INHERITANCE OF DROUGHT TOLERANCE IN SOME BARLEY GENOTYPES

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Abstract

Two field experiments were performed at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, during the two growing seasons 2006/2007 and 2007/2008, to study the inheritance of drought tolerance in some barley genotypes. Five diverse barley cultivars and lines namely Saico (P_1), Line 1 (P_2), Giza 126 (P_3), Line 2 (P_4), and Line 3 (P_5) were crossed in a half diallel. Parents and their 10 F_1 hybrids were planted in two experiments. The first experiment, received planting irrigation only (stress). The second was irrigated three times after planting irrigation (normal). Results showed that the mean performance under water stress decreased for all parents and their hybrids in all traits compared with normal irrigation. Analysis of variance revealed highly significant differences among genotypes for most traits, providing evidence for presence of large amount of genetic variability. Based on general combining ability estimates, the best combiners were P_1 for plant height, 100-grain weight and grain yield/plant under stress condition; P_2 for most studied traits under normal condition; and P_3 for most studied traits under the stress, normal and their combined, P_4 for spike length and 100-grain weight under drought condition. Meanwhile specific combining ability showed that the best hybrids were (P_1x P_3) for most studied traits under normal and stress conditions and their combined; (P2xP3) for number of grains/spike; 100-grain weight, and grain yield/plant under normal condition and their combined; (P_1XP_2) and (P_4XP_5) for most traits under drought condition and their combined. Moreover, significant positive heterosis values, over better parents, were obtained by (P_1X P_3) and (P_2 X P_3) for most traits under normal and stress conditions and their combined, as well as, (P_2XP_5) for number of spikes/plant and grain yield/plant under normal and stress conditions and their combined. Drought susceptibility index (DSI) over both irrigation treatments indicated that parents (P_1), (P_3), (P_4) and crosses, (P_1X P_2) and (P_3 X P_4) were tolerant for most traits, indicating the importance of these parents in this regard.

Key words: Barley, Hordeum vulgare, Drought, Combining ability, Heterosis.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is ancient as the origin of agriculture it self. The antiquity of barley is documented to periods of 5000 to 7000 B.C. or earlier. Until the sixteenth century, barley flour was used instead of wheat to make bread (Bukantis and Goodman, 1980). In Egypt, barley is one of the most important winter cereal crops. It is grown mainly in rainfed areas, where limited water supply is a feature such as in the Northwest Coastal region and North Sinai. Also it is grown over a wide range of soil variability and under many diverse climatic conditions compared with many other grain crops. So, it can be grown in irrigated saline and poor soils. It has utility as a feed and food grains, since ancient eras, it has been the preferred grains in hinge industry malt and as a starch source for alcoholic beverages.

Drought remains one of the most important factors threatening the food production through the world, Fashedfar et al. (1995).

The main objectives of this study were identification of superior parents and cross combinations from a 5 X 5 half diallel crosses of barley parental genotypes grown under drought stress.

MATERIALS AND METHODS

The present investigation was carried out at the experimental farm of Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt, during the two successive seasons 2006/2007 and 2007/2008. Five diversed barley cultivars and lines, namely Saico (P_1), Line 1 (P_2), Giza 126 (P_3), Line 2 (P_4), and Line 3 (P_5) were used as parents in half diallel cross mating design in 2006/2007 season (Table 1).

Table 1. Name and pedigree of barley parental genotypes.

Parent	Name / pedigree
Saico (P_1)	Saico
Line 1 (P_2)	Apm/HC1905//Robur/3/Arar/4/Baca"S"/3/AC253//CI05761
Giza 126 (P_3)	Baladi Bahtim/SD729 –Por 12762-BC
Line 2 (P_4)	Lignee527/NK127/6/Cita"S"/4/Apm/Rl/Manker/3/Maswi/Bon/5/ Copal"S"
Line3 (P_5)	Akrash//WI2291/WI2269/3/Arar/4/Baca"S"/3/Ac253 // CI08887 / CI 05761

In 2007/2008 season, seed of parents and their 10 F_1 hybrids were planted in two adjacent experiments. The first experiment was given planting irrigation only (drought stress condition). The second was irrigated three times after planting irrigation (normal irrigation). Amount of irrigation water supplied and total rainfall in m^3/fed for different treatments are presented in Table (2).

Table 2. Amount of irrigation water supplied and total rainfall in m^3/fed* for different treatments.

Treatment	Amount of irrigation water (m^3) supplied				Rainfall (m^3)	Total
	Sowing	First	Second	Third		
Stress	420	0	0	0	126	526
Normal	420	240	300	300	126	1386

*** Fedden (fed.) = 4200 m^2**

Each experiment was designated in a randomized complete block design with three replications. Plot size was two rows 1.5m long and 30cm apart with 15cm between plants within the row. All the recommended agronomic agricultural practices for barley production were applied at the proper time. Ten guarded plants were randomly taken from each plot to collect data on plant height (cm), spike length (cm), number of grains/spike, number of spikes/plant, 100–grain weight (g) and grain yield/ plant (g).

A drought susceptibility index (DSI), which provides a measure of stress resistance based on minimization of yield loss under stress compared with the optimum condition, rather than on yield level under stress. This index was used to estimate the relative stress injury because it accounted for variation in yield potential and stress intensity. This index could be estimated based on many traits. Lower susceptibility index than unity (DSI<1) is synonymous to high stress tolerance, while high stress susceptibility index (DSI >1) means high stress sensitivity. Data of yield and some related agronomic traits were used to estimate the drought susceptibility index (DSI) as suggested by Fisher and Maurer (1978) as follows: $DSI = (1 - Y_d / Y_p) / D$. Where: Y_d = Performance of a genotype under drought stress, Y_p= Performance of a genotype under normal irrigation, D = drought stress intensity = 1 - (mean Y_d of all genotypes / mean Y_p of all genotypes).

Analyses of variance for each experiment and the combined were performed for the two experiments (stress and normal irrigations) according to Snedecor and Cochran (1967). Combined analysis was carried out whenever homogeneity of variance was not significant.

Combining ability analysis was performed according to Griffing (1956) method 2 model 1(fixed model).

RESULTS AND DISCUSSION

Mean squares of barley genotypes for all studied traits in each enviroment and their combined are presented in Table (3). Statistical analysis revealed highly significant effects of irrigation treatments on all studied traits, indicating that the two irrigation regimes behaved differently for these traits. In addition, mean squares due to genotypes were highly significant for all traits, providing evidence for presence of large amount of genetic variability, which considered adequate for further biometrical assessment. Significant or highly significant differences for all traits were found among parents at the two conditions and their combined analysis .

Mean performance:

Mean performance of the five barley parents and their F_1 at stress and normal irrigation conditions and their combined were presented for all studied traits in Table (4).

With respect to plant height, the tallest parents were (P_3) under normal condition, (P_1) and (P_2) at water stress and (P_3) at their combined while the shortest was (P_5) under normal and water stress. The tallest crosses were; (P_2 x P_3) and their combined and (P_3 x P_4) at normal condition; (P_1 x P_3) at water stress and their combined. However, (P_1 x P_4) under normal condition and (P_3 x P_5) under water stress condition were the shortest. Mohamed (2001), Mohamed (2004), Farhat (2005), Samarah (2005) and Katta, et al. (2009) found similar results where water stress during vegetative growth and heading stages significantly decreased plant height of wheat.

With regard to spike length, the tallest spikes belonged to (P_2) and (P_4) under normal and water stress conditions and (P_4) at their combined. However, (P_1) showed the shortest spike length at normal condition and (P_5) at water stress condition. These results indicate the different genetic background of the parents. Among crosses, the tallest spike length was obtained from crosses; (P_1x P_3) and (P_2 x P_3) under normal and their combined and (P_1 x P_3) under water stress condition. However, the shortest was produced from (P_1 x P_5) under normal condition, and (P_3 x P_5) under water stress condition. Samarah (2005) and Katta, et al. (2009) found similar results.

As for number of grains per spike, the parent (P_4) was the highest under both conditions and their combined, while, (P_1) showed the fewest at normal condition and (P_5) at water stress condition. With regard to the crosses; (P_1 x P_3) and (P_2 x P_3) showed the highest number of grains at normal condition, the crosses (P_1 x P_3) and (P_1 x P_5) showed the highest number under water stress condition and their combined, while (P_1 x P_4) and (P_1 x P_5) showed the fewest number at normal condition, (P_2 x P_4) and (P_3 x P_5) showed the fewest number under water stress condition. Similar results were obtained by Samarah (2005) and Katta, et al. (2009).

With respect to spike number per plant, the highest parents were (P_1) under both conditions and their combined. The fewest number was produced from parent (P_3) at normal and (P_5) under water stress conditions. With regard to the crosses; the highest number of spikes was obtained from (P_2 x P_5) and (P_1 x P_3) at normal condition and their combined, (P_4 x P_5) and (P_3 x P_5) under water stress condition, while it was the fewest in, (P_1 x P_4) and (P_2 x P_4) under normal condition, (P_2 x P_3) under water stress condition. Moursi (2003), Mohamed (2004), Farhat (2005), Samarah (2005) and Katta et al. (2009) obtained similar results on wheat and barley.

With regard to 100-grain weight, the heaviest grains were obtained from (P_2) and (P_4) under normal condition, and from (P_4) under water stress condition and their combined. The heaviest grains of barley crosses were obtained from (P_2 x P_3) under normal condition and their combined, (P_1 x P_3) at water stress and their combined. However, the lightest grains of barley crosses were relative to, (P_4 x P_5) under normal condition, (P_2 x P_5) at water stress. Similar results were obtained by Mohamed (2004), Farhat (2005) Samarah (2005) and Katta et al. (2009).

As for grain yield per plant, the highest grain yield belonged to (P_4) and (P_2) under normal condition, (P_3) and (P_4) under water stress and their combined. However, the lowest yield was obtained from (P_5) under normal and water stress conditions. Regarding the hybrids, (P_1 x P_3) and (P_2 x P_3) yielded more than the other crosses at normal condition and their combined. (P_1 x P_2) and (P_1 x P_3) under water stress condition. However, the lowest yield belonged to (P_1 x P_4) under normal condition, (P_2 x P_4) at water stress condition. Samarah (2005), Abd El-Aty and El-Borhamy (2007) and Katta, et al. (2009) found similar results.

Combining ability analysis:

Analysis of variance for combining ability as outlined by Griffing (1956) method 2 model 1 in each environment as well as their combined for all the studied traits are presented in Table (5). Results indicated that mean squares of GCA and SCA were highly significant for all the studied traits under the two environments. The significance of GCA and SCA indicate the presence of both additive and non-additive types of gene effects in the genetic system controlling these traits. The GCA values were higher than those of SCA for most traits. Similar results were reported by Katta, et al. (2009).

General combining ability effects

Estimates of GCA effects of all genotypes for each trait in both environments are presented in Table (5). The GCA effects in this study were found to be significantly different for most traits.

As for plant height, significant or highly significant positive GCA values were detected for (P_3) under the two conditions and their combined and (P_1) under water stress condition only. On the other hand, highly significant negative GCA effects were detected for (P_5) under the two conditions and their combined.

With regard to spike length, significant or highly significant positive GCA effects were detected for (P_2) under all conditions, (P_3) under normal and combined, (P_4) under water stress and combined. On the other hand, highly significant negative GCA effects were detected for (P_5) under all conditions and (P_1) under normal irrigation. Similar results were obtained by Mansour (2007).

With respect to number of grains per spike, parents (P_2) and (P_3) showed significant or highly significant positive GCA effects under normal condition, while, GCA showed highly significant negative effects for (P_5) under normal and stress conditions, and (P_4) in combined data showed significant or highly significant negative GCA effects. Similar results were reported by Zeng et al. (2001), Sharma et al. (2003) Mansour (2007), and Eshghi and Akhundova (2009).

Concerning number of spikes per plant, significant or highly significant positive GCA effects were detected for (P_2) under normal condition, and (P_3) at combined. On the other hand, significant or highly significant negative GCA effects were detected for (P_2) under stress, (P_4) under normal and (P_5) under combined. Similar results were obtained by Ahmed (1990), Mahmoud (2006) and Mansour (2007).

Regarding 100-grain weight, significant or highly significant positive GCA effects were detected for (P_3) at all conditions, (P_1) and (P_4) under stress and combined, and (P_2) under normal conditions indicating that these genotypes could be considered as good combiners for this character. While, highly significant negative GCA effects were detected for (P_5) under all conditions and (P_2) at stress. Sharma et al. (2003), Mahmoud (2006), and Mansour (2007) reported similar results.

For grain yield per plant, the estimates of GCA effects were positive and highly significant for (P_3) at all conditions and (P_1) under stress. On the other hand, highly significant negative GCA effects were existed for (P_5) at all conditions, (P_2) under stress and (P_4) under normal irrigation. Similar results were obtained by Sharma et al. (2003), Mahmoud (2006), Mansour (2007) and Eshghi and Akhundova (2009).

Table 3. Mean squares for different barley genotypes, general and specific combining ability in diallel analysis for all studied traits at normal and stress conditions and their combined analysis.

S. 0. V	d .f		Plant height			Spike length			No. of grains/spike		
	Single	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
Replication	2	-	38.01**	73.67**	-	0.34**	0.75**	-	44.09**	4.53**	-
Environments	-	1	-	-	2295.33**	-	-	18.93**	-	-	815.50**
Rep. with environment	-	4	-	-	503.77**	-	-	4.23**	-	-	182.54**
Genotypes	14	14	232.40**	106.02**	253.30**	3.95**	3.01**	6.34**	167.62**	114.43**	257.20**
Parents	4	4	510.13**	90.79**	418.30**	2.86**	3.35**	5.70**	72.23**	59.31*	111.30**
Crosses	9	9	130.51**	98.99**	182.70**	3.88**	2.04**	5.34**	211.25**	125.09**	307.10**
P v s .C	1	1	38.49**	230.21**	228.70**	8.94**	10.38**	17.90**	156.50**	238.97**	391.70**
Genotypes x Env.	-	14	-	-	58.13**	-	-	0.52**	-	-	24.90**
Parents x Env.	-	4	-	-	182.65**	-	-	0.48*	-	-	20.19
Crosses x Env.	-	9	-	-	46.80**	-	-	0.58*	-	-	29.30
P v s .C x Env.	-	1	-	-	39.96**	-	-	0.14	-	-	4.14
GCA	4	4	232.16**	77.64**	120.91**	1.06**	0.83**	0.75**	56.38**	18.13**	28.56**
SCA	10	10	15.59**	18.42**	10.73**	1.42**	1.07**	1.20**	55.67**	46.15**	48.59**
GCA x Env.	-	4	-	-	188.89**	-	-	1.14**	-	-	45.95**
SCA x Enf	-	10	-	-	23.28**	-	-	1.29**	-	-	53.23**
Error	28	56	22.33	13.76	18.04	0.21	0.19	0.20	13.66	15.38	14.50
GCA/SCA	-	-	3.94	0.75	3.48	0.10	0.11	0.09	0.14	0.05	0.28
Total	44	89									

*and ** indicate significant at 0.05 and 0.01 levels of probability, respectively.

Table 3. Continued.

S. 0. V	d .f		No. of spikes/plant			100-grain weight			Grain yield/plant		
	Single	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
Replication	2	-	3.86**	0.47	-	0.03	0.04**	-	8.59**	4.24**	-
Environments	-	1	-	-	1356.60**	-	-	6.19**	-	-	4447.90**
Rep. with environment	-	4	-	-	273.07**	-	-	1.27**	-	-	894.72**
Genotypes	14	14	16.25**	3.87**	12.52**	0.34**	0.46**	0.61**	221.68**	58.71**	195.28**
Parents	4	4	2.93	2.99*	3.77*	0.61**	0.84**	1.19**	93.29**	90.09**	137.70**
Crosses	9	9	23.16**	3.72*	16.00**	0.25*	0.21**	0.32**	274.90**	5.43**	203.50**
P v s .C	1	1	7.34**	8.74**	16.20**	0.09	1.16**	0.92**	256.26**	412.71**	351.60**
Genotypes x Env.	-	14	-	-	7.61**	-	-	0.18**	-	-	85.12**
Parents x Env.	-	4	-	-	2.15	-	-	0.09**	-	-	11.73**
Crosses x Env.	-	9	-	-	10.80**	-	-	0.14*	-	-	110.40**
P v s .C x Env.	-	1	-	-	0.74	-	-	0.87**	-	-	151.16**
GCA	4	4	2.38**	0.72**	0.65	0.22**	0.35**	0.23**	87.55**	27.70**	36.67**
SCA	10	10	6.63**	1.52**	2.66**	0.07**	0.08**	0.05**	68.43**	16.32**	30.90**
GCA x Env.	-	4	-	-	2.45**	-	-	0.34**	-	-	76.58**
SCA x Env.	-	10	-	-	5.49**	-	-	0.10**	-	-	53.85**
Error	28	56	1.75	1.03	1.39	0.06	0.04	0.05	5.06	6.23	5.63
GCA/SCA	-	-	0.04	0.05	0.08	0.52	0.79	0.85	0.18	0.26	0.17
Total	44	89									

*and ** indicate significant at 0.05 and 0.01 levels of probability, respectively.

Table 4. Mean performance of parents and their F_1 crosses for all studied traits at the normal (N) and stress(S) conditions and their combined analysis.

Genotype	Plant height (cm)			Spike length (cm)			No. of grains/spike			No. of spikes/plant			100-grain weight (g)			Grain yield/plant (g)		
	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.
P_1	91.2	83.7	87.4	6.5	6.2	6.4	55.5	54.0	54.8	18.5	11.5	15.0	4.6	4.1	4.4	32.2	26.8	29.5
P_2	90.6	83.7	87.1	8.8	7.7	8.3	66.0	56.3	61.2	18.0	9.8	13.9	4.9	3.5	4.2	39.7	18.7	29.2
P_3	113.2	81.5	97.3	7.7	6.7	7.2	61.5	51.0	56.3	16.9	11.2	14.1	4.5	4.0	4.3	39.5	29.0	34.3
P_4	90.3	82.7	86.5	8.8	8.2	8.5	66.0	61.2	63.6	18.5	10.1	14.3	4.9	4.5	4.7	41.0	27.9	34.5
P_5	76.9	70.7	73.8	7.3	5.9	6.6	57.0	50.2	53.6	17.4	9.1	13.3	3.8	3.2	3.5	29.7	17.4	23.6
$P_1 x P_2$	96.6	92.9	94.8	9.0	8.3	8.7	64.8	62.4	63.6	19.2	12.2	15.7	4.4	4.4	4.4	42.7	30.2	36.5
$P_1 x P_3$	99.5	96.4	98.0	11.3	9.7	10.5	84.0	73.8	78.9	21.6	11.9	16.8	5.0	4.6	4.8	58.4	32.8	45.6
$P_1 x P_4$	87.7	85.2	86.5	7.9	7.7	7.8	57.8	53.6	55.7	15.5	10.8	13.2	4.7	4.3	4.5	34.3	27.4	30.9
$P_1 x P_5$	89.0	81.3	85.1	7.8	7.5	7.7	59.0	58.4	58.7	19.0	10.4	14.7	4.6	4.2	4.4	38.8	25.3	32.1
P_2xP_3	107.9	87.4	97.6	10.1	8.0	9.1	76.0	61.7	68.9	19.3	9.4	14.4	5.2	4.3	4.8	58.7	26.8	42.8
P_2xP_4	90.3	82.4	86.4	8.1	7.3	7.7	61.5	52.6	57.1	16.8	9.8	13.3	4.6	4.0	4.3	35.7	19.1	27.4
P_2xP_5	91.3	81.0	86.2	8.1	7.7	7.9	61.4	55.8	58.6	25.2	11.8	18.5	4.5	3.6	4.1	44.9	28.3	36.6
P_3xP_4	101.0	86.6	93.8	8.7	8.1	8.4	65.5	62.8	64.2	19.5	11.5	15.5	4.7	4.3	4.5	38.4	26.9	32.7
P_3xP_5	90.8	79.0	84.9	7.9	6.5	7.2	59.5	52.7	56.1	19.4	12.4	15.9	4.7	4.1	4.4	40.0	29.5	34.8
P_4xP_5	89.8	80.1	85.0	8.3	7.6	8.0	62.0	60.8	61.4	17.0	12.6	14.8	4.2	4.2	4.2	36.1	29.1	32.6
LSD 0.05	7.9	6.2	6.9	0.8	0.7	0.7	6.2	6.6	6.2	2.2	1.7	1.9	0.4	0.4	0.4	3.8	4.2	3.9
LSD 0.01	10.7	8.4	9.3	1.0	1.0	1.0	8.3	8.9	8.3	3.0	2.3	2.6	0.6	0.5	0.5	5.1	5.6	5.2

Specific combining ability effects

It could be noticed that most F_1 hybrids exhibited better performance than the better parents, revealing the superiority of these hybrids and the important role of dominance effect in the inheritance of studied traits. The estimated specific combining ability (SCA) effects of all barley parental combinations computed for all traits under normal and water stress are presented in Table (6).

Regarding plant height, the best crosses were (P_1 x P_2) under stress and combined and (P_1 x P_3) under stress, where they showed significant or highly significant and positive SCA effects, indicating the importance of dominance effect in these crosses for tallness. Similar results were obtained by Singh et al. (2002), Sharma et al. (2003) and Mansour (2007).

As for spike length, significant or highly significant positive SCA effects were obtained from crosses; (P_1 x P_3) at all conditions, (P_1 x P_2) under stress and combined, (P_2 x P_3) at normal and combined, (P_1 x P_5) and (P_2 x P_5) under stress and (P_4 x P_5) under combined, this means that these crosses could be considered as the best for this trait. Ahmed (1990), Mahmoud (2006) and Mansour (2007) had similar results.

With respect to number of grains per spike, barley crosses; (P_1 x P_3) at all conditions, (P_2 x P_3) under normal condition, (P_2 x P_5) at combined and (P_4 x P_5) under water stress condition showed significant or highly significant positive SCA effects. These crosses are considered to be promising for improving this trait. Similar results were obtained by Zeng et al. (2001), Sharma et al. (2003) and Mansour (2007).

As for number of spikes per plant, significant or highly significant and positive SCA effects were obtained from crosses; (P_1 x P_3) at normal and combined, (P_2 x P_5) under normal and stress conditions, (P_4 x P_5) under stress and combined, (P_1 x P_2) under stress, (P_2 x P_3) under combined, (P_3 x P_4) under normal and (P_3 x P_5) under stress conditions. These results indicate that these crosses could be considered promising in this respect.

Regarding 100-grain weight, significant or highly significant positive SCA effects were estimated for the crosses; (P_2 x P_3) at all conditions, (P_1 x P_3) and (P_1 x P_5) under stress condition and combined, (P_3 x P_5) under normal condition and combined, and (P_1 x P_2) and (P_4 x P_5) at water stress condition. These results indicated that, these crosses were superior to the others. Similar results were obtained by Sharma et al. (2003) and Mansour (2007).

As for grain yield per plant, estimates of SCA effects were significant or highly significant and positive for the crosses; (P_1 x P_3) and (P_2 x P_5) at all conditions, (P_2 x P_3) at normal and combined, (P_4 x P_5) at normal and water stress, (P_1 x P_2) under stress and (P_1 x P_5) under normal irrigation. These results indicate the superiority of these crosses in this trait. Similar results were achieved by Sharma et al. (2003), Mahmoud (2006) and Mansour (2007).

Table 5. Estimates of general combining ability effects of five barley parents for all studied traits at normal (N) and stress (S) conditions and their combined analysis.

Parent	Plant height			Spike length			No. of grains/spike			No. of spikes/plant			100-grain weight			Grain yield/plant		
	N	S	Comb.	N	S	Comb.	N	S	Comb	N	S	Comb.	N	S	Comb.	N	S	Comb.
P_1	-1.05	3.05**	1.00	-0.20 *	0.1	-0.05	-0.91	1.33	0.14	-0.09	0.38	0.21	0.03	0.17**	0.11**	-0.43	1.88**	0.72
P_2	0.69	1.32	1.00	0.33 **	0.23 *	0.29••	1.81 *	-0.26	0.10	0.63 *	-0.43*	0.77	0.11 *	-0.18**	-0.03	2.83**	-2.18**	0.33
P_3	9.02**	1.50 *	5.26••	0.41 **	-0.09	0.15•	3.57**	0.86	0.22	0.19	0.25	2.21••	0.12 *	0.12**	0.11••	4.19**	1.92**	3.06••
P_4	-1.86	-0.31	-1.08	0.01	0.31**	0.16•	-0.6	0.75	-0.54•	-0.94**	-0.14	0.08	0.04	0.19**	0.12••	-2.16**	0.31	-0.93
P_5	-6.80**	-5.56**	-6.18**	-0.54 **	-0.55**	-0.55••	-3.87**	-2.68**	0.08	0.21	-0.06	-3.28••	-0.31**	-0.30**	-0.30**	-4.43**	-1.93**	-3.18••
LSD 0.05	1.89	1.48	1.55	0.18	0.18	0.14	1.48	1.57	0.45	0.53	0.41	1.13	0.1	0.08	0.08	0.9	1.00	1.28
LSD 0.01	2.55	2	2.07	0.25	0.24	0.19	1.99	2.12	0.60	0.71	0.55	1.50	0.13	0.11	0.10	1.21	1.35	1.71
C.V %	5.04	4.44	4.79	5.49	5.88	5.68	5.79	6.78	6.26	7.07	9.25	7.95	5.36	5.11	5.28	5.59	9.53	7.14

*and ** indicate significant at 0.05 and 0.01 levels of probability, respectively.

Table 6. Estimates of specific combining ability effects of F_1 crosses for all studied traits at normal (N) and stress (S) conditions and their combined analysis.

Cross	Plant height			Spike length			No. of grains/spike			No. of spikes/plant			100-grain weight			Grain yield/plant		
	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.
P_1x P_2	3.23	4.89 *	4.06 *	0.46	0.47 *	0.47 *	0.07	3.51	0.24	-0.83	1.29 *	1.79	-0.35**	0.29**	-0.04	0.07	4.29 **	2.19
P_1x P_3	-2.21	8.24 **	3.02	2.69 **	2.17 **	2.43 **	17.50**	13.79**	1.51 *	2.74 **	0.28	15.65 **	0.21	0.22 *	0.21 *	14.37**	2.76 *	8.57 **
P_1x P_4	-3.14	-1.18	-2.16	-0.3	-0.17	-0.24	-4.49 *	-6.31 **	-1.28 *	-2.21**	-0.33	-5.40 **	0.04	-0.18	-0.06	-3.40 **	0.08	-1.67
P_1x P_5	3.07	0.18	1.62	0.16	0.46 *	0.31	-0.05	1.97	-1.17 *	-1.48 *	-0.88	0.96	0.23	0.27 *	0.25 *	3.37 **	-0.85	1.26
P_2xP_3	4.48	0.94	2.70	0.94 **	0.4	0.66 **	6.78 **	3.25	-0.78	-0.2	-1.35 *	5.01 **	0.35 **	0.28 *	0.31 **	11.43**	0.88	6.16 **
P_2xP_4	-2.32	-2.21	-2.26	-0.66**	-0.77**	-0.72	-3.55	-5.74 **	-1.13	-1.63 *	-0.63	-4.65 **	-0.18	-0.13	-0.13	-5.23 **	-5.23**	-5.23 **
P_2xP_5	3.72	1.61	2.67	-0.1	0.56 *	0.23	-0.38	0.9	3.45 **	5.61 **	1.29 *	0.26	0.05	-0.04	0.01	6.23 **	6.28 **	6.25 **
P_3xP_4	0.07	1.74	0.91	-0.16	0.36	0.11	-1.31	3.4	0.96	1.53 *	0.39	1.04	-0.07	-0.09	-0.08	-3.87 **	-1.54	-2.72
P_3xP_5	-5.12 *	-0.58	-2.85	-0.36	-0.38	-0.38 *	-4.03 *	-3.33	0.79	0.3	1.28 *	-3.69 *	0.30 *	0.16	0.23 *	-8.55 **	-0.06	-4.31 *
P_4xP_5	4.76	2.34	3.55	0.46	0.35	0.40 *	2.64	4.91 *	0.41	-0.99	1.80**	3.78 *	-0.18	0.26 *	0.02	2.44 *	4.52 **	3.48
LSD 0.05	4.88	3.83	4.01	0.48	0.45	0.37	3.82	4.05	1.16	1.37	1.05	2.91	0.26	0.22	0.20	2.32	2.58	3.31
LSD 0.01	6.58	5.17	5.33	0.64	0.61	0.49	5.15	5.46	1.54	1.84	1.41	3.87	0.34	0.29	0.27	3.13	3.48	4.41
C.V	5.04	4.44	4.79	5.49	5.88	5.68	5.79	6.78	6.26	7.07	9.25	7.95	5.36	5.11	5.28	5.59	9.53	7.14

*and ** indicate significant at 0.05 and 0.01 levels of probability, respectively.

Heterosis percentages

The estimations of heterosis over better parent for all studied traits under normal and water stress conditions are presented in Table (7).

As for plant height, highly significant positive heterosis over better parent was obtained by the cross (P_1 x P_2) at water stress and combined, and (P_1 x P_3) under water stress. Singh et al. (2002), Eid (2006) and Mansour (2007) found significant positive heterotic effects for plant height in their studies.

Regarding spike length, results in Table (7) show significant or highly significant positive heterosis values over better-parent for crosses; (P_1 x P_3) at all conditions, (P_1 x P_5) at stress and combined, (P_2 x P_3) under normal and combined and (P_1 x P_2) under water stress condition. Similar results were recorded by El-Bawab (2003), Eid (2006) and Mansour (2007).

For number of grains per spike, highly significant positive heterotic effects over the better parents were recorded for barley crosses; (P_1 x P_3) under all conditions, (P_2 x P_3) under normal and combined and (P_1 x P_5) under combined. Similar results were obtained by El-Seidy (1997a&b), Singh et al. (1997), Zeng et al. (2001), El-Bawab (2003), Eid (2006) and Mansour (2007).

With respect to number of spikes per plant, significant or highly significant positive values of heterosis over better parents were detected for crosses; (P_2 x P_5) under all conditions, (P_1 x P_3) under normal and combined, (P_3 x P_5) at combined, and (P_4 x P_5) under water stress condition. Similar results were obtained by Abul-Naas et al. (1993), El-Seidy (1997a), El-Bawab (2003), Mahmoud (2006), Eid (2006) and Mansour (2007).

With respect to 100-grain weight, results in Table (7) showed significant or highly significant positive heterosis values over better parent for crosses; (P_1 x P_3) under stress and combined conditions and (P_2 x P_3) under combined. Similar results were recorded by El-Bawab (2003), Eid (2006) and Mansour (2007).

Concerning grain yield per plant, results presented in Table (7) showed highly significant positive heterosis over better parent for crosses; (P_2 x P_5) under all conditions, (P_1 x P_3) and (P_2 x P_3) under normal and combined, (P_1 x P_2) under combined, and (P_1 x P_5) under normal irrigation. Similar results were obtained by El-Bawab (2003), Eid (2006), Mahmoud (2006) and Mansour (2007).

Drought susceptibility index (DSI)

Drought susceptibility index (DSI) of all genotypes calculated for all studied traits are presented in Table (8).

As for plant height, all parents possessed DSI less than one, except (P_3) revealing that these parents were tolerant to drought. For hybrids, the lowest and highest DSI recorded for (P_1 x P_4) and (P_2 x P_3), respectively. For spike length all parents possessed DSI less than one, except (P_2), (P_3) and (P_5), revealing that these parents were less susceptible to spike length reduction. Hybrid, (P_2 x P_3) was the most susceptible cross, while (P_1 x P_4) was tolerant.

Table 7. Estimates of heterosis over better –parent of F_1 crosses at normal (N) and stress (S) conditions and their combined analysis.

Cross	Plant height			Spike length			No. of grains/spike			No. of spikes/plant			100-grain weight			Grain yield/plant		
	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.
$P_1 x P_2$	5.96	11.04 **	8.37 **	2.88	8.67 *	4.85	-1.80	10.76	4.01	3.78	6.09	4.67	-9.98 *	5.21	1.15	7.72	12.62	23.56 **
$P_1 x P_3$	-12.08 **	15.26 **	0.65	47.48**	44.18 **	45.83 **	36.59 **	36.67 **	40.27 **	16.52 **	3.04	11.67 *	7.82	10.68 *	10.34 **	47.81 **	12.86	33.14 **
$P_1 x P_4$	-3.81	1.83	-1.13	-9.52 *	-6.11	-8.24 *	-12.36 *	-12.42 *	-12.39 **	-16.34**	-5.80	-12.33 *	-3.34	-5.25	-4.26	-16.34**	-1.86	-10.45 *
$P_1 x P_5$	-2.42	-2.84	-2.62	8.05	20.27 **	15.91 **	3.51	8.22	31.87 **	2.70	-9.57	-2.00	0.54	2.27	1.15	20.45 **	-5.67	8.64
P_2xP_3	-4.64	4.45	0.32	15.24**	4.90	9.04 **	15.15 **	9.42	22.40 **	7.41	-15.67 *	2.14	5.91	6.76	11.76 **	48.00 **	-7.57	24.82 **
P_2xP_4	-0.34	-1.46	-0.88	-7.62	-11.71 *	-9.41 **	-6.82	-14.12 *	-10.30 **	-9.30	-2.98	-6.99	-6.22	-11.56**	-8.51 **	-12.85**	-31.59**	-20.46 **
P_2xP_5	0.86	-3.17	-1.12	-7.43	1.18	-4.24	-6.97	-1.03	-4.17	39.81 **	20.27 *	33.09 **	-8.88 *	1.97	-3.57	13.18 **	51.42 **	25.34 **
P_3xP_4	-10.77 **	4.73	-3.64	-0.95	-1.74	-1.18	-0.76	2.66	0.86	5.41	2.54	8.39	-4.02	-5.01	-4.26	-6.21	-7.46	-5.22
P_3xP_5	-19.73 **	-3.04	-12.78 **	3.26	-3.73	0.00	-3.25	3.24	-0.27	11.48	11.34	13.17 *	5.97	1.13	3.53	1.27	1.61	1.46
P_4xP_5	-0.55	-3.09	-1.76	-4.76	-7.78	-6.47 *	-6.06	-0.65	-3.46	-8.11	24.83 **	3.50	-14.87**	-7.13	-10.64 **	-11.86 *	4.19	-5.37
LSD 0.05	7.90	6.20	5.02	0.77	0.74	0.53	6.18	6.56	4.50	2.21	1.70	1.39	0.41	0.35	0.26	3.76	4.18	2.81
LSD 0.01	10.66	8.37	6.78	1.04	0.99	0.71	8.34	8.85	6.07	2.99	2.29	1.88	0.56	0.47	0.36	5.07	5.63	3.79

*and ** indicate significant at 0.05 and 0.01 levels of probability, respectively.

Regarding, number of grains/spike, (P_1) and (P_4) possessed DSI less than one, suggesting that these parents were tolerant for number of grain/spike. Hybrids, (P_1 x P_2) and (P_4 x P_5) were the most tolerant crosses, while (P_2 x P_3) was the most susceptible. For number of spikes/plant, (P_1) and (P_3) were tolerant for number of spikes/plant, whereas hybrids (P_1 x P_4) and (P_4 x P_5) were the most tolerant crosses, but (P_2 x P_5) was the most susceptible. For 100- grain weight, all parents were tolerant except for (P_2) and (P_5). Regarding hybrids, (P_1 x P_2) and (P_4 x P_5) were the most tolerant crosses, while (P_2 x P_5) was the most susceptible. For grain yield/plant the parents (P_1), (P_3), and (P_4) gained the lowest DSI, indicating that these parents were the lowest affected parents by water stress, while, (P_2) had the highest DSI, showing that this parent was the most susceptible one. Results indicated that most hybrids were tolerant to drought for grain yield/plant. Similar results were obtained by Katta, et al. (2009).

Table 8. Susceptibility index for barley parents and their F_1 crosses based on all studied traits.

Genotype	Plant height	Spike length	No. of grains /spike	No. of spikes/ plant	100-Grain weight	Grain yield /plant
Saico (P_1)	0.76	0.44	0.28	0.91	0.95	0.48
Line 1 (P_2)	0.71	1.19	1.52	1.10	2.48	1.50
Giza 126 (P_3)	2.60	1.24	1.76	0.81	0.97	0.76
Line 2 (P_4)	0.78	0.65	0.75	1.09	0.71	0.91
Line3 (P_5)	0.74	1.83	1.23	1.15	1.37	1.18
P_1x P_2	0.35	0.74	0.38	0.88	0.00	0.83
P_1x P_3	0.29	1.35	1.25	1.08	0.70	1.25
P_1x P_4	0.26	0.24	0.76	0.73	0.74	0.57
P_1x P_5	0.80	0.37	0.63	1.09	0.76	0.99
P_2xP_3	1.76	1.98	1.94	1.23	1.51	1.54
P_2xP_4	0.81	0.94	1.49	1.00	1.13	1.32
P_2xP_5	1.04	0.47	0.94	1.28	1.74	1.05
P_3xP_4	1.32	0.66	0.42	0.99	0.74	0.85
P_3xP_5	1.20	1.69	1.18	0.87	1.11	0.75
P_4xP_5	1.00	0.80	0.20	0.62	0.00	0.55

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وراثة تحمل الجفاف فى بعض التراكيب الوراثية من الشعير

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الملخص العربى

أقيمت تجربتان حقليتان بالمزرعة البحثية بمحطة البحوث الزراعية بسخا بمحافظة كفرالشيخ خلال الموسمين ٢٠٠٧/٢٠٠٦ و ٢٠٠٨/٢٠٠٧ لدراسة وراثة تحمل الجفاف فى بعض التراكيب الوراثية من الشعير واستخدم لذلك خمسة تراكيب وراثية من الشعير وهى :١- سايكو , ٢- سلالة١, ٣-جيزة ١٢٦ ,٤- سلالة٢ ، ٥- سلالة ٣. تم التهجين بينها فى صورة نصف دائرية. الآباء الخمسة والهجن العشرة الناتجة منها تم زراعتها فى تجربتين. التجربة الأولى تم ريها بربة الزراعة فقط (ظروف اجهاد مائى), أما التجربة الثانية فتم ريها ثلاث ريات بعد رية الزراعة (رى كامل). أظهرت النتائج انخفاض متوسط الأداء للآباء والهجن فى كل الصفات المدروسة تحت ظروف الجفاف. كما أن تحليل التباين اظهر تأثيرات عالية المعنوية للتراكيب الوراثية فى معظم الصفات موضحا الاختلافات الوراثية بين الآباء. التقديرات الخاصة بالقدرة العامة على الائتلاف تشير الى أن الصنف سايكو كان أب مشارك جيد لطول النبات, وزن المائة حبة ومحصول الحبوب للنبات تحت ظروف الجفاف؛ سلالة١ كان أب مشارك جيد فى معظم الصفات تحت معاملة الرى الكامل ؛الصنف جيزة ١٢٦كان أب مشارك جيد لمعظم الصفات المدروسة تحت كلا المعاملتين والتحليل التجميعى بينما كانت سلالة٢ أب مشارك جيد لطول السنبلة ووزن المائة حبة تحت ظروف الجفاف. أظهرت تقديرات القدرة الخاصة على الائتلاف أن أفضل الهجن كان: الهجين (سايكو X جيزة ١٢٦) بالنسبة لمعظم الصفات تحت كلا المعاملتين و التحليل التجميعى, الهجين (سلالة١ X جيزة ١٢٦) بالنسبة لعدد حبوب السنبلة, وزن المائة حبة ومحصول الحبوب للنبات تحت معاملة الرى الكامل و التحليل التجميعى والهجينان (سايكو X سلالة١) و (سلالة٢ X سلالة٣) بالنسبة لمعظم الصفات المدروسة تحت ظروف الجفاف و التحليل التجميعى . تقديرات قوة الهجين بالمقارنة بالأب الأفضل أظهرت أن أفضل الهجن هى: (سايكو X جيزة ١٢٦) و (سلالة١ X جيزة ١٢٦) بالنسبة لمعظم الصفات تحت كلا المعاملتين و التحليل التجميعى ، (سلالة١ X سلالة٣) بالنسبة لعدد السنابل للنبات ومحصول الحبوب تحت كلا المعاملتين و التحليل التجميعى .

بناء على معامل الحساسية المحسوب بالنسبه للصفات المدروسة، فإن الصنف سايكو و الصنف جيزة ١٢٦ و سلالة ٢ والهجن (سايكو X سلالة١) و (جيزة ١٢٦ x سلالة٢) كانت متحملة للجفاف فى معظم الصفات. و قد أظهرت الدراسة أن معظم الهجن التي تضمنت الصنف جيزة ١٢٦ (الأب ٣) وسلالة ٢ (الأب ٤) كانت متحملة للجفاف فى معظم الصفات المدروسة مما يبين أهمية هذين الأبوين فى تحمل الجفاف.