

<http://www.pjbs.org>

**PJBS**

ISSN 1028-8880

# **Pakistan Journal of Biological Sciences**

**ANSI***net*

Asian Network for Scientific Information  
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

## Screening of Wheat (*Triticum aestivum* L.) Genotypes for Some Important Traits Against Natural Terminal Heat Stress

<sup>1</sup>Ubaidullah, <sup>1</sup>Raziuddin, <sup>2</sup>Tila Mohammad, <sup>3</sup>Hafeezullah, <sup>1</sup>Sardar Ali and <sup>1</sup>Abdul Wahab Nassimi

<sup>1</sup>Department of Plant Breeding and Genetics, NWFP Agricultural University, Peshawar, Pakistan

<sup>2</sup>Crop Breeding Division, Nuclear institute for Food and Agriculture, Peshawar, Pakistan

<sup>3</sup>Department of Agronomy, NWFP Agricultural University, Peshawar, Pakistan

**Abstract:** Wheat production is often reduced by terminal heat stress therefore present study was aimed to characterize wheat genotypes for their heat tolerance for some important traits. Plant material was composed of sixteen wheat (*Triticum aestivum* L.) genotypes including two check cultivars. Wheat genotypes were sown in the field at two dates i.e., November 15 (normal sowing) and December 13 (delayed sowing) during winter seasons of 2003-2004 and 2004-2005. Combined analysis of variance (for two years) showed that mean values for years were highly significant at  $p \leq 0.01$  for majority of the traits, differences were significant ( $p \leq 0.05\%$ ) for grain filling duration while non-significant for days to emergence. For seasons; differences were highly significant for all parameters, whereas for genotypes; the differences were highly significant for all parameters except grain filling duration where differences were non significant whereas, response for different interactions was variable. In present experiment, generally late sowing imposed negative effects on all traits. However, two years combined data showed that minimum difference between early and late sowing was 23 days for heading (CT-4), 7 cm for leaf area (CT-12, 13 and 14), 6.3 cm for plant height (CT-10) and 3 days for grain filling duration (CT-9) whereas, CT-10 matured 29 days earlier when sown late in comparison to the normal sowing time. From the experiment it was concluded that CT-4 and CT-10 had built in terminal heat stress escape mechanism which could be used for the development of new early maturing variety.

**Key words:** Wheat, *Triticum aestivum* L., terminal heat stress, flag leaf area, grain filling duration

### INTRODUCTION

Wheat is the world primer crop since it supplies 72% of the calories and protein in the average diet (Heyne, 1987) therefore; its grain and products are important components of our daily diet. The average per capita consumption of wheat in the country is 318 g daily contributing 83% of the total cereal intake (Byerlee *et al.*, 1986). In addition, more than half of the daily requirements of iron and riboflavin are met by amount of wheat available to an adult man.

In Pakistan area under wheat cultivation remained nearly constant in last two decades due to the cropping intensity and crop competition with little prospect of further increasing acreage in near future. Area under wheat is reported to be 8.2162 million hectares, out of which 7.1278 million hectares is irrigated and 1.0884 million hectares entirely depends on natural precipitation with an average yield of 2555 and 1182 kg ha<sup>-1</sup> from irrigated and rainfed area, respectively (Anonymous, 2005). This indicates that wheat yield of the country is quite low both in irrigated and rain fed area is very low in comparison to

its potential yield. The main reasons for lower yield of wheat per unit area in Pakistan are; delayed sowing due to late picking of cotton and late harvesting of sugarcane and rice crops, use of poor quality seed, imbalance use of fertilizers, shortage of irrigation water especially in rain-fed areas, infestation of weeds and diseases and unwanted rain showers at the harvest and many others. Among the environmental factors delayed sowing is one of the most crucial non-monetary factors for the growth and grain yield of wheat. It has been reported that 50% of wheat in Pakistan is planted late i.e., during the month of December. According to Khan (2003) a yield loss of 42 kg ha<sup>-1</sup> day or 1% day occurs if planting is delayed from 10th November until 10th January. For obtaining good and healthy crop it must be provided with optimum climatic conditions during its various stages of growth and development.

Continual and terminal heat stress is a problem in 40% of the wheat growing areas of the world (Fisher and Byerlee, 1991) whereas, damage due to heat stress under late planting conditions has become an important factor

limiting wheat yields in many parts of the Asian subcontinent, due to the rice-wheat cropping system (Aslam *et al.*, 1989). Terminal or late heat stress especially during anthesis and grain filling stage of the late planted wheat is the major constraints of wheat yield (Macas *et al.*, 2000; Khalifa *et al.*, 1998). Growing food demand for the growing population and global warming is further pushing the wheat crop to heat stress environments (Chopra and Viswanathan, 1999).

Increased heat tolerance in late planted wheat is very essential to enhance and stabilize wheat productivity (Talbert *et al.*, 2000; Dhanda and Sethi, 2002). Therefore breeding efforts at selecting genotypes with increased heat tolerance is therefore, one of the most vital objectives in wheat improvement programs (Macas *et al.*, 2000). The sources of identifiable heat stress tolerance traits and availability of simple, fast and reliable screening test for heat tolerance have been major limitations of these programs.

Keeping in view the importance of wheat and its lower yield due to terminal heat stress imposed by late sowing in the country, an experiment was conducted to observe the influence of planting dates on final outcome in terms of various qualitative traits by comparing their performance with normal sowing. The executions of this research lead to the identification and selection of the improved wheat genotypes showing built-in genetic tolerance to late planting/terminal heat stress. This material could be utilized for development of early maturing high yielding, widely adapted and good quality varieties particularly suitable for cultivation under late planting conditions in the country.

## MATERIALS AND METHODS

To study the response of wheat genotypes to heat stress and to determine suitable planting time of wheat genotypes introduced from CYMMIT, an experiment was

conducted in which sixteen wheat genotypes were tested at Nuclear Institute for Food and Agriculture (NIFA) Tarnab, Peshawar in two consecutive years 2003-04 and 2005. The list of genotypes along with their entry number and pedigree are given in Table 1.

Genotypes were evaluated for some important traits under normal (15th November) and delayed planting (13th December) conditions in RCBD design. Seeds of each genotype were planted in four rows of 2.5 m each. Row to row and plant to plant space were kept 50 and 30 cm, respectively. The experiment was replicated thrice. Normal agricultural practices e.g., hoeing, weeding, fertilizer application and irrigations were applied.

Ten plants from the two central rows of each genotype from each replication at random were selected for data recording. Days to 80% emergence were recorded from the date of sowing till 80% of the seedlings emerged from the soil and were clearly visible. Days to 50% heading (stage when ears emerged after the unfolding of the flag leaf) were recorded from the date of sowing to the date of 50% heading. Flag leaf area (cm<sup>2</sup>) was measured in centimeter using the formula suggested by Muller (1991) i.e., maximum width×length×0.74. Plant height (cm) was recorded from the base of plant to the tip of the spike, excluding awns of the main tiller in centimeter. Grain filling duration was recorded as the period from anthesis/pollination to physiological maturity. Days to physiological maturity were recorded as the period from date of sowing to the date of maturity (when 90% of the crop turned yellow). Data recorded was then statistically analyzed with the help of computer software, MSTAT-C.

## RESULTS AND DISCUSSION

According to combined analysis of variance (Table 2) mean squares for main factors viz., for years; differences were highly significant for days to heading,

Table 1: List of wheat genotypes with their parentage and pedigree used to study the effects of terminal heat stress on some important traits

Genotypes	Line	Parentage and pedigree
CT-1	CT-02055	MRL/BUC/VEENo.7/3/URES/PRL CMSS92M00145S-015M-0Y-0Y-050M-13Y-3M-0Y
CT-2	CT-02361	KAMBARAI CGSS95B00016F-099Y-099B-099Y-099B-23Y-0B
CT-3	CT-02362	KAMBARAI CGSS95B00016F-099Y-099B-099Y-099B-24Y-0B
CT-4	CT-02390	FRET2 CGSS96Y00146T-099B-099Y-099B-12Y-0B
CT-5	CT-02019	KAUZ//STAR/LUCO-M CMBW90M4986-OTOPY-47M-015Y-015M-2Y-0B
CT-6	CT-02009	PUNJAB-96-OPAK
CT-7	CT-02173	LIRA//BUC/PVN/3/HEL/3*/CNO79//2*SERI/4/PRLII/ CMSS93Y02800T-8Y-010Y-010M-010Y-9M-0Y
CT-8	CT-02192	SW89.5277/BORL95//SKAUZ CMSS93Y03172T-19Y-010M-010Y-010M-4Y-3M-0Y
CT-9	CT-02314	KAKATSI CG68-099Y-099M-10Y-1M-2Y-0B
CT-10	CT-02375	PEWIT2 CGSS96Y00139T-099B-099Y-099B-23Y-0B
CT-11	CT-02193	SW89.5277/BORL95//SKAUZ CMSS93Y03172T-19Y-010M-010Y-010M-5Y-1M-0Y
CT-12	CT-01286	CNDO/R143/ENTE/MEXI_2/3/... CMSS93B01824M-040Y-73Y-010M-010Y-010M-1Y-0M
CT-13	CT-02003	EVD2-1 1012/KAUZ CM104386-0AP-0L-2AP-0AP-2AP-0TS-0AP
CT-14	CT-02204	KAUZ/PASTOR CMSS93B00025S-48Y-010M-010Y-010M-2Y-0M
Bakhtawar-92	Check	KAUZ S CM 67458-4Y-1M-3Y-1M-5Y-0B
Saleem-2000	Check	SHAM-6//KITE/PGO

Table 2: Mean square values for emergence, heading, flag leaf area, plant height, maturity and grain filling duration of wheat genotypes for terminal heat stress

Mean values							
Source	DF	DEM	DHD	FLA	PHT	DMT	GFD
Year	1	0.1 <sup>NS</sup>	2581.3**	636.6**	2871.4**	4265.8**	112.5*
Season	1	4.6**	30401.3**	2245.4**	9668.8**	47470.6**	2248.5**
Y×S	1	0.2 <sup>NS</sup>	338.0**	118.1*	267.7**	2373.0**	18.1 <sup>NS</sup>
R (L.Y)	8	1.2	4.5	12.3	26.6	4.2	18.9
Genotype	15	2.5**	23.5**	263.6**	628.6**	6.5**	21.4 <sup>NS</sup>
Y × G	15	0.2 <sup>NS</sup>	5.1**	75.9**	39.4**	5.8*	13.7 <sup>NS</sup>
S × G	15	1.5**	11.6**	83.9**	42.6**	7.8**	20.2 <sup>NS</sup>
Y×S×G	15	0.2 <sup>NS</sup>	5.5**	36.0*	23.0*	4.2 <sup>NS</sup>	21.1 <sup>NS</sup>
Error	120	0.2	1.4	20.2	12.8	3.2	16.5
Total	191						

DF = Degree of Freedom, DEM = Days to emergence, DHD = Days to heading, FLA = Flag Leaf Area, PHT = Plant Height, DMT = Days to maturity, GFD = Grain filling duration, \*\* = Significant at  $p \leq 0.01$  probability level, \* = Significant at  $p \leq 0.05$  probability level NS = Non Significant at  $p \leq 0.05$

Table 3: Mean values for days to emergence of wheat genotypes grown in normal and late conditions

Genotypes	2003-2004			2004-2005			Combined		
	Normal	Late	Diff.	Normal	Late	Diff.	Normal	Late	Diff.
CT-1	6	15	-9	6	15	-9	6	15	-9
CT-2	6	15	-9	6	15	-9	6	15	-9
CT-3	6	15	-9	6	15	-9	6	15	-9
CT-4	5	14	-9	5	14	-9	5	14	-9
CT-5	6	15	-9	6	15	-9	6	15	-9
CT-6	6	15	-9	6	15	-9	6	15	-9
CT-7	6	15	-9	6	15	-9	6	15	-9
CT-8	6	17	-11	6	17	-11	6	17	-11
CT-9	6	16	-10	6	16	-10	6	16	-10
CT-10	5	15	-10	5	15	-10	5	15	-10
CT-11	6	17	-11	6	17	-11	6	17	-11
CT-12	6	15	-10	6	17	-12	6	16	-10
CT-13	6	17	-11	5	17	-11	6	17	-11
CT-14	6	16	-10	6	16	-10	6	16	-10
Bakhtawar-92	6	16	-10	6	16	-10	6	16	-10
Saleem-2000	5	15	-10	5	15	-9	5	15	-10

flag leaf area, plant height and days to maturity, differences were significant for grain filling duration while non-significant for days to emergence. For seasons; differences were highly significant for all parameters studied, whereas for genotypes; the differences were highly significant for all parameters except grain filling duration where differences were non significant. Variable responses were observed for interactions of the main factors, viz. Y×S, Y×G, S×G and Y×S×G.

**Days to emergence:** During 2003-04, the data for day to emergence ranged from 5 (for CT-4 and CT-10) to 6 days (all other genotypes) for normal sowing and 14 days (CT-4) to 17 days (CT-8, CT-11 and CT-13) for late sowing. The difference between mean values of early and late sowing for emergence ranged from -9 to -11 days (Table 3). In 2004-05, data for emergence ranged from 5 days (CT-4, CT-10, CT-13 and Saleem 2000) to 6 days (all other genotypes) for normal sowing and 14 days (CT-4) to 17 days (CT-8, CT-11, CT-12 and CT-13) for late sowing. The difference between normal and late sowing ranged from -9 days (CT-1 to CT-7 and Saleem 2000) to -12 days (CT-12). The over all two years (2003-05)

combined data for emergence showed a range of 5 days (CT-4, CT-10 and Saleem-2000) to 6 days (for rest of the genotypes) in normal sowing and 14 days (for CT-4) to 17 days (CT-8, CT-11 and CT-13) for late sowing whereas the differences ranged from -9 (CT-13) to -12 days (CT-1 to 7).

In our experiment generally early sowing produced earlier seedlings with few exceptions. Similarly, Micanovic *et al.* (1994) reported negative effect of delayed sowing on seedling emergence.

**Days to 50% heading:** In 2003-04, the data for 50% heading ranged from 118 days (CT-4) to 127 days (CT-14) for normal sowing and 88 days (CT-8) to 94 days (CT-5) for late sowing (Table 4). The difference ranged from 28 to 36 days for CT-4 and CT-13 and CT-14 respectively. During 2004-05 the data ranged from 119 days (CT-7) to 126 days (CT-14) for normal sowing and 102 days (CT-12 and CT-13) to 108 days (CT-5, CT-6 and Saleem-2000) for late sowing. The difference between sowing ranged from 15 (CT-5 and Saleem-2000) to 24 days (CT-12). The overall data for two years ranged from 120 (CT-2 and CT-11) to 127 days (CT-14) in normal sowing while data for late

Table 4: Mean values for days to 50% heading of wheat genotypes grown in normal and late conditions

Genotypes	2003-2004			2004-2005			Combined		
	Normal	Late	Diff.	Normal	Late	Diff.	Normal	Late	Diff.
CT-1	124	91	33	124	105	18	124.0	98.0	26.0
CT-2	121	90	31	123	104	19	122.0	97.0	25.0
CT-3	120	91	29	123	104	19	121.5	97.5	24.0
CT-4	118	90	28	122	104	18	120.0	97.0	23.0
CT-5	125	94	31	124	108	15	124.5	101.0	23.5
CT-6	123	93	31	126	108	17	124.5	100.5	24.0
CT-7	122	91	31	119	104	16	120.5	97.5	23.0
CT-8	120	88	31	121	104	17	120.5	96.0	24.5
CT-9	124	89	35	123	105	18	123.5	97.0	26.5
CT-10	121	90	31	122	106	16	121.5	98.0	23.5
CT-11	122	90	33	122	104	17	122.0	97.0	25.0
CT-12	125	92	33	126	102	24	125.5	97.0	28.5
CT-13	126	90	36	124	102	21	125.0	96.0	29.0
CT-14	127	91	36	126	104	22	126.5	97.5	29.0
Bakhtawar-92	123	91	33	123	105	18	123.0	98.0	25.0
Saleem-2000	123	91	33	123	108	15	123.0	99.5	23.5

Table 5: Mean values for flag leaf area (cm<sup>2</sup>) of wheat genotypes grown in normal and late conditions

Genotypes	2003-2004			2004-2005			Combined		
	Normal	Late	Diff.	Normal	Late	Diff.	Normal	Late	Diff.
CT-1	40.4	26.2	14.1	42.1	26.2	15.9	41.3	26.2	15.1
CT-2	41.3	32.2	9.1	44.0	30.8	13.1	42.7	31.5	11.2
CT-3	43.8	30.6	13.1	30.5	30.6	-0.1	37.2	30.6	6.6
CT-4	46.2	32.6	13.6	39.6	32.6	6.9	42.9	32.6	10.3
CT-5	49.6	31.1	18.5	48.6	31.1	17.4	49.1	31.1	18.0
CT-6	56.6	34.9	21.7	33.5	34.9	-1.5	45.1	34.9	10.2
CT-7	34.1	27.9	6.2	33.4	27.9	5.5	33.8	27.9	5.9
CT-8	45.0	35.6	9.4	35.8	35.6	0.2	40.4	35.6	4.8
CT-9	49.5	44.8	4.7	49.5	44.8	4.7	49.5	44.8	4.7
CT-10	44.2	40.5	3.7	44.2	40.5	3.7	44.2	40.5	3.7
CT-11	48.3	44.8	3.5	48.3	44.8	3.5	48.3	44.8	3.5
CT-12	41.0	41.0	0.0	32.5	32.5	0.0	36.8	36.8	0.0
CT-13	38.3	38.3	0.0	40.8	40.8	0.0	39.6	39.6	0.0
CT-14	43.0	43.0	0.0	40.7	40.7	0.0	41.9	41.9	0.0
Bakhtawar-92	45.0	31.8	13.2	34.9	26.2	8.8	40.0	29.0	11.0
Saleem-2000	43.2	31.8	11.5	32.4	26.3	6.1	37.8	29.1	8.7

sowing ranged from 96 days (CT-8 and CT-13) to 101 days (CT-5). CT-7 showed minimum difference (23 days) while CT-12, CT-13 and CT-14 showed the maximum difference of 29 days.

In our experiment earlier heading was recorded for all genotypes in late sowing in comparison to early sowing which could possibly be due to terminal heat stress. The present findings are in agreement to Waraich *et al.* (1982) who reported earlier 50% heading delayed due to sowing. Our results are also supported by Ihsanullah and Mohammad (2001) who reported genetic differences among wheat genotypes for days to heading. However, Khalifa *et al.* (1998) found variable response for days to heading depending upon the genotypes.

**Flag leaf area:** In 2003-04, data for flag leaf area ranged from 34.1 (CT-7) to 56.6 cm<sup>2</sup> (CT-6) for normal sowing and 26.2 (Bakhtawar-92) to 44.8 cm<sup>2</sup> (CT-9 and CT-11) for late sowing. The difference between normal and late sowing ranged from 21.7 (CT-6) to 0.0 (CT-12, CT-13 and CT-14) (Table 5). In 2004-05, data ranged from 49.5 (CT-9) to 30.5 cm<sup>2</sup> (CT-3) for normal sowing and 44.8 (CT-9) to 26.2 cm<sup>2</sup> (CT-1) for late sowing. The maximum difference

of 17.4 was observed for CT-5, while the minimum difference (-1.5) was observed for CT-6 between normal and late sowing. Of the sixteen genotypes tested, only CT-6 produced greater flag leaf area in late sowing in comparison to early sowing (Table 5). Combined data for years (2003-05) ranged from 49.1 for CT-5 to 33.8 cm<sup>2</sup> for CT-7 in normal sowing while 44.8 cm<sup>2</sup> for CT-9 and CT-11 and 33.8 cm<sup>2</sup> for CT-1 in late sowing. The over all difference of two years showed that CT-5 showed maximum difference of 18.0 cm<sup>2</sup> while CT-12, CT-13 and CT-14 produced similar leaf area in both sowing (Table 5).

From the above data it can be concluded that generally normal sowing produced greater flag leaf area in comparison to the late sown plants. Whereas, CT-12, CT-13 and CT-14 produced similar flag leaf area in both sowing conditions. Since, biomass and canopy photosynthesis are highly related with flag leaf area and genotypic difference in flag leaf area duration, therefore, these genotypes needs to be retested and could be used in breeding programs. Similarly reduced leaf area in response to delayed sowing is reported by Ashraf and Bhatti (1998). Present results are in conformity to the

earlier findings of Micanovic *et al.* (1994) who reported reduced leaf area in response to late sowing in wheat. However, according to Lonhard (1991) late sowing retarded leaf area index but had little effect on the size of flag leaf.

**Plant height (cm):** In 2003-04, data for plant height ranged from 99.9 cm (CT-5) to 123.9 cm (CT-2) for normal sowing and 82.5 cm (CT-13) to 106.7 cm (CT-2) for late sowing (Table 6). The difference for plant height between normal and late sowing ranged from 21.3 cm for Bakhtawar-92 to 13.3 cm for CT-1. In 2004-05 data ranged from 85.2 cm (CT-5) to 114.8 cm (CT-2) for normal sowing and 72.5 cm (CT-5) to 100.4 cm (CT-10) for late sowing. The maximum difference of 21.8 cm was observed for CT-4, while the minimum difference was -2.6 cm for CT-10. Combined data for two years (2003-05) ranged from 92.6 cm (CT-5) to 119.4 cm (CT-2) in normal sowing while 77.9 cm (CT-5) to 102.5 cm (CT-2) for late sowing. The over all performance of two years showed that CT-4 showed maximum difference of 20.9 cm while the minimum difference was observed by CT-10 (6.3 cm).

All genotypes used in the present experiment produced shorter heights in response to late sowing in comparison to their early sowing. The decrease in plant height may have been occurred due to shortening of growth and photosynthetic period due to terminal heat stress associated with late sowing. The present results are in agreement with those of Mishra *et al.* (2000) who observed significantly negative effects of delayed planting on plant height. Present results are also similar to the earlier findings of Knapp and Knapp (1978). In addition, Ibrahim *et al.* (1986) found a reduction of 20% in plant height due to late sowing.

**Grain filling duration:** The data for grain filling duration (Table 7) in 2003-04 ranged from 43 days (CT-4) to 39 days (CT-1 and CT-13) for normal sowing and 38 (CT-9) to 30 days (CT-14) for late sowing. The difference between normal and late sowing ranged from 4 days (CT-9) to 10 days (CT-14). During 2004-05 the data ranged from 47 days (CT-7) to 41 days, (CT-9) for normal sowing and 39 days (CT-2, CT-3, CT-7, CT-8, CT-11 and CT-12) to 33 days (CT-5) for late sowing. The difference ranged from 3 days (CT-12) to 13 days (CT-5). The combined data for two years ranged from 40 days (CT-14) to 45 days (CT-7) for normal seasons while 33 days (CT-5) to 38 days (CT-2, CT-7, CT-8, CT-9 and CT-10) in late sowing. CT-9 showed minimum difference (3 days) while CT-5 showed maximum differences of 10 days for grain filling duration.

In our experiment generally, genotypes required more days for grain filling when grown earlier in comparison to late sowing which could have positive effects on grain yield. Negative effects of shorter growing period on all phases of plant growth such as tillering, flowering and grain filling is reported by Khan (2003). Talbert *et al.* (2000) have reported that terminal heat stress especially during grain filling stage of the late planted wheat is considered one of the major environmental factors drastically reducing wheat production. Randhawa *et al.* (1981) found lower grain filling duration in response to delayed sowing. Gebeyehou *et al.* (1982) reported that longer grain filling duration had a positive effect on kernels/spike and kernel weight.

**Days to maturity:** During 2003-04, the data for days to maturity ranged from 161 days (CT-4) to 167 days (CT-14, Bakhtawar-92 and Saleem-2000) for normal sowing and

Table 6: Mean values for plant height (cm) of wheat genotypes grown in normal and late conditions

Genotypes	2003-2004			2004-2005			Combined		
	Normal	Late	Diff.	Normal	Late	Diff.	Normal	Late	Diff.
CT-1	103.1	89.7	13.3	94.0	80.7	13.3	98.6	85.2	13.4
CT-2	123.9	106.7	17.2	114.8	98.3	16.5	119.4	102.5	16.9
CT-3	121.1	101.6	19.5	109.0	93.2	15.8	115.1	97.4	17.7
CT-4	111.5	91.5	20.0	108.0	86.2	21.8	109.8	88.9	20.9
CT-5	99.9	83.2	16.7	85.2	72.5	12.7	92.6	77.9	14.7
CT-6	108.6	92.3	16.3	93.9	77.6	16.2	101.3	85.0	16.3
CT-7	110.0	92.6	17.4	101.7	82.3	19.4	105.9	87.5	18.4
CT-8	103.1	86.6	16.5	92.7	77.0	15.8	97.9	81.8	16.1
CT-9	100.9	85.5	15.4	98.6	85.5	13.1	99.8	85.5	14.3
CT-10	115.6	100.4	15.2	97.8	100.4	-2.6	106.7	100.4	6.3
CT-11	101.0	87.1	13.9	92.4	87.1	5.3	96.7	87.1	9.6
CT-12	102.7	89.3	13.4	94.1	89.0	5.1	98.4	89.2	9.2
CT-13	102.1	82.5	19.5	90.1	83.0	7.1	96.1	82.8	13.3
CT-14	101.0	85.9	15.1	93.5	87.0	6.5	97.3	86.5	10.8
Bakhtawar-92	105.6	84.2	21.3	88.0	74.5	13.5	96.8	79.4	17.4
Saleem-2000	100.0	84.2	15.8	89.6	79.9	9.7	94.8	82.1	12.7

**Table 7: Mean values for grain filling duration of wheat genotypes grown in normal and late conditions**

Genotypes	2003-2004			2004-2005			Combined		
	Normal	Late	Diff.	Normal	Late	Diff.	Normal	Late	Diff.
CT-1	39	33	6	43	38	5	41	36	5
CT-2	42	36	6	43	39	4	43	38	5
CT-3	42	35	7	44	39	5	43	37	6
CT-4	43	36	7	44	38	6	44	37	7
CT-5	41	33	8	45	33	13	43	33	10
CT-6	41	35	6	43	34	9	42	35	7
CT-7	42	36	6	47	39	8	45	38	7
CT-8	42	36	6	46	39	7	44	38	6
CT-9	41	38	4	41	37	4	41	38	3
CT-10	42	37	5	43	38	5	43	38	5
CT-11	43	35	8	43	39	4	43	37	6
CT-12	40	33	6	42	39	3	41	36	5
CT-13	39	32	8	43	38	5	41	35	6
CT-14	40	30	10	40	35	4	40	33	7
Bakhtawar-92	44	36	8	44	37	7	44	37	7
Saleem-2000	42	36	6	45	35	10	44	36	8

**Table 8: Mean values for days to maturity of wheat genotypes grown in normal and late conditions**

Genotypes	2003-2004			2004-2005			Combined		
	Normal	Late	Diff.	Normal	Late	Diff.	Normal	Late	Diff.
CT-1	163	125	39	166	143	23	165	134	31
CT-2	163	126	37	167	143	23	165	135	30
CT-3	162	126	36	167	143	24	165	135	30
CT-4	161	126	35	166	142	24	164	134	30
CT-5	166	127	39	169	141	28	168	134	34
CT-6	165	128	37	168	142	26	167	135	32
CT-7	164	127	37	166	143	23	165	135	30
CT-8	162	124	38	167	143	24	165	134	31
CT-9	165	127	38	167	142	25	166	135	31
CT-10	163	127	37	167	144	23	165	136	29
CT-11	165	125	40	167	143	24	166	134	32
CT-12	165	126	38	169	142	27	167	134	33
CT-13	165	125	40	167	140	27	166	133	33
CT-14	167	124	42	166	140	26	167	132	35
Bakhtawar-92	167	125	42	168	143	25	168	134	34
Saleem-2000	167	125	42	168	143	25	168	134	34

124 days (CT- 8 and CT-14) to 128 days (CT-6) for late sowing. The difference between mean values ranged from 35 days (CT-4) to 42 days (CT-14, Bakhtawar-92 and Saleem- 2000) (Table 8). In 2004-05, data ranged from 166 days (CT-4, CT-7 and CT-14) to 169 days (CT-5) for normal sowing and 140 days (CT-and CT-14) to 144 days (CT-10) for late sowing. The difference between normal and late sowing ranged from 23 days (CT-5) to 28 days (CT-1, CT-2 and CT-10). The two years (2003-05) combined data showed that maturity ranged from 165 days (CT-10) to 168 days (CT-5, Bakhtawar-92 and Saleem-2000) in normal seasons and 132 days (CT-14) to 136 days (CT-10) in late sowing. The over all difference ranged from of 29 days (CT-14) to 35 days (CT-10).

In present experiment, for late sowing, genotypes were planted 30 days later than normal sowing but maturity was recorded almost at the same time in both normal and late sown populations. Hence on over all bases, early maturity was recorded in late sowing which

could be beneficial for avoiding terminal heat stress. Present results coincide with those of Begum and Saifuzzaman (1987) who reported that sowing dates have direct relationship with physiological maturity and the advancement in sowing dates attains early maturity. These results are also supported by the finding of Ashraf (1968), who concluded that wheat sown early required more days to mature as compared with crop sown late in the season.

## REFERENCES

- Anonymous, 2005. Agricultural Statistics Section, Federal Bureau of Statistics. Government of Pakistan, Islamabad, pp: 9-12.
- Ashraf, M., 1968. Effect of different planting times and seed rate level on the growth, yield and quality of Mexican wheat under Lyllapur conditions. M.Sc. Thesis, Univ. Lyllapur (Faisalabad) Pakistan.

- Ashraf, M. and A.S. Bhatti, 1998. Effect of delayed sowing on some parameters of photosynthesis in wheat (*Triticum aestivum* L.). Wheat Information Service, pp: 46-48.
- Aslam, M., A. Majid, P.R. Hobbs, N.I. Hashim and D.R. Byerlee, 1989. Wheat in the rice-wheat cropping system of the Punjab. PARC/CYMMIT Paper No. 89-3. CYMMIT, Mexico.
- Begum, F. and M. Saifuzzaman, 1987. Studies on the grain development of wheat as affected by dates of sowing. Proceedings of the 12th Annual Bangladesh Science Conference, Dhaka, Bangladesh. BAAS, pp: 25.
- Byerlee, D.R., P.R. Hobbs, B.R. Khan, A. Majid, M.R. Akhtar and N.I. Hashim, 1986. Increasing wheat productivity system: A review from the farmer's field. PARC/CYMMIT Publication No. 7.
- Chopra, R.K. and C. Viswanathan, 1999. Evaluation of heat stress tolerance in irrigated environment of *T. aestivum* and related species. I. Stability in yield and yield components. Euphytica, 106: 169-180.
- Dhanda, S.S. and G.S. Sethi, 2002. Tolerance to Drought Stress among Selected Indian Wheat Cultivars. J. Agric. Sci. Cambridge: Cambridge University Press, 139: 319-326.
- Fisher, R.A. and D.R. Byerlee, 1991. Trends of Wheat Production in the Warmer Areas; Major Issues and Economic Considerations. In: Wheat for Nontraditional, Warmer Areas, Saunders, D.A. (Ed.), CYMMIT, Mexico, pp: 3-27.
- Gebeyehou, U., G., D.R. Knott and R.J. Baker, 1982. Relationship among duration of vegetative and grain filling phases, yield components and grain yield in long duration cultivars. Crop Sci., 22: 287-290.
- Heyne, E.G., 1987. Wheat and Wheat Improvement. 2nd (Edn.), Madison, Wisconsin, USA., pp: 32-40.
- Ibrahim, A.F., A. Kandil, A.H. Elhatter and A.K. Eissa, 1986. Effect of sowing date and weed control on grain yield and its components in some wheat cultivars. Crop Sci., 157: 199-207.
- Ihsanullah and F. Mohammad, 2001. Correlations of yield and yield associated traits in spring wheat. Sarhad J. Agric., 17: 97-100.
- Khalifa, M.A., A.A. Ismail, G.R. Nagar and I.A. Amen, 1998. Response of some genotypes of bread and durum wheats to differences in sowing dates. Assiut. J. Agric. Sci., 29: 31-46.
- Khan, M.A., 2003. Wheat Crop Management for Yield Maximization. Agriculture Department, Government of Punjab, Lahore, Pakistan.
- Knapp, W.R. and J.S. Knapp, 1978. Responses of winter wheat to date of planting and full fertilization. Agron. J., 70: 1048-1056.
- Lonhard, B.E., 1991. Effect of sowing date on leaf area of some wheat cultivars. Novenytermeles, 40: 141-152.
- Macas, B., M.C. Gomes, A.S. Dias, J. Coutinho, C. Royo, and M.M. Nachit, 2000. The tolerance of durum wheat to high temperatures during grain filling. Durum wheat improvement in the Mediterranean region: New challenges. Proceedings of a Seminar, Zaragoza, Spain, pp: 12-14.
- Micanovic, D., S. Lomovic and D. Cric, 1994. Effect of seeding date on some wheat leaf parameters. Literature Update on Wheat, Barley and Triticale, 2: 135-136.
- Mishra, D.K., R.A. Khan and M.S. Baghel, 2000. Stability of wheat varieties under various dates of sowing. Ann. Agric. Res., 21: 564-566.
- Muller, J., 1991. Determination of leaf area by means of linear measurements in wheat and triticale (brief report). Arciv. Fuchtungsforchung, 21: 121-123.
- Randhawa, A.S., S.S. Dhillon and D. Singh, 1981. Productivity of wheat varieties as influenced by the time of sowing. J. Res. Punjab Agric. Univ., 18: 227-233.
- Talbert, L.E., S.P. Lanning, R.L. Murphy and J.M. Martin. 2000. Grain filling duration in twelve hard red spring wheat crosses. Crop Sci., 41: 1390-1395.
- Waraich, S.A., Yasmin and S. Ashraf, 1982. Genetic parameters influenced by seeding dates in wheat. Pak. J. Agric. Res., 3: 273-276.