SINAI Journal of Applied Sciences 11 (5) 2022 879-890

Available online at www.sinjas.journals.ekb.eg

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SINAI Journal of Applied Sciences

Print ISSN 2314-6079
Online ISSN 2682-3527

ARU-EGYPT SJAS Trust Science | It Creates

GENETIC ANALYSIS OF DIALLEL CROSS IN WHEAT UNDER TWO LOCATIONS

Mohamed M. Hassan[1*]; M.H. Mubarak[1]; A.S. Attaya[1] and A.I. Yahya[2]

1. Dept. Plant Prod., Fac. Environ. Agric. Sci., Arish Univ., Egypt.
2. Dept. Wheat Res., Inst. Field Crops Res., A.R.C., Egypt.

ARTICLE INFO

Article history:
Received: 19/07/2022
Revised: 31/08/2022
Accepted: 27/10/2022
Available online: 30/10/2022

Keywords:
Wheat,
(*Triticum aestivum* L.),
Diallel analysis,
Gene action,
combining ability.

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ABSTRACT

Heterosis and nature of genetic effects on plant growth and some yield characters were studied in a 6x6 diallel crosses, without reciprocals, in the F_1 generation in wheat to define and select efficient and prospective materials to be used in hybridization programs in order to improve grain yield of wheat in Egypt. Parents and F_1 were evaluated using a randomized complete block design (RCBD) with three replications for quantitative characters in 2019/2020 season. Significant genotypes mean squares of parents and crosses were obtained for all characters. Significant heterosis in F_1 generation was obtained for all studied characters. The heterosis of grain weight/ plant relative to better parent varied from 16.50 to 33.95% in F_1 crosses. Two crosses, *viz*. P_3xP_5 and P_5xP_6 had the best values of heterosis for total yield. General (GCA) and specific (SCA) combining ability mean squares were significant for all characters except No. of tellers/plant. Besides, MSe (Mean Square error) (GCA)/ MSe (SCA) ratios indicated the relative importance of additive gene action in their inheritance for maturity date and height up to flag leaf in two locations, No. of plants in location one, total plant weight and straw. The two parents P_2 and P_3 gave the highest positive significant ĝi effects for total yield/plant in F_1 generation. The three crosses P_1xP_3, P_3xP_5 and P_5xP_6 showed significantly desirable heterotic effects for most studied traits.

INTRODUCTION

Wheat is the most important cereal crop in Egypt. Increasing wheat production to narrowing the gap between production and consumption is vital in Egypt. Big variation in wheat productivity in different parts of the country should be reduced to achieve a projected high productivity, through diversification of wheat breeding programs and developing new set of wheat cultivars with high yielding.

Heterosis is a complex phenomenon, which depends on the balance of different combinations of gene effects as well as on the distribution of plus and minus alleles in the parents of a mating system. In self-pollinated crops, like wheat, the scope for utilization of heterosis mainly depends upon the direction and magnitude of heterosis. Heterosis over better parent may be useful in identifying the best crosses but these hybrids can be of immense practical value if they involve the best cultivars of the area **(Prasad *et al.*,1998)**. Production of wheat hybrid seed is expensive and the economics of the commercial production of hybrid wheat have not yet been worked out. Further advancement in yield of this important species requires adequate information regarding the nature of the combining ability of the parents available in a wide array of genetic material to be used in the hybridization programme and also the nature of gene action involved in the expression of traits of economic importance.

* **Corresponding author: E-mail address:** manzer2050@gmail.com
https://doi.org/ 10.21608/SINJAS.2022.151046.1132

According to **Arunachalam (1976), Baker (1978), Esmail (2002), Joshi *et al*. (2004), Hasnain *et al.* (2006), Farooq *et al* (2010), El-Hosary and Nour El-Deen (2015), Al-Saadoon *et al.* (2017)** as well as **El-Gammaal and Yahya (2018),** the combining ability is a most reliable biometrical tool to circumvent plant breeding programs. The diallel analysis also provides a unique opportunity to test a number of lines in all possible combinations.

The present study aimed at estimating heterosis in F_1 and comparing combining ability obtained those of F_1 resulting from a set of diallel crosses for certain quantitative traits of wheat.to be used in breeding programs in order to improve wheat productivity.

MATERIALS AND METHODS

Six parents of bread wheat were selected for this study representing a wide range of variability. The code number, names, and pedigree for the genotypes are presented in Table 1.

These parents were crossed in all possible combinations excluding reciprocals during 2018/2019 growing season, giving seeds of 15 crosses from F_1. In 2019/2020 season, the experiment involved parents and F_1 crosses, under two locations the first location was planting in El-Arish, location one (L1) and the second location was planting in Etay El-Baroud location (L2). The experiment was conducted in a randomized complete block design with three replications. Plots of parents and F_1's consisted of three rows, with 3 meter long and 30 cm apart, plants within row were 20 cm apart. The recommended agricultural practices for wheat production were applied. Data were recorded on individual plant basis: 10 for F_1 and parents were chosen randomly from each plot. The following traits were measured: Days to maturity, number of tellers/plant, height to flag leaf, number of spikelets/spike, total grain and straw weight/ plant.

Heterosis relative to better parent was computed according to **Bhatt (1971)** as a deviation of F_1 mean performance from the better parent mean value. The general and specific combining ability estimates were determined according to **Griffing (1956)** for method 2 model 1.

RESULTS AND DISCUSSION

Analysis of variance of F_1 generations for all studied characters is shown in Table 2. Genotypes, parents and crosses mean squares were significant for all traits in F_1 generation. The parents *vs* crosses mean squares were highly significant for most characters studied in the F_1 under the location 1. Significant differences among genotypes for total yield and related characters in different sets of material of wheat were reported by **Joshi *et al*. (2004), Seleem and Koumber (2011), El-Hosary and Nour El Deen (2015), AL Saadoon *et al*. (2017) as well as El-Gammaal and Yahya (2018).**

Mean performance values of the parents and F_1 generation for all traits are presented in Table 3. For maturity date, the F_1 hybrids of P_2xP_3, P_2xP_5 and P_2xP_6 had the lowest values under the two locations and in combined analysis, respectively, hybrid P_2xP_5 was the latest cross in days to maturity.

For plant heights up to flag leaf, the F_1 hybrid: (P_1x P_5) showed the lowest value. On the other hand, the hybrids P_1xP_3 and P_3 x P_6 had the highest values under the two locations.

F_1 hybrids (P_3xP_5, $P_4xP_6$and P_5xP_6) had the highest number of tellers/plant. For number of spikelets/spike, F_1 hybrids of P_1xP_3, P_1xP_5 and P_3xP_5 has the highest values for this character. The F_1 hybrid P_1xP_3, P_1xP_4, P_3 x P_5 and P_5xP_6 were the highest hybrids for total yield/plant. As for straw yield, the F_1 hybrids P_1xP_3, P_2xP_6 and P_5xP_6 exhibited the highest weight.

Table 1. The code number, name, pedigree and selection history of the studied parental bread wheat varieties

No.	Variety	Pedigree	Origin
1	**Giza 171**	Sakha 93 / Gemmeiza9 GZ003-101-1GZ-1GZ-2GZ-0GZ	**Egypt**
2	**Sakha 95**	PASTOR//STTE/MO/3/CHEN/AEGILOPSSQUARROSA(TAUS)// BCN/4/WBLL1.	**Egypt**
3	**Misr 3**	ATTILA*2/PBW65*2/KACHU	**Egypt**
4	**Misr 2**	SUPER-KAUZ/BAVIACORA-92[3589][3686]	**Egypt**
5	**Giza 168**	MRl/BUG/SEPICM933046-8M-OY-OM•2Y-O3-OGZ	**Egypt**
6	**Sakha 8**	Cn067//SN64/KLRE/3/8156 PK3418-65-15-05	**Egypt**

Table 2. Significance of mean squares from ordinary analysis for all characters studied in F1 generation

			Maturity date			No. of tillers			Height to flag leaf (cm)		Number of spikelets		
S.O.V	**S**	**C**	**L1**	**L2**	**Comb.**	**L1**	**L2**	**Comb**	**L1**	**L2**	**L1**	**L2**	**Comb**
Location		1			32.51**			125.28**					70.07**
Rep.xloca	2	4	1.19	1.59*	1.39*	0.14	6.22**	3.18**	73.83**	0.71	0.19	1.83**	1.01**
Genotypes	20	20	14.35**	10.65**	5.31**	15.98**	10.02**	4.16**	65.40**	28.55**	17.60**	2.31**	1.97**
Genotypes x loca		20			19.69**			21.84**					17.94**
Parents	5	5	14.89**	7.96**	4.78**	6.10**	11.26**	1.55**	137.18**	31.88**	32.00**	2.02**	3.26**
pare x loc		5			18.06**			15.81**					30.76**
Crosses	14	14	14.18**	12.37**	5.77**	20.36**	6.37**	4.59**	43.99**	28.23**	10.70**	2.54**	1.19**
cro x loc		14			20.79**			22.14**					12.05**
Pvscross	1	1	14.03**	0.06	1.54	4.01**	54.89**	11.07**	6.34	16.36**	42.17**	0.42	6.37**
P vs F1 x loc		1			12.55**			47.83**					36.22**
Error	40	80	0.61	0.45	0.53	0.34	0.46	0.40	5.47	0.75	0.19	0.25	0.22
Total	62	125	5.06	3.78			5.38	3.73	27.01	9.72	5.81	0.96	

Table 2. Cont.

			Biological yield/ plant (g)		Straw yield (g)		Length of flag region (cm)	
S.O.V	**S**	**C**	**L1**	**L2**	**L1**	**L2**	**L1**	**L2**
Location		1			10.45	644.68**	33.92**	7.87
Rep.xloca	2	4	6.30	1042.73**	174.31**	332.80**	51.02**	36.37**
Genotypes	20	20	367.34**	640.18**				
Genotypes x loca		20						
reps x genotypes x location		80			84.73**	570.82**	69.29**	27.92**
Parents	5	5	85.20**	1171.10**				
pare x loc		5			186.56**	260.84**	46.58**	38.21**
Crosses	14	14	441.56**	488.71**				
cro x loc		14			450.68**	150.11	21.81*	52.79**
Pvscross	1	1	738.94**	106.08				
P vs F1 x loc		1			5.42	51.15	5.13	2.57
Error	40	80	5.56	75.36	60.06	161.15	20.86	13.64
Total	62	125	122.29	288.76	10.45	644.68**	33.92**	7.87

L1: refer to El-Arish L2: refer to Etay El-Baroud

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

Table 3. Mean performance of all studied genotypes (parents and F1 generation) for all studied traits

Trait		MD			No. of tillers			Height to flag leaf (cm)		Number of spikelet			Biological yield/ plant (g)		Straw yield (g)		length of flag region (cm)	
Genotype		L1	L2	Comb.	L1	L2	Comb.	L1	L2	L1	L2	Comb.	L1	L2	L1	L2	L1	L2
1	P1	129.67	130.33	130.00	9.00	14.23	11.62	65.33	73.17	25.00	21.33	23.17	59.95	95.50	37.30	53.00	30.00	31.00
2	P2	125.67	127.33	126.50	10.00	16.41	13.21	55.13	74.78	25.00	22.67	23.83	59.11	122.50	32.03	70.83	32.71	32.22
3	P3	130.00	132.33	131.17	12.33	15.29	13.81	47.08	70.50	17.00	23.67	20.34	46.72	110.00	24.73	67.50	40.16	30.00
4	P4	131.00	130.33	130.67	12.61	11.75	12.18	51.97	67.00	25.00	23.33	24.17	49.33	74.17	23.85	40.00	40.41	31.33
5	P5	132.00	130.67	131.33	10.69	11.48	11.09	46.97	68.00	21.00	22.29	21.65	52.69	73.78	34.01	39.67	36.00	24.55
6	P6	131.00	129.67	130.33	10.00	13.90	11.95	53.44	67.33	21.00	22.67	21.83	51.11	85.00	28.53	44.17	29.67	33.17
7	1*2	131.33	130.33	130.83	10.44	11.83	11.14	49.45	70.00	17.00	22.67	19.83	40.00	98.33	19.21	55.83	30.00	31.17
8	1*3	128.33	131.67	130.00	9.19	12.17	10.68	62.06	72.00	19.00	23.33	21.17	47.97	110.83	27.56	62.50	31.08	36.33
9	1*4	128.67	130.67	129.67	6.28	12.10	9.19	59.83	71.67	21.00	22.33	21.67	27.92	102.50	13.17	56.67	30.00	31.50
10	1*5	131.33	133.67	132.50	6.92	10.28	8.60	47.98	65.50	19.83	24.33	22.08	25.86	78.33	14.34	40.83	36.42	22.33
11	1*6	129.67	130.33	130.00	7.19	8.41	7.80	56.02	70.83	21.00	23.00	22.00	34.61	65.00	18.96	30.00	31.62	30.50
12	2*3	126.67	128.33	127.50	10.83	10.31	10.57	53.58	70.76	21.00	20.33	20.67	42.97	76.89	18.63	42.44	30.03	29.20
13	2*4	126.67	131.33	129.00	9.67	12.57	11.12	54.40	69.11	21.00	22.87	21.93	53.67	96.56	29.70	54.22	35.72	33.22
14	2*5	124.33	126.33	125.33	10.00	12.18	11.09	54.35	71.33	21.00	22.00	21.50	42.53	99.17	25.05	55.83	28.73	35.17
15	2*6	125.67	126.33	126.00	11.92	12.28	12.10	58.88	75.00	21.00	21.33	21.17	60.67	88.33	40.47	46.67	31.57	34.00
16	3*4	129.00	130.33	129.67	9.39	11.09	10.24	53.19	73.33	21.00	23.00	22.00	45.92	90.00	27.25	50.00	37.31	35.33
17	3*5	131.00	133.00	132.00	15.42	11.55	13.49	52.86	68.67	25.00	22.00	23.50	70.58	86.67	32.23	41.67	43.83	35.17
18	3*6	129.33	129.33	129.33	9.08	11.86	10.47	52.36	79.00	17.00	23.00	20.00	42.39	99.17	19.34	53.33	32.33	33.00
19	4*5	130.67	130.33	130.50	11.89	11.57	11.73	52.41	68.83	21.00	22.33	21.67	61.39	75.83	35.76	38.33	35.73	36.17
20	4*6	129.00	130.33	129.67	10.00	14.18	12.09	52.32	71.83	21.00	22.00	21.50	43.56	85.83	20.31	45.83	33.04	32.50
21	5*6	131.00	130.33	130.67	15.00	14.30	14.65	50.67	71.00	21.00	22.67	21.83	43.56	105.83	20.31	62.50	35.42	30.50
LSD 5%		1.07	0.93	1.00	0.81	0.94	0.87	3.22	1.19	0.61	0.68	0.64	3.24	11.94	3.20	9.83	3.11	2.20
LSD 1%		1.54	1.33	1.44	1.16	1.35	1.26	4.63	1.72	0.87	0.98	0.93	4.66	17.17	4.61	14.15	4.48	3.17

Heterosis

Mean squares for parents *vs*. crosses in F_1 generation, as an indication of average of heterosis in F_1 for all crosses were significant for all studded treats in location 1 except heights to flag leaf, in location 2, number of tellers/ plant and heights to flag leaf, (Table 2). The heterotic effects relative to better parent are presented in Table 4. The most significant and desirable heterosis relative to better parent was exhibited by three crosses (P_2xP_5, P_2xP_6 and P_4xP_6) for days to maturity, crosses (P_2xP_5), (P_2xP_6) and (P_4xP_6) for No. of tillers/ plant, two crosses (P_3xP_5 and P_3xP_6) for height to flag leaf, crosses (P_1xP_5 and P_3xP_5) for No. of spikelets/ spike, crosses (P_2xP_6) and (P_5xP_6) for straw yield/ plant.

For total biological yield/ plant crosses (P_3xP_5 and P_4xP_5), under location 1, were highly significantly positive, cross (P_5xP_6) under location 2, were highly significantly positive, in addition. These hybrids exhibited heterosis for one or more of the contributing characters. Significant positive heterotic effects relative to higher yielding parent were obtained by **Fonseca and Patterson (1968), Prasad *et al*. (1998), Abdullah *et al.* (2002), El-Hosary and Nour El Deen (2015), Al Saadoon *et al*. (2017), El-Gammaal and Yahya (2018), and Yahya (2020)**.

Table 4. Heterosis percentage relative to better parent for studied traits in the studied F_1wheat crosses

H BP	MD			No. of tillers			Plant height up to flag leaf (cm)		Number of spikelet's			Biological yield/ plant (g)		Straw yield (gm)		Length of flag region (cm)	
	L1	L2	Comb.	L1	L2	Comb.	L1	L2	L1	L2	Comb.	L1	L2	L1	L2	L1	L2
1*2	4.51**	2.36**	3.43**	4.43	-27.89**	-15.65**	-24.32**	-6.39**	-32.00**	0.00	-16.78**	-33.27**	-19.73**	-48.49**	-21.17**	-8.28	-3.27
1*3	-1.03*	1.02**	0.00	-25.46**	-20.41**	-22.66**	-5.02*	-1.59	-24.00**	-1.42	-8.63**	-19.98**	0.76	-26.10**	-7.40	-22.61**	17.19**
1*4	-0.77	0.26	-0.26	-50.24**	-14.99**	-24.58**	-8.42**	-2.05*	-16.00**	-4.30**	-10.35**	-53.43**	7.33	-64.69**	6.92	-25.77**	0.52
1*5	1.29**	2.56**	1.92**	-35.32**	-27.75**	-25.97**	-26.57**	-10.48**	-20.67**	9.17**	-4.68**	-56.86**	-17.98**	-61.56**	-22.96*	1.18	-27.96**
1*6	0.00	0.51	0.00	-28.07**	-40.94**	-34.73**	-14.26**	-3.19**	-16.00**	1.47	-5.04**	-42.26**	-31.94**	-49.18**	-43.40**	5.41	-8.04*
2*3	0.80	0.79*	0.79*	-12.16**	-37.19**	-23.46**	-2.81	-5.38**	-16.00**	-14.10	-13.29**	-27.30**	-37.23**	-41.82**	-40.07**	-25.23**	-9.38*
2*4	0.80	3.14**	1.98**	-23.36**	-23.38**	-15.79**	-1.32	-7.58**	-16.00**	-2.00	-9.24**	-9.21**	-21.18**	-7.25	-23.44**	-11.62**	3.11
2*5	-1.06**	-0.79*	-0.92*	0.00	-25.76**	-16.00**	-1.41	-4.61**	-16.00**	-2.94	-9.79**	-28.06**	-19.05**	-21.78**	-21.17**	-12.16*	9.15*
2*6	0.00	-0.79*	-0.40	19.17**	-25.19**	-8.39*	6.80*	0.29	-16.00**	-5.90**	-11.20**	2.63	-27.89**	26.36**	-34.11**	-3.49	2.51
3*4	-0.77	0.00	-0.77*	-25.55**	-27.45**	-25.85**	2.34	4.01**	-16.00**	-2.83	-8.97**	-6.93*	-18.18**	10.18	-25.93**	-7.68	12.77**
3*5	0.77	1.79**	0.64	25.00**	-24.42**	-2.35	12.28**	-2.60**	19.05**	-7.06**	8.57**	33.95**	-21.21**	-5.22	-38.27**	9.14*	17.22**
3*6	-0.51	-0.26	-0.77*	-26.35**	-22.44**	-24.19**	-2.02	12.06**	-19.05**	-2.83	-8.40**	-17.06**	-9.85	-32.20**	-20.99**	-19.50**	-0.50
4*5	-0.25	0.00	-0.13	-5.73	-1.56	-3.72	0.85	1.23	-16.00**	-4.29**	-10.34**	16.50**	2.24	5.15	-4.17	-11.59**	15.43**
4*6	-1.53**	0.51	-0.51	-20.72**	1.99	-0.78	-2.10	6.68**	-16.00**	-5.71**	-11.03**	-14.78**	0.98	-28.80**	3.76	-18.25**	-2.02
5*6	0.00	0.51	0.26	40.27**	2.85	22.58**	-5.18	4.41**	0.00	0.00	0.00	-17.34**	24.51**	-40.27**	41.50**	-1.61	-8.04*

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

Combining Ability

The analysis of variance for both general (GCA) and specific (SCA) combining ability shows that the mean squares were highly significant for all studied characters in F1 generation except No. of tillers/ plant (Table 5) which indicates the importance of both additive and non-additive gene effects in the inheritance of such characters.

The relative importance of additive and non-additive gene actions is essential for the development of an efficient hybridization program. The concept of combining ability as a measure of gene action refers to the capacity or ability of genotype to transmit superior performance to its crosses. The value of an inbred line depends on its ability to produce superior hybrids in combination with other variety. If both GCA and SCA mean squares are significant, it is vital to determine the type of gene action which is important in determining the performance of progeny. To overcome such situation, the magnitude of mean squares can be used to assume the relative importance of general and specific combining ability mean squares which were highly significant. Hence, GCA/ SCA ratio was used to reveal the nature of genetic variance involved. The ratio of MSGCA/ MSSCA (Table 5) displays the relative importance of additive gene action effects in their inheritance. Therefore, selection for these traits in early generations would be effective in developing the high yield in varieties in wheat breeding programs. The preponderance of additive genetic variation gene action for total yield and its related characters in F_1 generation indicate that the parents involved in these crosses could be selected based on their GCA values. The genetic variance was previously reported to be mostly due to additive for yield traits by **El-Seidy and Hamada (1997)**.On the other hand, the non-additive genetic variance was previously reported to be the most prevalent for plant height by **Abd El-Aty and Katta (2002)**; No. of spike/plant and No. of kernels/ spike by **Abd El-Aty and Katta (2002)**; for 200-grain weight by **Abd El-Aty and Katta (2002)**; For grain yield/ plant by **Siddique *et al*. (2004) and Al Saadoon *et al*. (2017).**

General combining ability effects

General combining ability effects ĝi of individual parent for each trait from F_1 generation are presented in Table 6. The estimates of ĝi effects obtained from F_1 in most cases. High positive response would be of interest for all studied characters except plant height and MD where negative in plants.

The parent P_2 (Sakha 95) exhibited significant desirable ĝi effect among all the tested parents in maturity date, total yield/ plant and straw yield in two locations, No. of spikelets/spike in location 1, No. of tillers/ plant and height to flag leaf, in location 2. The variety P_3 (Misr 3) gave significant positive ĝi effects for No. of tillers/plant and total yield/ plant in location 1, height to flag leaf, total yield/ plant and straw yield in location 2. The parental variety P_5 (Giza 168) expressed significant positive ĝi effects for No. of tillers/ plant, No. of spikelets/spike and straw yield in location 1. The parental P_6 (Sakha 8) expressed significant positive ĝi effects for maturity date, No. of tillers/ plant and plant height up to flag leaf, in location 2. Such results suggested that a great opportunity for selection would be possible for total yield and its components having a semi-dwarf plant height up to flag leaf hence can response to different locations. Therefore, the mean performance of the genotypes could be a reliable and effective indication for their general combining ability effects for most characters. Therefore, selection among the tested parental population for initiating any proposed breeding program could be practiced either on mean performance or ĝi effects basis with similar efficiency. These results are in harmony with those obtained by **Hasnain *et al*. (2006), Seleem (2006), Gurmani *et al*. (2007), El-Shaarawy and Koumber (2010), Seleem and Koumber (2011), El-Hosary and Nour El Deen (2015), Al Saadoon *et al.* (2017) as well as El-Gammaal and Yahya (2018)**.

Specific Combining Ability Effects

Specific combining ability effects ŝij of F_1 for all characters are presented in Table 7.

Table 5. Mean square estimate of combining ability analysis for all studied traits in F1 generation

	Maturity date			No. of tillers			Height to flag leaf (cm)		Number of spikelet's			Biological yield/ plant (g)	
S.O.V	**L1**	**L2**	**Comb.**	**L1**	**L2**	**Comb.**	**L1**	**L2**	**L1**	**L2**	**Comb.**	**L1**	**L2**
GCA	10.66**	7.88**	4.21**	7.82**	1.57**	1.34**	38.70**	11.94**	5.11**	0.36**	0.61**	59.53**	264.48**
SCA	2.83**	2.11**	0.96**	4.49**	3.93**	1.40**	16.17**	8.71**	6.12**	0.90**	0.67**	143.42**	196.36**
GCA / SCA	3.77	3.73	4.40	1.74	0.40	0.96	2.39	1.37	0.83	0.40	0.92	0.42	1.35
Genotypes x Loc.			19.69**			21.84**					17.94**		
GCA x Loc.			14.33**			8.04**					4.86**		
GCA x Loc. /GCA			14.97			5.75					7.24		
SCA x LOC.			3.98**			7.03**					6.35**		
SCA x LOC. / SCA			0.94			5.23					10.35		
GCA x Loc. / SCA x LOC.			3.60			1.14					0.76		
Error	0.20	0.15	0.18	0.11	0.15	0.13	1.82	0.25	0.06	0.08	0.07	1.85	25.12

Table 5. Cont.

			Straw yield (g)		Length of flag region (cm)	
S.O.V	**S**	**C**	**L1**	**L2**	**L1**	**L2**
GCA	5	5	19.09**	138.93**	38.55**	10.87**
SCA	15	15	71.11**	101.60**	9.83**	12.54**
GCA / SCA			0.27	1.37	3.92	0.87
Genotypes x Loc.		20				
GCA x Loc.		5				
GCA x Loc. /GCA						
SCA x LOC.		15				
SCA x LOC. / SCA						
GCA x Loc. / SCA x LOC.						
Error	40	80	1.81	17.05	1.71	0.86

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

Table 6. Estimates of parental general combining ability effects for all studied traits in F1 generation

	Maturity date			No. of tillers			Height up to flag leaf (cm)		Number of spikelet's			Biological yield/ plant (g)	
Parent	**L1**	**L2**	**Comb.**	**L1**	**L2**	**Comb.**	**L1**	**L2**	**L1**	**L2**	**Comb.**	**L1**	**L2**
P1	0.58**	0.78**	0.34**	-1.82**	-0.42**	-0.56**	3.65**	-0.03	0.07	0.08	0.04	-4.74**	0.74
P2	-2.25**	-1.72**	-0.99**	0.03	0.68**	0.18**	0.52	1.15**	0.47**	-0.40**	0.02	2.99**	8.02**
P3	0.04	0.78**	0.20**	0.75**	0.12	0.22**	-1.07*	1.03**	-1.28**	0.16	-0.28**	1.14*	5.44**
P4	0.25	0.32*	0.14*	-0.02	-0.20	-0.05	-0.08	-0.97**	0.97**	0.18	0.29**	-0.38	-5.13**
P5	1.04**	0.49**	0.38**	1.00**	-0.47**	0.13*	-3.07**	-1.90**	0.32**	0.02	0.09*	1.89**	-5.84**
P6	0.33*	-0.64**	-0.08	0.07	0.28*	0.09	0.05	0.72**	-0.53**	-0.05	-0.15**	-0.90*	-3.24
LSD gi 5%	0.29	0.25	0.13	0.22	0.26	0.11	0.88	0.33	0.17	0.19	0.08	0.89	3.27
LSD gi 1%	0.39	0.34	0.17	0.30	0.34	0.15	1.18	0.44	0.22	0.25	0.11	1.19	4.37
LSD gi-gj 5%	0.81	0.70	0.21	0.61	0.70	0.18	2.42	0.90	0.46	0.51	0.13	2.44	8.98
LSD gi-gj 1%	1.08	0.93	0.28	0.81	0.94	0.24	3.24	1.20	0.61	0.69	0.18	3.26	12.01

Table 6. Cont.

	Straw yield (g)		Length of flag region (cm)	
Parent	**L1**	**L2**	**L1**	**L2**
P1	-1.63**	0.15	-2.27**	-1.12**
P2	2.03**	5.76**	-1.98**	0.55
P3	-0.80	4.29**	2.21**	0.78*
P4	-0.88*	-3.19*	1.92**	1.08**
P5	1.85**	-4.01**	1.86**	-1.79**
P6	-0.56	-2.99*	-1.74**	0.51
LSD gi 5%	0.88	2.69	0.85	0.60
LSD gi 1%	1.17	3.60	1.14	0.81
LSD gi-gj 5%	2.41	7.40	2.34	1.66
LSD gi-gj 1%	3.22	9.90	3.13	2.22

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

Table 7. Estimates of specific combining ability effects of the parental combination for all studied traits in F1 generation

	Maturity date			No. of tillers			Height to flag leaf (cm)		Number of spikelet			Biological yield/ plant (g)	
sij=s 1 x 2	**L1**	**L2**	**Comb.**	**L1**	**L2**	**Comb.**	**L1**	**L2**	**L1**	**L2**	**Comb.**	**L1**	**L2**
S 1 x 2	3.86**	1.12**	1.24**	-8.55**	-8.55**	0.27	-8.55**	-2.06**	-4.57**	0.46*	-1.03**	-5.99**	-1.87
S 1 x 3	-1.43**	-0.05	-0.37	5.65**	5.65**	0.00	5.65**	0.07	-0.82**	0.56*	-0.06	3.83**	13.22**
S 1 x 4	-1.31**	-0.59*	-0.47	2.44*	2.44*	-0.48*	2.44*	1.73**	-1.07**	-0.46*	-0.38*	-14.70**	15.45**
S 1 x 5	0.57	2.24**	0.70**	-6.43**	-6.43**	-0.96**	-6.43**	-3.51**	-1.60**	1.70**	0.03	-19.03**	-8.01*
S 1 x 6	-0.39	0.04	-0.09	-1.51	-1.51	-1.31**	-1.51	-0.80*	0.43*	0.44*	0.22	-7.49**	-23.94**
S 2 x 3	-0.27	-0.88**	-0.29	0.30	0.30	-0.79**	0.30	-2.36**	0.78**	-1.96**	-0.30	-8.89**	-28.01**
S 2 x 4	-0.48	2.58**	0.53*	0.14	0.14	-0.25	0.14	-2.01**	-1.47**	0.55*	-0.23	3.32**	2.22
S 2 x 5	-3.60**	-2.59**	-1.55**	3.08**	3.08**	-0.45	3.08**	1.15**	-0.82**	-0.16	-0.25	-10.09**	5.54
S 2 x 6	-1.56**	-1.46**	-1.51**	4.49**	4.49**	0.20	4.49**	2.19**	0.03	-0.75**	-0.36*	10.84**	-7.89*
S 3 x 4	-0.43	-0.92**	-0.34	0.52	0.52	-0.73**	0.52	2.34**	0.28	0.12	0.10	-2.58*	-1.75
S 3 x 5	0.77*	1.58**	0.59*	3.18**	3.18**	0.71**	3.18**	-1.39**	4.93**	-0.72**	1.05**	19.81**	-4.37
S 3 x 6	-0.18	-0.96**	-0.29	-0.44	-0.44	-0.75**	-0.44	6.32**	-2.22**	0.36	-0.47**	-5.59**	5.53
S 4 x 5	0.23	-0.63*	-0.10	1.74	1.74	0.10	1.74	0.77*	-1.32**	-0.41	-0.43*	12.14**	-4.64
S 4 x 6	-0.73*	0.49	-0.06	-1.46	-1.46	0.32	-1.46	1.15**	-0.47*	-0.67**	-0.28	-2.90**	2.76
5*6	0.48	0.33	0.20	-0.13	-0.13	1.42**	-0.13	1.24**	0.18	0.16	0.08	-5.18**	23.47**
LSD Sij 5%	0.67	0.58	0.52	2.00	2.00	0.46	2.00	0.74	0.38	0.42	0.34	2.01	7.41
LSD Sij 1%	0.89	0.77	0.70	2.67	2.67	0.61	2.67	0.99	0.50	0.57	0.45	2.69	9.92
LSD sij-sik 5%	1.20	1.04	0.78	3.61	3.61	0.68	3.61	1.34	0.68	0.76	0.50	3.64	13.40
LSD sij-sik 1%	1.61	1.39	1.04	4.83	4.83	0.91	4.83	1.79	0.91	1.02	0.67	4.87	17.93
LSD sij-skl 5%	1.11	0.96	0.30	3.34	3.34	0.26	3.34	1.24	0.63	0.71	0.19	3.37	12.41
LSD sij-skl 1%	1.49	1.29	0.39	4.47	4.47	0.34	4.47	1.66	0.84	0.95	0.25	4.51	16.60

Table 7. Con.

	Straw yield (g)		Length of flag region (cm)		Grain yield/plant (g)		
sij=s 1 x 2	**L1**	**L2**	**L1**	**L2**	**L1**	**L2**	**Comb.**
S 1 x 2	-7.02**	-0.17	0.35	-0.09	1.04	-1.71	-0.17
S 1 x 3	4.16**	7.97*	-2.75**	4.84**	-0.32	5.25**	1.23
S 1 x 4	-10.16**	9.62**	-3.55**	-0.28	-4.54**	5.83**	0.32
S 1 x 5	-11.72**	-5.39	2.94**	-6.58**	-7.31**	-2.62**	-2.48**
S 1 x 6	-4.70**	-17.25**	1.74	-0.71	-2.80**	-6.69**	-2.37**
S 2 x 3	-8.43**	-17.69**	-4.10**	-3.96**	-0.46	-10.32**	-2.69**
S 2 x 4	2.71**	1.58	1.88	-0.23	0.61	0.64	0.31
S 2 x 5	-4.67**	4.00	-5.05**	4.58**	-5.42**	1.53	-0.97
S 2 x 6	13.16**	-6.18*	1.39	1.12	-2.32**	-1.71	-2.01**
S 3 x 4	3.08**	-1.18	-0.71	1.65*	-5.66**	-0.56	-1.56*
S 3 x 5	5.34**	-8.70**	5.87**	4.35**	14.47**	4.33**	4.70**
S 3x 6	-5.14**	1.95	-2.02*	-0.11	-0.45	3.58**	0.78
S 4 x 5	8.94**	-4.55	-1.94*	5.06**	3.20**	-0.10	0.78
S 4 x 6	-4.10**	1.93	-1.03	-0.91	1.19	0.83	0.50
5*6	-6.82**	19.42**	1.41	-0.04	1.65*	4.05**	1.42
LSD Sij 5%	1.99	6.11	1.93	1.37	1.62	1.80	1.44
LSD Sij 1%	2.66	8.17	2.59	1.83	2.17	2.41	1.91
LSD sij-sik 5%	3.59	11.04	3.50	2.47	2.92	3.25	2.15
LSD sij-sik 1%	4.81	14.77	4.68	3.31	3.91	4.35	2.85
LSD sij-skl 5%	3.33	10.22	3.24	2.29	2.71	3.01	0.81
LSD sij-skl 1%	4.45	13.68	4.33	3.06	3.62	4.03	1.08

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

The results show highly significant desirable ŝij values for some crosses in the F_1 generation. This result is expected increased the additive portion.

As for days to maturity the crosses P_1xP_4, P_2xP_5 and P_2xP_6 in the two locations, P_1xP_3 and P_4xP_6 in location 1, P_2xP_3, P_3xP_4, P_3xP_6 and P_4xP_5 in location 2, in F_1 generation gave significant and negative ŝij effects. With regard to No. of tillers/ plant five and two crosses expressed significant and positive ŝij effects at F_1 generation, under two locations, respectively.

Such results indicate that the cross P_5xP_6 in the two locations, P_1xP_2, P_2xP_6, P_3xP_5 and P_4xP_5 under location 1, cross P_4xP_6 under location 2, of F_1 recorded the highest desirable ŝij effects. As for height to flag leaf, the crosses P_1xP_4, P_2xP_5 and P_2xP_6 under the two locations, P_1xP_3 and P_3xP_5 under location 1, the crosses P_3xP_4, P_4xP_5, P_4xP_6 and P_5xP_7 under location 2, in F_1 generation gave significant and positive ŝij effects for this trait.

For No. of spikelets/spike, crosses P_1xP_6, P_2xP_3 and P_3xP_5 under location 1, crosses P_1xP_2, P_1xP_3, P_1xP_5, P_1xP_6 and P_2xP_4 under location 2, in F1 generation, had significant positive ŝij effects.

For total grain yield/ plant, crosses P_1xP_3, P_2xP_4, P_2xP_6, P_3xP_5 and P_4xP_5 under location 1, crosses P_1xP_3, P_1xP_4 and P_5xP_6 under location 2, in F_1 generation, had significant positive ŝij effects. The cross P_5xP_6 gave the highest desirable ŝij effects in F_1 generation.

For straw yield plant^{-1}, crosses P_1xP_3, P_2xP_4, P_2xP_6, P_3xP_4, P_3xP_5 and P_4xP_5 under location 1, crosses P_1xP_3, P1xP_4 and P_5xP_6 under location 2, in F1 generation, had significant positive ŝij effects.

If crosses of high SCA involve both parental lines which also are good combiners, they could be exploited for breeding varieties. Nevertheless, if crosses of high SCA involve only one good combiner, such combinations would throw out desirable transgressive segregates provided that the additive genetic system in the good acts in the same direction to reduce undesirable characteristics and maximize the character under consideration. Therefore, the mean performance of crosses could be a reliable and effective indication for their specific combining ability effects for all studied traits.

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الملخص العربي

التحليـــل الوراثي للهجـــن التبادلية في القمح تحت موقعين

محمد منظر حسن[1]، محمد حسن مبارك[1]، أحمد سعد عطايا[1]، عبدالعزيز ابراهيم يحيى[2]

1. قسم الإنتاج النباتي، كلية العلوم الزراعية البيئية، جامعة العريش، مصر.

2. قسم بحوث القمح، معهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية، مصر.

يهدف البحث إلى اختيار الهجن المتميزة لاستخدامها في تحسين محصول حبوب القمح فى مصر ودراسة قوة الهجين والقدرة على التالف للمحصول ومكوناته فى الجيل الأول تحت موقعين، الأول المزرعة البحثية بكلية العلوم الزراعية جامعه العريش والثاني المزرعة البحثية بمركز بحوث آيتاي البارود. أجري التهجين النصف تبادلي بين ستة تراكيب وراثية من قمح الخبز في موسم 2018-2019 وتم إنتاج حبوب الجيل الأول وقيمت الآباء والجيل الأول معًا فى تصميم القطاعات الكاملة العشوائية بثلاث مكررات للمحصول ومكوناته في موسم (2019/2020) تحت موقعين. كان التباين الراجع إلى التراكيب الوراثية (الاباء – الهجن) معنويا فى كل الصفات. وأيضا كانت قوة الهجين معنوية في كل الصفات تحت الدراسة. تراوحت قيمة قوة الهجين الموجبة والمعنوية مقارنة بالأب الأفضل من 16,5% إلى 33,95%. وكانت الهجن (P_3 x P_5),(P_5x P_6) هما الافضل في المحصول الكلى للنبات. وكان التباين الراجع للقدرة العامة والخاصة على التآلف معنويا لكل الصفات المدروسة ما عدا صفة عدد الاشطاء والنسبة بينهم تشير إلى أهمية الفعل الجيني المضيف فى توريث جميع الصفات تحت الدراسة. وأظهرت الآباء (P_3 وP_2) قدرة عالية على التآلف ومرغوبة لمعظم الصفات تحت الدراسة. أعطت الهجن الأربعة (P_1 x P_3, P_2 x P_6 , P_3 x P_5, P_4 x P_5) تأثيرات قدرة خاصة على التالف عالية المعنوية لمعظم الصفات المدروسة في الجيل الأول. ويمكن استخدام تلك الهجن في برنامج التربية.

الكلمات الاسترشادية: القمح، تحليل دياليل، التأثير الجيني، القدرة على الجمع.

REVIEWERS:
Dr. Ali Elhosary | elhosaryaa@yahoo.com
Dept. Agronomy, Fac. Agric., Benha Univ., Egypt.
Dr. ElSayed Hassan | drelsayed11154@gmail.com
Dept. Plant Prod., Fac. Technol. and Develop., Zagazig Univ., Egypt.