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RESEARCH ARTICLE

Influence of sowing dates and temperature variability on bread wheat productivity for some exotic and Egyptian genotypes under upper Egypt conditions

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Abstract

Considering the rapid climatic changes in the past few years, the effect of high temperature on wheat productivity is global concern. Heat stress is one of the major abiotic stresses reducing wheat production. Heat stress reduces grain weight and number, chlorophyll content and photosynthesis activity. This study was carried out during two successive seasons 2018/2019 and 2019/2020 at Almatana agricultural Research Station, Luxor, Upper Egypt, to investigate the effect of two sowing dates 20th November (favorable sowing date) and 10th January (late sowing date, after sugarcane harvest) on yield characters, of twenty bread wheat genotypes**.** The objective was to understand heat stress effects on grain yield and its components to estimate some selection indices for heat tolerance in wheat. The studied characters were number of spikes/m2, number of kernels/spike, 1000-kernel weight and grain yield (ton/ha). Results indicated that sowing dates and genotypes had significant effects for all studied characters. Delaying sowing date after sugarcane harvest reduced no. of spikes/m^2, no. of kernels/spike, 1000-kernel weight and grain yield by an average of 31.62, 32.85, 32.76 and 37.74%, respectively, compared to the favorable sowing date. Highest grain yield (8.81) t/ha under favorable sowing date was for gemmeiza11, while shandaweel1 gave (5.92) t/ha the highest grain yield under late sowing date. Heat susceptibility index (HSI) over all two seasons ranged from 0.78 for Shandaweel1, to 1.23 for genotype Line8.

Keywords: Bread wheat, Genotypes; Grain yield; High temperature; Sowing dates.

1. Introduction

Food security means that all the people, at all places and all times, have social, physical, and economic access to safe, and adequate food that meets their preferences and food needs for a healthy and active life as defined by the United Nations' Committee on World Food Security (IFPRI, 2021).

Extreme temperature is one of the main abiotic stress factors limiting the growth and productivity of wheat varieties. Despite exposure of cultivars to heat stress may differ with the stage of plant development, all reproductive and vegetative stages are affected by high temperature (Wahid *et al.*, 2007).

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In the Arab World, Egypt the most populous country, it's also considered the largest importer of wheat globally. Consumption of this cereal per capita is the highest in the world. Simultaneously, ensure accessibility to this important staple food by all Egyptian nationals has also been a fundamental part of the nation's social policies. The strategic relevance of the wheat has resulted in a strong involvement of the State at all levels of the wheat value chain. In 2020, the total cultivated area is estimated at 1.4 million hectares, while the Egyptian wheat production approximately 8.9 million tons (FAO, 2020).

Luxor governorate represent Upper Egypt region situated in the southern part of the country, the region is characterized by high temperature. Sugarcane the main crop in Luxor governorate followed by wheat. The cultivated area of sugarcane and wheat in (2020) was about 28000 and 17000 hectare, respectively. The area of old ratoon crops is about 10% of sugarcane total area (Sugar crops council, 2020). Farmers in Luxor governorate aim to maximize the economic benefit gained from their fields through growing wheat after harvest the old ratoon crops of sugarcane to satisfy their food and social needs. However, it was found that sowing wheat after harvest the old ratoon crops of sugarcane delays planting wheat to January (more than 50 days), which negatively reflects in a substantial reduction in growth characters and quality traits as well as wheat yield.

Optimum planting date affects the solar radiation, temperature and water available for the crop (Silva *et al.*, 2014). Increased grain yield comes from suitable sowing dates, superior varieties as well as favorable environmental conditions (Coventry *et al.*, 2011).

Grain yield is a complex character depends on several components: number of spikes per unit area, number of kernels/spike and kernel weight, and highly affected by environmental fluctuations, improving one of these component might have positive or negative impact on other components character (Chandra *et al.*, 2004).

Our objectives were to understand the effects of high temperature on grain yield and its components and screen some exotic lines and local cultivars of bread wheat for heat tolerance and used in breeding programs.

2. Materials and methods

2.1. Growing conditions

Seventeen bread wheat lines had been selected from High Rainfall Wheat Yield Trail (22^{nd} HRWYT - CIMMYT) plus three Egyptian cultivars i.e., Shandaweel1, Giza171 and Gemmeiza11 (Table 1) were evaluated under two sowing dates in 2018/19 and 2019/20 seasons.

Sowing dates were 20^{th} November, and 10^{th} January in the two seasons. The experimental design was randomized complete blocks (RCBD), with three replications for each sowing date. The plot size was 3.5 m long with 2.4 m width (3.5 x 2.4 = 8.4 m^2). Each plot included 12 rows; 20 cm apart between rows. The recommended practices of wheat production were applied all over the growing seasons. The agronomic characters studied were Number of spikes/m^2 (S/m^2), Number of kernels/spike (K/S), 1000-kernel weight (1000-KW) and Grain yield (GY).

2.2. Climatic data

Monthly temperature and means of maximum, minimum temperature from sowing date to booting, booting to heading and heading to maturity of favorable and late sowing dates are summarized in Table (2).

2.3. Statistical analysis

Data were subjected to the standard analysis of variance and the combined analysis of variance according to (Gomez and Gomez 1984).

Heat susceptibility index (HSI) was estimated according to (Fischer and Maurer, 1978) as: HSI = (1 - Yd / Yp) / D. Where: Yd = mean yield under stress conditions, Yp = mean yield under non-stress conditions = potential yield, D = Heat stress intensity = 1 - (mean Yd of all genotypes under heat / mean Yp of all genotypes under favorable).

Table 1. Names and pedigrees of the studied bread wheat genotypes.

Ent. No.	Ent. Name	Pedigree	Origin
1	Line1	FRANCOLIN #1/BLOUK # CMSS06B00010S-0Y-099ZTM-099NJ-099NJ-09RGY-0B-8BMX-0RGY	CIMMYT
2	Line2	MUTUS//ND643/2*WBLL1 CMSS08Y00224S-099Y-099M-099NJ-099NJ-4RGY-0B	CIMMYT
3	Line3	MUTUS//ND643/2*WBLL1 CMSS08Y00224S-099Y-099M-099NJ-099NJ-16RGY-0B	CIMMYT
4	Line4	ND643/2*WBLL1//KACHU CMSS08Y00235S-099Y-099M-099NJ-3RGY-0B	CIMMYT
5	Line5	ND643/2*WBLL1//KACHU CMSS08Y00235S-099Y-099M-099NJ-7RGY-0B	CIMMYT
6	Line6	ND643/2*WBLL1//KACHU CMSS08Y00235S-099Y-099M-099NJ-099NJ-3RGY-0B	CIMMYT
7	Line7	ND643/2*WBLL1//KACHU CMSS08Y00235S-099Y-099M-099NJ-099NJ-6RGY-0B	CIMMYT
8	Line8	TUKURU//BAV92/RAYON/3/ND643/2*WBLL1 CMSS08Y00351S-099Y-099M-099NJ-099NJ-4RGY-0B	CIMMYT
9	Line9	CHIBIA//PRLII/CM65531/3/FISCAL*2/4/TAM200/TURACO CMSS08Y00850T-099TOMP-099Y-099M-099NJ-099NJ-2RGY-0B	CIMMYT
10	Line10	CHIBIA//PRLII/CM65531/3/FISCAL*2/4/NIINI #1 CMSS08Y00851T-099TOMP-099Y-099M-099NJ-8RGY-0B	CIMMYT
11	Line11	MUTUS*2//ND643/2*WBLL1 CMSS08Y00872T-099TOMP-099Y-099M-099NJ-099NJ-9RGY-0B	CIMMYT
12	Line12	FRANCLN/BAVIS #1//FRANCOLIN #1 CMSS08Y00912T-099TOMP-099Y-099M-099NJ-099NJ-8RGY-0B	CIMMYT
13	Line13	WBLL1*2/BRAMBLING//TM200/TUI/3/VILLAJUAREZF2009 CMSS08Y00912T-099TOMP-099Y-099M-099Y-2M-0RGY	CIMMYT
14	Line14	WHEAR/KUKUNA/3/C80.1/3*BATAVIA//2*WBLLI*2/4/NIINI #1 CMSS08Y00924T-099TOMP-099Y-099M-099NJ-099NJ-8RGY-0B	CIMMYT
15	Line15	WHEAR/KUKUNA/3/C80.1/3*BATAVIA//2*WBLLI*2/4/NIINI #1 CMSS08Y00924T-099TOMP-099Y-099M-099NJ-099NJ-12RGY-0B	CIMMYT
16	Line16	WBLLI/KUKUNA//TACUPETOF2001/3/BERKUT//PBW343*2/KUKUNA CMSS08B00153S-099M-099Y-13M-0RGY	CIMMYT
17	Line17	VILLAJUAREZF2009/5/BABAX/LR42//BABAX*2/4/SNI/TRAP#1/… CMSS08B00153S-099M-099Y-15M-0RGY	CIMMYT
18	Shandaweel1	SITE/MO/4/NAC/TH.AC//3*PVN/3/MIRLO/BUC CMss93B00567S-72Y-010M-010Y-010M-3Y-0M-0THY-0SH	EGYPT
19	Giza171	SAKHA 93/GEMMEIZA 9 GZ 2003-101-1GZ-4GZ-1GZ-2GZ-0GZ	EGYPT
20	Gemmeiza11	BOW"S"/KZ"S"//7C/AERY 82/3/GIZA 168/SAKHA 61 GM78922-GM-1GM-2GM-1GM-0GM	EGYPT

Table 2. Mean maximum, minimum air temperature (C) during growth stage in favorable and late sowing date at Almatana Research Station.

Months	2018/2019			2019/2020		
	Max	Min	Avg	Max	Min	Avg
November	28.30	14.91	21.61	30.56	16.84	23.70
December	21.87	9.46	15.67	23.83	9.65	16.74
January	20.78	7.24	14.01	20.65	7.67	14.16
February	24.12	10.30	17.21	23.61	9.72	16.67
March	27.25	12.63	19.94	28.90	14.73	21.82
April	32.63	17.52	25.08	32.73	18.83	25.78
May	40.09	24.18	32.14	38.32	23.60	30.96

Almatana Research Station - Luxor governorate 25˚25'18"N 32˚32'06"E

3. Results and discussion

3.1. Heat stress impacts on wheat

Globally, wheat production had been largely affected by the high temperatures. An increase in temperature by 1°C reduces wheat production by 6% (Asseng *et al.*, 2011).

All the different stages of wheat development are affected by heat stress, resulting in a huge reduction in grain yield. However, the effect of heat stress is related to the period of exposure to high temperature during the growth stage. (Padam and Mukti, 2020) (Table 2).

3.2. Analysis of variance

Results in table 3 indicated that sowing dates, genotypes and (genotypes x sowing dates) had significant effects for all studied characters in both growing seasons.

Table 3. Analysis of variance for grain yield and its components across the two sowing dates and wheat genotypes in 2018/19 and 2019/20 seasons.

SOV	df	Means of squares			
		2018/2019 season			
		S/M^2	K/S	1000-KW	GY
Sowing dates (SD)	1	537655.56**	8175.17**	7602.53**	238.82**
Error	4	223.33	106.63	33.01	0.31
Genotypes (G)	19	3141.75**	202.77**	140.32**	6.76**
G x SD	19	66.42**	8.38**	5.3**	0.6**
Pooled Error	76	1920.50	25.52	15.85	0.11
		2019/2020 season			
		S/M^2	K/S	1000-KW	GY
Sowing dates (SD)	1	572103.14**	10850.69**	10100.59**	224.28**
Error	4	7789.06	13.31	54.93	0.02
Genotypes (G)	19	3234.98**	142.34**	107.97**	4.6**
G x SD	19	117.01**	3.42**	5.74**	0.31**
Pooled Error	76	1597.18	44.21	17.19	0.15

3.3. Effect of sowing dates

Heat stress (delaying the sowing) decreased significantly all studied traits no. of spikes per unit area, no. of kernels/spike, 1000-kernel weight and Grain yield (Tables 4).

Among yield components, no. of spikes/m^2 was least affected (31.62%) by heat stress. Increase and decrease in no. of spike/m^2 it's due to the high production of tillers in favorable sowing date which Low temperatures during of vegetative stage and high temperatures decrease the period of vegetative stage in late sowing date (Ayeneh *et al.,* 2002).

No. of kernels/spike was affected more by high temperature and reduced by 32.85%. The decrease in no. of kernels/spike is due to the increase in number of sterile spikelets (Modarresi *et al.,* 2010). The period of flowering, which begins about 20 days before flowering and lasts 10 days after anthesis, withstands temperature up to a maximum of 31°C without any reduction in number of grains (Talukder *et al.*, 2014). High temperature reduces number of days to anthesis, and thus a few number of grains/spike.

Results showed that high temperature begun in start of grain filling and continued until ripening had a negative impact on 1000-kernel weight (32.76%) reduction. Grain development depends on the grain duration rate and grain filling period which is highly sensitive to heat stress (Padam and Mukti, 2020). 1°C - 2°C rise in temperature reduce grain weight due to decrease in grain filling period. High temperatures during grain filling may reduce grain yield up to 24% (Nahar *et al.*, 2010). Grain yield was most affected 37.74%

by heat stress, (6.72 t/ha) under favorable sowing date compared to (4.18 t/ha) under late sowing date. (Asseng *et al.*, 2015) evaluated 30 varieties of wheat in 30 different locations worldwide at different temperatures 15°C to 32°C. Results showed 28% reduction in grain yield by increasing temperature 2°C and the reduction could be 55% for 4 °C rise in temperature. It was also founded that 1°C increase in temperature could reduce grain yield by 6%. (Riaz *et al.*, 2021) reported that wheat grain yield is highly influenced by photosynthesis, which is one of the most important physiological processes for the plant.

Under heat stress conditions many authors have reported that poor germination, reduced number of tillers, reduced pollination and fertilization, decreased in number of spikes per unit area, number of grains/spike and grains weight, all these lead to decreased wheat grain yield. (Irfaq *et al.*, 2005).

Table 4. Mean comparisons of the studied traits in over the two sowing dates.

Sowing dates	Mean			
	S/m^2	K/S	1000-KW	GY (t/ha)
20th November	393	49	47.75	6.718
10th January	269	33	32.11	4.183
Reduction %	31.62	32.85	32.76	37.74
LSD 0.05	47.77	6.73	4.63	0.418

3.4. Mean performance of genotypes

Considerable genetic variation was observed between wheat genotypes for their resilience to high temperatures. To improve or develop wheat genotypes for high temperatures tolerance, the initial step is to assess all the cultivated species genetic variability for high temperatures tolerance and to select genotypes a high ability to withstand heat stress (Riaz *et al.*, 2021).

In general, genotypes are evaluated through location and time according field conditions by modifying sowing dates or choosing locations, which are featured by high temperature (Rane and Nagarajan, 2004).

Mean number of spikes/m^2 for genotypes indicated that Shandaweel1 had the highest number of spikes/m^2 (381) and the lowest belonged to Line9 see (Table 5). The greatest number of kernels/spike (367) belonged to Giza171 (63) and least number of kernels/spike was (26) for Line14 (Table5). Data in (Table 6) showed that 1000-kernel weight obtained from Giza171 (48.95 g) and 1000-kernel weight (31.52 g) belonged to Line1. Results in (Table 6) indicated that the highest grain yield produced by Gemmeiza11 (7.23 t/ha) and the lowest belonged to Line17 (4.160 t/ha).

3.5. Genotypes x sowing dates

Grain yield is the most important character to evaluate the flexibility of wheat to environmental changes. Mean of grain yield for all genotypes in the tow sowing dates are presented in (Table 6).

The combined average for grain yield over two seasons ranged from (5.13 t/ha) for Line17 to (8.81 t/ha) for Gemmeiza11 with an average of (6.72 t/ha). The Line1, Line2, Line3, Line4, Line5, Line6, Line7, Line8, Shandawee1, Giza171 and Gemmeiza11 had the highest grain yield compared to the grand mean over two seasons under favorable sowing date (20th November). Under late sowing date 10th January the lowest and highest grain yield were (3.19 t/ha) and (5.92 t/ha) for Line17 and Shandaweel1, respectively.

Table 5. Mean of spikes/m^2 and number of kernels/spike affected by seasons and genotypes.

Genotype	S/m^2				K/S			
	D1	D2	Mean	Reduction %	D1	D2	Mean	Reduction %
Line1	415	286	350	31.12	44	28	36.08	35.98
Line2	392	266	329	32.27	50	34	41.67	31.65
Line3	415	291	353	29.79	52	35	43.50	32.15
Line4	390	271	330	30.55	50	34	41.75	32.44
Line5	400	271	335	32.29	51	36	43.08	29.93
Line6	401	273	337	31.96	46	31	38.25	32.48
Line7	414	297	355	28.30	46	31	38.33	33.94
Line8	396	268	332	32.24	48	32	39.58	33.33
Line9	367	248	307	32.47	55	36	45.33	35.15
Line10	373	258	315	30.97	51	34	42.00	33.66
Line11	397	257	327	35.35	51	33	41.83	34.87
Line12	391	257	324	34.40	51	35	42.83	30.92
Line13	369	248	309	32.79	45	28	36.75	37.87
Line14	374	257	316	31.28	40	26	33.17	34.85
Line15	391	269	330	31.24	41	27	34.08	33.74
Line16	392	272	332	30.65	51	34	42.50	32.24
Line17	391	268	329	31.37	42	28	35.00	32.67
Shandaweel1	445	316	381	28.93	62	44	52.92	28.38
Giza171	443	304	374	31.28	63	43	52.75	31.65
Gemmeiza11	392	273	332	30.31	59	40	49.25	32.10
Mean	393	269	331	31.62	49	33	41.53	32.85
LSD 0.05	45	51			6.8	6.7		

D1: Favorable sowing date (20th November).
D2: Late sowing date (10th January).

Table 6. Mean of 20 genotypes for 1000-kernel weight (g) and grain yield (t/ha) averaged two seasons.

Genotype	1000-KW				GY (t/ha)			
	D1	D2	Mean	Reduction %	D1	D2	Mean	Reduction %
Line1	38.50	24.55	31.52	36.24	8.61	5.20	6.90	39.64
Line2	44.74	30.10	37.42	32.72	8.13	4.83	6.48	40.59
Line3	48.65	33.49	41.07	31.18	7.46	4.37	5.92	41.40
Line4	43.91	29.29	36.60	33.29	7.33	4.37	5.85	40.40
Line5	45.56	30.24	37.90	33.64	7.38	4.25	5.82	42.41
Line6	42.86	26.43	34.65	38.34	7.08	4.53	5.81	36.03
Line7	44.73	29.18	36.95	34.76	6.73	4.06	5.39	39.69
Line8	54.02	36.34	45.18	32.72	6.91	3.70	5.30	46.44
Line9	50.17	31.72	40.94	36.78	6.29	4.27	5.28	32.15
Line10	41.26	28.78	35.02	30.24	6.40	4.06	5.23	36.52
Line11	43.81	29.59	36.70	32.47	6.34	3.91	5.12	38.38
Line12	48.80	32.42	40.61	33.57	6.22	3.99	5.11	35.84
Line13	45.15	31.48	38.31	30.29	6.17	4.01	5.09	35.04
Line14	48.93	34.15	41.54	30.21	6.00	3.59	4.79	40.25
Line15	56.36	39.09	47.72	30.65	5.99	3.52	4.76	41.19
Line16	46.16	31.10	38.63	32.63	5.70	3.72	4.71	34.83
Line17	44.21	29.69	36.95	32.85	5.13	3.19	4.16	37.88
Shandaweel1	53.82	36.68	45.25	31.85	8.39	5.92	7.15	29.49
Giza171	58.33	39.57	48.95	32.16	8.73	5.60	7.16	35.88
Gemmeiza11	54.18	37.70	45.94	30.41	8.81	5.64	7.23	36.01
Mean	47.75	32.11	39.93	32.76	6.72	4.18	5.45	37.74
LSD 0.05	4.48	4.84			0.45	0.39		

D1: Favorable sowing date (20th November).
D2: Late sowing date (10th January).

3.6. Heat susceptibility index (HSI)

Heat tolerance as measured by heat susceptibility index reflects the stability of performance of genotypes under no-stress, and heat stress environment.

HSI <1 indicates the tolerance of genotype to heat stress whereas.

HIS >1 indicates susceptibility of the genotypes under stress. Means of grain yield (t/ha) of the 20 genotypes simultaneously grown under favorable sowing date (D1) and late sowing date (D2) are shown in (Table 7).

Heat susceptibility index (HSI) established on grain yield for the genotypes under study in the two seasons. Shandaweel1 then Line9 followed by Line16, Line13, Line6, Line12, Giza171 and Gemmeiza11 and in the latter Line10 had HSI values below unity for the mean of the two seasons, so these genotypes were considered to be tolerant to heat stress.

Table 7. The mean of grain yield of 20 genotypes in favorable and heat stress with heat susceptibility index (HSI).

Genotypes	2018/2019			2019/2020			Over all		
	D1	D2	HSI	D1	D2	HSI	D1	D2	HSI
Line1	8.13	4.86	0.98	9.09	5.53	1.12	8.61	5.20	1.05
Line2	7.83	4.19	1.13	8.43	5.47	1.01	8.13	4.83	1.08
Line3	7.25	4.01	1.09	7.68	4.74	1.10	7.46	4.37	1.10
Line4	7.17	4.17	1.02	7.48	4.57	1.12	7.33	4.37	1.07
Line5	7.37	3.71	1.21	7.40	4.80	1.01	7.38	4.25	1.12
Line6	6.35	3.79	0.98	7.81	5.26	0.94	7.08	4.53	0.95
Line7	6.40	3.65	1.05	7.06	4.47	1.05	6.73	4.06	1.05
Line8	6.28	3.12	1.23	7.53	4.28	1.24	6.91	3.70	1.23
Line9	5.76	3.87	0.80	6.82	4.66	0.91	6.29	4.27	0.85
Line10	5.83	3.42	1.01	6.97	4.71	0.93	6.40	4.06	0.97
Line11	5.68	3.19	1.07	7.00	4.62	0.98	6.34	3.91	1.02
Line12	5.85	3.71	0.89	6.59	4.28	1.01	6.22	3.99	0.95
Line13	5.56	3.42	0.94	6.77	4.59	0.92	6.17	4.01	0.93
Line14	5.36	3.00	1.07	6.64	4.17	1.07	6.00	3.59	1.07
Line15	5.86	3.05	1.17	6.12	4.00	1.00	5.99	3.52	1.09
Line16	4.91	3.06	0.92	6.49	4.37	0.94	5.70	3.72	0.92
Line17	4.45	2.88	0.86	5.81	3.50	1.14	5.13	3.19	1.00
Shandaweel1	7.85	5.30	0.79	8.93	6.53	0.77	8.39	5.92	0.78
Giza171	8.70	5.40	0.92	8.76	5.80	0.97	8.73	5.60	0.95
Gemmeiza11	8.76	5.47	0.92	8.86	5.82	0.99	8.81	5.64	0.95
Mean	6.27	3.69	---	7.17	4.67	---	6.72	4.18	---

4. Conclusion

In conclusion, the results of this investigation provided the lines, Line6, Line9, Line10, Line12, Line13 and Line16 were suitable lines to be cultivated under heat stress areas, further the three Egyptian cultivars Shandaweel1, Giza171 and Gemmeiza11 showed low heat susceptibility index (HSI<1) for grain yield and were thus consider as heat tolerant cultivars.

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5. References

Asseng, S., Foster, I. and Turner, N.C. (2011) 'The impact of temperature variability on wheat yields' *Global Change Biol.* 17: pp.997-1012.

Asseng, S., Ewert, F., Martre, P., Rötter, R.P. and Lobell, D.B. (2015) 'Rising temperatures reduce global wheat production' *Nat Clim Change*. 5: pp.143-147.

Ayeneh A, Van-Ginkel M, Reynolds MP, Ammar K (2002). Comparison of leaf, spike, peduncle and canopy temperature depression in wheat under heat stress. Field Crops Res. 79: 173-184.

Chandra, D., Islam, M.A. and Barma, N.C.D (2004) 'Variability and interrelationship of nine quantitative characters in F bulks of five wheat crosses' *Pak. J. Bio. Sci.,* 7(6): pp. 1040-1045.

Coventry, D.R., Gupta, R.K., Poswal, R.S., Chhokar, R.S., Sharma, R.K., Yadav, V.K., Gill, S.C., Mehta, A., Kleemann, S.G.L., Bonamano, A. and Cummins, J.A. (2011) 'Wheat quality and productivity as affected by varieties and sowing time in Haryana' *India. Field Crops Research,* 123(3): pp. 214-225.

FAO. (2020) *'Food and Agriculture Organization of United Nations'* http://www.fao.org/statistics.

Fischer, R.A. and Maurer, R.O. (1978) 'Drought resistance in spring wheat cultivars. I: Grain yield responses' *Aust. J. Agric. Res.* 29: pp. 897-912.

Gomez, K.A. and Gomez, A.A. (1984) *'Statistical Procedures for Agricultural Research'* John Wiley and Sons.Inc. New York, USA.

IFPRI (2021) *'International food policy'* Research institute online report August 2021. https://www.ifpri.org.

Irfaq, M., Muhammad, T., Amin, M. and Jabbar, A. (2005) 'Performance of yield and other agronomic characters on four wheat cultivars under natural heat stress' *Inter. J. Bot.,* 1: pp. 124-127.

Modarresi, A., Mohammadi, V., Zali, A. and Mardi, M. (2010) 'Response of wheat yield and yield related traits to high temperature' *Cereal Research Communications* 38(1): pp. 23–31.

Riaz, M.W., Yang, L., Yousaf, M.I., Sami, A., Mei, X.D., Shah, L., Rehman, S., Xue, L., Si, H. and Ma, C. (2021) 'Effects of Heat Stress on Growth, Physiology of Plants, Yield and Grain Quality of Different Spring Wheat (*Triticum aestivum* L.) Genotypes' *Sustainability.* 13, 2972. su13052972.

Nahar, K., Ahamed, K.U. and Fujita, M. (2010) 'Phenological variation and its relation with yield in several wheat (*Triticum aestivum* L.) cultivars under normal and late sowing mediated heat stress condition' *Not Sci Biol.* 2(3): pp. 51-56.

Padam, B.P. and Mukti, R.P. (2020) 'Heat Stress Effects and Tolerance in Wheat' *A Review. Journal of Biology and Today's World.* 9(3): pp. 217.

Rane, J. and Nagarajan, S. (2004) 'High temperature index for field evaluation of heat tolerance in wheat varieties' *Agri Sys.* 79: pp. 243-255.

Silva, R.R., Benin, G., Almeida, J.L., Fonseca, I.C.B. and Zucareli, C. (2014) 'Grain yield and baking quality of wheat under different sowing dates' *Acta Scientiarum Agron.,* 36(2): pp. 201-210.

Sugar crops council (2020) *'Production of sugar in Egypt'* sugarcane council report, pp. 13-34.

Talukder, A., Mcdonald, G.K. and Gill, G.S. (2014) 'Effect of short-term heat stress prior to flowering and early grain set on the grain yield of wheat' *Field Crops Res.* 160: pp.54-63.

Wahid, A., Gelani, S., Ashraf, M. and Foolad, M.R. (2007) 'Heat tolerance in plants: an overview' *Environmental and Experimental Botany* 61: pp.199–223.