Minufiya J. Agric. Res. Vol. 34 No.2: 625 - 640 (2009) "http://www.mujar.net"

DETECTION OF EPISTASIS IN THE INHERITANCE OF GRAIN YIELD AND ITS COMPONENTS IN BREAD WHEAT (*Triticum aestivum* L.) USING TRIPLE TEST CROSS ANALYSIS

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(Received: Jan. 14 , 2009)

ABSTRACT: *The three testers i.e. the two parents Gemmeiza 9 and Sids 7 and their F_1 were crossed to twenty three varieties of bread wheat to estimation of gene action through triple test cross .Testers were detected to be highly significant for all traits studied . Lines Vs testers mean square estimates were detected to highly significant for all traits except plant height and grain yield per plant . The two testers Gemmeiza 9 and Sids 7 were found to differ significantly from each other according to their genetic background in all characters investigated . Genotypes, hybrids and parents were found to be highly significant for all traits studied under investigation . Hybrids Vs parents mean square were found to be highly significant for all traits studied .The twenty three wheat varieties and lines were also found to be highly significant for all traits studied. Significant epistasis was detected for all characters studied except Number of spikes per plant and plant height. (Additive × additive) (I) epistatic type were detected to be highly significant for maturity date, spike length , number of kernels per spike , spike yield and 1000- kernels weight and it was found to be only significant for heading date . (J) epistatic type (Additive × dominance) and (L) epistatic type (dominance × dominance) appeared to be highly significant for heading date , maturity date , spike length , number of kernels per spike , 1000- kernels weight and grain yield per plant and it was found to be only significant for number of spikelets per spike and spike yield . The mean square estimates due to sums (L1i + L2i) and due to differences (L1i – L2i) were found to be highly significant for all traits studied . The additive genetic variances (D) was found to be much larger in magnitudes than the dominance genetic variance (H) for all traits under investigation except number of kernels per spike and spike yield and that resulted in (H/D)½ to be less than one confirming that these characters were influenced predominantly by the additivity of the genes and also the role of partial dominance in the inheritance of these traits. The correlation coefficients between sums and differences were found to be negative and significant for number of spikes per plant, spike length, number of kernels per spike and spike yield indicating that the increasing type of genes are dominant in these four traits . However, for the remaining* *characters studied , the correlation coefficients were found to be insignificant hence the dominance was ambidirectional.*

Key words : *Triple test cross, Additive , Dominance, Epistasis, Wheat .*

INTRODUCTION

Choice of the most efficient breeding methodology mainly depend upon the type of gene action controlling the inheritance of the agronomic traits. Therefore , unambiguous tests of the genetic components help the breeder for rightful decision making about the most effective breeding method to be applied .

The Triple Test Cross (TTC) is one of the multiple mating design that helps to estimate the genetic architecture of polygenic characters. Its power in detecting epistasis and flexibility in terms of accommodating large samples from the population are some of its advantages (Pooni *et al.*, 1994; Kearsey and Pooni, 1998). This design is most flexible in that it can be applied to any population with any level of inbreeding, any gene frequency and degree of linkage disequilibrium or gene correlations. In the absence of epistasis this design provides a more efficient estimate of additive and dominance components (Roy, 2000; Viana, 2005).

The objectives of the present study are to establish: (1) The role of non-allelic interaction (epistasis) in the inheritance of grain yield and its components using triple test cross given by Kearsey and Jinks (1968) and modified by Ketata *et al.* (1976) (2) The detection and estimation of additive (D) and dominance (H) components of genetic variation according to Kearsey and Jinks (1968), Jinks *et al.* (1969) and Jinks and Perkins (1970).

MATERIALS AND METHODS

This experiment was carried out at the Experimental Farm of Gemmeiza Agriculture Research Station, Egypt during the three successive seasons 2005 / 2006, 2006 / 2007 and 2007 / 2008 growing season. The two wheat varieties Gemmeiza 9 and Sids 7 were crossed to produce their F1 to be used as three testers. Twenty three varieties and Lines was crossed to the three testers i.e. Gemmeiza 9 (P1), Sids 7 (P2) and their F1 (Gemmeiza 9× Sids 7) to generate 69 crosses i.e. 23 L1i, 23 L2i and 23 L3i progeny families of a triple test cross design in 2006 / 2007 winter growing season as described by Ketata *et al* (1976) . The names, pedigree and origin of these varieties are presented in Table (1)The sixty nine families (crosses), their twenty three parents and the three testers were grown in a randomized complete block design with three replicates in 2007 / 2008 winter growing season. The experimental units consisted of single rows 2 meters long with row to row distance of 30 cm and plant to plant distance of 10 cm, all the normal agronomic practices were followed as usual in the ordinary wheat fields in the area of the study. Ten competitive plants from each row were scored for

Table (1): The name, pedigree and origin of the twenty five wheat cultivars used in this study.

No.	Name	Pedigree	Origin
1	Testers : P1	(Gemmeiza 9): ALD "S" /HUAC // CMH 74 A. 630/SX CGM 4583 - 5 GM - 1GM - OGM	Egypt
2	P2	(Sids 7): MAYA"S"/MON"S"CMH74.A592/3/SAKHA8*2 SD10002-8SD-1SD-1SD-0SD	Egypt
3	F1	(Gemmeiza 9 × Sids 7)	Egypt
4	Lines : Line 1	(Gemmeiza 7) : CMH 74A. 630/SX//SERI 82/AGENT CGM 4611-2GM-3GM-1GM-oGM	Egypt
5	Line 2	(Gemmeiza 10) : MAYA 74 "S" /ON //1160 - 147/3/BB/GLL/41 CHAT "S" /5/ CROW "S". CGM 5820 – 3GM -1 GM - 2GM - OGM.	Egypt
6	Line 3	(Sakha 93): Sakha 92/TR 810328 S 8871-1 S-2S-1S-OS.	Egypt
7	Line 4	(Giza 168): MRL/ BUC// SERI - CM 93046-8 M-OY-OM-2Y-OB-OGZ.	Egypt
8	Line 5	(MILAN): CM 75113-B-5M-2Y-3B-0Y-0CF-0M-0CHL-0AP	Mexico
9	Line 6	SAKHA 61/3/MILDRESS MO73/POL//T.AEST-BON/CNO-7C CGM4615-2GM-10GM-1GM-0GM	Egypt
10	Line 7	(PRINIA) : CM90722-23Y-0M-2E-3Y-1Y-0M-5SJ-010Y-0M-1SJ-0Y- OP	Mexico
11	Line 8	Kauz*2/TRAP//KAUZ - CRG744-9Y-10M-0Y-0HTY-0AP	Syria
12	Line 9	Cham4//Vee's'/Snb's' - ICW91-0008-5AP-0TS-2AP-0TS-2AP-0L	Syria
13	Line 10	(IRENA): CM91575-28Y-0M-0Y-1M-0Y	Mexico
14	Line 11	SAKHA 12/5 /KVZ//CNO 67 /PJ 62/3/YD"S"/BLOS"s"/4/K 134 (60)/ VEE S. 14665-4S-1S-0SY-0S	Egypt
15	Line 12	SKAAUZ*2/SRIMA - CMBW 91M 02694F OTOBY-7M-010Y—010M-010Y	Mexico
16	Line 13	MILAN /MUNIA CMSS 92 M01740S-015M-0Y-0Y-050M-5Y-3M-0Y-1PZ-0Y-3PZ-0Y	Mexico
17	Line 14	SOROCA - CMSS 96Y 02567S-040Y-020M-050SY-020SY-4M-OY	Mexico
18	Line 15	Bb / 7C *2// Y50 E /Kal* 3 / 3 / Skha 8 /4/ Rrv W w 15 /3/ PJ // On * Bon /5/ CMH 76A 912 / CMH 76 A .769 // BUC /2 * CMH 76 .1084 /3/ CMH 76A.912 / CMH 76A769 // CMH 79A.955.	Egypt
19	Line 16	KAUZ /6/ ATL 66 /H567.71 // ATL 66 /5/ PMN5 // S948 A1 4*CNO67 /3/ PMNS /4/ CMH75A.66	Egypt
20	Line 17	SW 89.3064 *2 /BORL 95	Egypt
21	Line 18	VEE/CMH77A917//VEE/3/GANFRENCH/6/CMH79A955 /4/AGA/3/4*SN64/CNO 67//INIA66/5/NAC	Mexico
22	Line 19	CMH76.1084/2*CMH72A429//SUNSU/6/CMH79A955/4/ AGA/3/4*SN64/CNO 67//INIA66/5/NAC	Mexico
23	Line 20	CMH83.2517/GANFRENCH	Mexico
24	Line 21	GEM Line#27/PL//CMH 79 A.955*2/CNO79//CMH79A.955/ BOW"s"//GEM# 7	Egypt
25	Line 22	GEM Line#27/PL//CMH 79 A.955*2/CNO79//CMH79A.955/ BOW "s"//Sids# 6	Egypt
26	Line 23	GEM LINE#27/PL//CMH 79 A.955*2/CNO79//CMH79A.955/ BOW"S"//GEM# 9	Egypt

the subsequent quantitative i.e. Heading date(day), Maturity date(day), Number of spikes per plant, Plant height (cm), Spike length(cm), Number of spikelets per spike, Number of kernels per spike, Spike yield(g), 1000-kernels weight(g) and Grain yield per plant(g).

Biometrical analysis:

Test of epistasis and detection and estimation of additive (D) and dominance (H) components of genetic variations were carried out according to Kearsey and Jinks (1968), Jinks *et al.* (1969) and Jinks and Perkins (1970) and modified by Ketata *et al.* (1976).

The triple test cross families were firstly subjected to the convential two way analysis of variance for (L1i, L2i and L3i) and (L2i and L3i) sets of families for each character studied. The variance of the comparison (L1i + L2i – 2 L3i) was used to test the presence of epistasis, where L1i, L2i and L3i are the means of the i th family in respect of the tester concerned. The variance of sums (L1i + L2i) and differences (L1i – L2i) were used to detect the presence of additive (D) and dominance (H) components of genetical variation respectively.

RESULTS AND DISCUSSION

Epistasis have frequently been observed by many scientists in wheat , althought most of the biometrical designs dealing with the components of genetic variation assume the absence of epistasis . Consequently , most of the information on the genetic analysis is biased due to the presence of epistasis . Triple test cross , however, provides not only a precise test for epistasis but also unbiased estimates of additive (D) and dominance (H) components if epistasis is absent . In self pollinated crops epistasis is perhaps more important to breeder than dominance because the later is necessarily ephemeral in such crops .

The mean performances of the triple test cross sixty nine families together with the twenty three varieties and the three testers for all traits studied are presented in Table (2). Also, the mean squares of the analysis of variance for all traits studied are presented in Table (3) . Genotypes, hybrids and parents were found to be highly significant for all traits studied indicating the presence of substantial amount of the genetic variability which can be assessed by means of the triple test cross analysis. Hybrids Vs parents mean square estimates, as an average heterosis over all crosses, were found to be highly significant for all traits studied .The twenty three wheat varieties and lines were also found to be highly significant for all traits studied . The three testers i.e. the two parents and their F_1 were detected to be highly significant for all traits studied . The two testers Gemmeiza 9 and Sids 7 were found to differ significantly from each other according to their genetic background in all characters investigated .The unbiased estimates

Table (2) : Mean performances of the triple test cross families for all traits studied.

A-Hybrids		Heading date (day)	Maturity date (day)	Number of spikes per plant	Plant height (cm)	Spike length (cm)	Number of spikelets per spike	Number of kernels per spike	Spike yield (g)	1000-kernels weight (g)	Grain yield per plant (g)
Line 1	× P1	100.67	150.00	12.43	126.70	13.93	25.07	80.45	4.79	54.04	30.78
	× P2	97.07	148.20	11.73	121.67	14.27	23.47	69.67	4.26	57.48	29.49
	× F1	99.33	149.10	12.67	122.70	13.63	24.00	70.57	3.93	56.44	28.79
Line 2	× P1	102.13	149.60	13.93	114.17	11.83	24.07	75.63	3.91	50.38	27.84
	× P2	97.63	147.07	14.60	110.90	12.63	23.20	70.77	3.75	48.37	33.25
	× F1	99.90	150.10	13.43	111.47	12.77	24.33	74.27	3.75	49.94	34.07
Line 3	× P1	98.53	150.77	12.07	111.20	11.63	23.20	65.07	3.46	53.26	26.31
	× P2	93.10	144.70	11.43	109.57	13.33	23.33	67.93	3.83	47.84	30.71
	× F1	96.83	148.33	12.50	110.23	12.60	22.67	63.33	3.34	49.71	23.19
Line 4	× P1	99.60	150.20	13.07	118.07	12.27	23.30	59.65	3.18	48.16	28.48
	× P2	92.80	148.97	13.37	111.10	13.20	23.00	66.93	3.32	47.11	27.29
	× F1	96.47	149.30	12.63	113.03	12.43	22.60	61.97	2.74	46.41	30.97
Line 5	× P1	102.83	150.70	13.60	116.30	11.90	23.13	57.23	3.19	48.71	33.01
	× P2	95.80	147.43	13.73	113.37	12.67	22.47	63.70	3.46	48.67	31.90
	× F1	99.33	148.87	15.07	116.00	12.57	22.93	61.33	3.41	52.18	35.37
Line 6	× P1	104.17	151.07	10.53	130.70	12.43	23.73	68.63	3.99	56.34	25.75
	× P2	98.27	148.43	11.73	128.40	13.60	23.20	62.00	3.71	62.51	24.83
	× F1	99.50	148.53	10.97	126.50	13.10	23.07	67.80	3.89	52.63	24.17
Line 7	× P1	104.87	150.87	13.07	121.53	12.23	23.20	60.50	3.44	48.91	28.04
	× P2	99.37	149.93	12.93	116.83	13.33	23.13	60.47	3.51	52.59	30.74
	× F1	100.70	151.40	13.63	117.63	12.53	22.93	58.60	3.10	55.33	32.65
Line 8	× P1	101.57	151.13	11.60	116.73	11.53	22.73	64.17	3.42	49.51	26.69
	× P2	95.00	147.10	14.13	113.53	12.37	22.53	64.60	3.44	50.59	32.73
	× F1	97.43	149.00	12.10	113.63	12.23	23.40	71.07	3.71	47.33	36.08
Line 9	× P1	102.53	151.33	12.73	123.67	13.17	24.40	73.43	3.69	43.96	27.58
	× P2	98.33	149.07	11.83	117.77	13.33	23.13	69.43	3.34	46.96	30.87
	× F1	99.67	150.17	12.43	119.53	13.37	23.93	73.47	3.48	42.47	24.52
Line 10	× P1	99.73	150.10	12.43	118.20	12.53	23.87	75.23	4.19	49.31	29.39
	× P2	94.17	145.93	12.93	111.97	13.70	24.00	81.15	4.37	54.32	31.36
	× F1	95.53	147.80	11.97	114.07	12.60	23.53	80.60	4.16	52.56	32.94
Line 11	× P1	94.50	147.87	11.97	113.27	11.53	22.33	43.70	3.03	57.65	23.28
	× P2	88.47	147.17	12.30	113.50	12.97	22.03	70.70	4.27	52.07	29.84
	× F1	92.73	147.67	11.63	113.93	12.60	22.13	61.00	3.33	53.76	26.52
Line 12	× P1	101.67	149.97	13.07	121.20	12.50	24.20	70.23	3.45	49.13	26.71
	× P2	95.77	148.23	11.90	116.27	12.90	23.53	74.13	3.74	45.82	29.30
	× F1	100.10	149.70	13.33	118.10	13.23	23.47	69.10	3.54	49.12	30.92
Line 13	× P1	101.00	149.80	12.40	124.07	11.63	22.70	66.30	3.44	52.54	27.55
	× P2	95.37	148.93	13.20	121.57	12.97	23.07	63.07	3.68	51.28	22.20
	× F1	99.30	148.97	11.73	123.13	11.90	22.33	59.97	3.18	53.03	26.50
Line 14	× P1	102.63	150.17	11.87	126.87	11.67	22.73	57.40	3.46	54.08	31.68
	× P2	97.20	147.97	14.53	123.00	13.00	23.40	67.60	3.89	53.36	29.31
	× F1	98.43	148.27	13.17	124.57	12.37	23.47	59.23	3.41	56.45	24.89

Table (2) : Cont.

A-Hybrids		Heading date (day)	Maturity date (day)	Number of spikes per plant	Plant height (cm)	Spike length (cm)	Number of spikelets per spike	Number of kernels per spike	Spike yield (g)	1000-kernels weight (g)	Grain yield per plant (g)
Line 15	× P1	100.53	149.53	12.93	127.03	11.43	22.93	70.37	3.85	53.52	30.21
	× P2	92.60	145.47	7.90	117.57	15.17	23.47	94.50	6.31	63.87	29.29
	× F1	96.53	148.17	12.43	120.83	12.77	23.53	77.87	4.33	55.30	26.78
Line 16	× P1	98.73	149.27	15.47	119.60	12.07	23.00	71.27	3.40	51.53	40.99
	× P2	95.00	147.77	15.10	118.50	12.93	22.40	73.07	3.66	54.26	38.66
	× F1	97.13	148.77	14.13	113.63	12.17	22.67	67.43	3.09	51.17	26.71
Line 17	× P1	98.47	148.90	20.63	134.03	11.97	22.47	64.83	3.61	55.41	35.34
	× P2	93.53	147.20	12.10	132.47	13.30	22.53	70.00	4.35	57.84	37.44
	× F1	96.00	148.23	12.93	137.73	13.07	23.73	73.60	4.15	57.25	38.56
Line 18	× P1	102.50	149.50	13.17	129.10	13.20	24.53	52.30	3.34	60.79	28.24
	× P2	92.30	146.43	8.47	117.10	15.83	23.53	95.80	5.56	60.94	32.69
	× F1	97.23	148.70	11.90	121.77	13.47	23.07	67.97	3.95	55.32	29.20
Line 19	× P1	100.73	148.33	12.50	128.47	13.50	23.53	46.47	2.97	63.38	23.89
	× P2	91.47	144.73	4.70	120.23	18.80	23.40	117.30	8.35	65.52	25.48
	× F1	95.70	146.97	9.27	120.77	14.53	23.67	71.50	4.36	63.30	25.62
Line 20	× P1	102.33	151.13	10.57	119.63	12.93	24.13	54.43	2.87	56.63	21.60
	× P2	94.30	147.83	5.60	114.20	18.07	25.40	116.67	8.18	69.08	30.42
	× F1	99.70	149.60	10.70	116.40	14.27	24.13	67.70	4.70	58.01	35.20
Line 21	× P1	101.47	149.67	10.60	122.60	13.37	23.80	54.55	3.89	68.03	34.05
	× P2	96.47	147.43	8.13	119.20	17.70	25.20	105.80	7.60	65.13	36.77
	× F1	98.03	148.33	9.93	122.03	14.17	23.73	70.03	4.58	62.50	30.39
Line 22	× P1	100.00	149.33	10.87	124.20	12.83	23.67	69.17	4.06	57.25	30.76
	× P2	92.87	145.80	6.33	113.47	16.57	25.27	104.00	6.84	62.00	28.57
	× F1	98.87	149.00	10.60	119.93	14.77	23.93	78.30	4.74	63.44	34.20
Line 23	× P1	104.93	151.30	12.20	137.63	13.07	25.07	74.77	4.06	52.75	28.44
	× P2	98.40	147.27	9.10	128.50	14.33	24.73	65.87	4.06	59.24	29.33
	× F1	101.47	150.00	11.07	135.13	14.17	25.20	68.37	3.69	51.44	24.75

Table (2) : Cont.

B-Lines	Heading date (day)	Maturity date (day)	Number of spikes per plant	Plant height (cm)	Spike length (cm)	Number of spikelets per spike	Number of kernels per spike	Spike yield (g)	1000-kernels weight (g)	Grain yield per plant (g)
Line 1	97.67	148.30	11.27	124.87	13.53	24.47	72.10	3.80	51.36	28.52
Line 2	102.50	151.13	12.63	105.30	11.07	22.40	67.07	3.14	46.47	27.13
Line 3	94.13	148.50	14.50	105.40	11.40	21.87	55.60	2.93	41.56	28.44
Line 4	95.67	149.67	13.33	107.47	11.60	22.33	70.57	3.05	40.85	23.88
Line 5	105.07	149.53	15.30	114.57	10.90	21.93	61.43	2.76	44.63	29.43
Line 6	104.90	148.67	11.83	136.07	12.23	23.27	55.30	3.33	59.66	25.18
Line 7	106.60	153.50	15.77	115.27	12.17	22.73	62.15	2.69	47.61	29.85
Line 8	98.10	146.87	15.13	107.87	10.73	21.87	68.15	3.08	41.8	32.45
Line 9	102.20	152.40	15.90	120.20	12.10	22.40	65.77	2.89	39.48	24.61
Line 10	96.57	147.20	15.47	114.87	11.47	22.87	71.90	3.14	45.09	29.08
Line 11	88.33	144.53	10.27	107.23	10.90	21.53	52.30	2.86	50.9	21.36
Line 12	100.73	146.17	13.97	108.30	11.17	22.67	73.50	3.22	36.75	24.64
Line 13	100.13	147.23	16.70	117.83	10.20	21.07	57.07	2.81	47.91	32.79
Line 14	99.97	148.63	12.93	124.50	10.93	21.73	61.93	2.82	46.38	22.10
Line 15	98.17	146.80	10.20	122.03	11.53	23.07	78.53	4.68	52.68	29.28
Line 16	97.57	147.03	17.27	112.77	11.27	21.93	67.23	3.11	48.12	38.26
Line 17	96.30	146.77	13.60	121.50	11.70	22.00	62.97	3.11	44.75	34.72
Line 18	100.27	147.83	11.97	118.90	13.33	24.07	73.20	3.89	49.74	29.26
Line 19	94.53	143.20	6.77	124.13	14.90	23.87	106.60	6.16	55.62	25.75
Line 20	100.97	150.30	6.53	103.50	14.33	24.60	89.03	4.81	56.59	20.42
Line 21	98.03	148.63	7.97	123.73	14.40	24.33	92.23	6.15	68.99	32.73
Line 22	98.03	148.33	6.70	109.67	15.70	26.20	89.63	5.66	64.07	29.94
Line 23	110.33	156.53	10.97	144.53	13.50	25.87	77.33	3.84	47.49	26.26

Table (2) : Cont.

C-Testers	Heading date (day)	Maturity date (day)	Number of spikes per plant	Plant height (cm)	Spike length (cm)	Number of spikelets per spike	Number of kernels per spike	Spike yield (g)	1000-kernels weight (g)	Grain yield per plant (g)
P 1	105.13	152.67	13.13	123.20	12.57	24.73	72.8	3.95	50.41	32.79
P 2	88.67	140.27	4.73	103.80	17.50	27.24	110.05	7.03	66.05	21.60
F 1	97.30	148.90	13.13	118.63	13.13	24.20	57.6	3.31	55.85	27.34

Table (3) : Mean squares of the analysis of variance of (L1i, L2i and L3i) triple test cross hybrids for all traits studied.

Source of variance	d.f.	Heading date (day)	Maturity date (day)	Number of spikes per plant	Plant height (cm)	Spike length (cm)	Number of spikelets per spike	Number of kernels per spike	Spike yield, (g)	1000-kernels weight, (g)	Grain yield per plant, (g)
Replication	2	79.00	43.81	18.78	32.23	0.62	1.69	1.83	1.38	1.01	20.18
Genotype	94	46.20**	13.80**	18.70**	185.39**	7.40**	3.38**	575.02**	3.90**	139.32**	55.25**
Hybrids	68	35.27**	7.24**	12.95**	136.89**	6.32**	1.91**	545.58**	3.70**	103.98**	52.35**
Parents	25	75.20**	31.97**	34.94**	299.33**	9.30**	7.45**	670.99**	4.47**	199.58**	58.44**
Lines	22	64.38**	24.66**	31.63**	310.96**	6.86**	5.67**	533.17**	3.55**	184.25**	57.61**
Testers	2	203.52**	121.24**	70.56**	308.62**	21.86**	7.92**	2184.80**	11.88**	189.12**	93.89**
P1 vs P2	1	406.73**	230.64**	105.84**	564.54**	36.51**	9.45**	2081.34**	14.22**	366.91**	187.75**
Lines vs Tester	1	45.53**	13.89**	36.58**	24.86	37.83**	45.45**	675.44**	9.90**	557.95**	5.73
Hybrids vs Parents	1	65.03**	6.82*	4.19*	634.79**	33.27**	2.16*	177.52**	3.07**	1035.95**	173.00**
Error	188	0.92	0.80	3.09	7.30	0.32	0.61	22.95	0.22	5.86	7.90

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

of additive (D) and dominance (H) gene action and the unambiguous test of epistasis would only be achieved when the testers are different from each other in their characteristics . However, when this condition of difference is not met , the estimates will be biased to unknown extent (Kearsey and Jinks, 1968 and Jinks *et al.*, 1969). Lines Vs testers mean square estimates were detected to be highly significant for all traits except plant height and grain yield per plant .

Test for epistasis:

Analysis of variance for testing the presence of epistasis in a triple test cross for all traits studied are presented in Table (4). Results of the triple test cross analysis revealed the presence of epistasis in all characters studied except number of spikes per plant and plant height , however, the magnitude of this epistasis was found to be varied according to the trait under investigation . The epistatic effects were found to be highly significant for heading date , maturity date , spike length , number of kernels per spike , spike yield , 1000- kernels weight and grain yield per plant , while the level reduced to only significant for number of spikelets per spike . Further partitioning of the resultant epistasis revealed that the mean square estimates of (I) epistatic type (additive × additive interaction) were detected to be highly significant for maturity date, spike length , number of kernels per spike , spike yield and 1000- kernels weight and it was found to be only significant for heading date . The presence of (J) epistatic type (Additive × dominance) and (L) epistatic type (dominance × dominance) were detected to be highly significant for heading date , maturity date , spike length , number of kernels per spike , 1000- kernels weight and grain yield per plant and it was found to be only significant for number of spikelets per spike and spike yield . The additive × additive epistatic type (I) was found to be much larger in magnitudes than the other two epistatic types (J) additive × dominance and (L) dominance × dominance for six out of the eight characters which exhibited the two types of epistasis (I) and (J+L) , indicating that fixable components of epistasis were more important than nonfixable one in the inheritance of these traits of heading date , maturity date , spike length , number of kernels per spike , spike yield and 1000-kernel weight. In a highly self-fertilized crop like wheat , the fixable component of epistasis could be easily exploited . The presence of .epistasis could have important implications in a breeding programme. Standard hybridization and selection procedures could take advantage of epistasis if it is additive × additive type as in heading date , maturity date , spike length , number of kernels per spike , spike yield and 1000-kernel weight. A greater importance of epistasis was also reported in wheat by Eissa (1994) , Comber (2001), Sadat Noori and Sokhansanj (2004) , Koumber (2006), Salama (2007) and Hendawy (2008) .

Table 4: Analysis of variance for testing the presence of epistasis in a triple test cross for all traits studied.

Source of variance	d.f.	Heading date (day)	Maturity date (day)	Number of spikes per plant	Plant height (cm)	Spike length (cm)	Number of spikelets per spike	Number of kernels per spike	Spike yield, (g)	1000-kernels weight, (g)	Grain yield per plant, (g)
Total of epistasis	23	13.317**	5.773**	13.524	50.971	5.006**	3.562*	456.643**	3.477**	122.204**	271.151**
I type epistasis	1	0.028*	15.783**	31.878	118.175	11.854**	2.412	1903.388**	37.917**	229.415**	1.256
J + L epistasis	22	13.921**	5.318**	12.690	47.916	4.695**	3.614*	390.882**	1.912*	117.331**	283.419**
I type epistasis × block	3	0.377	0.082	35.354	111.086	0.121	6.496	117.469	0.611	1.619	12.583
J + L epistasis × block	66	4.642	2.248	9.463	29.267	1.653	1.739	92.423	0.914	15.932	44.787
Total epistasis × block	69	4.457	2.154	10.588	32.825	1.586	1.946	93.512	0.901	15.309	43.387

*, ** Significant at 0.05 and 0.01 probability levels, respectively.
(I) = additive × additive , (L) = dominance × dominance , (J) = additive × dominance

Detection and estimation of additive and dominance genetic variance components:

The analysis of variance for sums (measuring additive genetic variance) and differences (measuring dominance genetic variance) and the estimation of additive (D) and dominance (H) genetic components are presented in Table (5). The mean square estimates due to sums (L1i + L2i) and due to differences (L1i – L2i) were found to be highly significant for all traits studied . These results would indicate that both additive and dominance genetic variance appeared to predominantly affect all characters measured. Consequently, it could be concluded that selection procedures based on the accumulation of additive effects would be successful in improving all traits studied. However, to maximize selection advance, procedures which are known to be effective in shifting gene frequency when both additive and non-additive genetic variances are involved would be preferred. Similar results were previously obtained by Eissa (1994) , Comber (2001), Sadat Noori and Sokhansanj (2004), Koumber (2006),Salama (2007) and Hendawy (2008) .

The additive genetic variances (D) was found to be much larger in magnitudes than the dominance genetic variance (H) for all traits under investigation except number of kernels per spike and spike yield and that resulted in $(H/D)^{1/2}$ to be less than one confirming that these characters were influenced predominantly by the additivity of the genes and also the role of partial dominance in the inheritance of these traits. As for number of kernels per spike and spike yield , the dominance genetic variance (H) was found to be larger n magnitudes than the additive genetic variance and that resulted in $(H/D)^{1/2}$ to be more than unity confirming the role of the overdominance in the inheritance of there two characters .

The direction of dominance and types of genes exhibiting dominance were detected by calculating the correlation coefficients between sums (L1i + L2i) and differences (L1i – L2i) (Table 5). If (r) is negative and significant, then increasing type of genes are dominant and vice-versa. The correlation coefficients between sums and differences were found to be negative and significant for number of spikes per plant, spike length, number of kernels per spike and spike yield indicating that the increasing type of genes are dominant in these four traits .However, for the remaining characters studied , the correlation coefficients were found to be insignificant hence the dominance was ambidirectional.

The results obtained here would indicate that epistasis is an integral component of the genetic variance of mostly all traits studied and hence detection, estimation and consideration of epistasis is important for the formulation of breeding programme to improve wheat population for such traits. If epistasis is ignored no presice conclusion can be drawn about the relative importance of the other component of genetic variation additive and dominance where such estimation of additive and dominance would be

Table 5: Mean squares from analysis of variance for sums and differences and estimates of additive (D), dominance (H) and degree of dominance in triple test cross for all traits studied.

Source of variance	d.f.	Heading date (day)	Maturity date (day)	Number of spikes per plant	Plant height (cm)	Spike length (cm)	Number of spikelets per spike	Number of kernels per spike	Spike yield, (g)	1000-kernels weight, (g)	Grain yield per plant, (g)
Sums (L_{1i} + L_{2i})	22	67.22**	11.21**	42.14**	452.57**	17.47**	6.73**	854.24**	7.84**	401.67**	158.11**
Error	44	1.51	2.06	8.66	19.02	0.82	1.39	36.95	0.65	10.12	23.27
Difference (L_{1i}- L_{2i})	22	8.07**	5.28**	21.17**	31.29**	7.05**	1.99*	1646.79**	9.03**	62.11**	36.02**
Error	44	1.17	0.86	4.47	11.63	0.40	1.09	32.41	0.36	7.05	14.70
D		87.621	12.196	44.648	578.06	22.209	7.1234	1089.716	9.5796	522.0652	179.78
H		9.197	5.8925	22.261	26.205	8.8682	1.1994	2152.502	11.554	73.41786	28.426
$(H/D)^{0.5}$		0.324	0.695	0.706	0.213	0.632	0.410	1.405	1.098	0.375	0.398
r		-0.22	-0.39	-0.77	0.22	-0.82	-0.19	-0.58	-0.86	-0.35	0.12

*, ** Significant at 0.05 and 0.01 probability levels, respectively.
r = correlation coefficients between sums (L1i + L2i) and differences (L1i – L2i)

biased by epistasis to unknown extent as in the present materials (Sood and Dawa, 1999). It could therefore be concluded that additive × additive epistatic type coupled with additive genetic variance were found to be preponderant for mostly all traits and hence the possible improvement of these traits through standard hybridization and selection in early generations. Also, additive × dominance (J) and dominance × dominance (L) epistatic type coupled with the other two components of genetic variance additive and dominance were preponderant for heading date , number of spikelets per spike and grain yield per plant , in such situation, biparental matings may be attempted in F_2 and subsequent generations and selection may be postponed till late generation to allow sufficient epistasis to get fixed, same conclusion was also drawn by Comber (2001), Hendawy *et al.,* (2007) and Hendawy (2008) .

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تحديد دور التفوق فى وراثة المحصول ومكوناته فى قمح الخبز باستخدام تحليل التهجين الثلاثى الإختبارى

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الملخص العربى :

أجرى هذا البحث فى مزرعة محطة البحوث الزراعية بالجميزة – مركز البحوث الزراعية وذلك فى الثلاثة مواسم المتتالية ٢٠٠٦/٢٠٠٥ ، ٢٠٠٧/٢٠٠٦ ، ٢٠٠٨/٢٠٠٧ وقد تم استخدام خمسة وعشرون صنف وسلالة من أقماح الخبز المختلفة وذلك لعمل المواد التجريبية اللازمة لموديل التهجين الثلاثي الاختباري وذلك بهدف دراسة كل من :-

١- دور التفوق فى وراثة صفة المحصول ومكوناته .

٢- تقدير التباين الوراثي المضيف والتباين الوراثي السيادي

وقد تم تحليل البيانات باستخدام طريقة التهجين الثلاثي الاختباري (Triple test cross) طبقا Kearsey and Jinks (1968) and modified by Ketata *et al.* (1976) . وكانت الصفات المدروسة هي :- ميعاد طرد السنابل – ميعاد النضج – عدد السنابل على النبات – ارتفاع النبات – طول السنبلة الرئيسية – عدد السنيبلات في سنبلة الساق الرئيسية – عدد الحبوب فى سنبلة الساق الرئيسية – محصول سنبلة الساق الرئيسية – وزن الألف حبة – محصول الحبوب للنبات الفردي .

ويُمكن تلخيص النتائج المتحصل عليها فى الآتى :

١. كانت قيم التباين الراجعة إلى الكشافات الثلاثة عالية المعنوية لجميع الصفات المدروسة كما كانت الاختلافات بين الأصناف الثلاثة وعشرون والكشافات الثلاثة عالية المعنوية لكل

الصفات المدروسة عدا صفة ارتفاع النبات ومحصول الحبوب للنبات الفــردي كمــا كانــت الاختلافات بين الكشافين جميزة ٩ وسدس ٧ عالية المعنوية وذلك لكل الصفات المدروسة.

٢. كانت قيم التباين الراجعة إلى التراكيب الوراثية والهجن والآباء عاليــة المعنويــة لجميــع الصفات المدروسة كما كانت الاختلافات بين الهجن والآباء عالية المعنوية لكــل الــصفات المدروسة.

٣. كان الفعل الجيني التفوقى عالي المعنوية لكل الصفات المدروسة عدا صفة عــدد الــسنابل على النبات وصفة ارتفاع النبات وكان التباين الراجع إلــى طــرز التفــوق المــضيف × المضيف عالي المعنوية للصفات التالية ميعاد النضج وطول السنبلة وعــدد الحبــوب فــي السنبلة ومحصول السنبلة ووزن الآلف حبة، بينما كان طرز التفوق المــضيف × الــسائد والسائد × السائد عالي المعنوية للصفات التالية ميعاد الطرد وميعاد النضج وطول الــسنبلة وعدد الحبوب في السنبلة ووزن الآلف حبة ومحصول الحبوب للنبات الفردي .

٤. كان التباين الوراثي المضيف ذو قيمة أعلى من التباين السيادي وذلك فــي كــل الــصفات المدروسة عدا صفة عدد الحبوب في السنبلة ومحصول السنبلة كما لعبت السيادة الجزئيــة دوراً في وراثة كل الصفات المدروسة .

٥. كان معامل الارتباط سالباً لجميع الصفات المدروسة عدا صفة ارتفاع النبات وصفة محصول الحبوب للنبات الفردي .