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DIALLEL CROSSES OF BREAD WHEAT UNDER TWO SOWING DATES

1. GENETIC ANALYSIS OF YIELD AND ITS COMPONENTS

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ABSTRACT

A half-diallel set of crosses among seven bread wheat genotypes, namely; Giza 168 (P1), Sakha 93 (P2), Gemmeiza 10 (P3), Shorawaki BW 20313 (P4), IG 43251 ICBW 2060015 (P5), IG 4198 ICBW 207010 (P6) and IG 41897 ICBW 201657 (P7) was done during 2005/2006 and 2006/2007 growing seasons. The F_1's of twenty-one crosses and their seven parents were grown in a field experiment under two sowing dates; 26th of November (normal sowing date) and 24th of December (late sowing date) in 2007/2008 season at the Experimental Farm of South Valley University, Qena. Days to 50% heading, plant height, No. of spikes/plant, spike length, No. of spikelets/spike, No. of kernels/spike, grain yield/plant, thousand kernel weight (TKW) and harvest index were studied. General (GCA) and specific (SCA) combining ability variances and effects and the genetic parameters were estimated. The results revealed that, wheat genotypes differed in their responses under different sowing dates for the studied traits. Both GCA and SCA variances were highly significant for all studied traits at the two sowing dates and their combined data except for GCA variance for spike length, which was significant only at combined data. Based on the GCA/SCA ratio, non-additive type of gene action was found to be of greater importance over additive effect in inheritance of all studied traits. The parental line IG 41897 ICBW 201657 (P7) proved to be the best general combiner for grain yield/plant at the two sowing dates and their combined data. The most desirable SCA effects for grain yield/plant were found in the two crosses; P2 X P3 and P4 X P5 at the two sowing dates and their combined data. Results indicated that both additive and non-additive gene effects were involved in the control of the all studied traits in both sowing dates. In addition, most of the variation was attributed to the non-additive gene effects. The average degree of dominance indicated that all studied traits might be controlled by over dominance effects in both sowing dates. Narrow-sense heritability values were low in most studied traits.

Key words: ***Wheat, Sowing dates, Diallel cross, Combining ability, Type of Gene action, Heritability***

INTRODUCTION

In Egypt, there is an urgent need to increase the productivity of wheat (*Triticum aestivum* L.) to reduce the food gap resulting from population increase. The breeders have to develop a new set of varieties with higher production.

Planting in a proper date is one of the most important factors affecting the productivity of wheat. Abdullah *et al* (2007) reported decline of 1000-grain weight (TKW) with delayed sowing from 25th Oct. to 10th Jan. Furthermore, El-Marakby *et al* (2007) found a reduction in grain yield/plant by delaying sowing date from 8th November to 8th December while days to heading was increased. Haj *et al* (2007) found that late November sowing dates (November 20th and 28th) generally produced higher number of spikes/m^2, No. of grains/spike, TKW and final grain yield than those of late sowings (December 15th and 25th). Also, days to heading, plant height, 1000-grain weight and grain yield/ha were negatively affected as a result of late date (20th December) compared to the normal sowing date (17th November), while three genotypes performed well with respect to harvest index under the late planting condisions (Khan *et al* 2007).

Estimation of the types of gene action involved in the expression of traits, the level of additive effects, and the degree of dominance are very important in developing a breeding method for the trait of interest (Hallauer and Miranda 1988). In this respect, many genetic models were introduced to estimate the different genetic parameters as approaches of Griffing (1956) and Hayman (1958). Combining ability analysis is the most widely used biometrical tool for identifying parental genotypes in terms of their ability to combine in hybrid combinations. With this method the resulting total genetic variation is partitioned into the variance effect of general combining as a measure of additive gene action and specific combining ability as a measure of non-additive gene action. Hendawy (1994), Patil *et al* (1995), Menon and Sharma (1997), Esmail (2002), Singh *et al* (2004), Hasnain *et al* (2006), Biljana and Marija (2007), Muhammad *et al* (2007) and Nazan (2008) reported the importance of both additive and non-additive gene effects in the inheritance of some traits in wheat.

The present study was undertaken to study the nature and magnitude of gene actions and to identify the best general combiners and the best crosses on the basis of their general and specific combining ability for the studied traits in bread wheat at two sowing dates under stress conditions (salinity each of soil and irrigation water) under Upper Egypt environment.

MATERIALS AND METHODS

The present study was performed at the Experimental Farm, Faculty of Agriculture, South Valley University, Qena (600 km. south of Cairo, 26°11'N and 32°44'E) during 2005-2008 growing seasons. The soil of the experimental site is loam in texture throughout its profile (53.08% sand, 18.2% silt and 28.72% clay). The soil and irrigation water salinity (EC_e) were 11.61 and 6.5 dS m^{-1}, respectively. In 2005/2006 season, seven parental genotypes of bread wheat (*Triticum aestivum* L.), namely; Giza 168 (P1), Sakha 93 (P2), Gemmeiza 10 (P3), Shorawaki BW 20313 (P4), IG

43251 ICBW 2060015 (P5), IG 4198 ICBW 207010 (P6) and IG 41897 ICBW 201657 (P7) were used in a half diallel cross mating design and seeds of 21 F_1's were produced. In 2006/2007 season, the parents were crossed again to produce more F_1 seeds. In 2007/2008 season, the 28 genotypes (seven parents and 21 F_1 crosses) were evaluated under two different sowing dates, normal (26 November) and late (24 December) in two separate experiments. In each experiment, the genotypes were sown in a randomized complete blocks design with three replicates; with plots having two rows for each F_1 and three rows for each parent. Each row was 3m long spaced 20 cm apart with 10 cm between plants within rows. The recommended cultural practices of wheat production in the region were applied.

Number of days to 50% heading was recorded in each plot for each sowing date as number of days from sowing till complete emergence of the main stem spike from the sheath of flag leaf of 50% of plants. In addition, at harvest time, for each sowing date, ten random competitive plants were taken from each plot to record the following data:

1- Plant height (cm).
2- Number of spikes/plant.
3- Spike length (cm).
4- Number of spikelets/spike.
5- Number of kernels/spike.
6- Grain yield/plant (g).
7- Thousand kernel weight (TKW) (g).
8-Harvest index (HI) in % was calculated as follows: HI= Grain weight/plant (g.) X 100 / biological weight (g)

The data were statistically analyzed on the basis of entry mean according to Gomez and Gomez (1984). Combining ability analysis was carried out using Method II, Model I as suggested by Griffing (1956).The combined analysis was calculated over the two different sowing dates to test the interaction of the different genetic components with the two sowing dates and was done whenever the homogeneity of variances was detected. Also, types of gene action, genetic ratios and heritability were calculated according to the method of Hayman (1958).

RESULTS AND DISCUSSION

Mean Performance

The analysis of variance of each sowing date together with their combined data for the studied traits are presented in Table (1). Sowing dates mean squares were found to be highly significant for all studied traits except No. of kernels/spike, which was non-significant and spike length, which was only significant. Crosses means under normal sowing date were higher than those under late date for No. of days to 50% heading, plant height, 1000-kernels weight and harvest index (Table 2). In contrast, for the rest traits, means under late sowing date were higher than those under early sowing date. Parents' performances were in this line for most traits.

Genotypes mean squares were found to be highly significant for all studied traits at the two sowing dates and their combined data, indicating existence of differences among these genotypes. The interaction of genotypes with the dates of sowing were highly significant for all studied traits, reflecting the fact that these genotypes behaved differently in their performance from sowing date to another. In this connection, reduction in one or more of the studied traits as a result of delaying sowing date were also obtained by Subedik *et al* (1997), Abdullah *et al* (2007), El-Marakby *et al* (2007), Haj *et al* (2007), Khan *et al* (2007), Hardan (2008) and Ibrahim *et al* (1986). However, Khan *et al* (2007) reported that three genotypes performed well with respect to harvest index under late planting conditions. Also, days to heading was increased by delaying sowing date from 8th November to 8th December (El-Marakby *et al* 2007).

Combining Ability Analysis

Results of the analysis of variance presented in Table (1) show that, both general (GCA) and specific (SCA) combining ability variances were found to be highly significant for all studied traits at the two sowing dates and their combined data, except GCA variance for spike length which was only significant at combined data. This would indicate the importance of both additive and non-additive gene effects in the expression of these traits. The ratio of GCA/SCA was used to clarify the nature of the genetic variances, involved. It was found to be less than unity for all studied traits at the two sowing dates and their combined data, indicating that non-additive gene effects were of greater importance than additive ones in the inheritance of these traits. Both general and specific combining ability variances were also detected by Hendawy (1994), Patil *et al* (1995), Menon and Sharma (1997), Ahmed (1999), Javaid *et al* (2001), Esmail (2002), Gouis *et al* (2002), Hamada (2003), Joshi *et al* (2004), Singh *et al* (2004), Hassani *et al* (2005), Hasnain *et al* (2006), Biljana and Marija (2007), Chowdhary *et al* (2007), Muhammad *et al* (2007) and Nazan (2008).

The interaction of sowing dates with both types of combing ability were found to be highly significant for all studied traits, suggesting that the variance magnitude of different types of gene action were fluctuated from sowing date to another and selection for these traits should be done under more environments.

Table 1. Mean squares of ordinary and combining ability analysis for the studied traits at the two sowing dates and the combined data.

Source of variation	D.F.	Days to 50% heading	Plant height (cm)	No. of spikes / plant	Spike length (cm)	No. of spikelets /spike	Number of kernels/spike	Grain yield/plant (g)	1000-kernel weight (g)	Harvest index (%)
Normal sowing date										
Reps.	2	0.14	33.55	0.107	0.056	1.512	16.369	0.462	6.463	1.706
Genotypes	27	81.76**	333.22**	11.148**	6.109**	45.406**	129.672**	19.19**	112.799**	496.044**
GCA	6	221.17**	523.29**	2.173**	6.425**	83.307**	87.623**	12.965**	37.579**	638.415**
SCA	21	41.93**	278.91**	13.713**	6.018**	34.577**	141.686**	5.745**	134.291**	455.367**
Error	54	1.2	9.57	0.478	0.506	2.981	7.869	0.328	6.923	4.911
GCA/SCA	-	**0.59**	**0.21**	**0.02**	**0.12**	**0.27**	**0.07**	**0.25**	**0.03**	**0.16**
Late sowing date										
Reps.	2	0.05	7.41	0.143	0.488	9.905	15.679	0.146	66.2	9.176
Genotypes	27	13.63**	467.66**	6.238**	7.831**	34.963**	187.055**	10.541**	181.944**	467.782**
GCA	6	24.78**	330.27**	6.099**	5.386**	32.692**	192.205**	9.444**	120.3**	870.44**
SCA	21	10.45**	506.92**	6.277**	8.53**	35.612**	185.584**	10.854**	199.557**	352.736**
Error	54	1.2	11.52	0.316	0.489	2.164	8.987	0.097	17.537	5.642
GCA/SCA	-	**0.27**	**0.07**	**0.11**	**0.07**	**0.10**	**0.12**	**0.10**	**0.07**	**0.28**

Table 1. Cont.

Source of variation	D.F.	Days to 50% heading	Plant height (cm)	No. of spikes / plant	Spike length (cm)	No. of spikelets /spike	No. of kernels/spike	Grain yield/plant (g)	1000-kernel weight (g)	Harvest index (%)
Combined across two dates										
Dates	1	4210.01**	1244.24**	128.63**	1.95*	120.024**	18.667	39.266**	727.459**	796.48595**
Rep. within dates	4	0.1	20.48	0.13	0.272	5.708	16.274	0.304	36.332	5.4411
Genotypes	27	64.54**	520.53**	7.23**	6.159**	39.9**	185.986**	16.983**	173.536**	529.85268**
GCA	6	172.36**	757.11**	3.75**	1.101*	62.166**	204.48**	14.068**	118.451**	922.492**
SCA	21	33.73**	452.93**	8.23**	7.604**	33.539**	180.702**	17.816**	189.274**	417.67**
Genotypes X dates	27	30.86**	280.35**	10.16**	7.781**	40.468**	130.741**	12.748**	121.208**	433.97334**
GCA X dates	6	73.59**	96.44**	4.52**	10.711**	53.833**	75.346**	4.086**	39.425**	586.365**
SCA X dates	21	18.65**	332.9**	11.76**	6.944**	36.65**	146.568**	15.223**	144.574**	390.433**
Error	108	1.2	10.55	0.4	0.498	2.573	8.428	0.213	12.23	5.27618
GCA/SCA	-	0.57	0.19	0.05	0.02	0.21	0.13	0.09	0.07	0.25

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

Table 2. Mean performance of the wheat parental varieties and their F_1 crosses at the two sowing dates and the combined data for the studied traits.

Genotype	Days to 50% heading			Plant height (cm)			No. of spikes / plant		
	D1	D2	Com.	D1	D2	Com.	D1	D2	Com.
P1	87.33	79.67	83.50	57.50	84.67	56.08	2.00	5.67	3.83
P2	86.00	78.67	82.33	68.03	51.70	59.87	2.00	7.67	4.83
P3	93.00	79.33	86.17	68.70	45.00	56.85	2.67	7.00	4.83
P4	103.00	79.67	91.33	82.97	62.27	72.62	3.33	7.67	5.50
P5	91.00	79.00	85.00	70.93	62.50	66.72	2.33	7.67	5.00
P6	102.00	88.33	95.17	70.00	75.67	72.83	3.00	6.00	4.50
P7	97.67	83.33	90.50	63.67	67.80	65.73	2.33	7.67	5.00
XP	94.92	81.14	87.71	68.83	59.94	64.4	2.52	7.05	4.8
P1 X P2	87.00	81.00	84.00	74.87	65.00	69.93	4.67	5.00	4.83
P1 X P3	89.00	80.00	84.50	91.80	64.37	63.08	2.67	5.00	3.83
P1 X P4	86.00	81.00	83.50	67.90	81.67	74.78	6.33	4.00	5.17
P1 X P5	85.00	79.00	82.00	73.50	59.37	66.43	5.67	7.67	6.67
P1 X P6	84.00	82.00	83.00	63.87	72.10	67.98	7.00	5.00	6.00
P1 X P7	87.00	80.00	83.50	77.77	87.50	82.63	7.00	6.00	6.50
P2 X P3	88.00	82.00	85.00	79.17	64.00	71.58	6.33	6.33	6.33
P2 X P4	90.00	88.00	85.00	72.20	65.50	68.85	4.00	8.00	6.00
P2 X P5	92.00	81.00	86.50	81.17	73.00	77.08	3.67	7.00	5.33
P2 X P6	86.00	80.00	83.00	82.77	79.50	81.13	5.67	3.67	4.67
P2 X P7	85.00	82.00	83.50	91.00	99.00	95.00	3.67	8.00	5.83
P3 X P4	93.00	83.00	88.00	69.50	86.17	77.83	2.33	4.67	3.50
P3 X P5	94.00	84.00	89.00	81.50	70.37	75.93	7.00	6.00	6.50
P3 X P6	92.00	82.00	87.00	76.67	72.87	74.77	4.33	5.00	4.67
P3 X P7	89.00	83.00	86.00	87.50	84.17	85.83	7.00	4.67	5.83
P4 X P5	94.00	82.00	88.00	75.00	86.50	80.75	7.67	8.00	7.83
P4 X P6	96.00	80.00	88.00	88.50	77.0	82.75	6.00	8.00	7.00
P4 X P7	93.00	81.00	87.00	101.37	77.50	89.43	7.33	5.00	6.17
P5 X P6	97.00	83.00	90.00	87.37	72.87	80.12	4.67	7.67	6.17
P5 X P7	99.00	85.00	92.00	72.87	81.00	76.93	2.33	4.00	3.17
P6 X P7	95.00	82.00	88.50	95.87	52.50	74.18	3.00	7.00	5.00
XF_1	90.52	81.57	86.05	79.15	74.85	77.00	5.16	5.98	5.6
L.S.D. at 5%	1.61	1.66	1.12	4.55	4.99	3.32	1.02	0.83	0.68

Table 2. Continued

Genotype	Spike length (cm)			No. of spikelets /spike			Number of kernels/spike		
	D1	D2	Comb.	D1	D2	Com.	D1	D2	Com.
P1	6.37	8.97	7.67	12.67	14.33	13.5	23.00	22.33	22.67
P2	7.10	6.23	6.67	12.33	10.33	11.33	22.67	20.67	21.67
P3	6.37	4.17	5.27	9.67	14.00	11.83	22.00	21.00	21.50
P4	7.27	6.50	6.88	10.67	12.00	11.33	17.67	11.00	14.33
P5	8.47	5.67	7.07	11.67	10.00	10.83	15.33	15.67	15.50
P6	6.93	7.00	6.97	9.67	11.00	10.33	13.00	5.33	9.17
P7	6.97	7.07	7.02	13.67	12.33	13.00	17.67	20.00	18.83
XP	7.07	6.51	6.8	11.48	12	11.7	18.76	16.57	17.66
P1 X P2	7.57	8.30	7.93	5.00	13.67	9.33	16.00	24.67	20.33
P1 X P3	6.30	10.07	8.18	11.33	18.00	14.67	25.67	29.00	27.33
P1 X P4	5.40	10.50	7.95	15.00	20.67	17.83	14.67	31.67	23.17
P1 X P5	8.50	8.67	8.58	17.67	13.00	15.33	18.67	23.00	20.83
P1 X P6	6.67	8.80	7.73	12.00	17.67	14.83	17.00	27.67	22.33
P1 X P7	6.77	9.00	7.88	19.00	14.67	16.83	23.00	24.00	23.50
P2 X P3	11.17	7.67	9.42	11.00	16.67	13.83	27.60	26.00	26.50
P2 X P4	7.00	6.50	6.75	8.00	12.00	10.00	27.67	14.00	20.83
P2 X P5	8.40	8.50	8.45	7.00	16.67	11.83	30.00	26.67	28.33
P2 X P6	7.70	6.50	8.60	7.67	15.67	11.67	19.00	42.00	30.50
P2 X P7	7.50	10.00	8.75	11.67	14.00	12.83	24.00	28.00	26.00
P3 X P4	8.00	10.20	9.10	20.00	17.67	18.83	34.00	28.00	31.00
P3 X P5	7.50	8.67	8.08	16.67	12.67	14.67	27.67	16.33	22.00
P3 X P6	8.17	9.20	8.68	10.00	23.67	16.83	15.00	22.67	18.83
P3 X P7	9.50	10.20	9.85	19.00	13.67	16.33	18.00	27.67	22.83
P4 X P5	7.00	8.50	7.75	15.67	7.00	11.33	20.67	12.67	16.67
P4 X P6	9.67	6.27	7.97	13.67	13.67	13.67	18.67	15.00	16.83
P4 X P7	11.00	6.37	9.68	16.67	16.00	16.33	25.67	38.67	32.17
P5 X P6	9.50	7.87	8.68	13.67	17.00	15.33	15.00	18.67	16.83
P5 X P7	8.47	9.00	8.73	14.67	17.67	16.17	27.00	21.00	24.00
P6 X P7	9.87	5.77	7.82	17.67	16.00	16.33	41.67	22.00	31.83
XF_1	8.17	8.64	8.4	13.48	15.6	14.5	23.14	24.73	23.9
L.S.D. 5%	1.08	1.06	0.75	2.62	2.23	1.69	4.26	4.41	2.97

Table 2. Continued

Genotype	Grain yield/plant (g)			1000-kernel weight (g)			Harvest index (%)		
	D1	D2	Com.	D1	D2	Com.	D1	D2	Com.
P1	0.99	3.31	2.15	25.32	34.09	29.71	33.23	33.46	33.35
P2	1.75	5.12	3.44	38.46	31.00	34.73	28.32	31.28	29.80
P3	1.31	4.79	3.05	36.02	31.16	33.59	24.93	30.31	27.62
P4	1.01	3.37	2.19	26.12	26.46	26.29	45.00	14.90	29.95
P5	1.09	2.74	1.92	33.53	23.26	28.39	31.47	18.90	25.19
P6	1.24	0.31	0.77	30.13	8.27	19.20	14.43	10.74	12.59
P7	1.11	6.31	3.71	28.64	28.79	28.72	32.52	22.71	27.62
XP	1.22	3.71	2.46	31.17	26.15	28.7	29.99	23.19	26.6
P1 X P2	3.89	3.78	3.83	40.84	31.72	36.28	38.99	61.90	50.44
P1 X P3	3.03	4.56	3.79	41.59	31.36	36.48	60.59	32.86	46.72
P1 X P4	3.40	4.56	3.98	37.14	35.10	36.12	34.20	28.46	31.33
P1 X P5	3.68	6.12	4.89	37.69	34.63	36.16	33.17	29.22	31.20
P1 X P6	3.20	4.58	3.89	43.29	32.54	37.91	27.87	50.65	39.26
P1 X P7	7.07	5.57	6.32	40.56	41.75	41.16	39.65	49.58	44.62
P2 X P3	7.06	6.59	6.82	42.06	41.51	41.79	37.88	48.66	43.27
P2 X P4	4.75	5.30	5.02	43.13	35.38	39.26	42.08	32.59	37.33
P2 X P5	3.83	7.54	5.68	30.54	40.53	35.54	48.16	35.66	41.91
P2 X P6	4.97	5.10	5.04	40.90	27.84	34.37	31.10	39.06	35.08
P2 X P7	3.59	10.00	6.80	41.13	40.05	40.59	38.93	40.19	39.56
P3 X P4	3.10	4.45	3.77	34.14	46.05	40.09	46.52	52.49	49.50
P3 X P5	8.03	3.12	5.58	41.69	35.18	38.43	37.25	36.75	36.99
P3 X P6	2.00	3.93	2.97	34.48	36.24	35.36	18.64	44.99	31.82
P3 X P7	7.64	3.40	6.02	41.69	37.40	39.54	80.25	26.74	53.49
P4 X P5	7.18	5.45	6.32	43.46	39.08	41.27	41.98	22.64	32.31
P4 X P6	4.30	7.07	5.68	38.33	40.49	39.41	42.88	32.27	37.57
P4 X P7	11.18	3.78	7.48	53.74	24.75	39.24	38.55	27.94	33.24
P5 X P6	2.55	6.75	4.65	33.56	41.23	37.39	22.21	23.72	22.96
P5 X P7	2.48	2.10	2.29	33.86	22.03	27.95	24.92	15.57	20.25
P6 X P7	4.86	5.69	5.27	39.25	36.55	37.89	41.13	19.66	30.39
XF_1	4.85	5.26	5.05	39.67	35.78	37.7	39.38	35.79	37.6
L.S.D. 5%	0.84	0.46	0.47	3.996	6.36	3.69	3.26	3.49	2.35

D1: Normal sowing date, D2: Late sowing date and Comb.: Combined data across sowing dates

Estimates of GCA effects (g_i) at both sowing dates and their combined data are given in Table (3). High positive values of GCA effects would be of interest in most traits under investigation. On the contrary, for No. of days to 50% heading and plant height, high negative GCA effects would be useful. The parental varieties Giza 168 and Sakha 93 showed highly significant negative GCA effects for No. of days to 50% heading at the two sowing dates and their combined data. These two parents may be considered as good general combiners and can be used in breeding for improving earliness of heading. For plant height, the two parental varieties Giza 168 and Gemmeiza 10 exhibited highly significant negative estimates of GCA effects at the two sowing dates and their combined data. The parental line Shorawaki BW 20313 showed highly significant positive estimates of GCA effects for No. of spikes/plant at the late sowing date, while had only significant GCA effects at the normal sowing date and the combined data. For spike length, Giza 168 had highly significant positive values of GCA effects at the late sowing date only. The parents, IG 41897 ICBW 201657 and Gemmeiza 10 showed highly significant positive GCA effects for No. of spikelets/spike at the normal sowing date and at the late sowing date, respectively. For No. of kernels/spike, Giza 168 had highly significant positive GCA effects for the later trait at the late date only. For grain yield/plant, the parents; IG 41897 ICBW 201657 and Sakha 93 exhibited highly significant positive estimates of GCA effects at the two sowing dates and their combined data and at the late sowing date and the combined data, respectively. Thus, these two parents appeared to be the best general combiners for grain yield. For 1000-kernel weight (TKW), the parental variety Gemmeiza 10 had significant positive GCA effects at the late sowing date only. The three parental varieties Giza 168, Sakha 93 and Gemmeiza 10 exhibited highly significant positive estimates of GCA effects for harvest index at the late sowing date and the combined data, while at the normal sowing date the highly significant positive GCA effects were exhibited by Gemmeiza 10, Shorawaki BW 20313 and the line IG 41897 ICBW 201657.

Estimates of specific combining ability effects for each cross at the two sowing dates and the combined data are presented in Table (4). The cross of Sakha 93 with the parental line IG 4198 ICBW 207010 exhibited highly significant negative SCA effects for No. of days to 50% heading at the two sowing dates and the combined data. The parental variety Sakha 93 was found to be poor combiner for this trait. For plant height, the hybrid combination IG 4198 ICBW 207010 X IG 41897 ICBW 201657 showed highly significant negative SCA effects at the late sowing date and the combined data. These two parental lines were found to be poor general combiners for this trait. The two crosses; Sakha 93 X Gemmeiza 10 and Gemmeiza 10 X IG 41897 ICBW 201657 exhibited highly significant

Table 3. Estimates of general combining ability effects for the seven parents evaluated at the two sowing dates and their combined data for the studied traits.

Parent	Days to 50% heading	Plant height (cm)	No. of spikes /plant	Spike length (cm)	No. of spikelets /spike	Number of kernels/spike	Grain yield/plant (g)	1000-kernel weight (g)	Harvest index (%)
					Normal sowing date				
P-1	-4.339**	-8.650**	0.148	-1.026**	0.169	-1.709*	-0.553**	-0.947	0.553
P-2	-3.524**	0.520	-0.444*	0.040	-3.201**	1.402	0.040	1.694	-0.242
P-3	-0.079	-2.113*	-0.111	0.022	0.392	1.661	0.251	0.787	3.781**
P-4	2.921**	3.094**	0.481*	-0.063	0.725	0.032	0.412*	0.212	4.472**
P-5	1.254**	0.079	-0.037	0.348	0.540	-0.746	-0.255	-1.379	-2.925**
P-6	2.476**	2.498**	0.074	0.251	-1.090*	-2.672**	-0.762**	-1.171	-9.252**
P-7	1.291**	4.572**	-0.111	0.429	2.460**	2.032*	0.866**	0.804	3.612**
SE for gi	0.339	0.955	0.213	0.220	0.533	0.866	0.177	0.812	0.684
					Late sowing date				
P-1	-1.032**	-3.297**	-0.667**	0.930**	1.000*	2.698**	-0.353**	0.922	6.497**
P-2	-0.921**	-2.179*	0.370*	-0.218	-0.889	2.328*	1.064**	1.340	6.612**
P-3	0.116	-4.120**	-0.481**	-0.062	1.444**	1.106	-0.259**	2.565*	4.666**
P-4	-0.587	3.317**	0.333	-0.174	-0.704	-2.190*	-0.181	0.754	-3.881**
P-5	-0.032	-0.101	0.630**	-0.262	-1.481**	-3.561**	-0.266**	-0.864	-6.640**
P-6	1.561**	1.017	-0.185	-0.388	0.815	-2.561**	-0.582**	-3.951**	-3.254**
P-7	0.894**	5.362**	0.000	0.175	-0.185	2.180*	0.577**	-0.764	-4.001**
SE for gi	0.337	1.048	0.173	0.216	0.454	0.925	0.096	1.292	0.733
					Combined across the two dates				
P-1	-2.685**	-5.974**	-0.259	-0.048	0.585	0.495	-0.453**	-0.013	3.525**
P-2	-2.222**	-0.829	-0.037	-0.089	-2.045**	1.865*	0.552**	1.517	3.185**
P-3	0.019	-3.116**	-0.296	-0.020	0.918	1.384	-0.004	1.676	4.224**
P-4	1.167**	3.206**	0.407*	-0.119	0.011	-1.079	0.116	0.483	0.296
P-5	0.611	-0.011	0.296	0.043	-0.471	-2.153**	-0.260	-1.122	-4.782**
P-6	2.019**	1.758	-0.056	-0.069	-0.138	-2.616**	-0.672**	-2.561*	-6.253**
P-7	1.093**	4.967**	-0.056	0.302	1.140*	2.106*	0.721**	0.020	-0.194
SE for gi	0.338	1.002	0.194	0.218	0.495	0.896	0.142	1.079	0.709

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

Table 4. Estimates of specific combining ability effects for the studied traits of F_1 crosses evaluated at two sowing dates.

Cross	Days to 50% heading			Plant height (cm)			No. of spikes / plant		
	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.
P1 x P2	3.398**	1.500	2.441*	6.428*	-0.650	2.889	0.463	-0.954	-0.245
P1 x P3	1.954*	-0.537	0.708	-4.006	0.657	-1.674	-1.870**	-0.102	-0.986
P1 x P4	-4.046**	1.167	-1.439	-3.113	10.520**	3.704	1.204	-1.917**	-0.356
P1 x P5	-3.380**	-1.389	-2.384*	5.502*	-8.361**	-1.43	1.056	1.454**	1.254*
P1 x P6	-5.602**	0.019	-2.792**	-6.550*	3.254	-1.648	2.278**	-0.398	0.939
P1 x P7	-1.417	-1.315	-1.366	5.276	14.309**	9.793**	2.463**	0.417	1.439*
P2 x P3	0.139	1.352	0.745	4.191	-0.828	1.682	2.389**	0.194	1.292*
P2 x P4	-0.861	0.056	-0.403	-7.983**	-6.765*	-7.374	-0.537	1.046*	0.255
P2 x P5	2.806**	0.500	1.653	3.998	4.154	4.076	-0.352	-0.250	-0.301
P2 x P6	-4.417**	-2.093*	-3.255**	3.180	9.535**	6.357*	1.537*	-2.769**	-0.616
P2 x P7	-4.231**	0.574	-1.829	9.339**	24.691**	17.015**	-0.278	1.380**	0.551
P3 x P4	-1.306	2.019*	0.356	-8.050**	15.843**	3.896	-2.537**	-1.435**	-1.986**
P3 x P5	1.361	2.463*	1.912	6.965*	3.461	5.213	2.648**	-0.398	1.125*
P3 x P6	-1.861	-1.130	-1.495	-0.287	4.843	2.278	-0.130	-0.583	-0.356
P3 x P7	-3.676**	0.537	-1.569	8.472**	11.798**	10.135**	2.722**	-1.102*	0.81
P4 x P5	-1.639	1.167	-0.236	-4.743	12.157**	3.707	2.722**	0.787	1.755**
P4 x P6	-0.861	-2.426*	-1.644	6.339*	1.539	3.939	0.944	1.602**	1.273*
P4 x P7	-2.676**	-0.759	-1.718	17.132**	-2.306	7.413*	2.463**	-1.583**	0.44
P5 x P6	1.806	0.019	0.912	8.220**	0.824	4.522	0.130	0.972	0.551
P5 x P7	4.991**	2.685**	3.838**	-8.354**	-4.613	-1.87	-2.019**	-2.880**	-2.449**
P6 x P7	-0.231	-1.907	-1.069	12.228**	-25.006**	-6.389*	-1.463*	0.935	-0.264
SE for sij	0.985	0.981	0.983	2.777	3.047	2.914	0.620	0.504	0.565
SE for sij-sik	1.463	1.458	1.46	4.125	4.526	4.33	0.921	0.749	0.839
SE for sij-skl	1.369	1.364	1.366	3.858	4.234	4.05	0.862	0.701	0.785

Table 4. Cont.

Cross	Spike length (cm)			No. of spikelets /spike			Number of kernels/spike		
	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.
P1 x P2	0.656	-0.524	0.662	-4.944**	-1.111	-3.028*	-5.741*	-3.074	-4.407
P1 x P3	-0.592	1.087	0.248	-2.204	0.889	-0.657	3.667	2.481	3.074
P1 x P4	-1.406*	1.631**	0.113	1.130	5.704**	3.417*	-5.704*	8.444**	1.37
P1 x P5	1.282*	-0.113	0.584	3.981**	-1.185	1.398	-0.926	1.148	0.111
P1 x P6	-0.455	0.146	-0.154	-0.056	1.185	0.565	-0.667	4.815	2.074
P1 x P7	-0.532	-0.217	-0.375	3.389*	-0.815	1.287	0.630	-3.593	-1.481
P2 x P3	3.208**	-0.165	1.522*	0.833	1.444	1.139	1.889	-0.148	0.87
P2 x P4	-0.873	-1.220	-1.047	-2.500	-1.074	-1.787	4.185	-8.852**	-2.333
P2 x P5	0.116	0.869	0.492	-3.315*	4.370**	0.528	7.296**	5.185	6.241*
P2 x P6	-0.488	1.994**	0.753	-1.019	1.074	0.028	-1.778	19.519**	8.87**
P2 x P7	-0.866	1.931**	0.533	-0.574	0.407	-0.083	-1.481	0.778	-0.352
P3 x P4	0.145	2.324**	1.235	5.907**	2.259	4.083**	10.259**	6.370*	8.315**
P3 x P5	-0.766	0.880	0.057	2.759	-1.963	0.398	4.704	-3.926	0.389
P3 x P6	-0.003	1.539*	0.768	-2.278	6.741**	2.231	-6.037*	1.407	-2.315
P3 x P7	1.153	1.976**	1.564*	3.167*	-2.259	0.454	-7.741**	1.667	-3.037
P4 x P5	-1.181	0.824	-0.178	1.426	-5.481**	-2.028	-0.667	-4.296	-2.481
P4 x P6	1.582*	-1.283*	0.149	1.056	-1.111	-0.028	-0.741	-2.963	-1.852
P4 x P7	2.738**	0.254	1.496*	0.500	2.222	1.361	1.556	15.963**	8.759**
P5 x P6	1.005	0.406	0.705	1.241	3.000*	2.12	-3.630	2.074	-0.778
P5 x P7	-0.206	0.976	0.385	-1.315	4.667**	1.676	3.667	-0.333	1.667
P6 x P7	1.290*	-2.131**	-0.421	3.315*	-0.296	1.509	20.259**	-0.333	9.963**
SE for sij	0.639	0.628	0.633	1.550	1.320	1.439	2.518	2.691	2.605
SE for sij-sik	0.949	0.932	0.94	2.302	1.961	2.138	3.740	3.997	3.87
SE for sij-skl	0.887	0.872	0.879	2.153	1.835	2.0	3.499	3.739	3.62

Table 4. Cont.

Cross	Grain yield/plant (g)			1000-kernel weight (g)			Harvest index (%)		
	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.
P1 x P2	0.500	-1.804**	-0.652	2.556	-3.913	-0.679	1.683	16.153**	8.918**
P1 x P3	-0.571	0.299	-0.136	4.216	-5.498	-0.641	19.262**	-10.945**	4.159*
P1 x P4	-0.362	0.225	-0.069	0.338	0.053	0.195	-7.822**	-6.798**	-7.31**
P1 x P5	0.585	1.866**	1.226**	2.479	1.201	1.84	-1.451	-3.276	-2.364
P1 x P6	0.612	0.642*	0.627	7.874**	2.195	5.034	-0.424	14.765**	7.17**
P1 x P7	2.851**	0.477	1.664**	3.170	8.220*	5.695	-1.509	14.445**	6.468**
P2 x P3	2.863**	0.911**	1.887**	2.045	4.234	3.139	-2.653	4.740*	1.044
P2 x P4	0.394	-0.456	-0.031	3.690	-0.085	1.802	0.853	-2.780	-0.963
P2 x P5	0.141	1.869**	1.005*	-7.305**	6.679	-0.313	14.334**	3.049	8.691**
P2 x P6	1.789**	-0.252	0.768	2.843	-2.920	-0.039	3.601	3.063	3.332
P2 x P7	-1.219*	3.489**	1.135**	1.095	6.102	3.599	-1.434	4.940*	1.753
P3 x P4	-1.466**	0.016	-0.725	-4.393	9.356*	2.482	1.269	19.066**	10.168**
P3 x P5	4.131**	-1.222**	1.455**	4.745*	0.108	2.426	-1.603	6.082**	2.239
P3 x P6	-1.392**	-0.099	-0.746	-3.000	4.252	0.626	-12.883**	10.939**	-0.972
P3 x P7	2.617**	-0.788**	0.915*	2.565	2.224	2.394	35.859**	-6.567**	14.646**
P4 x P5	2.120**	1.027**	1.573**	7.093**	5.815	6.454*	3.439	0.518	1.979
P4 x P6	0.747	2.959**	1.853**	1.755	10.316**	6.035	10.663**	6.766**	8.714**
P4 x P7	5.996**	-1.489**	2.253**	15.187**	-8.616*	3.286	-6.532**	3.183	-1.675
P5 x P6	-0.333	2.728**	1.198**	-1.424	12.674**	5.625	-2.610	0.975	-0.818
P5 x P7	-2.037**	-3.080**	-2.559**	-3.098	-9.711**	-6.404*	-12.761**	-6.428**	-9.595**
P6 x P7	0.850	0.822**	0.836*	2.083	7.890*	4.987	9.773**	-5.724**	2.024
SE for sij	0.514	0.280	0.413	2.362	3.759	3.138	1.989	2.132	2.061
SE for sij-sik	0.764	0.416	0.615	3.508	5.584	4.662	2.955	3.167	3.062
SE for sij-skl	0.715	0.389	0.575	3.282	5.223	4.361	2.764	2.962	2.864

*** and ** Significant at 5% and 1% levels of probability, respectively**
D1= normal sowing date, D2= Late sowing date and Comb. = combined data across sowing dates.

positive SCA effects for spike length at the normal sowing date and the combined data and at the late sowing date and the combined data, respectively. For no. of spikelets/spike, the hybrid combination Gemmeiza 10 X Shorawaki BW 20313 had highly significant positive estimates of SCA effects at the normal sowing date and the combined data. Highly significant positive estimates of SCA effects were detected in the crosses; IG 4198 ICBW 207010 X IG 41897 ICBW 201657 and Shorawaki BW 20313 X IG 41897 ICBW 201657 at the normal sowing date and the combined data and the late sowing respectively. These two crosses included low X high general combiner parents for no. of kernels/spike. Concerning grain yield/plant, the two crosses; Sakha 93 X Gemmeiza 10 and Shorawaki BW 20313 X IG 43251 ICBW 2060015 showed highly significant positive SCA effects at the two sowing dates and their combined data. Out of them, the cross Sakha 93 X Gemmeiza 10 included high X low general combiner parents. Moreover highly significant positive SCA effects were exhibited by the crosses, Shorawaki BW 20313 X IG 41897 ICBW 201657, Giza 168 X IG 41897 ICBW 201657 and Gemmeiza 10 X IG 43251 ICBW 2060015 at the normal sowing date and the combined data and Giza 168 X IG 43251 ICBW 2060015, Sakha 93 X IG 41897 ICBW 201657, Shorawaki BW 20313 X IG 4198 ICBW 207010 and IG 43251 ICBW 2060015 X IG 4198 ICBW 207010 at the late sowing date and combined data. Furthermore, the hybrid combinations; (Sakha 93 X IG 4198 ICBW 207010 and Gemmeiza 10 X IG 41897 ICBW 201657) and (Sakha 93 X IG 43251 ICBW 2060015 and IG 4198 ICBW 207010 X IG 41897 ICBW 201657) had highly significant positive SCA effects at the normal sowing date and at the late sowing date, respectively. Therefore, these thirteen crosses seemed to be good F_1-cross combinations for improving grain yield/plant at one of the two sowing dates. The cross Shorawaki BW 20313 X IG 43251 ICBW 2060015 showed highly significant positive SCA effects for 1000-kernel weight at the normal sowing date and the combined data. The two parents of this cross were found to be poor general combiners for this trait. Concerning harvest index, the hybrid combination Shorawaki BW 20313 X IG 4198 ICBW 207010 showed highly significant positive SCA effects at the two sowing dates and their combined data.

The results obtained could indicate that the excellent hybrid combinations were obtained from crossing high by low, low by high and low by low general combiners. Therefore, it could be concluded that GCA effects of the parental genotypes were generally unrelated to the SCA effects of their respective crosses. Similar conclusion was also obtained by Hendawy (1989 and 1994).

3

Types of gene action, genetic ratios and heritability

The estimates of variance components of genetic variation are given in Table (5). The "D" parameter estimating the additive effect was much smaller than the dominance parameter "H" for F_1 crosses in the two sowing dates, indicating that non-additive genes are responsible for most of the genetic variation for all studied traits. The average degree of dominance as measured by the $(H_1 / D)^{1/2}$ ratio was much higher than unity under two sowing dates, indicating over dominance. The "F" parameter is positive in the two sowing dates, except for spike length in the normal date, number of spikes / plant, number of spikelets / spike in the two sowing dates and for harvest index in the late date, indicating that there were more dominant than recessive alleles. Data presented in Table (5) also show that the value $(H_2/4H_1)$ measuring UV was not equal to 0.25, indicating non-equal distribution of dominant and recessive alleles among the seven parents analyzed. Similar results concerning components of variation and ratios derived from Hayman's analysis were obtained for one or more of the studied traits in wheat (Hassablla *et al* 1984, Mahdy 1988, Kherialla 1994, Taleei and Beiji 1996, Hoshiyar *et al* 2003, Khan and Habib 2003, Rahman *et al* 2003, Inamullah 2004, Zečević *et al* 2005, Dere and Yilirim 2006, El-Marakby *et al* 2007 and Hussain *et al* 2008).

Narrow-sense heritability values were small in magnitude for all studied traits in the two sowing dates except for No. of days to 50% heading in the normal sowing date, which was moderate, indicating that the additive component was smaller than the other components of variance. In this concern, narrow sense heritability values ranging from low to moderate were found for one or more of the studied traits by Mahdy 1988, Ahmed (1999), Hassani *et al* (2005), Koumber and Esmail (2005), El-Marakby *et al* (2007) and Hussain *et al* (2008).

CONCLUSION

Non-additive type of gene action was found to be great importance over additive effect in inheritance of all studied traits. The parental line (P7) proved to be the best combiner for grain yield/plant at the two sowing dates and their combined data. The most desirable SCA effects for grain yield/plant were found in the two crosses; P2 X P3 and P4 X P5 at the two sowing dates and their combined data.

Table 5. Estimates of genetic components of variation, some of derived ratios and narrow sense heritability (%) in F_1 diallel crosses analysis for the studied traits under the two sowing dates.

Component	Days to 50% heading		Plant height		Number of spikes / plant	
	D_1	D_2	D_1	D_2	D_1	D_2
D	44.93** ± 2.07	11.37** ± 0.95	51.01** ± 13.49	95.95** ± 13.03	-0.24 ^{ns} ± 0.76	0.47 ^{ns} ± 0.31
H_1	55.36** ± 4.98	14.61** ± 2.28	353.58** ± 32.47	594.92** ± 31.37	14.14** ± 1.82	7.44** ± 0.74
H_2	40.81** ± 4.39	8.09** ± 2.01	266.29** ± 28.61	524.89** ± 27.64	14.21** ± 1.6	7.07** ± 0.65
F	27.46** ± 4.97	15.46** ± 2.27	37.89 ^{ns} ± 32.35	119.69** ± 31.26	-0.56 ^{ns} ± 1.81	- 0.14 ^{ns} ± 0.73
$(H1/D)^{1/2}$	1.11	1.13	2.63	2.49	7.72	3.96
U.V	0.18	0.14	0.19	0.22	0.25	0.24
KD/KR	1.76	3.99	1.33	1.67	0.74	0.93
h^2_n %	59	28	40	14	3	19
Component	**Spike length**		**Number of spikelets /spike**		**Number of kernels / spike**	
D	4.3** ± 0.46	1.74** ± 0.32	- 0.36 ^{ns} ± 1.78	1.07 ^{ns} ± 3.0	8.6 ^{ns} ± 11.47	32.47* ± 14.71
H_1	6.8** ± 1.12	9.43** ± 0.78	48.27** ± 4.3	38.88** ± 7.22	176.89** ± 27.61	212.9** ± 35.42
H_2	5.99** ± 0.98	7.76** ± 0.69	30.02** ± 3.79	36.9** ± 6.36	156.58** ± 24.33	195.38** ± 31.2
F	- 0.37 ^{ns} ± 1.12	2.69** ± 0.78	- 0.93 ^{ns} ± 4.28	- 2.64 ^{ns} ± 7.2	13.08 ^{ns} ± 27.51	22.74 ^{ns} ± 35.29
$(H1/D)^{1/2}$	125.81	2.33	11.55	6.04	4.53	2.56
U.V	0.22	0.21	0.16	0.24	0.22	0.23
KD/KR	- 0.55	1.99	0.8	0.66	1.4	1.32
h^2_n %	23	13	48	20	15	19
Component	**Grain yield / plant (g)**		**1000-kernel weight (g)**		**Harvest index (%)**	
D	- 0.07 ^{ns} ± 0.54	3.7** ± 0.13	18.45 ^{ns} ± 10.0	55.92** ± 13.57	81.4** ± 17.3	71.68** ± 12.01
H_1	25.81** ± 1.3	14.8** ± 0.32	148.0** ± 24.07	200.67** ± 32.68	601.09** ± 41.66	419.3** ± 28.9
H_2	23.57** ± 1.15	11.99** ± 0.28	120.95** ± 21.21	170.15** ± 28.79	524.82** ± 36.71	365.25** ± 25.47
F	0.003 ^{ns} ± 1.3	5.18** ± 0.32	40.49 ^{ns} ± 23.98	80.97* ± 32.56	44.16 ^{ns} ± 41.5	- 29.08 ^{ns} ± 28.8
$(H1/D)^{1/2}$	18.87	2.0	2.83	1.89	2.72	2.42
U.V	0.23	0.2	0.2	0.21	0.22	0.22
KD/KR	1.0	2.08	2.26	2.24	1.22	0.85
h^2_n %	15	18	6	4	29	44

*value is significant when it exceeds 1.96 after dividing it with its standard error, ** value is highly significant when it exceeds 2.57 after dividing it with its standard error, ^{ns} non significant.

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تقييم الهجن الدائرية من قمح الخبز تحت ميعادي زراعة

١. التحليل الوراثي للمحصول ومكوناته

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تم تنفيذ هذه الدراسة خلال الفترة من ٢٠٠٥/٢٠٠٦ إلى ٢٠٠٧/٢٠٠٨م بالمزرعة التجريبية لكلية الزراعة جامعة جنوب الوادي بقنا وذلك باستخدام طريقة الهجن الدائرية (الديالل) بكل الطرق الممكنة بدون الهجن العكسية بين سبعة تراكيب وراثية من قمح الخبز هي: الأب الأول Giza 168 (P_1) و الأب الثاني Sakha 93 (P_2) و الأب الثالث Gemmeiza 10 (P_3) والأب الرابع SHORAWAKI BW 20313 (P_4) والأب الخامس IG 43251 ICBW 2060015 (P_5) والأب السادس IG 4198 ICBW 207010 (P_6) والأب السابع IG 41897 ICBW 201657 (P_7) . تم تقييم الآباء والجيل الأول في تجربتين مستقلتين في ميعادي زراعة الأول ٢٦ نوفمبر (الميعاد المناسب) و الثاني ٢٤ ديسمبر (الميعاد المتأخر). تم دراسة صفات عدد الأيام حتى طرد ٥٠% من السنابل وارتفاع النبات وعدد السنابل / نبات وطول السنبلة وعدد السنيبلات / سنبلة وعدد الحبوب في السنبلة و محصول حبوب النبات ووزن ال١٠٠٠ حبة ومعامل الحصاد. تم تقدير كلا من القدرتين العامة والخاصة على الائتلاف وكذلك المقاييس الو راثية. أشارت النتائج إلى تباين استجابة التراكيب الوراثية لميعادي الزراعة لكل الصفات تحت الدراسة. كما كانت قيم التباين للقدرتين العامة والخاصة على الائتلاف عالية المعنوية لمعظم الصفات المدروسة تحت كلا من ميعادي الزراعة والتحليل المشترك لهما. كما بينت نسب القدرة العامة إلى القدرة الخاصة على الائتلاف أهمية المكون الغير مضيف عن المكون المضيف في وراثة كل الصفات المدروسة. كما أظهر الأب السابع قدرة تآلف عالية لمحصول الحبوب/نبات وذلك تحت ميعادي الزراعة والتحليل المشترك لهما، كما ظهر الهجينين (P2 X P3) و (P4 X P5) كأفضل الهجن حيث تفوقا في قدرتهما الائتلافية الخاصة لمحصول حبوب النبات تحت ميعادي الزراعة والتحليل المشترك لهما. أشارت النتائج أيضا إلى أهمية كل من المكون الوراثى المضيف (D) والسيادي (H_1) في وراثة كل الصفات المدروسة لميعادي الزراعة إلا أن الجينات ذات التأثير السيادي كان لها الأثر الأكبر في وراثة تلك الصفات وذلك من خلال كبر قيمة المكون الوراثى السيادي (H_1) عن المكون الوراثى المضيف (D) لكل الصفات تحت الدراسة وللميعادين. وأشارت درجة السيادة إلى احتمالية تحكم السيادة الفائقة في وراثة كل الصفات المدروسة تحت ميعادي الزراعة. وكانت تقديرات كفاءة التوريث الخاصة منخفضة في معظم الصفات المدروسة