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Heterosis and Genetic Parameters for Yield and its Attributes of some Bread Wheat Varietal Crosses at High-N and Low-N Environments

Cross Mark

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ABSTRACT

Six wheat varieties were single crossed at 2017/18. Six parents and its 15 F_1 single-crosses were cultivated under N-normal and N-stress at 2018/19, to study heterosis and the genetic parameters for yield and its components under normal and N-stress. Mean squares of wheat-gentypes, parent, F_1-crosses and parent versus cross were highly significant or significant for most of traits under both conditions. The highest desirable heterosis and heterobeltiosis were detected by crosses No. 7 and No.8 for earliness; No.14, No.8 and No.3 for 100-Grain weight; crosses No.8 and No.13 for number of spikelets/spike; crosses No.9, No.7 and No.13 for number of grains per spike; cross No.4 for number of spikes/plant; crosses No.3, No.12 and No.10 for grain yield per plant, therefore, it might be decided that these crosses may be beneficial for enhancing wheat grain-yield programs under low or high N conditions. The median grade of dominance was greater than one for all characters under both conditions, suggesting the importance of over dominance gene effects in the genetics of these traits. Heritability in broad sense ($h_{b.s.}$) had high values for all traits under both conditions. Lower heritability estimates in narrow sense ($h^2_{n.s.}$) were detected for all the studied traits under both conditions, except each of spikes number /plant, weight of 100-grain and protein % at both conditions which had moderate values of narrow sense heritability, reflecting the part of environmental factors and dominance genes in heirloom scheme of these characters.

Keywords: Wheat, Heterosis, Genetic Components, Heritability, Yield, N-Stress.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an essential supplier of both carbohydrates and protein in human and livestock nourishment (El-Hosary *et al*, 2019). Grains protein contents are essential quality factor in wheat, as it helps to determine baking quality (Bushuk 1977). Protein contents of wheat are mainly influenced by varieties, available nitrogen, wetness, and temperature specifications under which the crop is cultivated (Fowler *et al*. 1990). Changes in protein content with application of fertilizer N differ with cultivar (Clarke *et al*. 1990 and Fowler *et al*. 1990). Hybrid wheat may be one way of increasing yield. Numerous genetic studies have shown the existence of major genes conferring enhanced grain protein concentration without adverse effects on yield (El-Saadoown, 2017 and 2018). Nevertheless, plant breeders' experience shows that simultaneous selection of grain protein concentration and yield exists only occasionally successful at enhancing both characters (Bakhsh *et al*., 2003). Al-Naggar *et al*. (2016) showed that meams of heterobeltiosis were either significant or nonsignificant but non-favorable, except for height of plant under both low and high N, and grains number/spike under low N. However, some crosses for each trait showed significant and favorable heterobeltiosis, and under low–N, the highest favorable and significant heterobeltiosis estimate was shown by L27 x Gem 7 for grain yiled per plant (14.94%), and grains per spike (25.82%), L25 x L26 for 100-grain weight (13.87%), L 25 x L 27 for spiks per plant (12.53%), L 27 x Gem 9 for grtains per spike (26.19%) and Gem 7 x Gem 9 for BYPP (28.99%). The improving of yield-rich and qualitly better wheat cultivars is not feasible with no previous awareness of their genetic-properties. The breeders consequently strive, with the help of appropriate quantitative genetic techniques, to merge the preferred properties of various cultivars.

Heterosis in wheat F1-crosses for early maturity, along with grain yield and its attributes and grain-quality traits were researched by Ahmad et al. (2016), Maich et al. (2017), Yadav (2017) and Ranjitha et al. (2018) they established that heterosis values over the mid- and better- parent differed from positive to negative and from significant to non-significant for the studied characters. Selection would be successful during the early generations when additive gene action is predominant. Otherwise, the selection would be at later generations when these effects are fixed in the homozygous lines. Analysis of diallel crosses for grain-yield and its associated characteristics might provide fascinating knowledge about gene action sort, which would be useful in specific circumstances to comprehend the kind of gene action engaged in the manifestation of a characteristic. It be able to detect genotypes having the most dominant and recessive alleles accountable for the representation of particular characteristic. This facilitates breeders to achieve effective selection in the isolating generations, prominent to the development of specific traits in breeding inhabitants at stress-conditions.

The current study targeted to estimate heterosis and heterobeltiosis, genetic parameters for yield and its components of wheat varietal crosses at N-natural and N-shortage restrictions.

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MATERIALS AND METHODS

The genetic structural utilized in this study as parental varieties consist of 6-bread wheat cultivars (*Triticum aestivum* L.), representative a broad range of diversity for numerous characteristics. Names and the history of these cultivars are submitted in Table-1.

Table 1. Names of parents and the history of the utilized parental cultivars.

No	Name	Pedigree
P1	Giza 168	MRL/BUE/SERI CM93046-8M-0Y-0M-2Y-0B
P2	Sakha 94	Opata / Rayon // Kauz CMBW90Y3180-0TOPM-3Y-010M-010M-010Y-10M-015Y-0Y-0AP-0S.
P3	Shandweel 1	SITE//MO/4/NAC/TH.AC//3*PVN/3/MIRLO/BUC.
P4	Gemmeiza 11	BOW"S"/KVZ"S"//7C/SER182/3 /GIZA168/SAKHA 61 GM7892-2GM-1GM-2GM-1GM-0GM
P5	Sids 12	BUC//7C/ALD/5/MAYA74/ON//1160.147/3/BB/GLL/4/CHAT"S"/6/MAYA/VUL//CMH74A.630/4*SX SD7096-4SD-1SD-1SD-0SD
P6	Misr 1	OASIS / SKAUZ // 4*BCN /3/ 2*PASTOR CMSS00Y01881T-050M-030Y-030M-030WGY-33M-0Y-0S

At 2017/2018, the parental cultivars were planted at 3-various times to overwhelm the variations in time of flowering. All the feasible parental mixtures not including reciprocal crosses were produced among the 6-varieties, giving 15 F_1-crosses. At 2018/2019, the 21 entries (6-parents and their 15-F_1 crosses) were assessed in two individual nitrogen fertilization levels trials. The 1st trial (high-N environment) was fertilized with 80 kg N/fed. The 2nd trial (low-N environment) was fertilized with 40 kg N/fed. The fertilizer of nitrogen as ammonium nitrate type (33.5% N) with the previous rates were included in two quantities. The 1st amount was 30% with sowing and the 2nd dosage was 70% before the 1st watering. The two trials were conducted in a Randomized Complete Block Design (RCBD) in 3 replicates in the Farm of Agron. Dept., Fac. of Agric., Mansoura Univ., Governorate of Dakahlia, Egypt.

Every replicate comprised of 21-genotypes as well as two borders, each genotype was planted in one row, 4 m lengthy and 25 cm width with 20 cm among plants. Twenty-seeds were penetrated by hand in the lines on 10th Nov. 2018, in every line. Both two experimentations were given fertilizer of calcium super-phosphate by rate of 15 kg P_2O_5/fad, in one and only dosage during soil preparing. All the rest agricultural procedures, except for N-fertilization, were employed as advised for wheat farming. The two outer plants from every line and the two outer rows of every plot were eliminated to escape the effect of border line.

Data of the following characteristics were recorded for 10 protected plants randomly chosen for each line in evry replicate; days to flowering (day), spike length (cm), spikelets number/spike, grains number/spike, spikes number/plant, weight of 100-grain (g), grain yield per plant (g) and protein content.

Statistical analyses:

The data of measured characteristics were analyzed on basis of plot mean. All achieved data were exposed to the statistical analysis of the Randomized Complete Block Design by 3-replicates to assess the variations amongst the studied different genotypes in every nitrogen regimes according to Snedecor and Cochran (1980). The means of the studied wheat genotypes were assessed utilizing the values of Least Significant Differneces (LSD) at 0.05 and 0.01 probability levels, conferring to Gomez and Gomez (1984).

Heterosis Estimates:

Heterosis as suggested by Mather and Jinks (1982) was established for single cross as the proportion variation of means of F_1 from mid parents (MP) and better parents (BP) means and conveyed as percentages for each situation of high-N and low-N, as follows:

Heterosis over the mid parents (H_{MP}) % = (F_1-MP)/MP × 100

Heterosis over the better parents (H_{BP}) % = (F_1 – BP)/BP × 100

Where:

F_1 = mean values of the 1st generation, MP = value of the mean of the mid parents computed by utilizing the median mean of the two parents and BP = value of mean of the better parents.

The heterosis effect significance for F_1 values for the mid and better parents were tested agreeing to the subsequent recipe:

LSD for heterosis over mid parents = t $_{(0.05 \text{ or } 0.01)}$ x $(3MSe/2r)^{1/2}$

LSD for heterosis over better parents = t $_{(0.05 \text{ or } 0.01)}$ x $(2MSe/r)^{1/2}$

Where:

t= value of tabulated "t" at stated level of probability for degrees of freedom of the experimental error, MS_e = experimental error mean squares from the analysis of variance, and r = replicates number.

Hayman Analysis:

Dividing the total genetical variance to its consistent sections; effects of additive and dominance genetical were estimated utilizing the diallel-analysis technique as outlined by Hayman (1954 and 1958). Estimates of the genetic variation components were components of variability due to effects of additive gene (D), effects of mean of covariance of additive and dominance over the arrays (F), component of variability due to effects of dominant gene (H_1), dominance indicated a symmetry of positive and negative effects (H_2), dominance effects as the algebraic sum over all loci in heterozygous phase in all crosses (h^2) and component of variation due to environmental effect (E). To test each of these components, standard error for each component was calculated according to Singh and Chaudhary (1985).

The above estimates were then used to compute the following proportions: the mean grade of dominance at each locus $(H_1/D)^{1/2}$, the ratio of genes with positive and negative effects in the parents ($H_2/4H_1$), the ratio of dominance and recessive genes in the parents (K_D/K_R), an estimator of groups number genes which are involved in the performance of the trait and exhibit dominance to certain degree (K). Moreover, broad ($h^2_{b.s}$) and narrow senses ($h^2_{n.s}$) heritabilities were assessed utilizing the formulation of Mather and Jinks (1982), for the F_1 generations as follows:

$$\textbf{Heritability in narrow sense } (h_{ns}\%) = \frac{1/2D+1/2H_1-1/2H_2-1/2F}{1/2D+1/2H_1-1/4H_2-1/2F+E}$$

$$\textbf{Heritability in broad sense } (h_{bs}\%) = \frac{1/2D+1/2H_1-1/4H_2-1/2F}{1/2D+1/2H_1-1/4H_2-1/2F+E}$$

RESULTS AND DISCUSSION

Analysis of variance:

Analysis of variance for grain-yield, its attributes and grain-quality characteristics are represented in Table-2. Results directed visibly that mean squares due to all wheat genotypes, parents, crosses and parents versus crosses were highly significant or significant for all the studied grain-yield, its attributes and grain-quality characters under both high-N and low-N environments, excepting each of; genotypes, parents and crosses for spike length under normal condition, parents and crosses for spike length under N-stress, parents for grains number/spike and spikes number/plant under both conditions, parents versus crosses for spikes number/plant under both conditions, reflecting a sort of heterosis for these characters. The significance of source of variations due to the genotypes comprising parents and its cross combinatios were also noticed in most aforementioned investigations, as in Abdel-Moneam & Sultan (2009); Abdel-Moneam (2009); Kumar & Kerkhi (2015); Ahmad *et al*. (2016); Farhat & Darwish (2016); Saeed *et al.* (2016); Qabil, (2017); Thomas *et al*. (2017); Abdel-Moneam & Leila (2018) and Bhumika *et al*. (2018).

Table 2. Mean squares of wheat genotypes, parents, crosses and parents versus crosses for the examined grain-yield, its attributes and gran-quality characteristics at high-N and low-N environments.

S. V	D.F	Flowering date (day)		Spike length (cm)		Spikelets number/spike	
		High-N	Low N	High-N	Low N	High-N	Low N
Genotypes	20	51.70**	63.23**	1.597	2.086**	5.03**	6.06**
Parents	5	9.56**	12.99**	1.556	1.556	3.12*	4.27**
Crosses	14	46.66**	78.09**	0.724	0.737	2.98**	1.95
P. V Cross	1	332.96**	106.48**	14.025**	23.625**	43.21**	72.69**
Error	40	0.93	1.02	0.890	0.840	1.11	1.01
		Grains number /spike		Spikes number /plant		100-Grain weight (g)	
S. V	D.F	High-N	Low N	High-N	Low N	High-N	Low N
Genotypes	20	272.67**	196.11**	8.97**	4.65**	0.55**	0.77**
Parents	5	76.37	69.52	5.33	1.87	0.63**	0.76**
Crosses	14	176.20**	116.89**	10.58**	5.59**	0.55**	0.76**
P. V Cross	1	2604.70**	1938.13**	4.63	5.34	0.11	1.04**
Error	40	58.57	34.52	3.26	1.55	0.07	0.03
		Grain yield / plant (g)		Protein %			
S. V	D.F	High-N	Low N	High-N	Low N		
Genotypes	20	37.45**	17.00**	2.347**	2.192**		
Parents	5	30.61**	9.08**	2.554**	0.926**		
Crosses	14	38.30**	15.44**	1.895**	2.287**		
P. V Cross	1	59.70**	78.47**	7.638**	7.185**		
Error	40	0.58	0.87	0.367	0.209		

***, ** significant at 5% and 1% levels of probability, respectively.**

Estimates of heterosis:

For flowering time, results presented in Table-3 clearly indicate that crosses No. 7 (P_2 x P_4) and No.8 (P_2 x P_6) had highly-significant negative (suitable direction for earliness) heterosis relative to their mid- and better-parents under N-stress conditions, and cross No.11(P_3 x P_5) over better parent at N-stress condition.

Table 3. Heterosis percentages relative to mid- and best-parents for flowering-date and weight of 100-grain under high-N and low-N situations.

Crosses	Flowering date				100-grain weight			
	High-N		Low-N		High-N		Low N	
	MP	BP	MP	BP	MP	BP	MP	BP
1-P1XP2	0.52	1.04	1.59*	3.23**	-9.17**	-14.75**	-3.56**	-6.31**
2-P1XP3	0.17	1.03	3.19**	4.30**	-6.41**	-11.43**	-5.36**	-8.62**
3- P1XP4	2.62**	4.26**	-0.87	2.15*	0.86**	-6.12**	10.11**	5.93**
4-P1XP5	8.33**	9.47**	1.57*	4.30**	-1.67**	-6.31**	3.29**	2.36**
5-P1XP6	7.69**	8.25**	3.16**	5.38**	-4.38**	-10.72**	0.48**	-6.17**
6- P2XP3	1.71*	3.13**	0.52	1.05	8.95**	7.99**	1.09**	-5.06**
7- P2XP4	4.21**	5.32**	-3.42**	-2.08*	9.19**	8.22**	6.48**	-0.36**
8- P2XP5	9.95**	10.53**	-4.12**	-3.13**	9.01**	7.30**	12.30**	10.08**
9- P2XP6	5.15**	6.25**	10.88**	11.46**	-5.48**	**6.00-	8.82**	-1.07**
10-P3XP4	0.69	3.19**	0.52	2.46**	6.34**	4.48**	-1.14**	-1.52**
11- P3XP5	8.43**	10.53**	-1.55*	0.00	-5.90**	-6.56**	-1.23**	-5.46**
12- P3XP6	9.83**	10.20**	11.46**	12.63**	1.06**	-0.38	0.50**	-2.93**
13-P4XP5	11.11**	11.70**	8.81**	9.18**	11.50**	8.78**	8.39**	3.37**
14- P4XP6	9.38**	11.70**	6.30**	7.22**	3.54**	3.19**	12.93**	9.48**
15- P5XP6	-0.52	1.05	6.67**	7.22**	1.56**	-0.58	9.34**	1.25**
LSD 5%	1.38	1.59	1.44	1.66	0.37	0.42	0.24	0.28
LSD 1%	1.84	2.13	1.93	2.23	0.49	0.57	0.32	0.37

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

For one-hundred grains weight, results submitted in Table-3 reveal that highly-significant or significant positive heterosis values relative to mid- and better-parents were noticed by eight and six crosses, respectively, under normal nitrogen fertilization condition. However, under nitrogen stress condition, highly-significant or significant positive heterosis relative to mid- and best-parents were identified by 11 and 6 crosses, respectively. The greatest percentages of heterosis and heterobeltiosis under N-stress condition were showed by cross No.14 (12.93 and 9.48%), cross No.8 (12.30 and 10.08%) and cross No.3 (10.11 and 5.93%), respectively.

With respect to length of spike, highly-significant or significant positive heterosis values were revealed over mid- and best-parents for 13 and 11 crosses, and extended from 1.64 % for cross No.1 to 9.24% for cross No.13 for mid-parent heterosis, and ranged between 1.56% for cross No.12 to 6.67% for cross No.9 for heterobetiosis pecentages under normal nitrogen fetilization condition. While under N-stress condition, highly-significant positive heterosis values were demonstrated over mid-parents for all the studied F_1-crosses. The highest heterosis relative to mid-parents were verified by cross No.3 (17.65%), cross No.14 (16.83%) and cross No.9 (10.48%) under N-stress condition. While, positive and significant heterobetiosis were obtained by 12 crosses at N- stress condition, and ranged between 1.79 % for cross No.2 and (15.69%) for cross No.14, as shown in Table-4.

Concerning to spikelets number/spike, results in Table-4 showing that highly-significant and positive direction heterosis values relative to mid-parents at both high-N fertilization and low nitrogen conditions were obtained by all the studied 15 F_1 crosses. The highest percentages were recorded by cross No.8 (15.38% and 20.0%) followed by cross No.13 (13.24 and 18.26%) under normal and N-stress condition, respectively. On the other hand, heterotic percentages over better parent were significant or highly significant and positive values for 12 and 14 crosses under normal and N-stress conditions, respectively. The largest heterobeltiosis percentages were belonged to cross No.8(11.94 and 17.86%) followed by cross No.13(11.59 and 15.75%) under normal and N-stress conditions, respectively.

Table 4. Heterosis percentages relative to mid- and best-parents for length of spike and spikelets No. /spike under high-N and low-N environments.

Crosses	Spike length				Spikelets number/spike			
	High-N		Low-N		High-N		Low-N	
	MP	BP	MP	BP	MP	BP	MP	BP
1-P1XP2	1.64*	0.00	3.77**	1.85*	2.29**	-1.47	10.09**	9.09**
2-P1XP3	0.00	-1.56*	5.56**	1.79*	5.80**	4.29**	10.34**	4.92**
3- P1XP4	7.32**	6.45**	17.65**	15.38**	6.57**	5.80**	12.28**	8.47**
4-P1XP5	8.33**	4.84**	8.57**	7.55**	5.19**	4.41**	13.51**	12.50**
5-P1XP6	4.13**	1.61*	8.74**	7.69**	10.00**	6.94**	15.25**	7.94**
6- P2XP3	3.23**	0.00	1.82**	0.00	12.78**	7.14**	14.78**	8.20**
7- P2XP4	2.48**	1.64*	7.69**	3.70**	4.55**	0.00	9.73**	5.08**
8- P2XP5	6.78**	5.00**	6.54**	5.56**	15.38**	11.94**	20.00**	17.86**
9- P2XP6	7.56**	6.67**	10.48**	7.41**	11.11**	4.17**	12.82**	4.76**
10-P3XP4	-0.80	-3.12**	3.77**	-1.79*	5.04**	4.29**	10.00**	8.20**
11- P3XP5	8.20**	3.13**	2.75**	0.00	6.57**	4.29**	9.40**	4.92**
12- P3XP6	5.69**	1.56*	8.41**	3.57**	8.45**	6.94**	9.68**	7.94**
13-P4XP5	9.24**	6.56**	6.80**	K23.77**	13.24**	11.59**	18.26**	15.25**
14- P4XP6	8.33**	6.56**	16.83**	15.69**	9.22**	6.94**	11.48**	7.94**
15- P5XP6	5.98**	5.08**	7.69**	5.66**	5.04**	1.39	7.56**	1.59
LSD 5%	1.35	1.56	1.31	1.51	1.50	1.74	1.43	1.66
LSD 1%	1.80	2.08	1.75	2.02	2.01	2.32	1.92	2.22

***and **, reveal significant at 5% and 1% probability levels, respectively.**

For grains number spike^{-1}, results in Table-5 exhibited that highly-significant or significant and positive heterosis relative to mid- and best-parents were achieved by 10 and 6 crosses under high-N fertilization condition, respectively. The greatest heterosis were showed by cross No.13(34.25 and 27.04%) followed by cross No.9 (32.94 and 27.17%) cross No.7 (25.39 and 18.89%) and cross No.3 (21.25 and 27.17%) cross No.7(25.39 and 18.89%) and cross No.3 (21.25 and 19.93%) relative to mid- and better parents under high-N situation. However, under low-N, there were 11 and 9 crosses showed positive highly-significant or significant heterosis and heterobeltiosis, respectively. The highest percentages of heterosis relative to mid- and better-parents were documented by cross No.9 (33.62 and 27.87%), cross No.7 (27.15 and 25.22 %) and cross No.13(24.94 and 20.87%) under N-stress condition, respectively.

Regarding spikes number plant^{-1}, results (Table-5) demonstrate that highly-significant or significant and positive direction heterosis percentages relative to mid- and best- parents at high nitrogen fertilization condition were postulated by 10 and 5 crosses. These desirable heterosis percentages ranged from 3.37% for cross No.9 to 20.88% for cross No.12 over mid parents and form 6.52% for cross No.3 to 14.0% for cross No.15 over better parent under normal condition. On the other side, under N-stress condition, there were 8 and 1 crosses showed significant or highly significant positive heterosis and heterobeltiosis, respectively, and the highest heterosis and heterobeltiosis were exhibited by cross No.4 (22.86% and 16.22%).

Table 5. Heterosis percentages relative to mid- and best-parents for grains No./spike and spikes number/plant under high-N and low-N environments.

Crosses	Grains No. spike^{-1}				Spikes No. plant^{-1}			
	High-N		Low-N		High-N		Low-N	
	MP	BP	MP	BP	MP	BP	MP	BP
1-P1XP2	12.36*	5.43	17.65**	14.41**	-18.60**	-23.91**	-13.85**	-15.18**
2-P1XP3	10.46	9.06	6.72	2.75	- 2.27**	-6.52**	-1.49	-2.91
3- P1XP4	21.25**	19.93**	20.17**	18.64**	10.11**	6.52**	15.49**	7.89
4-P1XP5	10.25	3.26	17.07**	11.86*	4.17**	0.00	22.86**	16.22**
5-P1XP6	9.80	7.61	9.17*	7.38	11.58**	8.16**	15.94**	11.08
6- P2XP3	18.20**	12.27	17.15**	9.80*	7.32**	4.76**	6.06**	3.00
7- P2XP4	25.39**	18.89**	27.15**	25.22**	6.02**	2.33	2.86**	-5.29
8- P2XP5	4.76	4.55	3.20	1.35	-6.67**	-16.00**	1.45	-5.35
9- P2XP6	32.94**	27.17**	33.62**	27.87**	3.37*	-6.12**	0.00	-5.58
10-P3XP4	13.17*	12.96*	11.34**	5.88	3.53**	2.33	-2.78	-7.89
11- P3XP5	12.55*	6.69	8.09	0.39-	-4.35**	-12.00**	-4.23**	-8.11
12- P3XP6	8.24	7.43	5.01	2.75	20.88**	12.24	11.43**	8.33
13-P4XP5	34.25**	27.04**	24.94**	20.87**	1.08-	-8.00**	1.33	0.00
14- P4XP6	15.51**	14.44*	18.99**	15.57**	8.70**	2.04	13.51**	10.50
15- P5XP6	17.39**	12.08	17.65**	10.66*	15.15**	14.00**	12.33**	10.87
LSD 5%	10.94	12.63	8.40	9.70	2.58	2.98	1.78	2.05
LSD 1%	14.64	16.90	11.24	12.97	3.46	3.99	2.38	2.12

***and **, reveal significant at 5% and 1% probability levels, respectively.**

For grain yield plant^{-1}, results showed that highly-significant and positive direction heterosis relative to both mid- and best-parents were gotten from 11 and 8 crosses and ranged from 3.71% for cross No.15 to 41.78 % for cross No.6 and form 2.91% for cross No.5 to 32.76% for cross No.12 relative to mid and better parents, respectively, under high nitrogen condition. While, under low-N, highly-significant or significant and positive direction heterosis values relative to mid- and best-parents were detected by 13 and 11 crosses, and the highest heterosis heterobeltiosis were showed by cross No.3 (33.90 and 23.23%) followed by cross No.12 (30.01 and 27.77%) and cross No.10 (30.61 and 17.13%), respectively. Consequently, it might be decided that these crosses may be beneficial for developing wheat grain-yield program under low or high N conditions (Table-6). Similar results were obtained by Abdel-Moneam (2009); Abdel-Moneam, *et al.* (2014) and Abdel-Moneam and Ibraheem (2015).

For protein %, data in Table-6 confirmed that greatest and positive percentages of heterosis relative to mid- and best-parents were documented by crosses No.7 (P_2 x P_4), No.8 (P_2 x P_5), No.11 (P_3 x P_5) and No.12 (P_3 x P_6) at both situations. Also, heterosos and heterobeltiosis were recorded by crosses No.1 (P_1 x P_2) and No.9 (P_2 x P_6), and over mid-parents were detected by crosses; No.2 (P_1 x P_3), No.3 (P_1 x P_4), No.4 (P_1 x P_5), No.6 (P_2 x P_3), No.10 (P_3 x P_4) and No.13 (P_4 x P_5) under high nitrogen condition.

Table 6. Heterosis percentages relative to mid- and best-parents for grain yield plant^{-1} and protein % at high-N and low nitrogen environments.

Crosses	Grain yield /plant				Protein %			
	High-N		Low-N		High-N		Low-N	
	MP	BP	MP	BP	MP	BP	MP	BP
1-P1XP2	-10.80**	-23.61**	7.59**	4.10**	8.81**	7.30**	1.06**	-3.73**
2-P1XP3	31.86**	19.27**	15.19**	11.96**	5.03**	-2.32**	6.68**	6.03**
3- P1XP4	-1.04	-4.52**	33.90**	23.23**	4.15**	1.56**	10.28**	6.18**
4-P1XP5	5.49**	4.81**	23.95**	19.05**	4.11**	-5.93**	4.84**	2.08**
5-P1XP6	14.67**	2.91**	6.01**	4.82**	0.06	-4.90**	6.15**	6.05**
6- P2XP3	41.78**	33.35**	14.06**	7.37**	2.85**	-3.09**	17.93**	11.69**
7- P2XP4	12.79**	-0.35	16.46**	10.58**	6.03**	4.83**	5.58**	4.42**
8- P2XP5	7.53**	-7.41**	8.85**	1.30	16.40**	6.51**	21.52**	12.86**
9- P2XP6	14.70**	8.79**	9.15**	4.47**	8.82**	4.83**	-3.76**	-8.25**
10-P3XP4	18.99**	11.28**	30.61**	17.13**	5.91**	0.89	1.49**	-2.86**
11- P3XP5	-18.58**	-25.93**	-10.13**	-11.22**	26.55**	22.65**	29.68**	27.02**
12- P3XP6	33.63**	32.46**	30.01**	27.77**	12.59**	10.04**	13.36**	12.57**
13-P4XP5	-19.88**	-22.22**	4.33**	-7.44**	5.39**	-2.55**	11.76**	4.88**
14- P4XP6	11.78**	3.68**	12.83**	2.78**	-3.20**	-5.72**	-5.94**	-9.36**
15- P5XP6	3.71**	-6.40**	-5.45**	-8.19**	-1.57**	-6.70**	-0.92**	-3.62**
LSD 5%	1.09	1.26	1.33	1.54	0.87	1.00	0.65	0.75
LSD 1%	1.46	1.69	1.78	2.06	1.16	1.34	0.87	1.01

***and **, reveal significant at 5% and 1% probability levels, respectively.**

Hayman analysis:

Assumptions of the diallel-analysis are diploid segregations, no reciprocal variations, homozygous parents, no multiple alleles, no epistasis, uncorrelated gene distribution and no interaction between genotypic x environment (Hayman, 1958). Breakdown of any one or any combinations of these assumptions overturns to some levels the supposition achieved by the means of the analysis. Consequently, two tests were commissioned to screen the characteristics for such breakdowns. These two tests, which were adopted by Verhalen *et al.* (1971), are: uniformity of Wr and Vr and analysis of the (Wr, Vr) regression.

Estimates of genetic and environmental components:

The assessments of genetic and environmental elements of variation for yield, its components and grain quality traits at normal and N-stress conditions are given in Table-7.

The additive component (D) for yield, its components and grain quality traits under both studied conditions was not significant, except spikelets number/spike and 100-grain weight at N-stress condition, which were highly significant. These results indicated that the non-additive gene effect is important in the genetic control for all investigated grain-yield, its attributes, and grain-quality characters at both high and low nitrogen fertilization, excepting of spikelets No. spike^{-1} and weight of one-hundred grains at low-N condition, which the additive gene effect is important in the genetic control in it.

It is obvious that dominance genetic variances i.e. (H1) and (H2) were extremely significant instead of all the investigated grain-yield, its attributes, and grain-quality characteristics at both high and low N environments. Similar results were obtained by Mohamed (2004) for No. of grains/spike at normal and stress conditions. Also, Farhat (2005) and Sultan *et al.* (2010 and 2011) reported the same for plant height, grain yield per plant, weight of 100-grain at normal and stress conditions.

It's interest to note that additive genetic variances (D) were smaller than those of dominance genetic variances (H1) for all the studied yield, its components and grain quality traits at both normal and N-stress conditions, indicating that the selection for these characters might be extra effective in lately segregating generations for improving such characters. Abd EL-Aty (2002), Farhat (2005) and Sultan *et al.* (2010 and 2011) found similar results for plant height.

Negative and significant or insignificant (F) value were recorded for spikes number /plant at both conditions, spikelets number/spike and grains number /spike at normal, and 100-grain weight at N-stress condition, indicating excess of recessive alleles in the parents. However, (F) value was significant or insignificant and positive for the other traits, reflecting that the dominant genes were more frequent than recessive genes among the parental genotypes. Similar results were obtained by Mohammed (2001), Mohamed (2004), Abdel-Moneam and Sultan (2009) and Sultan *et al.* (2010 and 2011) for height of plant, grains No. per spike and grains-yield plant^{-1} at high and low nitrogen conditions.

The estimates of (h^2) values, the algebraic sum of dominant effects over all loci in heterozygotes, were found to be significant and positive for all the investigated grain-yield, its attributes, and grain-quality characters at both high-N and low-N environments, excepting of spikes number /plant at both conditions, and 100-grain weight and grain yield / plant at normal condition, indicating the prevalence of positive genes controlling these characters and suggesting that dominance was unidirectional. These results are in accordance with that obtained by Mohamed (2004) and Sultan *et al.* (2010 and 2011) for height of plant and grains-yield per plant at normal and stress conditions and Farhat (2005) found the same results for plant height and weight of 100-grain.

Table 7. Genetic components estimations for grain-yield, its attributes, and grain-quality characteristics under high-N)and low-N environments.

Characters	Cond.	D	F	H_1	H_2	h^2	E
Flowering date	High-N	2.18±3.19	1.68±7.79	69.36±8.09**	64.96±7.23**	71.38±4.87**	1.01±1.20
	Low-N	3.27±6.53	-5.05±15.96	72.07±16.59**	58.01±14.82**	22.42±9.97*	1.06±2.47
Spike length	High-N	0.23±0.13	0.30±0.31	1.25±0.32**	1.17±0.28**	2.87±0.19**	0.286±0.05**
	Low-N	0.25±0.34	0.61±0.84	2.18±0.87*	1.88±0.78*	4.95±0.53**	0.270±0.13*
Spikelets /spike	High-N	0.63±0.36	-0.41±0.87	3.55±0.91**	3.63±0.81**	9.11±0.55**	0.41±0.13**
	Low-N	1.07±0.28**	0.02±0.67	4.24±0.70**	4.40±0.63**	15.51±0.42**	0.35±0.10**
Grains /spike	High-N	5.77±27.60	-17.73±67.43	259.18±70.06**	246.56±62.59**	551.81±42.13**	19.69±10.43
	Low-N	11.15±23.43	7.15±57.24	203.59±59.48**	185.83±53.14**	412.05±35.77**	12.02±8.86
Spikes /plant	High-N	0.60±0.55	-3.02±1.34	3.51±1.39*	2.80±1.24*	0.35±0.83	1.17±0.21**
	Low-N	0.13±0.59	-1.37±1.43	3.00±1.49*	2.66±1.33*	0.88±0.89	0.49±0.22*
100-grain weight	High-N	0.19±0.10	0.30±0.25	0.79±0.26**	0.58±0.23*	0.01±0.16	0.02±0.04
	Low-N	0.25±0.04**	-0.01±0.10	0.49±0.11**	0.35±0.09**	0.22±0.06**	0.01±0.02
Grain yield / plant	High-N	9.04±5.54	13.63±13.53	52.50±14.06**	41.36±12.56**	12.25±8.45	1.17±2.09
	Low-N	2.05±2.18	2.02±5.32	20.43±5.52**	18.21±4.94**	16.41±3.32**	0.98±0.82
Protein %	High-N	0.68±0.36	0.37±0.88	2.00±0.92*	1.75±0.82*	1.56±0.55**	0.169±0.14
	Low-N	0.17±0.34	0.12±0.84	2.49±0.87**	2.02±0.78**	1.47±0.52**	0.141±0.13

Proportion of genetic components:

Proportion of genetic components for the investigated grain-yield, its attributes, and grain-quality characteristics at high-N and low-N environments are presented in Table-8.

The average grade of dominance as specified by $(H_1/D)^{1/2}$ was greater than one for all the investigated grain-yield, its attributes, and grain-quality characteristics at high-N and low-N environments, suggesting the importance of over dominance gene impacts in the inheritances of these characteristics. The results are in a line with that attained by Sajid (1995) for weight of 100-grain and grain yield per plant at normal conditions, and by Farhat (2005), Abdel-Moneam & Sultan (2009) and Sultan *et al.* (2010 and 2011) for number of spikes per plant at normal conditions, number of grains per spike and grain yield at stress conditions.

The proportion of genes with positive and negative effects ($H_2/4H_1$) was nearly equal to 0.25 for all the studied yield, its components and grain quality traits under normal and N-stress conditions, except each of 100-grain weight at both conditions, spikes number /plant and grain yield / plant at normal condition, and protein % at N-stress condition, indicating that the positive and negative alleles were equally distributed among the parents. However, 100-grain weight at both conditions, spikes number/plant and grain yield/plant at normal condition, and protein % at N-stress condition exhibited unequal distribution. In this regard, (H2) was less than (H1) for number of grains per spike at both conditions, confirming the above results. These results are in good agreement with those obtained by Mohamed (2004) for plant height, number of grains per spike at normal and stress conditions and grain yield per plant at stress condition and Farhat (2005) and Sultan *et al.* (2010 and 2011) for number of grains per spike at normal conditions and grain yield per plant at normal and stress conditions.

The proportion of dominant to recessive alleles (K_D/K_R) in the parents was extra than one for all the investigated grain-yield, its attributes, and grain-quality characteristics at high-N and low-N environments, suggesting the preponderance of dominant alleles, except of spikes number /plant at both conditions, spikelets number/spike, grains number /spike at normal condition, and 100-grain weight at N-stress condition (K_D/K_R) which was lesser than unity, viewing an extra of recessive alleles among parents. Farhat (2005) observed similar results for number of grains per spike, weight of 100-grains and grain yield per plant at normal and stress conditions; Mohamed (2004) for number of grains per spike and grain yield per plant at normal and stress conditions and by Awaad (2002), Mostafa (2002) and Sultan *et al.* (2010 and 2011) for grains-yield per plant at normal condition.

Regarding the gene blocks No. (h^2/H2), the data showed that spikes number /plant, weight of 100-grain, grain-yield/plant, protein % at both conditions had (h^2/H_2) values less than one, indicating that these traits were governed at least by one gene block. While the other traits were controlled at least by three gene blocks. Similar results were obtained by Farhat (2005) for number of grains per spike at normal condition, weight of 100-grains and grain-yield per plant at normal and stress environments.

Lower estimates of narrow sense heritability ($h^2_{n.s.}$) were noticed for all the investigated grain-yield, its attributes, and grain-quality characteristics at high-N and low-N environments, excepting each of spikes/plant, weight of 100-grains and protein % at both environments, reflecting the role of environmental factors and dominance type of gene action in inheritances scheme of the characteristics. Meanwhile, the exceptions characteristics which had moderate values of heritability in narrow sense, reflecting the necessity of additive gene action in influencing these agronomic characters, and so selection could be accomplished in the medium segregating generations. Generally, the results are in harmony with that formerly acquired by El-Borhamy (2000), Mohamed (2004), Farhat (2005) and Sultan *et al.* (2010 and 2011) at normal and stress conditions.

Heritability in broad sense ($h_{b.s.}$) had high values for the investigated grain-yield, its attributes, and grain-quality characteristics at high-N and low-N environments, implying that most of the phenotypic variances in these characters was due to genotypic impacts. Similar results were obtained by El-Morshedy (2004) and Sultan *et al.* (2010 and 2011).

Table 8. Proportion of genetic components for the investigated grain-yield, its attributes, and grain-quality characteristics at high-N and low-N environments.

Characters	Cond.	$(H_1/D)^{1/2}$	$H_2/4H_1$	K_D/K_R	h^2/H_2	h^2(n.s)	h^2(b.s)
Flowering date	High-N	5.64	0.23	1.15	1.10	0.12	0.95
	Low-N	4.69	0.20	0.72	0.39	0.42	0.96
Spike length	High-N	2.32	0.23	1.75	2.46	0.02	0.51
	Low-N	2.96	0.22	2.40	2.63	0.04	0.62
Spikelets /spike	High-N	2.37	0.26	0.76	2.51	0.27	0.77
	Low-N	1.99	0.26	1.01	3.53	0.24	0.81
Grains /spike	High-N	6.7	0.24	0.63	2.24	0.18	0.80
	Low-N	4.27	0.23	1.16	2.22	0.16	0.83
Spikes /plant	High-N	2.41	0.20	-0.02	0.12	0.54	0.71
	Low-N	4.80	0.22	-0.04	0.33	0.44	0.76
100-grain weight	High-N	2.05	0.18	2.29	0.02	0.23	0.90
	Low-N	1.42	0.17	0.98	0.63	0.68	0.97
Grain yield / plant	High-N	2.41	0.20	1.91	0.30	0.22	0.92
	Low-N	3.16	0.22	1.37	0.90	0.17	0.85
Protein %	High-N	1.71	0.22	1.38	0.89	0.32	0.81
	Low-N	3.85	0.20	1.21	0.73	0.28	0.84

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قوة الهجين والقياسات الوراثية لصفات المحصول ومكوناته لبعض الهجن الصنفية لقمح الخبز تحت ظروف التسميد الطبيعي والإجهاد النيتروجيني

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أجريت التهجينات النصف دائرية بين ستة أصناف متباعدة وراثية من قمح الخبز خلال موسم 2018/2017، تم تقييم الآباء الستة والـ 15 هجين الناتجة في تجربتين منفصلتين الأولى تحت ظروف التسميد النيتروجيني الطبيعي والثانية تحت ظروف الاجهاد النيتروجيني خلال موسم 2019/2018، وذلك لدراسة قوة الهجين والقياسات الوراثية لصفة المحصول ومكوناته لهذه الهجن الصنفية تحت الظروف العادية ونقص النيتروجين وذلك في تصميم القطاعات كاملة العشوائية في ثلاث مكررات لكل تجربة وذلك بالمزرعة البحثية بكلية الزراعة بجامعة المنصورة محافظة الدقهلية. أظهرت تحليل التباين أن متوسطات مربعات كل من التراكيب الوراثية والآباء والهجن والتفاعل بين الآباء مع الهجن كانت معنوية أو عالية المعنوية لمعظم الصفات المدروسة تحت كلا ظروف التسميد الطبيعي وظروف نقص النيتروجين مما يعكس وجود نوع من قوة الهجين في هذه الصفات. سجلت أعلي قوة هجين في الاتجاه المرغوب بالنسبة لمتوسط الأبوين وبالنسبة للأب الأفضل للهجن أرقام 7 و8 لصفة التبكير؛ والهجن أرقام 14، 8 و 3 لصفة وزن 100 حبة، معظم الهجن المدروسة لصفة طول السنبلة، والهجن أرقام 8، 13 لصفة عدد السنيبلات بالسنبلة، والهجن أرقام 9، 7، 13 لصفة عدد الحبوب بالسنبلة، والهجين رقم 4 لصفة عدد السنابل بالنبات، الهجن أرقام 3 (33.90 و 23.23%)، 12 (30.01 و 27.77%)، 10 (30.61 و 17.13%) لصفة محصول الحبوب للنبات، ومن ثم يمكن أن تكون هذه الهجن مفيدة في برنامج تربية وتحسين محصول الحبوب للقمح تحت ظروف التسميد النيتروجيني المنخفض أو المرتفع. كانت قيم متوسط درجة السيادة أكبر من الواحد الصحيح لكل الصفات المدروسة تحت كلا الظروف الطبيعية والاجهاد، مما يدل على أهمية السيادة الفائقة للجينات المؤثرة في توريث هذه الصفات. كانت قيم كفاءة التوريث بمعناها الواسع مرتفعة لكل الصفات المحصولية والجودة المدروسة وهذا يشير إلى أن معظم التباينات المظهرية في هذه الصفات يرجع إلي التباينات الوراثية، كانت قيم كفاءة التوريث بمعناها الضيق منخفضة لكل الصفات المدروسة تحت كلا الظروف، ما عدا كل من: عدد السنابل بالنبات، وزن 100 حبة و نسبة البروتين بالحبوب تحت كلا الظروف حيث كانت قيما متوسطة، مما يعكس دور العوامل البيئية والفعل الجيني السيادي في وراثة معظم تلك الصفات لذلك يفضل ممارسة الانتخاب في الأجيال الانعزالية المتأخرة، ماعدا الصفات الأخرى المستثناه والتي سجلت قيما متوسطة لكفاءة التوريث بمعناها الضيق مما يشير ذلك إلى أهمية الفعل الجيني التجميعي المتحكم في وراثة تلك الصفات لذلك يفضل ممارسة الانتخاب في الأجيال الانعزالية المبكرة والمتوسطة.