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(Original Article)

Impact of Late Sowing on Performance of Barley Genotypes Under Aswan Conditions

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Abstract

Climate change on a global scale and an expanding human population have disturbed food security globally. One of the main abiotic factors affecting the productivity and quality of barley is heat stress. The aim of this study was to evaluate the performance of fifteen barley genotypes for heat stress and yield traits under two sowing dates, timely and late sowing (10th November and 10th December) during the 2022-23 and 2023-24 seasons. The current work was conducted at the Experimental Research Station, Faculty of Agriculture and Natural Resources, Aswan University, Egypt. The genotypes were grown in a Randomized Complete Block Design (RCBD), with three replications. The obtained results revealed that the sowing date on 10^{th} November recorded the highest mean values for flowering date, number of spikes m^{-2}, number of grains $spike^{-1}$, 1000-grain weight, and maturity date in the first and second seasons, respectively. Data indicated that genotype Giza 126 (G_3) recorded the highest average values of seed yield as 3,213 and 2,815 kg fed^{-1} under timely sowing date (10^{th} November). In contrast, the lowest mean values of seed yield were recorded from $G_1{\times}G_2$ (2,219 and 1,699 kg fed^{-1}) and $G_1{\times}G_4$ (1,953 and 1,654 kg fed^{-1}) in the first and second seasons, respectively. The genotypes Giza 126 (G_3), $G_3{\times}G_4$ and G3×G5 significantly outperformed all studied genotypes for grain yield under both timely and late sowing dates. From the results of heat tolerant indices, Giza 126 (G_3), $G_3{\times}G_4$, $G_3{\times}G_5$, and $G_4{\times}G_5$ were considered as tolerant genotypes to heat stress because they exhibited higher values for mean productivity (MP), geometric mean productivity (GMP), tolerance Index (TOL), stress susceptibility index (SSI), and yield Index (YI), and lower values of yield stability index (YSI).

Keywords: *Barley genotypes, Heat tolerant indices, Sowing dates, Yield contributing traits.*

Introduction

Under Climate change conditions, researchers and farmers are working to generate climate-resilient crops using improved agricultural techniques, and cutting-edge technology to solve these problems and ensure food security. Barley (*Hordeum vulgare* L.) is one of the winter cereals and the oldest crops grown globally for use as food, feed, and malt. It ranks fourth among cereal crops. It is

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grown in arid and semiarid areas that suffer from low soil fertility and water deficiency (Mariey *et al.,* 2023). It is more profitable and stable compared to the other major crops, and it can replace wheat as the dominant crop, for its tolerance to abiotic stress (Seadh *et al.,* 2022). Hence, it is favored by farmers with limited resources due to its low input requirement (Rezaei *et al.,* 2022). According to the (FAO, 2022), barley cultivated area, production, and productivity in Egypt were estimated to be 69,751 fed., 104,092 tons, and 12.44 ardab fed^{-1} (1 ardab= 155kg and 1 fed= 4200 m2), respectively.

Growing degree days (GDD) is a very important factor for plant growth and development and exhibits necessary useful temperature accumulation, and it describes the stages from the emergence stage to the physiological maturity phase for crops (Vasilescu *et al*., 2022). Heat stress or heat shock is defined as an elevated temperature from 10 to 15 ºC above usual. Heat stress is one climatological extreme that negatively impacts plant growth and productivity by greatly affecting plant activities like seed germination, development, photosynthesis, and reproduction (Hasanuzzaman *et al.,* 2011). Anatomical changes due to high temperatures cause decreased cell size, stomatal closure, reduced water loss, and larger xylem vessels in both the shoot and the root *(Cabusora,* 2024). Air temperature is considered one of the main weather parameters affecting the physiological and yield of crops. An increase of 1 °C i in the average daily temperature above the optimal temperature during grain filling results in a 3.1day shortening of the filling period and a 3-5% or 2.8 mg decrease in grain weight (Novo, 2001 and Bisht *et al*., 2019). Furthermore, by 2050, the average temperature is potential for the country's major barley-sowing areas to increase by about 1.5-2 °C (McCarl *et al*., 2015 and Abdelghany *et al*., 2024). Sowing date is one of the essential agricultural practices which control barley growth and production. Timely sowing of barley realizes optimum environment for crop growth for more dry matter accumulation hence, higher grain yield (Renu *et al*., 2023). So, modifying the sowing date and utilizing improved genotypes can alleviate the harmful effects of adaptation to climate change on the yield of barley, particularly temperature (Moustafa *et al.,* 2021). On the contrary, delaying planting could lead to poor grain filling and low biomass production as a result of higher temperature conditions when the crop maturity (Potterton and McCabe, 2018; Amarjeet *et al.,* 2020; Bhagat *et al.,* 2023). Consequently, late sowing can cause heat stress, particularly during the grain-filling period, resulting in the differentiation of sensitive and tolerant barley genotypes. To realize yield sustainability, it is a must to cultivate barley genotypes that are resistant to the heat conditions carried on by global climate *change* (Seval and Yıldırım, 2023).

Concerning the selection of heat-tolerant genotypes, many indices could be used based on grain yield under heat-stressed and non-stressed conditions, like mean productivity (MP), geometric mean productivity (GMP), and yield index (YI), besides were chosen based on the evaluation of values of heat-stress indices. (Mansour and Heakel, 2015; Bahrami *et al*., 2021; Bhagat *et al*., 2023).

The objective of the study was to classify fifteen barley genotypes by heat tolerance indices and their productivity through timely and late sowing dates under Aswan general soil and climatic conditions.

Materials and Methods

1-Description of Experimental site

Fifteen barley genotypes (*Hordeum vulgare* L.) were performance evaluated for two seasons (2022-23 and 2023-24) at two planting dates at the Experimental Farm, Faculty of Agriculture and Natural Resources, Aswan University, Aswan Governorate (Latitude: 23°59' 49" N and Longitude: 32°51' 41" E.). The meteorological data were recorded from the Center Laboratory for Agricultural Climate (CLAC), Ministry of Agriculture, Egypt, as shown in Table 1.

Table 1. The average degrees of minimum and maximum temperature, growing degree days, relative humidity, and wind speed at the experimental site for the two growing seasons.

Month	Air temperature [ºC]				GDD (ºC day)		Relative humidity [%]		Wind speed [m/s]	
	T_{min}	T_{max}	T_{min}	T_{max}						
	2022-23		2023-24		2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
November	17.00	32.87	14.77	30.45	613.05	678.3	36.47	36.77	0.21	0.13
December	10.94	25.00	11.04	27.48	417.57	597.06	43.37	41.01	0.25	0.11
January	7.36	21.75	9.04	25.83	311.70	5z40.48	41.67	41.61	0.31	0.15
February	8.42	25.37	9.24	25.39	347.06	484.82	35.33	31.52	0.41	0.36
March	12.27	29.35	14.22	32.79	505.61	728.65	22.49	23.20	0.57	0.47
April	20.19	40.03	18.11	36.85	768.30	851.88	14.55	16.61	0.31	0.52

Tmin: minimum temperature[ºC], Tmax: maximum temperature[ºC]and GDD: Growing degree days

2-Plant Material and experimental design

Fifteen barley genotypes were evaluated under timely and late sowing; the genotypes are presented in Table 2. The experiments utilized a Randomized Complete Block Design (RCBD) using split-plot arrangement with three replications. Two sowing dates (10th November and 10th December) were laid out in the main plots and fifteen genotypes were distributed in the sub-plots. The plot size was 4.2 m^{-2} and consists of 6 rows 0.2 m apart, 3.5 m long.

Table 2. The origin and pedigrees of the five barley cultivars used in the study

No.	Cultivars	Pedigree	Origin
G1	**Giza-124**	Giza 117/Bahteem 52// Giza 118/FAO 86	Egypt
G2	**Giza-2000**	Giza 117 / Bahtim 52 // Giza 118 / FAO 86/3/ Baladi 16/Gem. (Giza 121)	Egypt
G3	**Giza-126**	Baladi Bahteem/S D729-Por12762-BC	Egypt
G4	**Giza-130**	Comp.cross"229//Bco.Mr./DZ02391/3/Deir Alla 106	Egypt
G5	**Giza-123**	Giza 117 /FAO86	Egypt
G6		G1*G2	Egypt
G7		G1*G3	Egypt
G8		G1*G4	Egypt
G9		G1*G5	Egypt
G10		G2*G3	Egypt
G11		G2*G4	Egypt
G12		G2*G5	Egypt
G13		G3*G4	Egypt
G14		G3*G5	Egypt
G15		G4*G5	Egypt

The agronomic practices recommended for barley production in the study area are applied through the growing season under sandy soil conditions (Table 3).

Table 3. The mechanical and chemical properties of the experimental soil.

Soil properties	Physical properties				Chemical properties					
	Clay (%)	Silt (%)	Sand (%)	Soil Texture	OM (%)	pH	EC (ds m^{-1})	Available NPK		
								Total N (%)	P (ppm)	K (ppm)
2022-23	3.02	2.28	94.70	**Sandy**	0.09	8.25	0.25	0.08	8.00	175
2023-24	3.07	2.26	94.67		0.09	8.24	0.26	0.08	7.89	176

As per the Association of Official Analytical Chemists (A.O.A.C.) 1995.

3-Traits measurement

The studied traits included plant height in cm (PH), number of days to flowering (DF), number of days to maturity (DM), number of spikes m^{-2} (SM), number of grains $spike^{-1}$ (GS), thousand grain weight in gram (TGW), grain yield in kg fed^{-1} (GY), biological yield (BY) and harvest index (HI).

4-Heat tolerance Indices

Tolerance indices were calculated based on grain yield under both timely (November) and late sowing (December) as follows

1-Mean Productivity (MP) = (Ypi + Ysi)/2 (Fernandez, 1992)

2-Geometric Mean Productivity (GMP) = $\sqrt{(\mathrm{Ypi} \times \mathrm{Ysi})}$ (Fernandez, 1992)

3-Tolerance Index (TOL) = Ypi - Ysi (Rosielle and Hamblin, 1981)

4-Yield Stability Index (YSI) = Ysi/Ypi (Bouslama and Schapaugh, 1984)

Where: Ysi, is the yield of cultivar in late sowing; Ypi is the yield of cultivar in timely sowing; SI is stress intensity.

5-Stress susceptibility index (SSI) = $[1-(Ys/Yp)]/[1-(\bar{Y}s/\bar{Y}p)]$ (Fischer and Maurer, 1978).

6-Yield Index (YI) = $(Ys/\bar{Y}s)$ (Gavuzzi, *et al.,* 1997).

Where: Yp and Ys: grain yield of each genotype under timely and late sowing, respectively. $\bar{Y}p$ and $\bar{Y}s$: mean grain yield of all genotypes timely and late sowing, respectively.

5-Statistical analysis

The data from each season, spanning two sowing dates, was analyzed statistically using the MSTAT-C Statistical Software Package as outlined by Gomez and Gomez (1984). To detect the difference between means, the least significant difference (LSD) was calculated at the 5% level of probability.

Results and Discussion

1-Effect of sowing dates

Heat stress influences barley's growth, development, yield, and yield components. All studied traits were negatively impacted by late sowing, and the fifteen barley genotypes performed differently for the sowing dates in both seasons. According to the results, in the 1st and 2nd seasons, respectively, sowing date in 10th November recorded the highest mean values for flowering date (78.94 and 78.47 days), number of spikes m^{-2} (452.67 and 437.87 spikes), number of grains spike^{-1} (59.20 and 57.20 grains), 1000-grain weight (49.96 and 48.66 g), and maturity date (114 and 113 days) in Tables 4, 5 and 6. Crop sown under a timely sowing date scored the heaviest grain yield (2428 and 2200 kg fed^{-1}) and harvest index (45.38 and 46.96 %) compared with late sowing date in both seasons, respectively. Based on the previous result, November 10th is a timely date to cultivate barley, which might be attributed to favorable weather conditions during this period under Aswan conditions compared to late sowing date as the temperature reduced sharply. Delay in the sowing of barley leads to less grain yield due to reduced assimilate transport to the sink owing to decreased leaf area (source) to intercept light radiation causing reduced photosynthesis, and prevailing unfavorable weather conditions such as high temperatures during the grain filling. Agwa and Mohamad (2020) found that the sowing date of barley on 5th November produced the longest growing degree days (GDD) at maturity, the maximum plant height, number of grains spike^{-1}, 1000-grain weight, number of spikes m^{-2}, grain yield, and harvest index compared with other sowing dates. Early sowing date has the most increase in yield and its attributes of barley (Seadh *et al.*, 2022).

Table 4. Plant height, flowering date and spike length as affected by sowing dates and genotypes and their interactions during 2022-23 and 2023-24 growing seasons.

Traits	**Plant height (cm)**				**Flowering date (days)**				**Spike length (cm)**			
Seasons	**2022-23**		**2023-24**		**2022-23**		**2023-24**		**2022-23**		**2023-24**	
Treatments	**Sowing dates (SD)**											
Gynotypes (G)	**Timely**	**Late**	**Timely**	**Late**	**Timely**	**Late**	**Timely**	**Late**	**Timely**	**Late**	**Timely**	**Late**
G1: Giza-124	112.66	111.00	115.00	107.60	75.60	71.66	72.00	64.00	8.33	8.00	8.00	7.6
G2: Giza-2000	112.00	110.66	120.00	107.00	76.60	70.00	76.00	52.00	8.66	8.33	6.00	6.30
G3: Giza-126	109.66	108.66	117.00	96.60	85.33	81.33	84.00	65.00	11.00	10.66	11.00	11.00
G4: Giza-130	97.33	96.00	90.00	86.60	68.00	63.33	72.00	57.00	7.66	7.66	8.00	7.00
G5: Giza-123	99.00	99.33	95.00	85.00	66.00	57.00	62.00	48.00	7.33	7.66	5.60	6.00
G6: G1×G2	121.33	122.66	121.00	110.60	75.66	71.00	73.00	53.00	8.33	8.33	8.00	6.33
G7: G1×G3	110.66	108.66	116.00	98.00	86.66	81.33	87.00	75.00	9.66	9.00	8.00	7.33
G8: G1×G4	111.33	111.66	113.60	95.00	82.00	77.66	85.00	64.00	8.33	8.00	6.00	6.00
G9: G1×G5	109.66	114.33	105.00	85.33	82.00	77.00	84.00	67.00	8.66	8.33	8.00	6.66
G10: G2×G3	112.33	110.00	107.30	80.00	79.00	74.66	74.00	59.00	8.33	8.33	8.00	6.66
G11: G2×G4	95.66	96.00	88.00	75.60	80.66	75.66	76.00	74.00	9.00	8.66	8.30	6.33
G12: G2×G5	118.00	117.33	110.00	98.00	79.66	74.66	78.00	46.00	9.33	9.33	9.00	6.66
G13: G3×G4	118.66	119.00	112.30	100.00	82.00	75.33	86.00	52.00	10.66	10.66	11.00	11.00
G14: G3×G5	109.66	100.66	99.00	84.66	79.66	74.33	82.00	64.00	10.33	10.33	9.00	8.00
G15: G4×G5	102.33	101.66	107.00	85.33	85.33	79.66	86.00	58.00	10.33	10.00	9.00	8.00
General mean	**109.35**	**108.51**	**107.75**	**93.02**	**78.94**	**73.64**	**78.47**	**59.87**	**9.06**	**8.89**	**8.19**	**7.39**
	$LSD_{0.05}$											
Sowing dates (SD)	**NS**		**1.44**		**0.58**		**2.85**		**NS**		**NS**	
Genotypes (G)	**3.46**		**2.81**		**3.14**		**3.48**		**0.93**		**1.58**	
SD × G	**NS**		**5.48**		**NS**		**17.70**		**NS**		**4.17**	

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

The barley sown on a late sowing date led to exposure to unsuitable weather conditions or high temperatures resulting in deficit soil moisture thus affecting all stages from germination to maturity due to sown late. The temperature increase could negatively impact plants, leading to cell injuries, and disruption of both protein synthesis, and certain vital enzyme functions (Bhupenchandra *et al*., 2022). Late sowing wheat or barley crops accompanied delayed the crop emergence due to low temperature at the germination stage and higher temperature at the reproductive stage, consequently, reduce yield and its attributes (Yusuf *et al.,* 2019 and Agwa and Mohamad 2020).

Table 5. Number of spikes m^{-2}, Number of grains spike^{-1} and 1000-grain weight as affected by sowing dates and genotypes and their interactions during 2022-23 and 2023-24 growing seasons.

Traits	Number of spikes m^{-2}				Number of grains spike^{-1}				1000-grain weight (g)			
Seasons	2022-23		2023-24		2022-23		2023-24		2022-23		2023-24	
Treatments	Sowing dates (SD)											
Gynotypes (G)	Timely	Late	Timely	Late	Timely	Late	Timely	Late	Timely	Late	Timely	Late
G1: Giza-124	403	395	380	310	58	36	52	47	48.06	48.96	52.76	49.66
G2: Giza-2000	457	447	461	333	58	35	61	52	49.46	47.53	46.1	44
G3: Giza-126	570	537	572	464	68	40	70	68	56.16	53.33	56	52
G4: Giza-130	453	443	446	186	60	35	56	56	48.33	46.1	46	44
G5: Giza-123	438	428	427	302	58	33	52	52	52.66	49.7	52	48.66
G6: G1×G2	385	376	339	254	54	27	45	46	44.76	42.20	41	40
G7: G1×G3	455	412	438	337	60	37	59	53	43.33	42.66	43.46	39.66
G8: G1×G4	343	366	324	234	54	26	44	45	42.46	41.43	40	40
G9: G1×G5	384	377	363	354	54	27	52	46	53.03	42.23	50	49.13
G10: G2×G3	422	328	381	249	54	35	52	47	49.46	49.8	49.4	46.3
G11: G2×G4	447	420	428	334	58	36	61	54	51.66	50.13	51.2	41.7
G12: G2×G5	449	441	447	328	58	37	59	46	48.36	52.43	41	40.3
G13: G3×G4	545	530	543	423	66	40	69	62	54.16	52.46	55	51
G14: G3×G5	520	503	513	411	64	38	64	60	53.9	52.46	53	50.73
G15: G4×G5	519	502	506	351	64	37	62	57	53.56	52.16	53	50
General mean	**452.67**	**433.67**	**437.87**	**324.67**	**59.20**	**34.60**	**57.20**	**52.73**	**49.96**	**48.24**	**48.66**	**45.81**
	LSD$_{0.05}$											
SD	**4.91**		**11.48**		**1.14**		**1.46**		**1.49**		**0.766**	
G	**11.76**		**26.56**		**4.96**		**5.47**		**2.16**		**1.66**	
SD × G	**NS**		**64.00**		**NS**		**18.88**		**NS**		**6.49**	

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

2-Genotypes performance

Results exhibit significant differences among the fifteen tested genotypes of barley (Tables 4, 5, and 6). All studied traits were adversely influenced by high temperatures or late sowing dates of barley genotypes tested. The highest values of plant height (cm) were obtained by $G_1 \times G_2$, while $G_2 \times G_4$ had the lowest plant height under timely and late sowing dates in both first and second seasons. Regarding flowering date, Giza123 (G_5) was the earliest genotypes, while $G_1 \times G_3$ was the latest genotype for flowering date. Regarding to maturity Giza130 (G_4) was the earliest genotype, while $G_1 \times G_4$ was the latest genotype under the two seasons. The greatest spike length (cm) was obtained by Giza126 (G_3), (11.00, 10.66, 11.00, and11.00) followed by the $G_3 \times G_4$, $G_3 \times G_5$, and $G_4 \times G_5$, while the least belonged to Giza123 (G_5), (7.33, 7.66, 5.60, and 6.00 followed by the $G_1 \times G_4$ in the first and second seasons under timely and late sowing dates, respectively. The greatest number of spikes m^{-2} was obtained by Giza126 (G_3) followed by the $G_3 \times G_4$, $G_3 \times G_5$, and $G_4 \times G_5$, while the least was belonging to G_8 followed by the $G_1 \times G_2$, concerning a number of grains spike^{-1} and 1000-grain weight. Giza126

(G_3) was the best genotype followed by the $G_3×G_4$, $G_3×G_5$, and $G_4×G_5$, while the least belonged to $G_1×G_4$ followed by the $G_1×G_2$. Concerning grain yield results exhibit that the Giza126 (G_3) attained the highest value of seed yield 3,213 and 2,815 kg fed^{-1} under timely sowing date, followed by the $G_3×G_4$, $G_3×G_5$, and $G_4×G_5$ in the first and second seasons, respectively. In contrast, the lowest value of seed yield was recorded from $G_1×G_2$ (2,219 and 1,699 kg fed^{-1}) and $G_1×G_4$ (19,53 and 16,54 kg fed^{-1}) in the first and second seasons, respectively. Barley genotypes showed varying responses for yield and its components, especially under environmental stress (Gharib *et al.,* 2021 and Moustafa *et al.,* 2021). Many studies proved that barley genotypes exhibited significant differences in yield and its components attributed to differences in their genetic background (Agwa *et al*., 2020; Habib *et al.,* 2021; Seadh *et al*., 2022; Mariey *et al*., 2023).

Table 6. Maturity date, growing degree days and heat use efficiency as affected by sowing dates and genotypes and their interactions during 2022-23 and 2023-24 growing seasons.

Traits	Maturity date (days)				Grain yield (kg fed^{-1})				Harvest index (%)			
Seasons	2022-23		2023-24		2022-23		2023-24		2022-23		2023-24	
Treatments	Sowing dates (SD)											
Gynotypes (G)	Timely	Late	Timely	Late	Timely	Late	Timely	Late	Timely	Late	Timely	Late
G1: Giza-124	117	112	112	108	2493	1454	2109	1433	44.33	24.85	47.47	33.29
G2: Giza-2000	118	112	116	105	2289	1525	2304	1440	55.51	30.38	55.46	34.36
G3: Giza-126	116	111	113	106	3213	1848	2815	1688	47.26	34.35	43.67	37.30
G4: Giza-130	101	95	101	94	2283	1873	2191	1419	44.24	43.84	66.46	44.39
G5: Giza-123	120	106	109	102	2338	1625	2419	1530	42.32	46.68	49.62	36.24
G6: G1×G2	112	116	116	103	2219	1537	1699	1294	41.87	31.04	41.63	36.95
G7: G1×G3	122	116	118	96	2226	1530	1852	1568	44.46	33.64	41.05	38.78
G8: G1×G4	122	116	124	111	1953	1309	1654	1345	51.45	45.69	46.94	45.68
G9: G1×G5	119	113	121	107	2051	1446	2125	1532	39.29	39.26	44.97	49.04
G10: G2×G3	118	113	119	97	2268	1463	2417	1648	44.64	30.55	44.77	51.32
G11: G2×G4	110	106	113	98	2420	1569	1892	1413	40.69	35.71	45.97	47.06
G12: G2×G5	113	107	123	94	2450	2014	1914	1310	46.57	54.04	36.93	31.20
G13: G3×G4	107	102	103	95	2826	1800	2665	1852	46.06	44.32	42.68	43.46
G14: G3×G5	108	104	104	95	2709	1416	2610	1548	45.73	40.74	40.76	40.26
G15: G4×G5	109	104	105	95	2691	1415	2336	1418	46.28	28.85	47.64	47.19
General mean	**114**	**108**	**113**	**100**	**2428**	**1588**	**2200**	**1496**	**45.38**	**37.59**	**46.36**	**41.10**
LSD$_{0.05}$												
SD	0.34		5.32		47.88		100.55		0.24		1.15	
G	3.01		4.33		54.17		138.45		0.86		3.33	
SD × G	NS		6.19		142.39		535.00		2.65		13.18	

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

3-Effect of interaction

The data in (Tables 4, 5, and 6) showed that all studied traits were not significantly influenced by the sowing dates x genotypes in the first season, except grain yield/kg fed-^{1} and harvest index % which excreted significantly influenced by the sowing dates x genotypes in both seasons. The highest values of a plant height (cm) were obtained by $G_1×G_2$, (121.33 to 122.66) and (121.00 to 110.60), while $G_2×G_4$ had the lowest plant height (95.66 to 96.00) and (88.00 to 75.60), in the two seasons under timely and late sowing dates, respectively. The genotype $G_1×G_3$ recorded the highest average values for the flowering date (86.66 to 81.33 days) and (87.00 to 75.00 days), while Giza123 (G_5) recorded the lowest in the two seasons (66.00 to 57.00 days) and (62.00 to 48.00 days) under timely and late sowing dates, respectively. The greatest mean values of spike length (cm), was obtained from Giza126 (G_3), (11.00 and 10.66 cm) and (11.00 cm), while the lowest spike length (cm) were recorded by Giza123 (G_5) (7.33 and 7.66 cm) and (5.60 and 6.00 cm) in the two seasons under timely and late sowing dates, respectively. As well as the greatest number of spikes m^{-2}, (570.0 and 537.0) and (572.0 and 464) were obtained by Giza126 (G_3), while the lowest number of spikes m^{-2}, (343.0 and 366.0) and (324.0 and 234.0) were registered by $G_1 \times G_4$, in the two seasons under timely and late sowing dates, respectively. The greatest average values of kernels number spike^{-1} were obtained by Giza126 (G_3), while the lowest mean values were recorded by $G_1 \times G_4$, in the two seasons under timely and late sowing dates, respectively. Moreover, the maximum thousand kernels weight was recorded by genotypes Giza126 (G_3), $G_3 \times G_4$, $G_3 \times G_5$, and $G_4 \times G_5$, while the lowest was recorded by genotypes $G_1 \times G_4$ and $G_1 \times G_2$, in the two seasons under timely and late sowing dates, respectively. The heaviest 1000 grain weight (54.16.20 and 56.00 g) in both seasons under timely sowing dates, respectively. The lightest 1000 grain weight (40.00 and 39.66 g) in the second season under timely and late sowing dates. The greatest mean values of maturity date were recorded by genotypes $G_1 \times G_4$ and $G_1 \times G_3$, while the lowest was recorded by genotypes Giza126 (G_3), $G_3 \times G_4$, and $G_3 \times G_5$, in the first and second seasons, under timely and late sowing dates respectively. Genotype Giza126 (G_3) recorded the highest values for grain yield followed by the $G_3 \times G_4$, $G_3 \times G_5$, and $G_4 \times G_5$. While, the lowest average values of grain yield was recorded from $G_1 \times G_2$ and $G_1 \times G_4$ in the first and second seasons, under timely and late sowing dates respectively. The maximum gain yield/kg fed^{-1}(3,213 and 2,815 kg fed^{-1}) in both seasons under timely sowing dates, respectively. The minimum grain yield/fed. (1,309 kg fed.$^{-1}$) in the 1st season was obtained by $G_1 \times G_4$ under late sowing dates. Also, the greatest mean value of harvest index% (66.46% in the 2st season) were recorded by Genotype Giza130 (G_4), under timely sowing dates, while the lowest was recorded by genotype Giza124 (G_1), in the 1st season, under late sowing dates. Finally, the difference between cultivars under different sowing dates can be attributed to genetic makeup. These findings agree with those reported by Juskiw and Helm (2003) and Soleymani *et al.* (2011).

4-Heat tolerance indices

To assess six heat tolerance indices of fifteen barley genotypes, mean productivity (MP), geometric mean productivity (GMP), tolerance Index (TOL), yield stability index (YSI), stress susceptibility index (SSI), and yield Index (YI) were estimated based on grain yield under timely and late sowing dates in Tables 7 and 8. Results exhibit that the Giza126 (G_3) attained to be the highest genotype and accounted the highest value of seed yield 3,213 and 2,815 kg fed^{-1} under timely sowing date, followed by the $G_3 \times G_4$, $G_3 \times G_5$, and $G_4 \times G_5$ in the 1st and 2nd seasons, respectively. In contrast, the lowest value of seed yield recorded from $G_1 \times G_2$ (2,219 and 1,699 kg fed^{-1}) and $G_1 \times G_4$ (1,953 and 1,654 kg fed^{-1}) in the first and second seasons, respectively. From the results of heat tolerant indices, Giza126 (G_3), $G_3 \times G_4$, $G_3 \times G_5$, and $G_4 \times G_5$ were considered tolerant to heat stress because they exhibited higher values for MP, GMP, TOL, SSI, and YI, and lower values of yield stability index (YSI), as well as achieved the maximum grain yield under timely sowing date. High values of MP, STI, GMP, YSI, and YI, are better indices for the stable and tolerant genotypes chosen (Lamba *et al.***,** 2023). When stress susceptibility index (SSI) <1 indicates the tolerance of the genotype to heat stress, while SSI >1 indicates the sensitivity of the genotypes to heat stress (Mohiy *et al.***,** 2021). Hammami *et al.* (2024) found that barley-tolerant genotypes were significantly less affected by stress factors than sensitive genotypes.

Table 7. Estimation of tolerance indices for barley genotypes based on grain yield under timely and late sowing dates during 2022-23 and 2023-24 growing seasons.

Traits / Seasons	Mean productivity (MP)		Geometric Mean Productivity (GMP)		Tolerance Index (TOL)	
Treatments	Sowing dates (SD)					
Gynotypes (G)	**2022-23**	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**
G1: Giza-124	3220	2825.65	1903.89	1738.62	1039	675.7
G2: Giza-2000	3051.5	3024	1868.35	1821.47	764	864
G3: Giza-126	4113	3659.3	2404.87	2179.96	1413	1127.3
G4: Giza-130	3219.5	2900.95	2067.86	1763.55	410	772
G5: Giza-123	3150.5	3184	1949.16	1923.81	713	889
G6: G1×G2	2987.5	2346.3	1846.78	1483.07	682	404.4
G7: G1×G3	2991	2636.75	1845.47	1704.53	696	284.3
G8: G1×G4	2607.5	2326.65	1598.89	1491.68	644	308.7
G9: G1×G5	2774	2891.9	1722.13	1804.90	605	593
G10: G2×G3	2999.5	3191.3	1821.56	1934.41	805	869.3
G11: G2×G4	3204.5	2598.5	1948.58	1635.05	851	479
G12: G2×G5	3457	2569.3	2221.32	1583.82	436	603.4
G13: G3×G4	3750	3536	2285.26	2198.57	978	758
G14: G3×G5	3417	3489.15	1958.55	2095.88	1293	1016.7
G15: G4×G5	3398.5	3045.75	1951.34	1820.43	1276	918.3
General mean	**3246.06**	**2948.37**	**1959.60**	**1811.98**	**840.33**	**704.21**

Table 8. Estimation of tolerance indices for barley genotypes based on grain yield under timely and late sowing dates during 2022-23 and 2023-24 growing seasons.

Traits / Seasons	Yield Stability Index (YSI)		Stress susceptibility index (SSI)		Yield index (YI)	
Treatments	Sowing dates (SD)					
Gynotypes (G)	**2022-23**	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**
G1: Giza-124	0.583	0.679	1.204	1.001	0.915	0.958
G2: Giza-2000	0.666	0.625	0.964	1.171	0.960	0.962
G3: Giza-126	0.560	0.599	1.271	1.251	1.133	1.128
G4: Giza-130	0.820	0.647	0.519	1.100	1.179	0.948
G5: Giza-123	0.695	0.632	0.881	1.148	1.023	1.022
G6: G1×G2	0.693	0.761	0.888	0.743	0.967	0.865
G7: G1×G3	0.687	0.846	0.903	0.479	0.963	1.048
G8: G1×G4	0.670	0.813	0.953	0.583	0.824	0.899
G9: G1×G5	0.705	0.721	0.852	0.872	0.910	1.024
G10: G2×G3	0.645	0.618	1.025	1.124	0.891	1.034
G11: G2×G4	0.648	0.747	1.016	0.791	0.987	0.944
G12: G2×G5	0.822	0.685	0.514	0.985	1.268	0.876
G13: G3×G4	0.653	0.709	1.000	0.907	1.163	1.237
G14: G3×G5	0.523	0.640	1.379	1.192	0.921	1.101
G15: G4×G5	0.526	0.606	1.370	1.227	0.890	0.947
General mean	**0.659**	**0.679**	**0.983**	**0.970**	**0.999**	**1.000**

Conclusion

All studied traits were adversely influenced by high temperatures or late sowing dates of barley genotypes tested. Barley genotypes show varying responses for yield and its components, especially under environmental stress. Based on the previous result, November 10th is a timely date to cultivate barley, which might be attributed to favorable weather conditions during this period under Aswan conditions compared to the late sowing date as the temperature reduced sharply. The results also showed the genotypes Giza126 (G_3), $G_3 \times G_4$ and $G_3 \times G_5$ significantly outperformed all studied genotypes for grain yield under timely and late sowing dates conditions. The high values of tolerant indices i.e. MP, GMP, TOL, SSI, and YI are better indices for tolerant genotypes chosen.

References

Abdelghany, A. M., Lamlom, S. F and Naser, M. (2024). Dissecting the resilience of barley genotypes under multiple adverse environmental conditions. BMC Plant Biology, 24(16): 1-17.

Agwa, A.M. and Mohamad, S. M. (2020). Effect of sowing date, cultivar, and seeding rate on barley under sandy soil conditions in Egypt. Egypt. J. Plant Breed., 24(2):319-343.

Amarjeet, B., Singh, J., Kumar, Kumar, M., Sharma, R and Kaushik, P. (2020). Effect of sowing date, seed rate and row spacing on productivity and profitability of barley (*Hordeum vulgare* L) in north India. doi:10.20944/preprints202001. 0380.v1.

Bahrami, F., Arzani, A and Rahimmalek, M. (2021). A novel tolerance index to identify heat tolerance in cultivated and wild barley genotypes. bioRxiv., 2020-5: e125971. https//: doi.org/10.1101/2020.05.31.125971

Bhagat, M. A.; Kaur, N and Kaur, S. (2023). Effect of sowing dates on the phenology, grain yield and stress tolerance indices of barley (*Hordeum vulgare* L.) genotypes under subtropical conditions of Punjab. J. Agrometeorology, 25(1):113-119.

Bhupenchandra, I., Chongtham, S. K.; Devi, E. L., Choudhary, A. K., Salam, M. D., Sahoo, M. R., Bhutia, T. L., Devi, S. H., Thounaojam, A. S., Behera, C., Kumar, A., Dasgupta, M., Devi, Y. P., Singh, D., Bhagowati, S., Devi, C. P., Khaba, H. R and C. I. (2022). Role of biostimulants in mitigating the effects of climate change on crop performance. Front. Plant Sci. 13:967665: 1-20.

Bisht, H., Singh,D.K., Mishra, A.K., Sarangi, A., Prajapati, V.K., Singh, M. and Krishnan, P. (2019). Heat unit requirement of wheat (Triticum aestivum L.) under different thermal and moisture regimes. J. Agrometeorology 21(1): 36-41.

Bouslama, M and Schapaugh, W. T. (1984). Stress tolerance in soybean. Part 1: Evaluation of three screening techniques for heat and drought tolerance. Crop Sci., 24, 933-937.

Cabusora, C. C. (2024). Developing climate-resilient crops: adaptation to abiotic stress affected areas. Technology in Agronomy 4 (e005): 1-12.

FAO (2022). Food and Agriculture Organization. Faostat, FAO Statistics Division, January, 2022. http://www. https://www.fao.org/faostat /en/#data /QC.

Fernandez, G. C. J. (1992). Effective selection criteria for assessing stress tolerance. In : Proceedings of the International Symposium on Adaptation of Vegetables and Other Food Crops in Temperature and Water Stress, Kuo, C.G. (Ed.), Publication. Tainan Taiwan.

Fischer, R. A. and Maurer, R. (1978). “Drought resistance in spring wheat cultivars. i. grain yield responses.” Aust. J. Agri. Res., 29(5): 897-912.

Gavuzzi, P., Rizza, F., Palumbo, M., Campanile, R. G., Ricciardi, G.L and Borghi, B. (1997). Evaluation of field and laboratory predictors of drought and heat tolerance in winter cereals. Can. J. Plant Sci., 77: 523-531.

Gharib, M., Qabil, N., Salem A., Ali, M., Awaad, H and Mansour, E. (2021). Characterization of wheat landraces and commercial cultivars based on morpho-phenological and agronomic traits. Cereal Res. Commun. 49, 149-159.

Gomez, K. A. and A. A. Gomez (1984). Statistical Procedures for Agriculture Research. 2nd ed. John Wiley and Sons. New York, USA. 680pp.

Habib, Md., Mannan, Md., Karim, Md., Miah, Md and Singh, H. (2021). Water deficit stress tolerance assessment in barley cultivars using drought tolerance indices.

Hammami, Z.; Tounsi-Hammami, S., Nhamo, N., Rezgui, S and Trifa, Y. (2024). The efficiency of chlorophyll fluorescence as a selection criterion for salinity and climate aridity tolerance in barley genotypes. Front. Plant Sci. 15(1324388): 1-17.

Hasanuzzaman, M., Hossain, M. A. and Fujita, M (2011). Nitric oxide modulates antioxidant defense and the methylglyoxal detoxification system and reduces salinity-induced damage of wheat seedlings. Plant Biotechnology Reports 5, 353-365.

Juskiw, P. E and Helm, J. H. (2003): Barley response to seeding date in central Alberta. Canadian Journal of Plant Science, 83(2): 275-281.

Lamba, K., Kumar, M., Singh, V., Chaudhary, L., Sharma, R., Yashveer, S and Dalal, M. S. (2023). Heat stress tolerance indices for identification of the heat tolerant wheat genotypes. Scientific Reports, 13(10842): 1-13.

Mansour, E and Heakel, M. Y. (2015). Evaluation of barley genotypes under terminal heat stress at grain filling period using polyethylene tunnels. Middle East J. Agric. Res., 4(4): 1101-1112.

Mariey, S. A., EL-Bialy, M. A., Khedr, R. A., Mohamed, E. N., Meleha A. M and Khatab, I. A. (2023). Comprehensive evaluation and economic analysis in some barley genotypes under soil salinity. Asian Journal of Agriculture, 7(1): 20-33.

McCarl, B. A., Musumba, M., Smith, J. B., Kirshen, P., Jones, R and El-Ganzori, A. (2015). Climate change vulnerability and adaptation strategies in Egypt’s agricultural sector. Mitig Adapt Strateg Glob Chang. 20:1097-109.

Mohiy, M., Salous, M. S and Elmoselhy, O. (2021). Influence of sowing dates and temperature variability on bread wheat productivity for some exotic and Egyptian genotypes under upper Egypt conditions. SVU-International J. Agricultural Sci., 3 (4): 172-179.

Moustafa, E. S. A., El-Sobky, E. E. A., Farag, H. I. A., Yasin, M. A. T., Attia, A., Rady, M. O. A., Awad, M. F and Mansour, E. (2021). Sowing date and genotype influence on yield and quality of dual-purpose barley in a salt-affected arid region. Agronomy, 11(717): 1-14.

Novo, P. (2001). Cultivar and year effect on grain filling of winter barley. Plant Breeding and Seeds Cience, 45(2): 45-58.

Potterton, E. M and McCabe, T. (2018). The effect of sowing date and nitrogen rate on the grain yield, grain quality and malt analyses of spring malting barley for distilling in Ireland. The Journal of Agricultural Science, 156 (4): 515-527.

Renu, A. K., Dagar, C. S. and Singh, R. (2023). Study the relationship of barley with growth-yield, weather and agrometeorological condition under different growing environments. The Pharma Innovation J. 12(4): 1764-1769.

Rezaei, E. E., Rojas, L. V., Zhu, W and Cammarano, D. (2022). The potential of crop models in simulation of barley quality traits under changing climates: A review. Field Crops Res., 286 (108624): 1-11.

Rosielle, A. A. and Hamblin J. (1981). Theoretical aspects of selection for yield in stress and non-stress environment. Crop Sci., 21, 943-946.

Seadh, S. E., El-Kassaby, A. T., Mansour, M. and El-Waseef, M. M. M. (2022). Response of some barley cultivars to different sowing dates, N-fertilizer and seeding rates. J. of Plant Production, Mansoura Univ., 13(1):9-15.

Seval, E. and Yıldırım, M. (2023). Yield and quality changes in barley genotypes during high temperature stress caused by late sowing. Romanian Agricultural Research, 40: 1-13.

Soleymani, A., Shahrajabian, M. H and Naranjani, L. (2011). Determination of the suitable planting date and plant density for different cultivars of barley (*Hordeum vulgare L.*). African Journal of Plant Science, 5(3): 284-286.

Vasilescu, L., Petcu, E., Sîrbu, A., Lazăr, C., Epure, L. I., Petcu, E., Cană, L and Toader, M. (2022). Barley yield response to agro-climatic indices variability. Scientific Papers. Series A. Agronomy, LXV (1):567-576.

Yusuf, M., Kumar, S., Dhaka, A. K., Singh, B and Bhuker, A. (2019). Effect of Sowing Dates and Varieties on Yield and Quality Performance of Wheat (*Triticum aestivum* L.). Agricultural Science Digest. 39(4): 306-310.

تأثير الزراعة المتأخرة علي أداء الطرز الوراثية للشعير تحت ظروف أسوان

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الملخص

تســـببت التغيرات المناخية والزيادة الســـكانية فى حدوث خلل غذائى على مســـتوى العالم ويعتبر الإجهاد الحرارى أحد أهم العوامل غير الحيوية التى تؤثر على إنتاجية وجودة محصـــول الشعير.

نُفذ هذا البحث فى مزرعة كلية الزراعة والموارد الطبيعية جامعة أســـوان خلال موســـمى الزراعة 2023/2022 ، 2024/2023 بهدف تقييم أداء بعض التراكيب الوراثية للشـــعير تحت ظروف الأجهاد الحرارى وصـــفات المحصـــول. حيث تم تنفيذ تجربتين منفصـــلتين (الزراعة فى الميعاد الأمثل ، والزراعة المتأخرة). وتم أســتخدام تصــميم القطاعات الكاملة العشــوائية فى ثلاث مكررات.

أظهرت نتائج الموســـمين الأول والثانى على التوالى أن ميعاد الزراعة 10 نوفمبر أفضـــل ميعاد للزراعة حيث أعطى أعلى متوســـطات القيم لموعد التزهير وعدد الســـنابل/م^2 وعدد حبوب السنبلة ووزن ال1000 حبة وتاريخ النضج. وأظهرت النتائج أن التركيب الوراثى G_3 (جيزة 126) سجل أعلى قيمة لمحصول الحبوب (3213 الى 2815 كجم/فدان) تحت موعد الزراعة الأمثل (10 نوفمبر) وسـجل التركيب الوراثى $G_1\times G_2$ ، $G_1\times G_4$ أقل قيمة لمتوسـط محصـول الحبوب (2219 الى 1699) ، (1953 الى 1654كجم/فدان) خلال الموســـمين الأول والثانى على التوالى. وتفوقت التراكيب الوراثية G_3 (جيزة 126) ، $G_3\times G_4$ ، $G_3\times G_5$ فى محصـــول الحبوب عن باقى التراكيب الوراثية الأخرى خلال الموسمين الأول والثانى تحت ميعاد الزراعة الأمثل والمتأخر على التوالى.

أظهرت التراكيب الوراثية G_3 (جيزة 126) ، $G_3\times G_4$ ، $G_3\times G_5$ تحملا للجفاف لأنها أعطت قيما عالية لمتوسط الأنتاجية (MP) ومتوسط الأنتاج الهندسى (GMP) و مؤشر التحمل للأجهاد (TOL) و مؤشر القابلية للأجهاد (SSI) و مؤشر المحصول (YI) وأعطت قيما منخفضة لمؤشر ثبات المحصول (YSI).

الكلمات المفتاحية : *الشعير, الأجهاد الحرارى , مؤشر التحمل للأجهاد, مواعيد الزراعة.*