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Research Article

Evaluation of Some Barley Varieties under the Influence of Different Irrigation Rates

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Abstract: The field experiment was conducted in the Experimental Farm, Sakha Agricultural Research Station, A. R. C., Kafr El-Sheikh Governorate, Egypt, during 2014/15 and 2015/16 seasons to study the responses of twelve Egyptian barley cultivars, i.e. Giza 117, Giza 118, Giza 121, Giza 123, Giza 124, Giza 125, Giza 126, Giza 2000, Giza 132, Giza 133, Giza 127 and Giza 128 under normal and stress irrigation using some growth and yield measurement to determine the most tolerance one could be used to obtained high grain yield under water stress conditions. The experimental design as split plot design with three replications. The results indicated that, all the studied characters were significantly affected by water stress in both growing seasons and their combined analysis, except for total chlorophyll content in both seasons, 1000-grain weight in both seasons and combined analysis, maturity date and harvest index in the first season. The results indicated that, the normal irrigation exceed the stress irrigation for all studied traits in both seasons and their combined analysis, except total chlorophyll content and harvest index in both seasons and their combined analysis and 1000-grain weight in the first season.

Keywords: Barley grnotypes, water stress, growth characters, grain yield, yield components.

1. INTRODUCTION

Barley (*Hordeum vulgare*), is one of the first cultivated grains, particularly in Eurasia as early as 10,000 years ago. (Zohary and Hopf (2000). Barley has been used as animal fodder, as a source of fermentable material for beer and certain distilled beverages, and as a component of various health foods. It is used in soups and stews, and in barley bread of various cultures. Barley grains are commonly made into malt in a traditional and ancient method of preparation.

In 2016, barley was ranked fourth among grains in quantity produced (141 million tonnes) behind maize, rice and wheat (FAO STAT 2016). In 2016 the World harvested area of barley was 46.92 million hectares. While, the total harvested area in Egypt in 2016 were 77566 hectares (FAO STAT, 2016). Drought is considered as a major limiting factor for plant production in arid and semi-arid regions (Munns, 2002). Drought reduces plant growth by influencing many physiological and biochemical processes, such as photosynthesis (Abdalla, 2011 and Azadeh *et al.*, 2014). Drought reached the top of its negative impact on crops by reducing fresh and dry biomass production as well as yield production (Lisar *et al.*, 2012). Barley (*Hordeum vulgare*, L.) is the main crop grown in a large scale in rainfed areas of Egypt. It was adapted long time ago to survive and grow satisfactorily under adverse conditions, such as drought and moisture stress. It is considered one of the most suitable crops that can be grown over a wide range of soil variability and under many adverse condition crops. The ability of a cultivar to produce high and satisfactory yield over a wide range of stress and non-stress environments is very important. Finlay (1968) believed that stability over environments and yield potential are more or less independent of each other. Blum (1979) suggested that one method of breeding for increased performance under water stressed conditions might be to breed for superior yield under optimum conditions on the assumption that the best lines would also perform well under sub optimum conditions. The ideal situation would be to have a highly stable genotype with high yield potential (Finlay and Wilkinson, 1963 and Smith, 1982). The aims of the present work, was to examine some barley genotypes under normal and drought condition using some growth

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and yield measurement to determine the most tolerance one could be used to obtained high biological and grain yield under water stress conditions.

MATERIALS AND METHODS

The field experiment was conducted at the Experimental Farm, Sakha Agricultural Research Station, A. R. C., Kafr El-Sheikh Governorate, Egypt, during 2014/15 and 2015/16 seasons to study the responses of twelve barley cultivars under normal and stress irrigation.

Soil samples were randomly taken from the experimental area at a depth of 0 to 30 cm from soil surface before barley sowing. The soil properties are shown in Table 1.

Table (1): Soil analysis of the Experimental Field at Sakha Agricultural Research Station at 2014/15 and 2015/16 Seasons.

Determin	Sa	Silt	Cla	Text	p	E.C(ds
1st Season	13.	24.	61.	Clay	7.	2.1
2nd	15.	23.	60.	Clay	8.	2.9

In the first season, the maximum temperature was high and the relative humidity and rainfall were low compared with the second season (Table 2).

Experimental Design:

This experiment was laid out in split plot design with three replications, two rates of irrigation (normal and water stress condition (sowing irrigation only) were in main plots and twelve barely cultivars as shown in Table 3 were tried in a sub-plot. Grains were hand drilled at the recommended sowing rate of barley in the irrigated land in Egypt (50 kg $fed.^{-1}$). Each genotype was sown in six rows of 3.5 m, spaced with 20 cm among rows. The normal irrigation treatment were irrigated twice after sowing, at 45 days after sowing at tillering stage and 75 days after sowing at booting stage (normal condition), while, the drought irrigation treatments were given just sowing irrigation only (drought stress condition). Sowing was done in first of December in both seasons. All recommended culture practices were applied at proper time according to ministry of agriculture recommended.

Table (2): Maximum, minimum temperature and rainfall during the growing seasons of barley crop at Sakha Agricultural Research Station, (ARC), Egypt.

Month	Temperature (C°)				Rainfall (mm)	
	2014/15		2015/16			
	Ma	Mi	Ma	Mi	2014/	2015/
Dec.	19	11	20	13	35	15
Jun.	17	6	17	10	18	12
Feb.	21	8	22	11	23	5
Mar.	23	10	23	13	14	18
Apr.	28	11	28	16	3	2
May.	31	13	29	19	-	-

Table (3): Name and pedigree of twelve barley cultivars.

Genotyp	Name\Cross	Origi
Giza117	Baladi 16/Palestine 10	Egypt
Giza 118	Atlas*Vaughn	Egypt
Giza 121	Baladi16/Gem	Egypt
Giza 123	Giza 117//FAO86	Egypt
Giza 124	Giza 117/ Bahteem 52// Giza	Egypt
Giza 125	Giza 117/ Bahteem 52// Giza	Egypt
Giza 126	Baladi Bahteem/SD729-por12762-	Egypt
Giza 2000	Cr366-13-1/Giza121	Egypt
Giza 132	Rihane-05//As46/Aths*2" Aths/	Egypt
Giza 133	Carbo/Gustoe	Egypt
Giza 127	WI2291/Bags/Harmal-02	Egypt
Giza 128	WI2291/4/11012-270-	Egypt

Water application was mentiored via a water meter as shown in Table 4. Irrigation water at sowing approximately 500 m3/fed. And the non-stress treatment was irrigated twice after 45 and 75 days after sowing (DAS) in each season.

Table-4. Amount of supplied water in $m^3 fed^{-1}$ at different barley critical growth stages, rainfall amount and total water supplied at 2014/2015 and 2015/2016 Seasons.

Treatment	Growth Season	Growth Stages			Irrigation			
		Sowing irrigation	35 days after sowing	75 days after sowing	Water (m^3)	Rainfall mm	Rainfall m^3 fed	Total m^3 fed
normal irrigation	2014/2015	500	350	400	1250	93	391	1641
	2015/2016	500	375	425	1275	52	218	1493
Water stressed	2014/2015	500	-	-	550	93	391	941
	2015/2016	500	-	-	500	52	218	718

Data Recorded:

Data recorded for ten traits i.e. total chlorophyll content, maturity date, plant height (cm), number of spikes/m², spike length (cm), number of grains/ spikes, 1000-grain weight (g), biological yield (kg/fed.), grain yield (kg/fed.) and harvest index.

DSI estimated:

Drought susceptibility index was determined according to Fischer and Maurer, (1978) as the following equation:

DSI= (1- Ys/ Yp) /DI

Where:

DI=1-(grand mean Ys/grand mean Yp) and the most tolerance genotypes had DSI ≤ zero or near to zero.

Total chlorophyll content:

Total chlorophyll was extracted in 80% acetone and determined spectrophotometrically as recommended by Metzner *et al.*, (1965).

Statistical Analysis.

All collected data were subjected to analysis of variance according to Gomez and Gomez (1984). All statistical analysis was performed using analysis of variance technique by means of Costat (2005) computer soft were package.

RESULTS AND DISCUSSION

A- Analysis of variances:

Mean squares of all studied barley genotypes for all the studied characters under the two irrigation environments in both seasons of 2014/15 and 2015/16 and their combined data are presented in Table (5 a and b).

As shown in Table (1), soils are considered good soils if the EC is less than 4 mmhos and PH 7. But, if the EC is more than 4 mmhos, the soil is low saline soils and the sensitive crops are affected. The soil is considered as moderate saline, if the EX is more than 4 and PH less than 8.5 accompanied with the exchangeable sodium less than 15.

All the studied characters were significantly affected by water stress in both growing seasons and their combined analysis, except for total chlorophyll in both seasons, 1000-grain weight in both seasons and combined analysis, maturity date and harvest index in the first season. These results could be changed by seasonal changing with respected to these traits. The decreases values in the first season for some traits especially grain yield and yield components under stress condition may be due to the highest amount of rainfall in the second season. The results indicated that, the normal irrigation exceed the stress irrigation for all studied traits in both seasons and their combined analysis, except total chlorophyll and harvest index in both seasons and their combined analysis and 1000-grain weight in the first season. Similar result was obtained before by Saman *et al.*, 2014. who indicated that, analysis of variance revealed significant differences among barley genotypes for number of grains per spike (P<0.01), 1000 grain weight (P<0.01) and harvest index (P<0.05) at both non-stressed and stressed conditions. Significant differences were observed among genotypes for spike number/m^2 (P<0.01) and grain yield (P<0.01) in non-stressed and for plant height at stressed conditions (P<0.01).

Water resulted in decreased grain weight and this may be due to reduce the final grain weight by curtailing the duration of the grain filling stage. Moisture stress applied just before or during the maturity process greatly reduced seed weight (Robins and Domingo, 1962). The average reduction in yield caused by drought stress was 28.05% (Vaezi *et al.*, 2010). These results were in harmony with those of Samarah *et al.*, (2009) and Abu-El-Lail *et al.*, (2016).

If water stress occurred during and following heading, the yield reduction was much more severe resulting in fewer heads, fewer spikelets /spike, and fewer kernels per spike (Robins and Domingo, 1962). Severe drought stress at 20% field capacity until grain maturity reduced grain yield by reducing the number of tillers, spikes and grains per plant and individual grain weight (Samarah *et al.*, 2009). Also, Saeidi *et al.*, (2013) found that, post anthesis water deficiency caused 22, 18.3, 5.9, 5.5 and 21.9 percent reduction in grain yield, biomass, thousand grain weight, number of grains per spike and number of spikes per m^2 in average respectively, but had no significant effect on harvest index. These results go in line with those obtained by El-Kholiey and Hamid (2000) and Abu-El-Lail *et al.*, (2016).

Table (5 a): Effect of irrigation treatments on barley characters in both growing seasons and their combined data.

Treatments	Total chlorophyll			Maturity date			Plant height			Number of			Spike length		
	S_1	S_2	Com	S_1	S_2	Co	S_1	S_2	Co	S_1	S_2	Co	S_1	S_2	Co
Normal	42.	41.	42.0	127.	129.	128.	114.	120.	117.	628.	552.	590.	8.1	11.	9.71
Stress	45.	44.	44.8	125.	125.	125.	98.6	96.0	97.3	430.	434.	432.	6.6	6.4	6.54
F-Test	**NS**	**NS**	*****	**NS**	******	******	******	******	******	******	******	******	******	******	******
$LSD_{0.05}$	-	-	**1.96**	-	-	-	-	-	-	-	-	-	-	-	-
$LSD_{0.01}$	-	-	-	-	**3.12**	**2.4**	**14.8**	**23.3**	**19.0**	**188.**	**112.**	**150.**	**1.4**	**4.5**	**3.02**

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

Table (5 b): Effect of irrigation treatments on barley characters in both growing seasons and their combined data.

Treatments	Number of			1000-grain			Biological yield			Grain yield			Harvest index		
	S_1	S_2	Co	S_1	S_2	Co	S_1	S_2	Com	S_1	S_2	Co	S_1	S_2	Co
Normal	50.	58.	54.6	54.	55.	55.0	2179.	2009.	2094.	945.	891.	918.	43.	44.	44.0
Stress	42.	42.	42.5	55.	55.	55.1	1566.	1755.	1661.	690.	837.	763.	44.	48.	46.2
F-Test	**	**	**	NS	NS	NS	**	*	**	**	**	**	NS	*	*
$LSD_{0.05}$	-	-	-	-	-	-	-	**198.6**	-	-	-	-	-	**2.5**	**1.60**
$LSD_{0.01}$	**7.6**	**15.**	**11.5**	-	-	-	**583.6**	-	**412.4**	**242.**	**51.5**	**147.**	-		

NS, * and ** indicated not significant, significant at 0.05 and significant at 0.01 levels of probability, respectively

Effect of Barley Cultivars:

The results in Table (6) showed that, all the twelve studied cultivars were significantly different in all the studied characters over both irrigation treatments in both seasons and the combined data. All studied traits were differed in the two seasons of study and the combined data with averages of:

For total chlorophyll content Giza 127 followed by Giza 126 cultivars give the highest values for total chlorophyll content in the both seasons and the combined data, while, the lowest chlorophyll content in both seasons and the combined data were obtained by Giza 118 followed by Giza 123.

With regard to maturity date Giza 132 expressed the earliest cultivars among all tested cultivars, it showed the lowest values for maturity date in both seasons and the combined data. On the other side, Giza 125 was the latest one among all tested cultivars where, it gave the highest mean values for maturity date in both seasons and the combined data.

With respect to plant height (Table 6), the results indicate that most cultivars were taller than Giza 133 except Giza 2000 in the first season. Giza 121 followed by Giza 123 were the tallest among all tested cultivars. While, Giza 133 and Gize 2000 followed by Giza 126 were the shortest among all tested cultivars in both seasons and their combined data.

According to number of Spikes /m^2 the presented data in Table 6 showed that Giza 2000 followed by Giza132 recorded the highest values of spikes number/m^2 in both seasons and their combined data. On the other hand, Giza121 expressed the lowest number of spikes/ m^2 in the first season while, Giza 125 showed the lowest number of spikes/ m^2 in the second season and the combined data.

With regard to spike length presented in Table 5 the results showed that Giza 2000 followed by Giza 132 then Giza 125 recorded the highest values of spikes length in both seasons and their combined data. On the other hand, Giza 126 scored the lowest spike length in both seasons and the combined data.

With respect to number of grains/spike in Table 6 the results indicate that Giza 125 followed by Giza 127 among all tested cultivars recorded the highest values of number of grains/spike in both seasons and their combined data. On the other hand, Giza 132 scored the lowest number of grains/spike in both seasons and the combined data.

According to 1000-grain weight the presented data in Table 5 showed that Giza 124 followed by Giza 128 among all tested cultivars have the heaviest 1000-grain weight in both seasons and their combined data. On the other hand, Giza 133 scored the lowest 1000-grain weight in both seasons and the combined data.

For biological yield (kg/fed.) the Results in Table 6 indicated that Giza 126 followed by Giza 118 and then Giza 2000 respectively gave the highest biological yield/fed among all test cultivars in both seasons and their combined data. While, Giza 133 scored the lowest biological yield/fed in both seasons and the combined data compared with all other cultivars.

With respect to grain yield (kg/fed.) the results in Table 6 indicated that Giza 126 in first season and combined data, Giza 2000 in the second season and Giza 127 in both seasons and the combined data gave the highest grain yield/fed among all test cultivars. While, Giza 123 in the first season, Giza 125 in the second season and Giza 133 in the combined data scored the lowest grain yield/fed compared with all other cultivars.

According to harvest index the highest harvest indices were found in Giza 133 in both seasons and their combined data where, these values exceeded all other cultivars, while the lowest harvest indices were obtained from Giza 118 in the first season and the combined data and Giza 126 in the second season. These results could be due to the genetic variation performance between these cultivars which played the major role in this respect.

Table (6). Comparison between barley cultivars means for all studied traits in both growing seasons and their combined data.

Cultivars	Total chlorophyll content			Maturity date			Plant height		
	S_1	S_2	Comb.	S_1	S_2	Comb.	S_1	S_2	Comb.
Giza117	40.26	41.1	40.68	126.25	127.27	126.76	112.75	111.00	111.88
Giza 118	37.96	36.25	37.10	126.75	128.27	127.51	113.88	115.5	114.69
Giza 121	43.88	42.45	43.17	126.00	126.77	126.38	118.88	115.63	117.26
Giza 123	40.48	37.43	38.96	126.75	129.02	127.88	117.38	113.75	115.57
Giza 124	45.41	42.88	44.15	127.5	127.88	127.69	112.50	112.25	112.38
Giza 125	46.25	44.85	45.55	131.25	129.13	130.19	105.13	112.25	108.69
Giza 126	46.38	45.13	45.76	127.75	126.38	127.07	96.75	101.63	99.19
Giza 2000	46.38	44.60	45.49	125.50	126.88	126.19	95.50	104.88	100.19
Giza 132	44.23	43.85	44.04	124.75	125.13	124.94	102.00	101.50	101.75
Giza 133	45.56	44.85	45.20	125.00	127.27	126.13	96.38	92.13	94.26
Giza 127	46.96	47.47	47.21	127.75	127.25	127.50	101.38	105.5	103.44
Giza 128	43.81	43.47	43.64	125.75	128.38	127.07	105.00	113.25	109.13
F-Test	**	**	**	**	**	**	**	**	**
$LSD_{0.05}$	-	-	-	-	-	-	-	-	-
$LSD_{0.01}$	**3.82**	**1.95**	**2.13**	**2.11**	**0.95**	**1.15**	**6.42**	**5.64**	**4.24**

Table (6). Cont.

Cultivars	Number of spikes/m²			Spike length			Number of grains/spike		
	S_1	S_2	Comb.	S_1	S_2	Comb.	S_1	S_2	Comb.
Giza117	478.67	490.33	484.50	7.00	7.50	7.25	49.50	48.75	49.13
Giza 118	514.11	496.10	505.11	7.75	8.88	8.32	52.50	54.75	53.63
Giza 121	448.21	460.`18	448.21	7.75	8.38	8.07	54.00	56.25	55.13
Giza 123	522.09	498.16	510.13	7.25	8.88	8.07	49.50	58.50	54.00
Giza 124	460.33	467.07	463.70	7.25	10.00	8.63	48.00	63.00	55.50
Giza 125	470.08	420.14	445.11	8.33	9.77	9.05	57.00	63.75	60.38
Giza 126	564.00	492.33	528.17	5.58	7.63	6.61	52.50	51.75	52.13
Giza 2000	741.33	615.25	678.29	8.75	12.00	10.38	23.00	28.00	25.50
Giza 132	684.67	598.13	641.40	8.50	9.52	9.01	22.50	23.00	22.75
Giza 133	488.00	462.06	475.03	7.00	7.88	7.44	48.00	50.25	49.13
Giza 127	512.33	480.08	496.21	6.00	8.38	7.19	57.00	57.75	57.38
Giza 128	468.67	444.14	456.41	7.42	7.63	7.53	49.50	48.00	48.75
F-Test	**	**	**	**	**	**	**	**	**
$LSD_{0.05}$	-	-	-	-	-	-			
$LSD_{0.01}$	**65.61**	**22.11**	**34.35**	**0.86**	**1.13**	**0.70**	**5.72**	**6.59**	**4.33**

Table 6: Cont.

Cultivars	1000-grain weight (g)			Biological yield (ton/fed.)			Grain yield (ton/fed)			Harvest index		
	S_1	S_2	Comb.	S_1	S_2	Comb.	S_1	S_2	Comb.	S_1	S_2	Comb.
Giza117	55.63	55.80	55.72	1879.21	1914.03	1896.62	784.89	822.72	803.81	41.74	42.98	42.36
Giza 118	56.28	57.58	56.93	2063.57	1999.73	2031.65	791.89	869.40	830.65	39.46	43.47	41.47
Giza 121	53.90	54.67	54.29	1816.17	1842.92	1829.55	768.33	813.33	790.83	42.21	44.13	43.17
Giza 123	51.58	51.53	51.56	1697.67	1633.35	1665.51	719.33	805.83	762.58	42.79	49.28	46.04
Giza 124	62.45	63.65	63.05	1765.44	1858.57	1812.01	777.50	838.65	808.08	43.89	46.00	44.95
Giza 125	51.81	50.70	51.26	1832.33	1795.00	1813.67	775.17	797.92	786.55	42.28	47.83	45.06
Giza 126	58.03	58.60	58.32	2212.86	2134.10	2173.48	1018.21	891.43	954.82	46.11	41.25	43.68
Giza 2000	54.35	53.68	54.02	2018.67	2020.40	2019.54	890.00	970.00	930.00	44.48	48.03	46.26
Giza 132	55.40	55.22	55.31	1845.00	2054.38	1949.69	850.00	853.45	851.73	46.01	46.40	46.21
Giza 133	50.50	51.03	50.77	1467.15	1524.80	1495.98	684.60	813.75	749.18	47.14	53.05	50.10
Giza 127	51.65	52.53	52.09	2037.86	1900.35	1969.11	925.00	932.15	928.58	45.55	49.20	47.38
Giza 128	58.53	57.28	57.91	1836.67	1913.35	1875.01	829.50	862.08	845.79	45.13	44.87	45.00
F-Test	**	**	**	**	**	*	**	**	**	**	**	**
$LSD_{0.05}$	-	-	-	-	-	**126.20**	-	-	-	-	-	-
$LSD_{0.01}$	**4.07**	**2.12**	**2.28**	**269.32**	**203.20**	-	**111.50**	**54.68**	**61.60**	**3.58**	**7.07**	**3.93**

* and ** indicated not significant, significant at 0.05 and significant at 0.01 levels of probability, respectively.

B- Effect of the interaction between barley cultivars and irrigation treatments.

The presented data in Table 7 indicate that the interaction between irrigation treatments and barley cultivars had a highly significant and or significant in both seasons and their combined analysis for all studied traits, except for Total chlorophyll in first season and combined analysis, plant height and spike length in first season and harvest index in the combined analysis. The significant of the interaction may be an indicator about the wide difference between all cultivars in their responses to water stress condition.

1- Total Chlorophyll Content:

From the results shown in (Table 7) it could be clear that, Giza 127 seemed to be the most stable one among all tested cultivars where, it gave the highest values of Total chlorophyll under normal condition with averages of 46.67, 46.67 and 46.67 in both seasons and the combined data, respectively. These values insignificant increased under stress condition with averages of 47.25, 48.27 and 47.76 in both seasons and the combined data, respectively. On the other side the behavior of all others cultivars differed from environment to another and ranked differently from stress to normal irrigation. Also, the results in Table 7 showed that, Giza 2000 cultivars seemed to be the most sensitive one to water stress among all tested cultivars in this traits in both seasons and the combined data. Where, the Total chlorophyll contents of Giza 2000 genotype sharply increased from 44.30, 41.67 and 42.99 under normal condition to 48.45, 47.53 and 47.99 under stress condition 76 in both seasons and the combined data respectively. These results agreed with Rana *et al.*, 2006 reported that, the photosynthesis per unit leaf area was not initially reduced by stress, particularly in the more-tolerant cultivars, as the chlorophyll per unit area was higher in stress than non-stress conditions (the leaves were narrower, the cells were smaller, and so the chloroplast density was greater).

2- Days To Maturity:

Days to maturity affected by irrigation treatments and barley cultivars as well as their interactions at both growing seasons and the combined data are presented in Table 7.

From the presented data it could be detected that Giza 121 and Giza 132 were the earliest among all tested cultivars under normal irrigation in both season and the combined data, While, Giza 2000, Giza 132 and Giza 133 were the earliest among all tested cultivars under normal irrigation in both season and the combined data. On the other hand, Giza 125 was the most sensitive one among all tested cultivars in this trait to water stress condition where, their average number of days to maturity significantly decreased from 135.00, 130.00 and 132.75 under normal irrigation to 127.00, 127.77 and 127.64 under stress irrigation in both seasons and their combined data.

3- Plant Height:

From the presented data it could be detected that, Giza 118, Giza 121, Giza 123 and Giza 124 were the tallest among all tested cultivars under normal and stress irrigation in both season and the combined data. Our data indicated that all tested cultivars affected seriously under stress irrigation. Giza 123 was the most sensitive one among all tested cultivars in this trait to water stress condition where, their plant height reduced from 107.50, 95.50 and 101.50 under normal irrigation to 127.00, 127.77 and 127.64 under stress irrigation in both seasons and their combined data respectively. In both seasons, a tallest plant was achieved when plants were grown under the well-watered treatment compared with those plants grown under the stress treatments. The reduction in plant height with drought severity could be attributed to lower crop growth rate and the decrease in relative water content. These results are in harmony with those of Bagheri and Abad (2007), Samarah *el al.*, (2009) and Vaezi *el al.*, (2010).

4- Spikes Number/M^2:

From the obtained data in Table 7 it could be clear that Giza 2000 and Giza 132 had the highest number of spikes/m^2 among all tested cultivars under normal and stress irrigation in both season and the combined data. Our data indicated that all tested cultivars affected seriously under stress irrigation. Giza 118 was the most sensitive one among all tested cultivars in this trait to water stress condition where, their number of spikes/m^2 reduced from 624.00, 582.00 and 603.00 under normal irrigation to 404.00, 410.00 and 407.00 under stress irrigation in both seasons and their combined data respectively. The reduce of number of spikes/m^2 under water stress environment has been reported by many researchers before such as, Nowruzi *et al.*, (2017). They found that the yield components of number of spikes/m^2 can effectively contribute to selection of barley drought tolerant cultivars. Also, Abu-El-Lail *et al.*, (2016). Found that drought stress reduced grain yield (ardab/fad) by reducing the number of spikes/m2. These results agree with those obtained by Mollah and Paul (2011), Zare *el al.*, (2011) and Ali *el al.*, (2012).

5- Spike length:

Results collected on spikes number/m^2 and spike length as affected by irrigation treatments, the interaction between barley cultivars and irrigation treatments was insignificant in both growing season Table 7. From the obtained data in Table 6 it could be clear that Giza 125, Giza 2000 and Giza 132 had the highest spike length among all tested cultivars under normal irrigation in both season and the combined data, While, Giza 118, Giza 123, Giza 124 and Giza 2000 had the highest spike length among all tested cultivars under stress irrigation in both season and the combined data. Our data indicated that all tested cultivars affected seriously under stress irrigation. Giza 125 was the most sensitive one among all tested cultivars in this trait to water stress condition where, their spike length reduced from 9.50, 12.77 and 11.14 under normal irrigation to 7.17, 6.77 and 6.97 under stress irrigation in both seasons and their combined data respectively. Many researchers found similar result such as, Refay (2010), Mollah and Paul (2011), Zare *el al.*, (2011) and Ali *el al.*, (2012).

6- Number Of Grains/Spike:

With regard to number of grain/spike (Table 7) the result showed that Giza 125, and Giza 127 had the highest number of grains/spike among all tested cultivars under normal irrigation in both season and the combined data, While, Giza 121, Giza 123 and Giza 127 had the highest number of grains/spike among all tested cultivars under stress irrigation in both season and the combined data. Our data indicated that all tested cultivars affected seriously under stress irrigation. Giza 125 was the most sensitive one among all tested cultivars in this trait to water stress condition where, their number of grains/spike reduced from 66.00, 78.50 and 72.25 under normal irrigation to 48.00, 51.00 and 49.50 under stress irrigation in both seasons and their combined data respectively. Drought stress reduced grain yield (ardab/fad) by reducing the number of kernels (Abu-El-Lail *et al.*, 2016). This result was in harmony with those by Refay (2010), Mollah and Paul (2011), Zare *el al.*, (2011) and Ali *el al.*, (2012).

According to Ceccarelli (1987), water deficit during the early stage of plant development induces a reduction in spikelets primordia, while water deficit late in the plant development increases death of the flower and the entire spikelet. The number of grains per spike (fertility) depends on water availability during the early vegetative phase and during shooting stage. If water deficit occurs after the flowering stage, it induces a decrease of grain weight and thus its yield.

7- 1000-Grain Weight (G):

With respect to 1000-grain weight, highly significant effect was obtained in both seasons and the combined data. Highly significant interactions between barley cultivars and irrigation treatments were observed in both seasons and their combined data as shown in Table 7. The result showed that Giza 124, Giza 126 and Giza 128 had the highest 1000-grain weight among all tested cultivars under normal and stress irrigation in both season and the combined data. Our data indicated that all tested cultivars affected seriously under stress irrigation. Giza 133 was the most sensitive one among all tested cultivars in this trait to water stress condition where, their 1000-grain weight reduced from 53.70, 55.10 and 54.40 under normal irrigation to 47.30, 46.97 and 47.14 under stress irrigation in both seasons and their combined data respectively. In the contrast of Giza 133 all tested cultivars showed an increase in 1000-grain weight under stress irrigation compared with normal irrigation in both seasons and the combined data. The yield components of thousand grain weight can effectively contribute to selection of barley drought tolerant cultivars. Nowruzi *et al.*, (2017). Abu-El-Lail *et al.*, (2016). Found that drought stress reduced grain yield (ardab/fad) by reducing the number of spikes/m^2, the number of kernels/spike and 1000-kernel weight. Our results are in agreement with those obtained by Menshawy *et al.*, (2006), Samarah *el al.*, (2009) and Refay (2010).

8- Biological yield:

For biological yield the presented data in Table 7 the Results indicated that highly significant different among irrigation treatments in both seasons, where the irrigated treatment out yielded the stressed treatment. the result showed that Giza 118, Giza 126 and Giza 2000 had the highest biological yield among all tested cultivars under normal irrigation in both season and the combined data, While, Giza 126 and Giza 132 had the highest biological yield among all tested cultivars under stress irrigation in both season and the combined data. Our data indicated that all tested cultivars affected seriously under stress irrigation. Giza 126 was the most sensitive one among all tested cultivars in this trait to water stress condition where, their biological yield reduced from 2660.00, 2410.70 and 2535.35 under normal irrigation to 1765.71, 1857.50 and 1811.61 under stress irrigation in both seasons and their combined data respectively. The superiority of Giza 126 in this study has been reported before by Noaman *et al.*, (1997). Who, showed that the new drought tolerant cultivar Giza 126 proved to be superior for grain yield, biological yield and straw yield compared to the other cultivars, and exhibited wide adaptability across different environments under rainfed conditions. The biological and grain yields were decreased under drought stress. The yield component of biological yield can effectively contribute to selection of barley drought tolerant cultivars (Nowruzi *et al.*, 2017). Akash *et al.*, (2009). Found that the reduction in biological yield caused by drought stress ranged from 19% to 45% in all studied cultivar. These results are confirmed by. Bagheri and Abad (2007), Khayatnezhad *el al.*, (2010), Refay (2010), Mollah and Paul (2011), Zare *el al.*, (2011), Alkordi (2017) and El-Seidy *et al.*, (2017).

9- Grain Yield:

The result shown in Table 7 indicate that Giza 126, Giza 2000 and Giza 127 had the highest grain yield among all tested cultivars under normal irrigation in both season and the combined data, While, Giza 2000, Giza 132 and Giza 127 had the highest grain yield among all tested cultivars under stress irrigation in both season and the combined data. Our data indicated that all tested cultivars affected seriously under stress irrigation. Giza 126 was the most sensitive one among all tested cultivars in this trait to water stress condition where, their grain yield reduced from 1225.00, 1092.87 and 1158.94 under normal irrigation to 811.43, 690.00 and 750.72 under stress irrigation in both seasons and their combined data respectively. The grain yield/plant under stress environments is dependent up on stress susceptibility yield potential, and stress escape. The susceptibility of a plant genotype to stress in the product of many physiological and morphological traits for which effective selection criteria have not yet been developed (Fisher and Maurer, 1978). Therefore, grain/plant and attributes remain as major selection criteria for improved adaptation to stress environments in many breeding programs. As a result of water stress condition, the average of grain yield for these cultivars decreased. Several investigators reported that, drought stress reduced photosynthesis and translocation rates and increased respiration, which reduced available assimilates for grain filling and finally decreased grain yield (El-Naggar, 2010).

10- Harvest Index:

The irrigation treatment × cultivars interaction effect was highly significant in both seasons, but it was insignificant in the combined data. The result shown in Table 7 indicate that Giza 133 and Giza 127 had the highest harvest indices among all tested cultivars under normal and stress irrigation in both season and the combined data. Our data indicated that harvest indices of all tested cultivars increase under stress irrigation compared to normal irrigation in both season and the combined data.

CONCLUSION:

This study showed that, the best cultivars of barley for yield parameters and some of its components under drought conditions were Giza 118, Giza 126, Giza 2000, Giza 132 and Giza 127 in both seasons and the combined data.

Table 7: Effect of the interaction between barley cultivars and irrigation treatment on all studied characters in both growing seasons and their combined data.

Cultivars	Total chlorophyll content			Maturity date			Plant height		
	S_1	S_2	Comb.	S_1	S_2	Comb.	S_1	S_2	Comb.
				Normal irrigation conditions					
Giza117	39.47	40.70	40.09	127.00	128.77	127.89	118.50	128.50	123.50
Giza 118	36.07	34.10	35.09	127.00	130.27	128.64	119.27	133.00	126.14
Giza 121	42.27	39.10	40.69	125.50	128.27	126.89	127.27	129.50	128.39
Giza 123	39.47	36.33	37.90	127.00	130.77	128.89	127.27	132.00	129.64
Giza 124	44.17	41.80	42.99	128.00	129.27	128.64	122.00	120.00	121.00
Giza 125	45.40	43.50	44.45	135.00	130.50	132.75	112.77	121.00	116.89
Giza 126	44.77	42.30	43.54	129.00	127.50	128.25	103.50	108.50	106.00
Giza 2000	44.30	41.67	42.99	127.00	130.27	128.64	103.00	116.00	109.50
Giza 132	43.47	42.43	42.95	126.00	126.50	126.25	110.00	116.00	113.00
Giza 133	43.97	43.10	43.54	125.50	129.27	127.39	104.27	105.00	104.64
Giza 127	46.67	46.67	46.67	129.50	129.00	129.25	110.27	114.00	112.14
Giza 128	43.07	43.50	43.29	125.00	129.00	127.00	113.00	123.00	118.00
				Water stress conditions					
Giza117	41.05	41.50	41.28	125.50	125.77	125.64	107.00	93.50	100.25
Giza 118	39.85	38.40	39.13	126.50	126.27	126.39	108.50	98.00	103.25
Giza 121	45.50	45.80	45.65	126.50	125.27	125.89	110.50	101.77	106.14
Giza 123	41.50	38.53	40.02	126.50	127.27	126.89	107.50	95.50	101.50
Giza 124	46.65	43.97	45.31	127.00	126.50	126.75	103.00	104.50	103.75
Giza 125	47.10	46.20	46.65	127.50	127.77	127.64	97.50	103.50	100.50
Giza 126	48.00	47.97	47.99	126.50	125.27	125.89	90.00	94.77	92.39
Giza 2000	48.45	47.53	47.99	124.00	123.50	123.75	88.00	93.77	90.89
Giza 132	45.00	45.27	45.14	123.50	123.77	123.64	94.00	87.00	90.50
Giza 133	47.15	46.60	46.88	124.50	125.27	124.89	88.50	79.28	83.89
Giza 127	47.25	48.27	47.76	126.00	125.50	125.75	92.50	97.00	94.75
Giza 128	44.55	43.43	43.99	126.50	127.77	127.14	97.00	103.50	100.25
F-Test	Ns	**	NS	**	**	**	NS	**	**
$LSD_{0.05}$	-	-	-	-	-	-	-	-	-
$LSD_{0.01}$	-	2.76	-	2.99	1.34	1.62	-	7.98	6.00

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

Table 7: Cont.

Cultivars	Number of spikes/m²			Spike length			Number of grains/spike		
	S_1	S_2	Comb.	S_1	S_2	Comb.	S_1	S_2	Comb.
				Normal irrigation conditions					
Giza117	557.33	564.00	560.67	8.00	9.00	8.50	54.00	54.00	54.00
Giza 118	624.00	582.00	603.00	8.50	10.27	9.39	57.00	61.50	59.25
Giza 121	560.00	584.00	572.00	9.00	10.50	9.75	57.00	63.00	60.00
Giza 123	636.00	560.00	598.00	7.50	10.77	9.14	48.00	64.50	56.25
Giza 124	512.00	514.00	513.00	7.50	13.00	10.25	48.00	78.00	63.00
Giza 125	596.00	484.00	540.00	9.50	12.77	11.14	66.00	78.50	72.25
Giza 126	664.00	504.00	584.00	6.00	10.50	8.25	60.00	63.00	61.50
Giza 2000	874.67	638.00	756.34	9.50	16.00	12.75	22.00	32.00	27.00
Giza 132	764.00	640.00	702.00	9.50	11.27	10.39	22.00	22.50	22.25
Giza 133	584.00	508.00	546.00	8.00	10.27	9.14	54.00	61.50	57.75
Giza 127	608.00	540.00	574.00	6.50	11.00	8.75	63.00	66.00	64.50
Giza 128	561.33	512.00	536.67	8.50	9.77	9.14	60.00	58.50	59.25
				Water stress conditions					
Giza117	400.00	416.00	408.00	6.00	6.00	6.00	45.00	43.50	44.25
Giza 118	404.00	410.00	407.00	7.00	7.50	7.25	48.00	48.00	48.00

Giza 121	336.00	336.00	336.00	6.50	6.27	6.39	51.00	49.50	50.25
Giza 123	408.00	436.00	422.00	7.00	7.00	7.00	51.00	52.50	51.75
Giza 124	408.00	420.00	414.00	7.00	7.00	7.00	48.00	48.00	48.00
Giza 125	344.00	356.00	350.00	7.17	6.77	6.97	48.00	51.00	49.50
Giza 126	464.00	480.00	472.00	5.17	4.77	4.97	45.00	40.50	42.75
Giza 2000	608.00	592.00	600.00	8.00	8.00	8.00	24.00	24.00	24.00
Giza 132	605.33	556.00	580.67	7.50	7.77	7.64	23.00	23.50	23.25
Giza 133	392.00	416.00	404.00	6.00	5.50	5.75	42.00	39.00	40.50
Giza 127	416.00	420.00	418.00	5.50	5.77	5.64	51.00	49.50	50.25
Giza 128	376.00	376.00	376.00	6.33	5.50	5.92	39.00	37.50	38.25
F-Test	*	**	**	NS	**	**	**	**	**
$LSD_{0.05}$	0.92	-	-	-	-	-	-	-	-
$LSD_{0.01}$	-	1.59	0.99	-	31.27	48.58	**8.09**	**9.32**	**6.12**

Table 7: cont.

Cultivars	1000-grain weight (g)			Biological yield (kg/fed.)			Grain yield (kg/fed)			Harvest index		
	S_1	S_2	Comb.	S_1	S_2	Comb.	S_1	S_2	Comb.	S_1	S_2	Comb.
Normal irrigation conditions												
Giza117	54.80	56.10	55.45	2265.00	1918.90	2091.95	950.00	787.10	868.55	41.93	41.00	41.47
Giza 118	56.37	57.80	57.09	2600.00	2091.97	2345.99	925.00	913.80	919.40	35.93	43.67	39.80
Giza 121	52.70	53.07	52.89	2235.00	1793.33	2014.17	950.00	766.67	858.34	42.50	42.77	42.64
Giza 123	55.00	52.57	53.79	2190.00	1606.70	1898.35	900.00	736.67	818.34	41.10	45.83	43.47
Giza 124	59.40	62.10	60.75	1886.67	2152.13	2019.40	883.33	874.80	879.07	46.90	40.63	43.77
Giza 125	51.17	49.60	50.39	1923.67	2093.33	2008.50	885.00	793.33	839.17	46.17	38.13	42.15
Giza 126	56.60	57.87	57.24	2660.00	2410.70	2535.35	1225.00	1092.87	1158.94	46.10	45.37	45.74
Giza 2000	52.70	51.87	52.29	2200.00	2353.30	2276.65	900.00	1130.00	1015.00	41.00	48.07	44.54
Giza 132	56.60	55.97	56.29	2090.00	2043.77	2066.89	975.00	921.90	948.45	46.70	45.10	45.90
Giza 133	53.70	55.10	54.40	1811.67	1374.60	1593.14	825.00	677.50	751.25	45.63	49.43	47.53
Giza 127	50.60	52.37	51.49	2350.00	2035.70	2192.85	1050.00	964.30	1007.15	44.60	47.43	46.02
Giza 128	59.40	58.57	58.99	1940.00	2236.70	2088.35	875.00	1036.67	955.84	45.13	46.30	45.72
Water stress conditions												
Giza117	56.45	55.50	55.98	1493.43	1909.17	1701.30	619.78	858.33	739.06	41.54	44.97	43.26
Giza 118	56.20	57.37	56.79	1527.14	1907.50	1717.32	658.79	825.00	741.90	42.99	43.27	43.13
Giza 121	55.10	56.27	55.69	1397.33	1892.50	1644.92	586.67	860.00	723.34	41.93	45.50	43.72
Giza 123	48.15	50.50	49.33	1205.33	1660.00	1432.67	538.67	875.00	706.84	44.47	52.73	48.60
Giza 124	65.50	65.20	65.35	1644.22	1565.00	1604.61	671.67	802.50	737.09	40.88	51.37	46.13
Giza 125	52.45	51.80	52.13	1741.33	1496.67	1619.00	665.33	802.50	733.92	38.39	57.53	47.96
Giza 126	59.45	59.33	59.39	1765.71	1857.50	1811.61	811.43	690.00	750.72	46.13	37.13	41.63
Giza 2000	56.00	55.50	55.75	1837.34	1687.50	1762.42	880.00	810.00	845.00	47.95	48.00	47.98
Giza 132	54.20	54.47	54.34	1600.00	2065.00	1832.50	725.00	985.00	855.00	45.32	47.70	46.51
Giza 133	47.30	46.97	47.14	1122.63	1675.00	1398.82	544.19	950.00	747.10	48.65	56.67	52.66
Giza 127	52.70	52.70	52.70	1725.71	1765.00	1745.36	800.00	900.00	850.00	46.50	50.97	48.74
Giza 128	57.65	56.00	56.83	1733.33	1590.00	1661.67	784.00	687.50	735.75	45.13	43.43	44.28
F-Test	**	**	**	**	**	**	**	**	**	**	**	**NS**
$LSD_{0.05}$	-	-	-	-	-	-	-	-	-	-	-	-
$LSD_{0.01}$	**5.76**	**3.00**	**3.22**	**380.87**	**287.37**	**236.68**	**157.68**	**77.33**	**87.12**	**5.06**	**10.00**	-

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

11- Drought Susceptibility Index (DSI) For Biological Yield and Grain Yield (Kg/Fed.):

11-1. Biological Yield:

For biological yield the presented data in Table 8 the result indicated that there were highly significant different among all genotypes in both seasons. the result showed that Giza 124, Giza 125, G2000 and Giza 128 had the most desirable DSI values biological yield among all tested cultivars the first season only and G 117, G 121 and G 123 showed desirable DSI values in the second season, While, Giza 132 and Giza 133 had excellent DSI values in the second season and combined data for biological yield among all tested cultivars. Our data indicated that all tested cultivars affected seriously with stress irrigation.

11-2. Grain Yield:

The result shown in Table 8 indicate that Giza 2000 and Giza 128 had the excellent DSI values for grain yield among all tested cultivars in the first season, While, Giza 117, Giza 121 and Giza 123 had excellent

DSI values for grain yield among all tested cultivars in the second season. Only the two genotypes G 132 and G 133 showed desirable DSI values in the second season and combined data. Our data indicated that all tested cultivars affected seriously under stress irrigation. Giza 132 and G133 were the most tolerance Genotypes among all tested cultivars in this trait to water stress condition.

Table 8: Drought susceptibility index (DSI) for biological yield and grain yield (kg/fed.) for all tested genotypes in both seasons and their combined data.

	Biological yield (kg/fed.)			Grain yield (kg/fed)		
	S_1	S_2	Comb.	S_1	S_2	Comb.
Giza117	1.21	0.04	0.90	1.29	-1.49	0.89
Giza 118	1.47	0.70	1.30	1.07	1.60	1.15
Giza 121	1.33	-0.44	0.89	1.42	-2.00	0.93
Giza 123	1.60	-0.26	1.19	1.49	-3.09	0.81
Giza 124	0.46	2.16	0.99	0.89	1.36	0.96
Giza 125	0.34	2.26	0.94	0.92	-0.19	0.75
Giza 126	1.19	1.82	1.38	1.25	6.07	2.09
Giza2000	0.59	2.24	1.09	0.08	4.66	1.00
Giza 132	0.83	-0.08	0.55	0.95	-1.13	0.59
Giza 133	1.35	-1.73	0.59	1.26	-6.62	0.03
Giza 127	0.94	1.05	0.99	0.88	1.10	0.93
Giza 128	0.38	2.29	0.99	0.39	5.54	1.37
F Test	**	**	**	**	**	**
LSD 5%	**0.38**	**0.65**	**0.28**	**0.36**	**1.08**	**0.39**
LSD 1%	**0.54**	**0.94**	**0.40**	**0.52**	**1.56**	**0.56**

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