Egypt. J. Plant Breed. 23(8):1713– 1737(2019)

COMBINING ABILITY IN SOME BARLEY GENOTYPES UNDER RAINFED AND IRRIGATION CONDITIONS

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ABSTRACT

Two field experiments were conducted at Maryout Agricultural Research Station of Desert Research Center, North Western Coast, Egypt under irrigated and rainfed conditions. Six wheat genotypes were used to evaluate half diallel cross (15 F_1 hybrids) during the two winter seasons 2015/16 and 2016/17. Mean squares due to the genotypes (parents and their F_1's) and irrigation treatments were significant, indicating that the presence of wide diversity among genotypes and the highly differences between the two regimes for all traits under study. Positive and significant heterotic effects were found for most crosses for plant height, grain yield/plant and its components under irrigation and rainfed treatments except for the two crosses $P_4 \times P_6$ and $P_5 \times P_6$. Mean squares due to both GCA and SCA were highly significant or significant for all the studied traits under irrigated and rainfed conditions. Detection of high GCA/SCA ratios (that exceeded unity) for most studied traits indicated that the largest part of the total genetic variability for these traits was the result of additive and additive×additive gene action types. The superiority of three parents (P_2, P_3 and P_5) was identified and these parents appeared to be good general combiners for improving most studied traits. Hybrid combinations of these parents might have desirable transgressive segregations, providing that the additive genetic system present in different crosses for increasing grain yield/plant and its components under the two water regimes. For SCA, the desirable inter-and intra-allelic interactions were presented in six crosses combinations ($P_1 \times P_3$, $P_2 \times P_3$, $P_2 \times P_4$, $P_3 \times P_5$, $P_3 \times P_6$ and $P_4 \times P_5$), which showed desirable significant specific combining ability under both irrigation treatments. These crosses might be of interest in barley breeding programs to produce higher yielding lines with tolerance to environmental stresses, since most of them involve at least one good parental combiner for the trait of interest under irrigated and rainfed conditions.

Key words: ***Barley, Rainfed and irrigated conditions, Gene action, Diallel cross, Heterosis, GCA, SCA***.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is considered one of the most important cereal crops in the world with great adaptation in many regions and low input requirements and better adaptability to harsh environment such as drought, soil moisture as well as salinity/alkalinity in newly reclaimed lands and marginal land, barley is known as a poor people crop and also it grown on a large scale in the arid and dry areas (El-Seidy 2003). Also, barley is one of the domesticated cereals after wheat, rice and maize and is the main crop and widely grown under the rainfed areas of the north coastal region and in the newly reclaimed saline soil lands in Egypt which produced 108 thousand MT in 2018/19 (FAO 2019) this crop used for animal feeding and as main human feeding resources especially in arid and semi-arid areas.

In Egypt, water is a vital input for crop production. Introducing high yielding varieties is one of the most important methods for increasing crop yield. The decline in barley productivity might be attributed to adverse environmental conditions such as drought, salinity, reduced soil fertility, and high temperature, as well as certain biotic stresses such as leaf rust, powdery mildew, net blotch, and viral diseases. The lack of adequate genetic variability aggravated the adverse effect of previously mentioned biotic and abiotic stresses (El-Banna 2012). However, the main common stress encountered is the water deficient stress which known as the drought stress (Mahajan and Tuteja 2005). In several studies, it has been shown that the breeding programs for developmental genes are key factors in the determination of yield potential under drought condition (Forster *et al* 2004 and Madakemohekar *et al* 2018).

Genetic condition of different agricultural plants is considered as one of the most essential factors for the success of breeding crops. Furthermore, understanding the mode of gene effects; inheritance, magnitude and interaction is essential to formulate an efficient breeding program for development of superior genotypes (Madakemohekar *et al* 2015). Therefore, understanding the genetic control of drought tolerance is of a great importance for the application of breeding methods in the development of genotypes with improved tolerance (Madhukar *et al* 2018b and Patial *et al* 2018). Genetic system and gene action involved in the expression of yield and yield attributes are reliable in the F_1 generation (Mather and Jinks 1982). Diallel mating especially half diallel provided simple convenient method for estimating genetic parameters (Ghannadha *et al* 1995 and Pal and Kumar 2009). So diallel cross is used to study the genetic diversity and polygenic system of quantitative traits as the most important traits inherited in a quantitative manner (Xing-Yang and Yang 2006). Analysis of combining ability can provide useful information regarding the selection of capable parents in the hybridization program, as well as the methods and strength of the effect of genes governing the expression of certain quantitative traits (Abdel-Moneam and Leilah 2018 and Madhukar *et al* 2018a).Such findings on the traits determining crop productivity may be useful in the development of an efficient breeding program. Therefore, promising crosses are valuable for improvement of targeted traits inside and among populations as well as the production of cultivars (Viana *et al* 1999).

The present investigation aimed to understand the genetic architecture of yield and yield components, nature of gene action and relative magnitude of combining ability of six barley diverse genotypes in addition to their F_1 crosses using diallel cross mating design and identify higher yielding genotypes under irrigated and rainfed conditions.

MATERIALS AND METHODS

Two field experiments were carried out in the two successive seasons 2015/16 and 2016/17 at Maryout Agricultural Research Station of Desert Research Center, North Western Coast, Egypt. Sowing dates were; Nov. 20 and Nov. 25 in the first and second seasons, respectively under rainfed and irrigated conditions to evaluate the response of six genotypes of barley that included one local cultivar (Giza 2000) and five introduced genotypes from ICARDA presented in Table (1). These genotypes were used to obtain all possible 15 F_1 crosses. These genotypes were chosen from our previous screening experiments for drought tolerance according to Farag *et al* (2012)

Table 1. Name, origin, pedigree and/or selection history of the six divergent barley genotypes.

No.	Name	Pedigree and/or selection history	Origin
1	Giza 2000	Giza121*L366/3/1(G117/Bahteem52//G118/FAO86)	EGYPT
2	L14	Lignee527/Arar ICB92-0755-22AP-0AP-6AP-0AP-0AP-1AP-0AP	ICARDA
3	L18	Eldorado//Alanda/Zafraa ICB94-0184-0AP-5AP-0AP-0AP-11AP-0AP	ICARDA
4	L24	Rt013/6/Caco'S'/3/Api/CM67//1594/4/P1382934/5/Lignee527/NK1272 ICB98-0893-0AP-17AP-0AP-7TR-0AP	ICARDA
5	L25	Lignee527/Chn-01//Gusbe/5/Alanda-01/4/W12291/3/Api/CM67//L2966-69 ICB96-0432-0AP-4AP-10TR-1TR-0AP	ICARDA
6	L26	Arar/Rhn-03/8/Api/CM67//Hma-03/4/Cq/Cm//Apm/3/RM1508/5/Attiki/6/Aths/7/ DeirAlla106/Cel/3/BcoMr/Mzq//Apm/5106 ICB94-0486-0AP-15AP-11TR-10TR-0AP	ICARDA

ICARDA: International Center for Agricultural Research in the Dry Area.

In the first season (2015/2016) the six parents were crossed in all possible combinations excluding reciprocals to obtain a total of 15 F_1's, whereas in the second season (2016/2017), the six parents along with their 15 F_1 hybrids (21 entries) were sown under two water regimes (non-stress and stress). In the non-stressed experiment, the plants were irrigated five times after sowing; meanwhile the plants under the stressed experiment were left to rainfed conditions and each experiment was designed in a randomized complete block design with three replications. The experimental plot consisted the parental genotypes along with their 15 F_1 progenies were distributed in 3 and 1 rows, respectively with 1.5 m long and individually spaced 10 cm within and 20 cm between rows. The ordinary cultural practices for barley production through growing season were followed. Table (2) exhibits the meteorological data of the site collected from meteorological desert research lab during each growing season.

Table 2. Monthly average weather data at Maryout during 2015/16 and 2016/17 growing seasons.

Month	T† (C°)	R.H. • %	W.S.♦ at 2m m/sec	Amount Rainfall (mm)
2015/16 season				
Nov.2015 (Mean)	16.77	75.32	2.32	60.80
Dec. 2015(Mean)	13.61	73.87	2.97	28.10
Jan.2016 (Mean)	12.76	73.77	2.83	63.40
Feb. 2016(Mean)	13.89	75.92	3.19	54.30
March. 2016(Mean)	16.68	76.48	3.63	27.10
April.2016 (Mean)	14.23	65.90	2.57	15.90
May.2016(Mean)	19.71	61.51	4.18	14.60
Total				264.20
2016/17 season				
Nov. 2016(Mean)	19.30	70.76	2.45	25.60
Dec. 2016(Mean)	15.00	73.34	2.75	74.30
Jan.2017 (Mean)	13.70	67.46	2.83	47.70
Feb. 2017(Mean)	14.17	72.96	3.11	72.30
March.2017(Mean)	15.63	68.56	3.52	4.40
April.2017 (Mean)	18.20	67.46	4.04	6.10
May.2017 (Mean)	21.63	63.44	3.60	7.60
Total				238.0

†T = Temperature, ● R.H.% = Relative humidity percentage, ♦ W.S. = Wind speed.

Observations and measurements were recorded on ten guarded plants randomly chosen for each plot and genotype in each water regime for the following traits; plant height (cm), spike length (cm), no. of spikeletes/spike, no. of branches/plant, spike weight (g), no. of grains/spike, 1000-grain weight (g), grain yield/plant (g) and straw yield/plant (g).

For testing the significance of genotypic differences, the ordinary randomized complete block analysis was firstly carried out according to Steel and Torrie (1980). The heterosis was expressed as percentage increase or decreases of F_1's over better parent (heterobeltiosis) and mid parent (heterosis) was also calculated according to the methods suggested by Kempthorne (1957). Meanwhile, the estimates of combining ability variances and effects were calculated using Griffing's method 2, model 1(1956), while the ratio of GCA to SCA variance was calculated according to Singh and Choudhary (1985).

RESULTS AND DISCUSSION

Analysis of variance

Mean squares for barley genotypes were highly significant for all studied traits under irrigated and rainfed conditions (Table 3). This indicated to the presence of wide diversity among genotypes and the variability that existed among populations increases the chances for isolating new recombinations in the segregating generation. Similar results were recorded by (Rizza *et al* 2004, Ali *et al* 2009, Eshghi *et al* 2010, Singh 2011, Noshadifard and Zare 2012, El-Shawy *et al* 2013 and Abdel-Moneam and Leilah 2018).

Mean performance

The mean performance results showed that highly significant differences among the studied genotypes for all studied characters Tables (4, 5 and 6). The most of parental genotypes and crosses recorded the highest values under well water treatment compared to rainfed conditions. For plant height the parental genotype P_6 and the two crosses $P_1 \times P_6$ and $P_5 \times P_6$ had the highest values ranged from 85.33 to 55.25 cm under irrigation and rainfed treatments, respectively. While, the parental genotype P_6 registered the highest values 11.00 and 8.05 cm for spike length under both treatments.

Table 3. Mean squares of barley genotypes for different studied traits under irrigated and rainfed treatments.

Traits		SOV	Replication	Genotypes	Error
		df	2	20	40
Irrigated	Plant height (cm)		2.71	143.75**	2.23
	Spike length (cm)		0.005	5.04**	0.01
	No. of spikeletes/spike		0.49	6.83**	0.38
	No. of branches per plant		0.04	4.53**	0.05
	Spike weight (g)		0.15*	1.76**	0.03
	No. of grains per spike		1.78	117.75**	0.73
	1000 grain weight (g)		0.51	56.49**	9.51
	Grain yield per plant (g)		5.59	166.67**	1.70
	Straw yield/plant (g)		27.04	353.73**	3.59
Rainfed	Plant height (cm)		0.24	93.16**	0.59
	Spike length (cm)		0.01	3.30**	0.005
	No. of spikeletes/spike		0.06	5.38**	0.26
	No. of branches per plant		0.23	1.38**	0.04
	Spike weight (g)		0.01	1.12**	0.01
	No. of grains per spike		0.01	93.46**	0.54
	1000 grain weight (g)		1.01	38.04**	6.43
	Grain yield per plant (g)		1.78	20.69**	0.60
	Straw yield/plant (g)		8.58	94.15**	2.91

***, **: Denote significance at $P \leq 0.05$ and 0.01 probability levels, respectively.**

Table 4. Mean performance of Barley genotypes (G) for plant height (cm), spike length (cm) and no. of spikeletes/spike under irrigated and rainfed treatments.

Characters	Plant height (cm)		Spike length (cm)		No. of spikeletes/spike	
Genotypes	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
P_1	81.67	35.25	6.60	4.28	25.33	16.25
P_2	75.00	46.25	9.53	6.68	24.67	17.50
P_3	72.33	48.75	7.53	4.40	22.67	13.25
P_4	54.67	38.25	6.33	4.53	21.67	15.25
P_5	78.33	50.50	9.33	6.10	23.67	16.75
P_6	85.33	55.25	11.00	8.05	26.33	18.75
$P_1 \times P_2$	79.00	54.25	9.57	5.45	26.33	16.75
$P_1 \times P_3$	74.67	42.75	9.30	6.70	26.00	18.50
$P_1 \times P_4$	68.00	47.00	7.83	4.75	27.00	15.75
$P_1 \times P_5$	72.67	50.00	8.73	5.43	25.67	17.50
$P_1 \times P_6$	84.67	57.25	9.13	6.45	24.67	17.50
$P_2 \times P_3$	76.00	47.75	10.33	7.23	26.67	17.75
$P_2 \times P_4$	69.00	49.25	9.60	6.80	25.33	17.50
$P_2 \times P_5$	74.67	53.50	9.53	7.00	24.33	17.75
$P_2 \times P_6$	75.33	53.75	10.40	7.11	27.00	19.50
$P_3 \times P_4$	69.67	48.50	7.90	5.70	25.33	18.50
$P_3 \times P_5$	76.33	53.75	10.60	6.38	26.67	17.25
$P_3 \times P_6$	70.67	51.00	10.63	6.35	24.67	17.50
$P_4 \times P_5$	75.00	50.00	10.07	6.48	25.67	17.50
$P_4 \times P_6$	68.00	49.00	8.33	4.75	22.33	18.00
$P_5 \times P_6$	84.00	56.75	9.53	6.55	24.67	17.75
LSD 5% G	2.46	1.27	0.15	0.11	1.01	0.84

Table 5. Mean performance of Barley genotypes (G) for no. of branches/plant, spike weight (g) and no. of grains/spike under irrigated and rainfed treatments.

Characters	No. of branches/plant		Spike weight (g)		No. of grains/spike	
Genotypes	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
P_1	2.81	2.16	3.31	2.01	65.67	38.00
P_2	2.28	1.59	5.02	3.05	69.33	46.00
P_3	2.11	1.25	4.69	2.07	62.33	34.50
P_4	2.37	2.16	3.59	2.20	55.00	33.25
P_5	2.81	2.27	4.25	2.91	61.67	45.50
P_6	2.49	1.48	5.00	3.65	71.33	51.50
$P_1 \times P_2$	3.77	3.42	4.64	2.32	69.67	40.75
$P_1 \times P_3$	5.35	2.84	5.14	3.36	74.33	51.75
$P_1 \times P_4$	2.37	2.50	4.96	2.31	76.33	49.75
$P_1 \times P_5$	4.56	2.39	3.64	2.57	63.67	46.00
$P_1 \times P_6$	2.98	2.95	4.41	2.88	66.67	47.25
$P_2 \times P_3$	4.21	2.39	5.43	3.44	75.67	50.25
$P_2 \times P_4$	4.56	3.10	5.46	2.41	83.67	52.25
$P_2 \times P_5$	2.72	2.73	4.85	3.39	67.67	50.50
$P_2 \times P_6$	4.79	3.52	5.63	3.78	73.67	46.25
$P_3 \times P_4$	2.81	3.23	5.44	3.01	72.67	44.00
$P_3 \times P_5$	5.70	3.81	5.29	3.04	71.67	51.00
$P_3 \times P_6$	2.89	2.95	5.43	3.64	75.00	50.50
$P_4 \times P_5$	2.98	2.50	5.65	3.83	73.33	50.25
$P_4 \times P_6$	2.11	1.82	3.36	2.19	66.33	44.25
$P_5 \times P_6$	2.54	2.73	3.92	2.22	67.67	45.00
LSD 5% G.	0.39	0.37	0.30	0.20	1.41	1.22

Table 6. Mean performance of Barley genotypes (G) for 1000 grain weight (g), grain yield/plant (g) and straw yield/plant (g) traits under irrigated and rainfed treatments.

Characters	1000 grain weight (g)		Grain yield/plant (g)		Straw yield/plant (g)	
Genotypes	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
P_1	35.64	24.45	5.33	3.99	11.72	8.79
P_2	42.86	30.20	8.38	3.94	18.43	8.67
P_3	42.86	33.28	10.42	2.37	22.92	5.22
P_4	48.69	32.10	8.75	4.12	19.26	9.05
P_5	46.36	30.42	8.04	5.85	17.68	12.88
P_6	42.39	31.55	9.64	4.57	21.21	10.05
$P_1 \times P_2$	41.10	28.85	10.30	7.49	22.65	16.48
$P_1 \times P_3$	46.84	29.40	16.03	7.97	38.26	22.74
$P_1 \times P_4$	36.38	26.67	18.34	5.39	40.34	11.86
$P_1 \times P_5$	46.02	32.92	10.91	5.51	24.00	12.12
$P_1 \times P_6$	36.82	22.02	15.25	7.59	33.54	16.70
$P_2 \times P_3$	48.73	33.52	10.66	6.79	23.46	14.94
$P_2 \times P_4$	44.42	30.23	17.81	10.34	30.56	17.07
$P_2 \times P_5$	41.89	29.94	13.76	9.79	42.59	21.64
$P_2 \times P_6$	43.52	29.15	11.10	7.92	24.41	16.62
$P_3 \times P_4$	47.82	33.19	20.55	8.74	41.46	19.22
$P_3 \times P_5$	49.91	34.88	22.71	11.26	45.28	24.54
$P_3 \times P_6$	49.81	34.75	23.26	10.94	48.54	23.53
$P_4 \times P_5$	46.50	32.86	13.47	8.60	29.63	18.92
$P_4 \times P_6$	44.39	26.08	14.07	3.61	30.95	7.93
$P_5 \times P_6$	47.64	24.16	6.29	5.04	13.83	11.10
LSD 5% G.	1.25	0.80	2.15	1.28	4.73	2.82

In addition, the two crosses $P_2 \times P_6$ and $P_4 \times P_5$ had high means for Spike weight trait. Taking mean performance for the three crosses $P_2 \times P_6$, $P_3 \times P_5$ and $P_2 \times P_4$ had the highest values for no. of spikelets/spike, no. of branches/plant and no. of grains/spike respectively under both treatments. Meanwhile, the three crosses $P_2 \times P_6$, $P_3 \times P_6$ and $P_4 \times P_5$ showed high mean performance for spike weight under the two water treatments. Concerning the two crosses $P_3 \times P_5$ and $P_3 \times P_6$ recorded the highest values for 1000 grain weight, Grain yield/plant and Straw yield/plant under the irrigation and rainfed treatments. Our results are in the same trend with (Eshghi *et al* 2010, Eshghi and Akhundova 2010, Singh 2011, Niazi *et al* 2013, El-Shawy *et al* 2013, Abdel-Moneam and Leilah 2018, Lal *et al* 2018, Madakemohekar *et al* 2018, Madhukar *et al* 2018b, and Naser *et al* 2018).

Heterosis

The Knowledge of degree and magnitude of heterosis is important for design the direction of future breeding programs and to select the most promising crosses which expect to have better segregants in the advance generations for grain yield and its components. In present investigation, the maximum range of positive significant heterosis and heterobeltiosis has been recorded for grain yield/plant and straw yield/plant ranging from 57.39 to 95.37% under irrigated and rainfed conditions (Tables 7, 8 and 9). Desirable and superior hybrids through the different crosses were identified for most of the studied traits.

The extent of heterotic effects for different characters was apparent (Tables 7, 8 and 9). For plant height six crosses, $P_1 \times P_2$, $P_1 \times P_4$, $P_2 \times P_4$, $P_3 \times P_4$, $P_3 \times P_5$ and $P_5 \times P_6$ were recorded significant and positive heterosis and/or heterobeltioses under irrigation and/or rainfed conditions. While, for spike length six crosses, $P_1 \times P_3$, $P_1 \times P_4$, $P_2 \times P_3$, $P_3 \times P_4$, $P_3 \times P_5$ and $P_4 \times P_5$ had significant and positive heterosis under irrigation and rainfed treatments. Furthermore, seven crosses, $P_1 \times P_3$, $P_1 \times P_5$, $P_2 \times P_3$, $P_2 \times P_6$, $P_3 \times P_4$, $P_3 \times P_5$ and $P_4 \times P_5$ gave significant and positive heterosis and heterobeltiosis under both treatments for no. of spikeletes/spike (Table 7).

While, for 1000 grain weight the two crosses $P_3 \times P_5$ and $P_3 \times P_6$ showed highly significant and positive effects for heterosis and heterobiltiosis under both treatments.

Table 7. Estimates of mid parent heterosis and better parent heterosis (heterobeltiosis) of barley for plant height, spike length and no. of spikeletes/spike under irrigated and rainfed conditions.

Characters	Plant height (cm)				Spike length (cm)			
Genotypes	Heterosis		Heterobeltiosis		Heterosis		Heterobeltiosis	
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
$P_1 \times P_2$	0.85	33.13**	-3.27**	17.30**	18.66**	-0.55	0.42	-18.41**
$P_1 \times P_3$	-3.03**	1.79	-8.57**	-12.31**	31.63**	54.38**	23.51**	52.27**
$P_1 \times P_4$	-0.25	27.89**	-16.74**	22.88**	21.11**	7.83**	18.64**	4.86**
$P_1 \times P_5$	-9.16**	16.62**	-11.02**	-0.99	9.60**	4.62**	-6.43**	-10.98**
$P_1 \times P_6$	1.40	26.52**	-0.77	3.62**	3.75**	4.62**	-17.00**	-19.88**
$P_2 \times P_3$	3.17**	0.53	1.33	-2.05**	21.10**	30.51**	8.39**	8.23**
$P_2 \times P_4$	6.42**	16.57**	-8.00**	6.49**	21.06**	21.32**	0.73	1.80*
$P_2 \times P_5$	-2.60**	10.59**	-4.67**	5.94**	1.06	9.55**	0.01	4.79**
$P_2 \times P_6$	-6.03**	5.91**	-11.72**	-2.71**	1.32	-3.46**	-5.45**	-11.68**
$P_3 \times P_4$	9.72**	11.49**	-3.68**	-0.51	14.00**	27.66**	4.91**	25.83**
$P_3 \times P_5$	1.33	8.31**	-2.55**	6.44**	25.74**	21.52**	13.61**	4.59**
$P_3 \times P_6$	-10.35**	-1.92	-17.18**	-7.69**	14.73**	2.01*	-3.36**	-21.12**
$P_4 \times P_5$	12.78**	12.68**	-4.22**	-0.92	28.61**	21.92**	7.73**	6.97**
$P_4 \times P_6$	-2.86**	4.81**	-20.31**	-11.31**	-3.87**	-24.48**	-24.27**	-40.99**
$P_5 \times P_6$	2.65**	7.33**	-1.56	2.71**	-6.25**	-7.42**	-13.36**	-18.63**
Mean	0.27	12.15	-7.53	1.79	13.48	11.34	0.54	-2.16
LSD 5%	2.10		1.08		0.14		0.10	

Characters	No. of spikeletes/spike			
Genotypes	Heterosis	Heterobeltiosis	Heterosis	Heterobeltiosis
	Irrigated	Rainfed	Irrigated	Rainfed
$P_1 \times P_2$	5.32**	-0.74	3.95**	-4.29**
$P_1 \times P_3$	8.33**	25.42**	2.65**	13.85**
$P_1 \times P_4$	14.89**	0.01	6.59**	-3.08**
$P_1 \times P_5$	4.78**	6.06**	1.34*	4.48**
$P_1 \times P_6$	-4.49**	0.02	-6.30**	-6.67**
$P_2 \times P_3$	12.67**	15.45**	8.11**	1.43*
$P_2 \times P_4$	9.32**	6.87**	2.68**	0.02
$P_2 \times P_5$	0.66	3.65**	-1.38*	1.43*
$P_2 \times P_6$	5.88**	7.59**	2.54**	4.00**
$P_3 \times P_4$	14.25**	29.82**	11.73**	21.31**
$P_3 \times P_5$	15.11**	15.00**	12.67**	2.99**
$P_3 \times P_6$	0.69	9.38**	-6.30**	-6.67**
$P_4 \times P_5$	13.23**	9.38**	7.60**	4.48**
$P_4 \times P_6$	-6.96**	5.88**	-15.19**	-4.00**
$P_5 \times P_6$	-1.32*	0.03	-6.30**	-5.33**
Mean	6.16	8.92	1.63	1.60
LSD 5%	0.87		0.72	

***, ** Significant at $P \leq 0.05$ and 0.01, respectively.**

Table 8. Estimates of mid parent heterosis and better parent heterosis (heterobeltiosis) of barley for no. of branches/plant, main spike weight and no. of grains/spike under irrigated and rainfed conditions.

Characters	No. of branches/lant				Main spike weight (g)			
Genotypes	Heterosis		heterobeltiosis		Heterosis		heterobeltiosis	
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
$P_1 \times P_2$	48.13**	82.40**	34.16**	58.33**	11.40**	-8.30**	-7.57**	-23.93**
$P_1 \times P_3$	117.48**	66.57**	90.39**	31.48**	28.50**	64.71**	9.59**	62.32**
$P_1 \times P_4$	-8.49**	15.74**	-15.66**	15.74**	43.77**	9.74**	38.16**	5.00**
$P_1 \times P_5$	62.28**	7.90**	62.28**	5.29**	-3.70**	4.47**	-14.35**	-11.68**
$P_1 \times P_6$	12.45**	62.09**	6.05**	36.57**	6.14**	1.77*	-11.80**	-21.10**
$P_2 \times P_3$	91.80**	68.31**	84.65**	50.31**	11.84**	34.38**	8.17**	12.79**
$P_2 \times P_4$	96.13**	65.33**	92.41**	43.52**	26.83**	-8.19**	8.76**	-20.98**
$P_2 \times P_5$	6.88**	41.45**	-3.20**	20.26**	4.64**	13.76**	-3.39**	11.15**
$P_2 \times P_6$	100.84**	129.32**	92.37**	121.38**	12.38**	12.84**	12.15**	3.56**
$P_3 \times P_4$	25.45**	89.44**	18.57**	49.54**	31.40**	40.98**	15.99**	36.82**
$P_3 \times P_5$	131.71**	116.48**	102.85**	67.84**	18.34**	22.09**	12.79**	4.47**
$P_3 \times P_6$	25.65**	116.12**	16.06**	99.32**	12.07**	27.27**	8.60**	-0.27
$P_4 \times P_5$	15.06**	12.87**	4.51**	6.73**	44.13**	49.90**	30.17**	39.66**
$P_4 \times P_6$	-13.17**	0.01	-15.26**	-15.74**	-21.77**	-25.13**	-32.80**	-40.00**
$P_5 \times P_6$	-4.15**	45.60**	-9.61**	20.26**	-15.24**	-32.32**	-21.60**	-39.18**
Mean	47.20	61.31	37.37	40.72	14.05	13.86	3.53	1.24
LSD 5%	0.31		0.28		0.24		0.14	

Characters	No. of grains/spike			
Genotypes	Heterosis		Heterobeltiosis	
	Irrigated	Rainfed	Irrigated	Rainfed
$P_1 \times P_2$	3.21**	-2.98**	0.49	-11.41**
$P_1 \times P_3$	16.14**	42.76**	13.19**	36.18**
$P_1 \times P_4$	26.51**	39.65**	16.23**	30.92**
$P_1 \times P_5$	0.02	10.18**	-3.05**	1.10
$P_1 \times P_6$	-2.67**	5.59**	-6.53**	-8.25**
$P_2 \times P_3$	14.95**	24.84**	9.14**	9.24**
$P_2 \times P_4$	34.59**	31.86**	20.68**	13.59**
$P_2 \times P_5$	3.31**	10.38**	-2.39**	9.78**
$P_2 \times P_6$	4.75**	-5.13**	3.28**	-10.19**
$P_3 \times P_4$	23.87**	29.89**	16.59**	27.54**
$P_3 \times P_5$	15.60**	27.50**	14.98**	12.09**
$P_3 \times P_6$	12.23**	17.44**	5.15**	-1.94*
$P_4 \times P_5$	25.70**	27.62**	16.74**	11.66**
$P_4 \times P_6$	5.01**	4.42**	-7.01**	-14.08**
$P_5 \times P_6$	1.76*	-7.22**	-5.13**	-12.62**
Mean	12.33	17.12	6.16	6.24
LSD 5%	1.20		1.03	

***, ** Significant at $P \leq 0.05$ and 0.01, respectively.**

Table 9. Estimates of mid parent heterosis and better parent heterosis (heterobeltiosis) of barley for 1000 grain weight, grain yield/plant and straw yield/plant under irrigated and rainfed conditions.

Characters	1000 grain weight (g)				Grain yield/plant (g)			
Genotypes	Heterosis		heterobeltiosis		Heterosis		heterobeltiosis	
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
$P_1 \times P_2$	4.71**	5.58**	-4.11**	-4.47**	50.26**	88.90**	22.91**	87.72**
$P_1 \times P_3$	19.34**	1.85*	9.29**	-11.66**	103.56**	150.63**	53.84**	99.75**
$P_1 \times P_4$	-13.72**	-5.68**	-25.28**	-16.92**	160.51**	32.92**	109.60**	30.83**
$P_1 \times P_5$	12.24	19.99**	-0.73	8.22**	63.20**	11.99**	35.70**	-5.81**
$P_1 \times P_6$	-5.63**	-21.36**	-13.14**	-30.21**	103.74**	77.34**	58.20**	66.08**
$P_2 \times P_3$	13.70**	5.61**	13.70**	0.72	13.40**	115.21**	2.30*	72.34**
$P_2 \times P_4$	-2.96**	-2.95**	-8.77**	-5.83**	107.94**	156.58**	103.54**	150.97**
$P_2 \times P_5$	-6.10**	-1.22*	-9.64**	-1.58*	67.60**	100.00**	64.20**	67.35**
$P_2 \times P_6$	2.10**	-5.59**	1.54*	-7.61**	23.20**	86.13**	15.15**	73.30**
$P_3 \times P_4$	4.47**	1.53*	-1.79*	-0.27	114.40**	169.34**	97.22**	112.14**
$P_3 \times P_5$	11.88**	9.51**	7.66**	4.81**	146.05**	173.97**	117.95**	92.48**
$P_3 \times P_6$	16.86**	7.20**	16.22**	4.42**	131.90**	215.27**	123.22**	139.39**
$P_4 \times P_5$	-2.16**	5.12**	-4.50**	2.37**	60.45**	72.52**	45.83**	36.72**
$P_4 \times P_6$	-2.53**	-18.05**	-8.83**	-18.75**	53.02**	-16.92**	45.95**	-21.01**
$P_5 \times P_6$	7.36**	-22.03**	2.76**	-23.42**	-28.85**	-3.26**	-34.75**	-13.85**
Mean	3.97	-1.36	-1.71	-6.68	78.03	95.37	57.39	65.89
LSD 5%	4.34		3.57		1.83		1.09	

Characters				
Genotypes	Heterosis		Heterobeltiosis	
	Irrigated	Rainfed	Irrigated	Rainfed
$P_1 \times P_2$	50.25**	88.77**	22.90**	87.49**
$P_1 \times P_3$	120.90**	224.63**	66.93**	158.70**
$P_1 \times P_4$	160.43**	32.96**	109.45**	31.05**
$P_1 \times P_5$	63.27**	11.86**	35.75**	-5.90**
$P_1 \times P_6$	103.70**	77.28**	58.13**	66.17**
$P_2 \times P_3$	13.47**	115.12**	2.36**	72.32**
$P_2 \times P_4$	62.17**	92.66**	58.67**	88.62**
$P_2 \times P_5$	135.89**	100.84**	131.09**	68.01**
$P_2 \times P_6$	23.16**	77.56**	15.09**	65.37**
$P_3 \times P_4$	96.59**	169.38**	80.89**	112.38**
$P_3 \times P_5$	123.05**	171.16**	97.56**	90.53**
$P_3 \times P_6$	119.99**	208.19**	111.78**	134.13**
$P_4 \times P_5$	60.42**	72.55**	45.78**	36.65**
$P_4 \times P_6$	52.95**	-16.96**	45.92**	-21.09**
$P_5 \times P_6$	-28.88**	-3.18**	-34.79**	-13.82**
Mean	77.16	94.85	56.50	64.71
LSD 5%	2.66		2.40	

***, ** Significant at P ≤ 0.05 and 0.01, respectively.**

Numbers of desired significant and positive for superior hybrids were found for no. of branches/plant, main spike weight, no. of grains/spike, grain yield/plant and straw yield/plant traits, 12, 7, 8, 12 and 12 crosses, respectively under irrigated and rainfed treatments. On the other hand, three crosses $P_1 \times P_3$, $P_3 \times P_6$ and $P_4 \times P_6$ and five crosses $P_1 \times P_4$, $P_1 \times P_6$, $P_2 \times P_4$, $P_2 \times P_5$ and $P_4 \times P_6$ recorded negative and highly significant heterotic effects under the irrigated and rainfed treatments for plant height and 1000 grain weight, respectively as well as the two crosses $P_4 \times P_6$ and $P_5 \times P_6$ showed significant and negative heterotic effects for most studied traits under both treatments (Tables 8 and 9).

The superiority of hybrids particularly mid parents and over best parent is more useful for commercial exploitation of heterosis and also indicated the parental combinations capable of producing the highest level of transgressive segregants. These observations were also substantiated by earlier reports of several workers, such as, Zhang *et al* (2015), Pesaraklu *et al* (2016), Lal *et al* (2018) and Madhukar *et al* (2018 a).

Combining ability variances

The analysis of variance for combining ability (Table 10) showed highly significant mean squares for both general (GCA) and specific (SCA)combining abilities for all studied traits under both irrigated and rainfed conditions which explain importance of both additive and non-additive gene effects on genetic control of all traits. The variance due to GCA was larger than that of SCA and the ratio of σ^2 GCA/σ^2SCA exceeded the unity for plant height, spike length and 1000 grain weight under both treatments and for no. of spikelets/spike under rainfed conditions as well as spike weight under well-watered one, revealing that the largest part of total genetic diversity associated with different characters is the result of additive and additive×additive types of gene action, so that direct selection could be useful for improving these traits whereas the rest of cases and the four traits, no. of branches/plant, no. of grains/spike, grain yield/plant and straw yield/plant under both treatments gave low ratio (less than unity), indicating the predominance of non- additive gene effects.

Table 10. Mean squares due to general combining ability (GCA), specific combining ability (SCA) for barley genotypes and ratio for a GCA to SCA effects for different studied traits under irrigated and rainfed treatments.

Characters		Plant height (cm)		Spike length (cm)		No. of spikeletes/spike	
SOV	df	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Genotype	20	143.72**	93.16**	5.04**	3.30**	6.83**	5.38**
GCA	5	432.53**	183.67**	12.22**	7.33**	6.00**	3.17**
SCA	15	47.45**	62.99**	2.65**	1.96**	7.10**	6.11**
Error	40	2.23	0.59	0.01	0.005	0.38	0.26
GCA/SCA		9.12	2.92	4.61	3.74	0.85	9.12
Characters		No. of branches/plant		Spike weight (g)		No. of grains/spike	
SOV	df	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Genotype	20	4.53**	1.38**	1.76**	1.12**	117.75**	93.46**
GCA	5	2.37**	0.16**	2.86**	0.78**	74.07**	67.23**
SCA	15	4.22**	1.78**	1.39**	1.24**	132.31**	102.20**
Error	40	0.05	0.04	0.03	0.01	0.73	0.54
GCA/SCA		0.56	0.09	2.06	0.63	0.56	0.66
Characters		1000 grain weight (g)		Grain yield/plant (g)		Straw yield/plant (g)	
SOV	df	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Genotype	20	56.49**	38.04**	166.67**	20.69**	353.73**	94.15**
GCA	5	124.07**	77.88**	66.22**	4.46**	228.44**	19.71**
SCA	15	33.96**	24.76**	73.44**	25.49**	395.50**	118.96**
Error	40	9.51	6.43	1.70	0.60	3.59	2.91
GCA/ SCA		3.65	3.15	0.90	0.17	0.58	0.17

***, ** Significant at P ≤ 0.05 and 0.01, respectively.**

It could be concluded that both additive and dominance genetic components seems to be important in controlling inheritance of the studied traits although the contribution of each component varied according to trait and irrigation technique. These findings are in agreement with those of Ahmed (1998), Afiah and Abdel-Hakim(1999), Budak(2000), Sharma *et al* (2002), El-Seidy (2003), Ali *et al* (2007), El-Sayed *et al* (2007), Madakemohekar *et al* (2015), Zhang *et al* (2015) , Pesaraklu *et al* (2016), Sultan *et al* (2016), Abdel-Moneam and Leilah (2018), Madhukar *et al* (2018 a), and Patial *et al* (2018) who reported that both additive and non additive gene effects were significant for most of the studied traits.

General combining ability (GCA) effects

The estimates of GCA effects for parents presented in Table (11) indicated to the presence of more genes for dwarfness (negative and significant) in two parental genotypes P_3 and P_4 under both water levels, while more genes were found for tallness than other (positive and significant) in four parental genotypes P_1, P_2, P_5 and P_6 under well-watered and/or rainfed treatments. Also, significant to highly significant and positive effects of GCA exhibited in P_2, P_5 and P_6 for spike length and two genotypes P_1 and P_2 under irrigated conditions and P_5 and P_6 under rainfed conditions for no. of spikeletes/spike, as well as, the two genotypes P_2 and P_3 for spike weight under both treatments. For no. of grains/spike the two parents P_2 and P_6 under both treatments and P_3 and P_5 under irrigated and rainfed conditions, respectively. Moreover, P_3 under both treatments for 1000 grain weight, grain yield/plant and straw yield/plant traits and P_5, P_2 and P_4 under irrigated conditions for the three traits respectively had significant and positive effects of GCA. These results cleared that among the parental set three genotypes, P_2, P_3 and P_5 are considered to be the best parental genotypes for most studied traits under both water regimes, indicating that these genotypes were promising parents as showing high GCA effects, i.e. represent the fixable component of genetic variance and so, these parents may be useful in hybrid breeding programs for improving the grain yield under both stress and non-stress conditions. In this regard, Jezowshi *et al* (2001), Baghizadeh *et al*(2003), Islam and Darrah(2005), Rohman *et al* (2006), Ordas *et al* (2008), Hassan (2009), Amer (2010), Kakani and Sharma (2010), Aghamiri *et al* (2012), Sultan *et al* (2016), Abdel-Moneam and Leilah (2018), Madhukar *et al* (2018 a), and Patial *et al* (2018) found similar trends.

Tale 11. Estimates of general combining ability effects for various traits under irrigated and rainfed conditions.

Characters	Plant height (cm)		Spike length (cm)		No. of spikeletes/spike	
Genotypes	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
P_1	2.59**	-2.94**	-0.77**	-0.63**	0.60**	-0.30**
P_2	0.29	0.97**	0.57**	0.57**	0.43**	0.14
P_3	-1.21**	-0.63**	-0.01	-0.15**	-0.11	-0.33**
P_4	-7.83**	-3.25**	-0.94**	-0.61**	-0.82**	-0.27**
P_5	2.21**	2.34**	0.40**	0.22**	-0.15	0.20*
P_6	3.96**	3.50**	0.76**	0.61**	0.06	0.57**
SE[g(i)]	0.28	0.14	0.02	0.01	0.11	0.09
SE[g(i)-g(j)]	0.43	0.22	0.03	0.02	0.18	0.15
Characters	No. of branches/plant		Spike weight (g)		No. of grains/spike	
Genotypes	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
P_1	0.21	0.07	-0.44**	-0.33**	-0.72**	-1.42**
P_2	0.20	0.08	0.40**	0.16**	2.65**	0.65**
P_3	0.32	-0.06	0.42**	0.08**	0.78**	-0.54**
P_4	-0.49	-0.01	-0.16**	-0.08**	-0.68**	-2.23**
P_5	0.03	0.04	-0.19**	0.10**	-2.55**	1.61**
P_6	-0.26	-0.13	-0.04	0.08**	0.53**	1.93**
SE[g(i)]	0.40	0.22	0.03	0.02	0.16	0.14
SE[g(i)-g(j)]	0.61	0.34	0.05	0.03	0.25	0.21
Characters	1000 grain weight (g)		Grain yield/plant (g)		Straw yield/plant (g)	
Genotypes	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
P_1	-3.97**	-2.68**	-0.62	-0.37	-2.63**	-0.73*
P_2	-0.60	0.61	2.39**	0.21	-0.46**	0.45
P_3	2.45**	2.51**	1.81**	1.55**	3.33**	1.14**
P_4	0.84	0.63	-1.32**	-0.22	4.28**	-0.41
P_5	1.69**	0.30	-0.91	0.35	-2.94**	0.72*
P_6	-0.40	-1.37**	-1.35**	-0.52	-1.57**	-1.17**
SE[g(i)]	0.57	0.47	2.41	0.47	0.14	0.32
SE[g(i)-g(j)]	0.89	0.73	2.73	0.73	0.22	0.49

***, ** Significant at P≤0.05 and 0.01, respectively.**

Specific combining ability (SCA) effects

Effects of specific combining ability in different crosses are given in Tables (12, 13 and 14). The results revealed that under well-watered and/or rainfed levels for plant height, the crosses ($P_1 \times P_3$, $P_1 \times P_5$, $P_2 \times P_3$, $P_2 \times P_5$, $P_2 \times P_6$, $P_3 \times P_6$ and $P_4 \times P_6$) attained negative and significant SCA effects, toward dwarfness; while the six crosses ($P_1 \times P_2$, $P_1 \times P_6$, $P_2 \times P_4$, $P_3 \times P_4$, $P_4 \times P_5$ and $P_5 \times P_6$) showed significant positive effects under both treatments, toward tallness. However, for spike length the following crosses ($P_1 \times P_2$, $P_1 \times P_4$ and $P_3 \times P_6$) under well-watered as well as ($P_1 \times P_6$, $P_2 \times P_5$ and $P_3 \times P_4$) under rainfed and ($P_1 \times P_3$, $P_2 \times P_3$, $P_2 \times P_4$, $P_3 \times P_5$ and $P_4 \times P_5$) crosses under both levels had positive and significant effects. Moreover, for no. of spikeletes/spike the three crosses ($P_1 \times P_4$, $P_2 \times P_4$, $P_2 \times P_6$ and $P_4 \times P_5$) under well-watered, the cross $P_1 \times P_3$ under rainfed and the three crosses ($P_2 \times P_3$, $P_3 \times P_4$ and $P_3 \times P_5$) under the two irrigation treatments showed positive and significant effects (Table 12).

Table 12. Estimates of specific combining ability effects for plant height, spike length and no. of spikeletes/spike traits under irrigated and rainfed conditions.

Characters	Plant height (cm)		Spike length (cm)		No. of spikeletes/spike	
Genotypes	irrigated	Rainfed	irrigated	Rainfed	irrigated	Rainfed
$P_1 \times P_2$	1.60*	9.75**	0.64**	-0.54**	0.22	-0.36
$P_1 \times P_3$	-1.23	-3.15**	0.95**	1.43**	0.43	1.86**
$P_1 \times P_4$	-1.28	3.72**	0.41**	-0.07**	2.14**	-0.95**
$P_1 \times P_5$	-6.65**	1.13**	-0.03	-0.21**	0.15	0.33
$P_1 \times P_6$	3.60**	5.22**	0.01	0.42**	-1.06**	-0.04
$P_2 \times P_3$	2.39**	-2.06**	0.64**	0.76**	1.27**	0.67**
$P_2 \times P_4$	2.02**	2.07**	0.84**	0.78**	0.64*	0.36
$P_2 \times P_5$	-2.35**	0.72	-0.57**	0.24**	-1.03**	0.14
$P_2 \times P_6$	-3.44**	-0.18	-0.06	-0.20**	1.44**	-0.73**
$P_3 \times P_4$	4.19**	2.91**	-0.28**	0.40**	1.18**	2.83**
$P_3 \times P_5$	0.81	2.57**	1.08**	0.26**	1.85**	1.36**
$P_3 \times P_6$	-6.60**	-1.34**	0.75**	-0.16**	-0.36	-0.01
$P_4 \times P_5$	6.10**	1.44**	1.48**	0.81**	1.56**	0.30
$P_4 \times P_6$	-2.65**	-0.71	-0.62**	-1.30**	-1.99**	0.42
$P_5 \times P_6$	3.31**	1.44**	-0.76**	-0.33**	-0.31	-0.29
SE[s(i,j)]	0.76	0.39	0.05	0.04	0.31	0.26
SE[s(i,j)-s(i,k)]	0.86	0.59	0.06	0.05	0.35	0.39
SE[s(i,j)-s(k,l)]	0.41	0.25	0.02	0.01	0.25	0.18

***, ** Significant at $P \leq 0.05$ and 0.01, respectively.**

Table 13. Estimates of specific combining ability effects for no. of branches/plant, spike weight and no. of grains/spike traits under irrigated and rainfed conditions.

Characters	No. of branches/plant		Spike weight (g)		No. of grains/spike	
Genotypes	irrigated	Rainfed	irrigated	Rainfed	irrigated	Rainfed
$P_1×P_2$	0.08	0.80	-0.04	-0.38**	-1.95**	-4.60**
$P_1×P_3$	1.54	0.26	0.54**	0.74**	4.59**	7.59**
$P_1×P_4$	-0.63	-0.12	0.84**	-0.15*	8.05**	7.28**
$P_1×P_5$	1.04	-0.29	-0.45**	-0.07	-2.74**	-0.32
$P_1×P_6$	-0.25	0.44	0.17	0.26**	-2.82**	0.62
$P_2×P_3$	0.41	-0.21	0.09	0.33**	2.56**	4.03**
$P_2×P_4$	1.57	0.66	0.50**	0.74**	12.02**	3.71**
$P_2×P_5$	-0.80	0.04	-0.09	0.27**	-2.11**	2.12**
$P_2×P_6$	1.56	1.00	0.54**	-0.70**	0.81	-2.44**
$P_3×P_4$	-0.30	0.93	0.46**	0.14*	2.89**	0.65
$P_3×P_5$	2.07	0.86	0.33**	-0.01	3.76**	3.81**
$P_3×P_6$	-0.45	0.57	0.32**	0.71**	4.01**	5.00**
$P_4×P_5$	0.16	-0.10	0.98**	0.95**	6.88**	6.75**
$P_4×P_6$	-0.42	-0.61	-1.16**	-0.68**	-3.20**	-1.57**
$P_5×P_6$	-0.52	0.25	-0.58**	-0.83**	0.01	-4.66**
SE[s(i,j)]	1.09	0.60	0.09	0.06	0.44	0.38
SE[s(i,j)-s(i,k)]	1.62	0.90	0.10	0.09	0.65	0.56
SE[s(i,j)-s(k,l)]	0.84	0.42	0.03	0.04	0.27	0.15

***, ** Significant at $P \leq 0.05$ and 0.01, respectively.**

Based on SCA effects for spike weight the crosses ($P_1×P_4$, $P_2×P_6$ and $P_3×P_5$) under irrigated conditions, ($P_1×P_6$, $P_2×P_3$ and $P_2×P_5$) as well as ($P_1×P_3$, $P_2×P_4$, $P_3×P_4$, $P_3×P_6$ and $P_4×P_5$) under irrigated and rainfed exhibited significant and positive effects. For no. of grains/spike seven crosses ($P_1×P_3$, $P_1×P_4$, $P_2×P_3$, $P_2×P_4$, $P_3×P_5$, $P_3×P_6$ and $P_4×P_5$) gave the highest positive and significant effects under both treatments. While the cross $P_1×P_3$ under well-watered as well as two crosses ($P_1×P_5$ and $P_3×P_6$)

under both treatments recorded significant and positive effects for 1000 grain weight. Meanwhile, the three crosses (P_1×P_3, P_2×P_4 and P_3×P_5) showed significant and positive effects under well- watered and rained treatments for grain yield/plant and straw yield/plant (Tables 13 and 14). These crosses exhibited higher yield and one of the parents in each cross was a good general combiner indicating that such combinations are expected to produce desirable transgressive segregants. These outcomes were corroborated by similar reports of Jui *et al (*1997), Choo *et al* (2001), Kularia and Sharma (2005), Ali *et al* (2009); Hassan (2009), Amer (2010), Eshghi Akhundova (2010), Madakemohekar *et al* (2015), Pesaraklu *et al* (2016), Sultan *et al* (2016), Abdel-Moneam and Leilah (2018), Madhukar *et al* (2018 a) and Patial *et al* (2018).

Table 14. Estimates of specific combining ability effects for 1000 grain weight, grain yield/plant and straw yield/plant traits under irrigated and rainfed conditions.

Characters	1000 grain weight (g.)		Grain yield/plant (g.)		Straw yield/plant (g.)	
Genotypes	irrigated	Rainfed	irrigated	Rainfed	irrigated	Rainfed
P_1×P_2	1.36	0.89	0.98	0.89	-2.87**	2.00*
P_1×P_3	4.04**	-0.46	3.88**	3.41**	5.96**	7.57**
P_1×P_4	-4.80**	-1.31	-0.42	-0.77	10.08**	-1.76*
P_1×P_5	3.99*	5.27**	3.51**	-1.22	0.96**	-2.63**
P_1×P_6	-3.12*	-3.96**	-0.64	1.73	9.13**	3.84**
P_2×P_3	3.56**	1.37	3.24**	-0.73	-8.01**	-1.42
P_2×P_4	-0.13	0.96	5.47**	4.19**	13.14**	9.26**
P_2×P_5	-4.51**	-1.00	-3.65	0.65	18.39**	1.61
P_2×P_6	0.21	-0.12	9.24**	1.48	-2.16**	2.57**
P_3×P_4	0.22	0.02	0.02	1.66	13.25**	3.72**
P_3×P_5	1.46	-0.96	6.09**	3.61**	1.29**	7.02**
P_3×P_6	3.45*	3.58**	-0.26	3.01**	12.18**	6.79**
P_4×P_5	-0.34	1.90	3.03**	1.72	-0.31	3.85**
P_4×P_6	-0.36	-3.21**	-4.31**	-2.40**	-0.36	-5.26**
P_5×P_6	2.05	-4.80**	-2.18	-1.54	-10.26	-3.21**
SE[s(i,j)]	1.58	1.30	1.61	1.30	0.39	0.87
SE[s(i,j)-s(i,k)]	2.36	1.94	1.86	1.94	0.59	1.30
SE[s(i,j)-s(k,l)]	1.24	1.07	1.34	1.12	0.19	0.46

***, ** Significant at $P \leq 0.05$ and 0.01, respectively.**

In conclusion, results showed that some yield components are more important for yield expression than others. In the selection program, however adjustments up to the desired levels of each component may have to be made in order to obtain the maximum grain yield potential. The six crosses $P_1 \times P_3$, $P_1 \times P_6$, $P_2 \times P_4$, $P_3 \times P_4$, $P_3 \times P_5$ and $P_3 \times P_6$ showed high SCA effects might include only one good combiner. such combinations might have desirable transgressive segregations, providing that the additive genetic system present in the crosses are acting in the same direction to reduce un-derisible plant characteristics and maximize the characters if interest which could be important in barley breeding programs for tolerance to environmental stresses and yield improvement.

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القدرة على التآلف فى بعض التراكيب الوراثية من الشعير تحت الظروف المطرية والرى العادي

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أجرى هذا البحث بهدف دراسة مكونات التباين الوراثى فى ستة تراكيب وراثية (أصناف وسلالات) متباعدة وراثيا وكافة الهجن الدائرية دون العكسية (١٥ هجين) من الشعير فى الجيل الأول للعديد من الصفات: إرتفاع النبات، طول السنبلة، عدد السنيبلات/سنبلة، عدد الأفرع/نبات، متوسط وزن السنبلة، عدد الحبوب/سنبلة، وزن الـــ ١٠٠٠ حبة، محصول الحبوب/نبات ومحصول القش /نبات. تم زراعة الآباء وإجراء التهجينات بمحطة بحوث مريوط، مركز بحوث الصحراء – الساحل الشمالي الغربي – مصر، للحصول على بذور الجيل الأول في موسم ٢٠١٥/١٦، كما تم زراعة الأباء وهجن الجيل الأول وتقييمها فى موسم ٢٠١٦/١٧ فى تجربتين منفصلتين ذات تصميم القطاعات الكاملة العشوائية فى ثلاث مكررات الاولى تحت ظروف الرى المطرى والثانية تحت ظروف الرى العادى. إستخدم تحليل جريفنج ١٩٥٦ الموديل الأول – الطريقة الثانية فى تحليل النتائج وراثيا ويمكن تلخيص النتائج فيما يلى: أظهرت النتائج وجود تباين واسع بين التراكيب الوراثية المدروسة، وسجلت معنوية عالية لتباين لكل الصفات تحت الدراسة في الآباء وهجن الجيل الأول ولقد اختلفت التراكيب الوراثية تحت الدراسة فيما بينها فى معظم الصفات تحت الدراسة تحت كلا من معاملتي الري، بينما اشارت النتائج الى وجود قوة هجين عالية وتفوق الهجن الناتجة على متوسط الابوين والاب الافضل وخاصة لصفتي محصول الحبوب ومحصول القش/نبات والهامة تحت معاملتي الري الكامل وتحت الظروف المطرية باستثناء الهجينين $P_4\times P_6$ و$P5\times P_6$. اشار تحليل التباين الراجع للقدرة العامة والخاصة على التآلف الى وجود معنوية لكل الصفات تحت الدراسة. وكانت النسبة بين تباين القدرة العامة والخاصة على التآلف ذات قيم عالية نسبياً (أعلى من الوحدة) لمعظم الصفات تحت الدراسة مما يدل على أهمية الفعل الجينى المضيف، المضيف×المضيف تحت معاملتي الرى. اوضحت النتاج الى تميز ثلاثة آباء (الثانى والثالث والخامس) والتى لها قدرة عالية على الإئتلاف العام لمعظم الصفات تحت الدراسة، وبالتالي يمكن الحصول على إنعزال متجاوز الحدود فى الأجيال الإنعزالية المتقدمة لهجن هذه الآباء والحصول على تراكيب وراثية عالية المحصول وذات قدرة عالية على تحمل الاجهادات البيئية. كما كانت تأثيرات القدرة الخاصة على الائتلاف معنوية لعدد ستة هجن ($P_1\times P_3$، $P_2\times P_3$، $P_2\times P_4$، $P_3\times P_5$، $P_3\times P_6$ و $P_4\times P_5$). مما يمكن معه الإستفادة من هذه الهجن فى برنامج التربية لإنتاج سلالات ذات محصول عالي وأكثر مقاومة للإجهادات البيئية وخاصة لوجود أب أو أكثر لها قدرة عالية على توريث صفاتها لهذه الهجن، وذات قدرة عامة على الإئتلاف عالية بالنسبة للصفات تحت الدراسة.