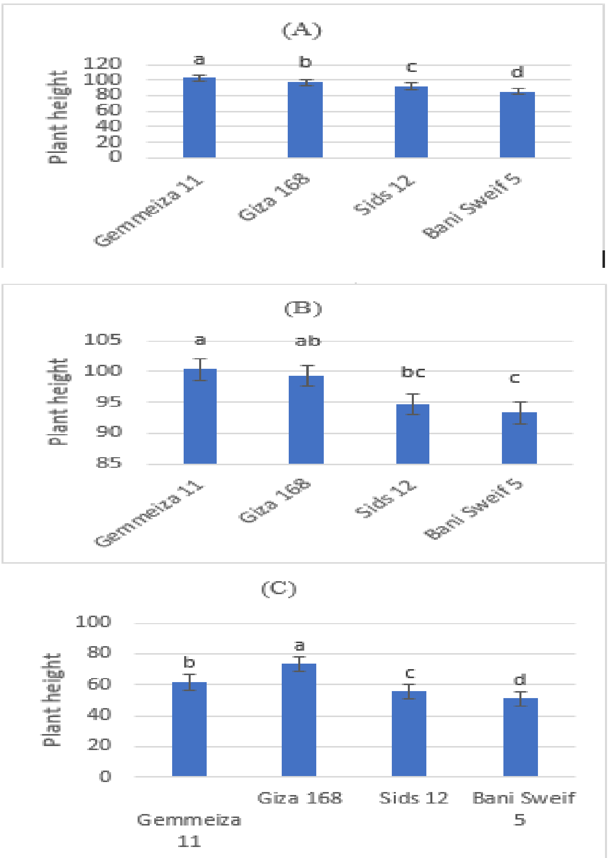

Fig 3. Plant height of four wheat genotypes (A): under normal conditions in 2019/2020 season. (B): under normal conditions in 2020/2021 season. (C): under heat-stressed conditions in 2020/2021 season.

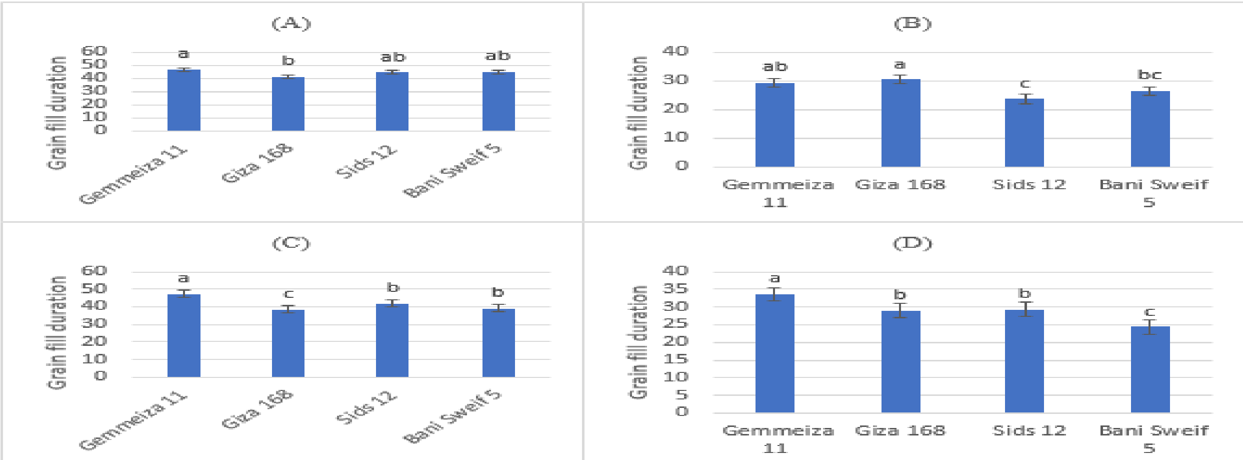

Fig 4. Grain filling duration (days) of four wheat genotypes (A): under normal conditions in 2019/2020 season. (B): under heat-stressed conditions in 2019/2020 season. (C): under normal conditions in 2020/2021 season. (D): under heat-stressed conditions in 2020/2021 season.

The most significant correlation was found between the number of days to maturity (DM) and grain filling duration (GFD) ($r = 0.87$) ($P < 0.001$). Whereas the lowest correlation ($r = -0.29$) was between the number of days to anthesis (DA) and Grain filling duration (GFD) (Fig. 5).

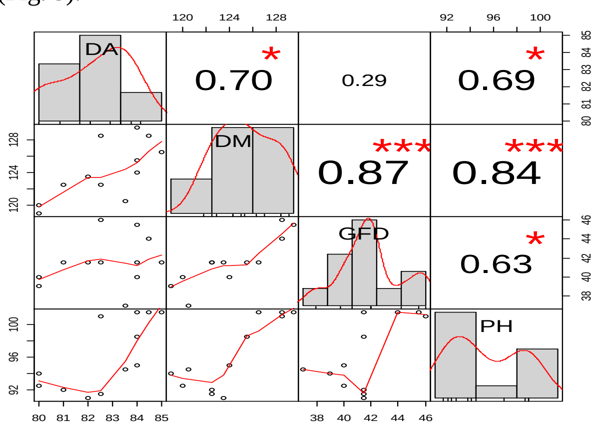

Fig 5. The correlations between plant phenology traits (number of days to anthesis (DA), number of days to maturity (DM), grain filling duration (GFD) and plant height (PH). Right-top represents the correlation coefficients among the five traits. The diagonal represents the frequency distribution for each of the five traits. Left-bottom represents the scatter distribution among the traits.

2- Grain yield and its components:

The analysis of variance in Table 2 revealed highly significant differences between cultivars for all traits in both seasons except for the number of grains/spike in season two under heat-stressed conditions, grain weight in the first season under heat-stressed conditions, grain yield in the first season under normal conditions and harvest index in the first season under both normal and heat-stressed conditions and in the second season under heat-stressed conditions. The highest genotype, for the number of spikes/m^2, was Bani Sweif 5 in the two seasons under both normal and heat-stressed conditions. On the other hand, the lowest cultivar for the number of spikes/m^2, was Gemmeiza 11, in the first season under normal and heat-stressed conditions and in the second season under normal conditions, which recorded 620.33, 523 and 708.66 respectively (fig 6A, 6B and 6C) while, Sids 12 was the lowest cultivar in the second season under heat-stressed conditions, which recorded 457.66 (fig 6D). Similar genotypic differences, in NS/m^2, were obtained by Johari-Pireivatlou and Maralian (2011); Shamsi *et al.* (2011). Related to the number of grains/spike, the highest cultivar was Sids 12 in the two seasons under normal and heat-stressed conditions, whereas, the lowest cultivar was Gemmeiza 11, in the two seasons (fig 7A, 7B, 7C and 7D). Similar genotypic differences, in NG/S, were obtained by Shamsi *et al* (2011). El-Daim *et al.* (2014) studied yield-related traits under heat-stressed conditions. A reduction in kernel number\spike and grain weight, etc due to heat stress was found. Riaz-ud-Din *et al.* (2010) found that there was a significant variation between cultivars in the depression of grain number per panicle.

Table 2. The variance analysis for the number of spikes /m^2 (NS/m^2), the number of grains/spike (NG/S), grain weight (mg), grain yield (ton/ha), straw yield (ton/ha), biological yield (ton/ha) and harvest index of four wheat genotypes in 2019/2020 and 2020/2021 seasons.

S.O. V	**df**	**Number of spikes /m^2**				**Number of grains/spike (NG/S)**				**Grain weight (GW)**				**Grain yield**	
		2019/2020		**2020/2021**		**2019/2020**		**2020/2021**		**2019/2020**		**2020/2021**		**2019/2020**	
		Normal	**H-S**	**Normal**	**H-S**	**Normal**	**H-S**	**Normal**	**H-S**	**Normal**	**H-S**	**Normal**	**H-S**	**Normal**	**H-S**
Rep.	2	3880.33	2850.25	118.08	146.58	12.58	9.08	4.08	1.75	1.357	5.41	1.07	3.62	0.0259	0.502
Genotypes	3	51346.3**	29129.42**	58655.42**	108384.22**	950.66**	152.97**	380.08**	59.19ns	52.46**	5.06 ns	59.84**	12.72**	3.01ns	2.19**
Error	6	1502.55	720.58	619.42	108384.22	33.91	16.64	6.42	14.19	1.269	9.55	2.33	0.72	1.10	0.33

S.O. V		Grain yield		Straw yield				biological yield				Harvest index			
		2020/2021		2019/2020		2020/2021		2019/2020		2020/2021		2019/2020		2020/2021	
		Normal	H-S	Normal	H-S	Normal	H-S	Normal	H-S	Normal	H-S	Normal	H-S	Normal	H-S
Rep.	2	8.71	0.11	4.91	0.16	0.29	0.08	4.53	0.52	7.96	0.33	6.82	1.71	15.57	1.83
Genotypes	3	20.33**	1.17**	9.73**	10.85**	22.64**	8.18**	24.93**	20.73**	60.45**	15.19**	0.31ns	16.39ns	133.88**	11.81ns
Error	6	1.03	0.05	1.75	0.59	1.29	0.78	1.55	0.98	1.58	0.96	13.81	6.62	10.61	7.90

ns: Not significant.* Significant at the 0.05 level of probability. Significant at the 0.01 level of probability.**

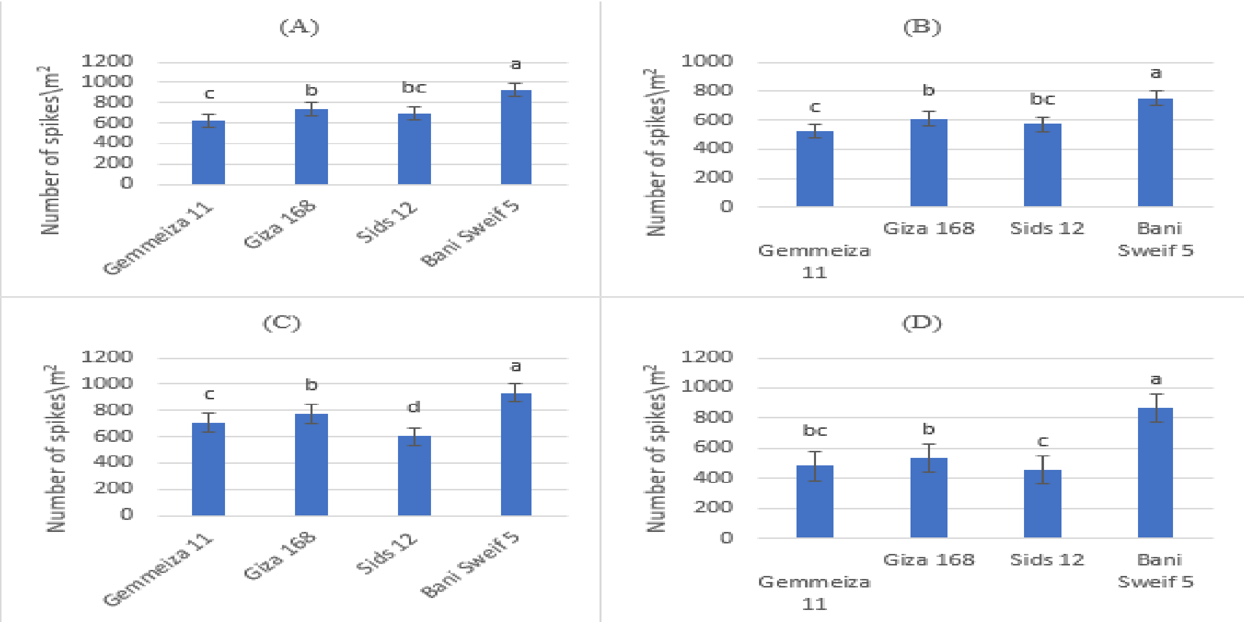

Fig 6. Number of spikes /m^2 (NS/m^2) of four wheat genotypes. (A): under normal conditions in 2019/2020 season (B): under heat-stressed conditions in 2019/2020 season. (C): under normal conditions in 2020/2021 season. (D): under heat-stressed conditions in 2020/2021 season.

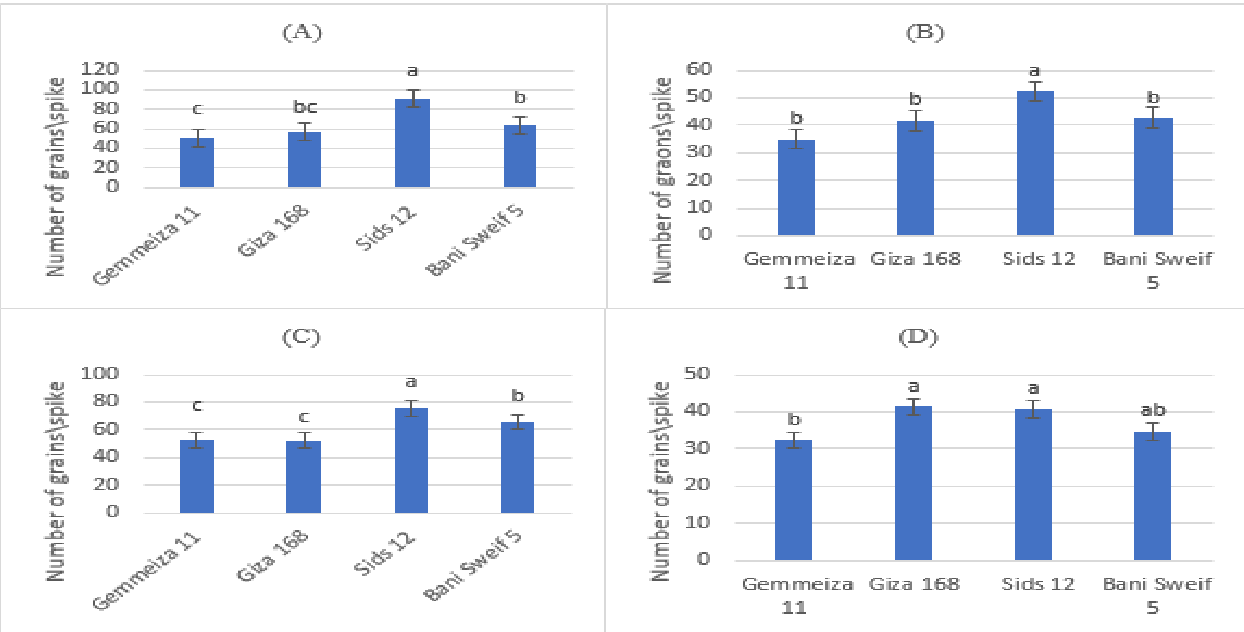

Fig 7. Number of grains/spike of four wheat genotypes (A): under normal conditions in 2019/2020 season. (B) under heat-stressed conditions in 2019/2020 season. (C) under normal conditions in 2020/2021 season. (D): under heat-stressed conditions in 2020/2021 season.

The highest genotype, for grain weight in the first season under normal conditions and in the second season under normal and heat-stressed conditions, was Gemmeiza 11, which recorded 51.56,50.06 and 25.97 mg, respectively. On the other hand, the lowest cultivar for grain weight was Bani Sweif 5 in the first and second seasons under normal conditions which recorded 41.7 and 39.8 mg, respectively (8A and 8B). Giza 168 was the lowest in the second season under the heat-stressed condition as it recorded 22.7 mg (fig 8C). Similar genotypic differences, in GW, were obtained by Singha *et al.* (2006). The reduction of grain yield and performance of wheat genotypes under heat-stressed conditions occurred due to the rotation in the plant-water relationship happened because of the high temperature (Qaseem *et al.* 2019), decreasing photosynthetic capability (Riaz-ud-Din *et al.* 2010), reducing metabolic activities (Farooq *et al.* 2011), Also because of the depression of pollen tube growth and increases the death-rate of pollen (Oshino *et al*. 2011). Castro *et al.* (2007) found that heat stress without regard to the stress duration led to the thousand kernel weight reduction. Mohammadi *et al.* (2006) studied the effect of heat stress on kernel number and kernel weight parameters. They found that there was a reduction in kernel weight due to the high temperature. Heat stress also reduced grain mass, kernel weight and water use efficiency (Shah and Paulsen 2011).

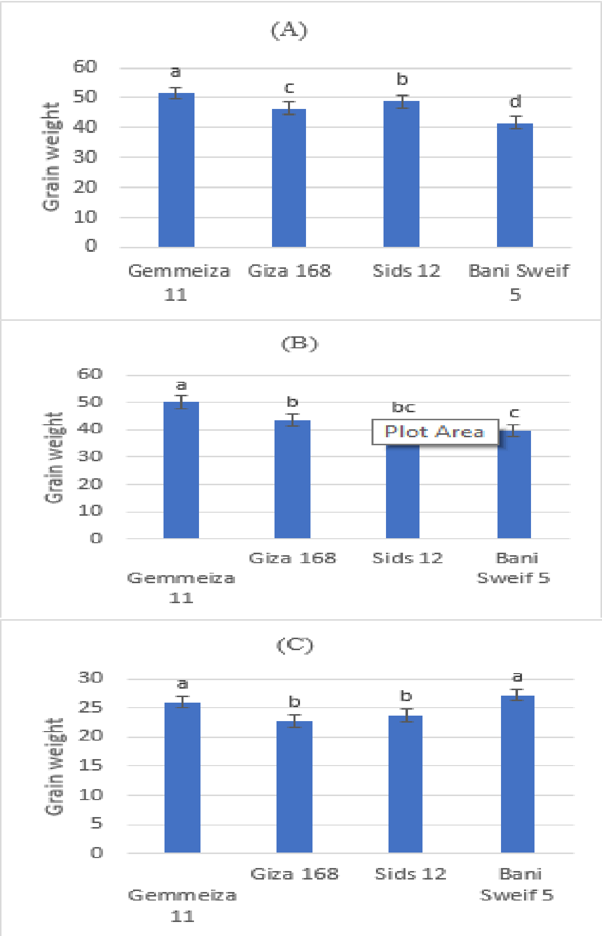

Fig 8. Grain weight of four wheat genotypes (A) under normal conditions in 2019/2020 season (B): under normal conditions in 2020/2021 season. (C): under heat-stressed conditions in 2020/2021 season.

Concerning grain yield, the highest genotype was Bani Sweif 5, in the first season under heat-stressed conditions (fig 9A) and in the second season under normal and heat-stressed conditions (fig 9B and 9C), which recorded 4.14, 13.56 and 4 ton/ha, respectively. On the other hand, the lowest cultivar under heat-stressed conditions was, Giza 168, in the first season (fig 9A) and second season (fig 9C), while Sids 12 was the lowest genotype in the second season under normal conditions, which was recorded 8.3 ton/ha (fig 9B). Similar genotypic differences, in grain yield, were obtained by Sarwar *et al*. (2010); Li *et al*. (2011). Riaz-ud-Din *et al*. (2010) studied ten cultivars of spring wheat under the impact of high temperature on grain formation and development. The results revealed that there was a (15.38%) reduction in grain yield under late planting (heat-stressed) conditions. The high temperature eventually reduced the grain yield under late planting conditions. Also, there was a significant variation between cultivars in the depression of grain weight per spike and single kernel weight under high-temperature conditions.

The highest genotype, for straw yield, was Bani Sweif 5, in the first season and second seasons under normal and heat-stressed conditions. On the other hand, the lowest genotype for straw yield was Giza 168, in the first season under normal and heat-stressed conditions and in the second season under heat-stressed conditions, which recorded 14.83, 6.76 and 5.76 tons/ha, respectively (Fig 10A, 10B and 10D). While Gemmeiza 11, was the lowest cultivar in the second season under normal conditions, which recorded 13.68 ton/ha (Fig 10C). The obtained results are in agreement with the results of El-Hag (2006); El-Hwary and Yagoub (2011).

The highest genotype, for biological yield, was Gemmeiza 11, in the first season under normal conditions, which recorded 29.5 tons/ha (Fig 11A) while, Bani Sweif 5 was the highest cultivar in the first season under heat-stressed conditions (Fig 11B) and in the second season under normal and heat-stressed conditions (Fig 11C and 11D), which recorded 15.29, 33 and 13.5 tons/ha, respectively. On the other hand, the lowest cultivar was Giza 168, in the first season under normal and heat-stressed conditions and in the second season under heat-stressed conditions, which recorded 23.66, 9.04 and 8.23 tons/ha, respectively. While Sids 12, was the lowest cultivar in the second season under normal conditions, which recorded 22.27 ton/ha. The obtained results are consistent with the findings of Ahmadizadeh *et al.* (2011); Hatim and Majidian (2012).

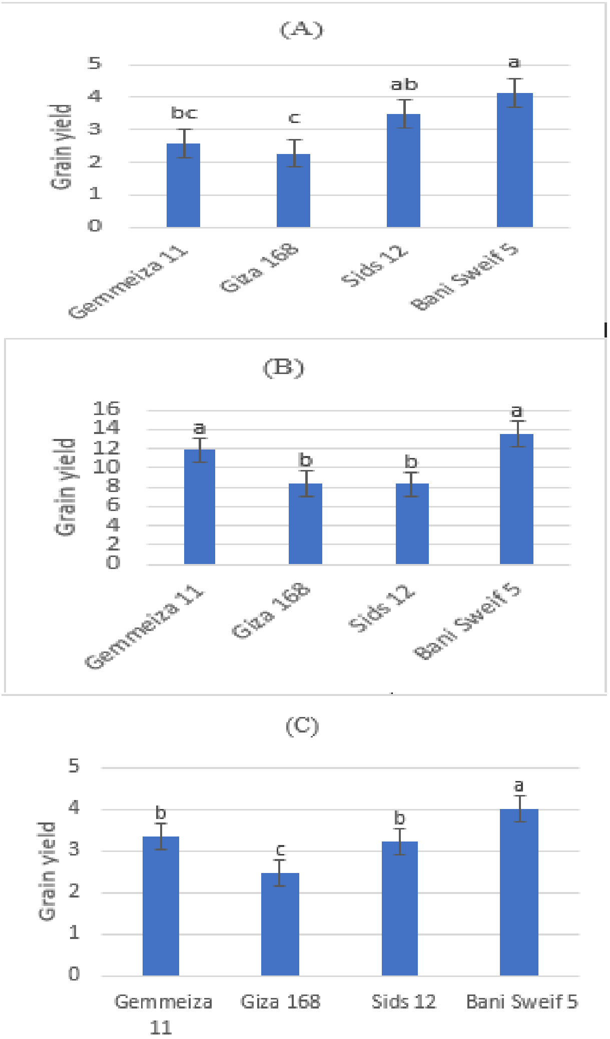

Fig 9. Grain yield of four wheat genotypes (A) under heat-stressed conditions in 2019/2020 season. (B) under normal conditions in 2020/2021 season. (C): under heat-stressed conditions in 2020/2021 season.

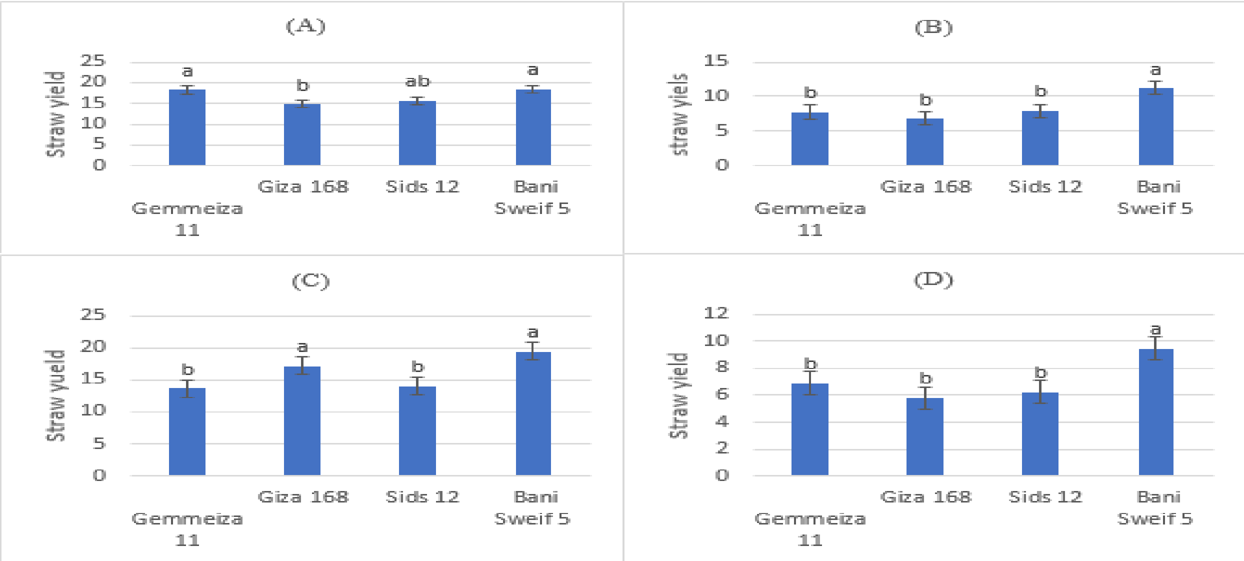

Fig 10. Straw yield of four wheat genotypes under normal and heat-stressed conditions in 2020/2021 season.

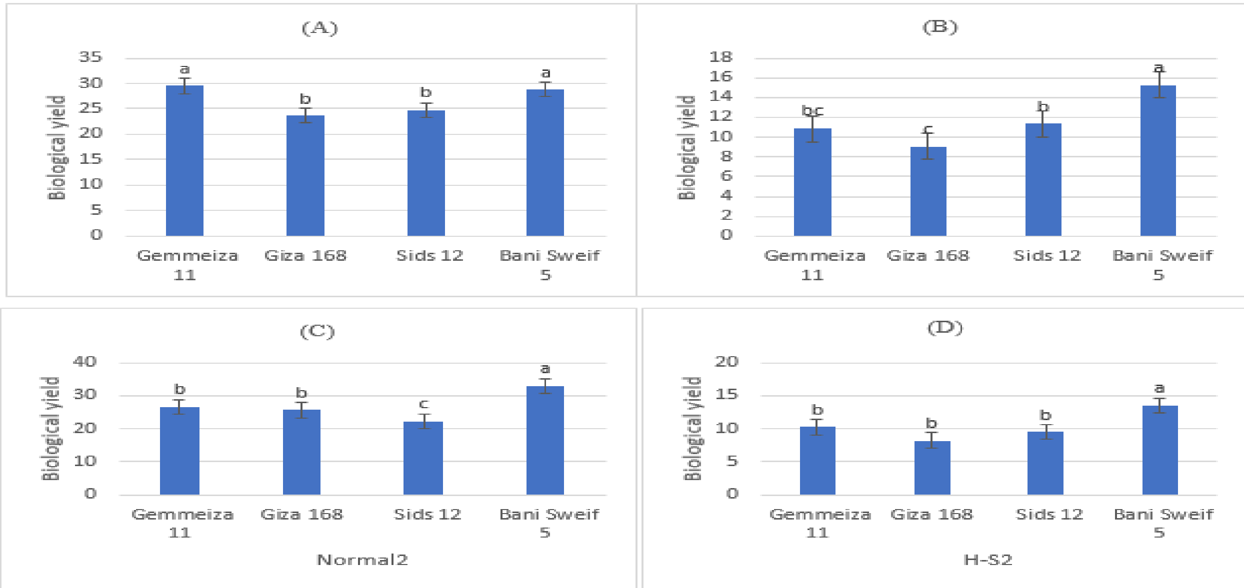

Fig 11. Biological yield of four wheat genotypes (A): under normal conditions in 2019/2020 season. (B): under heat-stressed conditions in 2019/2020 season. (C): under normal conditions in 2020/2021 season. (D): under heat-stressed conditions in 2020/2021 season.

Related to the harvest index in the second season under normal conditions, the highest cultivar was Gemmeiza 11, which, recorded 48.63%. On the other hand, the lowest genotype was Giza 168, which recorded 32.84% (Fig 12).

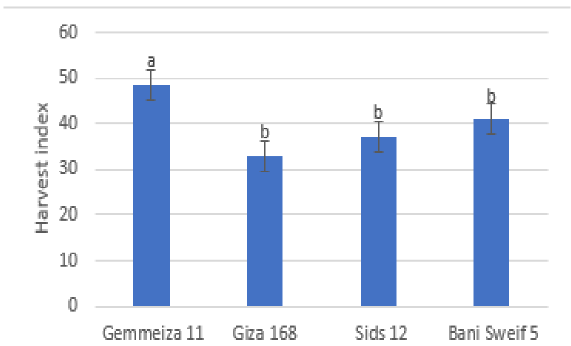

Fig 12. Harvest index of four wheat genotypes under normal conditions in 2020/2021 season.

The obtained results are consistent with the findings of Ahmadizadeh *et al*. (2011); Jatoi *et al.* (2011); Jemal *et al*. (2015).

The correlation between biological yield and straw yield showed the strongest significant correlation (r = 0.93) (P < 0.001). whereas there were reverse correlations between both of the following number of grains/spike (NG/S), grain weight (GW) (r = -0.41), number of grains/spike and grain yield (r = -0.31), number of grains/spike and biological yield (r = -0.23), grain weight and biological yield (r = -0.20), grain weight and straw yield (r = -0.26), straw yield and harvest index (r = -0.28) and number of grains/spike and harvest index (r = -0.29) (Fig. 13).

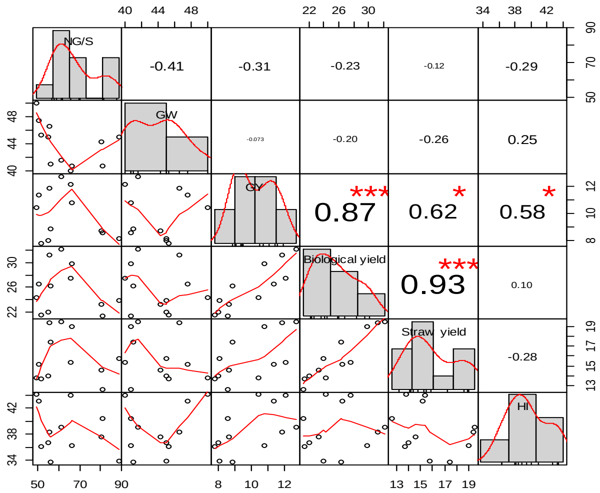

Fig. 13. The correlations between grain yield and its components (number of grains/spike (NG/S), grain weight (GW, mg), grain yield (GY, ton/ha), biological yield (ton/ha), straw yield (ton/ha) and harvest index (%). The correlation coefficients between the five traits are shown at the top right. Each of the five qualities has its frequency distribution, which is represented by the diagonal. The scatter distribution among the traits is shown on the left bottom.

CONCLUSION

Bani Sweif 5 cultivar was the highest cultivar under heat-stressed conditions for most of the grain yield and its components traits. Whereas it was the lowest for most plant phenology and grain development traits. These results showed that Bani Sweif 5 cultivar can be used for heat stress programs in wheat.

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تأثير الإجهاد الحراري على المحصول ومكوناته لبعض أصناف القمح المصرية

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الملخص

أجريت هذه الدراسة خلال موسمي (2020/2019، 2021/2020) بمنطقة أبو المطامير بمحافظة البحيرة بمصر لدراسة تأثير الإجهاد الحراري على المحصول ومكوناته لأربعة أصناف من القمح المصري (جميزة 11 - جيزة 168 - سدس 12 - بني سويف 5). تم قياس الصفات المظهرية وصفات تطور الحبوب (عدد الأيام حتى التزهير، عدد الأيام حتى النضج، ارتفاع النبات، فترة امتلاء الحبوب) وصفات محصول الحبوب ومكوناته (عدد السنابل بالمتر المربع، عدد الحبوب / السنبلة، وزن الحبوب، محصول الحبوب، محصول القش، المحصول البيولوجي ودليل الحصاد). أظهر تحليل التباين لهذه الصفات وجود فروق معنوية بين الأصناف لجميع الصفات في كلا الموسمين تحت الظروف الطبيعية وظروف الإجهاد الحراري. فيما يتعلق بالصفات المظهرية وصفات تطور الحبوب كان أعلى صنف تحت ظروف الإجهاد الحراري في معظم هذه الصفات هو جيزة 168 بينما كان بني سويف 5 هو الأقل. أما فيما يتعلق بصفات المحصول ومكوناته كان أعلى صنف تحت ظروف الإجهاد الحراري لعدد السنابل بالمتر المربع ومحصول الحبوب ومحصول القش والمحصول البيولوجي هو بني سويف 5. بينما كان جيزة 168 هو الأقل لوزن الحبوب ومحصول الحبوب ومحصول القش والمحصول البيولوجي. أوضحت هذه النتائج أن صنف بني سويف 5 يمكن استخدامه لبرامج الإجهاد الحراري في القمح.