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HETEROBELTIOSIS FOR MORPHO-PHYSIOLOGICAL AND YIELD CHARACTERS OF BREAD WHEAT UNDER DIFFERENT LEVELS OF NITROGEN

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ABSTRACT

A 6x6 half diallel cross fashion in F_1 generation was employed to study heterotic effects for days to heading, days to maturity, stay green duration, flag leaf area, flag leaf chlorophyll content, yield attributes and nitrogen use efficiency, beside grain protein content under 40.5 ppm available nitrogen (L_1), 75.5 kg N/fad., (L_1) and 110.5 kg N/fad., (L_3). The parental used in this study were Line 1(P_1), Line 2(P_2), Line 3(P_3), Sakha 93(P_4), Giza 168 (P_5) and Gemmeiza 10(P_6). Significant heterobeltiosis in the desired negative direction was observed for days to heading in both wheat crosses p_2x p_5 and p_4x p_6 at L_1 and L_3 levels and p_4x p_6 at L_3 level only. Wherease positive and significant heterobeltiosis were observed for days to maturity and stay green in the cross p_2x p_3 at L_2 level; flag leaf area in the crosses p_1x p_3 and p_2x p_3 at L_1 level and p_3x p_6 at L_2 level as well as in the p_1x p_4 and p_1x p_6 at L_2 and L_3 levels for flag leaf chlorophyll content. Significant heterobeltiosis in the desired positive direction were registered for spike length in the three crosses p_1x p_3, p_1x p_5 and p_3x p_6 at different nitrogen levels; number of fertile spikelets / spike in p_3x p_6 and p_5x p_6 at L_1 level and p_1x p_3 at L_3 level only. Number of sterile spikelets/spike scored desirable negative and significant heterobeltiosis in the crosses p_1x p_3, p_1x p_4, p_2x p_3, p_2x p_5, p_2x p_6, p_3x p_4, p_3x p_5, p_4x p_5 and p_4x p_6 at the three nitrogen levels. For yield and its components, positive and significant heterobeltiosis was recorded for number of grains/spike in the wheat crosses p_3x p_4 and p_4x p_6 at L_2 level; 1000- grain weight in the cross combination p_4x p_5 at L_1, L_2 and L_3 levels; grain yield/plant in the crosses p_1x p_5 and p_2x p_3 at L_1 level, p_1x p_6 at L_2 level and p_1x p_5 at L_3 level. Biological yield/plant gave significantly positive heterobeltiosis in the crosses p_3x p_4 and p_4x p_6 at L_1 level; p_1x p_4 and p_1x p_2 at L_2 and L_3 levels. Positive and significant heterobeltiosis was observed for nitrogen use efficiency in the wheat crosses p_1x p_2, p_2x p_5 and p_3x p_5. Finaly, positive and significant heterobeltiosis was recorded for grain protein content in the cross combinations p_1x p_2 and p_3x p_5 at L_1, L_2 and L_3 levels.

Key words: Heterobeltiosis, bread wheat, available nitrogen, morpho-physiological characters, nitrogen use efficiency.

INTRODUCTION

Heterosis has been exploited in a number of crops such as corn, bajra, sorghum, cotton and sunflowerv *etc*. However its use has been limited in self pollinated crops.

Heterobeltiosis is defined as the superior performance in growth, vigor, vitality, reproductive capacity, stress resistance, adaptability, grain yield, grain quality and other physiological characters of the F_1 population from the better parent.

Heterobeltiosis may be expressed as the amount by wich the mean of an F_1 hybrid exceeds its high performing parent. For example, Heterobeltiosis for characters such as

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yield usually implies that the F_1 has greater yield than its better yielding parent. On the other hand, heterobeltiosis for characters such as earliness usually implies that F_1 has a lower value than its earliear parent (Mather and Jinks, 1982).

In general, the expression of increased vigor of F_1 hybrid over the high performance parent is called positive heterosis and that of decreased vigor is designated as negative heterosis.

Heterosis in wheat has not been exploited yet, although several investigators detected significant heterosis in most F_1 cross of wheat for yield and its contributing characters and may produce transgressive segregants which could be selected to release new recombinant lines characterized by high yielding ability.

Heterobeltiosis is exteremely useful in identifying the best cross combinations displayed more favourable genes for the economic characters. The superiority of the hybrids over parent average was 32% (Livers and Heyne, 1986) and in the meantime certain hybrids yielded more than the better parent and as much as 25% (Awaad, 2002). Significant genetic variability and heterobeltiosis were recorded for stay green duration by Kumari *et al.* (2007) and Bahar *et al.* (2011), earliness, spike characteristics and yield contributing characters in wheat by Salama (2000), Awaad (2002), Awaad *et al.* (2013) and Sadeg *et al.* (2013). Considerable amount of heterosis was also recorded for grain protein content by El-Hosary *et al.* (2000) and Joshi *et al.* (2003).

Therefore, the aim of the present study was to estimate heterobeltiosis expressed as the percentage deviation of F_1 mean performance from the better parent for some morpho-physiological, nitrogen use efficiency and yield characters under three nitrogen levels.

MATERIALS AND METHODS

The present study was carried out at the Experimental Farm of Kafer El-Hamam, Agriculture Research Station, Agriculture Research Center, Sharkia Government, Egypt during the two winter successive seasons of 2009/2010 and 2010/2011. Six bread wheat genotypes have been employed in this investigation. The studied parental materials were chosen on the basis of wide differences among them in respect to morpho-physiological characters, yield and its attributes. The pedigree and origin of the wheat parental genotypes are presented in Table 1.

Crossing Technique and Experimental Layout

In 2009 /2010 season, six parental wheat genotypes were chosen to establish the field experimental work of this invistigation, also a half diallel set of crosses excluding reciprocal was achieved among the six parents to obtain 15 F_1 cross grains. In the second season of 2010/ 2011, the obtaind 15 F_1 cross grains together with the 6 parental genotypes were evaluated under three nitrogen fertilizer levels in three adjacent experiments. Befor N application, random samples (taken from 0 to 20 cm depth) were collected in each replication to determine soil N–content. The amount of available soil nitrogen in Kg/fad., was then estimated and found to be 40.5 ppm which expressed as low nitrogen level (L_1). Then 35 Kg N/fad., was added to give 75.5 kg N/ fad., which represents the normal level (L_2) as well as 70 kg N/fad., was added to give 110.5 Kg N/fad., wich considared as high N–level (L_3) which applied in two equal doses befor the first and second irrigations. Nitrogen was added in the form of amonium nitrate (33.5% N). No any organic fertilizer was added to the experiments and the preceded crop was cowpea.

In each nitrogen level, a randomized complete block design with three replicates was used. The experimental plot consisted of 6 rows *i.e.,* (2 rows for each parent and 2 rows for F_1). The row was 2.5 meter in length, and 20 cm apart. Plants spaced at 10 cm within rows and one plant was left/hill. Data were recorded on 10 individual competetive plants in each genotype in each replicate to study days to heading, days to maturity, stay green duration, flag leaf area, flag leaf chlorophyll content, spike length, number of fertile spikelets / spike, number of sterile spikelets/spike, number of spikes/plant, number of grains/spike, 1000 grain weight, grain yield/plant, biological yield/plant, nitrogen use efficiency and grain protein content.

For determination nitrogen use efficiency, grain and straw samples were taken from the studied plant materials to estimate N- content using Micro Kyeldahl method according to AOAC (1980). Nitrogen use efficiency was calculated according to Fageria *et al.* (1997).

Table 1. Pedigree and origin of the six parental bread wheat genotypes used in the present study

Name	Pedigree	Origin
Line 1	Sakha 93 / Sids 6 CGZ (16) 3 GM-2GM-OGM	Egypt
Line 2	Giza 168 / Sids 7 CGZ (7) 4GM - 2GM . OGM	Egypt
Line 3	Giza l68// CHIL / SLMI 75 CGZ(9) 2GM-2GM OGM	Egypt
Sakha 93	Sakha 92 / LTR 810 328 s 8871-15 – 25 – 15 – 05	Egypt
Giza 168	MRL / BVC//Seri	Egypt
Gemmeiza 10	Maya 74 "s" /ON //1160- M7/3/BB/G11/4/CHAT"s" / crow "s"	Egypt

Table 2. Some physical and chemical properties of the experimental site

Properties	The second season
Physical analysis	
Sand (%)	33.43
Silt (%)	31.50
Clay (%)	45.07
Soil texture	**Clay**
Chemical analysis	
Available (N) ppm	40.50
Available (P) ppm	21.23
Available (K) ppm	329.00

Statistical Procedures

Two steps are involved in the analysis of the data, the first step was the ordinary analysis of variance for testing the null hypothesis that there are no genotypic differences among the parent and F_1 's, when the significant differences among wheat genotypes are established, there is a need to proceed the second step analysis of genetic assessment as follows.

Heterosis assessment

1- Heterosis over the better parent (Heterobeitiosis)

$$= \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

The significant of heterosis was tested using :

S.E for B.P = F_1 – B.P = (VF_1 + VB.P) $^{0.5}$

Where: F_1 and B.P are the mean performance of the F_1 and better parent.

RESULTS AND DISCUSSION

The effect of the gene expression on phenotype of F_1 hybrid relative to the high performing parent, described as better parent heterosis or heterobeltiosis. Heterobeltiosis for earliness, morpho-physiological, yield component characters and grain protein content were calculated under three levels of nitrogen *i.e.,* (40.5, 75.5 and 110.5 Kg N / fad.)

Earliness Characters

Days to heading is considered as a good indicator for earliness rather than days to maturity as it less effected by the environmental changes. Data presented in Table 3 show heterobeltiosis percentage for days to heading at three nitrogen levels, 40.5, 75.5 and110.5 kg N/fad. Positive and significant heterosis over better parent was detected by the cross combinations $P_1 \times P_4$, $P_1 \times P_6$, $P_2 \times P_4$, $P_2 \times P_6$, $P_3 \times P_4$, $P_3 \times P_6$ and $P_4 \times P_5$ at L_1 level. Meanwhile positive and significant heterosis was also recorded by the wheat crosses $P_1 \times P_3$, $P_1 \times P_4$, $P_2 \times P_4$, $P_2 \times P_5$, $P_2 \times P_6$, $P_3 \times P_4$ and $P_3 \times P_6$ at L_2 level. Moreover, positive and significant heterosis was registered by the crosses $P_1 \times P_2$, $P_1 \times P_4$, $P_2 \times P_4$, $P_2 \times P_5$, $P_2 \times P_6$, $P_3 \times P_4$, $P_3 \times P_6$ and $P_4 \times P_6$ at L_3. These results indicate an accumulation of latness alleles. In this respect, positive and significant heterosis was detected for days to maturity by Ghanem (2001); Menshawy (2004) and Saleh (2006). On the other hand, desirable negative and significant heterosis over better parent was registered by the cross combinations $P_2 \times P_5$ and $P_4 \times P_6$ with values of -2.21 and -1.73% at L_1 and L_3, respectively. This result could be discussed based on accumulation of earliness alleles. Negative and significant heterosis was recorded for days to heading by Hamada (2003) and El-Moselhy (2009).

For days to maturity, wheat genotypes an accumulate higher dry matter for grain filling either through a longer grain filling period at a constant grain filling ratio or through a short grain filling period and a fast grain filling ratio (Sharma, 1994). Positive and highly significant heterobeltiosis percentage were observed for days to maturity (Table 3) in the wheat crosses $P_2 \times P_4$, $P_2 \times P_5$ and $P_2 \times P_6$ at L_1,L_2 and L_3 levels. The wheat crosses $P_1 \times P_5$ and $P_5 \times P_6$ refer to positive and significant heterosis at L_1 level. Meanwhile, positive and significant heterosis was recorded by the two corsses $P_1 \times P_2$ and $P_2 \times P_3$ at L_2 level as well as $P_1 \times P_2$, $P_2 \times P_3$ and $P_3 \times P_4$ at L_3 level, suggesting an accumulation of latness alleles. However, negative values of heterobeltiosis over better parent have been obtained by 6 out of 15 wheat crosses at different levels of nitrogen but did not reach the level of significance. Significantly positive or negative heterosis were found by Sadeg *et al.* (2013).

Morpho-physiological Characters

Stay green duration played an important role in prolongation photosynthetic activity. Data presented in Table 3 show heterobeltiosis percentage for 15 bread wheat crosses of stay green duration. Negative and significant heterosis over better parent was detected by the cross combinations $P_1 \times P_6$ at L_1, L_2 and L_3 levels; $P_1 \times P_4$ and $P_4 \times P_5$ at L_1 and L_3 levels; $P_2 \times P_6$ and $P_5 \times P_6$ at L_2 and L_3 levels as well as $P_2 \times P_4$, $P_3 \times P_4$ and $P_4 \times P_6$ at L_3 level only. These crosses were accumulated favourable earliness alleles for stay green duration character. On the other hand, desirable useful heterobeltiosis (1.651%) towards latness was registered by the cross $P_2 \times P_3$ at L_2 level. High degree of superiority for stay green duration was recorded among wheat genotypes by Kumari *et al.* (2007) and Bahar *et al.* (2011).

Flag leaf area contributed directly and indirectly with great part to grain yield variation. Data presented in Table 4 show heterosis for flag leaf area of 15 F_1 wheat crosses. Positive and significant heterosis over better parent was detected by the cross combinations $P_1 \times P_3$ and $P_2 \times P_3$ at low nitrogen level. Meanwhile, positive and significant heterosis was recorded by the cross $P_3 \times P_6$ at L_2 level. Suggesting an accumulation of increasing alleles for broader flag leaf area. Ghanem (2001); Awaad (2002); El-Sayed and Moshref (2005); Saleh (2006) and El-Moselhy (2009) they reported positive and significant heterotic effects in respect to flag leaf area. On the other hand, negative and significant heterosis over better parent was recorded by the crosses $P_1 \times P_5$, $P_2 \times P_4$ and $P_4 \times P_5$ at L_1, L_2 and L_3 levels. Also, negative and significant heterosis was recorded by most studied crosses under L_2 level and all the crosses under L_3 level. These results suggest accumulation of decreasing alleles for narrow flag leaf area. In this regard Ghanem (2001) and Saleh (2006) found negative and significant heterosis for flag leaf area. Also, Awaad *et al.* (2013) registered positive and significant heterobeltiosis for flag leaf area in both cross combinations Giza 168 × Sids 6 and ACSAD 935 × Line 1, and highly significantly negative heterobeltiosis in the cross ACSAD 925 ×Gemmeiza 10.

Table 3. Heterosis as percentage of better-parent "heterobeltiosis" for days to heading, days to maturity and stay green duration under three nitrogen levels

Crosses	Days to heading			Days to maturity			Stay green duration		
	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3
$P_1 \times P_2$	0	1.36	3.37**	0.740	2.378*	2.341*	-0.492	0.704	0
$P_1 \times P_3$	1.162	2.28*	1.49	0.970	0	0.455	-0.489	0.232	-0.684
$P_1 \times P_4$	4.528**	3.29**	3.29**	1.459	2.083	0.680	-2.11*	0	-2.64**
$P_1 \times P_5$	2.264*	1.09	1.46	3.160*	0	-1.136	0.238	0.467	-1.816
$P_1 \times P_6$	3.002**	0.725	1.09	2.189	0.923	-0.455	-2.112*	-2.027*	-3.756**
$P_2 \times P_3$	- 0.39	0	- 0.38	2.222	2.614*	2.341*	0.481	1.651*	-1.388
$P_2 \times P_4$	6.976**	5.681**	3.37**	3.207**	4.285**	3.042**	-0.938	-0.906	-3.311**
$P_2 \times P_5$	- 2.21*	2.27*	2.24**	2.96*	2.857*	2.341*	-0.238	-0.230	-0.911
$P_2 \times P_6$	3.488**	2.27*	2.988**	3.207**	2.857*	2.341*	-2.351	-2.925*	-3.093**
$P_3 \times P_4$	4.65**	4.95**	3.74**	0.956	2.083	2.296*	-1.644	-0.225	-3.311**
$P_3 \times P_5$	1.54	1.52	1.12	1.913	1.388	1.379	-0.238	-0.927	-1.360
$P_3 \times P_6$	3.48**	3.81**	1.86*	0.719	0.694	1.379	-0.016	-1.128	-0.446
$P_4 \times P_5$	2.95**	0.709	0	1.675	1.366	0.674	-3.056*	-1.363	-3.092**
$P_4 \times P_6$	- 0.35	- 1.39	- 1.73*	-0.689	-0.440	-1.324	-0.704	-0.229	-1.986*
$P_5 \times P_6$	0.36	- 1.07	- 1.40	3.107*	-0.440	1.125	-0.025	-2.027*	-3.318**

Flag leaf chlorophyll content helps to synthesize photothenthate products in plant. As presented in Table 4, flag leaf chlorophyll content attained positive and significant heterosis by the cross combinations $P_1 \times P_4$ and $P_1 \times P_6$ at L_2 level, suggesting accumulation of increasing alleles for chlorophyll content.

Otherwise, negative and highly significant heterosis was recorded by all the crosses expect the cross $P_1 \times P_5$ at L_1 level, $P_1 \times P_3$, $P_1 \times P_5$, $P_2 \times P_4$, $P_3 \times P_5$, $P_3 \times P_6$ and $P_4 \times P_6$ at L_2 level as well as $P_1 \times P_4$, $P_1 \times P_6$, $P_2 \times P_3$, $P_2 \times P_4$ and $P_4 \times P_6$ at L_3 level, suggesting accumulation of decreasing alleles for flag leaf chrophyll content. Positive or negative heterobeltiosis values have been recorded for flag leaf chlorophyll content by Awaad *et al.* (2013).

Spike Characteristics

Spike length considered as visual selection criterion aiming to improve grain yield in wheat breeding programs. Data present in Table 5 show heterobeltiosis percentage of spike length in 15 F_1 crosses. The results indicated positive and highly significant heterosis over better parent was detected by the cross combination $P_3 \times P_6$ at L_1 , L_2 and L_3 levels; $P_1 \times P_3$ at L_2 level and the cross $P_1 \times P_5$ at L_3 level. The foregoing results revealed an accumulation of increasing alleles responsible of long spike. Positive and significant heterosis for spike length was found by Akbar *et al.* (2010) and Bilgin *et al.* (2011). Otherwise, negative and highly significant heterosis over better parent was recorded by all the crosses, except the cross $P_3 \times P_6$ at L_1, L_2 and L_3 levels, and $P_1 \times P_3$ at L_2 level as well as the crosses $P_1 \times P_3$, $P_1 \times P_4$ and $P_1 \times P_5$ at L_3 level. This result could be disscussed based on accumulation genes with decreasing effect. In this respect, negative and significant heterosis was recorded by Ghanem (2001) and El-Moselhy (2009).

Number of fertile spikelets /spike for 15 F_1 crosses at L_1, L_2 and L_3 nitrogen levels presented in Table 5, cleary indicate positive and highly significant heterosis over better parent by the cross combinations $P_3 \times P_6$ and $P_5 \times P_6$ at L_1 level and the cross $P_1 \times P_3$ at L_3 level. The foregoing results indicated an accumulation of genes with increasing effect. On the other hand, negative and highly significant heterosis over better parent

Table 4. Heterosis as percentage of better-parent "heterobeltiosis" for flag leaf area and flag leaf chlorophyll content under three nitrogen levels

Crosses	Flag leaf area			Flag leaf chlorophyll content		
	L_1	L_2	L_3	L_1	L_2	L_3
$P_1 \times P_2$	4.140	-8.541*	-17.513**	-7.849**	-6.227**	-7.79**
$P_1 \times P_3$	13.834**	-3.789	-25.76**	-21.847**	1.175	-8.746**
$P_1 \times P_4$	2.972	-4.011	-14.74**	-11.08**	3.754*	1.629
$P_1 \times P_5$	-13.274**	-8.122*	-21.26**	-0.564	-1.229	-3.989*
$P_1 \times P_6$	-0.341	-15.651*	-19.71**	-11.30**	6.062**	-3.174
$P_2 \times P_3$	7.515*	-35.105**	-18.18**	-16.16**	-6.184**	-2.102
$P_2 \times P_4$	-21.178**	-31.45**	-20.84**	-5.69**	-0.663	2.055
$P_2 \times P_5$	-26.964**	-23.21**	-13.76**	-7.26**	-9.244**	-5.33**
$P_2 \times P_6$	0.191	-10.30**	-23.98**	-9.25**	-8.538**	-6.04**
$P_3 \times P_4$	-2.074	-18.34**	-15.43**	-7.75**	3.441	-4.42*
$P_3 \times P_5$	-4.304	-9.42**	-14.09**	-6.09**	-0.565	-9.34**
$P_3 \times P_6$	5.882	12.18**	-23.28**	-8.37**	-2.916	-6.84**
$P_4 \times P_5$	-29.297**	-32.68**	-14.38**	-8.558**	-5.877**	-4.54*
$P_4 \times P_6$	-6.190*	-5.964	-26.58**	-11.014**	-0.134	-1.430
$P_5 \times P_6$	-19.216**	-6.452	-11.70**	-6.569**	-4.360*	-6.46**

was recorded by the crosses $P_1 \times P_2$, $P_1 \times P_4$, $P_1 \times P_5$, $P_2 \times P_3$, $P_2 \times P_4$, $P_2 \times P_5$, $P_2 \times P_6$, $P_3 \times P_4$ and $P_4 \times P_5$ at L_1 level; $P_1 \times P_2$, $P_1 \times P_4$, $P_1 \times P_5$, $P_2 \times P_3$, $P_2 \times P_4$, $P_2 \times P_5$, $P_2 \times P_6$, $P_3 \times P_4$, $P_4 \times P_5$, $P_4 \times P_6$ and $P_5 \times P_6$ at L_2 level as well as all the crosses except $P_1 \times P_2$, $P_2 \times P_3$, $P_2 \times P_6$ and $P_5 \times P_6$ at L_3 level. These results indicated accumulation of genes with decreasing effect. It is interest to note that heterotic effect differed from level to another, it was negative and insignificant in $P_1 \times P_3$ cross at L_1,negative and significant (-0.587) at L_2, but exhibited positive and highly significant (+3.982) at L_3 level; which could be attributed to the differential response to nitrogen levels.

Number of sterile spikelets/spike (Table 5) reflected negative and highly significant heterosis over better parent in the desired direction by the cross combination $P_1 \times P_3$ at L_1 level; $P_2 \times P_6$, $P_4 \times P_5$ and $P_4 \times P_6$ at L_2 level as well as $P_1 \times P_3$, $P_1 \times P_4$, $P_2 \times P_3$, $P_2 \times P_5$, $P_3 \times P_4$, $P_3 \times P_5$, $P_4 \times P_5$and $P_4 \times P_6$ at L_3 level. This result indicated an accumulation of genes which decreased number of sterile spikelets/spike. On the other hand, positive and highly significant heterosis was recorded by all the crosses except $P_1 \times P_3$ at L_1 level, and all the crosses except $P_2 \times P_6$, $P_4 \times P_5$ and $P_4 \times P_6$ at L_2 level. Also positive and highly significant heterobeltiosis was recorded by the cross combinations $P_1 \times P_2$, $P_1 \times P_5$, $P_1 \times P_6$, $P_2 \times P_4$, $P_2 \times P_6$, $P_3 \times P_6$ and $P_5 \times P_6$ at L_3 level. This result indicated accumulation of genes with increasing effect. Heterobeltiosis was changes from environment to another as observed in the cross combinations $P_1 \times P_3$, $P_1 \times P_4$, $P_2 \times P_3$, $P_2 \times P_4$, $P_2 \times P_5$, $P_2 \times P_6$, $P_3 \times P_4$, $P_3 \times P_5$, $P_4 \times P_5$ and $P_4 \times P_6$, reflecting the great effect of nitrogen application on number of sterile spikelets / spike.

Table 5. Heterosis as percentage of better-parent "heterobeltiosis" for main spike characteristices under three nitrogen f levels

Crosses	Spike length			No. of fertile spiklets / spike			No. of sterile spiklets / spike		
	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3
$P_1 \times P_2$	-3.634**	-5.413**	-2.088**	-4.986**	-7.544**	0.433	39.54**	46.385**	11.76**
$P_1 \times P_3$	-10.230**	1.957*	0.079	-0.759	-0.587*	3.982**	-9.230**	69.930**	-5.555**
$P_1 \times P_4$	-14.49**	-3.032**	0	-6.261**	-4.830**	-5.466**	44.206**	40.361**	-12.048**
$P_1 \times P_5$	-10.82**	-5.245**	1.457**	-2.193**	-3.931**	-3.001**	49.431**	4.216**	15.606**
$P_1 \times P_6$	-11.08**	-3.691**	-3.544**	-0.468	-2.631**	-2.720**	27.756**	4.216**	23.571**
$P_2 \times P_3$	-1.944**	1.778**	-1.778**	-1.813**	-0.566**	-0.867	29.230**	69.930**	-32.52**
$P_2 \times P_4$	-8.728**	-0.54	-6.187**	-1.162*	-2.288**	-3.699**	14.163**	17.045**	40.361**
$P_2 \times P_5$	-7.86**	-13.147**	-6.187**	-2.719**	-2.921**	-2.862**	47.727**	26.704**	-14.117**
$P_2 \times P_6$	-4.226**	-3.637**	-2.861**	-2.719**	-2.311**	-1.122	1.503**	-22.421**	23.571**
$P_3 \times P_4$	-5.660**	-2.691**	-4.219**	-5.053**	-4.406**	-5.877**	17.167**	67.832**	-9.638**
$P_3 \times P_5$	-0.628	-3.263**	-5.015**	-0.606	-1.363**	-0.176	36.363**	18.881**	-1.734**
$P_3 \times P_6$	7.811**	3.531**	0.557**	2.344**	-1.184*	-1.727**	1.503**	46.853**	21.428**
$P_4 \times P_5$	-4.716**	-2.033**	-7.643**	-1.788**	-2.288**	-2.178**	34.09**	-1.704**	-13.85**
$P_4 \times P_6$	-5.094**	-1.745**	-5.254**	-0.268	-2.288**	-3.822**	47.210**	-22.72**	-7.142**
$P_5 \times P_6$	-2.588**	-2.889**	-2.473**	2.812**	-2.631**	-0.690	55.113**	26.704**	21.42**

Yield and its Components

Number of spikes/ plant (Table 6), indicated that at L_1 level, negative and highly significant over better parent heterosis was detected in all crosses, except the cross $P_2 \times P_3$ at L_1 level and $P_1 \times P_4$, $P_3 \times P_4$ and $P_3 \times P_5$ at L_2 level and all the crosses at L_3 level. This finding revealing an accumulation of decreasing alleles controlling number of spikes/ plant. There is one cross ($P_1 \times P_4$) show complete dominance towards better parent (the differ was zero). Negative and significant heterosis was found by Ghanem (2001); Abd El-Aty and Katta (2002); Awaad (2002); El Sayed and Moshref (2005) and El-Moselhy, (2009).

Number of grains /spike (Table 6) showed positive and significant hetorosis over better parent by both crosses p_3x p_4 and p_4xp_6 at L_2 level. This result indicated an accumulation of increasing alleles controlling number of grains / spike. On the other hand, negative and highly significant hetrosis were recorded by 10,8 and 10 out of 15 studied wheat cross combinations at L_1, L_2 and L_3 levels, respectively. These results indicated an accumulation of decreasing alleles controlling number of grains/spike. In this respect, similar results regarding negative or positive heterosis were also found for number of grains per spike by Ghanem (2001); Saleh (2006) and El Moselhy (2009).

1000- grain weight (Table 6), indicated positive and highly significant heterosis over better parent by the cross combinations p_1x p_2 , $p_2 \times p_3$, $p_2 \times p_5$ and $p_4 \times$ p_5 at L_1 level . Meanwhile, positive and highly significant heterosis were detected by the wheat crosses $p_1 \times p_4$ at L_3 level; $p_4 \times p_5$ and $p_4 \times p_6$ at L_2 and L_3 levels. These results revealed that the abovementioned wheat crosses were superior in 1000- grain weight under different nitrogen levels and could be considered the promising ones in wheat programs aiming to improve 1000-grain weight. Positive and significant heterosis for that character was found by Ghanem (2001); Hamada and El-Beially (2003) and Saleh (2006).

Table 6. Heterosis as percentage of better-parent "heterobeltiosis" for yield components under three nitrogen levels

Crosses	No. of spikes/plant			No. of grains/spike			1000-grain weight (g)		
	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3
$P_1 \times P_2$	-20.76**	-15.739**	-11.69**	-1 4.004**	-10.871**	-11.65**	9.824**	2.168	2.505
$P_1 \times P_3$	-34.75**	-4.73**	-11.36**	0.130	-0.972	-5.899*	2.243	-6.051**	-6.846**
$P_1 \times P_4$	-1.538**	0	-14.80**	-16.081**	-8.788**	-8.223**	2.443	3.769*	6.666**
$P_1 \times P_5$	-14.661**	-5.806**	-13.04**	-16.29**	-3.220	-7.087**	2.143	-5.955**	-5.992*
$P_1 \times P_6$	-2.555**	-15.061**	-18.18**	-19.70**	-6.699**	-7.549**	-4.200	-1.997	-1.254
$P_2 \times P_3$	-0.473	-7.660**	-6.705**	-4.815*	0.762	-1.734	14.868**	0.211	1.952
$P_2 \times P_4$	-7.692**	-17.523**	-19.436**	-14.982**	-7.812**	-5.315**	4.288*	-5.984**	-5.30**
$P_2 \times P_5$	-24.481**	-2.098**	-7.867**	-17.19**	-1.715	-6.739**	6.045**	0.440	0.276
$P_2 \times P_6$	-13.964**	-22.848**	-17.17**	-13.13**	-11.79**	-13.500**	3.532	-0.652	-0.211
$P_3 \times P_4$	-4.615**	-0.705	-10.07**	-13.49**	6.453**	-5.773*	0.754	-6.514**	-5.43*
$P_3 \times P_5$	-6.915**	-1.450	-7.86**	-3.667	0.647	-6.238**	-5.771**	-10.286**	-9.39**
$P_3 \times P_6$	-7.898**	-9.836**	-12.82**	-2.419	-6.095**	-6.612**	-10.197**	-12.90**	-9.05**
$P_4 \times P_5$	-17.565**	-11.160**	-19.13**	-9.079**	-11.35**	-9.455**	13.869**	5.172**	6.927**
$P_4 \times P_6$	-10.153**	-3.381**	-9.06**	-2.35	4.592*	-2.355	-1.285	6.297**	7.533**
$P_5 \times P_6$	-11.065**	-6.762**	-9.494**	-7.106**	-7.120**	-0.730	-1.190	-0.580	3.039

Grain yield / plant represent the final product of physiological processes which occure in plants *i.e.,* photosynthesis, metabolism, anabolism, translocation and accumulation in sinks. It is evident from the data presented in Table 7 that the cross combination p_1x p_5 exhibited positive and significant heterosis in the desired direction under L_1 and L_3 levels; p_2x p_3 at L_1 level as well as p_1x p_6 at L_2 level only. These results reveal the superiority of these crosses and the predominant role of dominance gene action in controlling wheat grain yield. It is interest to note that the wheat cross p_2x p_3 which exhibited desirable heterosis in grain yield / plant was also superior in flag leaf area and 1000-grain weight. In this respect, Awaad *et al.* (2013) pointed out that the F_1 exceeded the better parent for grain yield /plant in 3 out of 4 studied crosses. Also positive and significant heterosis was found for grain yield by Abd El-Nour (2005); Koumber and El- Beially (2005) and Akbar *et al.* (2010).

Biological yield/plant (Table 7) shows heterosis as percentage of better parent for biological yield/plant. positive and significant heterosis were detected by the cross combinations P_3 x P_4 and P_4 x P_6 with values of 9.906 and 17.807%, respectively at L_1 level. Also, positive and highly significant heterosis was reported by the cross combination P_1 x P_4 with values of 11.474 and 7.74%, at L_2 and L_3 levels, respectively, as well as the cross P_1 x P_2 with value of (15.615%) at L_3 level only . This finding revealed accumulation of genes with dominant effects which acting in positive direction. Heterotic effects found to be fluctuated from nitrogen level to another as a result of differential response to nitrogen. Similar conclusion was found by Saleh (2006).

Table 7. Heterosis as percentage of better-parent "heterobeltiosis" for grain and biological yields / plant under three nitrogen levels and N-use efficiency

Crosses	Grain yield/ plant (g)			Biological yield / plant(g)			N-use efficiency
	L_1	L_2	L_3	L_1	L_2	L_3	
$P_1 \times P_2$	3.045	3.445	1.499	-16.05**	-14.57**	15.615**	23.32**
$P_1 \times P_3$	3.329	3.210	1.457	-7.287	6.836	-3.338	-26.94**
$P_1 \times P_4$	3.118	3.208	1.494	-16.728**	11.474**	7.746**	-64.62**
$P_1 \times P_5$	3.835*	1.718	3.486*	-21.22**	0.158	-4.346	-21.86**
$P_1 \times P_6$	2.794	4.762*	1.565	-26.01**	-20.35**	-18.16**	-62.39**
$P_2 \times P_3$	4.323*	2.233	2.485	0.266	-3.898	-9.65**	-39.92**
$P_2 \times P_4$	3.147	0.930	1.971	5.170	-7.312	-12.05**	-47.39**
$P_2 \times P_5$	3.035	1.404	1.885	-16.46**	-1.492	-9.870**	17.81**
$P_2 \times P_6$	2.922	1.620	2.795	-9.15*	-15.13**	-18.01**	-48.04**
$P_3 \times P_4$	3.523	2.691	3.216	9.906*	3.411	2.398	-61.86**
$P_3 \times P_5$	2.245	2.775	1.565	-12.38**	-3.241	-12.51**	28.92**
$P_3 \times P_6$	2.825	2.722	1.843	-14.04**	-7.141	-5.984*	-51.67**
$P_4 \times P_5$	1.742	1.922	2.054	-22.13**	3.083	-1.552	-99.01**
$P_4 \times P_6$	1.136	2.348	1.125	17.807**	-3.761	-4.363	-66.52**
$P_5 \times P_6$	1.701	1.419	1.980	-23.52**	-6.617	-7.010**	-59.68**

N- use efficiency for 15 F_1 crosses (Table 7) cleary indicate positive and highly significant heterosis over better parent by the cross combinations $P_1 \times P_2$, $P_2 \times P_5$ and $P_3 \times P_5$. The foregoing results indicated an accumulation of genes with increasing effect. On the other hand, negative and highly significant heterosis over better parent was recorded by the crosses $P_1 \times P_3$, $P_1 \times P_4$, $P_1 \times P_5$, $P_1 \times P_6$, $P_2 \times P_3$, $P_2 \times P_4$, $P_2 \times P_6$, $P_3 \times P_4$, $P_3 \times P_6$, $P_4 \times P_5$, $P_4 \times P_6$ and $P_5 \times P_6$. These results indicated accumulation of genes with decreasing effect. Gorny *et al.* (2011) recorded positive and significant specific combining ability estimates for nitrogen utilization efficiency in four wheat crosses as well as negative and significant in 7 out of 15 F_2 crosses.

Grain protein content for 15 F_1 crosses under three levels of nitrogen (Table 8) indicated positive and significant heterosis over better parent by the cross combinations P_1xP_2 (11.74, 9.41 and 5.69%) and p_3x p_5 with value (8.07, 11.15 and 6.16%) at L_1, $L_2$and L_3 levels respectively and the cross P_2x P_5 (4.69 and 6.42 %) at L_1 and L_2 levels respectively. Also positive and significant heterosis was detected by the cross combination P_3x P_6 (38.56%) at L_1 level. These results revealed that the abovementioned wheat crosses were superior in grain protein content under different nitrogen levels and could be considered the promising ones in wheat programs aiming to improve bread wheat quality. Positive and significant heterosis in protein content was obtained by El-Hosary *et al.* (2000); Joshi *et al.* (2003) and El Moselhy (2009).

Table 8. Heterosis as percentage of better-parent "heterobeltiosis" for grain protein content under three nitrogen levels

Crosses	Grain protein content (%)		
	L_1	L_2	L_3
$P_1 \times P_2$	11.74**	9.41**	5.69**
$P_1 \times P_3$	-24.70**	-22.9**	-25.24**
$P_1 \times P_4$	-38.89**	-39.16**	-39.44**
$P_1 \times P_5$	-34.05**	-34.84**	-37.53**
$P_1 \times P_6$	-31.63**	-31.68**	-34.40**
$P_2 \times P_3$	-9.70**	-6.42**	-6.68**
$P_2 \times P_4$	-26.92**	-29.17**	-30.4**
$P_2 \times P_5$	4.69*	6.424**	1.92
$P_2 \times P_6$	-28.62**	-29.13**	-28.96**
$P_3 \times P_4$	-31.39**	-34.16**	-34.77**
$P_3 \times P_5$	8.07**	11.15**	6.16**
$P_3 \times P_6$	38.56**	-39.10**	-39.19**
$P_4 \times P_5$	-24.65**	-26.83**	-27.60**
$P_4 \times P_6$	-33.36**	-34.23**	-34.38**
$P_5 \times P_6$	-37.51**	-38.30**	-35.57**

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قوة الهجين للصفات المورفوفسيولوجية والمحصولية فى قمح الخبز تحت مستويات مختلفه من النيتروجين

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أجريت هذه التجربة خلال الموسم الشتوى لاعوام ٢٠٠٩/٢٠١٠، ٢٠١٠/٢٠١١ بمحطة البحوث الزراعية بكفر الحمام – الزقازيق – شرقيه باستخدام تحليل الدياليل لستة آباء وهجن الجيل الأول الناتجة عنها بهدف تقدير قوة الهجين لصفات عدد الأيام من الزراعة حتى طرد السنابل، عدد الأيام من الزراعة حتى النضج ، فترة بقاء الأوراق خضراء، مساحة ورقة العلم ، محتوى كلوروفيل ورقة العلم ، المحصول ومكوناته و كفاءة إستخدام النيتروجين ومحتوى الحبوب من البروتين تحت ثلاث مستويات من النيتروجين ،المستوى الأول هو الميسر فى التربة ٤٠,٥ كجم ن/ ف والمستوى الثانى تم إضافة ٣٥ كجم ن/ ف من السماد الآزوتى ليصبح ٧٥,٥ كجم ن/ ف والمستوى الثالث تم إضافة ٧٠ كجم ن/ف على المستوى الأول ليصبح ١١٠,٥ كجم ن/ ف وكانت الأباء هى سلالة ١ (P_1) ، سلالة ٢ (P_2) ، سلالة ٣ (P_3) وهم ثلاث سلالات من المدخلات الأقل من النيتروجين و٣ أصناف هم جميزة ١٠ (P_4) ، سخا٩٣ (P_5)، جيزة ١٦٨ (P_6)، وأظهرت النتائج وجود قوة هجين سالبة ومعنوية بالنسبة لصفة عدد الأيام من الزراعه حتى طرد السنابل فى الهجن $P_2 \times P_5$ ، $P_4 \times P_6$ تحت المستوى الأول والثالث والهجين $P_4 \times P_6$ تحت المستوى الثالث فقط . بينما كانت قوة الهجين موجبة ومعنوية لصفة عدد الأيام حتى النضج وفترة بقاء النبات أخضر فى الهجين $P_2 \times P_3$ تحت المستوى الثانى، وبالنسبة لمساحة ورقة العلم سجلت قوة هجين موجبة ومعنوية فى الهجن $P_1 \times P_3$ ، $P_2 \times P_3$ تحت المستوى الأول والهجين $P_3 \times P_6$ تحت المستوى الثانى ولصفة محتوى كلوروفيل ورقة العلم فى الهجن $P_1 \times P_4$ ، $P_1 \times P_6$ تحت المستوى الثانى والثالث، سجلت قوة هجين موجبة ومعنوية لصفة طول السنبلة فى الهجن $P_1 \times P_3$ ، $P_1 \times P_5$ ،$P_3 \times P_6$ تحت الثلاث مستويات من النيتروجين ولعدد السنيبلات الخصبة فى الهجن $P_3 \times P_6$ ، $P_5 \times P_6$ تحت المستوى الأول و $P_1 \times P_3$ تحت المستوى الثالث فقط، وأشارت النتائج إلى وجود قوة هجين سالبة ومعنوية لصفة عدد السنيبلات العقيمة فى الهجن $P_1 \times P_3$ ، $P_1 \times P_4$ ، $P_2 \times P_3$ ، $P_2 \times P_5$ ، $P_2 \times P_6$ ، $P_3 \times P_4$ ، $P_3 \times P_5$ ، $P_4 \times P_5$ ، $P_4 \times P_6$ تحت الثلاث مستويات من النيتروجين، ما يتعلق بالمحصول ومكوناته كانت قوة الهجين موجبة ومعنوية لعدد حبوب/السنبلة فى الهجن $P_3 \times P_4$، $P_4 \times P_6$ تحت المستوى الثانى ولوزن الألف حبة فى الهجين $P_4 \times P_5$ تحت الثلاث مستويات من التسميد الأزوتى وكذلك لمحصول الحبوب فى الهجن $P_1 \times P_5$ ، $P_2 \times P_3$ تحت المستوى الأول و $P_1 \times P_6$ تحت المستوى الثانى والهجين $P_1 \times P_5$ تحت المستوى الثالث وللمحصول البيولوجى فى الهجن $P_3 \times P_4$, $P_4 \times P_6$ تحت المستوى الأول والهجن $P_1 \times P_4$, $P_1 \times P_2$ تحت المستوى الثانى والثالث، أيضاً ظهرت قوة هجين موجبة ومعنوية لصفة كفاءة استخدام النيتروجين فى الهجن $P_1 \times P_2$، $P_2 \times P_5$ ، $P_3 \times P_5$، علاوة على ذلك فقد ظهرت قوة هجين موجبة ومعنوية لصفة محتوى الحبوب من البروتين فى الهجن $P_1 \times P_2$, $P_3 \times P_5$ تحت الثلاث مستويات من النيتروجين .

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