EFFECT OF HEAT STRESS ON SOME AGRONOMIC TRAITS OF BREAD WHEAT (*TRITICUM AESTIVUM,* L) GENOTYPES UNDER UPPER EGYPT CONDITIONS

Salah El-din A. Abd-Elmajeed; Ali M. Mousa and Abd El-Kareem A. Abd El-Kareem
National Wheat Program, Field crops Res. Inst., Agric. Res. Center, Giza.

ABSTRACT

Combined analysis of variance for all studied traits in twelve bread wheat genotypes showed highly significant differences among lines and sowing dates, as well as, the lines x sowing date interaction which showed significant and highly significant for all traits except grain yield. Delaying the sowing date to 20 December reduced grain yield, 1000 kernel weight, accumulated growing degree days (GDD), and duration of grain filling period by 30.0, 6.2, 10.3, and 11.4%, respectively when compared to normal sowing date (20 December), while the rate of grain filling period was increased by 7% when compared to the optimum sowing date (25 November).

Susceptibility index “s” for grain yield showed that lines 1, 2, 3, 7, 9 and 10 were the most tolerant lines to high temperature, meanwhile the other lines were the more susceptible. Line number 5 recorded the highest grain yield, longest duration with medium rate of grain filling under late sowing date. These results indicated that the tolerant lines may have genes controlling tolerance to heat stress. Hence, they could be use as parents in breeding programs in Upper Egypt.

Key Words: Genotypes, Growing degree days, Filling period and Temperature

INTRODUCTION

High temperature during grain filling is an important factor that drastically reduces wheat production in Upper Egypt. The reduction of grain yield results from: I) reduced numbers of grains/spike; II) shorter grain filling duration ; and III) assimilation inhibition of sucrose in grain. Heat stress reduces yield of wheat sown in December or January, however, some farmers used to seed wheat during these two months in the region. Genetic variation for rate and duration of grain filling has been observed in spring wheat (Darroch and Baker, 1990; Hunt *et al*., 1991; Darroch and Baker 1995; Abdel-Karim, 1998; El-Morshidy *et al*., 2001).

Vitkare *et al*. (1990) studied the effect of temperature during post-anthesis period on duration of grain filling and 1000 - grain weight in four early-maturing wheat cultivars in1987-88, sown on five sowing dates at 15 days intervals between 17 Nov. and 15 Jan. in order to produce variations in temperature during grain filling period. Results showed that duration of the grain filling period and 1000 -grain weight were decreased progressively with delay in sowing. An increase of 1°C in temperature during the post anthesis period decreased 1000- grain weight by an average of 4.33 gm and duration of the grain filling period by 2.185 days.

Rosenzweig (1991) reported that high temperature was the major cause of yield reduction because of shortening crop life cycle occurred with corresponding decreases in grain filling. Under controlled conditions from 25 to 35º C, mean grain weight declined by 16% for each 5° C increase in temperature (Asana and williams, 1965). In pot experiments, grain yield decreased by 17% for each 5°C increase over the optimum temperature (Wattal, 1965).

Reduction of grain growth by heat stress, may be explained mostly by effects of temperature on rate and duration of grain growth. Research on the effects of brief periods of ear warming after anthesis on ear metabolism have identified differential responses of starch and nitrogen accumulation in grain. (Bhullar and Jenner, 1983; Jenner 1991 (a and b); Hawker and Jenner, 1993; Shpiler and Blum (1986) reported that high temperature during the grain filling stage reduced grain weight due to reduction of grain filling duration but not rate of grain filling. High grain filling (GF) rates and short to medium GF durations are desirable breeding objectives for environments where the growing season is frequently shortened by heat and drought stress (Bruckner and Frohberg, 1987)

Sayed and Gadallah (1983) reported that grain yield was related to grain filling rate but not duration. Al-Khatib and Paulsen (1984) suggested that grain-filling rate decreased from the lowest to the highest temperature, but the change was smaller than the decrease in grain filling duration at the same temperature. Sayed and Ghandorah (1984) reported that under warm dry conditions, wheat cultivars with high GFRs and short GFDs could produce higher yields. However, Ahmed *et al*. (1994) suggested that high temperature during the post-anthesis period of late sowing wheat shortened the grain filling period resulting in a smaller endosperm, less grain weight and increased protein content. The high grain yields were associated with long grain filling periods, high rate of grain filling and high grain weight (Ghandorah,1989). El-Morshidy *et al*. (2001) found that high temperature (late planting date) reduced grain weight/main spike and duration of grain filling by 10.97 and 12.5%, respectively, when compared with the optimum planting date, while it accelerated the rate of grain filling by 5.55%.

The main objective of this work was to study the effect of heat stress on grain filling, as well as to estimate the parameters controlling grain weight and the duration of grain filling period and grain filling rate.

MATERIALS AND METHODS

The present investigation was carried out at the Agricultural Research Stations of El-mattana and New Valley in 2001/2002 and 2002/2003 seasons. Eleven selected lines and one local cultivar (Table 1) were grown under heat stress (late sowing date) and non-stress (optimum sowing date). The optimum sowing date was on 25 November, while the late was on 20 December in randomized complete block design (RCBD) with 4 replications.The experimental plot consisted of 6 rows, 3.5 m long and 20cm between rows. The recommended cultural practices of wheat production were applied throughout the growing season. The heat susceptibility index for each entry was computed according to Fischer and Maurer (1978) as follows:

$S = (1- Yd/ Yp) / D$ where;

Yd = average grain yield of the entry in stress environment,

Yp = average grain yield of the entry in non-stress environment,

D = environmental stress intensity; = 1-(mean Yd of all genotypes/mean Yp of all genotypes).

Accumulated growing degree days (GDD) were calculated by summing daily degree days calculated as follow: Tn = (T max.+ T min.) /2–Tb. Where, T max. and T min. are the maximum and minimum daily temperature and Tb is a base temperature of 5°C was used (Yasuda and Shimoyama,1965).

Data were recorded on The nine studied traits i.e.: (1) days to heading (DH), (2) days to maturing (DM), (3) grain yield (GY), (4) 1000-kernel weight (KW), (5) number of kernels/spike (KS), (6) number of spikes /m2 (SP/ M^2), (7) growing degree days (GDD), (8) duration of grain filling period (DGFP), and (9) rate of grain filling (RGF).

Average rate of grain filling was calculated by dividing 1000- kW by the duration of grain filling, while, grown degree-days was estimated as accumulated grown degree days from anthesis to the calculated point of physiological maturity. The combined analysis of variance performed according Gomez and Gomez (1984). Twelve genotypes under study are shown in Table(1). The average minimum and maximum temperatures prevailed during the post heading period at the two locations in the two seasons are given in Table(2).

Table (1). The twelve wheat genotypes tested in 2001/2002 and 2002/2003 season.

Entry No.	Name / Cross	Origin
1	Giza 165	Egypt
2	KAUZ*2/TRAP/ / KAUZ	Mexico
3	KAUZ*2/ YACO/ / KAUZ	Mexico
4	KAUZ*2/ MNV/ / KAUZ	Mexico
5	Tevee ‘S’ / Kaus ‘S’	Syria
6	Mexipak 65	Syria
7	Kaus ‘S’	Syria
8	MYNA/VUL//TURACO/3/TURACO	Syria
9	Prl ‘S’ /Vee ‘S’ /3/P106. 19//soty/Jt*3	Syria
10	CHAM 2/VEE ‘S’	Syria
11	Seri 82//Shuha ‘S’	Syria
12	Tevee ‘v’//Vee ‘s’/pvn ‘S’	Syria

Table 2

RESULTS AND DISCUSSION

At Upper Egypt, the optimum sowing date of spring wheat in the second half of November, heading occurs during February, and grain filling duration (from anthesis to physiological maturity) is completed until end of April, whereas in late sowing, heading usually occurs from the mid of March, and grain filling duration is completed until the end of May. Combined analysis of variance for all studied traits showed highly significant differences among lines and sowing dates as well as the lines x sowing date interaction which showed significant and highly significant for all traits except grain yield (Table 3).

Table (3). Combined analysis of variance over years, locations, sowing dates and genotypes for the studied traits.

S.O.V	d.f.	DH	DM	GY	1000kW	K/SP	SP/M^2	GDD	DGFP	RGF
Year	1	682.667**	8664.0**	7.784**	714.905**	214.562*	411995.010**	281921.31**	4414.59**	0.000
L (Y)	2	1786.302**	6049.594**	47.529**	1473.948**	2977.453**	342152.755**	1861964.25**	2742.01**	0.021**
R (LY)	12	8.679**	11668**	0.238**	13.756	40.700	1751.401**	17028.93**	3.14	0.000**
Factor(A)	1	9600.000**	19694.010**	36618**	1721.739**	249.776*	2169009.375**	77996880**	1872.67**	0.015**
Y x A	1	661.500**	1675.010**	3.161**	16.796	1002.011**	31212.094**	18085.43**	204.17**	0.002
LA (Y)	2	1399.427**	1177.083**	1.545**	29.363	2186.447**	1138478.818**	6717234**	61.27**	0.001**
Factor.(B)	11	53.394**	25006**	0.523**	167.110**	115.488*	3541.205**	383393	25.53**	0.000**
YB	11	7.792**	6.824**	0.063	29.868*	47.779	1530.885**	2226.58	4.61*	0.000*
LB (Y)	22	3.467**	9.332**	0.090*	40.511**	121.343**	2506.488**	2072.65	6.49**	0.000
AB	11	4.500**	10.834**	0.052	25.262*	116.243*	1618.511**	10978.13**	6.72**	0.000*
Y x A x B	11	3.784**	7.596**	0.111*	12.808	63.194	1146.196**	4615.37*	7.82**	0.000
LAB(Y)	22	3.217**	5.595**	0.064	35.219**	42.652	1518.507**	3061.34	6.87**	0.000**
Error	276	1.414	1.710	0.059	13.392	62.509	437.338	2482.34	2.68	0.000
CV%		1.46	1.11	16.49	9.68	16.50	8.9	7.18	4.58	26.77

* Significant at P> 0.05. ** Significant at P> 0.01.

As shown in Table (4 and 5)delaying the sowing date reduced grain yield, 1000-kernel weight, accumulated growing degree days (GDD), and duration of grain filling period by 30.0,6.2,10.3, and 11.4%, respectively, when compared with normal sowing date. However, the rate of grain filling was increased by 7% when compared with normal sowing date. The reduction may be due to increases in temperature during grain filling period which lead to early maturing, hence decreasing both the duration of grain filling period (DGFBs) and accumulated growing degree days (GDDs). These findings are in line with those reported by Rao *et al*. (1980), Ismail (1995), and Abdel-Karim (1998)

Results of rate grain filling (RGF) (Table 5), showed that the lines in the late sowing date had high rate of grain filling compared to the recommended sowing date, because high temperature during grain filling in the late sowing date tended to decrease grain growth period and hasten physiological maturity. Similar results obtained by El-Morshidy *et al*. (2001).

These results indicated that wheat genotypes under study had responded differently to heat stress, this show the importance of sowing date to identify the best lines which are tolerant to heat stress. These resultes agree with those reporeted by Bruckner and Frohberg (1987), Darroch and Backer (1995), Abdel-Karim (1998) and El-Morshidy *et al*. (2001)

Table 4

Average daily temperature during duration of grain filling were 26.7 and 29.1 (Table 2) under recommended and late sowing dates, respectively, grain maturity might have affected by high temperature which caused kernels to be sprinkled. Semilar results were obtained by Fischer and Maurer (1976) and Samre *et al*. (1989).

High temperature at post anthesis period of late sowing shortened the grain filling period and 1000-kernel weight, hence increasing of grain yield, same results were reported by Ahmed *et al*.(1994) and Abdel-Karim (1998).

Tabel 5: Average of accumulated growing degree days (GDD), duration of grain filling period (DGFP) and rate of grain filling period (RGFP) for 12 Lines under normal(N) and late planting dates(L) across locations and seasons.

Lines	GDD			DGFP			RGFP		
	N	L	Mean	N	L	Mean	N	L	Mean
1	691.594	666.075	678.834	36.375	32.438	34.406	0.050	0.036	0.043
2	702.000	655.281	678.641	37.625	33.688	35.656	0.047	0.033	0.040
3	713.094	655.781	684.438	36.250	32.750	34.500	0.050	0.036	0.043
4	723.906	656.719	690.313	37.688	33.438	35.563	0.046	0.032	0.039
5	735.063	658.656	696.859	38.313	34.813	36.563	0.052	0.036	0.044
6	742.848	659.438	701.141	37.250	33.938	35.594	0.047	0.032	0.040
7	750.063	607.656	678.859	38.875	34.813	36.844	0.044	0.031	0.038
8	754.813	654.813	704.813	37.625	32.063	34.844	0.042	0.028	0.035
9	758.406	653.000	705.703	39.000	33.875	36.438	0.044	0.031	0.038
10	761.719	648.063	704.891	37.250	33.000	35.125	0.048	0.038	0.043
11	764.063	639.563	701.813	40.000	33.938	36.969	0.037	0.036	0.037
12	763.625	629.500	699.063	39.063	33.563	36.313	0.046	0.035	0.040
Mean	738.849	648.712	693.780	37.943	33.526	35.734	0.046	0.034	0.040
LSD0.05	26.361	49.627	25.282	1.217	1.177	0.831	0.007	0.010	0.005

The relationships between duration and rate of grain filling and final grain weigh are important. Many researchers have found a positive association between rate of grain filling and final grain weight in wheat (Van Sanford, 1985; Bruckner and Frohberg, 1987; Hunt *et al*. 1991).

With regard to susceptibility index “S” for grain yield in Table (4) showed that the lines 1, 2, 3, 7, 9,and 10 were the most tolerant which had “S” less than one, meanwhile another lines were the most susceptible which had “S” more than one. These results indicated that the tolerant lines may be had genes controlling tolerance to heat stress. Hence, we can use these lines as parents in breeding programs in Upper Egypt.

Results showed that line No. 5 was the earliest maturing and the highest in grain yield (Table 4 and 5), long duration and medium in rate of grain filling under late sowing date (Table 5).

From the previous results to be clear up, the best plan for such hot environments is to sow late maturing cultivars early in the season, and to sow early maturing cultivars late where farmers have to plant wheat late in the season.

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تأثير الحرارة على بعض الصفات الزراعية لبعض سلالات قمح الخبز تحت ظروف مصر العليا

صلاح الدين احمد عبد المجيد ، علي مصطفي موسى وعبد الكريم احمد عبد الكريم
البرنامج القومي لبحوث القمح – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

تم إجراء هذا البحث بمحطتي البحوث الزراعية بالمطاعنة والوادي الجديد خلال موسمي الزراعة ٢٠٠٢/٢٠٠١ و ٢٠٠٣/٢٠٠٢ وذلك بهدف دراسة تأثير الحرارة العالية علي امتلاء الحبوب. وقد تم زراعة إحدى عشر سلاله من قمح الخبز بالاضافه ألي الصنف المحلي جيزة ١٦٥ وذلك في ميعادي زراعة مختلفين. وقد أظهرت تحليل التباين المشترك لكل الصفات المدروسة وجود فروق معنوية عالية بين السلالات ومواعيد الزراعة كما تراوح التفاعل بينهما بين المعنوي و عالى المعنوية لكل الصفات المدروسة فيما عدا محصول الحبوب. وقد أدى تأخير الزراعة الي نقص في محصول الحبوب ووزن الآلف حبه ودرجات حرارة النمو المجمعة وفترة امتلاء الحبوب بمعدل ٣٠ و ٦.٢ و١٠.٣ و١١.٤ % علي التوالي وذلك بالمقارنة بالزراعة في الميعاد الأمثل بينما زاد معدل امتلاء الحبوب بمعدل ٧% عندما قورن بالزراعة في الميعاد الأمثل. وقد اظهر معامل الحساسية لمحصول الحبوب أن السلالات ١ و٢ و٣ و٧ و ٩و ١٠ غالبا متحمله للحرارة العالية بينما السلالات الأخرى كانت اكثر حساسية. تشير النتائج إلي احتمال أن السلالات المتحملة للحرارة ربما تحتوى على بعض الجينات التي تتحكم في التقسية الحرارية ومن ثم يمكن استخدامها كأباء في برنامج التربية تحت ظروف مصر العليا. وتعتبر السلالة رقم ١٢ الأعلى في المحصول وذات فتره طويلة في امتلاء الحبوب ومتوسطة في معدل امتلاء الحبوب وذلك تحت ظروف الزراعة المتأخرة.