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DETERMINATION OF GENE EFFECTS AND VARIANCE IN THREE BREAD WHEAT CROSSES FOR LOW WATER (DROUGHT)

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ABSTRACT

The present work was carried out during 2005/2006 to 2008/2009. Three crosses among five parents, namely Gemmeiza9 x sahel 1, sakha 94 x zemamra 1 and sakha 94 x Promising line were grown in two experiments (normal irrigation (N) and drought stress (D). Five populations (P_1, P_2, F_1, F_2 and F_3) for each cross were used. Significant positive heterotic effects were found for all characters, except for number of spike plant^{-1} in the second and third crosses, number of kernels spike^{-1} in the first cross and 100-kernel weight (g) in the first and third crosses in drought and also number of spikes plant^{-1} in the third cross and number of kernels spike^{-1} in the second cross in normal irrigation. Over-dominance, above the higher parent, was detected for all characters, except for number of spikes plant^{-1} in the third cross, No. of kernels spike^{-1} in the first cross and 100-kernel weight (g) in the first and third crosses in drought, and also, except number of spikes plant^{-1} in the third cross and number of kernels spike^{-1}, in the second cross in normal irrigation. The other types of dominance were also studied. Inbreeding depression estimates were found to be significant and positive for number of kernels spike^{-1} in all crosses in F_2 and F_3, and also for grain yield in the first and second crosses in F_2, significant and negative for 100-kernel weight for third cross in F_2 and F_3 and also in the first cross in F_3 (drought), and also in normal irrigation inbreeding depression was positive and significant for 100-kernel weight in the first cross for F_2 and in all characters for second and third crosses except for number of kernels spike^{-1} and 100-kernel weight in the third cross. Additive gene effects were significant for all characters except for number of spikes plant^{-1} " in drought " and number of kernels spike^{-1} in normal in the first cross, and also significant (additive x additive) for all characters in both drought and normal except for 100-kernel weight in the third cross. F_2 deviation (E_1) was significant for all studied characters except for number of spikes plant^{-1} in third cross and grain yield plant^{-1} in the second and third crosses under drought, while under normal, (E_1) was significant for all studied characters except for number of spikes plant^{-1} and grain yield plant^{-1} in the second cross. Moreover, F_3 deviation (E_2) was significant in all characters except for grain yield and in all crosses except number of spikes plant^{-1} in the third cross and 100-kernel weight in the first cross under drought, and except for number of spikes plant^{-1} in the first and the second crosses, and 100-kernel weight in the third cross under normal irrigation. These results suggest the potential for obtaining further improvements in most studied characters. In addition, dominance and epistasis were found to be significant for most of the studied attributes. High to medium values of heritability estimates were found to be associated with low and moderate expected and actual grain in most characters at both drought and normal watering. Selection in segregating generations could be effective to produce lines have high yielding ability under drought condition.

Key words: ***Wheat, Drought tolerance, Genetic components, Five parameters model.***

INTRODUCTION

Wheat is one of the most important food crop in Egypt. The local consumption of wheat is increasing due to the continuous increase of population. Wheat breeder faced the difficulty of choosing the parental lines which when crossed would result in the highest proportion of desirable segregates and also with the difficulty in selection best genotypes from the progeny in early generations. The Egyptian wheat cultivars have relatively narrow genetic base, so, selection among these cultivars for increasing grain yield and its components is expected to be less effective. Hybridization between the local wheat cultivars and exotic materials would be the solution to increase genetic variability. Therefore, increasing wheat production vertically and/or horizontally becomes an important goal to reduce the amount of wheat imports, save foreign currency, and provide enough food to meet the increasing domestic demands. These targets could be realized by breeding new high yielding, early maturing, drought, heat and salt tolerant wheat varieties. Drought tolerant wheat cultivars will be directed to solve the problem of drought under rainfed areas and could be used to expand wheat areas under marginal conditions. Since decision making about effective breeding system to be used is mainly dicatated by type of gene action controlling the genetic variation, such information is helpful for the breeders to predict in early generations the effective breeding program, the potential of new recombination lines that could be developed following a series of selfing generations. Since, genetic information obtained from multi generations are reliable compared with these based on one generation, therefore, five populations (P_1, P_2, F_1, F_2 and F_3) are considered the one which may provide detailed genetic information for the employed genotypes.

Abul-Naas et al (1991) reported that dominance played an important role in genetic control for number of spikes plant^{-1}, number of kernels spike^{-1}, 100-kernel weight and grain yield plant^{-1}. On the other hand, El-Hosary et al (2000), showed that additive and non-additive gene effects have important roles in controlling the genetic system for yield and its components. Meanwhile, Abdel-Nour (2005) reported predominance of additive and additive x additive gene action in controlling the genetic system for yield and its components under normal and drought. And also Tammam (2005) showed that additive and additive x additive gene effects were mostly higher.

However, Abdel-Nour (2006a) revealed that additive and dominance gene effects were important for grain yield and number of kernels spike^{-1}.

On the other hand, Kheiralla (1994) studied the effects of drought stress on the components of genetic variation for earliness in wheat. He showed that additive and non-additive gene effects were found to be controlling earliness in both normal and drought environments. Narrow sense heritability was estimated to be 0.49 in the favorable environment and 0.67 under stress. In addition, concerning the heritability estimates, Hendawy (2003), El-Sayed (2004), Abdel-Nour (2006), Abd-Allah (2007) and Abd-Allah and Abdel-Dayem (2008) reported that narrow sense heritability estimates for yield and its components were medium to high.

This work was aimed to deal with genetic components and behavior from selection in three bread wheat crosses derived from five diverse bread wheat genotypes using five populations under normal and drought environments.

MATERIALS AND METHODS

Three crosses were used in the present study. They were derived from five widely diverse bread wheat genotypes. Names and pedigree of parental genotypes are given in Table (1). These genotypes were used to obtain the following three crosses: (1) Gemmeiza 9 x Sahel 1 (2), Sakha 94 x Zemamr- 1 and (3) Sakha 94 x (a promising line).

Table 1. The name, pedigree and origin of the five parental bread wheat genotypes.

No.	Name	Pedigree	Origin
P_1	Gemmeiza 9	ALD"s"/HUAC"S"//CMH74A.630/SX	Egypt
P_2	Sahel 1	NS732/Pima/ Vee"S"	Egypt
P_3	Sakha 94	Opta/Rayon//Kauz	Egypt
P_4	Zemamra-1	ICW91-0157-3AP-OTS-4AP-OTS-2AP-OI- OAP	ICARDA
P_5	A promising line	Giza158/5/CFN/CNO"S"//RON/3/BB/Nor67/ 4/t1/3/FN/TH/NAR59*2	Egypt

Cultivar Gemmiza 9 and Sakha 94 (high yield and high number of spikes plant^{-1}), Zemamra-1 from exotic materials (high yield, and has high number of spikes plant^{-1} and heavy kernel weight under drought). Two local genotypes Sahel 1 and promising line (both are good yielders and have high number of kernels spike^{-1} and also promising line have heavy kernel weight under drought).

The study was carried out at El-Giza Research Station during three successive seasons from 2005/2006 to 2007 / 2008. The final experiment (the fourth season) was conducted at Kafr El-Hamam Research Station, El-Sharkia Governorate, Agriculture Research Center, A.R.C. in 2008 / 2009 season,. In the first season (2005/2006), the parental genotypes were crosses to obtain F_1 seeds. In the second season (2006/2007), the hybrid seed of the three crosses were sown to give the F_1 plants. These plants were selfed to produce F_2 seeds. Crossing was repeated to ensure enough more fresh hybrid seeds. The new hybrid seed and part of the F_2 seeds were stored under refrigeration for further use. In the third season (2007/2008), F_1, F_2 and parents seed were sown to produce more F_2 seeds and F_2 plants were selfed to produce F_3 seeds.

In the fourth season (2008/2009) the five population P_1, P_2, F_1, F_2 and F_3 of each of the three crosses were sown in two adjacent experiments. The first experiment (stress experiment) was irrigated once (70 days after planting irrigation). The second experiment (non-stress or normal experiment) was irrigated four times after planting irrigation. A border of fifteen meters was set between the two experiments. Each experiment was arranged in a randomized complete blocks design with four replications. Rows were 4 m long spaced 20cm apart. The plants within rows were 10 cm apart. Each plot consisted of two rows for each parent and F_1, five rows for F_2 generation and 20 rows for F_3 families selected from F_2 at season 2007/2008 from each cross. Data were recorded on individual guarded plants from each plot (50 plants from F_2, 40 plants from F_3-bulk and 10 plants for parents and F_1) for No. of spikes plants^{-1}, No. of kernels spikes^{-1}, 100-kernel weight (g) and grain yield plant^{-1}. The proper culture practices were applied as recommended for wheat production in both experiments. The amounts of total rainfall during the fourth growing season are shown in Table (2).

Table 2. Monthly total rainfall at Sharkia during 2008/2009 winter season.

Month	Nov. 2008	Dec. 2008	Jan. 2009	Feb. 2009	Mar. 2009	Apr. 2009	May 2009
Rainfall mm/month	-	0.6	8.4	6.5	0.02	-	-

Table contents was estimates over 150 cm.

The amount of heterosis was expressed as the percentage increase of F_1 above better parent values. Inbreeding depression was calculated as the difference between the F_1 and F_2 means expressed as percentage of the F_1 mean, and the difference between the F_2 and F_3 means expressed as percentage of the F_2 mean. The T-test was used to determine the significance of these deviations where the standard error (S.E.) was calculated as following

S.E. for better parent heterosis

$\overline{F_1} - \overline{BP} = (V\overline{F}_1 + V\overline{BP})^{1/2}$

and S.E for inbreeding depression

$\overline{F_1} - \overline{F_2} = (V\overline{F_1} + V\overline{F_2})^{1/2}$

$\overline{F_2} - \overline{F_3} = (V\overline{F}_2 + V\overline{F}_3)^{1/2}$

In addition F_2 deviation (E_1) and F_3 deviation (E_2) were measured as suggested by Mather and Jinks (1971). Potence ratio (P) was also calculated according to Peter and Frey (1966).

Type of gene effects was estimated according to Singh and Chandhary (1985) five parameter model.

The standard Error of additive(d), dominance (h), dominance x dominance (l) and additive x additive (i) is obtained by taking the squares root of respective variation ' T ' test values are calculated upon dividing the effects of d*, h, l and i by their respective standard error.

$m = \overline{F_2}$

$d = 1/2\,\overline{P_1} - 1/2\,\overline{P_2}$

$h = 1/6\,(4\overline{F_1} + 12\,\overline{F_2} - 16\,\overline{F_3})$

$l = 1/3\,(16\,\overline{F_3} - 24\,\overline{F_2} + 8\,\overline{F_1})$

$i = \overline{P_1} - \overline{F_2} + 1/2\,(\overline{P_1} - \overline{P_2} + h) - 1/4\, l$

and $Vm = \overline{V F_2}$

$Vd = 1/4\,(\overline{VP_1} + \overline{VP_2})$

$Vh = 1/36\,(16\overline{VF_1} + 144\,\overline{VF_2} + 256\,\overline{VF_3})$

$Vl = 1/9\,(256\,\overline{VF_3} + 576\,\overline{VF_2} + 64\,\overline{VF_1})$

$Vi = \overline{VP_1} + \overline{VF_2} + 1/4\,(\overline{VP_1} + \overline{VP_2} + Vh) + 1/16\, V_l$

Heritability in broad and narrow sense was calculated according to Mather (1949) and parent off-spring regression according to Sakai (1960). Furthermore, the predicated and actual genetic advance (Δg) from selection were computed according to Johanson *et al* (1955).

The genetic gain as percentage of the F_2 and F_3 mean performance (Δg %) was computed using the method of Miller *et al* (1958).

RESULTS AND DISCUSSION

Genotypes differences were significant in most characters under investigation. The F_2 genetic variances were also significant for all studied characters in the three crosses under the two environments. Therefore, the different biometrical parameters used in this investigation were estimated. Means and variances of the five populations P_1, P_2, F_1, F_2 and F_3 for the characters studied in the three crosses under drought and normal conditions are presented in Table (3).

Heterosis relative to the better parent, inbreeding depression percentage, potence ratio (P), E1, E2 and different gene actions for the four studied characters under two environments are given in Table (4).

Significant positive heterosis was found for grain yield under drought and normal watering except first cross at normal irrigation; No. of spike plant^{-1} in the first cross and No. of kernels spike^{-1} in the second and third one under drought. Besides positive heterosis was found for No. of

Table 3. Means $(\bar{x})$ and variances (S^2) for the studied characters of the five populations (P_1, P_2, F_1, F_2 and bulk F_3 families) in three bread what crosses.

Character	Parameter	Drought P_1	Drought P_2	Drought F_1	Drought F_2	Drought F_3Bulk	Normal P_1	Normal P_2	Normal F_1	Normal F_2	Normal F_3Bulk
		Gemmeiza 9 x Sahel 1									
No. of spikes plant^{-1}	X	8.60	8.88	12.50	12.05	12.42	13.20	6.20	13.38	13.00	11.43
	S2	1.88	0.56	3.27	14.80	9.19	5.35	4.65	4.24	22.17	17.25
No. of kernels spike^{-1}	X	53.20	63.45	57.93	50.62	43.46	68.80	69.16	85.80	87.60	90.86
	S2	56.00	37.30	56.12	164.14	117.06	13.53	11.79	16.18	166.56	105.04
100-kernel weight(g)	X	4.67	4.40	4.63	4.68	4.85	4.83	3.95	5.07	4.90	4.87
	S2	0.027	0.021	0.037	0.135	0.089	0.08	0.09	0.05	0.39	0.25
Grain yield plant^{-1} (g)	X	16.92	19.74	27.59	24.14	23.71	28.42	14.05	29.09	28.70	27.51
	S2	5.04	3.58	5.89	53.00	33.71	13.59	5.39	15.51	66.22	47.39
		Sakha 94 x Zemamra-1									
No. of spikes plant^{-1}	X	10.02	9.5	8.17	7.95	7.50	13.68	11.10	14.27	13.60	13.00
	S2	1.23	0.59	1.84	4.44	3.45	1.20	0.96	0.93	9.46	6.88
No. of kernels spike^{-1}	X	53.32	45.64	71.67	66.39	48.02	77.43	61.57	74.10	64.72	63.99
	S2	9.56	13.23	2.60	94.40	57.63	6.45	8.65	6.02	39.99	29.08
100-kernel weight(g)	X	4.11	4.92	4.97	5.04	5.34	4.61	4.48	5.32	5.10	5.07
	S2	0.07	0.22	0.153	0.626	0.509	0.026	0.012	0.051	0.188	0.131
Grain yield plant^{-1} (g)	X	16.77	18.87	21.66	20.46	19.24	28.18	26.06	34.43	30.41	28.39
	S2	0.71	3.40	4.09	28.12	16.56	1.89	2.81	2.99	27.57	18.26
		Sakha 94 x Promising line									
No. of spikes plant^{-1}	X	10.02	8.8	9.67	9.62	9.21	13.68	9.44	11.14	9.88	9.00
	S2	1.23	1.39	1.47	12.20	7.57	1.20	3.68	2.39	12.90	10.70
No. of kernels spike^{-1}	X	53.32	57.23	74.86	69.05	57.93	77.43	70.18	90.87	89.98	88.89
	S2	9.56	4.38	11.28	104.08	65.23	6.45	13.04	10.52	89.55	61.11
100-kernel weight(g)	X	4.11	5.12	4.87	5.15	5.44	4.61	4.97	5.38	5.33	5.00
	S2	0.07	0.03	0.11	0.373	0.263	0.026	0.072	0.078	0.296	0.229
Grain yield plant^{-1} (g)	X	16.77	18.66	21.07	20.02	19.77	28.18	22.89	36.23	32.00	29.71
	S2	0.71	3.44	5.08	50.11	29.66	1.89	6.98	2.56	47.89	32.97

D= Drought **N= Normal irrigation**

Table 4. Heterosis, potence ratio, inbreeding depression and gene action parameters in the three bread wheat crosses.

Character			No. of spikes plant^{-1}			No. of Kernels spike^{-1}			100-kernel weight (g)			Grain yield plant^{-1} (g)		
Cross			1	2	3	1	2	3	1	2	3	1	2	3
Heterosis % over B.P		D	40.8**	-18.46**	-3.49	-8.7**	25.6**	30.81**	-0.86	1.01	-4.88**	28.45**	14.79**	12.92**
		N	1.36	4.31**	-18.57**	24.06**	-4.3**	17.36**	4.97**	15.48**	8.25**	2.36	22.18**	28.64**
Potence ratio %		D	27.46	6.12	0.43	-0.08	5.78	10.02	0.704	1.12	0.51	6.53	4.88	3.55
		N	1.05	1.46	-0.20	93.44	0.58	4.71	1.55	12.32	3.27	1.09	6.90	4.04
Inbreeding depression	drought	F_2	3.6	2.69	0.52	12.62**	7.37**	7.76**	-1.08	-1.41	-5.75**	12.5**	5.54*	4.98
		F_3	-3.05	5.66*	4.26	14.14**	27.67**	16.1**	-3.63**	-5.95	-5.63**	1.78	5.96**	1.25
	normal	F_2	2.84	4.70*	11.31**	-2.1	12.66**	0.98	3.35**	4.14**	0.93	1.34	11.68**	11.68**
		F_3	12.08**	4.41	8.91	-3.72*	1.13	1.21	0.61	0.59	6.19**	4.15	6.64**	7.16
Gene action parameters	Drought	m	12.05**	7.95**	9.62**	50.62**	66.39**	69.05**	4.68**	5.04**	5.15**	24.14**	20.46**	20.02**
		d	-0.14	0.26**	0.61**	-5.13**	3.84**	-1.96**	0.135**	-0.41**	-0.51**	-1.41**	-1.05**	-0.95**
		h	-0.68	1.35*	1.13	23.97**	52.51**	33.53**	-0.487**	-0.85**	-0.96**	3.45*	4.05**	1.37
		l	3.16	-1.81	-2.05	-18.69*	-83.89**	-43.81**	0.773**	1.41*	0.8	6.91	3.31	1.47
		i	-4.72**	3.46**	2.09**	14.11**	38.0**	10.03**	-0.312**	-2.11**	-2.23**	-8.63**	-3.54**	-3.15**
		E_1	1.43**	-1.02**	0.08	-7.51**	5.82**	3.99**	0.098**	0.30**	0.41**	1.19*	0.72	-0.63
		E_2	3.60**	-2.93**	-0.66	-29.34**	-25.11**	-14.28**	0.535	1.20**	1.40**	1.51	-1.0	0.76
	Normal	m	13**	13.60**	9.88**	87.60**	64.72**	89.98**	4.90**	5.10**	5.33**	28.70**	30.41**	32.0**
		d	3.50**	1.29**	2.12**	-0.18	7.93**	3.63**	0.44**	0.046**	-0.18**	7.19**	1.06**	2.65**
		h	4.44**	2.05**	3.19**	-9.89**	8.20**	3.50	0.19	0.227*	0.91**	3.43	8.07**	8.93**
		l	-7.36*	-1.41	-5.87*	12.59	21.12**	-3.44	0.29	0.43	-1.63**	-5.31	-0.05	-0.933
		i	7.76**	2.75**	8.98**	-27.07**	19.46**	-6.32**	0.39**	-0.42**	-0.04	9.95**	2.88*	3.52*
		E_1	1.46**	0.27	-1.47**	10.21**	-7.08**	7.64**	0.17**	0.17**	0.25**	3.54**	-0.37	1.12*
		E_2	-0.22	-0.66	-4.70**	26.94**	-15.62**	13.11**	0.27**	0.28**	-0.17	4.70**	-4.77**	-2.35*

D= Drought **N= Normal irrigation**

spikes plant^{-1} in the second cross, No. of kernels spike $^{-1}$ in the first and second crosses and 100-kernel weight in all crosses under normal irrigation.

Significant negative heterosis was found for No. of spikes plant^{-1} in the second cross, No. of kernels spike^{-1} in the first cross and 100-kernel weight in the third one under drought and also significant negative heterosis was found for No. of spikes plant^{-1} in the third cross and No. of kernels spike^{-1} in the second one under normal irrigation. These results indicated the presence of heterosis effects for these characters.

Similar results were reported by Gautam and Jain (1985), Khalifa (1997), El-Hossary *et al* (2000), Hendawy (2003), El-Sayed et al (2004), Tammam (2005), Abdel-Nour (2006), Abdel-Nour and Moshref (2006), Abd-Allah (2007) and Abd-Allah and Abd El-Dayem (2008).

Number of spikes plant^{-1}, number of kernels spike^{-1} and kernel weight are the main components of grain yield plant^{-1}. Hence, heterotic increase if found in one or more of these attributes with others attributes being constant would lead to favorable yield increase in hybrids. The lack of significance in heterosis of No. of spikes plant $^{-1}$ in the second cross, No. of kernels spike $^{-1}$ in the first cross and 100-kernel weight in the third one under drought and also No. of spikes plant^{-1} in third cross and No. of kernels spike^{-1} in second one under normal conditions could be due to the lower magnitude of the non-additive gene action. These results are in agreement with Amaya *et al* (1972). Ketata *et al* (1976). The pronounced heterotic effect detected for No. of spikes plant^{-1} in the first cross and No. of kernels spike^{-1} in the second and third crosses and crosses under drought and also, No. of kernels spike^{-1} in the second cross, No. of spikes plant^{-1} in the first cross and 100-kernel weight in all crosses under normal condition would be of interest in a breeding program for high yielding ability.

The potance ratio obtained indicated over dominance towards the higher parent were obtained for all characters except for No. of spikes plant^{-1} in the third cross, No of kernels spike^{-1} in the first cross and 100-kernel weight for all crosses under drought and also No. of kernels spike^{-1} in the first cross, 100-kernel weight in the second and third crosses and grain yield plant^{-1} in the second and third crosses under normal condition. Complete dominance was found for 100-kernel weight in the second cross under drought and also for all characters in the first cross except No. of kernels spike^{-1} and No. of spikes plant^{-1} in the second cross under normal condition. There was partial dominance towards the higher parent for No. of spikes plant^{-1} in the third cross and 100-kernel weight in the first and third crosses under drought and also No. of kernels spike^{-1} in the second cross under normal condition. Meanwhile, partial dominance towards the lower parent was found for No. of spikes plant^{-1} in third cross under normal irrigation. These results are in harmony with those obtained by Ketata *et al* (1976), Jatasra and Paroda (1980), Abul-Naas *et al* (1991), Hendawy (2003), Abdel-Nour (2006b), Abdel-Nour and Moshref (2006), Abdel-Allah(2007) and Abdel-Alla and Abdel-Dayem (2008).

Significant inbreeding depression was found for No. of spikes plant^{-1} in the second cross, No. of kernels spike^{-1} in all crosses and grain yield plant^{-1} in the first and second ones under drought. Although, under normal condition, significant inbreeding depression was found for all characters except for No. of kernels spike^{-1} in the first and the third crosses and grain yield in the first cross.

However, significant negative inbreeding depression (inbreeding gain) was detected for 100-kernel weight for all crosses under drought and only No. of kernels spike^{-1} in the first cross under normal irrigation. This is a valid result, since the expression of heterosis in F_1 may be followed by considerable reduction in F_2 performance. The obtained results for most cases were in harmony with those obtained by Gautam and Jain (1985), Khalifa *et al* (1997) and Abdel-Nour (2006b).

Significant heterosis and insignificant inbreeding depression were obtained for No. of spikes plant^{-1} in the first cross and grain yield plant^{-1} in the third cross under drought and also for No. of kernels spike^{-1} in the third cross under normal condition.

Moreover, significant positive heterosis and significant negative inbreeding depression for No. of kernels spike^{-1} in the first cross under normal condition were detected. The contradiction between heterosis and inbreeding depression estimates could be due to the presence of linkage between genes in these materials (Van der Veen 1959). These results indicated that selection in the segregation population for development grain yield under drought condition could be effective to produce lines that have high grain yield and high tolerance to drought stress. Similar results were obtained by Kheiralla, *et al* (1993), Farshadfar *et al* (2001) and Tammam (2005).

Nature of gene action was determined using the five parameter model (Table 4). The estimated mean effect of F_2 m. which reflects the contribution due to the overall mean plus the locus effect and interaction of fixed loci, was found to be highly significant for all the studied characters in all crosses under both drought and normal irrigation. The additive gene effect (d) were found to be significant and positive for No. of spikes plant^{-1} in the second and third cross, No. of kernels spike^{-1} in the second cross and 100-kernel weight in the first cross under drought, and for all characters for all crosses except No. of kernels in the first cross and 100-kernel weight in the third cross under normal condition. However, significant negative additive values (d) was obtained for all crosses for all characters except for No. of spikes plant^{-1} for all crosses, No. of kernels spike^{-1} in the second cross and 100-kernel weight in the first cross under drought and also, 100-kernel weight in third cross under normal condition. These results suggest the potential for obtaining further improvement for the former characters, i.e. that showed positive and significant values by using pedigree selection program.

Dominance gene effect (h) was found to be significant for all characters of all crosses, except number of spikes plant^{-1} in the first and third crosses and grain yield plant^{-1} in the third one (D) and also number of kernels spike^{-1} in the third cross, 100-kernel weight in the first cross and grain yield pant^{-1} in the first cross (N). when dominant gene are present, it would tend to favor the production of hybrid, while the existence of the additive gene action in the gene pool encourage the improvement of the character by selection program.

Dominance x dominance (l) types of gene action were found to be negative and significant for number of kernels spike^{-1} for all crosses and positive significant for 100-kernel weight in the first and second ones in drought condition and also negative significant for number of spikes plant^{-1} in the first and third crosses and positive significant for number of kernels spike^{-1} in the second one in the normal environment. These results confirm the importance role of dominance x dominance gene interactions in the genetic system controlling these characters. A significant additive x additive type of epistasis (i) was detected for all characters in all crosses for both two drought and normal irrigation except for 100-kernel weight in the third cross under normal irrigation. The important roles of both additive and non-additive gene actions in certain studied characters indicated that selection procedures based on the accumulation of additive effects would be very successful in improving these characters. Similar findings were reported by El-Hosary *et al* (2000), Hendawy (2003), Abdel-Nour (2006b), Abdel-Allah (2007) and Abdel-Allah and Abdel-Dayem (2008).

Significant and positive F_2 deviation (E_1) was found for all characters in the first cross under both condition (D and N), for No. of kernels spike^{-1} and 100-kernel weight in the second and third ones under drought condition and also positive significantly was found for No. of kernels spike^{-1} in the third cross, 100-kernel weight in the second and third crosses and for grain yield plant^{-1} in the third one under normal condition. On the other hand, insignificant F_2 deviations were detected for No. of spikes plant^{-1} in the third cross and for grain yield plant^{-1} in the second and third ones under drought condition and also for No. of spikes plant^{-1} and grain yield in the second one under normal condition. This may indicate that epistatic gene effects had major contribution in the inheritance of these traits.

F_3 deviation (E_2) was found to be significant and positive for No. of spikes plant^{-1} in the first cross and 100-kernel weight in the second and third ones under drought condition and for all characters except for No. of spikes plant^{-1} in the first cross, No. of kernels spike^{-1} in the third cross and 100-kernel weight in the second one under normal condition. While insignificant (E_2) values were detected for No. of spikes plant^{-1} in the third cross, 100-kernel weight in the first cross and for grain yield plant^{-1} in all crosses under drought and also for No. of spikes plant^{-1} in the first and second crosses and 100-kernel weight in the third one under normal condition. These results would ascertain the presence of epistasis in such magnitude as to warrant great deal of attention in a breeding program.

Heritability estimates in broad and narrow sense, and between generations (parent-offspring regression), are presented in Table (5). High

Table 5. Heritability and expected versus actual gain for all the studied characters in three crosses of bread wheat.

Character	cross	Heritability						Expected gain				Actual gain			
		Broad sense		Narrow sense		Parent - offspring regression		G. S		$\Delta g\%$ of F_2		G. S		$\Delta g\%$ of F_2	
		D	N	D	N	D	N	D	N	D	N	D	N	D	N
No. Of spikes plant^{-1}	1	87.1	78.59	75.78	44.38	81.46	61.49	6.00	4.30	49.82	33.11	5.09	5.26	40.97	46.03
	2	72.57	89.11	44.59	54.55	58.58	71.83	1.94	3.46	24.35	25.41	2.24	3.88	29.86	29.86
	3	88.84	81.22	75.89	34.11	82.36	57.66	5.46	2.52	56.76	25.54	4.67	3.89	50.69	43.17
No. of Kernels spike^{-1}	1	69.66	91.69	57.37	73.87	63.51	82.78	15.14	19.64	29.91	22.42	14.16	17.48	32.57	19.24
	2	91.03	82.40	77.90	54.56	84.47	68.48	15.59	7.11	23.48	10.98	13.21	7.61	27.51	11.89
	3	91.92	88.83	74.65	63.52	83.29	76.17	15.69	12.38	22.72	13.76	13.86	12.27	23.92	13.80
100-kernel weight (g)	1	79.26	81.28	68.15	71.79	73.59	76.54	0.52	0.92	11.03	18.85	0.45	0.79	9.32	16.19
	2	76.41	87.04	37.38	60.64	56.89	72.34	0.61	0.54	12.09	10.62	0.84	0.54	15.66	10.64
	3	81.23	80.17	58.98	45.27	70.11	62.72	0.74	0.51	14.41	9.52	0.74	0.62	13.62	12.37
Grain yield plant^{-1} (g)	1	90.87	82.63	72.79	56.87	81.83	69.75	10.92	9.53	45.22	33.22	9.79	9.89	41.28	39.96
	2	90.28	90.70	82.22	67.54	86.28	79.12	8.98	7.31	43.90	24.02	7.23	6.96	37.59	24.53
	3	93.86	92.04	81.62	62.31	87.74	77.18	11.90	8.88	59.45	27.76	9.84	9.13	49.79	30.73

D= Drought N= Normal irrigation

heritability values in broad sense were detected for all studied characters under both conditions ranged from 93.86% to 76.41% (indicating that superior genotypes for these characters could be identified from the phenotypic expression and illustrate the importance of straight forward phenotypic selection for improvement of these traits) except for No. of spikes plant^{-1} in second cross and No. of kernels spike^{-1} in first cross under drought condition were moderate broad sense heritabilities were detected and ranged from 69.66 % to 72.57 %.

Narrow sense heritability estimates ranged from 37.38 % for 100-kernel weight in the second cross to 82.22 % for grain yield plant^{-1} in the second cross under drought and ranged from 34.11 % for No. of spikes plant^{-1} in the third cross to 73.87 % for No. of kernels spike^{-1} in the first cross under normal condition. The parent-offspring regression heritability was found to be high to moderate and (ranged from 56.89% to 87.74%) under drought and (from 69.75 to 82.78%) under normal condition. The differences in magnitude of both narrow sense and parent-offspring regression heritability estimates for all the studied characters would ascertain the presence of both additive and non-additive gene effects in the inheritance of these characters. This conclusion was also confirmed by estimates of gene action parameter. Similar conclusions were also reported by Abdel-Nour and Moshref (2006), Tammam (2006), Abdel-Nour (2006a and b) and Abdel-Allah and Abdel-Dayem (2008).

Besides, Table (5) shows the expected versus actual genetic gain for all the studied characters. The expected genetic advance ($\Delta g\%$ F_2) and actual genetic advance ($\Delta g\% F_3$)ranged from low to moderate for all studied characters in all crosses under both drought and normal conditions except for kernels weight in all crosses were low under both conditions. These results indicated the possibility of practicing selection in early segregating generation to enhance these characters and hence selecting high yielding genotypes. Dixit *et al* (1970) pointed out that high heritability is not always associated with high genetic advance, but in order to make effective selection, high heritability should be associated with high genetic gain.

Generally, most of the significant biometrical parameters resulted from all crosses were higher in magnitude under drought condition, but results from the second and third crosses were higher than those obtained from the first one. Consequently, it could be concluded that the crosses (Gemmeiza 9 x Sahel 1), (Sakha 94 x Zemamra-1) and (Sakha 94 x Promising line) would be of interest in a breeding program for genetic improvement of wheat under low water condition (drought).

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تقدير التأثيرات الجينية وتبايناتها في ثلاثة هجن من قمح الخبز لنقص مياه الري (الجفاف)

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أجري هذا البحث في محطة بحوث الجيزة في ثلاثة مواسم من 2006/2005م إلى 2008/2007م ، ثم أجريت تجربة التقييم النهائي في محطة البحوث الزراعية بكفر الحمام – محافظة الشرقية في الموسم الرابع 2009/2008م على ثلاثة هجن من قمح الخبز ، بتحليل العشائر الخمسة (كل من الأبوين والأجيال الأول والثاني والثالث) لكل من الهجن الثلاثة (جميزة 9× ساحل 1، سخا 94× زيمامرا-1 وسخا 94 × سلالة مبشرة).

وكانت النتائج كما يلي :

١) كانت قوة الهجين في F_1 بالنسبة للأب الأفضل معنوية وموجبة لحبوب النبات للهجن الثلاثة تحت ظروف الجفاف ، عدد السنابل/نبات في الهجين الأول وعدد حبوب السنبلة بالنسبة للهجينين الثاني والثالث وذلك تحت ظروف الجفاف ، أما بالنسبة لظروف الري العادي فكانت قوة الهجين بالنسبة لحبوب النبات معنوية وموجبة في الهجينين الثاني والثالث ، عدد السنابل/نبات للهجين الثاني ، عدد الحبوب في السنبلة في الهجينين الأول والثالث وبالنسبة لوزن الحبوب كانت معنوية وموجبة في الثلاثة هجن.

٢) أوضحت دراسة طبيعة التوارث أن درجة السيادة كانت فائقة تجاه الأب الأعلى لجميع الصفات ما عدا عدد السنابل في النبات ووزن مائة حبة للهجين الثالث وعدد الحبوب في السنبلة في الهجين الأول تحت ظروف الجفاف وكذلك عدد السنابل في النبات في كل الهجن وعدد الحبوب في السنبلة للهجين الثالث تحت ظروف الري العادي .

كذلك أظهرت النتائج وجود سيادة جزئية تجاه الأب الأعلى لصفة عدد السنابل في النبات في الهجين الثالث تحت ظروف الجفاف . كذلك أظهرت سيادة جزئية تجاه الأب الأعلى لصفة عدد الحبوب في السنبلة في الهجين الثاني وسيادة جزئية تجاه الأب الأقل لصفة عدد السنابل في النبات في الهجين الثالث وذلك تحت الظروف العادية .

٣) كان تأثير التربية الداخلية موجباً ومعنوياً لصفة عدد السنابل/نبات للهجين الثاني ، صفة عدد الحبوب في السنبلة لكل الهجن الثلاثة وصفة محصول الحبوب للهجينين الأول والثاني لظروف تحت الجفاف ، وكذلك موجبة ومعنوية لكل الصفات لكل الهجن ما عدا صفة عدد الحبوب في السنبلة للهجينين الأول والثالث وصفة محصول الحبوب للهجين الأول تحت ظروف الري العادي ، بينما كان تأثير التربية الداخلية سالباً ومعنوياً لصفة وزن الحبوب للهجينين الأول والثالث تحت ظروف الجفاف وصفة عدد الحبوب في السنبلة للهجين الأول تحت الظروف العادية . أظهرت التأثيرات الوراثية المضيفة وكذلك الفعل الجيني غير المضيف دوراً هاماً في وراثة معظم الصفات المدروسة .

٤) كانت انحرافات الجيل الثاني (E1) وانحرافات الجيل الثالث (E2) معنوية لمعظم الصفات في الهجن تحت الدراسة مما يوضح أهمية الفعل الجيني التفوقي في وراثة الصفات .

٥) أظهرت التأثيرات الوراثية المضيفة وكذلك الفعل الجيني غير المضيف (السيادة والتفوق) دوراً هاماً في وراثة معظم الصفات المدروسة لكل من الري العادي وتحت ظروف الجفاف.

٦) أظهرت الكفاءة الوراثية بمعناها الواسع قيماً عالية لكل الصفات ، كما أظهرت كفاءة التوريث بمعناها الضيق وكذلك الكفاءة الوراثية المحسوبة من الانحدار بين الأجيال قيماً عالية إلى متوسطة مرتبطة بنسبة تحسين وراثي متوسط في معظم الصفات المدروسة .

والخلاصة أنه يمكن الاستفادة من الهجينين الثاني والثالث في برامج تربية القمح للحصول على سلالات جيدة متفوقة في المحصول وذلك بالنسبة لكل من تحت ظروف الجفاف والري العادي ، أما الهجين الأول فيمكن الاستفادة من تحت ظروف الجفاف فقط.

كما أن النتائج المتحصل عليها تدل على أن الانتخاب في الأجيال الانعزالية المبكرة قد يكون مفيداً ، ولكن سوف يكون أكثر كفاءة إذا تم تأجيله إلى الأجيال الانعزالية المتأخرة .