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ASSESSMENT OF GENE ACTION FOR GRAIN YIELD AND ITS ATTRIBUTES IN BREAD WHEAT USING THREE DIALLEL SIZES

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ABSTRACT: A study was carried out at the Experimental Farm, Faculty of Agriculture, Zagazig University, Egypt during the winter growing seasons of 2005/2006 and 2006/2007. Three diallel sizes excluding reciprocals among four, five and seven local and introduced bread wheat genotypes were used to assess the mean performance, types of gene action and heritability for wheat grain yield and some relevant characters under different diallel sizes. The results indicate high degree of genetic variability existed among parental wheat genotypes and their F_1 crosses for days to heading, flag leaf area, yield and its components and protein content .The number of superior genotypes that could be exploited through phenotypic selection was increased with increasing diallel size. The most desirable wheat genotypes that exhibited high grain yield and relevant characters were Sids 1 and Line 1 and their F_1 crosses (Gemmeiza 7 x Sids 1 and Sids 1 x Line 1 at 4x4 diallel size); Giza 168 and Line 2 and their F_1 crosses (Gemmeiza 9 x Line 2, Giza 168 x Line 2 and Line 2 x Line 3 at 5x5 diallel size) as well as Sids 4, Cham 4 and Cham 6 and their F_1 crosses (Gemmeiza 10 x Sids 4, Sids 4 x Cham 6 and Sakha 8 x Cham 4 at 7X7 diallel size). Consequently the breeder could be utilized the appropriate diallel size for isolating new recombinants with high yielding ability.

The additive and dominance genetic components and their derived parameters differed in magnitude from diallel size to another. In general, both additive and dominance genetic components were significant and involved in the inheritance of days to heading, yield and its components and protein content in most

cases at 4x4, 5x5 and 7x7 diallel sizes. The dominance component was larger in its magnitude than the additive [$(H_1/D)^{0.5}$ was more than unity] for the abovementioned characters. Additive gene action was the prevailed type controlling flag leaf area at 4x4 and protein content at 7x7 diallel level, whereas dominance component was more important in controlling flag leaf area at 5x5 and 7x7 diallel sizes. The covariance of additive and dominance gene effects in the parents (F value) was positive and significant for days to heading at 7x7 diallel size; flag leaf area and grain protein content at 4x4 diallel size as well as number of grains /spike and 1000-grain weight at 5x5 diallel size. The overall dominance effects of heterozygous loci (h^2) were positive and significant for flag leaf area at 4x4 and 5x5 diallel levels, number of grains/spike and grain yield/plant at 4x4 diallel level as well as number of spikes/plant and number of grains/spike at 7x7 diallel. The positive and negative alleles ($H_2/4H_1$) were approximately equally distributed among the parental populations for days to heading, 1000-grain weight and grain yield/plant at 4x4 and number of spikes/plant and grain yield/plant at 7x7 diallel size .Narrow sense heritability varied from diallel size to another, it was low (<30%) for number of grains/spike, 1000-grain weight and grain yield/plant at 4x4 and protein content in all diallel sizes and varied from low to moderate for that characters and number of spikes/plant at 5x5 and 7x7 diallel size. Furthermore, narrow sense heritability was high (>50%) for days to heading and flag leaf area in most cases.

Key words: Wheat, diallel, mean performance, gene action, heritability.

INTRODUCTION

Diallel analysis of (Hayman, 1954 a and b) have been used to give information on the genetic components of the parents and their F_1 crosses. When, additive gene action comprise the main component of genetic variance, the breeder could isolate new recombinants through phenotypic selection. However, the presence of non-additive gene action might suggests the exploitation of heterosis through hybrids. In this respect, some previous studies reported that both additive and dominance were significant with great role of dominance in controlling days to heading, flag leaf area, grain yield and most of its components (Hassan 1998 and

Meena *et al.,* 2005). Nevertheless, additive component was involved in the inheritance of yield contributing characters (Mang *et al.*, 2003).

Information on heritability are important in predicting the expected genetic gain from selection in segregating wheat populations. In this connection, estimates of heritability in narrow sense for days to heading, flag leaf area, grain yield and its components were reported by many investigators using various diallel sizes (Awaad 2005, El-Hosary *et al.*, 2005 and Iqbal *et al.*, 2007).

This investigation aimed to evaluate mean performance of bread wheat parents and their F_1 hybrids as to estimate types of gene action and heritability for days to heading, flag leaf area, yield and its components and grain protein content in three diallel sizes.

MATERIALS AND METHODS

Parental Genotypes and Experimental Layout

The present investigation was performed at the Experimental Farm. Fac. of Agric., Zagazig University, Egypt during the two winter growing seasons of 2005/ 2006 and 2006/ 2007 to study the inheritance of days to heading, flag leaf area and yield and its components using three diallel cross sets between 4, 5 and 7 diverse wheat genotypes. The origin and pedigree of the parental genotypes involved in the present study are illustrated in Table 1.

In 2005/2006, the parental genotypes of each diallel set were evaluated in a randomized complete block design experiment with three replications, at the mean time half diallel crosses were performed to obtain F_1 cross seeds .In 2006/2007, the obtained of 4x4, 5x5 and 7x7 diallel sizes of F_1 seeds were sown to produce F_1 plants.

The parental genotypes and their F_1 crosses of each diallel size were evaluated separately using a randomized complete block design experiments with three replications. Wheat grains were sown on the last week of November. Rows were 150 cm in length and 20 cm in width and plants were spaced at 10 cm within row. Each plot consists of 6 rows for each parent and 1 row for each F_1 cross. All the recommended agricultural practices for wheat

Table 1. Pedigree of parental wheat genotypes involved in three diallel cross sizes

No.	Genotypes	Pedigree	Origin
		4x4	
1	**Sakha 93**	Sakha 92/TR 810328	Egypt
2	**Gemmeiza 7**	CMH 74 A. 630/SX// Seri 82/3/Agent	Egypt
3	**Sidds 1**	HD 2172/ Pavon "s"// 1158.57/ Maya 74 "S"	Egypt
4	**Line 1**	KAUZ//PFAU/VEE #5	Mex/Syr
		5x5	
1	**Sakha 61**	INIA/RL 4220 7 C/3/YR	Egypt
2	**Gemmeiza 9**	ALD "S" HUAC "S" // CMH74A.630/SX	Egypt
3	**Giza 168**	MRL/BUC//Seri	Egypt
4	**Line 2**	ANGRA/2* CAZO	Mex/Syr
5	**Line 3**	NETOR/3/HE1/3* CN79 //2* SER	Mex/Syr
		7x7	
1	**Sakha 94**	Opta/Rayon//Kauz	Egypt
2	**Gemmeiza 10**	Maya 74 "S"/ ON//1160-1473/BB/G11/4/Cat "S"/5/Crow"s"	Egypt
3	**Sids 4**	Maya "S"/ Mons "S"// CMH 74A. 592/3/Giza 157*2	Egypt
4	**Sakha 8**	Indus/Norteno "S"	Egypt
5	**Cham 4**	Improved Check	Syria
6	**Line 4**	OASIS/SKAU2//4* BCN.	Mex/Syr
7	**Cham 6**	Improved Check	Syria

production were applied at the proper time. Days to heading, flag leaf area, number of spikes/plant, number of grains/spike, 1000-grain weight and grain yield/plant were recorded on ten competitive individual plants for each entry .Grain protein content, was estimated according to the micro-kjeldahl method to determine the total nitrogen in the grain and multiplied by 5.75 to obtain the percentage of protein according to A.O.A.C (1980).

Biometrical Assessments

The obtained data were subjected firstly to the conventional two way analysis of variance according to Steel and Torrie (1980). Assessment and quantifying the types of gene action were computed according to Hayman (1954 a and b).

RESULTS AND DISCUSSION

Mean Performance

Mean performance of days to heading, flag leaf area, yield and its components and grain protein content for parental wheat genotypes and their F_1 crosses at 4X4, 5x5 and 7x7 diallel sizes are presented in Tables 2 and 3. Highly significant differences were recorded between parental genotypes and their F_1 crosses for all the studied characters at different levels of diallel. These results provide evidence for the presence of adequate amount of genetic variability valid for further biometrical assessments. Similar findings were reported by Awaad (2002) and Iqbal *et al.* (2007).

For days to heading Table 2, it is noticeable in general that the crosses were earlier in heading than parents which averaged 98.04 and 96.92 days compared to 99.03 and 97.38 days for parents at 4x4 and 5x5 diallel sizes, respectively. In addition, at 4x4 diallel size the local wheat genotype Sakha 93 was the earliest, whereas Gemmeiza 7 was the latest. The good level of earliness pronounced in Sakha 93 was reflected in the performance of their F_1 crosses Sakha 93x Sids1 and Sakha 93 x Line 1. While at 5x5diallel size, the local wheat genotype Gemmeiza 9 and the exotic Line 2 were later in heading, whereas Giza168 and Sakha 61 as well as their F_1 crosses Sakha 61x Line 2, Sakha 61xLine 3, Gemmeiza 9 x Giza 168, Giza 168x Line 3, were the earliest ones than the remaining wheat genotypes. Furthermore, at 7x7 diallel size,

Table 2. Mean performance of parental genotypes and their F_1 crosses for days to heading and flag leaf area in three diallel cross sizes of bread wheat

Genotypes	4x4	
	Days to heading (day)	Flag leaf area (cm^2)
Sakha 93	95.33	46.54
Gemmeiza 7	101.86	65.64
Sids1	99.08	69.28
Line1	99.87	43.19
$\overline{\overline{X}}$	99.03	56.16
Sakha 93 x Gemmeiza 7	98.39	53.54
Sakha 93 x Sids1	95.41	53.66
Sakh 93 x Line 1	96.86	47.94
Gemmeiza 7 x Sids1	100.18	58.53
Sakha 93 x Line1	96.24	54.46
Sids1 x Line1	101.18	49.36
$\overline{\overline{X}}$	98.04	52. 91
L.S.D0.05	0.041	0.501
L.S.D0.01	0.057	0.688
	5x5	
Sakha 61	95.33	55.13
Gemmeiza 9	101.55	57.49
Giza 168	92.64	48.16
Line 2	100.14	41.61
Line 3	97.26	51.91
$\overline{\overline{X}}$	97.38	50.86
Sakha 61 x Gemmeiza 9	98.20	49.05
Sakha 61 x Giza 168	96.61	52.32
Sakha 61 x Line 2	93.60	39.18
Sakha 61 x Line 3	95.20	48.31
Gemmeiza 9 x Giza 168	101.23	50.68
Gemmeiza 9 x Line 2	102.39	52.43
Gemmeiza 9 x Line 3	94.39	46.37
Giza 168 x Line 2	99.63	48.28
Giza 168 x Line 3	92.10	46.63
Line 2 x Line 3	95.83	39.84
$\overline{\overline{X}}$	96.92	47.31
L.S.D0.05	0.442	7.800
L.S.D0.01	0.596	10.524

Table 2. Cont.

Genotypes	7x7	
	Days to heading (day)	Flag leaf area (cm^2)
Sakha 94	100.51	39.79
Gemmeiza 10	102.81	53.62
Sids 4	90.16	47.06
Sakha 8	98.25	51.68
Cham 4	101.24	47.85
Line 4	99.55	38.25
Cham 6	100.56	36.18
$\bar{\bar{X}}$	99.58	44.92
Sakha 94 x Gemmriza 10	103.69	45.22
Sakha 94 x Sids 4	99.92	42.36
Sakha 94 x Sakha 8	96.34	40.40
Sakha 94 x Cham 4	102.95	44.55
Sakha 94 x Line 4	98.25	37.57
Sakha 94 x Cham 6	101.69	39.42
Gemmeiza 10 x Sids 4	96.49	52.58
Gemmeiza 10 x Sakha 8	97.50	42.24
Gemmeiza 10 x Cham 4	99.74	45.29
Gemmeiza 10 x Line 4	100.25	40.42
Gemmeiza 10 x Cham 6	102.19	35.27
Sids 4 x Sakha 8	94.21	45.62
Sids 4 x Cham 4	97.21	54.33
Sids 4 x Line 4	100.36	46.25
Sids 4 x Cham 6	98.16	32.05
Sakha 8 x Cham 4	103.90	45.58
Sakha 8 x Line 4	102.69	44.65
Sakha 8 x Cham 6	98.72	40.09
Cham 4 x Line 4	98.99	36.94
Cham 4 x Cham 6	102.53	46.42
Line 4 x Cham 6	100.59	33.11
$\bar{\bar{X}}$	99.82	42.40
L .S. D 0.05	0.569	0.729
L.S.D 0.01	0.758	0.972

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

Table 3. Mean performance of parental genotypes and their F_1 crosses for yield, its components and protein content in three diallel cross sizes of bread wheat

Genotypes	No. spikes/plant	No. grains/spike	1000-grain weight (g.)	Grain yield/plant (g.)	Grain protein content (%)
	4x4				
Sakha93	8.43	66.53	43.65	17.56	11.02
Gemmeiza7	6.13	58.18	50.35	13.57	11.71
Sids1	8.85	62.68	50.20	22.09	10.33
Line 1	8.25	56.37	43.05	18.22	11.28
$\bar{\bar{X}}$	7.91	60.94	46.81	17.86	11.08
Sakha 93 x Gemmeiza 7	5.80	78.30	46.10	9.83	10.29
Sakha 93 x Sids 1	9.10	63.70	40 .15	12.56	11.30
Sakha 93 x Line 1	6.86	69.06	43. 23	21.30	11.53
Gemmeiza 7 x Sids 1	8.03	67.48	48.40	15.82	11.23
Gemmeiza 7 x Line 1	5.58	74.92	39.30	8.3[illegible]	[illegible]
Sids 1 x Line 1	8.43	63.28	54.60	14.29	9.96
$\bar{X}$	7.30	69.45	45.29	13.70	10.81
L.S.D 0.05	0.035	0.424	0.522	0.029	0.651
L.S.D 0.01	0.048	0.582	0.716	0.040	0.890
	5X5				
Sakha 61	7.72	48.09	56.30	15.98	8.87
Gemmeiza 9	6.60	70.95	47.10	15.13	10.59
Giza 168	10.57	64.57	43.65	22.92	11.86
Line 2	6.52	71.18	40.20	16.253	11.26
Line 3	7.33	65.50	55.35	18.09	11.04
$\bar{\bar{X}}$	7.74	64.05	48.52	17.67	10.72
Sakha 61 x Gemmeiza 9	5.70	60.00	47.93	15.70	11.04
Sakha 61 x Giza 168	6.14	61.54	45.46	15.91	10.26
Sakha 61 x Line 2	8.87	61.25	50.46	16.38	10.63
Sakha 61 x Line 3	7.91	66.67	52.05	14.67	11.21
Gemmeiza 9 x Giza 168	5.64	61.41	42.93	13.673	11.67
Gemmeiza 9 x Line 2	11.71	64.61	53.10	22.56	11.24
Gemmeiza 9 x Line 3	6.67	57.31	54.06	12.41	10.62
Giza 168 x Line 2	6.09	66.71	49.05	20.80	9.58
Giza 168 x Line 3	5.53	64.12	41.66	11.75	10.17
Line 2 x Line 3	9.47	62.00	48.10	19.56	12.10
$\bar{\bar{X}}$	7.37	62.56	48.48	16.34	10.85
L.S.D 0.05	1.423	4.704	4.423	0.653	1.580
L.S.D 0.01	1.920	6.346	5.968	0.881	2.194

Table 3. Cont.

Genotypes	7x7				
	No. spikes/plant	No. grains/spike	1000- grain weight (g.)	Grain yield/plant (g.)	Grain protein content (%)
Sakha 94	7.52	79.39	35.45	14.48	10.26
Gemmeiza 10	5.51	73.7	48.75	14.10	10.81
Sids 4	7.48	83.97	51.95	23.97	9.75
Sakha 8	7.85	56.76	48.90	15.23	9.40
Cham 4	6.42	51.81	57.80	18.45	9.46
Line 4	5.45	63.83	47.20	9.51	8.58
Cham 6	8.23	65.03	47.25	18.48	11.41
$\overline{\overline{X}}$	6.92	67.78	48.18	16.32	9.95
Sakha 94 xGemmriza 10	5.66	63.80	41.10	6.73	10.59
Sakha 94 x Sids 4	9.12	73.75	51.16	15.82	10.07
Sakha 9 x Sakha 8	9.63	56.71	46.93	15.59	9.63
Sakha 9 x Cham 4	9.06	57.32	58.20	12.32	9.59
Sakha 94 x Cham 4	9.06	57.32	58.20	12.32	9.59
Sakha 94 x Line 4	6.95	37.27	43.56	22.34	10.16
Sakha 94 x Cham 6	6.87	50.20	47.33	14.76	9.47
Gemmeiza 10 x Sids 4	9.50	60.02	52.33	21.94	10.65
Gemmeiza 10 x Sakha 8	5.89	60.33	44.35	10.64	10.36
Gemmeiza 10 x Cham 4	9.88	67.74	47.10	17.46	10.97
Gemmeiza 10x Line 4	10.17	57.70	50.85	18.50	10.93
Gemmeiza 10x Cham 6	10.90	42.55	41.90	16.73	9.58
Sids 4 x Sakha 8	5.20	48.29	49.20	9.44	10.06
Sids 4 x Cham 4	6.10	65.90	52.25	14.78	10.91
Sids 4 x Line 4	10.85	56.11	51.73	14.49	10.44
Sids 4 x Cham 6	11.07	59.77	56.97	24.62	11.22
Sakha 8 x Cham 4	12.58	59.91	61.73	25.07	10.49
Sakha 8 x Line 4	5.12	52.32	37.91	8.56	10.75
Sakha 8 x Cham 6	5.09	57.33	39.10	7.23	10.24
Cham4 x Line 4	5.37	74.23	51.13	10.47	10.17
Cham4 x Cham 6	6.01	63.73	47.06	13.47	11.69
Line 4 x Cham 6	10.94	46.82	46.00	16.93	11.18
$\overline{\overline{X}}$	8.19	57.70	48.47	15.14	10.43
L.S.D 0.05	0.984	4.447	5.355	0.481	0.802
L.S.D 0.01	1.311	5.926	7.136	0.641	1.069

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

the local cultivars Sids 4 and Sakha 8 were the earliest ones along with their F_1 crosses Gemmeiza 10 x Sids 4, Sids 4 x Sakha 8, Sids 4 x Cham 4, and Sids 4 x Cham 6 .These results suggest that genes controlling early heading have been transferred from the parents to their F_1 progeny.

For flag leaf area, data presented in Table 2 indicate that the local wheat cultivars Gemmeiza 7 and Sids 1 and their respective crosses Gemmeiza 7 x Sids 1 and Gemmeiza 7 x Line 1 have larger flag leaf area at 4x4 diallel size .In continuous, both the local cultivars Sakha 61 and Gemmeiza 9 gave the highest values of flag leaf area among the studied wheat genotypes. This is reflected in the performance of their F_1 cross combinations Sakha 61 x Gemmeiza 9, Sakha 61 x Gemmeiza 9, Sakha 61 x Giza 168, Gemmeiza 9 x Giza 168 and Gemmeiza 9 x Line 2 at 5x5 diallel size .Furthermore, at 7x7 diallel size, the three parental wheat genotypes Gemmeiza 10, Sids 4 and Sakha 8 as well as the exotic one Cham 4 gave larger flag leaf area among the studied wheat genotypes. The flag leaf area pronounced in that four parents was reflected in the broader flag leaf in their cross combinations Sakha 94 x Gemmeiza 10, Gemmeiza 10 x Sids 4, Gemmeiza 10 x Cham 4, Sids 4 x Sakha 8, Sids 4 x Cham 4, Sids 4 x Line 4 and Sakha 8 x Cham 4. These crosses are the promising for broader flag leaf area.

Mean performance of number of spikes/plant, number of grains/ spike, 1000-grain weight, grain yield/ plant and grain protein content for 4x4, 5x5 and 7x7 diallel sizes are presented in Table 3. The most desirable wheat genotypes exhibited high level of grain yield and its relevant characters were Sids1 and line1 and their F_1 crosses Gemmeiza 7 x Sids 1 and Sids 1 x Line 1 at 4x4 diallel size; Giza 168 and Line 2 and their F_1 crosses Gemmeiza 9 x Line 2, Giza 168 x Line 2 and Line 2 x Line 3 at 5x5 diallel size and Sids 4, Cham 4 and Cham 6 and their F_1 crosses Gemmeiza 10 x Sids 4, Sids 4 x Cham 6 and Sakha 8 x Cham 4 at 7x7 diallel size. Consequently the breeder could be utilized the appropriate diallel size for isolating new recombinants with high yielding ability.

For protein content, at 4x4 diallel, the most desirable wheat genotypes exhibited high level of protein content were Gemmeiza 7 and Line 1 as well as the F_1 crosses Sakha 93 x Sids 1 and Sakha 93 x Line 1, whereas, at 5x5 diallel size, the most promising wheat genotypes were Giza 168 and Line 2 as well . as their F_1 crosses Gemmeiza 9 x Giza 168, Gemmeiza 9 x Line 2 and Line 2 x Line 3.A 7x7 diallel level, the three parental wheat genotypes Sakha 94, Gemmeiza 10 and Cham 6 as well as their F_1 crosses Gemmeiza 10 x Line 4, Sids 4 x Cham 6, Cham 4 x Cham 6 and Line 4 x Cham 6 exhibited higher values of grain protein content. The obtained results indicate that these genotypes that could be used for isolating new recombinant lines with high protein content. It is of interest to note that the number of superior genotypes which could be exploited through breeding programs were increased with increasing diallel size.

Types of Gene Action, Genetic Ratios and Heritability

Data presented in Table 4 show additive (D) dominance (H_1 and H_2) and environmental (E) components and their derived parameters for days to heading at 4x4, 5x5 and 7x7 diallel sizes. The results indicate that both additive (D) and dominance (H_1 and H_2) genetic components were statistically highly significant at various levels of diallel sizes. The dominance genetic component was higher in its magnitude as compared to additive ones, resulting in average degree of dominance $(H_1 /D)^{0.5}$ more than unity, confirming the importance of overdominance gene action in controlling earliness. These results are in agreement with those reported by Awaad (2005) and Ismail (2006). On the contrary, many investigators suggested that additive gene action was more pronounced in the inheritance of days to heading of them Nazeer *et al.* (2004), Menshawy (2005) and Iqpal *et al.* (2007). The contradiction between the different findings may be due to the different materials used in.

The environmental variance had insignificant effect on earliness in all cases. The covariance of additive and dominance gene effects in the parents as indicated by F values were positive and significant for days to heading at 7x7 diallel size, revealing more frequent of dominant alleles than the recessive ones in the parents. Positive F value was detected by Awaad (2002) for days to heading.

The proportions of genes with positive and negative effects in the parents as indicated by $(H_2/4H_1)$ were near to its theoretical value (0.25) for days to heading at 4x4 diallel size, suggesting symmetrical

Table 4. Additive (D), dominance (H) genetic variances and their derived parameters for days to heading and flag leaf area in three diallel cross sizes of bread wheat

Genetic parameters	4x4		5x5		7X7	
	Days to heading (day)	Flag leaf area(cm^2)	Days to heading (day)	Flag leaf area(cm^2)	Days to heading	Flag leaf area(cm^2)
D±S.E	7.43**	167.57**	12.90**	32.23**	18.42**	46.87**
	2.31±	±2.83	±2.26	±8.05	±1.98	±7.13
H_1±S.E	14.77*	43.74**	30.44**	56.33**	24.65**	76.52**
	±6.77	±8.24	±6.11	±21.74	±4.77	±17.17
H_2±S.E	13.80*	32.00**	22.98**	47.58*	20.05**	65.62**
	±6.20	±7.60	±5.54	±19.72	±4.20	±15.13
F±S.E	2.42	88.93**	6.16	15.47	14.36**	14.21
	±5.94	±7.28	±5.65	±20.11	±4.75	±17.11
h^2±S.E	2.19	18.65**	0.53	27.89*	0.154	18.64
	±4.20	±5.16	±3.74	±13.31	±2.82	±10.16
E±S.E	0.03	6.76**	0.024	6.81*	0.429	0.067
	±1.03	±1.26	±0.92	±3.28	±0.700	±2.52
Derived parameters						
$[H_1/D]^{0.05}$	1.409	0.510	1.536	1.321	1.156	1.277
$H_2/4H_1$	0.233	0.182	0.188	0.211	0.203	0.214
KD/KR	1.261	3.161	1.368	1.443	2.01	1.269
Heritability in narrow sense	46.1	75.3	55.1	40.5	46.1	56.9

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

distribution of positive and negative alleles among the parental populations, while it was less than its maximum value (0.25) in the other cases.

The proportions of dominant to recessive genes in the parents (KD/KR) were more than unity for days to heading at 4x4, 5x5 and 7x7 diallel sizes, showing an excess of dominant alleles than recessive ones in the parents.

Narrow sense heritability (Tn) was moderate (46.1%) for days to heading at 4x4 and 7x7 diallel sizes and relatively high (> 50%) at 5x5 diallel one. Hereby phenotypic selection might be effective to isolate early heading genotypes. In this connection, moderate to high narrow sense heritability estimates were recorded for days to heading (Awaad 2002, Koumber and

Esmail 2005 and El-Marakby *et al.*, 2007).

It is worthy to note that, the components of genetic variance along with F value for earliness seemed to be increases in their magnitude with increasing diallel size from 4x4, 5x5 to 7x7 with some exceptions, however no trend was observed for the rest parameters. This result could be due to the number of parents involved in each diallel size as well as the genetic makeup of the parental genotypes.

For Flag leaf area the results indicate that, at 4x4 diallel size, additive component (D) was highly significant and greater in magnitude than the corresponding dominance (H_1 and H_2) one for flag leaf area, resulting in $(H_1/D)^{0.5}$ less than unity. However, at 5x5 and 7x7 diallel size both additive (D) and dominance (H_1 and H_2) genetic components were highly significant. The dominance component was larger in its magnitude than the additive one, resulting in $(H_1/D)^{0.5}$ more than unity, suggesting the important role of overdominant gene effects in this respect. Therefore hybrid breeding method could be used for improving flag leaf area. In this respect, additive genetic portion was the prevailed type controlling flag leaf area (Inamullah *et al.*, 2005). However, Singh-Hoshiyar *et al.* (2003) emphasized the importance of dominance genetic component in the inheritance of this character.

The (F value) was positive and highly significant for flag leaf area at 4x4 diallel size only compared with 5x5 and 7x7 ones. The sum of dominant alleles in heterozygous phase as described by (h^2) was positive and highly significant at both 4x4 and 5x5 diallel size, and insignificant at 7x7 diallel one. In this regard, Ghanem (2001) recorded positive and significant (h^2) values in flag leaf area.

The proportion of genes with positive and negative effects in the parents ($H_2/4H_1$) were less than its maximum value (0.25) in different cases, suggesting asymmetrical distribution of positive and negative alleles among the parental genotypes. KD/KR ratio suggest an excess of dominant alleles in controlling flag leaf area in different diallel sizes.

Narrow sense heritability varied from diallel size to another, it was high and valued 75.3% for 4x4 diallel and 56.9% for 7x7 diallel as well as moderate 40.5% for 5x5 diallel one. Thus, phenotypic selection could be used for enhancing flag leaf area. In this respect, moderate to high narrow sense heritability were recorded for flag leaf area by Singh-Hoshiyar *et al.* (2003).

Results concerning number of spikes/plant indicate that, genetic components and their derived parameters differed from diallel size to another. Both additive (D) and dominance (H_1 and H_2) genetic components were highly significant at 4x4 diallel size. Meantime, dominance component made up the most part of the total genetic variation as it is significant and larger in its magnitude than the corresponding additive one at 5x5 and 7x7 diallel sizes. In all cases, the average degree of dominance was more than unity, suggesting that exploiting dominance gene action through hybridization is more pronounced for improving this character. The importance of overdominance gene effects in controlling number of spikes/plant was also reported by Ammar (2003).

The F and h^2 values were insignificant at all sizes of diallel, except for h^2 at 7x7 diallel, which was significant, hereby dominance was mainly due to heterozygous loci and seemed to be active in positive direction in the expression of number of spikes/plant. Similar results were obtained by Koumber and Esmail (2005).

The proportions of genes with positive and negative effects in the parents as indicated by H_2 /$4H_1$ were less than its maximum value (0.25) at 4x4 and 5x5 diallel size, while it was around 0.25 at 7x7 diallel size, suggesting symmetrical distribution of positive and negative alleles among the parental populations. The proportion of dominant to recessive genes in the parents was less than unity (KD/KR <1) at 4x4 diallel, however it was more than unity (KD/KR >1) at 5x5 and 7x7 diallel sizes.

Narrow sense heritability estimates seemed to be decreased for number of spikes/ plant with increasing diallel size from 74.8, 17.5 to 4.8% at 4x4, 5x5and 7x7 diallel size, respectively. In this respect, low 17.8 to moderate 43.1% Tn values were recorded by El-Marakby *et al.* (2002) and El-Hosary *et al.* (2005). However, high 86.40 narrow sense heritability for number of spikes/plant in wheat cross Sakha 69 x ACSAD 945 was obtained by Awaad (2002).

For number of grains/spike 1000-grain weight, grain yield/

plant and protein content Table 5, the genetic component of variance and their derived parameters varied from diallel size to another. The results revealed that additive and dominance genetic components are highly significant for the three yield characters and protein content at 4x4, 5x5 and 7x7 diallel sizes, except grain yield/plant which exhibited insignificant additive genetic variance. Generally, the average degree of dominance $(H_1/D)^{0.5}$ was more than unity for yield characters and protein content at 4x4, 5x5 and 7x7 diallel levels which showed complete dominance mode of inheritance. In this connection, both additive and dominance genetic variances were significant with the preponderance of dominance gene action in controlling yield and its components (Singh-Hoshiyar *et al.*, 2003, Inamullah *et al.*, 2005, Meena *et al.*, 2005 and Ismail, 2006). Nevertheless, additive genetic portion was the prevailed type controlling yield and its components (Mang *et al.*, 2003).

The environmental variance (E) had significant effect on 1000-grain weight at 5x5 and 7x7 diallel levels and protein content at 4x4 and 5x5 diallel levels, but it was insignificant in the other cases. The covariance of additive and dominance gene effects in the parents (F value) was positive and significant for number of grains/ spike and 1000-grain weight at 5x5 diallel size and protein content at 4x4 diallel size, suggesting that the parental genotypes posses an excess of dominant alleles. The overall dominant effects of heterozygous loci (h^2) were positive and highly significant for both number of grains/spike and grain yield/plant at 4x4 diallel size and insignificant at 5x5 diallel size, while it was positive and significant for number of grains/spike only at 7x7 diallel one. Similar conclusion was recorded by Koumber and Esmail (2005) and Khalil (2006).

The proportions of genes with positive and negative effects in the parents as indicated by $(H_2/4H_1)$ were less than its maximum value (0.25) for number of grains/spike at 4x4 diallel size; number of grains/spike, 1000-grain weight and grain yield/plant at 5x5 diallel size as well as number of grains/spike and 1000-grain weight at 7x7 diallel one, provide evidence for asymmetrical distribution of positive and negative alleles among the parental

Table 5. Additive (D), dominance (H) genetic variances and their derived parameters for yield, its components and protein content in three diallel cross sizes of bread wheat

Genetic parameters	4x4					5x5				
	No. spikes/ plant	No. grains/ spike	1000-grain weight (g)	Grain yield/ plant (g)	Grain protein content (%)	No. spikes/ plant	No. grains/ spike	1000-grain weight (g)	Grain yield/ plant (g)	Grain protein content (%)
D±S.E	1.43**	16.48	10.37	12.17	0.255**	2.50	86.20**	47.67**	9.70	1.00**
	±0.36	±19.58	±12.67	±6.31	±0.060	±2.46	±15.20	±7.05	±6.25	±0.320
H_1±S.E	2.91**	188.98**	0.55*	73.58**	1.59**	21.15**	98.74*	75.08**	54.52**	2.57**
	±1.06	±56.92	±32.56	±18.35	±0.179	±6.64	±41.05	±19.06	±16.89	±0.866
H_2±S.E	2.08*	150.11**	84.45*	71.13**	1.42**	13.94*	64.85	51.64**	36.67*	1.92*
	±0.97	±52.54	±36.85	±16.94	±0.163	±6.03	±37.24	17.28	±15.32	±0.785
F±S.E	-1.04	29.20	80.43	-0.23	0.383*	8.13	103.97**	49.48**	18.14	1.47
	±0.93	±50.30	±34.01	±16.22	±0.156	±6.15	±37.97	±17.63	±15.63	±0.801
h^2±S.E	0.82	159.90**	0.908	38.94**	0.113	0.203	3.99	-1.82	4.51	-0.133
	±0.66	±35.64	±23.07	±11.49	±0.110	±4.07	±25.14	±11.67	±10.34	±0.530
E±S.E	0.034	4.45	5.67	0.022	0.074**	0.236	2.69	2.86*	0.053	0.275*
	±0.163	±8.75	±5.66	±2.82	±0.027	±1.00	±6.20	±1.88	±2.55	±0.130
Derived parameters										
$[H_1/D]^{0.05}$	1.423	3.385	2.852	2.458	2.496	2.907	1.070	1.255	2.370	1.600
$H_2/4H_1$	0.178	0.198	0.238	0.241	0.223	0.164	0.164	0.171	0.168	0.186
KD/KR	0.594	1.708	0.981	0.992	1.857	3.533	3.581	2.410	2.303	2.681
Heritability in narrow sense	74.8	23.7	22.4	29.4	4.8	17.5	29.8	40.6	33.7	10.9

Table 5. Cont.

Genetic parameters	7x7				
	No. spikes/ plant	No. grains/ spike	1000-grain weight(g)	Grain yield/plant(g)	Grain protein content (%)
D±S.E	1.16	136.09**	41.64**	20.57**	0.779**
	±1.70	±49.32	±10.94	±5.29	±0.263
H_1±S.E	24.81**	481.83**	104.62**	110.98**	1.909**
	±4.10	±118.74	±26.34	±12.75	±0.634
H_2±S.E	22.99**	354.54**	85.53**	103.142**	1.273*
	±3.61	±104.63	±23.21	±11.23	±0.559
F±S.E	2.38	209.79	23.31	19.24	1.204
	±4.08	118.32	±26.24	±12.70	±0.632
h^2±S.E	4.78*	297.37**	-1.52	4.08	0.628
	±2.42	±70.27	±15.58	±7.54	±0.375
E±S.E	0.117	2.46	3.60 *	0.044	0.123
	±0.602	17.43	±1.68	±1.87	±0.093
Derived parameters					
$[H_1/D]^{0.05}$	4.621	1.881	1.585	2.322	1.565
$H_2/4H_1$	0.231	0.183	0.204	0.232	0.166
KD/KR	1.571	2.387	1.429	1.504	2.950
Heritability in narrow sense	4.8	22.7	42.8	15.0	19.2

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

populations. On the other hand, $H_2/4H_1$, was near to 0.25 for grain yield/plant at both 4x4 and 7x7 diallel sizes as well as 1000-grain yield at 4x4 diallel size only, suggesting symmetrical distribution of positive and negative alleles among the parental populations. The proportions of dominant to recessive alleles in the parents were more than one (KD/KR >1) for number of grains/spike at 4x4 diallel size, number of grains/spike, 1000-grain weight and grain yield/ plant at 5x5 and 7x7 diallel sizes and protein content at 4x4, 5x5 and 7x7 diallel sizes. This result indicate an excess of dominant alleles. However, it was less than unity for 1000-grain weight and grain yield/plant at 4x4 diallel size, suggesting an excess of recessive alleles. In this respect, Awaad (1996) and Khalil (2006) found that the ratio of KD/KR was more than unity for number of grains/spike, 1000-grain weight and grain yield/plant. Otherwise, these findings are in contrary with those recorded by Ammar (2003) for number of spikes/plant, number of grains/spike, 1000 -grain weight and grain yield/plant under normal irrigation conditions.

Heritability estimates in narrow sense were found to be increased with increasing diallel size for both number of grains/spike and 1000-grain weight with values of 23.7; 22.4%; 29.8 and 40.6%; 22.7; 42.8% under 4x4, 5x5 and 7x7 diallel sizes, respectively. However, no trend was observed for grain yield/plant, where narrow sense heritability was low and valued 29.4 at 4x4 diallel size; 15.0% at 7x7 diallel size as well as moderate 33.7% at 5x5 diallel size. In this respect, different magnitudes of heritability were recorded by many investigators (Ammar 2003 and Abd El-Aty and Katta 2007).

Finally, the components of genetic variance and their derived parameters differed from diallel size to another based on number of parental genotypes involved in each diallel group as well as genetic makeup of parental materials.

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تعيين الفعل الجينى لمحصول الحبوب ومساهماته فى قمح الخبز باستخدام ثلاثة أحجام من الدياليل

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أجريت هذه الدراسة بالمزرعة التجريبية بكلية الزراعة – جامعة الزقازيق خلال الموسم الشتوى لأعوام ٢٠٠٥/٢٠٠٦ و ٢٠٠٦/٢٠٠٧. ولقد تم استخدام ثلاث أحجام من الدياليل بين أربعة، خمسة وسبعة آباء محلية ومستوردة من قمح الخبز وذلك لتحديد متوسط السلوك، مكونات التباين الوراثى وكفاءة التوريث للمحصول وبعض الصفات المرتبطة به.

ويمكن تلخيص أهم نتائج البحث فى النقاط الآتية:

١- سجلت اختلافات وراثية عالية بين الآباء وهجن الجيل الأول لصفات عدد الأيام حتى طرد السنابل، مساحة ورقة العلم، محصول الحبوب ومكوناته ومحتوى البروتين فى الحبوب.

٢- لوحظ أنة بازدياد حجم الدياليل تزداد فرصة الحصول على تراكيب وراثية مبشرة فى الأجيال الانعزالية وكان أكثر التراكيب الوراثية تفوقا فى المحصول والصفات المرتبطة به هى سدس١ وسلالة ١ والهجن الداخلة فيها (جميزة ٧ × سدس١) و (سدس١ × سلالة ١) وذلك فى دياليل ٤×٤، جيزة ١٦٨ وسلالة ٢ وهجنها (جميزة ٩× سلالة ٢)، (جيزة ١٦٨ × سلالة ٢) و (سلالة ٢× سلالة ٣) فى دياليل ٥×٥ وأيضا سدس ٤، الشام ٤ والشام ٦ وهجنها (جميزة ١٠× سدس ٤)، (سدس ٤× الشام ٦) و(سخا ٨× الشام ٤) فى دياليل ٧×٧. وبالتالى يجب على المربى استخدام حجم الدياليل المناسب لإمكانية عزل توليفات جديدة من التراكيب الوراثية عالية المحصول.

٣- كان الفعل الجينى المضيف والسيادى معنويا وهاما كما كان المكون السيادى اكثر اهمية فى وراثة صفة عدد الأيام حتى طرد السنابل، المحصول ومكوناته ومحتوى البروتين فى الحبوب فى معظم الحالات فى دياليل ٤×٤، ٥×٥ و ٧×٧. حيث وجد أن درجة السيادة $(H_1/D)^{0.5}$ كانت أعلى من الوحدة لهذه الصفات فى أحجام الدياليل الثلاثة.

٤- أظهرت النتائج أهمية الفعل الجينى المضيف فى وراثة صفة مساحة ورقة العلم فى دياليل ٤×٤ ومحتوى البروتين فى الحبوب فى دياليل ٧×٧، بينما كان الفعل الجينى السيادى هو المتحكم فى وراثة صفة مساحة ورقة العلم فى دياليل ٥×٥ و٧×٧، وكانت درجة السيادة أعلى من الوحدة.

٥- كانت قيمة F موجبة ومعنوية لصفات عدد الأيام حتى طرد السنابل فى دياليل ٧×٧، مساحة ورقة العلم ومحتوى البروتين فى الحبوب فى دياليل ٤×٤ وأيضا عدد حبوب/السنبلة ووزن الألف حبة فى دياليل ٥×٥.

٦- كانت قيمة h^2 موجبة ومعنوية لمساحة ورقة العلم فى دياليل ٤×٤ و ٥×٥، عدد حبوب/السنبلة ومحصول حبوب النبات فى دياليل ٤×٤ وكذلك عدد سنابل النبات وعدد حبوب/السنبلة فى دياليل ٧×٧.

٧- كان توزيع الأليلات الموجبة والسالبة $(H_2/4H_1)$ بين الآباء متماثلا لصفات عدد لأيام حتى طرد السنابل، وزن ألف حبة ومحصول حبوب النبات فى دياليل ٤×٤ وعدد السنابل/النبات ومحصول الحبوب النبات فى دياليل ٧×٧.

٨- اختلفت قيم كفاءة التوريث باختلاف حجم الدياليل وكانت قيم كفاءة التوريث بالمعنى المحدود منخفضة (<٣٠%) لعدد حبوب السنبلة، وزن الألف حبة ومحصول حبوب النبات فى دياليل ٤×٤ ومحتوى البروتين فى الحبوب فى جميع أحجام الدياليل، وأختلفت من منخفضة إلى متوسطة لهذه الصفات وعدد السنابل/النبات فى دياليل ٥×٥ و ٧×٧. علاوة على ذلك كانت كفاءة التوريث بالمعنى المحدود عالية (>٥٠%) لعدد الأيام حتى طرد السنابل ومساحة ورقة العلم فى معظم الحالات.