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Heterosis and Combining Ability for Yield and Yield Components in Bread Wheat under Different Nitrogen Rates

Cross Mark

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ABSTRACT

A one-way diallel cross among six common wheat genotypes were evaluated in F_1 at Etay EI-Baroud Agricultural Research Station during 2018/2019 and 2019/ 2020 seasons. These diallel F_1 crosses were made to determine heterosis and types of gene action for grain yield/plant and its attributes traits under different nitrogen rates. Highly significant and positive heterotic effects for 1000-kernel weight were detected in (P2×P3), (P2×P4), (P1×P5) and (P2×P6) at the three nitrogen rates. Meanwhile, the crosses (P1×P4), (P1×P6), (P4×P6) and (P5×P6) recorded positive and significant heterotic effects for 1000-kernel weight under normal (75 kg N/fed.) nitrogen rate. The grain yield/plant showed significant and negative heterotic effects relative to the better parent for most crosses at the three nitrogen rates except (P1×P2), which showed positive and significant heterotic effects. General combining ability (GCA) and specific combining ability (SCA) mean squares were highly significant for all traits, and GCA/ SCA ratios were greater than unity for all studied traits at three nitrogen rates.The parental genotypes P1 (Gemmeiza 12), P2 (Gemmeiza 9), P_3 (Giza 171), P4 (Line 1), P5 (Line 2), P6 (Line 3) appeared to be the best general combines for grain yield and some of its components in the three nitrogen rates. The cross combinations (P1×P2), (P2xP3) and (P2xP4), (P2xP5), (P2xP6), (P3xP5), (P4xP5), (P5xP6) were superior to their parental genotypes for heterosis relative to better parent, general and specific combining ability under three nitrogen rates.

***Keywords*:** Bread wheat, Nitrogen rates, Heterosis, combining ability

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world. In Egypt, it is the most important stable food. Geometrical increase in the Egyptian population has been a challenge for agricultural scientists in order to decrease the gap between the local production and consumption. The gap could be narrowed by increasing local production of wheat *via* two ways. The first way is through vertical expansion, which involves increasing wheat production per unit area through the development of new cultivars with high yielding ability, early maturity, diseases resistant and fertilizer responsive varieties to exploit various genetic parameters such as gene action, heterosis and heritability of important traits, as well as employing effective breeding strategies to obtain maximum improvement in the genetic yield potential of wheat. In order to evolve an effective hybridization program, combining ability is used to the magnitude of gene effect of the expression of quantitative traits. The estimates of combining ability effects can give an indication of the relative magnitude of genetic variance. These also provide a guide line for selecting elite parents and desirable cross combination to be used in the breeding programs for rabid improvement (Yadav and Sirohi 2011). Several others, Singh *et al.* (2015); Singh *et al.* (2000) and Joshi *et al.* (2003) reported that majority of genetic variances of grain yield as well as components were under control of additive nature of genes. On the other hand, Suleyman and Akguni (2007) and Abdel Nour *et al.* (2011) reported that grain yield per plant and most of the traits were under control of non-additive gene effects. Nitrogen (N) is one of the major inputs in wheat production systems. During the green revolution by Norman Borlaug which won a Nobel Peace prize for his developments in wheat production; the next development that could also have a vast effect on the worlds' nutrition could be the production of varieties that are nitrogen use efficient. Plant breeding programs have released many Mexican type semi dwarf varieties with greater responses to high nitrogen input.

The Egyptian wheat cultivars have somewhat narrow genetic background. Hybridization between the Egyptian wheat cultivars and exotic materials may be carried out to increase the genetic variability. Knowledge of the genetic relationship among individuals or populations is essential to breeders for planning crosses to gain better selections for high yield and developing new promising lines.

Diallel cross technique is a good tool for identification of hybrid combinations that have the potentiality of producing maximum improvement and identifying superior lines among the progeny in early segregation generations. Combining ability analysis of Griffing (1956) is most widely used as a biometrical tool for identifying parental lines in terms of their ability to combine in hybrid combinations

Therefore, the objectives of the present study were to:

Evaluate the performance of six parents of bread wheat, estimate heterosis relative to the better performing parent for the studied characters abilities and estimate the general and specific combining abilities with different environments represented by three nitrogen fertilization rates.

MATERIALS AND METHODS

This investigation was carried out at the Experimental Farm of Etay EL-Baroud, Agricultural Research Station, EL-Beheira Governorate during the two successive growing seasons of 2018/ 2019 and 2019/ 2020. Six common wheat varieties and/ or lines *(Triticum aestivum,* L. em Theil), which representing a wide range of genetic diversity for several agronomic characters, were selected for this study. Names and pedigree of these varieties and/ or lines are presented in Table 1.

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Table 1. The name and pedigree of the six bread wheat genotypes used in the study.

No.	Name	pedigree
P1	Gemmeiza 12	OYUS/3/SARA/THB//VEE CMSS97YOO227S-5Y-010M-010Y010M-2Y-1M-0Y-0GM
P2	Gemmeiza 9	ALD'S'/HUAC'S'//CMH74.630/5X CGM 4583-5GM-1GM-0GM
P3	Giza 171	GEMMEIZA 12/GEMMEZA 9 Gz2003-101-1Gz-4Gz-1Gz-2Gz-0Gz
P4	Line 1	TILILA/JUCHI/4/SERI.1B//KAUZ/HEVO/3/AMAD CMSS06Y00868T-099TOPM-099Y-099ZTM-099Y-099M-8WGY-0GM
P5	Line 2	KIRITATI/2*WBLL1 CGSS02B00118T-099B-099Y-099M-099Y-099M-18WGY-OB-0GM
P6	Line 3	CMH79A.955/CMH74A.487//CMH81A.744/WEAVER/TSC//WEAVER/6/CMH79A955/ 4/AGA/3/4*SN64/CNO67//INIA66/5/NAC/7/Gemmeiza#10

In 2018/ 2019 growing season, grains from each of the parental varieties and/ or lines were sown at various planting dates in order to overcome the differences in heading dates. During this season, all possible cross combinations without reciprocals were made between the six parents for giving a total of 15 F_1 seed hybrids

In 2019/ 2020 season, the parental genotypes and their respective 15 hybrids were sown on 25th of November in three adjacent experiments using three nitrogen fertilization rates; *ie*, 25 (low rate), 50 (moderate rate) and 75 (normal rate) kg N/fed. Each experiment was carried out in a randomized complete block design (RCBD) with three replicates.

Each plot consisted of two rows of each parent and their respective F_1 crosses. Each row was three meters long and 30 cm apart, Plant within row were 20 cm apart. Dry method of sowing was used in this concern. Other cultural practices of growing wheat were properly practiced as recommended.

Data for all studied traits were recorded on ten individual guarded plants, which taken at random from each plot of the F_1 and their respective parents. The recorded characters included plant height (cm), number of spikes/ plant, number of kernels/spike, 1000-kernel weight (g), and grain yield/ plant (g). The physical and chemical properties of the experimental soil site were presented in Table 2.

Table 2. Physical and chemical properties of the experimental site

Soil analysis	Physical properties				Chemical properties					
	Clay (%)	Silt (%)	Sand (%)	Texture	OM (%)	pH	EC , dsm^{-1}	Available NPK (ppm) N	P	K
	54.6	27.2	18.2	Clayey	0.68	7.9	1.93	48.5	43.0	238

Analysis of variance:

The data obtained from each trait were analyzed on individual plant mean basis. Analyses of variance were performed for the F_1 diallel crosses for each nitrogen rate. Heterosis was estimated according to the formula adopted by Bhatt (1971) as follows: Heterosis % over better parent value (Bp) = [F_1- Bp/ Bp] x 100. Differences between the parental genotypes and their F_1 hybrids were tested for significance using the L.S.D values test at 0.05 and 0.01 levels of probability. Estimates of both general and specific combining abilities were calculated according to Griffing (1956), method 2, model 1(fixed model).

RESULTS AND DISCUSSION

Analysis of variance for all studied traits, at each nitrogen rate was conducted (Table 3). Significant genotypes mean squares were observed for all the studied traits in each nitrogen rate, indicating a wide range of diversity among the investigated wheat materials. Results, also, showed that mean squares due to parents and crosses were significant for all studied traits at the three nitrogen rates, this means that the tested parents and their F_1 hybrids responded differently to the nitrogen rates.

The mean performance of the tested parents and their respective hybrids for all traits at the three nitrogen rates were presented in Table 4.

Table 3. Mean squares due to genotypes, general (GCA) and specific (SCA) combining ability for the studied traits under three rates of nitrogen.

sources	DF	Plant height N25	N50	N75	Number of spikes/plant N25	N50	N75	Number of kernels/spike N25	N50	N75
Replications	2	9.41*	2.93	2.02	2.20	4.95	0.39	14.31**	0,11	23.30**
Genotypes	20	121.76**	111.46**	145.34**	13.43*	12.53*	24.09**	403.59**	392.14**	352.81**
Parens (P)	5	469.57**	244.14**	216.23**	52.88**	27.74**	37.94**	1492.30	1308.07**	1043.87**
F_1's	14	149.62**	66.49**	122.40**	16.97**	7.46	20.80**	491.67	74.77**	123.75**
P *vs* F_1's	1	2244.31**	2112.55**	2688.80**	254.50**	240.49**	470.19**	7374.98	7574.14**	6860.67**
GCA	5	362.74**	402.24**	504.20**	23.99**	29.21**	53.21**	874.39**	1163.97**	993.07**
SCA	15	41.43**	14.54*	25.72**	9.91**	6.98	14.38*	246.65**	134.86**	139.39**
gca/sca		8.75	27.67	19.60	2.42	4.18	3.70	3.55	8.63	7.12
Error	40	3.94	4.28	4.22	1.50	1.16	1.41	12.77	14.80	15.63

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

Table 3. Cont.

Sources	DF	1000-kernel weight			Grain yield / plant		
		N25	N50	N75	N25	N50	N75
Replications	2	1.06	0.12	0.26	66.90**	9.30	18.91
Genotypes	20	28.61**	27.98**	43.06**	61.56**	84.91**	228.46**
Parens (P)	5	104.95**	48.93**	29.80**	235.16**	78.33*	112.61**
F_1's	14	31.64**	13.50*	50.36**	76.02**	86.82**	284.51**
P *vs* F_1's	1	474.59**	395.58**	801.58**	1140.35**	1652.50**	4504.89**
GCA	5	82.71**	74.22**	86.32**	68.43**	114.28**	305.77**
SCA	15	10.58*	12.57**	28.65**	59.27**	75.11**	202.69**
gca/sca		7.82	5.90	3.01	1.15	5.61	1.51
Error	40	1.63	1.58	1.20	9.18	7.01	12.56

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

Table 4. Means of studied traits of wheat parents and their diallel F_1 crosses under three levels of nitrogen.

Genotypes	Plant height (cm)			Number of spikes/plant			Number of kernels/spike		
	N25	N50	N75	N25	N50	N75	N25	N50	N75
P1	84.22	87.67	87.78	11.33	11.89	13.45	80.66	74.44	80.78
P2	107.00	109.78	108.89	11.56	10.78	12.33	81.22	83.44	81.56
P3	109.39	111.11	108.78	11.61	13.22	11.45	78.72	80.44	86.11
P4	107.00	109.00	108.56	12.61	11.44	9.22	89.22	91.33	93.33
P5	105.00	109.67	108.33	11.17	9.22	12.56	89.39	81.72	87.11
P6	97.44	102.05	100.67	3.56	4.60	3.83	129.56	131.65	130.11
P1×P2	104.83	99.44	99.78	13.33	12.55	14.33	96.17	81.33	85.44
P1×P3	101.67	102.22	97.50	11.66	12.33	7.83	79.22	83.89	83.17
P1×P4	99.00	98.72	99.44	11.33	12.17	9.34	82.50	89.83	84.67
P1×P5	99.50	99.11	97.11	9.50	11.11	8.83	67.50	81.78	82.00
P1×P6	93.00	100.56	99.67	8.50	10.67	8.33	86.00	89.78	94.00
P2×P3	109.06	108.11	110.00	9.00	8.11	9.67	86.55	78.67	88.89
P2×P4	104.17	104.05	110.56	8.00	10.22	14.94	81.83	85.78	85.56
P2×P5	100.45	108.44	112.78	9.17	8.34	14.67	78.06	87.78	88.17
P2×P6	108.33	106.05	113.00	9.94	8.11	13.11	88.28	87.28	93.78
P3×P4	109.11	113.11	110.61	8.89	10.67	8.72	83.45	81.89	84.11
P3×P5	107.11	110.11	116.22	10.33	9.00	13.56	83.44	81.67	97.22
P3×P6	104.33	110.39	111.89	8.50	8.61	9.67	84.83	94.22	101.28
P4×P5	110.78	112.22	109.11	8.11	10.33	10.22	87.56	89.22	99.17
P4×P6	104.11	106.17	105.78	8.78	8.17	7.45	90.22	95.78	89.22
P5×P6	108.78	108.44	108.33	10.89	11.56	10.33	93.00	92.44	98.11
LSD 0.05	2.73	2.84	2.82	1.68	1.48	1.63	4.91	5.29	5.44
LSD 0.01	3.93	4.09	4.06	2.42	2.13	2.35	7.07	7.61	7.82

Table 4. Continued

Genotype	1000-kernel weight (g)			Grain yield/plant (g)		
	N25	N50	N75	N25	N50	N75
P1	48.07	47.03	48.84	40.22	39.56	45.89
P2	49.23	46.84	55.52	36.50	36.83	38.06
P3	53.67	57.46	56.41	37.89	48.28	43.50
P4	51.99	48.58	50.24	39.39	45.56	37.84
P5	41.84	47.46	50.79	38.42	34.89	46.28
P6	47.95	49.73	50.19	29.22	41.31	30.33
P1×P2	48.49	52.72	45.53	41.33	46.89	52.67
P1×P3	51.61	55.12	57.04	42.83	47.28	31.75
P1×P4	50.41	53.28	52.27	40.17	50.28	32.50
P1×P5	50.69	51.66	51.49	31.83	41.78	33.19
P1×P6	47.40	50.76	53.18	33.17	42.56	30.44
P2×P3	55.76	55.64	56.31	33.55	33.44	38.39
P2×P4	52.88	52.02	57.47	30.67	43.89	55.00
P2×P5	49.86	52.23	57.44	29.17	34.61	51.44
P2×P6	50.78	50.72	54.83	32.48	35.72	50.83
P3×P4	54.61	54.31	50.90	35.72	45.56	36.11
P3×P5	52.67	55.38	44.17	34.38	35.78	57.33
P3×P6	51.46	54.54	50.83	31.00	40.89	40.61
P4×P5	47.35	50.61	49.63	32.44	41.89	42.36
P4×P6	49.19	49.22	54.73	30.89	35.33	28.39
P5×P6	47.51	48.92	55.39	43.33	48.89	43.72
LSD 0.05	1.76	1.73	1.51	4.17	3.64	4.87
LSD 0.01	2.53	2.49	2.17	5.99	5.24	7.01

For plant height, the parental variety Gemmeiza 12 and line 3 had the lowest mean values at the three nitrogen rates. On the other hand, Giza171 exhibited the highest parent mean value for this trait. The crosses P1×P4, P1xP5 and P1xP6 recorded the lowest mean values for plant height.

Meanwhile, the crosses P3xP4, P3xP5 and P4xP5gave the highest mean values for this trait at the three nitrogen rates. For parent mean performance, it was clear that increasing the rate of N fertilization, generally resulted in higher number of spikes/ plant. In this data, Gemmeiza12, Gemmeiza 9, Giza 171, Line 1 and Line 2 showed high number of spikes/plant at the three nitrogen rates. Also, the cross combinations P1xP2, P2xP4 and P2xP5 exhibited the highest mean values for this trait at the normal rate of N fertilization.

The parent line 3 expressed the highest number of kernels/ spike. Also, it recorded the highest values (129.56, 131.65 and 130.11) at the three nitrogen rates, respectively. Meanwhile, the crosses P3xP6 (Giza 171 x line 3), P4xP6 (line 1 x line 3) and P5xP6 (line 2 x line 3) exhibited the significantly highest mean values at the three nitrogen rates.

For 1000-kernels weight P3 (Giza171) exhibited the significantly highest parent mean values at three nitrogen rates. Also, the crosses P1xP3 (Gemmeiza12x Giza171), P1xP4 (Gemmeiza12 x Line1), P2 x P3 (Gemmeiza

9xGiza171), P2xP4 (Gemmeiza 9xLine1), P2xP5 (Gemmeiza 9x Line2), P2xP6 (Gemmeiza 9x Line3), P3 x P4 (Giza171 x Line1) and P3x P6 (Giza171 x Line3) recorded the significantly highest values at the three nitrogen rates.

The mean performance given in Table (4) showed that Gemmiza12 exhibited the highest mean values for grain yield/ plant under N25 and N75, P3 (Giza 171) under N50 and N75, P4 (Line1) under N50 and P5 (Line2) under N75. Also, the cross PlxP2 (Gemmiza12 x Gemmiza9) and P5x P6 (Line2 x Line3) showed the best values for grain yield/ plant at the three nitrogen rate. In this context the cross combination P1xP2 (Gem12x Gem9) was superior for grain yield/plant. Grain yield /plant tended to increase from (41.33) to (46.89) and (52.67) g with increasing nitrogen rates from low (N25) to moderate (N50) and high nitrogen rates (75 kg N/Fed), respectively. Such increase may be due to the important role of N stimulating assimilation activities and hence vegetative growth as well as spike initiation and grain filling, in addition to the favorable role of N in increasing number of grains/spike and spike grain weight recorded herein. These results are confirmed with the findings of Salem *et al.* (2000) and Yahya (2012).

Heterosis estimates:

Heterosis values, expressed as the percentage deviation of F_1 mean performance from its better parent, for all the studied traits at the three nitrogen rates were presented in Table 5. For plant height results showed significant and positive heterotic effects relative to better parent for almost all crosses except P2x P4 under N25 and N50 and P2x P5 under N25, which recorded significant and negative heterotic effect, it could be concluded that the progeny of this cross could be used in a breeding program for mechanical harvesting. Similar results were obtained by Abd-Allah and Mostafa (2009) and Yahya (2012).

For number of spikes/plant, most of crosses exhibited significant and negative heterotic effects, relative to the better parent, at the three nitrogen rates except the cross P1xP2 (Gem.12 x Gem.9) at three nitrogen rates. P1x P4 (Gem.12x Line1) under N50, p2xP4 (Gem.9 xLine1), P2xP5 (Gem.9 xLine2), P2xP6 (Gem.9 xLine3), P3 xP5 (Giza 171x Line2) and P3xP6 (Giza 171x Line3) under N75 was showed significant and positive heterotic effect .

Table 5. Estimates of heterosis (%) relative to better parent in wheat F_1 crosses under three rates of nitrogen.

Crosses	Plant height			Number of spikes/plant			Number of kernels/spike		
	N25	N50	N75	N25	N50	N75	N25	N50	N75
P1×P2	24.47**	13.43**	13.67**	15.37**	5.58**	6.59**	18.40**	-2.53**	4.77**
P1×P3	20.71**	16.60**	11.08**	0.46	-6.73**	-41.75**	-1.79	4.28**	-3.42**
P1×P4	17.54**	12.61**	13.29**	-10.12	2.33**	-30.57**	-7.54**	-1.64	-9.29**
P1×P5	18.14**	13.05**	10.63**	-16.18**	-6.53**	-34.31**	-24.49**	0.07	-5.87**
P1×P6	10.42**	14.70**	13.55**	-25.00**	-10.29**	-38.03**	-33.62**	-31.81**	-27.76**
P2×P3	1.92*	-1.52	1.13	-22.48**	-38.64**	-21.62**	6.56**	-5.72**	3.22**
P2×P4	-2.65**	-4.54**	1.84	-36.56**	-10.69**	21.16**	-8.28**	-6.08**	-8.33**
P2×P5	-4.34**	-1.12	4.10**	-20.68**	-22.67**	16.80**	-12.68**	5.19**	1.21
P2×P6	11.18**	3.92**	12.25**	-13.96**	-24.77**	6.30**	-31.86**	-33.70**	-27.93**
P3×P4	1.97*	3.77**	1.89	-29.50**	-19.33**	-23.79**	-6.47**	-10.34**	-9.88**
P3×P5	2.01*	0.40	7.29**	-11.00**	-31.96**	7.96**	-6.65**	-0.07	11.61**
P3×P6	7.07**	8.17**	12.25**	-26.79**	-34.89**	14.53**	-34.52**	-28.43**	-27.93**
P4×P5	3.53**	2.96**	0.72	-35.69**	-9.70**	-18.58	-2.05*	-2.31*	6.25**
P4×P6	6.85**	4.03**	5.08**	-30.40**	-28.63**	-19.26	-30.36**	4.87**	-31.43**
P5×P6	11.63**	6.26**	7.62**	-13.64**	25.30**	-17.71**	-28.22**	-29.78**	-24.60**

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

Table 5. Cont.

Crosses	1000- kernel weight			Grain yield/plant		
	N25	N50	N75	N25	N50	N75
P1×P2	-1.50	12.08**	-17.98**	2.76**	18.53**	14.77**
P1×P3	-3.83**	-4.07**	1.10	6.49**	-2.07*	-30.81**
P1×P4	-3.04**	9.66**	4.03**	-0.14	10.36**	-29.18**
P1×P5	5.44**	8.86**	1.37	-20.86**	5.61**	-28.28**
P1×P6	-1.39	2.07*	5.96**	-17.54**	3.02**	-33.66**
P2×P3	3.89**	-3.16**	-0.18	-11.45**	-30.73**	-11.75**
P2×P4	1.71*	7.07**	1.88	-22.15**	-3.66**	44.52**
P2×P5	1.28	10.06**	1.81	-24.08**	-6.04**	11.16**
P2×P6	3.16**	1.99*	-2.80**	-11.02**	-13.52**	33.57**
P3×P4	1.75	-5.49**	-9.78**	-9.31**	-5.63**	-16.98**
P3×P5	-1.86	-3.61**	-21.70**	-10.52**	-25.89**	23.88**
P3×P6	-4.12**	-5.08**	-2.80**	-18.18**	-15.30**	16.86**
P4×P5	-8.92**	4.16**	-2.28*	-17.64**	-8.05**	-8.47**
P4×P6	-5.38**	-1.02	8.93**	-21.58**	-22.44**	-24.97**
P5×P6	-0.92	-1.62	9.05**	12.8**0	18.35**	-5.52**

***and** indicate significant at 0.05 and 0.01 probability levels, respective.**

The number of kernels/spike recorded significant and negative heterotic effects relative to better parent for almost all crosses except (P1xP2), (P2xP3) under N25 and N75, (P1xP3), (P2xP5) and (P4xP6) under N50 and (P3xP5) and (P4xP5), which recorded a positive heterotic effects under N75.

Highly significant and positive heterotic effects for 1000-kernel weight were detected in (p1xP2), (P2xP4), (P2xP5) and (P2xP6) under N50 and (P1xP4) under N50 and N75, (P1xP5) under N25 and N50, (P1x P6) under N50 and N75, (P2xP4) under N25 and N50 and (P2xP6) under N25 and N50. These results agreed with earlier findings of Abd-Allah and Mostafa (2009), Sami *et al*. (2010), Ahmad *et al.* (2011) and Yahya (2012).

The grain yield/plant recorded significant and negative heterotic effects relative to better parent for all crosses under three nitrogen levels except P1 x P2 and P5 x P6 under three nitrogen levels, (P1 xP3) under N25, (P1xP4), (P1xP5) and (P1xP6) under N50, (P2 xP4), (P2x P5) and (P2 xP6), (P3xP5) and (P3 xP6) under N75, which had the significant and positive heterotic effect. These results agreed with earlier findings of Abd-Allah and Mostafa (2009), Sami *et al.* (2010), Ahmad *et al.* (2011) and Yahya (2012) and Abdel-Moneam *et al*. (2021).

Combining ability effects :

Combining ability implies the capacity of parent to produce progenies when crossed with other parent. In breeding programs, information on combining ability clues to the nature of gene action, describe parents and important yield traits may be found, combining ability studies, also, provide useful information for the promising selection of parents for effective breeding, besides elucidating the nature and magnitude of gene action involved. Such information is required to design efficient breeding programs for crop improvement .

Analysis of variance for combining ability, as outlined by Griffing's (1956) method 2 model 1, in each nitrogen rate for all studied traits is presented in Table 3.

Results indicated that, mean squares associated with general (GCA) and specific (SCA) combining ability were significant for all traits except SCA for number of spikes/plant at N50 level. That might indicate the importance of both additive and non-additive genetic variance in determining the performance of all studied characters. Similar results were also obtained by Yahya (2012).

To reveal the nature of genetic variance which had the greater role, GCA/ SCA ratios were found to be greater than unity for all studied traits. These results indicated that, the largest part of the total genetic variability associated with those measurements was a result of additive and additive × additive types of gene action. Similar results were found by several researches, among those are Abd EI-Majeed et al. (2004) and Yahya (2012), who reported that GCA/ SCA ratio was more than unity for all studied traits.

General Combining Ability effects (GCA):

Estimates of general combining ability (gi) for individual parental genotypes in each trait for each nitrogen rate, i.e. (25) low, (50) moderate and normal (75 kg/ fed), were presented in Table 6.

Table 6. Estimates of general combining ability effects (gi) of all traits F_1's diallel crosses under three rates of nitrogen.

Parents	Plant height			Number of spikes/plant			Number of kernels/spike		
	N25	N50	N75	N25	N50	N75	N25	N50	N75
P1	-4.74**	-2.02**	-0.03	-0.50**	-1.15**	2.55**	2.39**	-3.56**	1.42*
P2	-0.56**	2.52**	-2.63**	0.84**	1.17**	-2.52**	-2.20**	2.38**	-1.33*
P3	-0.47*	-1.27**	-2.71**	1.13**	2.04**	1.36**	-0.11	1.01**	-2.26**
P4	-0.64**	0.09	-0.14	2.45**	0.44**	-0.06	3.13**	0.91	4.34**
P5	-1.50**	-0.59**	-2.27**	1.00**	-0.36**	-0.13	7.21**	-1.49**	-4.26**
P6	-3.27**	-2.72**	-4.88**	-2.45**	-1.87**	-2.31**	19.10**	16.82**	14.31**
gi 0.05	0.33	0.36	0.36	0.13	0.1	0.12	1.09	1.26	1.33
gi 0.01	0.48	0.52	0.51	0.18	0.14	0.17	1.55	1.8	1.9
gi-gj0.05	0.8	0.87	0.86	0.31	0.24	0.29	2.61	3.02	3.19
gi-gj 0.01	1.15	1.25	1.23	0.44	0.34	0.41	3.72	4.32	4.56

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

Table 6 Cont.

Parents	1000-Kernel weight			Grain yield/plant		
	N25	N50	N75	N25	N50	N75
P1	-0.49**	-3.65**	-1.97**	-0.63	-6.30**	8.76**
P2	-2.21**	-3.69**	-5.21**	3.04**	0.89**	-12.11**
P3	-1.37**	-1.30**	-3.24**	1.17*	4.52**	1.65**
P4	0.24**	-1.84**	1.10**	3.82**	-0.34	1.28*
P5	-3.48**	-2.25**	-0.44**	3.01**	-2.18**	-2.92**
P6	0.01	0.05	1.16**	-1.51**	0.92**	-2.38**
gi 0.05	0.14	0.13	0.1	0.65	0.6	1.07
gi 0.01	0.2	0.19	0.15	0.86	0.85	1.53
gi-gj0.05	0.33	0.32	0.24	1.87	1.43	2.56
gi-gj 0.01	0.47	0.46	0.35	2.68	2.04	3.66

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

Results indicated that the parent P1 (Gemmeiza 12) expressed significant and negative (gi) effects for plant height and 1000-KWT at three nitrogen levels, number of kernels/spike at moderate nitrogen rate (50 Kg N/fed).and number of spikes/ plant and grain yield/ plant at N25 and N50. This particular parent (P1) exhibited significant and positive (gi) effects for number of spikes/ plant and grain yield/ plant at normal (75 Kg N/fed) and number of kernels/spike at N25and N75 kg/fed. .The parent P2 (Gem 9) gave highly significant and negative (gi) effects for plant height and number of kernels/spike at low (25 kg N/ fed) and normal (75 kg N/ fed) nitrogen rates, number of spikes/plant and grain yield/plant at normal rate (N75) and 1000-KWT at three nitrogen rates. This particular parent (P2) exhibited significant and positive (gi) effects for plant height, number of spikes/ plant and number of kernels/spike at moderate nitrogen rate and grain yield/plant at low and moderate nitrogen rate. The parent P3 (Giza 171) gave significant and positive (gi) effects for number of spikes/ plant and grain yield/Pl at three nitrogen rates and number of kernels/spike at moderate nitrogen rate (50 kg N/fed). This particular parent (P3) exhibited significant and negative (gi) effects for plant height and 1000-KWT at three nitrogen levels. The parent P4 (Line1) indicated highly significant and negative (gi) effects for plant height at low nitrogen rate (25 kg N/ fed) and 1000-KWT at a moderate nitrogen rate, while it exhibited significant and positive (gi) effects for number of spikes/ plant at N25 and N50, number of kernels/spike ,1000-kernels weight and grain yield/Pl at the low and normal nitrogen rate The parent P5 (line 2) showed highly significant and negative (gi) effects for plant height and 1000-kernels weight at three nitrogen rates, number of kernels/spike and grain yield/ Pl at N50 and N75 nitrogen rate, and number of spikes/plant at N50 nitrogen rate. Also, the parent P5 (Line2) has positive (gi) effects number of kernels/spike and grain yield at N25 and number of spikes/plant at N25 Nitrogen rate. The parent P6 (Line 3) gave significant and negative (gi) effects for plant height and number of spikes/plant at three nitrogen levels and also P6 showed highly significant and positive (gi) effects for number of kernels/spike at three nitrogen levels, 1000-Kw at N75 and grain yield/ plant at N50.

The results also revealed that this parent may be a good combiner for number of spikes/ plant, No of kernels/spike and grain yield/ plant at three nitrogen levels. P1 (Gem. 12) was a good combiner for number of spikes/ plant, number of kernels/spike and grain yield/plant at N75, parent 2 (Gem 12) was a good combiner for plant height, number of spikes/ plant and No of kernels/spike at N50 and grain yield/plant at N25 and N50. The data also indicated that parent P3 (Giza 171) was a good combiner for grain yield/ plant at the three nitrogen rates. The parent P4 (Line 1) showed significant and positive (gi) effects for Number of spikes/plant at the N25 and N50, Number of kernels/spike, 1000-KWT and grain yield/ plant at N50 and N75. The particular parent (P5) exhibited significant and positive effects (gi) for number of spike/Pl, number of kernels/spike and grain yield/plant at N25 nitrogen rate. Also, this parent (P6) (Line3) indicated significant and positive effects (gi) effects for number of kernels/spike at three nitrogen levels, 1000-KWT at N75 and grain yield/ Plant at N50 nitrogen rate.

From the previous results, it could be concluded that the parental genotypes P3 (Giza 171) seemed to be the best general combiners for number of spikes/plant and grain yield/plant at the three nitrogen rates. Also, P6 (line 3) was the best combiner for number of kernels/spike. In most traits, the values of (gi) effects differed from one nitrogen rate to other. This finding coincided with that reached, previously where significant GCA by nitrogen rates mean squares were detected (Table 3). These results are in agreement with those reported by Salem and Abd EI¬Dayem (2006), Yahya (2008), Abd-Allah and EI-Gammal (2009), Abd-Allah and Mostafa (2009) and Yahya (2012).

Specific Combining Ability effects (SCA)

Specific combining ability effects for 15 F_1 crosses were estimated for all studied traits at the three nitrogen rates (Table 7).

Table 7. Estimates of Specific combining ability effects (sij) of all traits in F_1's diallel crosses under three rates of nitrogen.

Crosses	Plant height			Number of spikes/plant			Number of kernels/spike		
	N25	N50	N75	N25	N50	N75	N25	N50	N75
P1xP2	6.58**	0.97	0.12	2.06**	1.23**	1.46**	15.32**	1.80	4.32
P1xP3	2.26*	1.19	-2.15*	0.51	0.22	-2.66**	0.67	5.17	-0.70
P1xP4	0.70	-0.58	1.19	0.34	0.15	-0.75*	0.32	5.62	0.49
P1xP5	1.77	-0.86	-2.09	-1.50**	-0.20	-2.96**	-12.72**	1.17	-3.37
P1xP6	-1.83	3.33**	2.99**	-0.42	0.91**	-0.19	-8.36*	-6.64	-3.58
P2xP3	0.35	-1.71	-1.50	-1.60**	-2.28**	-2.81**	5.43	-1.58	3.26
P2xP4	-3.43**	-4.03**	0.45	-2.44**	-0.09	2.88**	-2.93	0.04	-0.39
P2xP5	-6.58**	-0.31	1.72	-1.27**	-1.26**	0.90**	-4.75	5.64	1.04
P2xP6	4.20**	0.04	4.47**	1.58**	0.07	2.61**	-8.66**	-10.67**	-5.57
P3xP4	0.36	2.47*	0.52	-1.43**	-0.42	-0.97**	0.99	-3.04	-4.58
P3xP5	-1.07	-1.21	5.18**	0.01	-1.39**	2.17**	2.94	0.34	7.35
P3xP6	-0.95	1.81	3.37**	0.25	-0.21	1.55**	-9.81**	-2.91	-0.81
P4xP5	3.71**	2.64*	-0.54	-2.05**	0.04	-0.76*	3.42	2.41	8.98*
P4xP6	-0.06	-0.67	-1.34	0.69*	-0.57	-0.27	-8.05*	-6.85	-13.18**
P5xP6	5.17**	0.93	0.26	2.80**	3.53**	0.92*	-3.32	-6.58	-5.48
Sij0.05	1.98	2.15	2.12	0.54	0.6	0.71	6.42	7.44	7.86
Sij0.01	2.6	2.83	2.79	0.72	0.62	0.93	8.43	9.77	10.32
Sij-Sik0.05	4.41	4.8	4.73	1.68	1.3	1.58	14.3	16.58	17.51
Sij-Sik0.01	5.79	6.3	6.21	2.21	1.71	2.08	18.77	21.59	22.98
Sij-Skl0.05	3.78	4.11	4.06	1.44	1.12	1.36	12.26	14.21	15.01
Sij-Skl0.01	4.96	5.4	5.32	1.89	1.46	2.06	16.09	18.65	19.7

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

For plant height, the cross (P2xP6) exhibited significant and positive (Sij) effects for this trait. For number of spikes/ plant, crosses (P1xP2), (P2xP6) and (P5xP6) gave significant and positive (Sij) effects at the three nitrogen rates. The remaining crosses gave negative and significant or insignificant (Sij) effects at one or more of the nitrogen rates.

Table 7. continued

Crosses	1000- kernel weight			Grain yield/plant		
	N25	N50	N75	N25	N50	N75
P1xP2	-1.51**	2.11**	4.74**	4.18**	5.99**	9.02**
P1xP3	-0.66	0.41	1.23**	4.05**	2.47	-7.74*
P1xP4	0.25	2.73**	-0.06	1.95**	4.40**	-4.35
P1xP5	3.75**	1.47**	0.35	-6.29**	0.32	-9.97**
P1xP6	-0.85*	0.58	-2.33**	-2.63**	-0.57	-4.48
P2xP3	2.05**	1.00**	1.89**	-1.54**	-6.41**	-7.62*
P2xP4	1.29**	1.54**	2.00**	-3.85**	2.97	11.64**
P2xP5	1.48**	2.11**	1.09**	-5.26**	-1.89	1.76
P2xP6	1.10**	0.61	0.69*	0.38	-2.44	9.40**
P3xP4	-0.19	-0.29	2.80**	-0.43	0.73	-3.09
P3xP5	2.02**	1.15**	2.62**	-1.69**	-4.64**	11.81**
P3xP6	-0.50	0.32	-2.06**	-2.73**	-1.18	3.33
P4xP5	-1.18**	0.54	-5.76**	-3.05**	0.41	-0.52
P4xP6	-0.65	-0.83*	-1.19**	-2.27**	-7.81**	-6.25
P5xP6	0.88*	-0.77	2.57**	10.26**	10.16**	2.76
Sij0.05	0.82	0.79	0.6	0.65	3.52	6.32
Sij0.01	1.07	1.04	0.79	0.86	4.63	8.29
Sij-Sik0.05	1.82	1.77	1.34	10.28	7.85	14.07
Sij-Sik0.01	2.39	2.32	1.76	13.5	10.3	18.47
Sij-Skl0.05	1.56	1.52	1.15	8.81	6.73	12.06
Sij-Skl0.01	2.05	1.99	1.51	11.57	8.83	15.83

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

Concerning number of kernels/ spike, significant and positive (Sij) effects for this trait were detected for the crosses (P1xP2) under N25and (P4xP5) under N75 in one or more of the nitrogen rates. For 1000- kernel weight, crosses (P2xP3), (P2xP4), (P2xP5) and (P3xP5) exhibited significant and positive (Sij) effects in low, moderate and normal nitrogen rates. Also, crosses (P1xP2), (P1xP3), (P1xP4), (P1xP5), (P2xP6), (P3xP4) and (P5xP6) recorded significant and positive (Sij) effects in one or more of the nitrogen rates.

For grain yield/ plant, cross (P1 xP2) recorded Significant and positive (Sij) effects for this trait reaching 4.18 , 5.99 and 9.02 in low, moderate and normal, respectively.

Hence, these crosses are considered to be promising hybrids for varietal improvement purposes, as they showed high significant and positive values of specific combining ability effects and involved three general combiner parents P1 (Gem9) and P6 (Line3). In such hybrids, it could be expected that diverse genes contributing to the better general combining ability effects of the parents are available in the hybrids and in the segregating generation. These results agree with those found by Salem and Abd EI-Dayem (2006), Yahya

(2008), Abd-Allah and EI-Gammal (2009), Abd-Allah and Mostafa (2009) and Yahya (2012)

Finally, the results concerning general and specific combining abilities indicated that the excellent parental combinations were obtained from crossing good x good or goodx poor combiners. Also, the results showed that the best parental combinations overall heterosis and specific combining ability effects were (P2xP3), (P3xP4), (P2xP5) and (P3xP5) at low (25 kg N/ fed), moderate (50 kgN/fed), normal (75 kg N/fed). Therefore, these crosses might be promising in a breeding program for 1000-kernel weight (one of the major yield components).

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قوة الهجين والقدرة على الائتلاف للمحصول ومكوناته فى قمح الخبز تحت معدلات مختلفة من التسميد النيتروجينى

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تم تقييم هجن الجيل الاول الناتجة من التهجين الاحادى الجهة لستة اصناف وسلالات من قمح الخبز فى محطة البحوث الزراعية فى ايتاى البارود خلال موسمى (2018-2019) و (2019-2020) لتقدير قوة الهجين والقدرة على الائتلاف تحت ثلاث مستويات من التسميد النيتروجينى (25، 50و75 كجم نيتروجين/فدان). كظروف بيئية مختلفة ، وتم تنفيذ ثلاث تجارب لكل مستوي من مستويات التسميد النيتروجيني في تصميم قطاعات كاملة العشوائية في ثلاث مكررات لكل تجربة، وتم اجراء التحليل الوراثي طبقا للطريقة الثانية والنموذج الأول طبقا للعالم جريفينج 1956، كما تم حساب قوة الهجين بالنسبة لأفضل الأبوين لجميع الصفات المدروسة.و أشارت النتائج إلى أن التباين الراجع إلى التراكيب الوراثية كان معنويا لكل الصفات المدروسة. أظهرت الهجن (P2xP3), (P2xP4), (P1xP5) و (P2xP6) قوة هجين موجبة وعالية المعنوية لصفة وزن الألف حبة تحت مستويات الآزوت الثلاث، فى حين أن الهجن (P1xP4), (P1xP6), (P4xP6) و (P5xP6) أظهرت قوة هجين موجبة وعالية المعنوية لصفة وزن الألف حبة تحت مستوي 75 وحدة آزوت/فدان. وأظهرت معظم الهجن قوة هجين غير معنوية لصفة محصول الحبوب/نبات مقارنة بالأب الأفضل فيما عدا الهجين (P1xP2) الذى أظهر قوة هجين موجبة وعالية المعنوية.وكان التباين الراجع لكل من القدرة العامة والقدرة الخاصة على الإئتلاف عالى المعنوية لكل الصفات المدروسة و كانت النسبة بين التباين الراجع للقدرة العامة على الائتلاف الى التباين الراجع للقدرة الخاصة على الائتلاف تفوق الوحدة لكل الصفات المدروسة عند لكل من مستويات التسميد الثلاثة.و أظهر الاباء P1 (جميزة12), P2 (جميزة9), P3 (جيزة 171), P4 (سلالة 1), P5 (سلالة 2)و P6 (سلالة 3) قدرة عامة عالية على الائتلاف لصفة محصول الحبوب وبعض مكونات المحصول.أظهرت الهجن (P1xP2), (P2xP3), (P2xP4), (P2xP5), (P2xP6), (P3xP5) (P4xP5) و (P5xP6) تفوقا على باقى الهجن لكل من قوة الهجين والقدرة الخاصة على الائتلاف تحت الثلاث مستويات من التسميد النيتروجينى.