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Influence of sowing dates on yield and its components in some early maturing bread wheat genotypes

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ABSTRACT

Nine bread wheat early maturing promising lines and three local cultivars were evaluated at Mallawy Agric. Res. Stations, ARC, Egypt, for the two successive growing seasons of 2018/2019 and 2019/2020 under the two sowing dates, the recommended (SD1:30th November) and the late sowing date (SD2:30th December). A split-plot arrangement with three replicates was used in each season. The aim of this study was to select the best genotypes for early maturity and higher grain yield. The results showed significant differences among genotypes for all studied traits in the optimum sowing date (SD1) compared to late sowing date (SD2). The optimum sowing date (S1) produced the highest values for all studied traits in both seasons, while the late sowing date (S2) was recorded the earlier plants for heading and maturity dates. The studied genotypes differences significantly in all estimated traits, lines 1 and 2 had the earliest genotypes for heading days, while Giza 171 and line 8 were the latest one for this trait. On the other hand, lines 9 and 4 were the earliest genotypes for maturity date, while the latest one was recorded for Giza 171. Line 5 surpassed all the other genotypes in grain yield (28.31 and 23.17 ard. fed^{-1}) in the first and second seasons, respectively and it is appeared to be more tolerant to late sowing date as well as heat stress. The interaction (SD x G) had a significant effect on most studied traits. Lines 9 and 6 were the earliest genotypes for maturity when sown on 30 Nov. also, lines 9 and 4 were the earliest genotypes when sown on 30 Dec. The highest grain yield was obtained from line 4 followed by line 5 when sown on 30 Nov. and line 5 had the highest grain yield when sown on 30 Dec. in the first season. While, in the second season, lines 5 and 8 recorded the highest grain yield when sown on 30 Nov. and 30 Dec. respectively. Line 5 is suitable for planting in a wide range of planting dates (from 30th Nov. to 30th Dec.). Moreover, it is early maturing and can be recommended for late sowing (30th Dec.). Therefore, the results of the present study confirmed that lines 4, 5, 7 and 6 were superior over the other genotypes in producing the earliest maturity date and higher grain yield and can be used, in future, in bread wheat breeding programs for the development of wheat cultivars for high temperature stress condition at the terminal growth stage.

Keywords: Wheat, Sowing dates, Earliness, Yield and its components.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important one, not only in Egypt but also all over the world. In Egypt, wheat grains are used as food for humans and straw as fodder for animals. More than 30% of caloric intake is from wheat flour products, especially bread. Among the food crops, it is one of the most abundant sources of energy and proteins than any other cereal crop for the world population. The total wheat production has been steadily increased in Egypt due to high yielding cultivars, favorable weather conditions, and efficient use of resources, better storage facilities and governmental support for price policies. However, imports are still increasing every year to supply our growing population with wheat flour.

Temperature is an important factor for better production of wheat especially during the grain filling period in many parts of the world. In Egypt, the recommended planting date in wheat is from the second half to the end of November. However, the wheat planting date is often delayed, in potato-wheat, onion-wheat and cucurbit-wheat cropping patterns due to late harvest of these crops which causes a delay in wheat planting till after 25th December or even in sometimes up to 15th January. This condition causes great losses in yield due to high temperature during the grain filling period, it is associated with reduced No. of spike plant^{-1} and No. of kernels spike^{-1} (Din. and Singh, 2005; Sial *et al*., 2005).

Sokoto and Singh (2013) and Tripathy et al. (2020) reported that yield and its components were decreased with delay in sowing date while reaching the highest when sowing was applied on 21st Nov. and 5th Dec. and lowest on 19th Dec. and 2nd Jan. Mahgoub and Amin (2006) found a significant variation in yield and its components among wheat genotypes under recommended and late sowing. Babiker et al. (2017) reported that late sowing affects the growth, grain yield, while early planting recorded higher yields than late planting, due to the longer duration of grain development. In the late sowing date of wheat, low temperature prevailing during germination substantially affects the germination and seedling emergence. Tammam and Tawfelis (2004) reported that late sowing dates allow for subjecting the plant at different developmental stages to various temperature regimes. While high temperature during the grain filling period is a major environmental factor that drastically reduces wheat production in Upper Egypt.

Planting date is one of the most important agronomic factors which need great emphasis for highest grain yield of crops. Wheat grain yield is dependent on the environment, genetic factors, and the interaction between them (Coventry *et al*., 2011). Recommended planting dates positively affect the grain yield of wheat and causing better adjustment to the physiology, phenology, and environmental conditions (Silva *et al*., 2014). Besides, the appropriate sowing date also affects the water, temperature, and solar radiation available for the crop. The maximum values of some vegetative characters, yield attributes, and grain yields, as well as enhancement in biological and economical yield, occurred when wheat was planted earlier (Qasim *et al*., 2008).

Late planting date results in poor tillers and crop growth generally slow because of low temperature at sowing time. In late planting, the wheat genotype should be of short duration that helps to escape from the high temperature at the grain filling stage (Dubey *et al*., 2019). The recommended sowing date produced the highest grain yield than late sowing and gave wheat enhances germination per unit area, plant height, No. of spikelets spike^{-1}, No. of kernels spike^{-1}, and 1000-kernel weight over late planting date (Shazma *et al*., 2015 and Soad A. EL-Sayed *et al*., 2018).

Therefore, in Egypt, earliness has several advantages, for instance, early- maturing wheat cultivars are highly needed to fit in new crop intensive rotation, such as planting cotton after wheat and planting wheat after harvesting short duration vegetable crops. Also, wheat cultivars that can be harvested early could save more water and provide farmers more time to grow other crops. The objective of this investigation was to: (1) evaluate some earliness and agronomic characters for twelve genotypes under recommended and late sowing dates, (2) select lines with high grain yield under recommended and late planting date and can be used in breeding programs for the development of wheat varieties having the highest grain yield and early maturity under El-Minia Governorate conditions.

MATERIALS AND METHODS

Twelve bread wheat (*Triticum aestivum* L.) genotypes (nine promising genotypes were selected from F_6 lines in Mallawy breeding program (Hussein, 2016) tested for performance under terminal heat stress and three commercial varieties, used as checks) names, pedigree and selection history of those genotypes are presented in (Table 1) during 2018/2019 and 2019/2020 wheat growing seasons, at Mallawy Agriculture Research Stations. The geographical location is 27° 44' N latitude, 30° 50' E longitude, in Middle Egypt. The heat stress was simulated by using two sowing dates: 1) recommended (SD1:30th November), and 2) late sowing (SD2:30th December). The maximum and minimum temperature dates were given in Table (2). The experiment was laid out in Randomized Complete Block Design (RCBD) with a split-plot arrangement in three replications. Each genotype was grown in a sub-plot consisted of 6 rows, each 2.5 m long and 20 cm apart (plot area was 3 m^2). The sowing dates were assigned to the main plots.

In both seasons, wheat was preceded by Maize (*Zea maize*). The soil of experimental sites was well prepared. The seed rate was 60 Kg fed^{-1}. No organic manures were used and only chemical fertilizers. Phosphorus fertilizer in the form of superphosphate (15.5% P_2O_5) at the rate of 100 kg fed^{-1} was incorporated in the soil after the leveling. Nitrogen fertilizer at the rate of 75 kg N fed^{-1} (Urea 46% N) was applied in three portions, one-third of the nitrogen was applied as basal dose, and the remaining two-thirds of N fertilizer was applied in two equal splits each with first and second irrigations. All experimental plots were irrigated only once 25 days from planting until the maturity stage. Irrigation stopped after 120 and 110 days from sowing in the first and second seasons, respectively. The crop was harvested manually at physiological maturity when the vegetative parts turned to yellow. Harvesting was after 155, 150 days from SD1 and 140, 135 days from SD2 in the first and second seasons, respectively. Other agronomic practices were kept uniform for all treatments.

Table 1: Names, pedigree, selection history, No. of heading days (HD) and maturity (MD) of the twelve studied bread wheat genotypes.

Name	Pedigree and selection history	*HD	MD
Line 1	Sids 4 /Shandaweel 1. C.Mal2012-56-Mal-4Mal-2Mal-0Mal-0Mal.	75	124
Line 2	Sids 4 /Sids 12. C.Mal2012-35-Mal-2Mal-1Mal-0Mal-0Mal.	74	127
Line 3	Sids 4 /Sids 12. C.Mal2012-35-Mal-3Mal-2Mal-1Mal-0Mal.	83	125
Line 4	Sids 4 /Giza 168. C.Mal2012-89-0Mal-2Mal-3Mal-1Mal-0Mal.	78	126
Line 5	Sids 4 /Giza 168. C.Mal2012-89-1Mal-4Mal-1Mal-0Mal-0Mal.	81	124
Line 6	WHEAR/S0K0LL//Sids4. C.Mal2012-92-Mal-5Mal-3Mal-0Mal-0Mal.	82	124
Line 7	WHEAR/S0K0LL//Sids4. C.Mal2012-92-Mal-2Mal-1Mal-1Mal-0Mal.	84	127
Line 8	WAXWING*2//PBW343*2/KUKUNA/3/WHEAR/S0K0LL. C.Mal2012-86-Mal-6Mal-2Mal-0Mal-0Mal.	84	132
Line 9	R0LF07*2/KIRITATI//Sids4. C.Mal2012-41-2Mal-4Mal-2Mal-1Mal-0Mal.	78	127
Giza 168	MRL/BUC//Seri. CM93046-8M-0Y-0M-2Y-0B.	92	145
Sids 1	HD2172/Pavon"S"//1158.57/Maya74"S". Sd46-4Sd-2Sd-1Sd-0Sd.	93	146
Giza 171	Sakha 93 / Gemmiza 9. Gz2003-101-1GZ-4GZ-1GZ-2GZ-0Gz.	91	147

*Source: average for heading days and maturity representing of the recommended sowing date from this paper.

Table 2: Temperature degree in Mallawy Agriculture Research Station Farm at 15 days intervals starting from November 2018 to June 2020 during the two seasons of 2018/2019 and 2019/2020.

At 15 days period	Season 2018/2019			Season 2019/2020		
	Temperature ºC			Temperature ºC		
	Max.	Min.	Avg.	Max.	Min.	Avg.
15 November	26.32	11.75	19.04	27.72	13.71	20.72
1 December	23.01	7.87	15.44	23.61	8.99	16.30
15 December	22.10	6.56	14.33	23.08	6.97	15.03
1 January	19.46	6.90	13.18	24.75	5.58	15.17
15 January	20.57	5.47	13.02	22.29	6.00	14.15
1 February	22.40	6.19	14.30	24.65	8.93	16.79
15 February	21.81	9.03	15.42	24.32	9.59	16.96
1 March	23.10	8.57	15.84	26.80	12.13	19.47
15 March	24.23	10.35	17.29	25.95	11.57	18.76
1 April	26.40	12.51	19.46	27.85	13.83	20.84
15 April	28.50	13.90	21.20	31.48	14.54	23.01
1 May	29.20	14.24	21.72	32.33	16.88	24.61
15 May	34.07	17.40	25.74	37.40	18.55	27.98
1 June	34.20	21.18	27.69	38.20	22.59	30.40

Studied characters in both seasons:

From each plot, heading days (HD) and maturity days (MD) were recorded when 50% of the heads have emerged from the boots and when the top internodes were showing no green tissue, respectively. grain filling period (GFP) (number of days from heading to maturity) and grain filling rate (GFR) (grain yield divided by GFP) The No. of spikes m^{-2} was calculated from the internal two rows, in each plot, the number was adjusted to the number of spikes m^{-2} **(**SM^{-2}), and average plant height in cm from ten randomly selected plants.

At harvest time, 10 random spikes were collected from each plot and threshold to count the average No. of kernels $spike^{-1}$ (KS^{-1}) and 1000-kernel weight (g) (TKW). The two external rows were eliminated to avoid the border effect, and the 4 internal rows were harvested, weighed, to get the biological yield (BY), threshold to get grain yield (GY) were measured and converted into a ton and ardab $faddan^{-1}$, respectively, and harvest index (%).

Statistical analysis:

All analyses of variance were computed using the "GENSTAT" microcomputer program, VSN International (2016)**.** The least significant differences (LSD) at the level of 0.05 probability was employed to compare the differences among the treatment means **(**Gomez and Gomez, 1984) and simple correlation coefficients among all studied characters were calculated, and the genotype main effect plus G×E interaction (GGE-biplot) (Akcura and Kaya, 2008) was used to visualize the G×E interaction. The GGE-biplot of grain yield for the studied bread wheat genotypes were done for the four environmental conditions (two sowing dates x two years).

RESULTS

Analyses of variance (ANOVA):

The ANOVA for all the studied characters under the two planting dates is presented in Table (3). The analysis of variance showed significant or highly significant differences between the two sowing dates were detected for all characters except grain filling period, No. of kernels $spike^{-1}$ and harvest index in the second season which was insignificant differences. More importantly, genotypes showed highly significant differences for all the studied characters except harvest index in the two growing seasons. Furthermore, the interactions between planting dates and genotypes had significant or highly significant differences in most cases except grain filling rate in the first season**,** plant height and number of spikes per square meter in the second season and No. of kernels $spike^{-1}$ and harvest index in both seasons which insignificant differences.

Table 3: Mean squares for heading days (HD), maturity days (MD), grain filling period (GFP), plant height (PH) (cm), spikes per square meter (SM^{-2}), kernels per spike (KS^{-1}), 1000-kernel weight (TKW)(g), biological yield (BY) (ton fed^{-1}), grain yield (GY) (ard.fed^{-1}), grain filling rate (GFR) (g plot^{-1} day^{-1}) and harvest index (HI%) for twelve bread wheat genotypes at two growing seasons of 2018/2019 and 2019/2020.

Season	SOV	Df	MS				
			HD	MD	GFP	PH (cm)	SM^{-2}
2018/ 2019	Rep.	2	2.00	1.26	0.097	6.60	912.51
	SD	1	234.72 **	3916.13 **	2233.37**	3542.0 **	99012.52 **
	Error	2	0.72	5.38	3.01	14.93	337.50
	G	11	230.55 **	70.74**	63.04**	196.56 **	1942.80 **
	SD x G	11	26.36 **	11.97 **	19.74**	23.83 **	415.53 **
	Error	44	2.68	4.29	6.59	13.79	318.94
2019/ 2020	Rep.	2	18.01	4.35	35.54	1.04	1768.06
	SD	1	1292.01 **	1184.22 *	2.35 NS	938.89 **	86112.51 **
	Error	2	6.76	12.93	19.01	96.18	312.50
	G	11	120.01**	201.50 **	71.22**	93.56 **	1501.39 **
	SD x G	11	60.0 4**	48.22 **	101.01**	91.16 NS	1909.47 NS
	Error	44	4.81	6.93	11.61	25.51	466.04

Season	SOV	Df	MS					
			KS^{-1}	TKW (g)	BY (ton.fed^{-1})	GY (ard.fed^{-1})	GFR	HI%
2018/ 2019	Rep.	2	18.35	10.28	0.38	7.71	34.25	10.92
	SD	1	141.68 *	1698.67 **	72.90 *	177.13 *	581.83*	61.59 *
	Error	2	91.93	5.08	1.14	3.42	11.20	2.99
	G	11	327.56 **	202.67 **	4.90 **	36.16 **	205.44**	5.42 NS
	SD x G	11	34.11 NS	24.85 **	2.45 **	14.47 *	75.35 NS	5.59 NS
	Error	44	39.46	5.08	0.78	5.43	41.35	2.84
2019/ 2020	Rep.	2	53.85	4.41	2.05	1.81	34.02	8.19
	SD	1	1963.56 NS	240.32 **	167.11 **	839.99 **	5388.73 *	0.33 NS
	Error	2	39.85	0.62	1.06	4.63	61.50	1.24
	G	11	319.25 **	60.85 **	1.81 **	10.77 **	235.99**	14.33 NS
	SD x G	11	79.86 NS	77.64 **	2.81 **	7.99 *	319.69 **	14.11 NS
	Error	44	56.24	12.56	0.67	3.91	35.96	12.49

SD= Sowing date, G= Genotype, SD × G = Sowing date × Genotype, NS, *, ** Insignificant, Significant at 0.05 and 0.01 probability level, respectively.

I-Mean performance for agronomic characters:

I-1- Heading days (HD):

Data concerning heading days are considered in Table 4. The analysis of the data revealed that heading days were significantly (P ≤ 0.05) affected by planting dates and different used wheat genotypes. Also, the interaction between them was highly significant differences in the two growing seasons. It is clear from the mean values of the sowing date on 30th November showed maximum heading days, however those sown on 30th December exhibited minimum days to heading. It varied from 87.1 to 81.3 days in the first season and from 82.5 to 75.3 days in the second season. Days to heading for the twelve genotypes over the two dates, line 2 was significantly the earliest one, while Giza 171, Sids 1 and Giza 168 had the latest genotypes. In addition, the interaction (SD x G), Giza 171 had the latest genotype for days to heading followed by Sids 1, Giza 168 and Line 8 under the two sowing dates, they gave heads after 98.2, 96.6, 96.5, 89.1 and 88.6, 86.2, 84.4, 86 days when sown on 30 Nov. and 30 Dec., respectively. While, lines 2 and 6 were earlier and headed after 77.4 and 75.4 days when sown on 30 Nov. and 30 Dec., respectively (Table 4).

I-2- Maturity days (MD):

Data in Table 4 showed that different sowing dates, genotypes and interactions had a highly significant effect of maturity days. The delaying sowing date from 30th Nov. to 30th Dec. (30 days) dramatically decreased days to maturity by 12.3 and 8.1 days in the two respective seasons, by an average of 10.2 days (Table 4). Lines 9 and 4 were significantly the earliest genotypes (129 and 122.4 days) in the two seasons. While, Giza 171 had the latest one and came to maturity after 145.6 and 136.2 days from sowing in the two respective seasons. In case of the interaction between the experimental treatments, the longest period from sowing to maturity was recorded with Giza 171 (155 and 144.5 days) when sown on 30th Nov. and recorded the longest period (136.1 and 128 days) when sown on 30th Dec. in the tow respective seasons. On the other hands, lines 9 and 6 had the earliest genotypes when sown on 30th Nov. (133.6 and 124.3 days) in the first and second seasons, respectively, also, lines 9 and 4 were the earliest genotypes when sown on 30th Dec. (124.1 and 119.7 days) in the two respective seasons.

I-3- Grain filling period (GFP):

The means of grain filling period indicated that sowing dates (SD) in the first season only while genotypes (G) and (SD x G) significantly differed in the two growing seasons (Table 4). The normal sowing date recorded GFP of 54.1 and 48.8 days compared to the late sowing of 48.1 and 47.9 days in the two respective growing seasons by an average of 5.3 and 0.2 days. The average number of grain filling periods in the second season was less than those in the first season. The average number of GFP for wheat genotypes varied from 55.3 to 47.7 days in the first season and from 51.3 to 43.5 days in the second one in case of the interaction between sowing dates and genotypes for GFP, under recommended sowing date, Lines 7 and 5 were recorded the shortest grain filling periods (49.4 and 39 days) in the first and second seasons, respectively. However, Line 2 and Giza 171 had the longest period (61.1 and 58.5 days). Furthermore, under the late planting date, the grain filling period ranged from 44.3 to 53.2 days for Line 8 and Giza 168 in the first season and ranged from 44 to 50 days for Giza 171 and Line 1 in the second season, respectively.

I-4- Plant height (PH) (cm):

Plant height was significantly ($P \leq 0.05$) affected by sowing dates and genotypes in both seasons and by their interaction in the first season only (Table 4). Sowing on 30th November produced taller plants (112.9 and 104.9 cm) when compared to the other planting date (98.9 and 97.6 cm) in the two respective seasons. The plant height was significantly affected by different genotypes; line 2 had the significantly highest plants of 114.2 cm. However, the shortest plants were produced from line 3 of 95.8 cm in the first season. On the other hand, in the second season, the highest plants produced by line 6 (106.9 cm.) and shortest plants of 95.8 cm were recorded by Giza 168. The interaction between sowing dates and genotypes, produced the highest plants from Sids 1 and line 2 (122 and 110 cm) when sown on 30 Nov. and 30 Dec., respectively, whereas the shortest plants were from Giza 168 and line 3 (102 and 93 cm) when sown on 30 Nov. and 30 Dec., respectively (Table 4).

Table 4: Effect of sowing dates, genotypes and their interactions for heading days, maturity, grain filling period (GFP) and plant height (cm) in 2018/2019 and 2019/2020 growing seasons.

Treatment	Heading Days (HD)						Maturity days (MD)						Grain filling period (GFP) (day)						Plant height (PH) (cm)					
	2018/2019			2019/2020			2018/2019			2019/2020			2018/2019			2019/2020			2018/2019			2019/2020		
Genotype (G)	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**
Line 1	83.2	79.2	81.2	72.7	71.0	71.9	137.2	126.8	132.0	125.0	121.0	123.0	54.0	47.6	50.8	52.3	50.0	51.2	110	97	103.3	102	98	100.0
Line 2	77.4	76.5	77.0	73.3	75.7	74.5	138.5	124.5	131.5	125.7	123.3	124.5	61.1	48.0	54.6	52.4	47.6	50.0	118	110	114.2	112	93	102.5
Line 3	85.1	81.0	83.1	82.7	72.0	77.4	138.7	127.6	133.2	125.3	121.7	123.5	53.6	46.6	50.1	42.6	49.7	46.2	103	88	95.8	105	90	97.5
Line 4	81.7	78.6	80.2	79.3	73.0	76.2	133.8	125.9	129.9	125.1	119.7	122.4	52.1	47.3	49.7	45.8	46.7	46.3	112	93	102.5	98	93	95.8
Line 5	88.3	84.2	86.3	85.7	72.3	79.0	138.8	131.2	135.0	124.7	120.3	122.5	50.5	47.0	48.8	39.0	48.0	43.5	117	102	109.2	100	110	105.0
Line 6	84.0	75.4	79.7	82.7	72.7	77.7	137.9	126.1	132.0	124.3	121.3	122.8	53.9	50.7	52.3	41.6	48.6	45.1	118	105	111.7	112	102	106.9
Line 7	86.2	77.5	81.9	81.7	74.0	77.9	135.6	126.9	131.3	126.7	120.7	123.7	49.4	49.4	49.4	45.0	46.7	45.9	113	98	105.8	100	97	98.3
Line 8	89.1	86.0	87.6	86.0	80.3	83.2	140.2	130.3	135.3	132.0	127.7	129.9	51.1	44.3	47.7	46.0	47.4	46.2	118	100	109.2	112	98	105.0
Line 9	79.4	77.6	78.5	80.3	73.0	76.7	133.6	124.1	129.0	127.3	121.3	124.3	54.2	46.5	50.4	47.0	48.3	47.7	107	98	102.5	107	95	100.8
Giza 168	96.5	84.4	90.5	89.0	77.0	83.0	153.9	137.6	145.8	140.3	125.7	133.0	57.4	53.2	55.3	51.3	48.7	50.0	102	93	97.5	100	92	95.8
Sids 1	96.6	86.2	91.4	90.7	78.3	84.5	151.4	135.3	143.4	144.3	127.3	135.8	54.8	49.1	52.0	53.6	49.0	51.3	122	102	111.7	112	102	106.7
Giza 171	98.2	88.6	93.4	86.0	84.0	85.0	155.0	136.1	145.6	144.5	128.0	136.2	56.8	47.5	52.2	58.5	44.0	51.3	115	100	107.5	100	102	100.8
Mean (SD)	87.1	81.3	84.2	82.5	75.3	78.9	141.4	129.2	135.3	131.3	123.2	127.2	54.1	48.1	51.1	48.8	47.9	48.3	112.9	98.9	105.9	104.9	97.6	101.3
LSD 0.05 G	**3.82**			**2.57**			**4.46**			**3.23**			**2.9**			**4.0**			**4.32**			**6.21**		
SD	**0.66**			**1.05**			**0.98**			**1.27**			**1.2**			**NS**			**71.7**			**2.54**		
(SD x G)	**2.26**			**3.64**			**3.4**			**4.41**			**4.2**			**5.7**			**6.12**			**NS**		

SD 1, SD 2 = First and Second sowing date, G= Genotype, SD × G = Sowing date × Genotype and NS = Insignificant, respectively.

II-Yield and its components:

II-1- Number of spikes m^{-2} (SM^{-2}):

This is a very important parameter contributing toward grain yield. The data in Table (5) revealed that, it was significantly increased in the recommended sowing date as compared to the late planting with an average being 460 and 385.8 in the first and second sowing date, respectively. While in the second one, the mean No. of spikes m^{-2} was 456.9 and 387.3 in the first and second sowing date, respectively. The genotypes, also, differed from each other in their No. of spike m^{-2}. Line 5 produced a higher No. of spikes m^{-2} followed by genotypes 3, 7, 10, 6, Giza 171, 8 and Sids 1, in the first season, but with insignificant differences. While in the second season, line 5 produced a maximum No. of spikes m^{-2} without significantly with other genotypes. The interaction (SD x G) significantly affected No. of spike m^{-2} in the first season only, line 3 had the highest No. of spikes m^{-2} (478 spikes m^{-2}) without significance with Giza 171, line 5, Giza 168, line 8, 4, 7 and 6 when were sown on 30 Nov. while, line 5 produced higher No. of spikes m^{-2} (420 spikes m^{-2}) when sown on 30 Dec. However, line 2 and line 1 gave the lowest one (430 and 350 spikes m^{-2}) when sown on 30 Nov. and 30 Dec., respectively (Table 5).

II-2- A number of kernels spike^{-1} (KS^{-1}):

The means of a number of kernels spike^{-1} indicated that different sowing dates (SD) and significant in the first season only, while genotypes (G) significantly differed in the two growing seasons, but the interactions (SD x G) have insignificantly differed in both seasons (Table 5). The normal sowing date produced a higher No. of kernels spike^{-1} (69.7 and 62.3 kernels) compared to the late sowing date (59.2 and 59.5 kernels) in the two respective seasons. The average number of kernels spike^{-1} for wheat genotypes varied from 53.7 to 76.8 kernels in the first season and from 51 to 72.7 kernels in the second season. Line 3 recorded the highest No. of kernels spike^{-1} (76.8 and 72.0 kernels) in the two respective seasons.

II-3- 1000-kernel weight (TKW) (g):

This is a very important character of wheat as a yield component. The means of 1000-kernel weight (g) revealed that sowing dates (SD), genotypes (G) and the interactions (SD x G) were significantly differed in the two growing seasons (Table 5). Results indicated that the average 1000-kernel weight under recommended sowing date (30th November) produced the heavier grains 52.02 and 51.93 g than the late sown one has reduced the lightest grain weight 48.36 and 42.21 g in the two respective growing seasons. Line 7 recorded the heaviest grains 53.22 and 55.56 g in the two seasons, respectively. However, the lightest grains were recorded by Giza 168 and line 3 (45.41 and 39.46 g) in the two seasons, respectively. The interaction of (SD x G) indicated that in the first season, lines 1 and 7 had the heaviest grains 56.83 and 57.48 g when sown on 30 Nov. and 30 Dec. respectively, while, Sids 1 and Giza 168 were recorded the lightest grain weight 48.88 and 38.47 g when sown on 30 Nov. and 30 Dec. respectively. On the other hand, lines 7 and 9 in the second season gave the heaviest grains 60.23 and 54.61 g when sown on 30 Nov. and 30 Dec., respectively. While, line 3 had the lightest grain weight 46.28 and 32.64 g under two planting dates.

Table 5. Effect of sowing dates, genotypes and their interactions on No. of spikes m^{-2}, No. of kernels spike^{-1} and 1000-kernel weight (g) in 2018/2019 and 2019/2020 growing seasons.

Treatment	No. of spikes m^{-2} (SM^{-2})						No. of kernels spike^{-1} (KS^{-1})						1000-kernel weight (TKW)(g)					
	2018/2019			2019/2020			2018/2019			2019/2020			2018/2019			2019/2020		
Genotype (G)	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**
Line 1	443	350	396.7	466.7	373.3	420.0	83	59	71.0	68	77	72.7	56.83	49.22	53.03	47.98	41.90	44.94
Line 2	430	353	391.7	453.3	340.0	396.7	66	66	65.7	70	67	68.2	50.71	43.94	47.33	51.85	45.01	48.43
Line 3	478	413	445.0	440.0	360.0	400.0	82	72	76.8	75	69	72.0	53.30	49.57	51.44	46.28	32.64	39.46
Line 4	463	373	418.3	486.7	373.3	430.0	75	68	71.7	68	64	65.7	50.35	55.34	52.85	58.59	50.01	54.30
Line 5	473	420	446.7	476.7	423.3	450.0	73	64	68.3	67	56	61.7	51.61	54.51	53.06	47.12	34.31	40.71
Line 6	453	393	423.3	460.0	386.7	423.3	67	49	58.0	61	59	59.8	51.76	52.23	51.99	58.06	46.70	52.38
Line 7	460	410	435.0	473.3	396.7	435.0	65	45	55.2	58	58	57.8	48.96	57.48	53.22	60.23	50.89	55.56
Line 8	463	373	418.3	426.7	406.7	416.7	67	58	62.3	59	53	56.0	50.98	41.47	46.23	50.09	36.84	43.46
Line 9	440	370	405.0	470.0	380.0	425.0	67	65	66.0	55	51	52.8	52.94	53.16	53.05	55.03	54.61	54.82
Giza 168	467	403	435.0	416.7	396.7	406.7	60	54	56.8	52	50	51.0	52.36	38.47	45.41	46.63	37.84	42.24
Sids 1	447	377	412.7	423.3	376.7	400.0	60	48	53.7	54	51	52.8	48.88	43.27	46.08	53.00	37.63	45.31
Giza 171	473	373	423.3	430.0	420.0	425.0	72	64	67.8	61	60	60.7	55.53	41.72	48.63	48.26	38.19	43.23
Mean (SD)	460.0	385.8	422.9	456.9	387.8	422.4	69.7	59.2	64.4	62.3	59.5	60.9	52.02	48.36	50.19	51.93	42.21	47.07
LSD 0.05 G	**20.78**			**24.91**			**8.66**			**7.51**			**8.06**			**4.75**		
SD	**8.48**			**10.17**			**3.54**			**NS**			**1.48**			**1.08**		
(SD x G)	**29.39**			**NS**			**NS**			**NS**			**5.12**			**3.74**		

SD 1, SD 2 = First and Second sowing date, G= Genotype, SD × G = Sowing date × Genotype and NS = Insignificant, respectively.

II-4- Biological yield (SY) (ton fed^{-1}):

The data in Table 6 showed that biological yield was significantly (P ≤ 0.05) affected by sowing dates, genotypes and their interaction between them in the two growing seasons. The average biological yield was 11.733 and 10.972 tons fad^{-1} under the optimum sowing date in the two respective growing seasons compared to the other planting date 9.720 and 7.625 tons fad^{-1}. Meanwhile, the average of twelve genotypes varied from 9.275 to 12.134 tons fad^{-1} and from 8.726 to 10.804 tons fad^{-1} for Sids 1 and line 5, respectively in both seasons (Table 6). Concerning the effect of the interaction (SD x G), results in Table 6 indicated with each delay in sowing date there is a reduction in biological yield of all genotypes. In the first season, lines 4 and 5 recorded the maximum biological yield (13.626 and 11.620 tons fed^{-1}) when sown on 30 Nov. and 30 Dec., respectively. In the second season, lines 5 and 8 were recorded the highest biological yield (13.114 and 8.990 tons fed^{-1}) when sown on 30 Nov. and 30 Dec., respectively. On the other hand, Sids 1 had the minimum biological yield (9.706 and 9.704 tons fed^{-1}) under the recommended sowing date and line 3 was recorded (6.260 and 6.534 tons fed^{-1}) under late planting date in the two respective growing seasons.

II-5- Grain yield (GY) (ard. fad^{-1}):

Wheat grain yield was also significantly affected by different sowing dates, genotypes and the interactions between them (Table 6). The results revealed that the maximum grain yield was produced 25.10 and 24.24 ardab fed^{-1} when the crop was sown on 30 Nov. compared to sown on 30 Dec. which recorded the lowest grain yields 21.94 and 17.41 ardab fed^{-1} in the two respective seasons (Table 6). Average grain yield for the different genotypes in Table 6 showed that line 5 surpassed the other genotypes. It recorded 28.31 and 23.17 ardab fed^{-1}, and increasing in general means 4.80 and 2.35 ardab fed^{-1} in the two respective growing seasons. These results may be since line 5 recorded the highest No. of spikes m^{-2} and Thousand-kernel weight which are to be returned in high grain yield (Table 5). The interaction of (SD x G) showed that in the first season, line 4 recorded the highest grain yield (29.71 ardab fed^{-1}) followed by line 5 (29.56 ardab fed^{-1}) under the optimum planting date, while line 5 recorded the maximum grain yield (27.10 ardab fed^{-1}) compared with the other genotypes under late sowing date. On the other hand, in the second season, lines 5 and 8 gave the maximum grain yield 27.69 and 19.60 ardab fed^{-1} when sown on 30 Nov. and 30 Dec. respectively.

II-6- Grain filling rate (GFR) (g plot^{-1} day^{-1}):

The data in Table (6) illustrated that the different sowing dates and genotypes had a significant effect (P ≤ 0.05) with grain filling rate in both seasons and by their interaction in the second season only. The average number of GFR in the first season under recommended sowing date and late one was 49.2 and 48.6 g plot^{-1}day^{-1}, respectively, and in the second season were 53.3 and 38.9 g plot^{-1} day^{-1}. Line 5 recorded the highest values of grain filling rate (61.9 and 57.1 g plot^{-1} day^{-1}) in the two respective seasons, while Sids 1 had the lowest values (41.8 and 44.8 g plot^{-1} day^{-1}) in the two respective growing seasons. Furthermore, in the case of the interaction (SD x G) in the first season under the optimum and late planting date, Line 5 had the highest values of grain filling rate (62.1 and 61.8 g plot^{-1} day^{-1}). While, Line 2 and Giza 171 had the lowest values of grain filling rate (39.9 and 42 g plot^{-1} day^{-1}) under the two sowing conditions, respectively.

II-7- Harvest index (HI %) :

The relationship between total biological yield and grain yield of a crop is expressed in term of harvest index which ultimately determines the ability to convert the dry matter into economic yield. The analysis of the data revealed that the harvest index was significantly (P ≤ 0.05) affected by planting dates in the first season only. While, the genotypes and the interaction between genotypes and sowing dates were insignificant differences in the two growing seasons (Table 3). The highest values for harvest index were recorded from line 5 (35.02%) without significant differences from the other genotypes in the first season (Table 6). The late sowing date was recorded the highest values for this trait (33.16%) compared with the recommended sowing date. The interaction (SD x G) was recorded the highest value from lines 5 and 6 (35.06 and 36.73 %) when sown on 30 Nov. and 30 Dec. in the first season, respectively. The harvest index (HI) has been used to describe the proportion of harvestable biomass

Table 6: Effect of sowing dates, genotypes and their interactions on biological yield (ton. fed^{-1}) grain yield (ard. fed^{-1}), grain filing rate GFR (g plot^{-1}day^{-1}) and harvest index (HI %), in 2018/2019 and 2019/2020 growing seasons.

Treatment	Biological yield (BY) (ton fed^{-1})						Grain yield (GY) (ard. fed^{-1})						Grain filing rate (GFR) (g plot^{-1}day^{-1})						Harvest index (HI %)					
	2018/2019			2019/2020			2018/2019			2019/2020			2018/2019			2019/2020			2018/2019			2019/2020		
Genotype (G)	**SD 1**	**SD 2**	**lean G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**lean G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**	**SD 1**	**SD 2**	**Mean (G)**
Line 1	12.226	9.496	10.861	10.360	7.654	9.006	26.44	20.37	23.87	24.11	17.57	20.84	52.5	45.5	50.1	49.4	37.7	43.7	32.44	32.18	32.31	34.91	34.43	34.67
Line 2	10.920	11.154	11.036	10.920	7.000	8.960	24.71	22.27	23.49	22.40	15.71	19.06	39.9	53.1	45.8	45.8	35.4	40.9	33.94	29.95	31.95	30.77	33.66	32.22
Line 3	10.640	8.260	9.451	11.830	6.534	9.181	22.09	18.51	20.30	23.80	14.16	18.97	43.8	42.2	43.1	59.9	30.5	44.0	31.14	33.61	32.38	30.18	32.51	31.34
Line 4	13.626	9.870	11.749	11.316	8.214	9.765	29.71	21.31	25.51	26.29	18.20	22.24	60.1	47.6	54.1	61.2	41.8	51.4	32.71	32.39	32.55	34.85	33.24	34.04
Line 5	12.646	11.620	12.134	13.114	8.494	10.804	29.56	27.10	28.31	27.69	18.67	23.17	62.1	61.8	61.9	76.1	41.7	57.1	35.06	34.98	35.02	31.67	32.97	32.32
Line 6	11.946	10.034	10.990	10.616	8.214	9.415	25.36	24.57	24.97	22.56	19.29	20.93	50.3	51.6	51.0	58.1	42.5	49.7	31.84	36.73	34.29	31.88	35.23	33.55
Line 7	11.854	11.130	11.491	10.804	8.960	9.881	25.51	25.67	25.59	27.23	16.64	21.93	54.7	55.0	54.8	64.8	38.2	51.2	32.28	34.60	33.44	37.81	27.86	32.83
Line 8	11.854	9.286	10.570	10.336	8.990	9.649	24.43	20.84	22.63	24.43	19.60	22.01	51.3	50.7	51.0	46.7	44.3	45.6	30.91	33.66	32.29	35.45	32.70	34.08
Line 9	10.454	8.586	9.520	10.314	8.026	9.170	21.16	19.60	20.37	24.73	16.80	20.77	41.2	44.7	42.8	56.4	37.3	46.7	30.36	34.24	32.30	35.97	31.40	33.68
Giza 168	12.506	9.800	11.154	10.196	8.306	9.251	25.83	22.71	24.27	22.24	16.96	19.60	47.7	45.9	46.9	46.4	37.3	42.0	30.98	34.76	32.87	32.72	30.63	31.67
Sids 1	9.706	8.844	9.275	9.704	7.746	8.726	21.00	19.60	20.29	21.47	17.73	19.60	40.9	42.9	41.8	42.9	38.8	40.8	32.45	33.24	32.85	33.19	34.33	33.76
Giza 171	12.414	8.564	10.489	12.156	7.000	9.579	26.29	18.83	22.56	23.99	17.57	20.77	49.4	42.0	46.0	44.1	42.8	43.5	31.77	32.98	32.37	29.60	37.65	33.63
Mean (SD)	11.733	9.720	10.727	10.972	7.925	9.449	25.10	21.94	23.51	24.24	17.41	20.82	49.2	48.6	49.0	53.3	38.9	46.2	32.16	33.61	32.88	33.25	33.05	33.15
LSD 0.05 G	**1.039**			**0.963**			**2.69**			**2.31**			**7.35**			**7.08**			**NS**			**NS**		
SD	**0.424**			**0.393**			**1.10**			**0.94**			**3.00**			**2.89**			**0.41**			**NS**		
(SD x G)	**1.480**			**1.362**			**3.80**			**3.26**			**NS**			**10.01**			**NS**			**NS**		

SD1, SD 2 = First and Second sowing date, G= Genotype, SD × G = Sowing date × Genotype and NS = Insignificant, respectively.

III-Interrelationships among the studied traits:

The correlation coefficients among all possible pairs of various characters under the recommended sowing date are presented in Table (7, above diagonal). Results in Table (7) indicated that heading days had a significant and positive correlation with maturity days. Grain filling period showed a significant and negative correlation with grain filling rate. Grain filling rate had a significant and positive correlation with spikes per square meter and grain yield. A significant positive correlation was detected between grain yield and biological yield. The correlation coefficients among the studied traits under the late planting date are presented in Table (7, below diagonal). Heading days had a significant positive correlation with maturity days. Maturity days had a significant and positive correlation with 1000-kernel weight. Grain filling rate showed a significant positive correlation between grain yield and biological yield. A significant positive correlation was recorded between grain yield and biological yield.

Table 7: Correlation coefficients among heading days (HD), maturity days (MD), grain filling period (GFP), grain filling rate (GFR), plant height (PH)(cm), spikes per square meter (SM^{-2}), kernels per spike (KS^{-1}), 1000-kernel weight (TKW)(g), grain yield (GY)(ard.fed^{-1}) and biological yield (BY)(ton.fed^{-1}) under recommended sowing date (above diagonal-italic), and under late sown date (below diagonal).

Trait	HD	MD	GFP	GFR	PH	SM^{-2}	KS^{-1}	TKW	GY	BY
HD		0.846 **	0.131	-0.144	0.007	-0.315	-0.530	-0.447	-0.159	-0.007
MD	0.924 **		0.638	-0.548	0.047	-0.623	-0.525	-0.430	-0.370	-0.167
GFP	-0.350	0.035		-0.811*	0.077	-0.705	-0.211	-0.154	-0.461	-0.230
GFR	-0.034	-0.129	-0.227		-0.315	0.933 **	0.344	0.172	0.858 **	0.725
PH	0.163	0.107	-0.164	0.681		-0.429	-0.261	0.058	-0.340	-0.426
SM^{-2}	0.310	0.326	-0.010	0.440	0.144		0.503	0.347	0.827 **	0.729
KS^{-1}	-0.286	-0.437	-0.324	-0.303	-0.308	-0.438		-0.067	0.346	0.455
TKW	-0.730	-0.803*	-0.061	0.224	-0.016	-0.124	0.009		0.146	-0.044
GY	-0.160	-0.121	0.123	0.928 **	0.598	0.516	-0.458	0.260		0.890 **
BY	-0.261	-0.236	0.103	0.862 **	0.419	0.355	-0.396	0.353	0.901**	

*, ** Significant, highly significant at 0.05 and 0.01 probability level, respectively.

IV-GGE-Biplot:

The interaction (G×E) is reflected in inconsistent crop yield across environments. Variations in climate change and soil properties and the inherent potential of genotypes are among the major factors for variable crop yield (Yan and Hunt 2001; Yan *et al.,* 2002). GGE-biplot analyses for comparison of genotypes were performed to detect the ideal and desirable (Figure 1). An ideal genotype should have both high mean yield performance and high suitability across environments (Kaya *et al*., 2006; Yan and Tinker, 2006). The ideal genotypes should be in the center of concentric circles. In this study, line 5 (G5) was the ideal genotype.

In the ranking of genotypes based on their performance in all environments, a line is drawn that passes through the biplot origin and the environment. This line is called the axis for the environment (Yan and Tinker, 2006) and along it is the ranking of genotype. Thus, Figure 2 showed the rank of genotypes performance. From the graph, the highest yielder genotype was line 5 (G5) showed more stable. In the contrast, genotypes 2, 12, 9, 3 and 11 (G2, G12, G9, G3 and G11) were the lowest.

One of the most attractive features of GGE-biplot is its ability to show the "which-won-where" pattern of a genotype by environment dataset as it graphically addresses important concepts such as cross-over GE, mega-environment differentiation, specific adaptation, etc. (Yan and Tinker, 2006). The polygon view of the GGE biplot (Figure 3) indicates the best genotype(s) in each environment and groups of environments (Yan and Hunt 2001; Yan *et al.,* 2002).

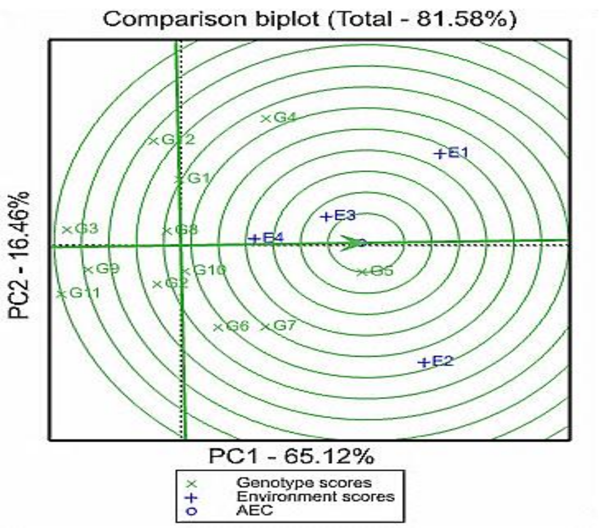

Fig.1. GGE-biplot focused scaling for comparison of the genotypes. E1 –E4 are the sowing dates and G1 – G12 are the genotypes.

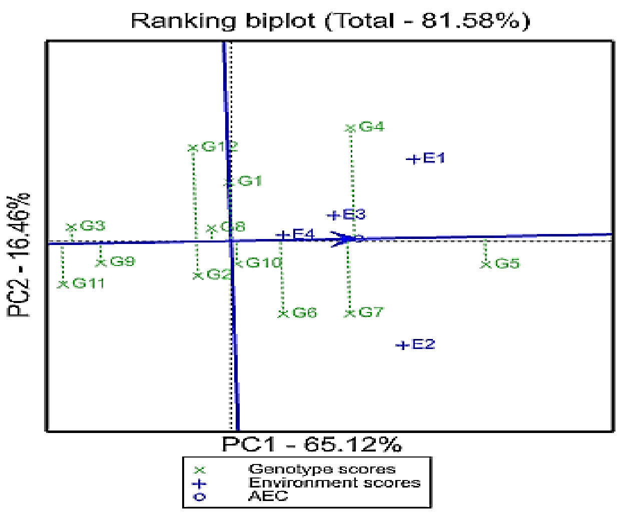

Fig. 2. Identification of winning genotypes across 4 environments. E1 –E4 are the sowing dates and G1 – G12 are the genotypes.

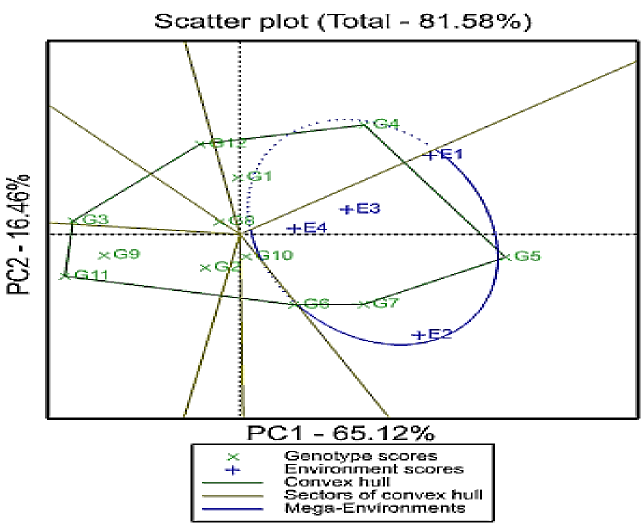

Fig. 3. The which-won-where view of the GGE-biplot to show which genotypes performed better in which in which environment for grain yield. G1-G9 are the genotypes, G10= Giza 168, G11= Sids 1 and G12= Giza 171. Sowing dates, E1, E3= recommended sowing date (30th Nov.) and E2, E4=late sowing date (30th Dec.) in the first 2019/2020 and second season 2020/2021, respectively.

DISCUSSION

The analysis of variance showed significant differences between the two sowing dates, genotypes and the interactions between them for most studied traits in the two growing seasons. These results suggested that the measurement of differences among wheat genotypes was adequate to provide a possibility to characterize the effect of late sowing conditions and could be attributed to their different genetic systems. Similar results were reported by Babiker et al. (*2017*), Elbasyoni (2018), Hagras (2019) and Abdelkhalik et al. (2021).

It is clear from the mean values of the sowing date on 30th November showed maximum heading days, however those sown on 30th December exhibited minimum days to heading. Line 2 was the earliest one, in addition, the interaction (SD x G), lines 2 and 6 were earlier when sown on 30 Nov. and 30 Dec., respectively. These findings may be due to the fact that heat units and the accumulated metabolites required for wheat flowering were reduced in late sowing and the atmospheric temperature starts rising (Table 2). Tammam and Tawfelis (2004), Mahdu et al. (2018) and Swami et al. (2019) stated that delaying the planting date concerning favorable date reduced the number of days from planting to heading in the wheat plant. The results are in line with those obtained by Marasini et al. (2016), Djanaguiraman et al. (2020) and Thapa et al. (2020).

Lines 9 and 4 were the earliest genotypes (129 and 122.4 days) in the two seasons. In case of the interaction between them, lines 9, 6 and 4 had the earliest genotypes when sown on 30th Nov. and 30th Dec. These results coincide with the findings of Mondal et al. (2016) who reported that early maturing genotypes are an excellent crop adaptation approach in regions suffering from terminal and continual to heat stress (late sowing). The delaying sowing date from 30th Nov. to 30th Dec. (30 days) dramatically decreased days to maturity by 12.3 and 8.1 days in the two respective seasons, by an average of 10.2 days. It means that the crop sown on 30 December matured earlier than the other date because it faced higher temperatures, which may be reflected on the growth cycle by decreasing vegetative growth period and plant photosynthetic capacity of the wheat plant, and then, decreasing grain yield. The average temperature in April was 20.33 °C in 2019 while it recorded 21.93 °C in 2020 and in May 2019 recorded 23.73 °C vs. 26.30 °C in 2020. These differences in temperature in the two years resulted in 8.1 days earlier in maturity in 2020. The higher temperature in April and May in 2020 (Table 2) decreased the grain filling period and resulted in the early maturity of wheat genotypes under investigation. Many researchers reported significant differences among genotypes for earliness and agronomic characters. These results are consistent with those reported by Amin and Mohamed (2012) and Tripathy et al. (2020).

The average of grain filling periods in the second season was less than those in the first season. Lines 7 and 5 had the shortest grain filling periods while line 2 and Giza 171 had the longest one in both seasons. This finding is mainly due to the high temperature dominated in the Middle Egypt region at heading time (Table 2). The average increases in temperatures in February and March were 1.23 and 2.96 C° which accelerated the physiological processes in wheat plants and decreased the grain filling period. Delaying planting date decreased duration of grain filling period for all genotypes when compared to the recommended planting date. The differences in temperature in the two seasons (Table 2) and two sowing dates resulted in decreased grain filling period of wheat genotypes under investigation. This reduction may be due to the high temperature during the post heading period decreased duration of the grain-filling period. The results are in line with those obtained by Irshad et al. (2012), Hagras and Moustafa (2019), Djanaguiraman et al. (2020) and Abdelkhalik et al. (2021).

This study indicated that sowing on 30th November gave the highest plants when compared to the other sowing date in the two growing seasons. This could be due to that long plant duration gave higher vegetative growth when sowing was carried out earlier. Decreasing plant height with delay in planting date was also reported by Qasim *et al*. (2008) and Tawfelis et al. (2011). This increment in plant height might be due to the fact that at early planting dates, a crop may have enjoyed better environmental conditions especially soil moisture, temperature and solar radiation which resulted in the tallest plants. These findings are in similar with those obtained by Tahir et al. (2009) and Desta *et al.* (2020) recorded an increase in plant height of wheat in early sowing.

No. of spikes m^{-2} was significantly increased in the optimum sowing date as compared to the late sowing. This could be due to the that the climatological conditions prevailing during the recommended sowing date favored the production of fertile tillers (Table 2). These results are similar to those reported by Mahdu *et al*. (2018) and Swami et al. (2019). Line 5 had the highest values for No. of spikes m^{-2} with insignificant differences among the genotypes; 3, 7, 10, 6, Giza 171, 8 and Sids 1. This result coincide with the findings of Shah et al. (2006) is relatively comparable to the present results; they obtained varied No. of spikes m^{-2} capacity in different wheat genotypes to produce fertile tillers. The recommended sowing date gave the highest No. of spikes m^{-2} than late sowing due to the ability of wheat plants to produce more tillers and consequently more spikes over late sowing. The results are in line with those obtained by Shazma et al. (2015) and Soad A. EL-Sayed et al. (2018).

The optimum sowing date recorded a higher No. of kernels $spike^{-1}$ compared to the late planting date in the two growing seasons. Line 3 had the highest No. of kernels $spike^{-1}$ (76.8 and 72.0 kernels) in the two respective seasons. That may be due to the high relative air temperature during the flowering and fertility stage of late sowing wheat plants, which could affect the number of fertile florets in the spike and then a final No. of kernels $spike^{-1}$ (Table 2). In addition, it plays a crucial role in prolonging the ear formation period and also reported that the No. of kernels $spike^{-1}$ is determined earlier before flowering. Due to the short grain filling period, less production of photosynthesis resulted in the low No. of kernels $spike^{-1}$ in late sown. The behavior of genotypes could be attributed to their different genetic systems. These findings are similar to those obtained by Acharya et al. (2017) and Thapa et al. (2020).

The average of 1000-kernel weight under recommended sowing date (30th Nov.), the plants had suitable and longer environmental conditions for vegetative growth, which resulted in the active photosynthesis and higher translocation of the assimilates to the kernels and produced heavier grains compared with the late sown one due to the exposure of the crop to a too much higher temperature (Hussain *et al*., 2018). Line 7 recorded the heaviest grains 53.22 and 55.56 g in the two growing seasons. Lines 1, 7 and 9 had the heaviest grains when sown on 30 Nov. and 30 Dec. These results are in line with the findings of Acharya et al. (2017), who reported that different wheat genotypes varied in seed index values. These differences between genotypes could be referred to as their genetic constitutions and their interaction with the prevailing environmental conditions (Shah *et al*., 2006; Hagras, 2019). An important notice in data of 1000-kernel weight is that, lines 1, 7 and 9 produced heavier grains under recommended and late sowing date (heat stress) in the two growing seasons. This finding may help breeders in selection under heat stress by selecting a higher 1000-kernel weight for high grain yield. These findings are in accordance with those obtained by Shazma et al. (2015) and Tripathy et al. (2020).

Biomass yield is one of the required traits by the agro-pastoral community for their livestock feed during dry season where forage is inadequate. Therefore, identification of higher biomass genotypes might fit with the need of the agro-pastoral community of study area. Biomass is affected by leaves area, plant growth and environments. When the developmental pattern of genotypes is so different between growths stages may be determined by comparisons with their biomass production over a long growth period. The highest biological yield was recorded under the recommended sowing date in the two respective growing seasons compared to the other planting date. Lines 4, 5 and 8 recorded the maximum biological yield when sown on 30 Nov. and 30 Dec. This may be as a result of the decrease in plant height and No. of spikes m^{-2}, due to delaying sowing date (Table 4 and 5), which could be reflected in reducing biological yield. These results are consistent with those reported by Qasim et al. (2008), Tawfelis *et al.* (2011) and Desta et al. (2020).

The maximum grain yield was produced when sown on 30 Nov. compared to sown on 30 Dec. These results can be divided into two reasons: Reason 1; the fact that planting earlier, produce higher vegetative and reproductive components like more No. of spikes m^{-2}, more No. of spikelets $spike^{-1}$ and more No. of kernels $spike^{-1}$, which in return more grain yield. Reason 2; may be due to the results of exposing late sowing wheat plants to high temperature from heading through maturity stage, which decreased the No. of kernels $spike^{-1}$ and produced small and shrinking kernels with a lower weight. These findings are similar with those found by Tawfelis et al. (2011), Tripathy *et al.* (2020) and Desta et al. (2020). Line 5 was superior overall genotypes for grain yield. These results may be due to the fact that line 5 recorded the highest No. of spikes m^{-2} which returned in high grain yield (Table 5). On the other hands, sowing date 30th Nov. is suitable for all tested genotypes except Lines 5 and 4 as their grain yield did not record a significant reduction compared to sown on 30th Dec. This is an advantage of saving one month time and irrigation water and it is the most important genotypes for showing excellent performance on grain yield than the other genotypes. The studied wheat genotypes were different responses for different thermo-natural environments, indicating the importance of evaluating genotypes in different environments in order to determine the best genotype for a given environment. These findings are similar with those found by Qasim et al. (2008) and Tawfelis et al. (2011).

Line 5 was superior overall genotypes for grain filling rate. It is recorded the highest values of grain filling rate in the two growing seasons. Also, it had the highest values of this trait under two sowing dates. It is clear that delaying planting date decreased duration of grain filling period for genotypes when compared with recommended planting date. These results may be due to the high temperature on grain production rate. These findings are similar with those obtained by Irshad et al. (2012), Hagras and Moustafa (2019) and Abdelkhalik et al. (2021).

Line 5 had the highest values for harvest index (35.02%) without significant differences from the other genotypes in the first season (Table 6). Sowing date 30th Dec. was recorded the highest values for this trait (33.16%) compared with the recommended sowing date. Lines 5 and 6 had recorded the highest value (35.06 and 36.73 %) when sown on 30th Nov. and 30th Dec. in the first season only. The harvest index (HI) has been used to describe the proportion of harvestable biomass. Hence it is more efficient when this genotype was selected to promote the harvest index. Saric and Loughman (2012) reported that biomass and harvest index could be used as indicators of nutrients uptake and translocation to the grain in different genotypes. Selection for high biomass and harvest index is sufficient to ensure high nutrients uptake and translocation of assimilating to the spike. These results are in harmony with those obtained by Shefazadeh et al*.* (2012) and Bayisa et al. (2019).

The results revealed that correlations among some characters were inconsistent between the two sowing date conditions. The relationships between grain filling rate and each of spikes per square meter and grain yield were positive under recommended sowing date indicating that the genotypes which have the long growth duration have the highest grain yield. On the other hand, these relationships under late sowing date were recorded between grain filling rate and each of grain yield and biological yield were positive, indicating the advantages of earliness under late sowing. Al-Karaki (2012) and Hagras and Moustafa (2019) reported that grain yield was strongly associated with spikes m^{-2} but not with grains $spike^{-1}$.

One of the most attractive features of GGE-biplot is its ability to show the "which-won-where" pattern of a genotype by environment dataset as it graphically addresses important concepts such as cross-over GE, mega-environment differentiation, specific adaptation, etc. (Yan and Tinker, 2006). The polygon view of the GGE biplot (Figure 3) indicates the best genotype(s) in each environment and groups of environments (Yan and Hunt, 2001; Yan *et al.,* 2002). Line 5 (G5) followed by lines 4 and 7 (G4 and 7) are the winning genotype for the mega-environment and suitable for planting in a wide range of planting dates (from 30th Nov. to 30th Dec.). Moreover, it is early maturing and can be recommended for late sowing (30th Dec.). On the other hand, the remaining genotype showed their high yield potentiality if planted on 30th Dec. Biplot was divided into seven sectors in Fig. 3; genotypes that fall in the same sector as with environment are said to be adapted to those environments. The result Fig. 3 indicated one mega environment. Line 5 (G5), the winning genotype for mega-environment and gave a high yield on 30th Nov. and 30th Dec. followed by genotypes G4, 7 and 6 are the winning genotypes for the mega-environment which consists of different sowing dates (E1, E2, E3 and E4). These genotypes are the most suitable to the mega environment. The other genotypes (G1, 2, 3, 8, 9, 10, 11 and 12) lying on the vertices did not respond at any of the sowing dates.

CONCLUSION

Data indicated that, in response to the sowing date, bread wheat genotypes showed variations in their growth and yield characters. Therefore, the best genotypes, lines 9 and 4 were the earliest genotypes for maturity date when sown on 30th Dec. On the other hand, lines 4 and 5 gave the highest grain yield when sown on 30th Nov. while, lines 5 and 7 recorded the highest grain yield when sown on 30th Dec. The result suggests that selection of lines 4, 5 and 7 that produced maximum grain yield. This study revealed that these genotypes can be used in future bread wheat breeding programs for the development of wheat cultivars for high temperature stress condition at the terminal growth stage (late sowing dates).

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تأثير مواعيد الزراعة على المحصول ومكوناتة لبعض السلالات المبكرة من قمح الخبز.

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الملخص

أجريت تجربة لتقييم تسعة سلالات قمح مبشرة مبكرة النضج بالإضافة إلى ثلاثة أصناف قمح تجارية في محطة البحوث الزراعية بملوى خلال موسمي الزراعة 2019/2018م و 2020/2019م تحت موعدي الزراعة (الميعاد الموصى به 30 نوفمبر- الميعاد المتأخر 30 ديسمبر). وقد أستخدم في هذه الدراسة تصميم القطاعات كاملة العشوائية في توزيع القطع المنشقة مرة واحدة فى ثلاث مكرارات. هدفت الدراسة إلى إختيار أفضل التراكيب الوراثية للتبكير والمحصول العالى تحت تأثير الإجهاد الحرارى الناتج لتأخير الزراعة عن الميعاد المناسب. أوضحت هذه الدراسة تفوق ميعاد الزراعة الأمثل على ميعاد الزراعة المتأخرحيث سجل أعلى القيم فى جميع الصفات محل الدراسة فى كلا الموسمين بينما ميعاد الزراعة المتأخر سجل أبكر النباتات فى صفتى عدد الأيام حتى التزهير وعدد الايام حتى النضج. بينما تأثرت جميع الصفات محل الدراسة تأثراً معنوياً باختلاف التراكيب الوراثية حيث تفوقت السلالات 1 ، 2 وكانت أبكر السلالات فى صفة التزهير بينما التراكيب الوراثية جيزة 171 والسلالة 8 كانتا متأخرة فى هذة الصفة. وسجلت السلالات 9 ، 4 أبكر السلالات فى صفة عدد الأيام حتى النضج بينما الصنف جيزة 171 كان متأخر فى صفة النضج. تفوقت السلالة 5 عن باقى التراكيب الوراثية الاخرى فى صفة المحصول حيث سجلت (28,31 ،23,17 أردب /فدان) فى السنة الأولى والثانية على التوالى مما يشير الى تحمل هذه السلالة لتأخير ميعاد الزراعة وظروف الإجهاد الحرارى. أدى التفاعل بين مواعيد الزراعة والتراكيب الوراثية المختلفة الى وجود إختلافات معنوية فى معظم الصفات محل الدراسة حيث كانت التراكيب الوراثية 9 ، 4 الأبكر فى صفة عدد الايام حتى النضج فى ميعاد الزراعة المتأخر30 ديسمبر. وسجلت التراكيب الوراثية 4 ، 5 ، 8 أعلى القيم لمحصول الحبوب (أردب/فدان) عند الزراعة فى الميعاد الأمثل والميعاد المتأخرفى كلا الموسمين على التوالى. أوضحت الدراسة أن السلالة 5 أكث ملائمة للزراعة في ميعادى الزراعة 30 نوفمبر و30 ديسمبر. علاوة على ذلك يمكن التوصية بملائمة السلالة 5 تحت الزراعات المتأخرة. علاوة على ذلك من هذة الدراسة تفوقت السلالات 4 ، 5 ، 8 ، 9 عن باقى التراكيب الوراثية فى صفة التبكير والمحصول العالى ويمكن التوصية بإدخالهم فى برامج التربية لتعظيم إنتاجية القمح من وحدة المساحة فى مواعيد الزراعة المتأخرة وتحمل الإجهاد الحرارى الناتج لتأخير الزراعة.

الكلمات المفتاحية : القمح ، مواعيد الزراعة ، التبكير ، المحصول ومكوناتة.