J. Plant Prod., Mansoura Univ. Vol. 1 (11): 1495 - 1513, 2010

GENETICAL STUDIES ON SOME AGRONOMIC CHARACTERS IN CERTAIN BREAD WHEAT CROSSES UNDER LOW NITROGEN FERTILIZER CONDITION

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ABSTRACT

Six parental cultivars and /or lines of bread wheat were used in a half diallel cross at Gemmeiza Agricultural Research Station, at Egypt during two growing seasons of, 2008/2009 and 2009/2010 to study combining ability and heterosis and their interactions under two nitrogen fertilizer levels (35 kg N/ faddan (low N)and 70 kg N/ faddan) for days to heading, grain filling period, plant height, number of spikes / plant, number of grains / spike, 1000- grain weight and grain yield / plant.

Nitrogen fertilizer levels mean squares were found to be highly significant for all studied traits. Being higher at normal nitrogen than those of low nitrogen fertilizer level. Genotypes, parents and the resultant crosses mean squares were found to be highly significant for all traits studied at the two nitrogen levels and their combined except for grain filling period at low nitrogen level of parents. Parent vs. crosses mean squares as an indication to average heterosis overall crosses were found to be highly significant at the two different nitrogen levels and their combined for grain filling period, plant height, 1000-grain weight and grain yield/plant. The interaction of nitrogen levels with genotypes, and crosses were found to be significant for all traits studied except days to heading.

General combining ability (GCA) and specific combining ability (SCA) mean squares were found to be highly significant for all traits studied at the different nitrogen fertilizer levels and their combined. This would indicate the importance of both additive and non- additive genetic variance in the inheritance of all traits studied. The interactions of nitrogen fertilizer levels with both types of combining abilities were found to be significant for all traits studied except days to heading and number of grains/spike.

The cultivar P_6 proved to be a good combiner for days to heading , plant height, number of grains / spike and 1000- grain weight at the two nitrogen fertilizer levels and their combined. The hybrid combination (P_4 x P_5) showed highly significant desirable SCA effects for plant height, 1000-grain weight and grain yield / plant. As for grain yield / plant, four hybrid combinations (P_2 x P_4),(P_2 x P_5), (P_2x P_6) and (P_3 x P_4) showed highly significant desirable heterosis which varied from 9.407% to 71.542 % relative to their better parents at both low and normal nitrogen fertilizer levels and their combined.

Keywords: bread wheat (*Triticum aestivum* L.), diallel crosses, Combining ability, heterosis, additive and dominance genetic components, Heritability.

INTRODUCTION

Wheat is the most widely grown and consumed food crop in Egypt. Breeding efforts are directed mainly towards producing high yielding cultivars in order to face the fastest increase in wheat consumption and consequently reduce wheat import. Moreover, increasing food demands have led to cultivate wheat under marginal conditions which characterized by many biotic stresses. So, adaptation of agricultural crops to meet the such new environment limited factors for increasing yield (Evans,1980).

Combining ability analysis of Griffing (1956), is most widely used as a biometrical tool for evaluating parental lines in terms of their ability to combine well in hybrid combinations. According to this method, the resulting of total genetic variation is partitioned into effects of general combining ability, as a measure of additive gene action and specific combining ability, as a measure of non- additive gene action .

Heterosis is a complex genetical phenomenon, which depends on the balance of different combinations of gene effects as well as on the distribution of plus and minus allels in the parents of a mating. In self- pollinated crops like wheat the scope for utilization of heterosis depends mainly upon the direction and magnitude of heterosis. Heterosis over better parent may be useful in identifying the best hybrid combinations but these hybrids can be immense practical value if they involve the best cultivars of the area (Prasad *et al*,1998).

Environmental fluctuations are highly affect the phenotypic expression of quantitative traits. Genotypic x environment interaction, depending upon their nature and magnitude, leads to bias estimates of gene effects and combining ability for various sensitive characters to environmental modulations. Such traits are less amenable to be improved the discover of both cytoplamic male sterility and genes which restores fertility in wheat has been encouraged many workers to examine F_1 hybrids which perform better than the available commercial varieties through selection Hendawy, 1994,Yadav *et al*, 1998 and Yang and Baker, 1991.

The objectives of the present investigation are to study (i) the potentiality of heterosis of grain yield and its components in a six parental diallel crosses, (ii) the magnitude of both general and specific combining ability and their interactions with two nitrogen fertilizer levels and (iii) type of gene action govern this materials and its utilization in a breeding program .

MATERIALS AND METHODS

The present investigation was carried out at Gemmeiza Agricultural Research Station, Agricultural Research Center, (ARC), Egypt, during two successive seasons 2008/2009 and 2009/2010. Six wheat genotypes different widely in their genetic diversity from a previous study were selected to establish the experimental materials for the study. The name and pedigree of these genotypes are presented in Table (1). In 2008/ 2009 growing season the six parents were crossed in all possible combinations excluding reciprocals, to obtain a total of 15 F_1 hybrids. The parental cultivars and / or lines and their possible fifteen crosses were sown in 2009/ 2010 season under two nitrogen fertilizer levels 35 kg. N. / fad., designated in the text as low (L) and 70 kg N/fad.as a normal (N) nitrogen levels, in two adjacent experiments.

Table (1): The names and pedigree of six bread wheat cultivars and lines

NO.	Genotypes	Pedigree	Origin
P_1	Line 1	Desconocido#6/4/B1-1133/3/CMH79A.955*2/CNO 79//79A.955/BOW's'	Mexico
P_2	Line 2	KAUZ/BAU	Mexico
P_3	Line 3	KAUZ/PASTOR	Mexico
P_4	Gemmeiza9	Ald "S" / Huac "S" // CMH77A . 630/Sx CGM4583 – 5GM – 1GM – 0GM .	Egypt
P_5	Gemmeiza 7	CMH74A.630/SX//SERI82 /Agent CGM4611- 2GM- 3GM- 1GM- 0GM	Egypt
P_6	Line 4	ParentSK47A-4-1/Sakha61/Mildress/Mo73/Pol//t.aest-BON/CNO-7C	Mexico

Each experiment was arranged in a randomized complete block design with three replicates. Each plot comprised two rows 3 meters long with 30 cm. between rows. Plants within rows were 10 cm. apart allowing a total of 60 plants per plot. Days to heading was recorded as a number of days from sowing to the first appearance of awns through the flag leaf sheaths for 50% from the plants in the plot . At maturity, twenty guarded plants were selected at random for the subsequent measurements as follows: grain filling period, plant height(cm), number of spikes / plant, number of grains / spike, 1000-grain weight (g)and grain yield / plant(g).

Estimates of both general and specific combining ability were calculated according to the procedures of Griffing (1956) as method 2, model 1 . The combined analysis was computed over the two nitrogen fertilizer levels to test the interactions of the different genetic components with the two nitrogen levels, as a two different environmental conditions,

and it was done whenever the homogeneity of variances was detected. Heterosis was expressed as percent deviation of the F_1 mean performance from the better parent values.

Heterosis (%) over better parent value = $\overline{F1} - \overline{BP} / \overline{BP} \times 100$

The data were also subjected to assess the components of genetic variance following the procedures described by Hayman (1954).

RESULTS AND DISCUSSION

The choice of the selection environment is one of the most frequency debated and still largely unresolved questions in plant breeding. Traditionally most plant takes place in high-yielding environments such as those on experimental stations (Simmonds,1991). This is based on the assumption, often (but not always) validated by data, that in high-yielding conditions there is more efficient control of environmental variation, better expression of genetic differences and hence higher heritabilities than in low-yielding environments. The assumption ignores the possibility that the genetic differences and higher heritabilities found in high input conditions can be largely irrelevant when the same genetic material is tested in low-input agricultural systems. The assumption is weakened even farther when plant breeding programs aim at sustainable improvement in crop yields (Ceccarelli *et al* 1992) where elements of a typical "high input package" such as genetic uniformity and high harvest index do not necessarily apply.

Analysis of variance:

Mean squares of a half diallel analysis which are presented in Table (2) indicated highly significant effects of genotypes for all studied traits under two fertilizer levels as well as their combined. The significance of mean squares indicated the presence of true genetic difference among these genotypes. Highly significant values for genotypes x nitrogen fertilizer levels except for, days to heading were detected indicating the presence of certain interactions between genotypes and nitrogen fertilizer levels.

Mean squares for nitrogen fertilizer levels were found to be highly significant for all studied traits with values being higher at normal nitrogen fertilizer level (70 kg N/fed.) than those of low one (35 kg N/fed.). Frey and Maldnado (1967) defined that the stress environment as the one in which mean performance for certain attribute is low. Consequently, low nitrogen fertilizer level may be considered as a stress environment, while the normal nitrogen level seemed to be non-stress one. Similar results were previously drawn by Hendawy (1994) , Koumber and Esmail (2005) and Koumber *et al* (2006).

Mean square due to parents were significant for all studied traits except grain filling period at low nitrogen fertilizer level. Also, mean squares due to the interactions between parents and nitrogen fertilizer levels were significant for all studied traits except for; days to heading, plant height and number of grains/spike. These results indicate that, the parental genotypes were differed in their mean performance for most studied traits and varied in response to nitrogen levels in all studied traits. At the same time, wide genetic diversity was detected between these parental genotypes.

The data in Table (2) also showed that, the crosses mean squares were highly significant for all studied traits. Mean squares due to the interactions between crosses and nitrogen fertilizer levels were highly significant for all studied traits except days to heading which indicate that these crosses behaved differently over different nitrogen levels. Mean squares associated with general and specific combining ability were significant for all studied traits. It is evident that additive and additive by additive types of gene actions were more important part of the total genetic variability. On the other hand, both additive and non-additive gene effects were involved in determining the performance of single cross progeny. The results showed that all other cases expressed high GCA/SCA ratios which, exceeded unity except grain filling period indicating the predominance of additive and additive by additive gene action in the inheritance of such cases. These results are similar to those reported by Hamada *et al* (2002) and Moussa and Morad (2009).

Mean squares of the interactions between nitrogen levels and both general and specific combining ability were significant for all studied traits except for, days to heading and number of grains/spike revealing that, the magnitude of both additive and additive by additive types of gene action fluctuated among nitrogen levels, thus selection for these traits may not be effective in a single environment but more than one environment may be required. These findings are in agreement with those obtained by Hamada (2003) and Koumber *et al* (2006).

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Mean performance:

The major objective of wheat breeder is to produce new genotypes with high yielding ability for grain yield as an end product. Thus, the choice of the parents to be used in crossing programs is the most important problem facing the breeders. If the parents are precisely selected, the desired recombinations will be found in the segregating generations. The use of a diallel cross technique and estimation of combining ability gave the breeders an effective procedure to evaluate the breeding materials and identify the most suitable parents that produce the better hybrids (Mahrous,1998) and Koumber (2001).

The genotype mean performances under low and normal fertilizer levels and their combined are presented in Table (3). The results showed that the mean values at high nitrogen fertilizer level (70kg N/faddan), being higher than those at low nitrogen fertilizer level (35 kg N/faddan).

The parental line (P_1) ranked the third for grain filling period and number of grains/spike and the fourth for plant height. The parental line (P_2) ranked the first for number of spikes/plant and the third for grain yield/plant.

Table (3): Genotypes mean performance at normal and low nitrogen fertilizer levels and their combined for yield and yield components.

Genotypes	Days to heading			Grain filling period			Plant height			No. of spikes/plant		
	L	N	Comb	L	N	Comb	L	N	Comb	L	N	Comb
P_1	101	103	102	52.667	57.000	54.833	108.2	116.4	112.3	5.43	9.3	7.37
P_2	102	104	103	53.000	57.333	55.167	115.43	123.33	119.38	14.50	19.7	17.10
P_3	96	99	97.5	54.333	56.667	55.500	106.83	119.07	112.95	7.50	10.17	8.83
P_4	103	104.7	103.8	51.667	58.000	54.833	102.53	110.87	106.7	11.23	18.63	14.93
P_5	94.3	97	95.7	54.000	55.333	54.667	110.9	116.9	113.9	6.73	8.47	7.60
P_6	93	95.3	94.2	52.000	51.000	51.500	90.27	97.73	94.00	5.50	7.98	6.74
$P_1 \times P_2$	98	100	99	50.000	56.333	53.167	101.83	115.83	108.83	7.17	12.00	9.58
$P_1 \times P_3$	97	100	98.5	46.000	56.000	51.000	103.00	116.33	109.67	6.00	10.00	8.00
$P_1 \times P_4$	100	102.3	101.2	45.000	47.333	46.167	97.73	113.83	105.78	7.23	12.07	9.65
$P_1 \times P_5$	98	101	99.5	56.333	57.000	56.667	105.00	113.27	109.13	9.27	16.73	13.00
$P_1 \times P_6$	97.7	101	99.3	48.333	53.000	50.667	96.00	98.03	97.02	4.17	6.50	5.33
$P_2 \times P_3$	98.7	101	99.8	45.333	49.333	47.333	96.67	122.33	109.5	10.9	15.00	12.95
$P_2 \times P_4$	101	104	102.5	52.667	58.000	55.333	93.67	103.5	98.58	13.00	18.17	15.58
$P_2 \times P_5$	95	98.3	96.7	54.000	58.000	56.000	106.17	115.17	110.67	11.33	16.23	13.78
$P_2 \times P_6$	97	100	98.5	51.333	53.000	52.167	99.00	110.43	104.72	10.33	13.17	11.75
$P_3 \times P_4$	98	100	99	50.333	54.000	52.167	106.00	113.83	109.92	9.50	13.17	11.33
$P_3 \times P_5$	96	99	97.5	53.667	55.000	54.333	106.67	114.83	110.75	9.00	9.23	9.12
$P_3 \times P_6$	95	97	96	49.667	53.333	51.500	106.67	110.33	108.50	11.00	12.00	11.50
$P_4 \times P_5$	98	101.7	99.8	49.333	56.333	52.833	96.57	104.00	100.28	9.00	16.97	12.98
$P_4 \times P_6$	98.3	100.3	99.3	49.000	53.000	51.500	96.17	102.00	99.08	8.42	13.17	10.79
$P_5 \times P_6$	94	97	95.5	50.333	53.000	51.667	95.00	102.17	98.58	4.67	7.92	6.29
Mean	97.7	100.3	98.97	50.905	54.667	52.786	101.92	111.44	106.68	8.67	12.69	10.68
L.S.D 5%	1.664	2.181	0.955	2.354	1.795	1.030	2.355	3.171	1.374	0.963	1.656	0.667
L.S.D 1%	2.923	3.832	1.266	4.137	3.154	1.336	4.138	5.571	1.823	1.692	2.909	0.884

L = low nitrogen level 35kg/fed.
N= normal nitrogen level 70kg/fed.
Comb.= combined

Table (3) : Cont.

Genotypes	No. of grains/spike			1000-grain weight			Grain yield/plant(gm)		
	L	N	Comb	L	N	Comb	L	N	Comb
P_1	79.5	85.33	82.42	42.67	64.86	53.77	19.23	34.27	26.75
P_2	66.33	72.00	69.17	44.33	46.13	45.23	32.40	43.67	38.03
P_3	77.17	80.00	78.58	81.87	79.83	80.85	31.1	63.57	47.33
P_4	56.00	58.33	57.17	41.67	44.51	43.09	26.33	65.20	45.77
P_5	83.40	88.00	85.70	50.89	57.50	54.20	26.17	35.85	31.01
P_6	87.10	93.93	90.52	65.51	70.89	68.20	24.90	37.00	30.95
P_1 x P_2	80.17	87.67	83.92	68.36	55.11	61.74	30.33	60.27	45.30
P_1 x P_3	85.00	95.00	90.00	64.27	57.29	60.78	23.27	74.17	48.72
P_1 x P_4	81.90	83.33	82.62	52.39	64.05	58.22	27.87	56.15	42.01
P_1 x P_5	70.57	73.00	71.78	61.77	47.62	54.70	24.97	71.00	47.98
P_1 x P_6	75.33	76.83	76.08	64.46	65.23	64.85	18.93	27.23	23.08
P_2 x P_3	64.00	65.67	64.83	60.13	69.54	64.84	26.35	58.27	42.31
P_2 x P_4	58.67	64.00	61.33	40.63	61.76	51.20	36.33	71.33	53.83
P_2 x P_5	71.67	77.00	74.33	44.10	62.05	53.08	43.57	62.82	53.19
P_2 x P_6	72.93	78.93	75.93	58.84	59.02	58.93	42.67	62.20	52.43
P_3 x P_4	86.83	89.00	87.92	59.82	72.11	65.97	35.23	72.00	53.62
P_3 x P_5	86.00	87.33	86.67	89.30	84.88	87.09	50.00	62.90	56.45
P_3 x P_6	73.00	80.67	76.83	53.73	71.01	62.37	38.50	66.17	52.33
P_4 x P_5	70.77	76.00	73.38	62.28	67.76	65.02	37.17	67.00	52.08
P_4 x P_6	66.00	72.67	69.33	56.28	59.24	57.76	28.07	62.00	45.03
P_5 x P_6	84.00	89.00	86.50	56.46	67.89	62.17	22.27	44.33	33.30
Mean	75.06	79.70	77.38	58.09	63.25	60.67	30.74	57.02	43.88
L.S.D 5%	2.176	2.602	1.180	2.228	2.830	1.255	3.383	3.851	1.784
L.S.D 1%	3.824	4.572	1.566	3.914	4.983	1.664	5.943	6.766	2.365

L = low nitrogen level 35kg/fed.
N= normal nitrogen level 70kg/fed.
Comb.= combined

The parental line (P_3) ranked the first for 1000- grain weight and grain filling period. The parental line (P_4) ranked the second for plant height, number of spikes/plant and grain yield / plant. The parental line (P_5) ranked the second for days to heading, grain filling period and number of grains / spike. The parental line (P_6) ranked the first for days to heading, grain filling period, plant height , and number of grains / spike.

The mean performance of the tested fifteen crosses at each nitrogen level as well as the combined data are presented in Table (3). Early heading date was found in cross (P_5 x P_6) followed by (P_3 x P_6) and then by cross (P_2 x P_5) at low and normal nitrogen fertilizer levels as well as the combined analysis. For grain filling period, the best three crosses (P_3 x P_5), (P_2 x P_5) and (P_1 x P_5) were found at the two nitrogen levels and their combined date. For plant height, the best three crosses were (P_1 x P_6), (P_2 x P_4) and (P_5 x P_6) at two levels of nitrogen and their combined analysis. The three crosses (P_2 x P_4) , (P_2 x P_5) and (P_4 x P_5) possessed the highest number of spikes / plant at the two levels of nitrogen as well as their combined analysis. For number of grains / spike the best three crosses (P_1 x P_3), (P_3 x P_4) and (P_3 x P_5) whereas found at two levels of nitrogen as well as their combined analysis. The four crosses (P_3 x P_5), (P_3 x P_4), (P_4 x P_5) and (P_1 x P_6) possessed the highest 1000- grain weight values at the two levels of nitrogen fertilizer as well as the combined data. The best four crosses for grain yield /

plant were (P_3 x P_5), (P_2 x P_4), (P_3 x P_4) and (P_2 x P_5) at the two levels of nitrogen and their combined.

Finally, we can concluded that, wheat grain yield and its major components i.e., number of grains/spike, 1000-grain weight, grain yield/plant and number of spikes per plant was mainly affected by shortage of nitrogen fertilization whereas the data in Table (3) showed a wide differences between the values of low and normal for the attributes that mentioned above. Thus, this confirm the importance role of nitrogen fertilization in increasing wheat grain yield.

Combining ability:

a- General combining ability

Estimates of the general combining ability effects for parents under two nitrogen levels for all studied traits are presented in Table (4). Highly significant positive values of general combining ability effects would be of interest for all traits studied except, days to heading, grain filling period and plant height which showed negative values and it would be useful from the breeder point of view. The results showed that, the parental line (P_1) showed significant negative general combining ability effects for grain filling period at low nitrogen fertilizer level and combined but, showed highly significant positive general combining ability effects for number of grains/spike at the two nitrogen fertilizer levels and their combined. The parental line (P_2) exhibited highly significant positive general combining ability effects for number of spikes/plant at the two nitrogen fertilizer levels and their combined and grain yield/plant at the low nitrogen level and combined data proving to be a good combiner for improving these traits. The parental line (P_3) showed significant negative general combining ability effects for days to heading at both levels of nitrogen and combined and significant negative general combining ability effects for grain filling period only at combined. Also, it exhibited highly significant positive general combining ability effects for; number of grains / spike, 1000-grain weight and grain yield/plant at the two nitrogen levels and their combined proving to be a good combiner for developing these traits. The parental line (P_4) showed highly significant negative general combining ability effects for plant height at the two nitrogen levels and their combined data. Also, it gave highly significant positive general combining ability effects for number of spikes / plant at the two nitrogen fertilizer level and their combined data and grain yield/plant at the normal level and combined. The parental line (P_5) showed highly significant negative general combining ability effects for days to heading at normal nitrogen fertilizer level and the combined proving to be a good combiner for earliness. Also, it exhibited highly significant positive general combining ability for number of spikes/plant at low nitrogen level only, number of grains/spike at the two nitrogen levels and their combined, 1000-grain weight at low nitrogen level and combined and grain yield/plant at the low nitrogen level only.

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The parental line(P_6) showed highly significant negative general combining ability effects for days to heading and plant height at the two nitrogen levels and their combined which considered as a good combiner for developing genotypes resistance to lodging and early mature. Meanwhile, it gave highly significant positive general combining ability effects for number of grains/spike and 1000-grain weight at the two nitrogen fertilizer level and their combined. The same conclusion was previously drawn by Hendawy *et al* (1993), Hendawy (1994) and Moussa and Morad (2009). On the other hand, it can be concluded that, general combining ability effects computed herein were found to be deviated significantly from zero in most cases. High positive values would be of interest in most cases i.e.; number of grains/spike, number of spikes/plant and 1000-grain weight. On the contrary, for plant height and days to heading, high negative values would be useful from breeder's point of view. Resistance to lodging is particularly important in a view of the desire to exploit yield promoting factor such as nitrogen fertilization and /or irrigation. Reduced lodging has usually been observed to be associated with a decrease in culm length and consequently, the search for suitable genetic variation and the incorporation of sources of short still straw into breeding program (Panthus 1973, Stance *et al*, 1979 and Hendawy 1994). The mean performance of the parental lines was considered as a good indication of their GCA effects for some traits only. Thus, selection with the tested parental genotypes when initiating any proposed breeding program could be practiced either on parental mean performance or general combining ability effects basis with similar efficiency. Such agreement might adding general combining ability effects that were found to be deviated from zero especially which having positive values whereas would be of interest in most another proof about the performance of additive genetic variance. Such conclusion was previously drawn by El-Haddad (1974), El-Shamarka (1980), Hendawy (1994) , Mahrous (1998) and Koumber *et al* (2006).

b- Specific combining ability

Estimates of the specific combining ability effects (SCA) for the fifteen crosses at the two nitrogen levels and their combined are presented in Table (5). The results indicated that, cross (P_1 x P_2) and (P_2 x P_5) showed significant negative desirable SCA effects for days to heading. While the two crosses (P_1 x P_4) and (P_2 x P_3) exhibited significant negative desirable SCA effects for grain filling period. The three hybrid combinations (P_1 x P_6), (P_2 x P_4) and (P_4 x P_5) exhibited significant negative desirable SCA effects for plant height. Two crosses (P_1 x P_5) and (P_3 x P_6) exhibited significant positive desirable SCA effects for number of spikes/plant. Six combinations (P_1 x P_2 , P_1 x P_3 , P_1 x P_4 , P_3 x P_4, P_3 x P_5 and P_5 x P_6) showed highly significant SCA effects for number of grains /spike. Meanwhile, four crosses (P_1 x P_4), (P_1 x P_6), (P_3 x P_5) and (P_4 x P_5) exhibited significant desirable SCA effects for 1000-grain weight. Five crosses (P_1 x P_2 , P_2 x P_5 , P_2 x P_6 , P_3 x P_6 and P_4 x P_5) showed significant desirable SCA for grain yield/plant. It is of interest to mention that, combination (P_4 x P_5) showed highly significant desirable

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SCA effects for plant height, 1000-grain weight and grain yield/ plant. Also, the cross (P_1 x P_2) had a desirable SCA effect for days to heading, number of grains/spike and grain yield/plant. Thus, it may took into our consideration these two crosses in our breeding program for improving both earliness and grain yield and its components.

Heterosis

The utilization of heterosis in various crops through the world has tremendously increased the production either for human food or for livestock feed. Heterosis is a complex phenomenon which depends on the balance of different combinations of genotypic effect as well as the distribution of plus and minus alleles in the parents. Heterosis is expressed as the percentage deviation of F_1 mean performance from the better parent of the trait. As it will be expected, better parent for plant height is the short one and that have a few days for both heading and maturity as well. (Mahrous,1998).

The cross (P_1 x P_2) showed highly significant desirable heterosis for days to heading at the two nitrogen levels and their combined Table (6)., Ten crosses at the low nitrogen level , three crosses at the normal nitrogen level and seven crosses at their combined data showed significant negative desirable heterosis for grain filling period. The cross (P_2 x P_4) exhibited highly significant negative desirable heterosis at the two nitrogen levels and their combined for plant height. Meanwhile, the crosses (P_1 x P_5) and (P_3 x P_6) exhibited positive significant desirable heterosis at the two nitrogen fertilizer levels and their combined for number of spikes/plant. Whereas, the two combinations (P_1 x P_3) and (P_3 x P_4) showed highly significant desirable heterosis which varied from 6.918 % to 12.528 % increasing over better parent at the two nitrogen fertilizer levels and their combined for number of grains / spike. For 1000-grain weight two crosses (P_3 x P_5) and (P_4 x P_5) exhibited highly significant desirable heterosis at the two nitrogen fertilizer levels and their combined. Concerning grain yield /plant , five hybrid combinations (P_2 x P_4), (P_2 x P_5), (P_2 x P_6), (P_3 x P_4) and (P_3 x P_6) showed highly significant desirable heterosis which the increasing was varied from 9.407 % to 71.542 % over the better parent at both low and normal nitrogen fertilizer levels and their combined data. Thus, these crosses may be practical of interest in wheat breeding programme for developing hybrid wheat genotypes, since it surpassed the best performing parents and possessed the most desirable SCA effect for grain yield and some of its components. These results agrees with those obtained by El-Hossary *et al* (2000) , Hamada *et al* (2002), Koumber *et al* (2006)and Moussa and Morad (2009).

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Genetic components:

According to Hayman (1954) approach, the half diallel analysis provides information about the genetic architecture of a character. Also, several ratios could be derived from these analysis. Results showed in Table 7 revealed that the additive component of genetic variance effect (D) was significant for all studied traits except; grain filling period under two nitrogen fertilizer levels and grain yield/plant under low nitrogen level indicating the presence of additive gene effect. Dominant component (H_1) was significant for all studied traits at the two nitrogen levels. Values of (H_1) for all studied traits were larger than the respective (D) under two nitrogen levels except, days to heading and number of spikes/plant and plant height at low level. However the values of (H_1) were smaller than the respective (D) for days to heading and number of spikes/plant under two nitrogen levels and plant height at the low level. This indicated the importance of the additive gene action in inheritance of these traits. The components of variation due to the dominance effects associated with gene distribution (H_2) was significant for all studied traits. The values of H_2 were consistently lower than those of H_1 values which complies with the theoretical assumption of Hayman (1954) and it could be need a further proof for the unequal proportions of positive and negative alleles in the parents at all loci for these traits. The overall dominance effects of heterozygous loci (h^2) was significant for grain filling period at low nitrogen level, plant height and grain yield/plant under two nitrogen levels. These results indicated that the effects of dominance which due to heterozygosity. The covariance of additive and dominance gene effects (F) was insignificant for all traits under nitrogen fertilizer levels except for days to heading and 1000-grain weight at two levels and plant height at the low one. F -value was negative for, grain filling period and grain yield/plant at low nitrogen level and plant height at normal level indicating an excess of recessive over dominant alleles. The degree of dominance $(H_1/D)^{0.5}$ were exceeded the unity for all studied traits under the two nitrogen levels except days to heading and number of spikes/plant at the two nitrogen levels and plant height at normal nitrogen level, indicating overdominance effect. Meanwhile, days to heading had a values near (0.5) refered to that no dominance effect for this trait while, $(H_1/D)^{0.5}$ values were near to unity for plant height at normal level of nitrogen and number of spikes/plant indicating that, complete dominance controlled of these traits. Values of ($H_2/4H_1$) under the two nitrogen levels for all studied traits were less than 0.25 revealing a symmetric distributions of positive and negative alleles among the parents. The proportion of dominant alleles in the parents are greater than the recessive ones (4d1) +F/(4Dh1) – F except for, grain filling period, grain yield/plant at low nitrogen level and plant height at normal nitrogen level. This conclusion is also supported by the fact that the value of (H_2 /4H1) was less than 0.25. Heritability value in narrow sense were higher for days to heading, number of spikes/ plant at the two nitrogen levels and plant height at normal level. Narrow sense heritability estimates were moderate for plant height at low level, number of grains/spike, 1000-grain weight and grain yield/plant at two nitrogen levels. Whereas, narrow sense heritability was low for grain filling period at two nitrogen levels. These results agrees with those obtained by Hassan *et al* (1996), Yadav *et al* (1998) , Hamada (2003), Koumber and Esmail (2005) and Koumber *et al* (2006)

Table (7): Estimate of genetic components of variation in a diallel cross for the studied traits under two nitrogen fertilizer levels

	Days to heading		Grain filling period		Plant height		No of spikes/ plant	
	L	N	L	N	L	N	L	N
D	18.043**	14.840**	0.474	6.079	74.76**	78.774**	13.021**	27.976**
H_1	4.970**	5.102*	35.217**	34.059**	121.889**	66.757**	10.711**	22.767*
H_2	3.762*	4.211*	30.787**	30.215**	93.014**	58.675**	9.512**	19.662*
h_2	1.466	-0.029	22.286**	7.889	77.189**	36.310**	0.073	0.349
F	8.764**	6.942**	-1.344	5.523	73.640*	-1.178	3.054	9.945
E	0.386	0.571	0.656	0.439	0.746	1.498	0.178	0.367
$(H1/D)^{½}$	0.525	0.586	8.624	2.367	1.277	0.921	0.907	0.902
$H_2/4H_1$	0.189	0.206	0.219	0.222	0.191	0.220	0.222	0.216
KD/KR	2.723	2.327	0.718	1.475	2.256	0.984	1.297	1.491
h^2 / H_2	0.390	-0.007	0.724	0.261	0.830	0.619	0.008	0.018
Heritability	0.798	0.730	0.272	0.216	0.385	0.731	0.686	0.667
r	0.161	-0.321	0.446*	0.836**	0.384	0.377	0.341	-0.169
R^2	0.026	0.103	0.199	0.699	0.147	0.142	0.117	0.028

L = low nitrogen level 35kg/fed.
N= normal nitrogen level 70kg/fed.

Table (7) :Cont.

	No of grains/spike		1000-grain weight		Grain yield/plant	
	L	N	L	N	L	N
D	134.669**	162.726**	257.348**	193.302**	20.807	198.640**
H_1	253.927**	296.621**	447.486**	294.890**	212.655**	513.411**
H_2	209.717**	245.610**	370.425**	211.486**	194.136**	476.742**
h_2	-0.396	-0.550	69.817	37.137	88.780*	590.878**
F	100.789	135.316	196.416*	173.239*	-30.005	68.634
E	0.929	1.088	0.870	1.009	1.445	1.814
$(H1/D)^{½}$	1.373	1.350	1.319	1.235	3.197	1.608
$H_2/4H_1$	0.206	0.207	0.207	0.179	0.228	0.232
KD/KR	1.749	1.890	1.815	2.139	0.632	1.241
h^2 / H_2	-0.002	-0.002	0.188	0.176	0.457	1.239
Heritability	0.423	0.386	0.425	0.490	0.410	0.408
r	-0.575**	-0.659**	-0.023	-0.509**	0.027	-0.839**
R^2	0.331	0.434	0.005	0.259	0.001	0.704

L = low nitrogen level 35kg/fed.
N= normal nitrogen level 70kg/fed.

The correlation coefficient (r) values between yr and (Wr+Vr) were significant and positive for grain filling period under the two nitrogen levels indicating that the dominant genes were operating towards decreasing these traits. Significant negative values were observed for; number of grains/spike at the two nitrogen levels and 1000-grain weight and grain yield/plant at the normal nitrogen level indicating that the dominant genes were operating towards increasing these traits while, the other traits were insignificant indicating ambidirectional dominance. The square values of (R^2) were less than unity for all studied traits under two nitrogen levels suggesting that non of the parental lines were completely dominant or recessive for the genes controlling any of these traits. These results agrees with those obtained by Hassan *et al* (1996) and Yadav *et al* (1998) and Koumber and Esmail (2005)

Graphical analysis:

The regression of parent-off spring covariance (Wr) on parental array variances (Vr) and their limiting parabola (Fig.1-7) of the six parental diallel crosses for the studied traits illustrated that the regression coefficients were deviated significantly from zero but not from unity for; plant height at normal fertilizer level, grain filling period, number of grains/spike, number of spikes/plant, 1000-grain weight and grain yield/plant at the two nitrogen fertilizer levels, suggesting that additive-dominance genetic model was satisfactory to explain the inheritance of these characters. However, the regression coefficient for; days to heading at the two nitrogen fertilizer levels and plant height at only the low nitrogen fertilizer level was deviated from zero and more than unity revealing that a complex genetic model was appropriate to explain the genetic mechanism of these characters.

The regression line intersect the Wr exist above the point of regression for; days to heading, number of spikes/plant at the two nitrogen fertilizer levels and plant height at the normal fertilizer level only, suggesting the importance of additive gene effect and degree of dominance in the range of partial dominance. On the other hand, the regression line was found to cut the (Wr) axis below the origin point for, plant height under low N fertilizer, grain filling period, number of grains/spike at the two levels of nitrogen fertilization, indicating predominance of non-additive gene effect and degree of dominance in the range of overdominance for these characters, which mainly due to complementary gene effects.

The relative position of array points on Wr-Vr graph indicated that the parental genotype number (6) contained a high frequency of recessive allels for; days to heading, plant height, number of grains/spike, number of spikes/plant and grain yield/plant. The same direction was obtained by the parental cultivar Gemmeiza 9 for days to heading and number of grains/spike. Meanwhile, the parental line number (3) for days to heading at the two levels of nitrogen, plant height at normal level of nitrogen fertilization, P_6 for grain filling period at two nitrogen fertilizer levels, $P_3$for number of spikes/plant at normal level of nitrogen fertilization, P_6 for 1000-grain weight, P_4 at the high level of nitrogen fertilization, P_1 for grain yield/plant at low level of nitrogen fertilization and P_3 at grain yield/plant at normal level of nitrogen fertilization had most of dominant genes.

From the previous results, it can be concluded that genetic analysis which carried out by different methods of diallel cross analysis gave similar results.

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دراسات وراثية على بعض الصفات المحصولية في هجن القمح تحت مستوى منخفض من التسميد النيتروجينى

جمال عبدالرازق الشعراوى و رضا محمد على قمبر
قسم بحوث القمح – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

أجرى هذا البحث في محطة البحوث الزراعية بالجميزة – مركز البحوث الزراعية فى الموسمين ٢٠٠٨/٢٠٠٩ و ٢٠٠٩/٢٠١٠ بهدف دراسة كل من قوة الهجين والقدرة العامة والخاصة على الائتلاف وتفاعلاتها مع مستويين من التسميد النيتروجينى تحت الدراسة وهما ٣٥ كجم ، ٧٠ كجم نيتروجين/فدان لبعض الصفات المحصولية وهى عدد الأيام حتى طرد السنابل ، فترة امتلاء الحبوب، طول النبات، عدد السنابل ، عدد الحبوب ، وزن الألف حبة ، محصول النبات الفردي . استخدم فى هذا البحث ستة أباء وهى جميزة ٧ – جميزة ٩ بالإضافة إلى ٤ أصناف مستوردة.

كانت النتائج المتحصل عليها كالاتى :-

- كان التباين الراجع لمستويات التسميد معنويا لكل الصفات المدروسة .
- كانت قيم التباين الراجع إلى التراكيب الوراثية والآباء والهجن عالية المعنوية لكل الصفات المدروسة تحت مستويات التسميد وكذلك التحليل المشترك لهما فيما عدا صفة فترة امتلاء الحبوب عند مستوى التسميد المنخفض.
- كانت قيم التفاعل بين التراكيب الوراثية والهجن معنوية لكل الصفات تحت الدراسة فيما عدا صفة عدد الايام حتى طرد السنابل . وكان التباين الراجع الى القدرة العامة والخاصة على التآلف عالي المعنوية لكل الصفات المدروسة تحت مستويات التسميد النيتروجينى والتحليل المشترك مما يدل على أهمية كل من الفعل الجيني المضيف والسيادى فى دراسة هذه الصفات .
- من محصلة هذه الدراسة يمكن استخدام الأب رقم ٦ لتحسين صفة التبكير وكذلك طول النبات لما له من قدرة عامة عالية على التالف فى اتجاة التبكير لتلك الصفات بالإضافة الى صفة عدد الحبوب و وزن الألف حبة .
- اظهر التحليل ان الهجين P4 ×P5 كان عالي المعنوية للقدرة الخاصة على التالف لصفة طول النبات – وزن الألف حبة ، ومحصول النبات

قام بتحكيم البحث

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Table (2): Mean square estimates of an ordinary analysis and combining ability analysis for yield and yield components under two nitrogen fertilizer levels and their combined .

Source of variation	d . f		Days to heading			Grain filling period			Plant height			No. of spikes/plant		
	Single	Comb.	L	N	Comb.	L	N	Comb.	L	N	Comb.	L	N	Comb.
Nitrogen(F)		1			213.46**			445.786**			2854.3**			512.23**
Replication with F	2	4	4.000*	1.063	2.532	0.619	4.000*	2.309	6.259	20.543**	13.401**	4.420**	2.981	3.70**
Genotypes	20	20	21.567**	18.921**	39.994**	27.938**	25.833**	44.736**	122.98**	167.970**	254.02**	23.145**	46.071**	63.06**
Parents (P)	5	5	55.289**	46.233**	101.161**	3.389	19.556**	12.783**	226.52**	240.820**	460.85**	39.597**	85.030**	117.98**
Crosses (C)	14	14	10.508**	10.422**	20.449**	31.213**	27.232**	49.767**	69.131**	141.68**	161.58**	18.866**	35.266**	47.73**
Parents vs cross	1	1	7.778**	1.335	7.779*	104.84**	37.644**	134.064**	359.190**	171.92**	514.05**	0.796	2.559	3.11*
Genotypes x F		20			0.494			9.036**			36.93**			6.16**
Parents x F		5			0.361			10.161**			6.48			6.65**
Crossesx F		14			0.481			8.678**			49.23**			6.40**
P vs. cross x F		1			1.334			8.420**			17.06*			0.25
GCA	5	5	24.589**	20.698**	45.113**	8.439**	8.528**	12.844**	72.103**	169.53**	224.93**	22.942**	44.804**	63.07**
SCA	15	15	1.389**	1.510**	2.737**	9.604**	8.639**	15.601**	30.624**	18.145**	37.92**	2.639**	5.541**	7.00**
GCA x F		5			0.174			4.122**			16.70**			4.68**
SCA x F		15			0.161			2.642**			10.85**			1.18**
Error	40	80	1.017	1.747	1.382	2.036	1.183	1.610	2.037	3.692	2.864	0.341	1.007	0.674

GCA / SCA			17.703	13.707	16.483	0.879	0.987	0.823	2.354	9.343	5.932	8.693	8.086	9.006

L = low nitrogen level 35kg/fed.
N= normal nitrogen level 70kg/fed.
Comb.= combined

Table (2): Cont

Source of variation	**d . f**		**No. of grains/spike**			**1000-grain weight**			Grain yield/plant		
	Single	**Comb.**	**L**	**N**	**Comb.**	**L**	**N**	**Comb.**	**L**	**N**	**Comb.**
Nitrogen(F)		1			677.16**			841.39**			21744**
Replication with F	2	4	23.970**	18.792**	21.38**	18.380**	4.482	11.43**	6.987	5.331	6.159
Genotypes	20	20	258.020**	289.45**	538.44**	468.52**	313.38**	626.16**	206.35**	590.64**	576.14**
Parents (P)	5	5	406.79**	491.44**	893.47**	774.66**	582.93**	1251.00**	66.756**	601.36**	433.79**
Crosses (C)	14	14	223.28**	237.96**	450.05**	369.41**	227.03**	412.84**	241.33**	433.32**	479.35**
Parents vs cross	1	1	0.543	0.252	0.768	325.39**	174.48**	488.21**	414.64**	2739.6**	2642.9**
Genotypes x F		20			9.02**			155.74**			220.85**
Parents x F		5			4.76			106.55**			234.33**
Crosses x F		14			11.18**			183.60**			195.29**
P vs. cross x F		1			0.03			11.66*			511.31**
GCA	5	5	168.62**	180.68**	347.16**	307.42**	221.33**	516.45**	108.54**	336.94**	329.43**

SCA	15	15	58.469**	68.42**	123.59**	105.76**	65.50**	106.14**	55.53**	150.19**	146.25**
GCA x F		5			2.13			12.30**			116.05**
SCA x F		15			3.30			65.12**			59.47**
Error	40	80	1.740	2.487	2.11	1.822	2.954	2.388	4.202	5.446	4.824
GCA / SCA			2.884	2.641	2.81	2.907	3.379	4.866	1.955	2.243	2.253

L = low nitrogen level 35kg/fed.
N= normal nitrogen level 70kg/fed.
Comb.= combined

Table (4): Estimates of general combining ability effects for yield and yield components under two nitrogen fertilizer levels and their combined

Genotypes	Days to heading			Grain filling period			Plant height			No. of spikes/plant		
	L	N	Comb	L	N	Comb	L	N	Comb	L	N	Comb
P_1	1.125	1.056	1.092	-0.667*	0.125	-0.271*	0.817		1.035	-1.991	-1.619	-1.805
P_2	1.25	1.181	1.215	0.375	0.833	0.604	1.846	4.233	3.040	2.638**	3.139**	2.889**
P_3	-0.875**	-0.861*	-0.868**	-0.333	-0.208	-0.271*	2.404	4.467	3.435	0.097	-1.140	-0.522
P_4	2.208	1.972	2.090	-0.833*	0.250	-0.292*	-2.279**	-2.646**	-2.463**	1.124**	2.743**	1.933**
P_5	-1.75	-1.361**	-1.556**	1.917	0.917	1.417	2.221	0.369	1.308	0.487**	-0.605	-0.546
P_6	-1.958**	-1.986**	-1.972**	-0.458	-1.917**	-1.188**	-5.008**	-7.704**	-6.356**	-1.381	-2.517	-1.949
L.S.D gi 5%	0.380	0.498	0.208	0.537	0.410	0.225	0.537	0.724	0.300	0.220	0.378	0.145
L.S.D gi 1%	0.667	0.875	0.276	0.944	0.720	0.298	0.944	1.271	0.398	0.386	0.664	0.193
L.S.D gi-gj 5%	0.588	0.771	0.337	0.832	0.635	0.364	0.833	1.121	0.486	0.341	0.585	0.017
L.S.D gi-gj 1%	1.034	1.355	0.448	1.115	1.115	0.483	1.463	1.969	0.644	0.598	1.028	0.022

Table (4): Cont

Genotypes	No. of grains/spike			1000-grain weight			Grain yield/plant		
	L	N	Comb	L	N	Comb	L	N	Comb
Line P_1	3.315**	3.575**	3.445**	-1.249	-2.967	-2.108	-6.423		-5.823
Line P_2	-5.668	-5.079	-5.374	-5.732	-5.377	-5.554	3.604**	0.386	1.995**
Line P_3	2.965**	2.471**	2.718**	10.549**	8.966**	9.758**	2.542**	7.688**	5.115**
Line P_4	-6.160	-7.029	-6.594	-6.480	-3.603	-5.041	0.265	7.469**	3.867**
Line P_5	3.044**	2.554**	2.799**	1.137**	0.304	0.721**	1.885**	-2.422	-0.268
Line P_6	2.503**	3.508**	3.006**	1.774**	2.675**	2.225**	-1.873	-7.900	-4.886
L.S.D gi 5%	0.497	0.594	0.258	0.508	0.647	0.274	0.772	0.879	0.389
L.S.D gi 1%	0.873	1.043	0.342	0.893	1.137	0.489	1.356	1.544	0.516
L.S.D gi-gj 5%	0.770	0.920	0.417	0.788	1.003	0.444	1.196	1.362	0.631
L.S.D gi-gj 1%	1.352	1.616	0.553	1.384	1.762	0.588	2.101	2.392	0.836

Table (5) : Estimates of specific combining ability for fifteen crosses evaluated at two nitrogen levels and their combined for yield and yield components

Cross	Days to heading			Grain filling period			Plant height			No. of spikes/plant		
	L	N	Comb	L	N	Comb	L	N	Comb	L	N	Comb
P_1xP_2	-2.042**	-2.506**	-2.274**	-0.613	0.708	0.048	-2.748**	-1.092	-1.920**	-2.142	-2.213	-2.177
P_1xP_3	-0.917	-0464	-2.690**	-3.905**	1.417	-1.244**	-2.140*	-0.826	-1.483*	-0.767	0.066	-0.350
P_1xP_4	-1.00	-0.946	-0.982*	-4.405**	-7.708**	-6.057**	-2.723**	3.787	0.532	-0.560	-1.751	-1.156
P_1xP_5	0.958	1.036	0.997	4.179	1.292	2.735	0.044	0.179	0.111	3.083**	6.264**	4.674**
P_1xP_6	0.833	1.661	1.247	-1.446	0.125	-0.661	-1.727*	-6.955**	-4.341**	-1.122	-2.057	-1.590
P_2xP_3	0.625	0.411	0.518	-5.613**	-5.958**	-5.786**	-9.502**	2.195	-3.654**	-0.496	0.308	-0.094
P_2xP_4	-0.125	0.577	0.226	2.220	2.250	2.235	-7.819**	-9.526**	-8.672**	0.577	-0.409	0.084
P_2xP_5	-2.167**	-1.756**	-1.961**	0.804	1.583	1.193	0.181	-0.901	-0.360	0.521	1.006	0.763*
P_2xP_6	0.041	0.536	0.289	0.512	-0.583	-0.036	0.244	2.466	1.355	0.415	-0.149	0.133
P_3xP_4	-1.00	-1.381*	-1.190**	0.595	-0.708	-0.057	3.956	0.574	2.265	-0.381	-1.130	-0.756
P_3xP_5	0.958	0.952	0.955	1.179	-0.375	0.402	0.123	-1.467	-0.672	0.729*	-1.715	-0.493
P_3xP_6	0.167	-0.423	-0.128	-0.446	0.792	0.173	7.352	2.133	4.742	3.623**	2.964**	3.294**
P_4xP_5	-0.125	0.786	0.330	-2.655**	0.500	-1.077*	-5.294**	-5.188**	-5.241**	-0.298	2.135**	0.919**
P_4xP_6	0.417	0.077	0.247	-0.613	0.001	-0.307	1.535	0.912	1.223	0.013	0.247	0.130
P_5xP_6	0.042	0.077	0.060	-2.030*	-0.667	-1.348**	-4.132**	-1.963	-3.047**	-2.127	-1.655	-1.891
L.S.D Sij 5 %	1.043	1.367	0.864	1.476	1.125	0.913	1.476	1.987	1.218	0.604	1.038	0.591
L.S.D Sij 1%	1.832	2.402	1.122	2.593	1.977	1.211	2.594	3.492	1.616	1.061	1.823	0.783
L.S.D Sij-Sik 5%	1.556	2.040	1.263	2.202	1.679	1.363	2.203	2.966	1.818	0.901	1.549	0.882
L.S.D Sij- Sik1%	2.735	3.585	1.675	3.870	2.950	1.808	3.871	5.211	2.411	1.583	2.721	1.169

L = low nitrogen level 35kg/fed. N= normal nitrogen level 70kg/fed. Comb.= combined

Table (5) : Cont.

Cross	No. of grains/spike			1000-grain weight			Grain yield/plant		
	L	N	Comb	L	N	Comb	L	N	Comb
P_1xP_2	7.456**	9.471**	8.463**	17.254**	0.205	8.729**	2.407*	8.085**	5.246**
P_1xP_3	3.656**	9.254**	6.455**	-3.114	-11.960	-7.538	-3.597	14.682**	5.543**
P_1xP_4	9.681**	7.088**	8.384**	2.039*	7.364**	4.701**	3.280*	-3.115	0.082
P_1xP_5	-10.86	-12.83	-11.84	3.801**	-12.97	-4.584	-1.241	21.626**	10.193**
P_1xP_6	-5.548	-9.950	-7.749	5.854**	2.273*	4.063**	-3.516	-16.660	-10.090
P_2xP_3	-8.361	-11.430	-9.893	-2.774	2.702*	-0.036	-10.540	-6.826	-8.683
P_2xP_4	-4.569	-3.592	-4.080	-5.238	7.484**	1.123*	1.719	6.460**	4.089**
P_2xP_5	-0.773	-0.175	-0.474	-9.386	3.874**	-2.756	7.332**	7.835**	7.583**
P_2xP_6	1.035	0.804	0.920	4.718**	-1.527	1.595**	10.190**	12.695**	11.443**
P_3xP_4	14.964**	13.858**	14.411**	-2.336	3.498**	0.581	1.286	-0.176	0.753
P_3xP_5	4.927**	2.608*	3.768**	19.526**	12.354**	15.940**	14.828**	0.616	7.722**
P_3xP_6	-7.532	-5.013	-6.272	-16.680	-3.884	-10.280	7.086**	9.360**	8.223**
P_4xP_5	-1.182	0.775	-0.203	9.536**	7.806**	8.671**	4.271**	4.935**	4.603**
P_4xP_6	-5.407	-3.512	-4.460	2.899**	-3.085	-0.093	-1.070	5.412**	2.171**
P_5xP_6	3.390**	3.238**	3.313**	-4.540	1.655	-1.443	-8.491	-2.363	-5.427
L.S.D Sij 5 %	1.364	1.631	1.046	1.396	1.777	1.112	2.120	2.414	1.581
L.S.D Sij 1%	2.397	2.866	1.388	2.453	3.123	1.475	3.725	4.241	2.097
L.S.D Sij-Sik 5%	2.036	2.434	1.562	2.084	2.653	1.660	3.164	3.602	2.359
L.S.D Sij- Sik1%	3.577	4.277	2.071	3.661	4.661	2.281	5.559	6.329	3.129

L = low nitrogen level 35kg/fed. N= normal nitrogen level 70kg/fed. Comb.= combined

Table (6): Heterosis percentage to better parent for yield and yield components under low and normal nitrogen fertilizer levels and their combined in the studied wheat crosses.

Cross	Days to heading			Grain filling period			Plant height			No. of spikes/plant		
	L	N	Comb	L	N	Comb	L	N	Comb	L	N	Comb
P_1xP_2	-2.970**	-2.913**	-2.941**	-5.064**	-1.170	-3.039**	-5.884**	-0.487	-3.087**	-50.575	-39.086	-43.957
P_1xP_3	1.042	1.010	1.026	-12.659**	-1.177	-6.990**	-3.588*	-0.057	-2.345**	-20.000	-1.633	-9.431
P_1xP_4	-0.990	-0.647	-0.817	-12.904**	-16.959**	-15.805**	-4.681**	2.677	-0.859	-35.606	-35.240	-35.378
P_1xP_5	3.887	4.124	4.008	6.961	3.013	3.639	-2.957*	-2.692	-2.820**	37.631**	79.928**	71.053**
P_1xP_6	5.018	5.944	5.487	-7.051**	3.922	-1.618**	6.352	0.307	3.209	-24.242	-30.108	-27.595
P_2xP_3	2.778	2.020	2.393	-14.465**	-12.942**	-14.198**	-9.516**	2.744	-3.054**	-24.828	-23.858	-24.269
P_2xP_4	-0.980	0.000	-0.485	1.935	1.163	0.912	-8.647**	-6.644**	-7.607**	-10.345	-7.783	-8.869
P_2xP_5	0.707	1.375	1.046	1.887	4.820	2.438	-4.268**	-1.483	-2.839**	-21.839	-17.597	-19.396
P_2xP_6	4.301	4.895	4.603	-1.282	3.922	1.294	9.676	12.995	11.401	-28.736	-33.164	-31.287
P_3xP_4	2.083	1.010	1.538	-2.581*	-4.706**	-4.863**	3.381	2.677	3.015	-15.428	-29.337	-24.105
P_3xP_5	1.767	2.062	1.917	-0.617	-0.602	-0.610	-0.156	-1.768	-1.948**	20.000**	-9.174	3.211**
P_3xP_6	2.151	1.749	1.948	-4.487**	4.575	0.000	18.169	12.893	15.426	46.667**	18.041**	30.194**
P_4xP_5	3.887	4.811	4.356	-4.517**	1.808	-3.354**	-5.819**	1.431	-6.014**	-19.879	-8.943	-13.056
P_4xP_6	5.735	5.245	5.487	-5.162**	3.922	-0.971	6.537	4.366	5.408	-25.072	-29.337	-27.733
P_5xP_6	1.075	1.749	1.416	-3.205*	3.922	0.324	5.244	4.537	4.876	-30.690	-6.489	-17.215
L.S.D 5 %	1.664	2.181	0.955	2.354	1.795	1.030	2.355	3.171	1.374	0.963	1.656	0.176
L.S.D 1%	2.923	3.832	1.266	4.137	3.154	1.366	4.138	5.571	1.823	1.692	2.909	0.884

L = low nitrogen level 35kg/fed. N= normal nitrogen level 70kg/fed. Comb.= combined

Table (6) : Cont.

Cross	No. of grains/spike			1000-grain weight			Grain yield/plant		
	L	N	Comb	L	N	Comb	L	N	Comb
P_1xP_2	0.881	2.735*	1.841**	54.189**	-15.031	14.822**	-6.379	38.017**	19.107**
P_1xP_3	6.918**	11.329**	9.202**	-21.497	-28.235	-24.824	-25.188	16.677**	2.923**
P_1xP_4	3.019*	-2.343	0.243	22.787**	-1.259	8.284**	5.824**	-13.880	-8.211
P_1xP_5	-15.388	-17.045	-16.239	21.386**	-26.584	0.926	-4.584	98.047**	54.745**
P_1xP_6	-13.509	-18.204	-15.945	-1.590	-7.974	-4.907	-23.963	-26.396	-25.417
P_2xP_3	-17.062	-17.917	-17.497	-26.558	-12.886	-19.808	-18.673	-8.337	-10.616
P_2xP_4	-11.557	-11.111	-11.324	-8.345	33.875**	13.186**	12.140**	9.407**	17.627**
P_2xP_5	-14.069	-12.500	-13.263	-13.336	7.919**	-2.060	34.465**	43.857**	71.542**
P_2xP_6	-16.265	-15.968	-16.111	-10.170	-16.735	-13.581	31.687**	42.445**	37.863**
P_3xP_4	12.528**	11.250**	11.877**	-26.937	-9.666	-18.411	13.290**	10.429**	13.275**
P_3xP_5	3.118*	-0.758	1.128	9.071**	47.612**	7.714**	60.772**	-1.048	19.261**
P_3xP_6	-16.188	-14.123	-15.116	-34.372	0.175	-22.857	23.794**	4.091*	10.564**
P_4xP_5	-15.148	-13.636	-14.372	22.375**	17.843**	19.971**	41.141**	2.761	13.804**
P_4xP_6	-24.225	-22.640	-23.402	-14.088	-16.429	-15.304	6.584**	-4.908	-1.601
P_5xP_6	-3.559	-5.252	-4.437	-13.816	-4.231	-8.834	-14.902	19.820**	7.392
L.S.D 5 %	2.176	2.602	1.180	2.228	2.836	1.255	3.383	3.851	1.784
L.S.D 1%	3.824	4.572	1.566	3.914	4.983	1.664	5.943	6.766	2.365

L = low nitrogen level 35kg/fed. N= normal nitrogen level 70kg/fed. Comb.= combined