Original Research Article

Effect of water deficit on productivity of some barley (Hordeum vulgare L.) genotypes

ABSTRACT

Two field experiments were laid out during 2019/2020 and 2020/2021 growing seasons at Sakha region, Kafr El-Sheikh Governorate, Egypt to evaluate the productivity and stress tolerance of ten barely genotypes under full irrigation and water stress conditions. Eight traits for barley were measured: days to maturity, plant height, spike length, number of grains/spike, number of spikes/m^2, 1000-grain weight, biological yield and grain yield. Also, stress susceptibility index (SSI) was calculated. Results showed that, all the studied traits were decreased under water stress conditions. Mean squares due to seasons, water treatments, genotypes and their interactions were significant or highly significant for most studied traits. From the results, Giza 133 and Line 3 were the earliest genotypes in maturity. Line 4 under normal irrigation and Giza 2000 and Line 5 under stress gave the highest values of grain yield and most of its components. From SSI data, Giza 124, Giza 126, Giza 2000, Line 3 and Line 5 considered as the most tolerant genotypes where it had values less than the unity. so, it can be used in improving barley productivity under water stress condition.

Key words: Barley, water deficit, tolerance index, yield potential.

1. Introduction

Barley (Hordeum vulgare L.) considered as one of the most valuable cereal grain crops is cultivated all over the world. Barley has a good adaptation to water stress, and it can be surveyed as a genetic model plant to illustrate drought resistance mechanisms **[1], [2].** Barley possesses some special properties that enable it to adapt desirably into different unsuitable environmental conditions compared to other crops. The phenomenon of diminishing barley yields under limited water supply situations is well known **[3],** therefore, drought stress reduces barley grain yield by negatively affecting the yield components which are determined at various plant development stages **[4], [5]**. Drought stress is a significant abiotic factor that can diminish photosynthesis efficiency by reducing leaf expansion, hence, causing premature leaf senescence and lower food production. Many papers on crop breeding for drought environments have been recently published **[6], [7], [8].** Drought factor is responsible for the greatest amounts of destruction to agricultural products among all other environmental stresses **[9], [10], [11].** Only the effect of genotype and the interaction between genotype and environment are important in selection of stable genotypes, both genotype effect and the interaction of genotype and environment should be examined **[12].** The objective of this study was to evaluate the productivity and stress tolerance of ten barely genotypes under full irrigation and water stress conditions and select barley genotypes that have considerable stress tolerance which can be used in barley improvement.

2. MATERIALS AND METHODS

Present study was conducted in Sakha region, Kafr El-Sheikh Governorate (Lat. 31° 06' 25.20" N, Long. 30° 56' 26.99" E, elevation above sea level 17 m), Egypt during 2019/2020 and 2020/2021 growing seasons. For each season, the tested genotypes were evaluated in two separate irrigation treatments using flood irrigation method. The first treatment involved the normal irrigation (two times after planting irrigation), while the second one included planting irrigation only (water stress) in addition to the amount of rainfed. All other cultural practices were applied according to the recommendations of the barley department for the region. The values of metrological data in 2019/2020 and 2020/2021 are presented in Table (1).

Table 1: Monthly means of air temperature (AT ^{O}C), relative humidity (RH %) and rainfall (mm/month) in winter seasons 2019/2020 and 2020/2021 at Sakha region.

Month	At ^{O}C 2019/20		At ^{O}C 2020/21		RH%		Rainfed (mm)	
	Max.*	Min.**	Max.	Min.	2019/20	2020/21	2019/20	2020/21
December	21.4	13.4	22.9	13.7	86.4	87.70	27.9	18.78
January	18.4	11.8	21.0	13.5	74.7	86.70	38.4	14.65
February	20.4	12.7	21.5	12.4	70.6	87.50	14.3	51.40
March	22.6	15.6	22.3	13.8	67.5	81.06	30.8	25.40
April	26.0	18.9	27.5	19.4	62.6	74.30	-	-

* Max = maximum temperature, ** Min = minimum temperature

2.1. Plant materials, experimental design and data recorded.

In randomized complete block design with four replicates, ten barley genotypes were grown. The planting date was December 5th in both growing seasons. Each genotype was sown in plot area 4.2m^2. The pedigree of the ten barley genotypes is presented in Table (2). Eight traits for barley were measured: days to maturity, plant height (cm), spike length (cm), number of grains/spike, number of spikes/m^2, 1000-grain weight (g), biological yield (ton/fedan) and grain yield (ardab/fedan) [ardab= 120kg and feddan= 4200m^2]. Harvest was done on first of May in both growing seasons.

More detail :[1j]Comment

Table 2. Name and pedigree of the studied ten barely genotypes.

Genotypes	Pedigree \ Name
Giza 124	Giza 117/Bahteem 52// Giza 118/FAO 86
Giza 126	Baladi Bahteem/SD729-por12762-Bc
Giza 133	Carbo/Gustoe
Giza 134	Alanda-01/4/WI2291/3/Api/CM67//L2966-69
Giza 2000	Cr366-13-1/Giza121
Line 1	Rihane-03//Lignee527NK1272/5/Arizona5908/Aths//Avt/attiki/3/s.t/ Barley/4/Aths/ Lignee640/6/Giza 126
Line 2	M64 - 76 / Bon // Jo / York /3/ M5/Galt // As 46 /4/Hj 34 - 80 / Astrix /5/ NK 1272/7/ Alanda/5/ Aths/4/Pro/TolI//Cer*2 /TolI/3/ 5106/6/Baca'S'/3/AC253 //CI08887/CI05761
Line 3	Giza 2000/4/CalMr/3/Alanda//Lignee527/Arar
Line 4	U.Sask.1766/Api//Cel/3/Weeah/4/Giza121/Pue
Line 5	Panniy/Salmas/5/Baca"s"/3/AC253//CI08887/CI05761/4/JLB70-01

Stress susceptibility index (SSI) was estimated according to [13] as: SSI = (1 - Yd/Yp)/D. Where: Yd = mean yield under stress, Yp = mean yield under normal irrigation = potential yield, D = stress stress intensity = 1 - (mean Yd of all genotypes/mean Yp of all genotypes. The analysis of variance was performed according to RCBD. Combined analysis across the two water treatments in the two seasons was performed when the assumption of errors homogeneity cannot be rejected [14]. Means of genotypes were compared using LSD at 0.05 probability level [15].

2.2. Applied irrigation water

The results in Table (3) indicated that the values of applied irrigation water under full irrigation were 1264.88 and 1325.97 m^3/feddan in the first and second season, respectively and it were 862.88 and 889.97m^3/feddan for water stress treatments in the first and second season, respectively. Furthermore, the applied irrigation amount under full irrigation was higher by 31.78 and 82.88% than the applied water under water stress treatment in the first and second season, respectively, which provide highly stressful environment for barley genotypes to test their ability to withstand water deficiency.

Table (3): Amount of applied water (m^3/feddan) under full irrigation and water stress treatments to barely genotypes in the two growing seasons.

Supplied water	2019/2020		2020/2021	
	Normal	Stress	Normal	Stress
Planting irrigation	395.00	395.00	427.00	427.00
First irrigation	208.00	-	211.00	-
Second irrigation	194.00	-	225.00	-
Total irrigation	797.00	-	863.00	-
Rainfall	467.88	467.88	462.97	462.97
Total of water	1264.88	862.88	1325.97	889.97

Feddan = 4200m^2

3. RESULTS:

3.1. Analysis of variance:

Table 4 show the analysis of variance for the studied traits across seasons and water treatments. Mean squares due to seasons, water treatments and genotypes were significant or highly significant ($P \leq 0.05$ or $P \leq 0.01$) for all the studied characters, except season for grain yield. These results also indicated that the two seasons and two irrigation treatments behaved differently and detected sufficient genetic variability among the studied genotypes.

Variances of seasons, water treatments and genotypes interaction were significant for all characters, except the interaction of seasons x water treatments for spike length, no. of grains/spike, 1000-grain weight and grain yield**.** These results are in line with those obtained many researchers **[16]**, **[17]**, **[18]**, **[19]**, **[20]**, **[21]**, **[5]**.

3.2. The effect of season, water treatments and their interaction:

Table 5 show means of seasons, water treatments and their interaction across all studied genotypes. Means of studied genotypes for all traits were significantly higher in 2020/2021 compared to 2019/2020. Averaging across the 10 entries, the water stress conditions reduced all studied traits.

3.3. Mean performance:

Averaging across the two seasons and water treatments are shown in Table 6. Days to maturity varied from 126.6 days in Giza 133 to 133.3 days in Line 2. From these results, using Giza 133 in breeding program as a source for earliness would be more effective.

In addition, plant height estimates were in the range of 106.1 cm in line 3 and 114.5 cm in Giza 126. Regarding spike length, Giza 134 showed the highest values (9.5cm), while Giza 133 showed the lowest values (6.2cm). Number of grains/spike estimates were in the range of 53.1 in line 3 and 69.2 in Giza 134. Besides, the lowest and highest No. of spikes/m^2 (379.8 and 450.4 spikes) were detected by Line 1 and Line 5, respectively. Also, the range of 1000-grain weight varied from 48.2 g in Line 3 to 57.6 g in Giza 2000. For biological yield, the data varied from 5.32 ton/feddan for Line 1 to 7.06 ton/feddan for Line 4. Moreover, the highest grain yield was observed by Line 4 (17.54 ardab/feddan), while the lowest value was obtained by Line 1 (14.13 ardab/feddan). From the previous results, the genotypes which showed desirable data could be used for improving barley crop.

Table (4): Analysis of variance for the all studied traits across the seasons, irrigation treatments and studied barley genotypes.

Comment [2j]: Combined Table 4, 5 and 6

SOV	df	Days to maturity	Plant height	Spike length	Number of grains/spike	Number of spikes/m^2	1000 grain weight	Biological yield	Grain yield
Seasons	1	112.20**	303.00**	1.00**	36.60**	8584.20**	70.50**	0.30**	0.01
Treatments	1	1395.40**	6243.40**	38.40**	1382.40**	19556.00**	130.80**	17.05**	194.59**
Seasons x Treatments	1	28.80**	120.80*	0.50	16.80	4068.60**	7.30	0.05**	2.98
Reps/Treatments/Seasons = Error (a)	12	1.64	18.87	0.11	3.91	100.71	3.23	0.01	0.79
Genotypes	9	59.50**	208.50**	18.70**	399.50**	9540.20**	133.60**	5.36**	27.82**
Seasons x Genotypes	9	2.70**	110.70**	0.40**	13.10**	755.50**	10.80**	0.05**	1.62**
Treatments x Genotypes	9	9.90**	151.20**	0.40**	13.00**	5405.60**	5.00**	0.12**	3.36**
Seasons x Treatments x Genotypes	9	7.60**	33.90*	0.50**	18.80**	807.2**	3.5*	0.03**	1.53**
Pooled error b	108	0.60	16.40	0.10	4.60	81.40	1.60	0.01	0.431
Total	159								

*, ** = significant at 0.05 and 0.01, probability levels, respectively.

Table 5. The mean performance of seasons, irrigation treatments and their interaction for the studied traits.

Season/treatment		Days to maturity (day)	Plant height (cm)	Spike length (cm)	Number of grains/ spike	Number of spikes/m^2	1000 grain weight (g)	Biological yield (ton/ feddan)	Grain yield (ardab/feddan
2019/20		127.90	108.10	8.10	61.60	415.00	51.80	6.17	16.00
2020/21		129.60	110.80	8.20	62.60	429.60	53.10	6.26	15.99
F test		**	**	**	**	**	**	**	NS
Normal		130.70	114.00	8.50	62.90	440.90	53.10	6.39	15.55
Stress		125.00	104.40	7.40	56.50	456.20	53.10	5.62	14.36
F test		**	**	**	**	**	**	**	**
2019/2020	Normal	130.50	113.40	8.60	64.90	431.10	52.90	6.48	16.97
	Stress	125.60	102.90	7.60	58.70	394.00	50.80	5.89	15.13
2020/2021	Normal	133.00	117.90	8.70	65.20	435.70	53.80	6.60	17.23
	Stress	126.20	103.70	7.80	60.00	423.60	52.40	5.92	14.75
$LSD_{0.05}$		1.11	5.67	0.50	3.01	12.65	1.79	0.15	0.92

*, ** = significant at 0.05 and 0.01, probability levels, respectively. NS = not significant.

Table 6. Mean performance of studied genotypes for the studied characters combined over seasons and irrigation treatments.

Genotypes	Days to maturity (day)	Plant height (cm)	Spike length (cm)	Number of grains/ spike	Number of spikes/m^2	1000 grain weight (g)	Biological yield (ton/ feddan)	Grain yield (ardab/feddan
Giza 124	127.90	109.20	8.00	59.70	448.50	53.10	6.01	14.95
Giza 126	128.80	114.50	7.80	58.60	415.30	49.40	5.88	15.00
Giza 133	126.60	101.60	6.20	61.10	401.80	53.90	6.21	16.23
Giza 134	129.50	110.00	9.50	69.20	433.10	54.10	6.42	16.80
Giza 2000	128.00	109.00	7.80	58.70	427.60	57.60	6.79	17.53
Line-1	128.30	110.50	8.20	61.10	379.80	49.70	5.32	14.13
Line-2	133.30	109.20	9.20	67.40	391.10	52.30	5.43	14.22
Line-3	127.30	106.10	6.90	53.10	435.30	48.20	6.24	16.38
Line-4	130.50	113.30	9.00	65.70	440.40	55.00	7.06	17.54
Line-5	127.70	111.10	9.10	66.70	450.40	51.30	6.81	17.17
Mean	128.80	109.40	8.20	62.10	422.30	52.50	6.22	15.99
LSD0.05	1.11	5.67	0.50	3.01	12.65	1.79	0.15	0.92

Ardab = 120kg , Feddan= 4200m^2

3.4. The effect of season and barley genotypes interaction:

Table 7 show means of all studied traits across the water treatments and seasons. Values of number of days to maturity ranged from 125.4 and 127.8 days in Giza 133 to 132.3 and 134.2 days in Line 2 in the first and second seasons, respectively. Plant height estimates varied from 101.6 and 101.5 cm in Giza 133 at the first and second season, respectively to 116.6 in Line 4 at the first season and 117.1 cm in Giza 126 at the second season. For spike length, values ranged from 6.2 cm in Giza 133 to 9.3 and 9.7 cm in Giza 134 in the first and second seasons, respectively. Values of No. of grains/spike varied from 52.2 and 54.0 grains in Line 3 to 68.0 and 70.4 grains in Giza 134 in the first season and second seasons, respectively. Besides, number of spikes/m^2 were in the range of 375.0 and 384.6 spikes in Line 1 and 447.2 in Line 5 and 459.5 spikes in Line 2 in the first and second seasons, correspondingly. In addition, the lowest 1000-grain weight was 47.6 g and 48.9 in Line 3 and the highest values were 57.7 and 57.6 g in Giza 2000 in the first and second season, respectively. For biological yield, values ranged from 5.17 and 5.47 ton in Line 1 to 7.01 and 7.11 ton in Line 4 in the first and second seasons, respectively. The highest grain yields were 18.02 ardab for Line 4 and 17.26 ardab for Giza 2000, while the lowest values were 13.88 and 14.38 ardab for Line 1 in the first season and second season, respectively.

3.5. The effect of irrigation treatments and barley genotypes interaction:

The means of all studied traits combined over the two seasons for the same water treatment are exhibited in Tables 8. Number of days to maturity ranged from 130.0 and 123.2 days in Giza 133 to 136.3 and 130.1 days in Line 2 under normal and water stress conditions, respectively. Plant height estimates varied from 104.6 and 98.5 cm in Giza 133 to 121.1 and 113.8 cm in Line 4 and Giza 126 under normal and water stress conditions, respectively. Concerning spike length estimates, values varied from 6.8 and 5.5 cm in Giza 133 to 9.9 cm in Line 2 and 9.2 cm in Giza 134 under normal and water stress conditions, respectively. The number of grains/spike varied between 55.3 to 51.0 grains in Line 3 to 71.6 in Line 2 and 67.5 grains in Giza 134 under normal and water deficit conditions, respectively. Besides, the number of spikes/m^2 went in the range from 395.7 and 363.8 spikes in Line 1 to 669.6 spikes in Line 3 and 440.9 spikes in Giza 124 under normal and water stress conditions, respectively. The lowest grain weights were 49.7 and 46.6 g in Line 3, while the highest values were 58.0 and 56.3 g in Giza 2000 under normal and water stress conditions, respectively. For biological yield, values ranged from 5.7 and 5.94 ton in Line 1 to 7.43 and 6.99 ton in Line 4 under normal and water stress conditions, respectively. The lowest values of grain yield were 15.39 ardab in Line 2 and 12.37 ardab for Line 1, while the highest values were 19.17 ardab in Line 4 and 16.73 ardab for Giza 2000 under normal and water stress conditions, respectively.

3.6. The effect of season, irrigation treatments and barley genotypes interaction:

The mean performance of all the studied traits of the interaction seasons, water treatments and barley genotypes are presented in Tables 9 and 10. The earlier genotype was belonged to Giza 133 under normal irrigation in the first season and under stress condition in the two seasons and to Line 3 under normal irrigation in the second season. While the highest numbers were recorded for Line 2 in the first and second season under normal and water stress conditions. For plant height, the shortest genotypes were Giza 133 under normal irrigation in the two seasons, Line 2 under stress in the first season and Line 3 in the second season, while tallest genotypes were Line 4 under normal and water stress conditions in the first season, Line 5 under normal irrigation and Giza 2000 under stress in the second season. For spike length and number of grains/spike, the highest values recorded for Giza 134 under normal irrigation in the first season and under stress condition in the two seasons and for Line 2 under normal irrigation in the second season. Moreover, the highest number of spikes/m^2 detected by Line 3 under normal irrigation in the first and second seasons and under stress condition in the second season and by Line 5 under stress condition in the first season. Besides, the highest grain weight was obtained by Giza 2000 under all conditions. Additionally, the highest value of biological yield was obtained by Line 4 under all conditions. At the same time, the highest values of grain yield were detected by Line 4 under normal irrigation in the two seasons, Giza 2000 in the first season and Line 5 in the second season under stress condition, respectively.

Table 7. Mean performance of interaction between seasons and barley genotypes for the all studied traits combined over water treatments.

Genotype	Days to maturity (day)		Plant height (cm)		Spike length (cm)		Number of grains/spike		Number of spikes/m^2		1000 grain weight (g)		Biological yield (ton/feddan)		Grain yield (ardab/feddan	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Giza 124	126.50	129.20	106.00	112.40	8.10	7.90	60.30	59.10	440.80	456.20	51.20	54.90	5.97	6.04	14.51	15.40
Giza 126	127.50	130.10	111.90	117.10	7.90	7.60	59.60	57.60	409.30	421.30	49.30	49.40	5.87	5.88	15.01	14.99
Giza 133	125.40	127.80	101.60	101.50	6.20	6.20	61.10	61.10	392.50	411.20	51.60	56.30	6.26	6.17	16.54	15.91
Giza 134	129.20	129.80	108.60	111.40	9.30	9.70	68.00	70.40	426.80	439.30	53.20	55.00	6.40	6.44	16.68	16.93
Giza 2000	127.20	128.90	105.30	112.70	7.70	7.90	57.90	59.40	416.70	438.50	57.70	57.60	6.80	6.79	17.80	17.26
Line-1	127.80	128.80	106.80	114.20	7.80	8.50	58.90	63.30	375.00	384.60	49.40	50.10	5.17	5.47	13.88	14.38
Line-2	132.30	134.20	105.70	112.80	9.20	9.30	66.90	67.90	392.00	390.10	51.90	52.60	5.35	5.50	13.91	14.54
Line-3	127.00	127.90	109.00	103.30	6.70	7.00	52.20	54.00	411.20	459.50	47.60	48.90	6.16	6.32	16.19	16.56
Line-4	130.10	131.00	116.60	109.90	8.90	9.00	65.40	66.00	438.50	442.20	54.90	55.20	7.01	7.11	18.02	17.05
Line-5	126.60	128.80	109.20	113.00	9.00	9.20	66.10	67.20	447.20	453.50	51.30	51.20	6.74	6.88	17.47	16.86
LSD0.05	0.79		4.01		0.35		2.13		8.94		1.27		0.11		0.65	

S_1 and S_2= first and second season, respectively. Ardab = 120kg , Feddan= 4200m^2

Table 8. Mean performance of interaction between irrigation treatments and barley genotypes for all studied traits combined over seasons.

Genotype	Days to maturity (day)		Plant height (cm)		Spike length (cm)		Number of grains/spike		Number of spikes/m^2		1000 grain weight (g)		Biological yield (ton/feddan)		Grain yield (ardab/feddan	
	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S
Giza 124	130.70	125.00	114.00	104.40	8.50	7.40	62.90	56.50	456.20	440.90	53.10	53.10	6.39	5.62	15.55	14.36
Giza 126	132.60	124.90	115.20	113.80	8.30	7.30	61.50	55.70	398.60	432.10	49.80	48.90	6.15	5.61	15.78	14.25
Giza 133	130.00	123.20	104.60	98.50	6.80	5.50	64.90	57.30	405.90	397.80	54.90	53.00	6.52	5.90	17.31	15.15
Giza 134	133.00	126.00	114.30	105.70	9.80	9.20	70.90	67.50	462.00	404.10	55.20	53.00	6.89	5.94	18.52	15.09
Giza 2000	131.90	124.10	115.30	102.70	8.00	7.50	60.10	57.20	414.20	441.00	58.00	56.30	6.95	6.64	18.34	16.73
Line-1	129.80	126.80	118.80	102.20	8.70	7.60	64.40	57.80	395.70	363.80	51.10	48.40	5.70	4.94	15.89	12.37
Line-2	136.30	130.10	119.80	98.60	9.90	8.50	71.60	63.20	417.30	364.80	53.30	51.30	5.79	5.07	15.39	13.06
Line-3	129.70	124.90	113.20	99.10	7.20	6.50	55.30	51.00	469.60	401.00	49.70	46.60	6.52	5.96	17.34	15.41
Line-4	132.50	128.60	121.10	105.50	9.50	8.40	69.20	62.20	462.60	418.10	56.20	53.80	7.43	6.69	19.17	15.90
Line-5	130.80	124.50	120.70	101.50	9.60	8.60	69.80	63.50	467.00	433.70	52.20	50.30	7.08	6.53	17.70	16.63
LSD0.05	0.93		5.88		0.45		2.68		15.16		0.61		0.14		0.70	

N and S= Normal and Stress condition, respectively. Ardab = 120kg , Feddan= 4200m^2

Table 9. The mean performance of days to maturity, plant height, spike length and number of grains/spike as affected by interactions among seasons, irrigation treatments and genotypes.

Genotypes	Days to maturity (day)				Plant height (cm)				Spike length (cm)				Number of grains/spike			
	S_1		S_2		S_1		S_2		S_1		S_2		S_1		S_2	
	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S
Giza 124	128.77	124.18	132.67	125.83	111.10	100.91	116.80	107.91	8.80	7.30	8.17	7.53	64.80	55.80	61.00	57.20
Giza 126	129.93	126.07	131.33	129.81	112.21	107.55	118.13	106.07	8.63	7.23	7.87	7.33	63.80	55.40	59.20	56.00
Giza 133	127.40	123.41	132.67	123.01	106.36	96.91	109.88	100.18	7.20	5.17	6.43	5.93	67.22	55.00	62.60	59.55
Giza 134	132.60	125.74	133.33	126.24	113.60	103.67	114.95	107.80	9.70	8.97	9.93	9.53	70.20	65.80	71.60	69.15
Giza 2000	130.17	127.16	133.67	128.10	119.98	110.67	120.63	114.70	7.83	7.47	8.20	7.60	59.00	56.80	61.20	57.60
Line-1	129.47	126.07	130.11	127.45	113.64	100.00	124.00	104.32	8.43	7.20	9.04	8.05	62.60	55.20	66.26	60.32
Line-2	135.84	128.80	136.73	131.71	115.65	95.67	124.05	101.57	9.67	8.63	10.20	8.42	70.00	63.80	73.18	62.55
Line-3	128.55	125.37	130.76	128.41	113.45	104.49	112.98	93.64	7.00	6.40	7.42	6.59	54.00	50.40	56.52	51.55
Line-4	132.12	128.00	132.89	129.11	122.15	111.07	120.00	99.90	9.54	8.27	9.54	8.47	69.24	61.60	69.24	62.85
Line-5	129.88	123.33	131.81	125.74	116.33	102.00	124.98	100.98	9.37	8.67	9.89	8.51	68.20	64.00	71.36	63.08
LSD0.05	1.11				5.67				0.50				3.01			

S_1 and S_2 = first and second season, respectively. N and S = Normal and Stress condition, respectively. Ardab = 120kg , Feddan= 4200m^2

Table 10. The mean performance of number of spikes/m^2, 1000 grain weight, biological yield and grain yield as affected by interactions among seasons, irrigation treatments and genotypes.

Genotypes	Number of spikes/m^2				1000 grain weight (g)				Biological yield (ton/feddan)				Grain yield (ardab/feddan)			
	S_1		S_2		S_1		S_2		S_1		S_2		S_1		S_2	
	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S
Giza 124	438.33	413.33	443.37	429.13	52.51	49.92	56.60	53.18	6.36	5.58	6.42	5.66	14.80	14.22	16.30	14.50
Giza 126	421.00	399.67	442.18	400.50	49.60	48.93	50.07	48.82	6.10	5.64	6.19	5.57	15.56	14.46	16.00	14.99
Giza 133	400.00	385.00	411.81	410.54	52.28	50.93	56.60	55.98	6.61	5.91	6.43	5.90	17.71	15.38	16.92	14.91
Giza 134	463.70	390.00	460.26	418.25	54.23	52.20	56.27	53.79	6.80	6.00	6.99	5.89	18.27	15.08	18.76	15.10
Giza 2000	421.67	411.67	460.78	446.29	58.93	56.42	58.97	57.19	6.97	6.61	6.92	6.66	18.66	16.95	18.01	16.50
Line-1	387.33	362.67	404.15	364.96	50.85	47.87	51.32	48.84	5.48	4.87	5.93	5.01	14.90	12.85	16.89	11.88
Line-2	421.33	362.67	413.35	366.88	53.13	50.75	53.48	51.80	5.66	5.04	5.92	5.09	15.04	12.79	15.74	13.33
Line-3	467.67	354.67	471.52	447.43	49.51	45.59	50.11	47.70	6.39	5.93	6.65	5.99	17.28	15.10	17.40	15.72
Line-4	460.93	416.00	464.27	420.21	56.04	53.67	56.44	53.99	7.41	6.62	7.46	6.75	19.17	16.87	19.17	14.94
Line-5	463.00	431.33	470.93	436.16	52.11	50.58	52.35	50.11	7.03	6.44	7.13	6.63	18.29	16.65	17.10	16.62
LSD0.05	12.65				1.79				0.15				0.92			

S_1 and S_2 = first and second season, respectively. N and S = Normal and Stress condition, respectively. Ardab = 120kg , Feddan= 4200m^2

Comment [3j]: Showin the ANOVA results in Table 9 and 10

3.7. Stress susceptibility index (SSI):

Stress susceptibility index (SSI) was calculated using the grain yield under normal irrigation and water stress conditions (Table 11). The SSI values represent tolerance, moderate tolerance or sensitivity and sensitivity if they were less than, equal or near to and above unity, respectively. Averaging the mean of SSI values across the two seasons, Giza 124, Giza 126, Giza 2000, Line 3 and Line 5 considered as the most tolerant genotypes where it had values less than the unity. Giza 133 considered as moderately tolerant, while Line 2 and Line 4 considered as moderately susceptible where it had values around the unity. On the other hand, Line 1 considered as the most susceptible genotype where it had value higher than the unity.

Table 11. Estimates of stress susceptibility index (SSI) based on grain yield for the studied genotypes in the two growing seasons.

Genotype	2019/2020	2020/2021	Mean
Giza 124	0.34	0.80	0.59
Giza 126	0.62	0.46	0.76
Giza 133	1.15	0.86	0.97
Giza 134	1.53	1.41	1.43
Giza 2000	0.80	0.61	0.68
Line-1	1.21	2.15	1.72
Line-2	1.31	1.11	1.17
Line-3	1.11	0.70	0.86
Line-4	1.05	1.60	1.32
Line-5	0.79	0.20	0.47

4. DISCUSSION:

According to the analysis of variance, the two seasons and two irrigation treatments behaved differently and the studied genotypes had sufficient variability. The tested genotypes responded differently to the water treatments and seasons based on the interactions among the studied factors, allowing for the selection of the most advantageous genotypes. In this regard, evaluation barley genotypes under normal irrigation compared to water stress conditions found to be effective in identifying tolerant genotypes to water deficit **[22].** In this respect, significant genetic variability among the studied genotypes under seasons and water treatments were found **[5]**. The highest values in the second season may be a result of the lowest temperature and higher relative humidity than in the first one. Similar results were obtained by **[23]**, **[5].** Results showed that, water deficit reduced all studied traits. These results were confirmed by **[20], [24], [25]**, **[5].** The reduction in number of grains/spike may be due to premature abortion of florets **[26].** Also, under water stress condition grain weight may be decreased due to a shortage in grain-filling period and hence lower dry matter accumulation, or a reduced rate and duration of starch accumulation in the endosperm **[21].** Also, grain yield was decreased under stress condition and this due to the decrease in number of spikes/m^2 **[27],** grain weight per spike **[21]**and grain number per spike **[28].**

5. CONCLUSION

Giza 124, Giza 126, Giza 2000, Line 3 and Line 5 considered as the most tolerant genotypes where it had values less than the unity of SSI. In addition, Giza 2000 and Line 5 were the highest yielding genotypes under stress condition, so it can be used in improving barley productivity under water stress condition.

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