FACULTY OF AGRICULTURE

Minia J. of Agric. Res. & Develop.
Vol. (28) No. 1 pp 47- 66, 2008

BREEDING FOR HEAT TOLERANCE IN BREAD WHEAT UNDER UPPER EGYPT CONDITIONS

I. A. Amin, and S.A. Ali
Wheat Research Department, Field Crops Research
Institute, ARC, Egypt.

Received 5 Nov. 2007 Accepted 15 Jan. 2008

ABSTRACT

Five bread wheat cultivars (*Triticum aestivum L.*) were crossed in all possible combinations excluding reciprocals for yield, yield components and other agronomic characters. The parents, F_1 and F_2 generations were evaluated under optimum and late sowing dates at Shandaweel Research Station. Significant differences were found among the genotypes for days to heading and maturity, grain filling index, no. of spikes/plant, no. of kernels/spike, 100-kernel weight and grain yield in the two generations under two planting dates. Late sowing date (heat stress) reduced days to heading and maturity by (13.2 and 6.6 %) and (13.8 and 9.6 %), grain filling index (12.6 and 15.0 %), number of spikes/plant (7.6 and 7.4 %), number of kernels/spike (2.1 and 1.7 %), 100-kernel weight (16.1 and 14.3 %), and grain yield /plant (20.9 and 31.2 %), in the $F_1$and F_2 generations respectively, when compared with optimum sowing date. Heat tolerance index showed that cultivars Giza 164, Giza 168 and Sids 1 were the best yielding parents in the favorable sowing date. Giza 164, Sakha 93, Sids1 and crosses (P_1xP_2), (P_1xP_3), (P_1xP_4) and (P_1xP_5), were the best yielding genotypes under heat stress condition. General and specific combining ability were significant for all traits under study in the two generations and environments except for no. of spikes/plant, while 100- kernel weight was insignificant for GCA in the two generations under optimum planting. Additive genetic component effects and non-additive (H_1 and H_2) were significant for most traits under both environments. Broad

sense heritability values were relatively high for all studied traits in the two planting dates and generations except for no. of spikes/plant and for 100- kernel weight in the F_2 generation. On the other hand, the values narrow sense heritability were intermediate for all traits, except for no. of spikes/plant, which was the lowest, confirming that additive and non-additive genetic variance in the inheritance of most of these traits in these materials.

INTRODUCTION

Many of the world's wheat plants are exposed to short periods of very high temperature during grain filling period. The average wheat yield loss due to moderately high temperature is estimated at 10-15 % mainly due to the reduced single kernel weight (Wardlaw and Wrigley, 1994). Overcoming the gap of cereal production depends mainly on horizontal extension of cultivated area of cereals. This is encountered by unfavorable conditions such as a drought, heat and high salinity of soil. The first step is to identify, the superior tolerant genotypes to be used in these programs. Continual heat stress (main daily temperature above 17.6 °C in the coolest month of the year) affects approximately 7 million ha of wheat in developing countries, while terminal heat stress is a problem in 40 % irrigated wheat growing areas of the world (Fischer and Byerlee, 1991). Crop damage due to high temperature under late planting condition has become an important factor limiting wheat yields. Therefore, it is highly desirable to develop varieties having tolerance to the heat encountered due to late planting in the region. Elahmadi, (1993) found that heat stress is known to cause stunted plant growth, reduced tillering, and accelerated development and lead to small heads, shriveled grains and low yields. By using some of these responses; days to heading and maturity, plant height and yield and its components; an easily identifiable character as indices for heat tolerance can be found.

Combining ability analysis provides a guideline to the breeder in evaluating and selecting the elite parents and desirable cross combinations to be used in the formulation of systemic breeding program for improving quantitative traits such as yield and yield attributes. Singh *et al.,* 1980 found that combining analysis in wheat involving ten diverse parents and their 45 F_1s and F_2 s progenies indicated significant differences for general combining ability among the parents and for specific combining ability among crosses for days to heading and maturity, spikes / plant, 1000-grain weight and grain yield/plant. Additive variance was higher than dominance deviation for all characters, (Mann and Sharma, 1995). The results of Kheiralla *et al.* (2001) indicated that additive and non-additive variance were highly significant for days to heading and maturity, no. of kernels /spike , 1000-kernel weight and grain yield/plant under normal and late sowing date (heat stress). the additive gene effect was the main type of gene action in the inheritance of all traits, except for 1000-kernel weight under late sowing date. Meanwhile, the dominance gene effect played an important role in the inheritance of grain yield / plant under both environments. Broad and narrow –sense heritability values were high for all traits under both environments, except for grain yield under the two environments and 1000-kernel weight under late sowing date. El-Sayed (2006), found that both additive and non- additive gene effects controlled genetic system of moropho-physiological traits (days to heading and maturity and plant height) and grain yield and its components. The additive gene effects were the most prevalent type under normal and late sowing date (heat stress) for these traits except for grain yield in F_1 under late sowing date and F_2 in the two sowing dates. Heritability values were high in both broad and narrow –sense for moroph-physiological traits in the two sowing dates and generations, while broad and narrow –sense values for yield and its components varied from intermediate to high in broad and intermediate to low in narrow sense values for all traits under two sowing dates and (F_1 and F_2)generations. He also found that heat tolerance index for grain yield ranged from (53.3-89.9), (60. 7-95.4) and (40.1-88.7) in the parents, F_1 and F_2 progenies respectively.

The objectives of this study were to identify, the genetic behavior of some agronomic and yield characteristics under normal and hot environment in the F_1 and F_2 generations, study the type of gene, action which control the agronomic and yield traits under normal and heat stresses, calculate heat tolerance index for grain yield for two generations and to identify the best combinations under heat stress to be used in heat breeding program in Upper Egypt.

MATERIALS AND METHODS

This investigation was carried out at Shandaweel Agricultural Research Station, ARC, Egypt during the three successive growing seasons 2003/04, 2004/05 and 2005/06. The genetical materials used in this study as parents included five bread wheat cultivars, which represent a wide range of diversity for several traits (Table 1).

Table 1: Local name, pedigree and origin of the five parents.

Ent. No	Name	Pedigree	Origin
1	Giza 164	KVZ / BUHO"S" // Kal / BB=VEERY"S" #5	Egypt
2	Giza 168	MRL / BUC // SERI.	Egypt
3	Sakha 93	SAKHA 92 / TR 810328	Egypt
4	Sids 1	HD21 / PAVON "S" // 1158.57 / MAYA74"S"	Egypt
5	Debeira		Sudan

In 2003/04 season, all possible cross combinations (excluding reciprocals) among the five parents were made. In 2004/05 growing season, ten seeds of each of the 10 F_1 hybrids and the parents were sown in the field in rows spaced 30-cm apart and 10 cm between plants within rows to produce seeds of the F_2 generation. In addition, the parents were crossed again to produce more hybrid seeds for each cross. In 2005/06 season, the parents, the F_1 hybrids and F_2 populations were grown in two sowing dates; 25th November (normal sowing date = N) and 25th December (late sowing date = heat stress = H). The experiment was designed in a Randomized Complete Block Design with three replications. Each of the parents and F_1 hybrids were represented by three rows, while each F_2 population was represented by six rows per block. Every row was 2-m long , spaced 30-cm apart and plants spaced 10 cm. The recommended agricultural practices for wheat were applied. Data were measured on a random samples of 10 guarded plants per row (10 plants for each parent and F_1 hybrids and 60 plants from the F_2 population in each replicate in the two dates) for number of spikes/plant (No. S/P), number of kernels/spike (No. K/S), 100-kernel weight g., (100-KW), and grain yield /plant g. (G.Y). .

The following measurements were recorded on plot basis of each of the parents, F_1 and F_2 populations. Days to heading (HD), days to maturity (MD), grain filling period (GFP),

Statistical analysis was performed on entry mean base. The variation among parents, F_1 hybrids and F_2 generations were partitioned into general and specific abilities as illustrated by Griffing (1956) Method II, model 1, and further genetic components were carried out as described by Hayman (1954).

Stress tolerance index (STI) = HTI for each entry was computed according to Farshadfar, *et al.* (2001) as follow:

STI = Yp x Ys/ (Yp) 2 x 100 =Heat Tolerance Index = HTI

Where;

Yp = grain yield under normal condition

.Ys = grain yield under stress condition.

RESULTS AND DISCUSSION

Analysis of variance and performance of wheat genotypes:-

Analysis of variance for the studied characters under normal and late sowing presented in Table 2, show significant differences among the genotypes for days to heading and maturity, grain filling period, no. of spikes/plant, no. of kernels/spike,100- kernel weight and grain yield under normal and late planting dates in the $F_1$and F_2 generations.

The mean performance under normal and late planting dates in the F_1 and F_2 generations for days to heading and maturity, grain filling period, no. of spikes/plant, no. of kernels/spike,100- kernel weight, grain yield and heat tolerance index are given in Tables 3 and 4. Results revealed that the earliest parents were P_1 and P_2 (87.8 and 82.0) and (87.8 and 84.5) days under both sowing dates respectively. Under normal and late planting dates the cross (P_2xP_5) was the earliest in the F_1 and (P_2xP_3) F_2 generations. Generally, it could be seen that delaying planting date (heat stress) reduced number of days to heading in the F_1 generation by (13.2 %) over all genotypes when compared with favorable condition. These results could be due to the fact that units and the accumulated metabolites required for wheat flowering were reduced in the late planting date. Similar results were reported by Abdel-Karim (1991), Abd El-Shafi and Ageeb (1993), Kheiralla *et al.*(2001) and El-Sayed (2006).

Table 2: Mean squares (M.S.) for genotypes and combining ability analysis in the F_1 and F_2 generation under normal (N) and heat stress (H).

Item	M.S							
	d.f	HD	MD	GFP	NO. S/P.	NO. K/S	100 KW	G.Y
F_1 hybrid								
Normal								
Reps	3	5.17	13.21	22.95	0.22	7.74	0.01	7.11
Genotypes	14	75.67**	40.41*	29.12*	3.14*	34.60*	0.120*	44.94**
GCA	4	143.75**	85.44**	48.83*	5.97*	39.95	0.101	25.75**
SCA	10	10.43**	22.40**	21.24**	2.00	32.46*	0.134*	52.63**
GCA/SCA		13.78	3.81	2.30	2.99	1.23	0.75	0.49
Error	42	2.39	1.04	4.67	1.20	9.11	0.02	2.16
Heat stress								
Reps	3	1.13	1.088	6.33	2.19	6.55	0.180	4.25
Genotypes	14	14.07*	12.98**	51.60*	3.62*	36.45*	0.158*	13.83*
GCA	4	23.16*	105.36**	68.35*	1.89	74.02**	0.225*	9.36*
SCA	10	2.69	60.02**	44.90*	3.62*	21.43	0.131**	15.62*
GCA/SCA		8.60	1.76	1.52	0.52	3.45	1.72	0.60
Error	42	2.69	3.52	6.49	1.47	8.73	0.02	3.64
F_2 Crosses								
Normal								
Reps	3	2.58	0.49	2.71	7.33	10.02	0.12	1.44
Genotypes	14	39.79**	25.54*	29.79*	5.31*	10.02**	0.17*	49.82*
GCA	4	79.26**	32.41**	58.17*	8.93	60.13**	0.04	72.80**
SCA	10	24.01**	22.79**	18.44*	3.86	61.63**	0.20*	40.63**
GCA/SCA		3.30	1.42	3.15	2.31	0.97	0.57	1.79
Error	42	1.78	2.11	5.25	2.30	2.03	0.07	3.14
Heat stress								
Reps	3	1.79	6.64	4.28	1.77	26.44	0.10	1.92
Genotypes	14	41.38**	14.69*	26.20*	5.03*	68.25*	0.14*	22.78*
GCA	4	87.29**	17.55**	6.94	8.63	49.61**	0.13*	46.61**
SCA	10	23.00**	13.55**	33.90**	3.59	75.85**	0.15**	13.24**
GCA/SCA		3.80	1.30	0.20 4.93	2.40	0.65	0.87	3.52
Error	42	2.29	1.22		2.22	6.39	0.04	2.12

**,* Significant 0.01 and 0.05 % levels of probalities, respectively.

Table 3: Mean performance of days to heading (HD), days to maturity (MD), grain filling (GFP) for parents, F_1 hybrids and F_2 populations under normal (N) and heat conditions (H).

Genotypes	HD		MD		GFP	
	N	H	N	H	N	H
Parents						
P_1 (Giza 164)	10 0.0	88.0	147.0	129.5	48.0	42.0
P_2 (Giza 168)	87.8	84.5	144.0	127.8	50.0	44.0
P_3 (Sakha 93)	87.0	82.0	139.0	127.0	47.0	47.0
P_4 (Sids 1)	102.0	88.0	150.0	140.0	46.0	50.0
P_5 (Debira)	100.8	87.0	148.0	136.3	51.0	44.0
F_1hybrids	100.0	84.3	145.0	124.0	45.0	43.0
1x2	99.5	83.8	148.0	125.2	48.3	41.0
1x3	99.5	83.5	148.0	125.3	48.5	41.0
1x4	96.3	83.5	147.0	125.3	51.5	41.0
1x5	97.0	83.0	146.0	127.5	48.5	44.0
2x3	98.3	84.3	142.0	126.8	48.5	43.0
2x4	87.0	83.0	148.0	126.8	50.0	47.0
2x5	96.0	83.0	148.0	128.0	52.0	48.0
3x4	94.5	83.8	149.0	128.8	54.3	47.0
3x5	97.8	86.0	148.0	128.5	53.3	42.0
4x5						
Average	96.6	83.8	146.9	126.6	50.00	43.7
L.S.D 0.05	3.55	3.34	2.19	4.06	5.51	4.38
F_2 Cross.						
1x2	93.5	90.3	143.8	133.0	50.0	40.0
1x3	97.0	91.0	148.0	131.5	51.0	42.0
1x4	93.3	91.3	144.8	132.0	51.5	42.0
1x5	94.0	89.0	145.5	129.8	51.5	42.0
2x3	87.0	86.3	143.0	130.3	54.0	45.0
2x4	92.5	88.0	148.3	131.0	55.5	43.0
2x5	94.5	85.0	145.5	131.8	49.5	44.0
3x4	94.3	84.5	146.3	132.8	52.0	45.0
3x5	94.0	86.5	147.8	133.0	54.0	45.0
4x5	95.3	89.0	144.5	131.0	49.0	43.0
Average	93.9	87.7	145.7	131.7	51.3	43.6
LSD 0.05	3.00	3.41	3.41	2.50	2.12	5.18

For days to maturity the parental mean ranged from 139 days for P_3 to 150 days for P_4 under favorable conditions, while it was reduced to 127 days for (P_3) to 140 days for P_4 under late planting. In the F_2 generation the cross (P_2xP_3) was the earliest for maturity date under the two environments. These results indicate that duration from planting to heading and maturity was reduced with the delay in sowing, but the reduction was slow down to the end of November and rapid after November.

Grain filling period, delaying the planting date (or exposed heat stress) reduced grain filling period by 12.6 and 15.0 % in the F_1 and F_2 generations respectively when compared with the normal planting date. The decrease in grain filling period could be due to increasing temperature during this period, causing decrease in grain yield. These results are similar to those reported by Brucker and Frohberg (1987), Abdel-Karim (1991) Abdel Ghani *et al.* (1993) and El- Morshidy *et al.* (2001). Fischer and Maurer (1978), They reported that grain yield was reduced by 4 % as a result of increasing temperature by 1 ^{o}c over the optimum temperature if such rise occurred from end of tillering until the grain filling stage.

The values of no. of spikes/plant ranged from 12.8 spikes (P_1) to 15.0 (P2) under normal planting date, but it was reduced to 12.5 (P_1) and to13.8 spike (P_4) under late planting date. The average F_1 hybrids for no. of spikes/plant ranged from 12.0 spikes for cross (P_1 x P_5) to 14.0 for (P_1 x P_2) and (P_3 x P_4) under normal condition, while it was reduced to 10.5 for cross (P_1 x P_5) under heat stress. The F_2 crosses ranged from 14.0 spikes for cross (P_3 x P_4) to 16.80 for cross (P_1 x P_5) under normal planting, and it was ranged from 12.0 spikes for cross (P_1 x P_2) to 14.3 (P_2 x P_4) under heat stress. Delaying planting date reduced no. of spikes/plant by 12.7, 7.6 and 7.4 % for parents, F_1 and F_2 generations respectively when compared with the optimum planting date. Similar results were obtained by Salim (2000) and El-Sayed (2006).

The performance no. of kernel/spike ranged from 43.3 for (P_3) to 48.8 kernel (P_4) in the favorable condition, but it was reduced to 41.0 for (P_5) and to 46.3 kernels/spike for (P_2) under late sowing date. The reductions of parents were 4.6 % as compared with recommended planting date. Over all average of no. of kernels/spike decreased by 2.11 and 1.74 % in the F_1 and F_2 progenies respectively. Khierall *et al.* (2001) found that no. of kernels/spike was reduced by 8.9 % in unfavorable condition as compared with favorable condition.

The parental average mean for 100- kernel weight ranged from 4.3 g for (P_5) to 5.0 g (P_4) in the favorable condition, but it was reduced to 3.5 g for (P_2) and to 4.1 g (P_4) under heat stress condition. The F_1 values ranged from 4.5 g for cross (P_1xP_2) to 5.0 g (P_1xP_3) in the non-stress condition and 3.7 g for (P_1xP_2) to 4.4 g gm (P_1xP_5) cross in the stress condition. The average reduction of 100- kernel weight of all F_1 was 16.1 % as compared with non-stress environment. The values of crosses average ranged from 3.6 for (P_2xP_4) to 4.0 g for (P_1xP_2) with 14.3 % reduction under heat stress. Similar results were obtained by Stone and Nicolas (1995), Kheiralla *et al.* (2001) and El-Sayed (2006). With regard to grain yield / plant the parental performance ranged from 21.78 for (P_5) to 29.38 g for (P_1) in the normal sowing date and it was 18.01 for (P_2) and 24.82 g for (P_1) under late sowing (Table 4). The cultivars Giza 164 (P_1), Giza 168 (P_2) and Sids1(P_4) were the highest yielding parents in the favorable sowing date, while the genotypes Giza 164 (P_1), Sakha 93 (P_3) and Sids1 (P_4) were the best yielding parents under late sowing, date (heat stress condition). Kheiralla et *al.* (2001) found that Giza 164 was the best yielding parent under heat stress. The grain yield of the F_1 ranged from (22.00 and 18.92) gm for cross (P_1xP_3) to (33.92 and 23.19) g for (P_4xP_5) in the favorable and late sowing respectively. On the other hand in the $F_{2\text{ crosses}}$ (P_1xP_4) and (P_1xP_5) were the best yielding and giving (29.72 and 35.74) and (22.22 and 21.90) g/plant under optimum and late planting dates, respectively. The yield reduction ranged from (20.87 and 31.18 %) in the F_1 and F_2 crosses as compared with non-stress environment. These results agree with those reported by Abd El-Shafi and Ageeb (1993) who found that late sowing dates reduced grain yield by 19.0 % when compared with the optimum sowing date in Upper Egypt. They also stated that the reduction in grain yield/plant by delaying sowing date decreased duration of grain filling period, particularly for late heading varieties. High temperature stress indirectly reduced yield by directly affecting various yield components as indicated in Table 4. These results agree with those reported by Abdel-Karim (1991), Kherialla *et al.* (2001) and El-Sayed (2006).

Table 4: Mean performance of grain yield and its components and heat index susceptibility for their parents, F_1 and F_2 generations under normal and heat stress conditions.

Genotypes	NO. S/P.		NO. K/S		100KW		G.Y		HTI
	N	H	N	H	N	H	N	H	
Parents									
P_1 (Giza 164)	12.8	12.8	43.5	42.5	4.88	3.83	29.38	24.82	84.5
P_2 (Giza 168)	15.0	13.5	48.0	46.3	4.42	3.54	29.17	18.01	61.7
P_3 (Sakha 93)	13.8	12.3	43.3	44.8	4.48	3.74	27.76	21.24	76.5
P_4 (Sids 1)	14.8	13.8	48.8	44.5	5.00	4.07	28.08	21.60	76.9
P_5 (Debira)	14.0	12.5	46.0	41.0	4.30	3.80	21.78	19.19	88.1
F_1 hybrids									
1x2	14.0	12.8	46.5	50.3	4.51	3.72	27.24	22.54	82.8
1x3	12.8	13.0	47.0	45.5	5.00	3.94	22.00	18.92	86.0
1x4	12.3	10.8	45.8	49.5	4.95	4.07	26.85	21.68	80.7
1x5	12.0	10.5	44.5	46.0	4.59	4.36	28.81	20.05	69.6
2x3	13.0	12.5	44.8	42.3	4.90	3.87	28.50	19.92	69.9
2x4	14.3	11.8	49.0	49.8	4.62	3.93	25.41	24.23	95.4
2x5	13.3	12.8	46.8	47.3	4.81	4.10	29.27	20.94	71.5
3x4	14.0	13.0	49.8	45.8	4.69	4.02	23.94	19.27	80.5
3x5	12.8	12.8	45.5	43.0	4.82	3.95	22.26	21.48	96.5
4x5	13.5	12.3	53.0	43.5	4.81	4.08	33.92	23.19	67.6
Average	13.2	12.2	47.3	46.3	4.77	4.00	26.82	21.22	-----
L.S.D 0.05	2.56	2.32	6.55	6.40	0.04	0.35	3.19	4.12	-----
F_2 Cross.									
1x2	15.3	12.0	49.0	49.0	4.22	4.00	22.50	18.00	80.0
1x3	14.8	12.3	43.0	49.0	4.99	3.90	23.71	19.21	81.0
1x4	16.0	14.0	47.0	48.0	4.22	3.90	29.72	22.22	74.8
1x5	16.8	13.3	46.0	44.0	4.64	3.70	35.74	21.90	61.3
2x3	14.8	13.5	42.0	44.0	4.56	3.90	24.47	15.21	62.2
2x4	14.5	14.3	48.0	46.0	4.58	3.60	27.30	16.83	61.7
2x5	14.8	12.3	42.0	43.0	4.58	3.70	26.76	13.44	50.2
3x4	14.0	13.8	46.0	43.0	4.50	3.80	22.20	16.04	72.2
3x5	15.7	13.0	47.0	43.0	4.36	4.00	23.65	16.05	67.9
4x5	15.3	12.5	50.0	48.0	4.44	3.70	28.33	18.51	65.3
Average	15.0	13.1	46.0	45.2	4.53	3.88	26.36	18.14	-----
LSD 0.05	3.41	3.34	4.59	5.17	0.57	0.48	4.00	0.03	-----

The values of heat tolerance index (HTI) for grain yield/plant show that genotypes Giza 164 (P_1) and Debira (P_5) were relatively the most tolerant parents to heat stress, while Sakha 93 (P_3) and Sids 1 (P_4) were moderate tolerant. Giza 168 (P_2) was the most susceptible parent. The crosses (P_2xP_5), (P_2xP_4) and (P_1xP_3) in the F_1 and (P_1xP_2) (P_1xP_3) and (P_1xP_4) in F_2 were the most tolerant to heat stress.

The results in Table 2 show that the variances of general and specific combining ability were significant for most characters. These results indicate the presence of additive and non-additive gene effects in the inheritance of the most studied traits. The ratio GCA/SCA mean squares was more than one for most traits under both environments, suggesting the predominant role of additive gene effects in the genetic control of the traits. These results are in agreement with the finding of El-Sayed (2004) and El-Sayed (2006).

Combining ability:-

Estimates of general combining ability (GCA) effects for studied traits are presented in Table 5. The parental genotypes (P_2) and (P_3), showed significant and negative GCA estimates for days to heading in both planting dates, except for (P_2) under late planting, hence these genotypes could be considered good combiners for improving earliness. For days to maturity, results revealed that (P_2) exhibited negative significant GCA estimates in both planting dates, while the GCA effect of (P_2) was negatively significant under normal planting date. Those parents could be considered a good combiners for earliness in maturity. Regarding grain filling period, the genotypes (P_3) for normal planting date and (P_4), under late planting had positive significant GCA estimates for grain filling period, they could be considered good combiners for long grain filling period in both planting dates. El-Morshidy *et al.* (2001), stated that the cultivars which are early in heading or maturity have long grain filling duration, and vice versa. On the other hand, the genotypes (P_4) exhibited positive significant GCA estimates in both planting dates and was good combiners for 100- kernel weight under late sowing date, therefore it could be used for producing heavy kernels. For grain yield/plant the results showed that the Giza 164 (P_1) was good combiner in both planting dates, while Giza 168 (P_2) was good combiner in normal planting date. These genotypes had positive significant GCA estimates and could be considered for increasing grain yield.

Table 5: Estimates of general combining ability effects of heading date, maturity date, grain filling period, no. spike/plant, no. kernels/spike, 100-kernel weight and grain yield/plant under normal and heat conditions.

Parent	HD	MD	GFP	NO. S/P.	NO. K/S	100KW	G.Y
Normal							
1	1.99*	1.49*	-1.76*	-0.61	0.85	-0.03	1.27*
2	-1.93*	-2.26*	0.41	0.53	-0.26	-0.06	1.00*
3	-2.90*	-1.37*	1.59*	-0.11	-1.61	0.08	-1.36*
4	1.85*	1.59*	0.63	0.39	1.46	0.05	0.65
5	0.99	1.55*	-0.87	-0.19	-0.44	-0.03	-0.56
L.S.d 0.05 (gi-gj)	1.21	0.75	1.59	0.78	2.23	2.23	1.00
Heat							
1	0.57	-1.69*	-0.44	-0.29	1.82	0.02	0.39*
2	-0.50	-1.44*	-2.19*	0.32	1.21	-0.13*	-0.48*
3	-1.36*	-1.01	-0.33	0.11	-1.36	-0.05	-0.71*
4	0.82	2.56*	1.06	0.11	0.28	0.09*	0.65*
5	047	1.59*	1.89*	-0.25	-1.96	0.07	0.15
L.S.d 0.05 (gi-gj)	1.14	1.38	1.88	0.78	2.18	0.09	1.41

* Significant at 0.05 level of variability.

Specific combining ability effects of the parental combinations for the studied traits under two planting dates and generations are shown in Table 6. Regarding days to heading, the cross (P_1xP_5), gave negative significant effect in the two environments and generations, while the crosses (P_2xP_5) and (P_3xP_4) were negatively significant in late sowing date. For maturity, the crosses (P_1xP_4), (P_1xP_5), (P_4xP_5) and (P_2xP_4) had negative significant effects in planting dates and generations, except for cross (P_2xP_4) under heat stress. Cross (P_1xP_5) exhibited negative significant SCA for heading and maturity (earliness). The crosses (P_3xP_4) and (P_3xP_5) had negative significant SCA values for grain filling period. For no. of spikes/plant (Table 7),

Table 6: Estimates of specific combining ability effects of heading date, maturity date, and grain filling under normal and heat conditions.

Parent	HD		MD		GFP	
	N	H	N	H	N	H
F_1 hybrid						
1x2	3.06*	-0.32	0.26*	-1.30	0.58	-0.76
1x3	3.52*	0.04	2.11*	-0.48	-0.85	0.63
1x4	-1.22	-2.39*	-0.60*	-4.1*	-1.63*	-0.51
1x5	-3.61*	-2.04*	-0.81*	-3.1*	-0.13	1.67
2x3	4.95*	0.36	2.17*	1.52	-1.52	2.63*
2x4	0.20	-0.57	0.16	-2.80*	-1.56	1.24
2x5	2.31*	-1.46*	2.44*	-1.85*	3.69*	1.92
3x4	0.17	-0.96	1.26*	-1.97*	2.51*	2.88*
3x5	-0.48	0.14	2.55*	-0.26	2.26*	4.31*
4x5	-1.98*	0.21	-0.92*	-4.08*	-1.27	1.92
S.Eij	0.71	0.67	0.47	0.67	0.75	1.11
L.S.D 0.05	1.52	1.46	1.00	1.75	1.60	2.63
F_2 cross.						
1x2	0.46	0.91	-0.68	1.31*	-1.14	-0.80
1x3	2.21*	2.33*	2.79*	-0.62	-0.68	0.88
1x4	-3.82*	-0.70	-2.07*	-1.73*	-1.04	1.74
1x5	-2.00*	-2.35*	-1.41*	-2.58*	-1.14	0.85
2x3	-3.89*	1.08	0.07	-0.62	0.93	2.17
2x4	-0.70	-0.45	3.71*	-1.48*	-1.68	4.77*
2x5	2.39*	-2.85*	1.18	0.67	-0.04	-2.12
3x4	-0.70	-3.27*	0.93	-0.16	-0.46	1.95
3x5	0.14	-0.66	2.64*	1.49*	-0.57	2.81
4x5	-0.89	-1.45*	-2.21*	-2.12*	-3.68*	-1.08
S.Eij	0.57	0.66	0.63	0.50	0.99	1.48
L.S.D 0.05	1.22	1.41	1.35	1.07	2.13	3.18

* Significant at 0.05 level of variability.

the crosses (P_1xP_3), (P_2xP_5), and (P_3xP_4) in the F_1 and cross (P_2xP_3) in the F_2 generation under heat stress, had positive significant SCA effect. In the F_2 generation four crosses (P_1xP_4), (P_1xP_5), (P_2xP_3) and (P_2xP_4) under normal planting and two crosses (P_1xP_5) and (P_4xP_5) in the late planting exhibited positive significant SCA effect for no. of kernels/spike. Also the best combination was obtained by cross (P_1xP_5) in the F_2 generation under both planting dates. Regarding 100-

Table 7: Estimates of specific combining ability effects for no. of spike/plant, no. of kernels/spike, 100- kernel weight and grain yield/plant under normal and heat conditions.

Parent	NO. S/P.		NO. K/S		100KW		G.Y	
	N	H	N	H	N	H	N	H
F_1 hybrids								
1x2	0.62	0.30	-1.56	3.30*	-0.10	-0.10	-0.99	1.45
1x3	0.01	0.76*	0.30	-0.88	0.25*	0.04	-3.87*	-1.95*
1x4	-0.99	-1.49*	-4.02*	1.48	0.22*	0.02	-1.03	-0.54
1x5	-0.67	-1.38*	-3.38*	0.23	-0.05	0.34*	2.14*	2.34*
2x3	-0.88	-0.35	-0.84	-3.52*	0.18	0.11	1.89*	-0.06
2x4	-0.13	-1.10*	0.33	2.33	-0.07	0.03	-3.17*	2.89*
2x5	-0.56	0.26*	-0.02	2.08	0.20	0.23*	1.87*	0.11
3x4	0.26	0.37*	2.44	0.91	-0.13	0.04	-2.31*	-1.84*
3x5	-0.42	-0.02	0.08	0.41	0.08	-0.00	-2.78*	0.87
4x5	-0.17	0.02	4.51*	-0.74	0.09	0.01	6.87*	1.23
S.Eij	0.47	0.17	1.32	1.29	0.10	0.10	0.80	0.83
L.S.D 0.05	NS	0.37	2.82	2.75	0.21	0.21	1.71	1.77
F_2 cross.								
1x2	-0.42	-0.73	-2.94*	-1.23	-0.31*	0.22	-4.99*	-0.09
1x3	-0.77	-0.69	-5.19*	2.35	0.42*	-0.03	-2.29*	0.11
1x4	0.19	-0.16	4.99*	1.02	-0.26*	0.05	1.41	1.78*
1x5	-0.10	-0.26	5.88*	5.10*	0.10	-0.14	6.49*	2.74*
2x3	0.01	1.42*	2.99*	-2.36*	-0.23	-0.06	1.10	-0.59
2x4	-0.52	1.20	3.17*	-2.33	0.13	-0.25	1.66*	-0.31
2x5	-1.31	-0.16	1.81	-4.01*	0.08	-0.07	0.15	-2.41*
3x4	-0.88	0.24	0.18	-3.51*	0.02	-0.19	-1.79*	-2.11*
3x5	-0.17	0.13	-0.44	-2.69*	-0.20	-0.00	-1.37	-0.81
4x5	-0.95	-1.38*	-0.51	6.49*	0.03	-0.18	1.02	0.31
S.Eij	0.66	0.64	0.88	1.10	0.10	0.10	0.77	0.63
L.S.D 0.05	NS	1.38	1.90	2.36	0.21	NS	1.65	1.35

. * Significant at 0.05 level of variability.

kernel weight, the crosses (P_1xP_3) in the two generations, (P_1xP_4) in the F_1 under normal condition, (P_1xP_5) and (P_2xP_5) under heat stress had positive significant SCA effects. For grain yield in the normal planting date the crosses (P_1xP_5), (P_2xP_3) and (P_4xP_5) in the F_1 and (P_1xP_5) and (P_2xP_4) in the F_2 had positive significant SCA effects, while under heat stress the crosses (P_1xP_5) and (P_2xP_4) in F_1 and the crosses (P_1xP_4) and (P_1xP_5) in the F_2 generation, showed positive significant SCA effects. The cross (P_1xP_5) have the highest positive significant SCA values for this character, under normal and stress conditions in the two generations. These results revealed that some of the crosses can be used in wheat breeding program for earliness, heat stress and high yield potential.

Genetic components:-

Estimates of the genetic components are presented in Table 8. The additive genetic components (D) were significant for all traits in the F_1 and F_2 generations under normal and late sowing dates, except for grain yield in the F_2 under the two environments. The dominant component (H_1) was significant for all studied traits in the two generations under normal and late sowing dates, except for no. of spikes/plant in the F_2 under the two environments. However the values of (H_1) were higher in magnitude than the respective (D) for days to heading, grain filling period, no. of spikes/plant, no. of kernels/spike and grain yield/plant in the F_1 generation under the two planting dates. In the F_2, the values of (H_1) for days to heading, no. of kernels/spikes and grain yield /plant under the two environments were higher in magnitude than the respective (D), indicating non- additive gene action as predominant type of action in the expression of these traits. Kheiralla *et al.* (2001) found that non- additive gene action played the main role in the inheritance of 100 kernels weight under late sowing and grain yield/plant under both planting dates. Similar results were reported by El-Sayed (2004) and El-Sayed (2006). The components of variation due to dominant effects associated with gene distribution (H_2) was significant for studied traits in the F_1 and F_2 generations under normal and late sowing dates, except for grain filling period in the F_1 no. of spikes/plant and no. of kernels/spike in the F_2 under heat stress. The values of (H_2) were consistently lower than those of (H_1) which complies with the theoretical assumption of Hayman (1954), and could be a further proof of the unequal proportions of positive and negative alleles in the parents at all loci for these traits.

Table 8: Estimates of genetic components for heading date, maturity date, grain filling, no .spike/plant, no. kernels/spike, 100 kernel weight and grain yield/plant under normal and heat conditions in the F_1hybrids and F_2 generation.

Item	HD	MD	GFP	NO. S/P.	NO. K/S	100KW	G.Y
F1 hybrids							
Normal							
D	54.81±4.58	12.79±0.53	8.33 ± 7.6	0.76±0.06	13.11±4.15	0.09±0.004	7.20±1.05
H1	104.5±5.58	8.83±0.51	39.74±7.6	1.14±0.06	26.58±4.15	0.08±0.004	17.99±1.05
H2	86.5±53.01	11.86±5.04	123.4±68.4	1.15±0.58	23.46±13.6	-0.02±0.01	4.06±0.01
F	5.88±5.60	6.86±1.96	-80.2±28.1	1.26±0.22	11.98±10.4	0.12±0.001	16.58±6.04
h^2	53.53±5.58	1.18±0.53	6.42±7.6	0.34±0.06	-2.53±4.15	-.02±0.004	0.04±0.01
(H1/D)1/2	1.38	0.83	2.18	1.22	1.42	0.93	0.50
H2/4H1	0.21	0.34	0.85	0.25	0.22	0.66	0.06
H. b.s	95.00	70.49	96.94	74.88	90.52	93.70	84.07
H. .n.s	57.94	44.00	48.71	49.88	61.83	78.26	58.59
Heat stress							
D	6.22±0.33	31.99±18.6	2.7±1.10	0.12±0.05	4.99±3.89	0.03±0.003	1.61±0.63
H1	12.77±0.33	9.21±8.60	4.98±1.10	1.30±0.05	30.62±14.0	0.02±0.003	7.87±0.63
H2	6.32±3.23	447.8±182	1.64±10.67	0.68±0.50	28.18±3.89	0.03±0.027	8.38±6.12
F	8.30±1.22	-395±68.5	-15.44±4.1	0.45±0.19	5.12±3.06	0.07±0.04	0.15±2.33
h^2	0.069±0.33	73.9±18.61	5.38±1.10	1.25±0.05	3.18±4.09	0.10±.003	1.74±0.63
(H1/D)1/2	1.43	0.54	1.36	3.29	6.14	0.74	2.21
H2/4H1	0.12	12.15	0.29	0.13	0.23	0.04	0.27
H. b.s	90.97	99.50	86.46	52.46	88.82	78.31	73.92
H. n.s	66.38	73.31	83.84	24.59	12.47	59.04	13.90
F2 Crosses							
Normal							
D	55.07±19.2	14.14±6.20	8.54±3.84	0.32±0.05	13.12±4.56	0.08±0.01	4.50±12.1
F	134.7±19.2	-83.74±6.2	-14.0±3.84	0.44±0.45	216.1±4.6	0.049±.001	528.2±12.1
H1	83.2±0.72	39.18±35.8	49.72±34.6	0.56±0.41	238.6±44.2	-0.04±0.01	469.8±112
H2	66.1±61.04	214.6±22.9	-59.7±14.2	-0.08±0.4	-26.5±15.2	0.02±0.003	50.28±44.4
F	41.39±19.2	0.48±6.3	12.71±3.84	2.25±0.04	9.52±4.6	0.02±0.001	.0.066±12.1
h^2	1.56	2.43	1.28	1.17	4.06	0.80	10.83
(H1/D)1/2	0.15	0.12	0.89	0.31	0.28	0.20	0.02
H2/4H1	92.88	97.84	95.62	29.48	98.13	70.83	99.44
H. b.s	29.80	89.92	63.27	18.27	23.63	44.25	32.16
H. n.s							
Heat stress							
D	6.23±5.0	32.79±31.8	3.10±2.70	0.52±0.02	4.09±3.55	0.03±0.01	2.0±2.56
H1	-149.6±5.0	-120.4±32	-29.0±2.7	-0.03±0.1	-34.0±3.55	0.008±0.01	-39.4±2.56
H2	40.18±38.5	83.04±63.7	65.39±25.1	0.02±0.18	9.42±18.5	0.032±.006	26.16±23.0
F	-192.1±18	175±117.6	-91.9±9.99	0.63±0.06	-41.9±13.1	0.007±0.00	-72.26±9.5
h^2	13.16±5.00	0.35±31.81	33.31±2.7	0.04±0.02	3.52±3.15	0.12±0.002	9.91±2.56
(H1/D)1/2	4.90	1.92	3.05	0.24	2.88	0.53	4.43
H2/4H1	0.07	0.08	0.56	0.17	0.07	1.00	0.17
H. b.s	99.04	99.42	96.78	32.44	87.82	47.83	98.01
H. n.s	86.47	76.86	63.97	22.07	76.62	21.74	79.25

The over dominant effects of heterozygous loci was significant for most studied characters in the F_1 and F_2 generations and in the two environments, indicating that the effect of dominance is due to heterozygosity. The average degree of dominance $(H_1/D)^{1/2}$ was more than unity of all traits under the two environments and generations, indicating the presence of over-dominance effect, except in the F_1 days to maturity and 100-kernel weight under the two planting dates and grain yield in the optimum condition. These results agree with those reported by Nayeem and Veer (1994), Abdel-Karim (1991), Kherialla *et al.(*2001) and El-Sayed (2006). The values of $H_2/4H_1$ were less than 0.25 for all studied traits in the F_2 generation under optimum and late sowing dates, except for grain filling period, revealing asymmetric distribution of positive and negative alleles among parents. Broad-sense heritability values were relatively high for all studied traits in the two planting dates and generations except for no. of spikes/plant and no. of spikes/plant in the F_2 generation which were moderated and low, respectively. On the other hand, the values of narrow sense heritability were moderate for all traits in the two sowing dates and generations, except for no. of spikes/plant which was low.

These results confirm that additive and non additive gene effect controlling of genetic system of these most this traits in tested materials and that selection in the early segregating generation for grain yield under normal and heat conditions could be effective. These results agree with those obtained by El-Sayed (2004) and El-Sayed (2006).

REFERENCES

Abdel-Karim, A.A(1991). Evaluation of some wheat germplasm under stresses. M. Sc. Thesis, Fac. Agric., Assiut Univ., Egypt.

Abdel-Shafi, A.M. and O.A.A Ageeb (1993). Breeding strategy for developing heat –tolerant wheat varieties adapted to Upper Egypt and Sudan. In Proceeding of the International Conferences. Wheat in Hot Dry, Irrigated Environment. Wad Medani, Sudan. 1-4 February.

Elahmadi, A.B. (1993). Development of wheat germplasm tolerant to heat stress in Sudan. Wheat in Hot Dry, Irrigated Environment. Wad Medani, Sudan. 1-4 February.

El-Morshidy, M.A.; K.A.A. Kheiralla and M.M. Zakaria (2001). Studies on grain filling under different planting dates in wheat. The second P1. Breed. Conf. October 2, 2001 Assiut University.

El-Sayed, A.G.A. (2006). Genetical studies on some bread wheat crosses under heat stress. M. Sc. Thesis, Fac. Agric., Minia Univ., Egypt.

El-Sayed, E.A.M. (2004). A diallel crosses analysis for some quantitative characters in bread wheat (*Triticum aestivum* L.). Egypt. J. Agric. Res., 82(4): 1665-1679.

Farshadfar; E.M. Ghananda; M. Zahravi and J. Sutka, (2001). Generation mean analysis of drought tolerance in wheat (*Triticum aestivum* L.). Acta Agronmica Hungarica, 49 (1), 59-66.

Fischer, R.A. and D.R. Byerlee. (1991). Trends of wheat production in the wamer areas: major issues and economic considerations. In: D.A. Saunders (ed), wheat for Nontraditional wann areas. Mexico, D.F. CYMMYT, pp. 3-27.

Fischer, R.A. and R.O. Maurer. (1978). Drought resistance in spring wheat cultivars. 1-Grain yield response. Aust. J. Agric. Res., 29: 897-912.

Griffing, B.(1956). Concept of general and specific combining ability in relation to diallel crossings systems. Aust. J. Biol. Sci., 9:463-493.

Hayman, B.I. (1954). The theory and analysis of diallel crosses. Genetics, 39: 789-809.

Kheiralla, K.A. and T.H.I. Sherif (1992). Inheritance of earliness and yield in wheat under heat stress. Assiut-J.of Agri.Sci., 23(1): 105-126.

Mann, M.S. and S.N. Sharma, (1995). Combining ability in the F1 and F2 generations of diallel cross in macaroni wheat (*Triticum durum Desf.*). Ind. J. Gene., 55:160-165.

Nayeem, K.A and M.V. Veer (1998). Gene effects for thermotolerance parameters and some yield components in bread wheat (*Triticum aestivum L.*) under normal and late sowing. Crop-Improvement. 25(2): 229-231.

Singh, K.P., C.S. Tyagi, D. Singh and V. Singh (1980) Combining ability analysis in wheat. Ind. J. Agric. Res., 14:247-253.

Stone, P.J. and M.E. Nicolas (1995). A survey of the effects of high temperature during grain filling on yield and quality of 75 wheat cultivars. Australian-Journal-of-Agricultural-Research. 46(3): 475-492.

Wardlaw, I.F and C.W. Wrigley. (1994). Heat tolerance in temperature cereals: On overview. Australian Journal of physiology, 21: 698-703.

التربية لتحمل الحرارة في قمح الخبز تحت ظروف مصر العليا

ابراهيم عبد الهادى أمين، صلاح الدين عبد الحليم على
قسم بحوث القمح – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية.

أجريت هذه الدراسة بمحطة بحوث شندويل خلال المواسم الشتوية ٢٠٠٣ / ٢٠٠٤، ٢٠٠٤/٢٠٠٥، ٢٠٠٥/٢٠٠٦م بهدف دراسة أداء ومعامل الحساسية للحرارة والأهمية النسبية للقدرة العامة والخاصة على الائتلاف وطبيعة فعل الجين ومعامل التوريث لصفات المحصول ومكوناته وبعض الصفات الأخرى تحت ظروف الإجهاد الحرأرى بمصر العليا وذلك فى الهجن الناتجة بكل الطرق الممكنة بدون التهجين العكسي لخمسة تراكيب وراثية من قمح الخبز. وقد تم تقييم الآباء والجيل الأول والثانى تحت بيئتين حرار يتين عن طريق الزراعة فى الميعاد الأمثل والمتأخر.

أظهرت النتائج ما يلى :-

١- وجود اختلافات معنويا بين التراكيب الوراثية في كل من الجيل الأول والثانى وميعادى الزراعة. وقد تسببت الزراعة المتأخرة فى نقص عدد أيام التزهير والنضج وفترة امتلاء الحبوب وعدد السنابل/ النبات وعدد الحبوب بالسنبلة

ووزن ١٠٠حبه ومحصول الحبوب بالنسب المئوية التالية (١٣,٢ ، ٦,٦) ، (١٣,٨ ، ٩,٦) ، (١٢,٦ ، ١٥,٠)، (٧,٦ ، ٧,٤) ، (٢,١ ، ١,٧)، (١٦,١ ، ١٤,٣) ، (٢٠,٩ ، ٣١,٢) فى الجيل الأول والثانى علــى التــوالى بالمقارنة بالميعاد الأمثل.

٢- اظهر متوسط الأداء ومعامل الإجهاد الحراري أن الأصناف جيزة ١٦٤ ، جيزة ١٦٨، ،سدس١ هى افضل الآباء بالنسبة لمحصول الحبوب تحــت الزراعــة المثلي والأصناف جيزة ١٦٤ ، جيزة ١٦٨، سخا ٩٣ وكذلك العــشائر مــن الجيل الثانى (جيزة ١٦٤× جيزة ١٦٨) ، (جيزة ١٦٤× سخا ٩٣) ، (جيــزة ١٦٤× سدس١) ، (جيزة ١٦٤× دبيرة) افــضل التراكيــب الوراثيــة تحــت الزراعة المتأخرة(الإجهاد الحر أرى).

٣- كانت القدرة العامة والخاصة على الائتلاف معنوية لكل الصفات التى درست في كل من الجيليين وميعادى الزراعة ماعدا صفتى عدد السنابل / النبات ووزن ١٠٠حبه .

٤- وجد أن المكون الوراثى المضيف والسيادى معنوي لغالبية الــصفات تحــت الدراسة في كل من الجيلين وميعادى الزراعة وهذه النتائج تؤكد أهميــة التأثير الجينى المضيف لغالبية الصفات بالاضافة الى التاثير الــسيادى فــى التحكم فى هذه الصفات.

٥- وجد من تقدير درجة التوريث بالمعنى الواسع أنها عالية نسبيا لكل الــصفات آلتي درست ماعدا صفة عدد السنابل/ النبات حيث كانت متوســطة ، ووزن ١٠٠حبه كانت منخفضة ومن ناحية أخرى كانت درجة التوريــث بــالمعنى الضيق متوسطة ماعدا صفة عدد السنابل/ النبات حيث كانت منخفضة.

يتضح من النتائج السابقة أن بعض التراكيب الوراثة يمكن الاستفادة منها فى التربيــة للتبكير وتحمل الحرارة فى الأجيال الانعزالية .