J. of Plant Production, Mansoura Univ., Vol. 11 (11):1115-1120, 2020

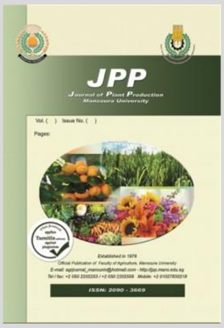
Journal of Plant Production

Journal homepage: www.jpp.mans.edu.eg
Available online at: www.jpp.journals.ekb.eg

Evaluation of some Bread Wheat Genotypes under Normal and Reduced Irrigations

Darwish, M. A. H; M. N. A. El-Hawary* and A. T. H. Moustafa

Wheat Research Department, Field Crops Research Institute, ARC, Egypt.



ABSTRACT

The present study was conducted at Sakha Agricultural Research Station's Experimental Farm to evaluate six wheat genotypes during 2017/18 and 2018/19 wheat growing seasons under normal irrigation (five irrigations) and reduced irrigation (only one irrigation after the establishment). A randomised complete block design with nine replicates was the experimental design. Two stress tolerance indices were calculated to differentiate the high yielder and water deficit tolerant wheat genotypes. Results showed that the irrigation effect was highly significant for all studied characters, except for number of kernels spike^{-1}. The mean values of all studied characters in the normal irrigation were higher than those recorded in the reduced irrigation, except for number of kernels spike^{-1} and 1000-kernel weight. There were a highly significant differences among genotypes for all the studied characters. The best cultivar was Misr 2 which recorded the highest values for grain filling rate, number of spikes m^{-2} and grain yield with a significant differences compared to the other studied genotypes. Two susceptible/tolerance indices indicated that the three genotypes namely Cham 4, Sakha 93 and Vorobey were identified as stress tolerant genotypes and the genotypes Cham 4 had the higher grain yield as well. Accordingly, it was recommended to be used in wheat breeding programs to transmit tolerance genes to the commercial cultivars for reduced irrigation.

Keywords: Wheat, irrigation treatments, tolerance indices, stress susceptible index, grain yield.

INTRODUCTION

Wheat is one of the most important sources of food. In recent years, interest in crop response to environmental stresses has received a great attention due to severe losses caused by these stresses. Drought, as an important abiotic stress, is a major restriction factor to agricultural production in arid and semi-arid regions.

Drought affects morphology, growth, and metabolism of plants, and limiting grain yield in most plants. Plant responses to drought stress are very complex and include adaptive changes or deleterious effects (Mehraban *et al.*, 2019). Morphological characters are affected by water stress due to limited available moisture in the soil, these characters also indicate how adaptive genotypes cope with water stress. These characters have the important role in determining yield components and are used in breeding programs for improving grain yield and introducing commercial varieties. Numerous studies showed that days to heading and maturity, plant height, number of spikes m^{-2}, grain and straw yields, harvest index, number of grains/spike, and 1000-grain weight were affected by different irrigation regimes (Zafarnaderi and Mohammadi, 2013, and Noreldin and Mohmoud, 2017).

During the last decades, in several countries, breeders have attempted to produce modern varieties that are highly productive and widely adapted to contrasting environments. Understanding plant responses to drought is of great importance and also a fundamental part for developing tolerant crops which is a promising approach to meet food demands for food security all over the world.

Therefore, the objective of this study was to identify the high yielding and drought tolerant wheat genotypes under reduced irrigation.

MATERIALS AND METHODS

Field experiment:

The present study was conducted at the Experimental Farm of Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt. During the 2017/18 and 2018/19 wheat growing seasons, six bread wheat (Triticum aestivum L.) genotypes were used and grown on 28 November. The name and pedigree of the studied genotypes are listed in Table 1.

Table 1. Name and pedigree and selection history of the studied wheat genotypes.

Ser	Genotype	Pedigree and selection history		Source
1	CHAM 4	FLK'S'/HORK'S'	CM39816-1S-1AP-0AP	ICARDA
2	SAKHA 93	SAKHA92/TR8103	S.8871-1S-2S-1S-0S	EGYPT
3	VOROBEY	CROC_1/AE.SQUARROSA (224)//OPATA M 85/3/ PASTOR	CMSS96Y02555S-040Y-020M-050SY-020SY-6M-0Y	CIMMYT
5	GEMMEIZA 12	OTUS /3/ SARA / THB // VEE	MSS97Y00227S-5Y-010M-010Y-010M-2Y-1M-0Y-0GM	EGYPT
4	MISR 1	OASIS / SKAUZ // 4*BCN /3/ 2*PASTOR	CMSS00Y01881T-050M-030Y-030M-030WGY-33M-0Y-0S	EGYPT
6	MISR 2	SKAUZ / BAV92	CMSS96M03611S-1M-010SY-010M-010SY-8M-0Y-0S	EGYPT

In each season, two separate irrigation experiments using the flood irrigation method evaluated the studied entries. The first one included four irrigations after planting irrigation (Normal irrigation treatment, N), while the second

---

* **Corresponding author.**
E-mail address: mnaelhawary@gmail.com
DOI: 10.21608/jpp.2020.130948

experiment was given one surface-irrigation after planting irrigation (reduced irrigation treatment, D).

Each experiment was surrounded by a wide border (5 m) to minimize water infiltration. The experimental site was close to the main drainage to avoid high water table effect. Recommended agricultural practices for wheat cultivation in old land in Egypt were applied at the proper time except for irrigation treatment. The preceding crop was maize in both seasons.

For each water regime, a randomised complete block design (RCBD) with nine replications was used. The area of the plot was 2.1 m2, consisting of two rows, 3.5 m long and 30 cm apart. At the rate of 300 seeds m-2, grains were manually drilled in rows.

The meteorological data from the Sakha Meteorological Station for the two winter growing seasons were reported, as shown in Table 2. Details of soil properties of the research sites in each season are summarized in Table 3.

Table 2. Monthly mean of air temperature (AT ^{O}C), relative humidity (RH %) and rainfall (mm/month) in winter seasons of 2017/2018 and 2018/2019 at Sakha location.

Month	AT ^{O}C 2017/18		AT ^{O}C 2018/19		RH%		Rainfall (mm)	
	Max.	Min.	Max.	Min.	2017/18	2018/19	2017/18	2018/19
December	21.51	15.41	20.23	14.32	65.13	75.64	32.95	21.71
January	18.86	14.04	19.64	12.70	60.01	67.69	9.61	14.91
February	21.54	14.51	19.59	14.96	62.22	70.70	25.21	15.31
March	25.52	16.60	22.06	18.22	67.51	72.22	0.00	17.31
April	27.81	19.95	25.81	20.65	66.33	68.79	10.61	3.91
May	37.01	28.01	33.01	26.30	55.26	57.10	0.00	0.00

Table 3. Mechanical and chemical soil analyses during the two growing seasons

Season	Sample depth	Soil structure	PH	EC dsm-1	Anions my/l				Cations mg/l			
					CO3--	HCO3--	CL^{-}	SO4^{--}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
2017/2018	0 -30	Clayey	8.61	2.33	-	2.5	10	43.32	10.6	6.1	12.38	0.29
	30 - 60	Clayey	8.7	2.1	-	2.25	12.5	9.11	6.6	4.9	8	0.33
2018/2019	0 - 30	Clayey	8.06	2.01	_	3	8.11	48.69	5.6	3.91	10.34	0.31
	30 - 60	Clayey	7.90	1.5	_	2.5	4.8	7.16	3.23	2.33	8.42	0.29

The studied characters were: number of days to heading and maturity, grain filling period (days) and grain filling rate (g plot^{-1} days^{-1}), plant height (cm), number of spikes m^{-2}, number of kernels spike^{-1}, 1000-kernel weight (g), grain yield plot^{-1} (kg plot^{-1}).

Statistical analysis

Data were subjected to combined analysis of variance of randomized complete block design over the two irrigation regimes (normal and reduced irrigations) on the two seasons as presented by Gomez and Gomez (1984). In order to confirm the homogeneity of individual error terms, the Levene test was run as a standard statistical step prior to the combined analysis (Levene, 1960). According to Waller and Duncan (1969), the Least Significant Difference (LSD) test was used to classify the significant differences between the proper items at probability level of 0.05.

Tolerance indices

Based on the difference between grain yield under normal (Yn) and stress (Ys) conditions over the two seasons, two stress tolerance indices were determined. Table 4 displays the names, equations and references of the indexes for stress tolerance. Genotypes that have the lowest values of these indices of tolerance are known to be more tolerant of decreased irrigation.

Table 4. The name, equation and reference of two stress tolerance indices.

Number	Index name	Formula	Reference
	% Reduction	$(Y_n-Y_s)*100/Y_n$	
1	Tolerance Index (TOL)	Y_n-Y_s	Rosielle and Hamblin, 1981
2	Stress Susceptibility Index (SSI)	$[1-(Y_s/Y_n)]/[1-(\overline{Y}_s/\overline{Y}_n)]$	Fisher and Maurer, 1978

- Y_n and Y_s indicate to average grain yield of each genotype under normal and stress conditions.

- $\overline{Y}_n$ and $\overline{Y}_s$ indicates to average grain yield overall genotypes under normal and stress conditions.

RESULTS AND DISCUSSION

The water table levels were deeper than 190 cm in the two seasons after 60 days of sowing during reduced irrigation treatment at the boot stage. Thus after 155 days of sowing under normal irrigation treatment, it reached the same depth.

Analysis of variance

Mean squares of all studied characters combined over the two irrigation regimes across the two seasons are illustrated in Table 5.

Table 5. Mean squares of the studied characters combined over the two irrigation regimes under the two growing seasons of 2017/2018 and 2018/2019.

S.O.V	Df	Days to heading (day)	Days to maturity (day)	Grain filling period (day)	Grain filling rate (g plot^{-1}day^{-1})	Plant height (cm)	No. of spikes m^{-2}	No. of kernels spike^{-1}	1000-kernel weight (g)	Grain yield plot^{-1} (kg plot^{-1})
Season (S)	1	661.50**	4873.50**	1944.00**	2654.10**	7.41	231542.52**	3584.64**	385.75*	1.54**
Irrigation (I)	1	675.57**	4374.00**	1611.57**	1317.67**	5807.41**	266844.74**	293.22	411.35**	8.21**
Y * I	1	13.50	13.50	0.0001	36.93	29.63	22407.41*	1891.16**	0.41	0.11
Error	32	8.62	19.43	17.64	64.98	30.32	3501.36	108.63	54.90	0.16
Genotypes (G)	5	230.69**	222.99**	213.18**	649.74**	3056.57**	28814.96**	1850.71**	160.93**	0.99**
G * S	5	0.001	0.003	0.0001	30.93	208.24**	8247.03*	506.60**	73.14*	0.10
G * I	5	17.10	37.90*	83.53**	402.16**	158.24**	8752.05*	199.30	93.95*	0.57**
G * S * I	5	0.002	0.004	0.001	70.30*	85.46*	13846.14**	232.94	50.34	0.17**
Error	160	11.88	11.84	17.94	26.33	28.80	2827.25	124.92	31.99	0.04
Total	215	22.17	60.85	39.41	74.72	134.72	6434.88	200.84	44.48	0.14

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

Table 6. Mean performance of studied genotypes for all characters over the two irrigation regimes across the two growing seasons.

Genotypes	Days to heading (day)	Days to maturity (day)	Grain filling period (day)	Grain filling rate (g plot^{-1}day^{-1})	Plant height (cm)	No. of spikes m^{-2}	No. of kernels spike^{-1}	1000-kernel weight (g)	Grain yield plot^{-1} (kg plot^{-1})
Cham 4	97	143	46	31.85	95	428	44	48.07	1.45
Sakha 93	96	149	53	25.02	94	401	50	45.02	1.33
Vorobey	97	147	51	25.80	97	353	51	44.72	1.28
Misr 1	102	151	49	29.75	110	350	58	44.43	1.44
Gemmeiza 12	97	148	50	28.84	107	324	61	49.39	1.44
Misr 2	101	149	48	36.61	117	441	62	44.77	1.76
LSD $_{0.05}$	1.61	1.60	1.97	2.39	2.50	24.75	5.20	2.63	0.098

Highly significant differences were found between the two seasons for all characters, except for plant height, indicating the important effect of the environmental conditions. Results showed that the irrigation regimes had highly significant effect on all the studied characters, except for number of kernels spike^{-1}. The mean squares of irrigation regimes explained that a large part of the total variation for most characters confirming the relative importance of irrigation treatments in water stress tolerance breeding programmes. A similar pattern was discovered by Abd El-Mohsen *et al.* (2015) and Farhat (2015). The interaction between growing seasons and irrigation regimes had insignificant effect on all the studied characters, with the exception of the number of spikes m^{-2} and number of kernels spike^{-1}. With regard to the genotypes effect, for all characters studied, there were highly significant differences between the genotypes studied. The interaction effect between genotypes and seasons had insignificant effect on all the studied characters, except for plant height, number of spikes m^{-2}, number of kernels spike^{-1} and 1000 kernels weight which was significant or highly significant. Concerning the interaction between genotypes and irrigation, its effect was highly significant on all the studied characters, except for days to heading and number of kernels spike^{-1} which had insignificant effect.

The significance of the interaction effects is due to the various abilities of the cultivars to adapt their characteristics to the environment, indicating the importance of testing genotypes in different environments in order to decide the best ones for a specific environment. The interaction effect among genotypes, seasons and irrigations regimes had a significant effect on grain filling rate, plant height and number of spikes m^{-2} only. Similar findings were reported by Thapa *et al.* (2017), Liu *et al.* (2017), Hooshmandi (2019) and Mehraban *et al.* (2019).

Mean performance

Results in Table 6 showed the mean performance of the studied genotypes for all the studied characters over the two irrigation regimes across the two growing seasons. The observed significant variation among the genotypes might partially reflect their different genetic backgrounds. It is obvious that the cultivar Sakha 93 was the earliest genotype for days to heading (96 days), followed by the genotypes Cham 4, Vorobey and Gemmeiza 12 (97 days), and the genotype Cham 4 was the earliest one in maturity (143 days) and had the shortest grain filling period (46 days), with significant differences compared to the other studied genotypes. These results indicated that the earliest genotypes for days to heading are not necessary to be the earliest for days to maturity. It is also noted that the early maturing genotypes had short grain filling period. The best cultivar was Misr 2 which recorded the highest values for grain filling rate (36.61 g plot^{-1} day^{-1}), number of spikes m^{-2} (441) and grain yield (1.76 kg plot^{-1}) with significant differences with the other genotypes. Wheat breeders always prefer the low values for grain filling period and high values for grain filling rate which coincide with Pireivatlou *et al*, (2011) who reported that The major factors for producing greater grain yield in wheat are considered to be the short effective grain filling period and high grain filling rate.

The tallest plant height were recorded for the genotype Misr 1 (110 cm), Gemmeiza 12 (107 cm) and Misr 2 (117 cm) while the shortest ones were Cham 4 (95 cm), Sakha 93 (94 cm) and Vorobey (97 cm). The maximum number of kernels spike^{-1} was produced by the two genotypes of Gemmeiza 12 (61) and Misr 2 (62), while the heaviest 1000-kernel weight was obtained by the genotypes Cham 4 (48.07 g) and Gemmeiza 12 (49.39 g).

Interaction Effect

The interaction effect between growing seasons and genotypes were insignificant for all the studied characters, except for plant height, number of spikes m^{-2}, number of kernels spike^{-1} and 1000-kernel weight (Table 7). The significant interaction effect indicated that wheat genotypes differently responded to the environmental conditions suggesting the importance of assessment of genotypes under different environments in order to identify the best genetic make up for a particular environment.

Results revealed that the tallest plants were recorded by the cultivar Misr 2 being 114 and 119 cm in the two seasons, respectively, while the shortest plants were obtained by the genotype Cham 4 (95 cm) in the 1st season and the cultivar Sakha 93 (92 cm) in the 2nd season. With respect to the number of spikes m^{-2}, it is clear that the cultivar Misr 2 gave the maximum values in the two growing seasons recording 523 and 360 spikes m^{-2}, respectively, while the lowest number of spikes m^{-2} were obtained by the cultivar Gemmeiza 12 recording 362 and 287 spikes m^{-2} in the two seasons, respectively. The cultivar Gemmeiza 12 gave the highest number of kernels spike^{-1} (69 kernels spike^{-1}) in the 1st season and the cultivar Misr 2 (65 kernels spike^{-1}) in the 2nd one, while the lowest values were produced by the cultivar Sakha 93 (53 kernels spike^{-1}) in the 1st season and the genotype Cham 4 (39 kernels spike^{-1}) in the 2nd season. Considering the weight of 1000-kernel, the cultivar Gemmeiza 12 gave the heaviest weight being 51 and 47.8 g in the two seasons, respectively, while the least weight was obtained by the cultivar Misr 1 (43.4 g) in the 1st season and the cultivar Misr 2 (41.4 g) in the 2nd one. These results are in harmony with those reported by Mehraban *et al.* (2019).

Table 7. Mean values of all studied characters as affected by the first-order interaction effect between growing season and genotypes.

Genotypes	Days to heading (day)		Days to maturity (day)		Grain filling period (day)		Grain filling rate (g plot^{-1}day^{-1})		Plant height (cm)		No. of spikes m^{-2}		No. of kernels spike^{-1}		1000-kernel weight (g)		Grain yield plot^{-1} (kg plot^{-1})	
	1st S	2nd S	1st S	2nd S	1st S	2nd S	1st S	2nd S	1st S	2nd S	1st S	2nd S	1st S	2nd S	1st S	2nd S	1st S	2nd S
Cham 4	95	99	139	148	43	49	36.21	27.48	95	96	502	353	49	39	49.2	46.9	1.55	1.35
Sakha 93	94	97	144	154	50	56	28.40	21.64	97	92	475	327	53	47	46.9	43.1	1.44	1.22
Vorobey	95	98	143	152	48	54	29.73	21.87	99	94	373	333	57	45	45.8	43.7	1.40	1.17
Misr 1	100	104	146	155	46	52	31.67	27.83	108	112	390	310	63	53	43.4	45.5	1.44	1.43
Gemmeiza 12	96	99	143	153	47	53	33.17	24.51	106	109	362	287	69	53	51.0	47.8	1.59	1.30
Misr 2	99	103	144	154	45	51	39.71	33.51	114	119	523	360	59	65	48.1	41.4	1.80	1.72
Mean	96	100	143	152	46	52	33.15	26.14	103	103	437	328	58	50	47.4	44.7	1.54	1.37
LSD $_{0.05}$	NS		NS		NS		NS		3.54		35.65		7.27		3.94		NS	

1st S: First season and 2nd S: Second season.

Table 8. Mean values of all studied characters as affected by the first-order interaction effect between irrigation regimes and genotypes.

Genotypes	Days to heading (day)		Days to maturity (day)		Grain filling period (day)		Grain filling rate (g plot^{-1}day^{-1})		Plant height (cm)		No. of spikes m^{-2}		No. of kernels spike^{-1}		1000-kernel weight (g)		Grain yield plot^{-1} (kg plot^{-1})	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
Cham 4	98	96	148	138	50	42	29.88	33.81	98	93	452	404	42	45	46.61	49.52	1.49	1.41
Sakha 93	97	95	154	144	57	50	25.64	24.40	98	91	484	317	48	52	42.93	47.1	1.45	1.20
Vorobey	99	95	153	142	54	48	26.45	25.15	102	92	416	290	48	54	41.31	48.13	1.40	1.17
Misr 1	104	100	154	148	50	48	34.49	25.01	118	102	392	307	61	55	43.76	45.1	1.69	1.18
Gemmeiza 12	99	96	153	142	54	47	32.32	25.36	112	103	371	278	58	64	47.37	51.41	1.71	1.18
Misr 2	104	98	153	146	49	48	43.91	29.31	124	110	533	349	62	62	46.13	43.41	2.14	1.38
Mean	100	96	152	143	52	47	32.12	27.17	108	98	441	324	53	55	44.69	47.45	1.65	1.25
LSD $_{0.05}$	NS		2.38		2.78		3.77		3.54		35.65		NS		3.94		0.16	

N: normal irrigation and D: reduce irrigation.

The interaction effect between irrigation regimes and genotypes was significant for all studied characters, except for days to heading and number of kernels spike^{-1} (Table 8). The mean values of all studied characters under normal irrigation were higher than those recorded in the reduced one, except for number of kernels spike^{-1} and 1000-kernel weight.

Results indicated that the genotype Cham 4 was the earliest maturing under both normal and reduced irrigation. The shortest grain filling period was obtained by the cultivar Misr 2 and the genotype Cham 4 under normal and reduced irrigation, respectively. Mehraban *et al.* (2019) indicated that early heading and maturity have an advantage of allowing drought escape, enabling the cultivar to efficiently utilize irrigation or rainfall during critical growth stages.

Under normal irrigation, the cultivar Misr 2 recorded the maximum values of grain filling rate (43.91 g plot^{-1} day^{-1}), number of spikes m^{-2} (533 spikes) and grain yield (2.14 kg plot^{-1}), while the genotype Cham 4 was the best one under the reduced irrigation, it was recorded (33.81 g plot^{-1} day^{-1}), (404 spikes m^{-2}) and (1.41 kg plot^{-1}) for grain filling rate, number of spikes m^{-2} and grain yield plot^{-1}, respectively.

The tallest plants were obtained by the cultivar Misr 2 while the shortest plants were given by the cultivar Sakha 93 under the two irrigation regimes. The maximum 1000-kernel weight were produced by the cultivar Gemmeiza 12 being 47.37 and 51.41 g under normal and reduced irrigations, respectively. These results indicated that water deficiency caused a significant decreases in most studied characters. Which are in agreement with those reported by Singh *et al.* (2018) and Abd El-Kreem *et al.* (2019).

The interaction effect between growing season, irrigation regime and genotypes had insignificant effect on all studied characters, except for grain filling rate, plant height, number of spikes m^{-2} and grain yield plot^{-1} (Table 9). The mean values of all the studied characters under normal irrigation were higher than those obtained in the reduced irrigation in both seasons, except for 1000-kernel weight. The insignificant interaction effect indicates that wheat genotypes responded similarly to the environmental conditions.

Results indicated that the cultivar Misr 2 gave the highest grain filling rate under normal irrigation, while the genotype Cham 4 had the highest values under reduced irrigation in both seasons.

The results revealed that the tallest plants were recorded by the cultivars Misr 1, Gemmeiza 12 and Misr 2, while the shortest plants were produced by Cham 4, Sakha 93 and Vorobey under the two irrigation regimes in both seasons.

The maximum number of spikes m^{-2} were obtained by the cultivar Misr 2 under normal irrigation in the 1st season and under reduced irrigation in the 2nd season. The genotype Cham 4 gave the highest number of spikes m^{-2} under the reduced irrigation in the 1st season, while the genotype Vorobey produced the highest number of spikes m^{-2} under normal irrigation in the 2nd season. This suggests that reducing irrigation can result in a clear reduction in number of spikes m^{-2}. These findings were in line with those obtained by Milad *et al.* (2016) and Singh *et al.* (2018). The current study showed a significant reduction in grain yield plot^{-1} due to reducing irrigation in both seasons. The cultivar Misr 2 produced the highest grain yield under normal irrigation in both seasons and under reduced irrigation in the 2nd one, while the highest grain yield was obtained by the genotype Cham 4 under the reduced irrigation in the 1st season.

Table 9. Mean values of days to heading, days to maturity, grain filling period, grain filling rate, plant height and Number of spikes m^{-2}as affected by the second-order interaction effect between irrigation regimes, genotypes and growing season

Genotypes	Days to heading (day)				Days to maturity (day)				Grain filling period (day)				Grain filling rate (g plot^{-1}day^{-1})				Plant height (cm)			
	1st S		2nd S		1st S		2nd S		1st S		2nd S		1st S		2nd S		1st S		2nd S	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
Cham 4	96	94	100	97	143	134	153	143	47	39	53	45	33.2	39.2	26.6	28.4	97	93	99	93
Sakha 93	95	93	99	96	149	140	159	149	54	47	60	53	29.8	27.0	21.5	21.8	99	95	97	86
Vorobey	97	93	101	96	148	138	158	147	51	45	57	51	29.6	29.9	23.3	20.4	104	95	99	88
Misr 1	102	98	106	101	149	143	159	152	47	45	53	51	37.2	26.1	31.8	23.9	117	98	119	105
Gemmeiza 12	97	94	101	97	148	138	158	147	51	44	57	50	39.5	26.9	25.2	23.8	113	99	111	107
Misr 2	102	96	106	99	148	141	158	150	46	45	52	51	47.0	32.4	40.8	26.2	122	106	125	113
Mean	98	95	102	98	148	139	158	148	49	44	55	50	36.1	30.2	28.2	24.1	109	98	108	99
LSD $_{0.05}$	NS				NS				NS						5.33				5.01	

1st S: First season and 2nd S: Second season. N: normal irrigation and D: reduce irrigation

Table 9. Cont.

Genotypes	No. of spikes m^{-2}				No. of kernels spike^{-1}				1000-kernel weight (g)				Grain yield plot^{-1} (kg plot^{-1})			
	1st S		2nd S		1st		2nd		1st		2nd		1st		2nd	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
Cham 4	472	533	431	275	50	48	35	42	46.8	51.6	46.4	47.4	1.55	1.55	1.42	1.28
Sakha 93	583	366	386	267	53	53	42	52	44.9	48.9	41.0	45.3	1.61	1.26	1.29	1.14
Vorobey	385	362	447	219	56	58	40	50	41.8	49.8	40.9	46.5	1.48	1.32	1.32	1.02
Misr 1	429	350	355	265	68	59	55	51	41.8	45.0	45.7	45.2	1.72	1.16	1.66	1.20
Gemmeiza 12	380	344	362	212	74	64	42	64	49.6	52.5	45.2	50.4	2.00	1.18	1.42	1.18
Misr 2	625	421	442	278	61	57	63	67	51.6	44.6	40.7	42.2	2.16	1.44	2.12	1.32
Mean	479	396	404	253	60	57	46	54	46.1	48.7	43.3	46.2	1.75	1.32	1.54	1.19
LSD $_{0.05}$	50.41				NS				NS				0.24			

1st S: First season and 2nd S: Second season. N: normal irrigation and D: reduce irrigation

Tolerance indices

The results in Table 10 show the mean grain yield under normal (Yn) and reduced irrigation (Ys) of the six wheat genotypes, as well as the estimates of two indices of stress tolerance and their respective ranks. Under normal irrigation, the grain yield varied from 1.40 kg plot^{-1} for the genotype Vorobey to 2.14 kg plot^{-1} for the cultivar Misr 2, with average of 1.64 kg plot^{-1} while under reduced irrigation, the mean grain yield ranged from 1.17 kg plot^{-1} for the genotype Vorobey to 1.41 kg plot^{-1} for the genotype Cham 4, with average of 1.25 kg plot^{-1}. Over the two irrigation regimes, the mean of grain yield varied from 1.29 kg plot^{-1} for the genotype Vorobey to 1.76 kg plot^{-1} for the cultivar Misr 2.

Generally, the mean reduction % of grain yield under reduced irrigation was 23.78 % less than its respective value under normal irrigation. Unfortunately, the highest grain yield reduction % (more than 30 %) was obtained by the three cultivars Misr 1, Gemmeiza 12 and Misr 2, which had the maximum grain yield under normal irrigation. On the contrary, the lowest grain yield reduction % values were achieved in the three genotypes, Cham 4 (5.37 %), Sakha 93 (17.24 %) and Vorobey (16.43 %), which had the minimum grain yield under normal irrigation. Accordingly, it is not necessary that the high yielder genotype under normal irrigation to be also high yielder under the reduced one. The current findings show that there is a genetic diversity between the genotypes tested in terms of grain yield under stress and non-stress conditions, enabling us to scan for stress-tolerant conditions.

The grain yield of the tested genotypes under both normal and reduced irrigation was formulated to calculate two tolerance indices as presented in Table 10. Genotypes having the lowest values of tolerance index (TOL) and stress susceptibility index (SSI) would be more stress tolerant.

Table 10. Two stress tolerance indices (STI) and their respective ranks of six wheat genotypes based on grain yield (kg plot^{-1}) under normal and reduced irrigation over the two seasons.

Genotype	Grain yield (kg plot^{-1})				Stress Tolerance Indices	
	Normal	Stress	Mean	Red. %	TOL	SSI
Cham 4	1.49	1.41	1.45	5.37	0.08	0.22
Sakha 93	1.45	1.20	1.33	17.24	0.25	0.72
Vorobey	1.40	1.17	1.29	16.43	0.23	0.69
Misr 1	1.69	1.18	1.44	30.18	0.51	1.26
Gemmeiza 12	1.71	1.18	1.45	30.99	0.53	1.30
Misr 2	2.14	1.38	1.76	35.51	0.76	1.49
Mean	1.64	1.25	1.45	23.78		
	Tolerance rank					
Cham 4	4	1	2	1	1	1
Sakha 93	5	3	5	2	2	2
Vorobey	6	6	6	3	3	3
Misr 1	3	4	4	4	4	4
Gemmeiza 12	2	4	3	5	5	5
Misr 2	1	2	1	6	6	6

It is obvious that the two susceptible/tolerance indices gave similar ranks for genotypes concerning the stress tolerance, where the three genotypes namely Cham 4, Sakha 93 and Vorobey were identified as stress tolerant genotypes. The three genotypes had the lowest values of tolerance stress indices, while the cultivars Misr 1, Gemmeiza 12 and Misr 2 were identified as susceptible genotypes under the current study. On the other hand, The similarity between the two indices in the ranking of stress tolerance genotypes can be due to the fact that both indices are functional. The current findings are in line with those obtained by the Abd El-Mohsen *et al.* (2015), Ali and El-Sadek (2016) and Mohammadi (2016).

It can be concluded that among the three stress tolerant genotypes, the genotype Cham 4 only had mean grain yield equal or exceeds the grand mean. Accordingly, it was preferred to cultivate it under shortage water conditions and can be used in wheat breeding program to transmit tolerance genes for reduced irrigation to the commercials cultivars.

REFERENCES

Abd El-Kreem, H.A., Thanaa, E.A.M. Abdelhamid, and M.N.A. Elhawary (2019). Tolerance indices and cluster analysis to evaluate some bread wheat genotypes under water deficit conditions. Alex. J. Agric. Sci., 64(4): 245-256.

Abd El-Mohsen, A.A., M.A. Abd El-Shafi, E.M.S. Gheith, H.S. Suleiman (2015). Using different statistical procedures for evaluating drought tolerance indices of bread wheat genotypes, Adv. Agric. Biol., 4(1): 19-30.

Ali, M.B. and, A.N. El-Sadek (2016). Evaluation of drought tolerance indices for wheat (*Triticumaestivum* L.) under irrigated and rainfed conditions. Communications in Biometry and Crop Science., 11(1): 77–89.

Farhat, W.Z.E. (2015). Response of 21 spring bread wheat genotypes to normal and reduced irrigation in north delta. J. of Plant Production, Mansoura Univ., 6 (6): 943 – 963.

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

Gomez, K. A. and A. A. Gomez (1984). Statistical procedures For Agricultural Research.2nd Ed. John Wiley & Sons, Inc.

Hooshmandi.B. (2019). Evaluation of tolerance to drought stress in wheat genotypes. IDESIA, 37,(2): 37-43

Levene, H. 1960. Robust tests for equality of variances. In Ingram Olkin, Harold Hotel ling, Italia, Stanford, Univ. Press, 278- 292.

Liu, X., B.C. Bowman, Y. Hu, X. Liang, W. Zhao, J. Wheeler, N. Klassen, H. Bockelman, M. J. Bonman and J. Chen (2017). Evaluation of agronomic traits and drought tolerance of winter wheat accessions from the USDA-ARS national small grains collection.Agronomy, 7(51): 1-16

Mehraban, A., A. Tobe, A. Gholipouri, E. Amiri, A. Ghafari, and M. Rostaii (2019). The effects of drought stress on yield, yield components, and yield stability at different growth stages in bread wheat cultivar (*Triticum aestivum* L.). Pol. J. Environ. Stud., 28 (2): 739-746.

Milad, I. M., Sanaa, Nawar, A. I. Shaalan, A. M., M. Eldakak and Rohila, S. Jai. (2016). Response of different wheat genotypes to drought and heat stresses during grain filling stage. Egypt, J. Agron., 38, (3): 369 -387.

Mohammadi, R. (2016). Efficiency of yield-based drought tolerance indices to identify tolerant genotypes in durum wheat. Euphytica, 211:71–89.

Noreldin, T. and M. SH. M. Mahmoud (2017). Evaluation of some wheat genotypes under water stress conditions in upper Egypt. J.Soil Sci. and Agric. Eng., Mansoura Univ., 8 (6): 257 – 265.

Pireivatlou, A.S., R. Aliyev and B.S. Lalehloo (2011). Grain filling rate and duration in bread wheat under irrigated and drought stressed conditions. J. of Plant Physiology and Breed., 1(1): 69-86.

Rosielle, A.A. and J. Hamblin (1981). Theoretical aspects of selection for yield in stress and non-stress environments. Crop Sci., 21 (6): 943-946.

Singh, S.P., M.K. Yadav; K. Singh and R.S. Sangar (2018). Effect of drought stress on the morphological and physiological characterization of the indian wheat (*Triticum aestivum*L.) genotype. Int. J. Curr.Microbiol. App. Sci., 7 (8): 1144-1155.

Thapa, S., S. K. Reddy, M.P. Fuentealba, Q. Xue, J. C. Rudd, K. E. Jessup, R. N. Devkota and S. Liu (2017). Physiological responses to water stress and yield of winter wheat cultivars differing in drought tolerance. J Agro Crop Sci.; 204:347–358.

Waller, R. A. and D. B. Duncan. 1969. A bay's rule for the symmetric multiple comparison proplem. J. Ame. Stat. Asocy. 64:1485-1503

Zafarnaderi, N.S.A. and S.A. Mohammadi (2013). Relationship between grain yield and related agronomic traits in bread wheat recombinant inbred lines under water deficit condition. Annals of Biological Research. 4 (4):7-11.

تقييم بعض التراكيب الوراثية من قمح الخبز تحت ظروف الري العادي والمخفض

محمد عبد الكريم حسن درويش، محمد نبيل عوض الهوارى* وأحمد طه حسن مصطفى
قسم بحوث القمح – معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية

أجريت هذه الدراسة في محطة البحوث الزراعية بسخا لتقييم سته تركيب وراثية من القمح تحت ظروف الري العادي (خمس ريات) والري المخفض (رية واحدة بعد رية الزراعة) خلال موسمي الزراعة 2018/2017 و2019/2018 حيث تم زراعة التجربة في تصميم القطاعات الكاملة العشوائية في تسع مكررات. تم استخدام مؤشرين لتحمل الاجهاد (دليل التحمل ودليل الحساسية للإجهاد) لتمييز تراكيب القمح الأكثر انتاجية وتحملا للإجهاد المائي. أظهرت النتائج أن تأثير عامل الري كان عالي المعنوية على كل الصفات تحت الدراسة عدا صفة عدد حبوب/السنبلة. سجلت جميع الصفات المدروسة أعلى القيم لها تحت ظروف الري العادي مقارنة بالري المخفض عدا صفتي عدد حبوب/السنبلة ووزن 1000 حبة. أوضحت النتائج وجود اختلافات عالية المعنوية بين التراكيب الوراثية من القمح لجميع الصفات تحت الدراسة. تبين من النتائج أن أفضل التراكيب الوراثية الصنف مصر 2 حيث سجل أعلى قيم لصفات معدل امتلاء الحبوب، وعدد السنابل بالمتر المربع ومحصول الحبوب مع وجود اختلافات جوهرية مقارنة بباقى التراكيب الوراثية المستخدمة. كما تبين من استخدام مؤشرين لتحمل الاجهاد أن التراكيب الوراثية الثلاثة (Cham 4 وسخا 93 و فوروبي) هي الأكثر تحملا للإجهاد ولكن التركيب الوراثي Cham 4 كان الأعلى محصولا وبناء على ذلك فانه يفضل استخدام التركيب الوراثي Cham 4 في برامج التربية لإنتاج أصناف تتحمل الإجهاد المائي.