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Evaluation of Twenty Barley Genotypes For Drought Tolerance Under Sandy Clay Soil

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THIS RESEARCH was conducted in order to identify the best barley genotypes that can be grown under drought stress conditions. This experiment was conducted in a randomized complete block design with three replications at the Agriculture Experimental Research Farm of the Faculty of Agriculture, Sohag University, during the 2006 to 2008 seasons. Twenty barley genotypes (covered, 2–rowed) and the two check cultivars Giza 127 and Giza 128 were evaluated for drought tolerance by measuring yield performance under three levels of irrigation (normal, moderately reduced and severely reduced). Drought stress reduced grain yield (ardab/fad) by reducing the number of spikes/m^2, the number of kernels/spike and 1000-kernel weight. This study showed that, the best genotypes of barley for all parameters studied under severe drought conditions were No. 17, No. 7 and No.13. The drought susceptibility index (DSI) of grain yield (ardab/fad) showed that nine genotypes had a (DSI) <1 and were relatively tolerant to drought stress. The results revealed that the reduction in grain yield for the highest genotype, (No. 17) and the lowest one, (No.9) due to drought increase was 22.66 and 26.28%, respectively, with a general mean of (28.82+1.35).

Keywords: Barley, *Hordeum vulgare*, Drought, Grain yield, Drought susceptibility.

Barley (*Hordeum vulgare* L.) is a major source of food today for a large number of people living in the semi arid areas of the world. In addition, this crop is cultivated in Egypt mainly under drought conditions which are not suitable for wheat growth. The total production of barley in Egypt in 2012/2013 season was 1085984 ardab (ardab =120 kg) from 78679 faddan (faddan = 4200 m^2) with an average grain yield of 13.80 (ard. /fad) (Bulletin of Agriculture Statistics, 2014). Drought stress is a major abiotic factor that limits agricultural production (Golbashy, 2010), more importantly in the rain-fed areas of the world**.** Drought stress affects 40 to 60% of the world’s agricultural lands (Shahryari & Mollasadeghi, 2011). Drought is the most significant constraint for crop production in the world; therefore, employing high-yielding cultivars tolerant to

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drought is an effective approach to reduce its detrimental effects (Dorostkar *et al.*, 2016). Under rain-fed conditions in Mahout, Egypt, drought stress in barley causes significant reduction in no. grains/spikes, 100-kernel weight and grain yield/plant, suggesting that 100- kernel weight is less sensitive to drought stress as compared to the other yield components (El-Shouny *et al.*, 2015). Breeding for drought resistance is complicated by the lack of fast, reproducible screening techniques and the inability to routinely create defined and repeatable water stress conditions when a large amount of genotypes are to be evaluated efficiently (Ramirez & Kelly, 1998). The objective of this study was to evaluate some barley genotypes for their tolerance to drought stress and for grain yield and its components, using defined, reproducible irrigation regimes.

Materials and Methods

Field experiments were carried out at the Agriculture Experimental Research Farm of the Faculty of Agriculture, Sohag University, during 2006-2007 and 2007-2008 seasons. Twenty doubled haploid lines of a backcross population between a wild barley accession from the Middle East (ISR 42-S) and a German barley cultivar (Scarlett) were tested (Univ. Bonn, Dept. of Crops Science and Plant Breeding) . Scarlett is a high yielding cultivar which has high quality malting characteristics; however, ISR 42-8 is a wild barley accession from the Middle East. The experiments were laid out in a Randomized Complete Block Design with three replicates. Each plot was represented by six 3m rows, 20 cm apart with 10 cm interarow spacing. Total area was 3.5 m^2. The agriculture practices recommended for barley production were applied through the growing season under sandy clay soil (Table 1).

TABLE 1. The mechanical and chemical properties of soil.

Soil property	2006/ 2007	2007/ 2008
Sand (%)	51.40	49.70
Silt (%)	18.70	19.40
Clay (%)	29.90	30.90
Soil texture	Sandy clay	
Organic matter (%)	2.86	2.91
Total N (%)	0.160	0.185
EC(ds/m) (1:1)	0.63	0.64
PH(1:1)	7.92	7.25

*According to Association of Official Analytical Chemists (A.O.A.C.) 1995.

In this experiment, the twenty genotypes of covered, 2–rowed barley and two check cultivars, namely, Giza 127and Giza 128 were grown in field under three different irrigation regimes (Table 2) as :

1. Normal irrigation (I_1): Every 10 days.
2. Moderate drought stress (I_2): Two times irrigation and the next irrigation were withheld starting from the third one.
3. Severe drought stress (I_3): One time irrigation and the next two times irrigation was withhold starting from the third one.

TABLE 2. Irrigation regimes followed in the evaluation experiments.

Time	20 Days	30 days	40 days	50 days	60 Days	70 days	80 days	90 days	100 days	110 days	120 days	130 days
I_1	*	*	*	*	*	*	*	*	*	*	*	*
I_2	*	*	–	*	*	–	*	*	–	*	*	–
I_3	*	–	–	*	–	–	*	–	–	*	–	–

*= Irrigation − = Skipping irrigation.

The studied characters in the evaluation experiment included days to heading, flag leaf area (cm^2), plant height (cm), spike length (cm), number of spikes /m^2, number of kernels/spike, 1000-kernel weight (g) and grain yield (ardab/fad).

Statistical analysis

The separate as well as combined analysis of variance for different characters was done on a plot mean basis after testing for homogeneity of errors variance according to Gomez & Gomez (1984). Revised Least Significant Difference (L.S.D.) at a significance level of 5% was used to compare means according to Waller & Duncan (1960). MSTAT_C (1991) computer software program was used to analysis of variance and Mean comparison of traits.

Drought susceptibility index (DSI)

Drought susceptibility index (DSI) was calculated for each genotype according to the method of Fischer & Maurer (1978) as follows:

SI= $$\left(1-\left(\frac{Yd}{Yw}\right)\right) / D$$

where;

(Yd) = mean yield for genotype in stress environment.

(Yw) =mean yield for genotype in normal environment.

D =environmental stress intensity which was calculated as:

= mean of all genotypes in stress.

= mean of all genotypes in normal environments.

Genotypes with "SI" value of 1.0 or more than one are susceptible to drought, while those with values less than 1.0 are less susceptible and tolerant to drought.

Results and Discussion

Combined analysis of variance over the two years (Table 3) revealed that all studied traits were highly significantly affected by irrigation regimes and genotypes. Furthermore, the mean squares due to genotype x years, genotypes x irrigation regimes, years x irrigation regimes and genotypes x irrigation regimes x year's interaction were significant. These results indicated that barley genotypes behaved differently when they were exposed to different stresses, suggesting that it is essential to test genotypes under different environments in breeding program to identify the best genotypes suitable for particular environment. These results were also in line with those obtained by Atia *et al*. (1996), El-Seidy (1997), Kheiralla *et al*. (1997) and El-Koliey & El-Hamid (2000).

Morphological characteristics

Days to heading

Under the third regime (severe drought) , the average number of days to heading for the earliest genotype No. **7** was 65.00 days which was significantly less than the latest genotype, No. 8, by 13.00 days (Table 4). The percent of decrease in days to heading under severe drought for the earliest genotype, No. 7 and the latest one, No.8, (compared with normal irrigation) as 19.75 and 13.00, respectively, with a general mean of 16.51±0.62. The drought susceptibility index (DSI) of days to heading indicated that eleven genotypes had DSI <1 and were relatively tolerant to drought stress. The results indicated that days to heading were reduced by increasing drought stress. The differences in days to heading may be due to the increase in adaptation to drier environment in many crops which has been linked to earlier flowering (Turner, 1979). Earliness probably is the most efficient drought escape mechanism, especially when the crop is grown in a stored environment (Ceccarelli , 1986). These results were in accordance with those of El- Seidy (1997), Kheiralla *et al*. (1997) and El-Madidi *et al*. (2005).

Flag leaf area (cm^2)

The average of flag leaf area for the highest genotype, No. 17 was 5.05 cm^2 which was significantly higher than the lowest one, No. 3, by 3.59 cm^2, under severe drought (Table 4). The percent decrease under severe drought of flag leaf area for the highest genotype, No. 17 and the lowest one, No.3 due to drought increase were 61.89 and 84.23%, respectively, with a general mean of (71.52±1.35).

Drought susceptibility index of flag leaf area showed that six genotypes had a DSI <1 and were relatively tolerant to drought stress. It is of interest to note that most genotypes which have DSI less than one gave the least decrease in flag leaf area. Turner (1986) reported that drought avoidance involved rapid morphological development, leaf rolling, leaf shading, reducing leaf area, and increased stomata and cuticular resistance. These results are in agreement with those obtained by Lowlor *et al*. (1981), Andersen *et al. (*1992) and Essa (2003).

TABLE 3. Combined analysis of variance over three irrigation regimes, two seasons and genotypes for the studied traits.

S.O.V	d.f	Mean squares (M.S.)							
		Days to Heading	Flag leaf Area	Plant Height	Spike Length	No. spikes/ M^2	No. of kernels/ spike	1000 kernel weight	Grain yield/ (ardab/fad)
Year (Y)	1	53.82**	0.745	2332.12**	0.109	13127.27**	44.66**	1219.76**	5.51**
Rep/Y	4	2.05	1.97	4.72	1.37	26.72	0.77	3.81	0.498
Irrigation (I)	2	6925.32**	2275.16**	38481.21**	300.36**	850529.93**	2944.79**	2424.36**	298.52**
Y*I	2	13.57**	2.51**	327.09**	9.71**	2323.05**	21.68**	94.83**	2.21**
Genotypes (G)	21	134.77**	13.09**	1303.96**	18.49**	22316.76**	74.60**	86.49**	11.21**
G*Y	21	12.01**	2.42**	196.73**	1.48**	4462.92**	24.30**	9.77**	1.34**
G*I	42	17.47**	3.71**	52.99**	0.47**	2587.94**	3.23**	9.27**	1.42**
G*Y*I	42	6.98**	4.45**	87.06**	0.53**	1945.89**	3.61**	5.31**	1.19**
Error	260	2.941	0.464	5.18	0.707	56.83	2.151	3.71	0.509

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

TABLE 4. Mean performance; percent decrease and drought susceptibility index (DSI) of days to heading and flag leaf area of barley genotypes as affected by irrigation regimes combined over two seasons.

Genotypes	Days to heading							Flag leaf area						
	Combined means Irrigation regimes			Mean	Percent decrease		DSI	Combined means Irrigation regimes			Mean	Percent decrease		DSI
	I_1	I_2	I_3		I_1- I_2 / I_1%	I_1- I_3/ I_1%		I_1	I_2	I_3		I_1- I_2 / I_1%	I_1- I_3/ I_1%	
1	86.16	79.50	68.66	**78.11**	7.73	20.31	1.23	9.80	4.68	2.81	**5.76**	52.24	71.33	1.00
2	88.16	82.00	74.50	**81.55**	6.99	15.49	0.94	10.31	5.01	2.90	**6.07**	51.41	71.87	1.00
3	90.83	86.66	77.83	**85.11**	4.59	14.31	0.87	9.26	5.45	1.46	**5.39**	41.14	84.23	1.18
4	89.83	86.00	77.50	**84.44**	4.26	13.73	0.83	10.80	6.63	2.78	**6.73**	38.61	74.26	1.04
5	82.33	79.66	67.66	**76.55**	3.24	17.82	1.08	11.96	6.52	3.21	**7.23**	45.48	73.16	1.02
6	86.50	80.50	73.00	**80.00**	6.94	15.61	0.95	11.91	5.41	3.76	**7.03**	54.58	68.43	0.96
7	81.00	78.50	65.00	**74.83**	3.09	19.75	1.20	10.21	7.11	4.91	**7.41**	30.36	51.91	0.73
8	89.66	83.83	78.00	**83.83**	6.50	13.00	0.79	11.50	6.69	3.40	**7.19**	41.83	70.43	0.98
9	88.16	81.33	74.00	**81.16**	7.75	16.06	0.97	12.40	5.61	2.80	**6.93**	54.76	77.42	1.08
10	84.16	80.66	68.66	**77.83**	4.16	18.42	1.12	11.17	6.20	3.06	**6.81**	44.49	72.61	1.02
11	88.50	82.33	74.50	**81.77**	6.97	15.82	0.96	10.56	7.46	2.68	**6.90**	29.36	74.62	1.04
12	90.00	82.83	77.33	**83.38**	7.97	14.08	0.85	10.98	5.68	2.51	**6.39**	48.27	77.14	1.08
13	81.00	76.50	73.00	**76.83**	5.56	9.88	0.60	10.85	6.15	3.12	**6.71**	43.32	71.24	1.00
14	88.83	84.00	69.66	**80.83**	5.44	21.58	1.31	14.06	8.03	4.63	**8.91**	42.89	67.07	0.94
15	88.00	83.33	74.00	**81.77**	5.31	15.91	0.96	13.06	6.81	4.56	**8.15**	47.86	65.08	0.91
16	89.33	81.50	72.00	**80.94**	8.77	19.40	1.17	11.55	5.91	2.69	**6.72**	48.83	76.71	1.07
17	85.33	81.33	69.50	**78.72**	4.69	18.55	1.12	13.25	6.40	5.05	**8.23**	51.70	61.89	0.87
18	83.50	79.16	73.16	**78.61**	5.20	12.38	0.75	9.43	5.13	2.38	**5.65**	45.60	74.76	1.05
19	85.66	78.83	69.16	**77.88**	7.97	19.26	1.17	14.10	5.60	3.68	**7.79**	60.28	73.90	1.03
20	90.50	83.00	75.50	**83.00**	8.29	16.57	1.00	12.66	6.41	3.54	**7.54**	49.37	72.04	1.01
G.127	88.66	81.66	74.00	**81.44**	7.90	16.54	1.00	11.43	7.58	3.13	**7.38**	33.68	72.62	1.02
G.128	88.33	78.00	71.66	**79.33**	11.69	18.87	1.14	11.25	7.26	2.96	**7.16**	35.47	73.69	1.03
Mean	**87.02**	**81.41**	**72.65**	**80.36**	**6.45±0.44**	**16.51±0.62**	**1.00±0.04**	**11.48**	**6.26**	**3.27**	**7.00**	**45.47±1.72**	**71.52±1.35**	**1.00±0.02**

Rev. L.S.D 5% Level			Rev. L.S.D 5% Level		
Irrigation regime	=	0.21	Irrigation regime	=	0.099
Genotype	=	0.84	Genotype	=	0.31
Interaction	=	1.54	Interaction	=	0.56

Plant height (cm)

The tallest genotype under severe drought, No. 1, was 84.00 cm tall, which was significantly higher than the shortest genotype, No. 11, by 26.17 cm. (Table 5). The percent decrease of plant height under severe drought for the tallest genotype, No. 1 and the shortest one, No.11 due to drought increase were 32.26 and 34.28 %, respectively, with a general mean of 2.70+0.59. Regarding DSI, nine genotypes had a DSI <1 and were relatively tolerant to drought stress. Plant height is reduced by water stress (Singh *et al.*, 1986). A severe reduction in plant height is a common type of plant response to water stress in barley as reported by Ceccarelli (1986). These results are in line with those obtained by El-Seidy (1997), Gaspar *et al*. (1998) and El-Madidi *et al*. (2005).

Spike length (cm)

The longest genotype in spike length, No. 7 was 9.00 cm which was significantly higher than the shortest genotype, No. 4, by 3.05 cm under severe drought (Table 5). The percent decrease of spike length for the longest genotype, No. **7** and the shortest one, No.4, due to drought increase were 31.90 and 32.40 %, respectively under severe drought, with a general average of 29.00±0.80. Drought susceptibility index (DSI) based on spike length indicated that seven genotypes had a DSI <1 and were relatively tolerant to drought stress. It is of interest to note that increasing stress reduced spike length. Skipping irrigation at any stage reduced spike length (Kheiralla *et al*., 2004). These results are in harmony with those reported by Kheiralla *et al*. (1989), Gaspar *et al*. (1998) and Hamam & Salman (2007).

Yield and yield components

Number of spikes / m^2

Under severe drought, the average number of spikes /m^2 for the highest genotype, No. 17 was 306.16 spikes which was significantly higher than the lowest genotype, No. 20, by 116.00 spikes (Table 6). The percent decrease in number of spikes/m^2, under severe drought, for the highest genotype, No. 17 and the lowest one, No.20 was 35.66 and 37.00 % respectively, with a general mean of 40.64±1.64, spikes/m^2. Results of (DSI) based on number of spikes /m^2 showed that nine genotypes had a DSI <1 and were relatively tolerant to drought stress. These results may be due to genetic variation. Generally, drought stress reduced number of spikes /m^2 by reducing number of tillers (Samarah, 2005). These results go in line with those reported by Tarred *et al.* (2002) and Hamam & Salman (2007).

TABLE 5. Mean performance; percent decrease and drought susceptibility index (DSI) of plant height and spike length of barley genotypes as affected by irrigation regimes combined over two seasons.

Genotypes	Plant height							Spike length						
	Combined means Irrigation regimes			Mean	Percent decrease		DSI	Combined means Irrigation regimes			Mean	Percent decrease		DSI
	I_1	I_2	I_3		I_1- I_2 / I_1%	I_1- I_3/ I_1%		I_1	I_2	I_3		I_1- I_2 / I_1%	I_1- I_3/ I_1%	
1	124.00	95.16	84.00	**101.05**	23.26	32.26	0.99	10.07	8.00	6.92	**8.33**	20.52	31.30	1.08
2	94.66	73.33	61.83	**76.61**	22.53	34.68	1.06	11.06	9.68	8.75	**9.83**	12.48	20.89	0.72
3	102.50	80.00	62.00	**81.50**	21.95	39.51	1.21	8.98	7.85	6.61	**7.81**	12.58	26.39	0.91
4	105.16	84.50	73.00	**87.55**	19.65	30.58	0.94	8.80	7.27	5.95	**7.34**	17.40	32.40	1.12
5	122.16	93.00	83.33	**99.50**	23.87	31.79	0.97	10.85	8.80	7.52	**9.05**	18.94	30.74	1.06
6	88.16	71.00	58.16	**72.44**	19.46	34.03	1.04	9.84	7.96	6.16	**7.98**	19.12	37.37	1.29
7	111.16	91.00	73.83	**92.00**	18.14	33.58	1.03	13.22	10.66	9.00	**10.96**	19.37	31.90	1.10
8	104.33	89.66	71.33	**88.44**	14.06	31.63	0.97	9.90	8.50	7.55	**8.65**	14.10	23.75	0.82
9	101.33	81.83	68.16	**83.77**	19.24	32.73	1.00	8.76	6.98	6.04	**7.26**	20.27	31.07	1.07
10	115.16	87.83	77.00	**93.33**	23.73	33.14	1.01	11.03	9.58	8.45	**9.69**	13.15	23.39	0.81
11	88.00	75.16	57.83	**73.66**	14.59	34.28	1.05	9.97	8.35	7.00	**8.44**	16.30	29.79	1.03
12	96.00	77.83	62.83	**78.88**	18.93	34.55	1.06	9.55	8.28	6.72	**8.18**	13.25	29.65	1.02
13	97.50	78.83	62.66	**79.66**	19.15	35.73	1.09	11.27	9.50	8.47	**9.74**	15.71	24.86	0.86
14	93.66	78.83	63.66	**78.72**	15.83	32.03	0.98	9.73	7.54	6.53	**7.93**	22.56	32.89	1.13
15	118.66	99.16	77.33	**98.38**	16.43	34.83	1.07	10.48	8.83	7.08	**8.80**	15.74	32.44	1.12
16	99.00	85.16	73.00	**85.72**	13.98	26.26	0.80	9.11	8.06	6.75	**7.97**	11.53	25.96	0.90
17	116.00	90.50	79.50	**95.33**	21.98	31.47	0.96	12.47	10.20	8.80	**10.49**	18.21	29.40	1.01
18	89.50	73.16	59.50	**74.05**	18.26	33.52	1.02	9.62	8.27	6.73	**8.20**	14.04	30.01	1.03
19	110.66	84.50	76.00	**90.38**	23.64	31.32	0.96	11.84	10.00	8.65	**10.16**	15.50	26.95	0.93
20	96.16	78.83	69.83	**81.61**	18.02	27.38	0.84	9.93	8.72	6.93	**8.53**	12.24	30.21	1.04
G.127	106.00	85.00	69.83	**86.94**	19.81	34.12	1.04	11.00	9.15	7.93	**9.36**	16.82	27.91	0.96
G.128	103.50	83.83	72.00	**86.44**	19.00	30.43	0.93	11.00	9.48	7.70	**9.39**	13.82	30.05	1.04
Mean	**103.78**	**83.55**	**69.84**	**85.73**	**19.49±0.66**	**32.70±0.59**	**1.00± 0.02**	**10.38**	**8.71**	**7.37**	**8.82**	**16.09±0.67**	**29.00±0.80**	**1.00±0.03**

Plant height — Rev. L.S.D 5% Level
Irrigation regime = 0.35
Genotype = 1.00
Interaction = 1.83

Spike length — Rev. L.S.D 5% Level
Irrigation regime = 0.173
Genotype = 0.251
Interaction = 0.574

TABLE 6. Mean performance; percent decrease and drought susceptibility index (DSI) of number of spikes /m² and number of kernels/ spike of barley genotypes as affected by irrigation regimes combined over two seasons.

Genotypes	Number of spikes /m²							Number of kernels/ spike						
	Combined means – Irrigation regimes			Mean	Percent decrease		DSI	Combined means – Irrigation regimes			Mean	Percent decrease		DSI
	I_1	I_2	I_3		I_1- I_2 / I_1%	I_1- I_3/ I_1%		I_1	I_2	I_3		I_1- I_2 / I_1%	I_1- I_3/ I_1%	
1	419.00	347.33	309.00	**358.44**	17.11	26.25	0.65	29.16	25.00	20.66	**24.94**	14.27	29.15	0.90
2	436.00	328.00	229.50	**331.16**	24.77	47.36	1.17	32.00	26.16	22.50	**26.88**	18.25	29.69	0.92
3	410.33	303.00	217.83	**310.38**	26.16	46.91	1.15	28.83	22.66	17.33	**22.94**	21.40	39.89	1.24
4	448.33	321.83	208.83	**326.33**	28.22	53.42	1.31	29.33	24.33	18.66	**24.11**	17.05	36.38	1.13
5	401.16	317.00	252.66	**323.61**	20.98	37.02	0.91	29.66	23.00	20.66	**24.44**	22.45	30.34	0.94
6	379.16	304.66	215.16	**299.66**	19.65	43.25	1.06	25.83	20.66	16.00	**20.83**	20.02	38.06	1.18
7	459.33	343.50	283.50	**362.11**	25.22	38.28	0.94	32.83	27.33	23.66	**27.94**	16.75	27.93	0.87
8	406.00	307.00	200.50	**304.50**	24.38	50.62	1.25	29.16	23.33	19.83	**24.11**	19.99	32.00	0.99
9	357.16	286.50	201.50	**281.72**	19.78	43.58	1.07	29.00	24.33	19.83	**24.38**	16.10	31.62	0.98
10	375.66	296.50	280.50	**317.55**	21.07	25.33	0.62	24.33	20.66	18.16	**21.05**	15.08	25.36	0.79
11	395.33	274.50	191.50	**287.11**	30.56	51.56	1.27	28.33	23.16	20.50	**24.00**	18.25	27.64	0.86
12	330.50	262.50	202.16	**265.05**	20.57	38.83	0.96	28.83	22.83	18.33	**23.33**	20.81	36.42	1.13
13	435.16	364.00	305.00	**368.05**	16.35	29.91	0.74	31.66	26.16	22.00	**26.61**	17.37	30.51	0.95
14	359.00	276.16	204.00	**279.72**	23.08	43.18	1.06	26.83	21.83	16.33	**21.66**	18.64	39.14	1.21
15	392.00	290.50	201.83	**294.77**	25.89	48.51	1.19	25.83	21.33	16.16	**21.11**	17.42	37.44	1.16
16	338.16	259.33	218.33	**271.94**	23.31	35.44	0.87	29.83	22.50	20.16	**24.16**	24.57	32.42	1.01
17	475.83	331.66	306.16	**371.22**	30.30	35.66	0.88	30.66	25.00	22.16	**25.94**	18.46	27.72	0.86
18	374.16	282.50	211.50	**289.38**	24.50	43.47	1.07	28.66	23.00	18.33	**23.33**	19.75	36.04	1.12
19	392.83	309.83	222.33	**308.33**	21.13	43.40	1.07	32.16	27.33	22.66	**27.38**	15.02	29.54	0.92
20	301.83	231.00	190.16	**241.00**	23.47	37.00	0.91	29.33	23.00	19.66	**24.00**	21.58	32.97	1.02
G.127	366.16	272.50	231.50	**290.05**	25.58	36.78	0.91	32.16	26.16	21.50	**26.61**	18.66	33.15	1.03
G.128	413.16	361.00	261.33	**345.16**	12.62	36.75	0.90	28.16	23.33	20.50	**24.00**	17.15	27.20	0.84
Mean	**393.92**	**303.22**	**233.85**	**310.33**	**23.02±0.93**	**40.64 ±1.64**	**1.00 ±0.04**	**29.21**	**23.78**	**19.80**	**24.26**	**18.59± 0.55**	**32.21 ±0.91**	**1.00 ±0.03**

Rev. L.S.D 5% Level			Rev. L.S.D 5% Level		
Irrigation regime	=	1.18	Irrigation regime	=	0.27
Genotype	=	3.30	Genotype	=	0.52
Interaction	=	5.72	Interaction	=	1.05

Number of kernels/spike

The highest average number of kernels/spike was 23.66 grains/spike for genotype, No. 7 which was significantly higher than the lowest genotype, No. 6, by 7.66 grains under severe drought stresses (Table 6). The percent decrease in number of kernels/spike for the highest genotype, No. **7** and the lowest one, No**.** 6 due to drought increase was 27.93 and 38.06%, respectively, with a general mean decrease of 32.21+0.91, kernels /spike. Eleven genotypes had a DSI based on number of kernels/spike < 1 and were relatively tolerant to drought stress. The reduction in number of kernels/spike by increasing drought stress may be due to the lack of water at tillering and or at flowering stage. Kheiralla *et al*. (1989) found that number of spikelets /spike decreased by skipping irrigation at any stage before flowering. These results are in line with those obtained by Andersen *et al.* *(*1992), El-Seidy (1997) and Hamam & Salman (2007).

1000 - kernel weight (g)

The average of 1000 - kernel weight for the highest genotype, No. 17 was 43.23 g which was significantly higher than the lowest genotype, No. 15, by 7.63 g, under severe drought stress (Table 7). The percent decrease of 1000 - kernel weight under severe drought for the highest genotype, No. 17 and the lowest one, No.15 due to drought increase were 16.91 and 22.51%, respectively, with a general mean of 17.70+0.84, g. Regarding the drought susceptibility index of 1000 kernel weight indicated that eleven genotypes had a DSI <1 and were relatively tolerant to drought stress. The application of severe drought decreased grain weight and this may be due to water stress which reduced 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 & Domingo, 1962). These results were in accordance with those of Assey *et al*. (1990) and Samarah (2005).

Grain yield (ardab/fad)

Under severe drought, the average of grain yield (ardab/fad) for the highest genotype, No. 17 was 8.67 ardab/fad, which was significantly higher than the lowest genotype, No. 9, by about 2.64 ardab/fad (Table 7). The percent decrease of grain yield for the highest genotype, No. 17 and the lowest one, No. 9 due to drought increase was 22.66 and 26.28%, respectively, with a general mean decrease of 28.82+1.35. Drought susceptibility index of grain yield ardab/fad indicated that the genotypes No. 10, 5 and 4 were the most tolerant of drought, which had DSI values of 0.69, 0.74 and 0.75, respectively. The results showed that nine genotypes had a DSI based on grain yield < 1 and were relatively tolerant to drought stress. A highly significant and negative correlation was obtained between the mean grain yield under severe drought stress and drought susceptibility index (r= -0.653**) (Buchner & Frohberg, 1987). The yield reduction was much more severe if moisture stress occurred during and following heading, resulting in fewer heads, fewer spikelets /spike, and fewer kernels per spike (Robins & 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, 2005). These results go in line with those obtained by Kheiralla *et al*. (1997), Tarred *et al.* (2002), Motawei & Abdalla (2003), El-Kholy *et al*. (2005) and Karami *et al*. (2005).

TABLE 7. Mean performance; percent decrease and drought susceptibility index (DSI) of 1000 kernel weight (g) and grain yield (ardab/fad) of barley genotypes as affected by irrigation regimes combined over two seasons.

Genotypes	1000 kernel weight (g)							Grain yield (ardab/fad)						
	Combined means Irrigation regimes			Mean	Percent decrease		DSI	Combined means Irrigation regimes			Mean	Percent decrease		DSI
	I_1	I_2	I_3		I_1- I_2 / I_1%	I_1- I_3/ I_1%		I_1	I_2	I_3		I_1- I_2 / I_1%	I_1- I_3/ I_1%	
1	44.19	41.86	38.81	**41.62**	5.27	12.17	0.69	10.36	8.59	7.83	**8.93**	17.08	24.42	0.85
2	45.93	41.40	37.48	**41.60**	9.86	18.40	1.04	11.38	8.99	7.88	**9.41**	21.00	30.76	1.07
3	47.74	41.67	38.08	**42.50**	12.71	20.23	1.14	10.73	8.27	7.31	**8.77**	22.93	31.87	1.11
4	48.46	40.25	36.95	**41.88**	16.94	23.75	1.34	8.98	8.18	7.03	**8.06**	8.91	21.71	0.75
5	45.64	42.09	40.83	**42.85**	7.78	10.54	0.60	10.63	9.89	8.37	**9.63**	6.96	21.26	0.74
6	47.75	42.40	39.71	**43.29**	11.20	16.84	0.95	10.28	8.08	6.68	**8.35**	21.40	35.02	1.22
7	51.36	46.59	42.34	**46.76**	9.29	17.56	0.99	11.51	9.84	8.48	**9.94**	14.51	26.32	0.91
8	45.86	42.13	37.15	**41.71**	8.13	18.99	1.07	10.60	9.23	6.91	**8.91**	12.92	34.81	1.21
9	45.27	40.64	38.23	**41.38**	10.23	15.55	0.88	8.18	7.11	6.03	**7.10**	13.08	26.28	0.91
10	48.55	44.62	41.68	**44.95**	8.09	14.15	0.80	10.49	9.27	8.41	**9.39**	11.63	19.83	0.69
11	47.28	40.39	38.18	**41.95**	14.57	19.25	1.09	10.62	8.68	7.13	**8.81**	18.27	32.86	1.14
12	54.88	44.73	40.63	**46.75**	18.49	25.97	1.47	10.29	7.74	6.55	**8.20**	24.78	36.35	1.26
13	50.49	46.63	42.98	**46.70**	7.65	14.87	0.84	11.05	10.10	8.25	**9.80**	8.60	25.34	0.88
14	48.67	40.26	36.95	**41.96**	17.28	24.08	1.36	10.89	8.66	7.17	**8.90**	20.48	34.16	1.19
15	45.94	37.60	35.60	**39.71**	18.15	22.51	1.27	9.18	7.57	6.45	**7.73**	17.54	29.74	1.03
16	44.15	38.75	35.79	**39.56**	12.23	18.94	1.07	11.30	7.72	6.61	**8.55**	31.68	41.50	1.44
17	52.03	46.21	43.23	**47.15**	11.19	16.91	0.96	11.21	10.46	8.67	**10.11**	6.69	22.66	0.79
18	47.27	42.14	40.15	**43.18**	10.85	15.06	0.85	11.23	8.46	7.04	**8.91**	24.67	37.31	1.29
19	45.25	40.86	38.40	**41.50**	9.70	15.14	0.86	10.42	8.43	7.43	**8.76**	19.10	28.69	0.99
20	47.41	41.78	39.25	**42.81**	11.88	17.21	0.97	8.81	7.50	6.17	**7.49**	14.87	29.97	1.04
G.127	48.52	42.02	40.31	**43.62**	13.40	16.92	0.96	10.39	10.11	8.30	**9.60**	2.69	20.12	0.70
G.128	45.32	41.49	39.58	**42.13**	8.45	12.67	0.72	10.43	8.38	8.31	**9.04**	19.65	20.33	0.71
Mean	**47.63**	**42.11**	**39.20**	**42.98**	**11.59±0.78**	**17.70±0.84**	**1.00±0.05**	**10.41**	**8.69**	**7.41**	**8.84**	**16.52±1.50**	**28.82±1.35**	**1.00±0.05**

1000 kernel weight: Rev. L.S.D 5% Level			Grain yield: Rev. L.S.D 5% Level		
Irrigation regime	=	0.36	Irrigation regime	=	0.12
Genotype	=	0.70	Genotype	=	0.28
Interaction	=	1.33	Interaction	=	0.53

Conclusion

It is concluded from the results of this study that barley genotypes respond differentially to drought stress. The results indicated that five genotypes, No's 5, 7, 10, 13, 17 were tolerant to drought stress and had a DSI < 1 for grain yield trait. In addition, severe drought stress reduced grain yield by reducing the number of spikes /m^2, number of kernels/spike and 1000-kernel weight compare results with performance under irrigated conditions. Yield components are the most important agronomic traits in selecting for genotypes tolerant to drought stress.

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تقييم عشرين تركيبا وراثيا من الشعير لتحمل الجفاف تحت ظروف التربة الرملية الطينية

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قسم التربية والوراثة – معهد بحوث المحاصيل السكرية – مركز البحوث الزراعية – الجيزة ، *قسم المحاصيل – كلية الزراعة – جامعة سوهاج – سوهاج و **قسم المحاصيل – كلية الزراعة – جامعة اسيوط – اسيوط – مصر .

أجريت هذه الدراسة من أجل تحديد أفضل التراكيب الوراثية والتى يمكن زراعتها تحت ظروف إجهاد الجفاف ، و أجريت هذه التجربة في تصميم القطاعات كاملة العشوائية فى ثلاثة مكررات في المزرعة البحثية بكلية الزراعة، جامعة سوهاج، في مواسم من عام ٢٠٠٦ إلى عام ٢٠٠٨. تم تقييم عشرين تركيبا وراثيا من الشعير (الثنائى المغطى) بالإضافة إلى صنفين للمقارنة وهما جيزة ١٢٧ و جيزة ١٢٨ لتحمل الجفاف عن طريق قياس الأداء للعائد من المحصول تحت ثلاثة مستويات من أنظمة الري (عادي، انخفاض معتدل وانخفاض حاد). إجهاد الجفاف أدى الى إنخفاض محصول الحبوب للفدان عن طريق إنخفاض عدد السنابل فى المتر المربع، وعدد الحبوب للسنبلة ووزن الألف حبة. وأظهرت هذه الدراسة أن أفضل التراكيب الوراثية من الشعير فى متوسط الأداء لجميع القياسات في ظل ظروف الجفاف الشديد هم (رقم ١٧، ٧ و ١٣). أظهر مؤشر الحساسية للجفاف (DSI) لمحصول الحبوب للفدان أن تسعة تراكيب وراثية كانت لها حساسية للجفاف أقل من الوحدة وكانت متحملة نسبيا لإجهاد الجفاف. أظهرت النتائج أن نسبة النقص فى محصول الحبوب لأعلى تركيب وراثى (رقم ١٧) وكذلك أقل تركيب وراثى (رقم ٩) بسبب زيادة الجفاف هى ٢٢,٦٦ و ٢٦,٢٨٪ على التوالي بمتوسط عام (٢٨,٨٢ + ١,٣٥).