



Evaluation of Wheat Genotypes for Earliness and Growth Traits Exposed to High Temperature through Delayed Planting

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Abstract: Wheat grain yield in Pakistan is low since it is adversely affected by various biotic and abiotic stresses. Taking abiotic stress, heat stress is one of the key reasons of reduced wheat productivity in Pakistan. The current study focuses on the assessment of the performance of advance wheat varieties at normal sowing and late sowing dates. For this purpose, eight genotypes were grown in a Randomized Complete Block Design with three replications at the experimental farm of Nuclear Institute of Agriculture, Tandojam. The observations were recorded on plant height (cm), days to heading, days to maturity, days to senescence, biological yield plant⁻¹ (g) and harvest index. The analysis of variance of all the genotypes at normal and high temperature revealed significant differences at $P \leq 0.01$ for all the traits, signifying the reliability of used materials for further breeding experiments in order to improve bread wheat at normal and stress conditions. Low reduction percentage in performance at late sowing for the traits days to heading and plant height was shown by the cultivar V3. Similarly, the genotype Sehar-2006 also showed low reduction percentage in performance for days to maturity, biological yield plant⁻¹ and seed index at high temperature. The above mentioned genotypes may prove better crop resources for stress breeding in wheat crop.

Keywords: Bread wheat, heat stress, earliness, delayed planting

1.

INTRODUCTION

Bread wheat belongs to family *Poaceae* and is regarded as major staple food with highly nutritive value, hence cultivated at large scale in many countries including Pakistan. It is second highest produced crop after only corn (Shoran *et al.*, 2003), offers a great segment of the total food supplements and dietary protein too, it is also grown in a range of environments (Jahangir *et al.*, 2014). This hexaploid wheat is preferred for principal food products and is also used as feed for livestock. It adds 10.1% to the value added in agriculture and 2.2 % in GDP of Pakistan. Plant breeders are always interested in production of superior wheat varieties by using good general combining genotypes in crossing programs and selecting promising transgressive segregants from resulting hybrids for seed yield and its related traits (Akbar *et al.*, 2009).

Wheat is superlatively adapted to cool environments, whereas moderately high temperature (25-32 °C) for extended period and very high temperature (33-40 °C) for a shorter time are very frequent in subtropical conditions of South Asian countries (Paulsen, 1994). Though wheat can be produced in warmer areas; however heat stress is a common constriction, particularly during anthesis and grain filling stage in many temperate areas of South and West Asia. Hence, heat stress is one of the main

constraints of wheat production in tropical and subtropical areas of the world (Ashraf and Harris, 2005).

Optimum planting time is one of the essential factors that affect wheat yield noticeably. Crop cultivation at inappropriate sowing time may result huge reduction in wheat grain yield. In general, wheat crop is grown during November that produces better yield; nonetheless any delay in cultivation causes a great reduction in tillers, seed index and grain yield and consequently a reduced yield is expected (Ansari *et al.*, 1989). In Pakistan, terminal heat stress is a key reason for low yield in wheat due to delayed sowing. Similarly, heat stress is a most important challenge to wheat productivity (Joshi *et al.*, 2007). Delayed planted wheat crop experiences from extreme yield losses which may surpass to 40-50%. Thus, a great effort is needed to enlarge gene pool of genotypes that show tolerant against terminal heat stress or harvested earlier without losing the grain yield and thus escape the biotic as well as abiotic stress.

2.

MATERIALS AND METHODS

The experiment consisted of eight wheat genotypes (V3, V5, Sundar, Saher-2006, Lasani, AS-2002, Kiran-95 and TJ-83) and was conducted at the experimental farm of Plant Breeding and Genetics Division, Nuclear Institute of Agriculture, Tandojam. The field study was conducted to determine the effects of heat stress on six

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earliness and growth traits (Days to heading, days to 75% maturity, Days to senescence, plant height, biological yield plant⁻¹ and harvest index) of bread wheat (*Triticum aestivum* L.). The experimental material was evaluated in two sowing date's viz. normal planting (15th November, 2012-13) and late planting (15th December, 2012-13). The sowing was done by drilling method. Both canal and tube well irrigations were applied to the crop and five irrigations were applied to both the experiments. All the required cultural operations were adopted uniformly in both the plots throughout the growing period as and when required. Daily minimum and maximum temperature was recorded throughout the season. Five plants of each genotype per replication and each trait as affected by heat stress was studied. Data recorded from selected plants were statistically analyzed using analysis of variance (ANOVA) according to Steel and Torrie (1980).

3. RESULTS AND DISCUSSION

Metrological data: The meteorological data on daily basis for minimum and maximum temperatures were recorded during entire cropping season (2012-13) at the experimental site, which are given in (Fig. 1). The high temperature was observed during the sowing of experiment in the second week of November. The temperatures reduced in the months of December and January, which persisted up, to first week of February. At the time of grain filling period during the month of

March, temperature exceeded from 30^oC which reached to 38^oC at ripening stage.

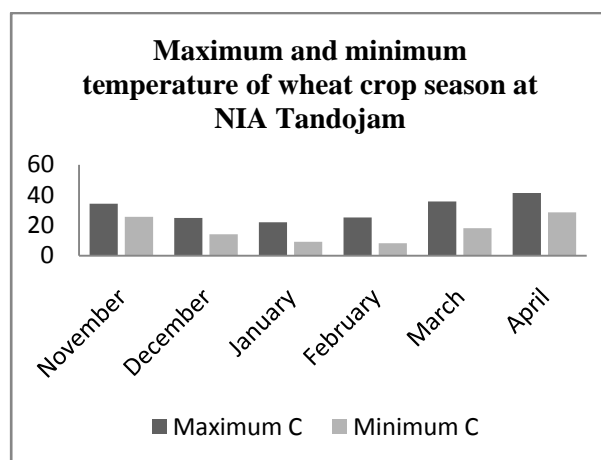


Fig. 1. Maximum and minimum temperature of wheat season, 2012-2013.

Analysis of variances: The analysis of variance for all the genotypes at normal and high temperature showed that studied genotypes differed significantly ($P \leq 0.01$) for all the characters under study, indicating the existence of great genetic variability among the genotypes (Table 1a and 1b). Results on overall mean performance of the studied characters are discussed in following paragraphs.

Table 1b. Mean squares of wheat genotypes under normal conditions.

Source of variation	Mean squares						
	D.F.	Days to heading	Days to 75% maturity	Days to senescence	Plant height	Biological yield plant ⁻¹	Harvest index
Replications	3	0.614	0.281	0.614	2.587	55.78333	354.467
Genotypes	7	185.031**	33.352**	32.602**	324.91**	772.808**	13.067**
Error	21	0.186	0.233	0.281	14.530	35.08619	2.137

**= significant at 1%

Table 1b. Mean squares of wheat genotypes under high temperature.

Source of variation	Mean squares						
	D.F.	Days to heading	Days to 75% maturity	Days to senescence	Plant height	Biological yield plant ⁻¹	Harvest index
Replications	3	0.083	0.041	0.083	13.454	4.524	149.238
Genotypes	7	104.428**	22.339**	16.50**	178.434**	125.772**	4.114**
Error	21	0.226	0.065	0.273	8.911726	8.894	4.857

**= significant at 1%

Plant height (cm): Plant height is regarded as one of the key characters in wheat crop breeding, and this has well documented that shorter wheat varieties not only improve seed yield but also demonstrate an enormous resistance against lodging and these wheat cultivars also offer great response for fertilizer uptake which results in rapid and vigorous growth. Maximum plant height was observed in variety Sundar (113.50 cm) and minimum in V3 (84.95 cm) at normal temperature. Maximum plant height was observed in V5 (99.95 cm) and minimum in AS-2002 (80.03 cm) at high temperature (**Table 2**). The average plant height of all eight genotypes was 88.16 cm. The decrease percent for plant height in stress condition among genotypes ranged from 3.17 to 15.15%. The genotypes V3 and V5 showed less reduction (3.17 and 6.10%, respectively), suggesting that these genotypes may be proved reliable plant resources in wheat breeding. However, genotypes Sundar and Lasani showed the highest reduction in plant height of 15.15 and 16.57%, respectively. Irfaq *et al.* (2005) also reported reduction in plant height of wheat genotypes due to late sowing and high temperature stress.

Table 2. The Mean difference and reduction (%) in plant height (cm) due to high temperature.

Genotypes	Plant height (cm)		Difference	Decrease (%) in high temperature
	Normal temperature	High temperature		
V3	84.95	82.25	2.70	3.17
V5	106.45	99.95	6.50	6.10
Sundar	113.50	96.30	17.20	15.15
Sehar-2006	94.60	85.55	8.05	8.50
Lasani	103.15	86.05	17.1	16.57
AS-2002	91.05	80.03	10.75	11.80
Kiran-95	98.25	88.75	9.50	9.66
TJ-83	96.40	86.40	10.00	10.37
Mean	98.54	88.16	10.22	10.16

Days to heading: Early maturity is a very importance trait, since early maturing varieties require less resources and vacant field earlier for other crops to be grown on time. Days to heading ranged from 70.75 in genotypes Sundar to 87.75 in TJ-83 at normal sowing, while days to heading ranged from 60.00 in genotype Sundar to 73.00 in variety TJ-83. Results indicated that days to heading of all the genotypes significantly reduced at late sowing conditions (65.50 days) as compared to normal time (78.96 days). Overall (17.04%) reduction was observed with late sowing. Two genotypes, V3 (13.60%) and V5 (14.75%) expressed

less reduction, demonstrating that these genotypes could be preferred for the wheat breeding in respect to protect grain yield through proper reproductive growth, while the genotypes Kiran-95, T.J-83 and AS-2002 showed the highest reduction percentage of 17.20, 17.20 and 17.80, respectively in days to heading (**Table 3**). The present findings are in agreement to Hakim *et al.* (2012) who reported 14-19% reduction for the period of days to heading in wheat genotypes due to delay in sowing.

Table 3. The Mean difference and reduction (%) in days to heading due to high temperature.

Genotypes	Days to heading		Difference	Decrease (%) in high temperature
	Normal temperature	High temperature		
V3	73.00	63.00	10.00	13.60
V5	75.5	60.75	14.75	14.75
Sundar	70.75	60.00	10.75	15.19
Sehar-2006	82.50	66.25	16.25	19.60
Lasani	72.25	60.75	11.50	15.91
AS-2002	84.25	69.25	15.00	17.80
Kiran-95	85.75	71.00	14.75	17.20
TJ-83	87.75	73.00	14.75	17.20
Mean	78.96	65.50	13.46	17.04

Days to 75% maturity: Days to 75% maturity ranged from 123.00 to 130.50 at normal sowing date. The maximum days to 75% were taken by the variety TJ-83 (130.50 days), while the minimum days recorded in genotype Sundar (123.00 days). At late sowing date, days to 75% maturity ranged from 102.25 in genotypes Lasani to 109.00 in TJ-83. On the basis of obtained findings, days to 75% maturity of all the genotypes significantly reduced at late sowing conditions (105.60 days) as compared to normal time (126.30 days). Overall 16.38% reduction was observed with late sowing. The decrease percent for days to 75% maturity among genotypes ranged from 14.17 to 19.36%. Two genotype Sehar-2006 and V3 showed less reduction (14.14 and 14.84% respectively), whereas genotypes Lasani and V5 showed the highest reduction in days to maturity (19.36 and 17.65%, respectively) (**Table 4**). It is noted that less reduction in days to maturity will result in vigorous growth thus indicating the genotypes are expected to produce satisfactory grain yield in stress conditions also. Therefore, the genotypes Sehar-2006 and V3 may be proved choice breeding materials for stress breeding in respect to early maturity. These results are in concurrence to Nahar *et al.* (2010), who also observed up to 15% reduction in maturity period of wheat genotypes due to the effect of heat stress.

Table 4. The Mean difference and reduction (%) in days to 75% maturity due to high temperature.

Genotypes	Days to maturity		Difference	Decrease (%) in high temperature
	Normal temperature	High temperature		
V3	123.30	105.00	18.30	14.84
V5	126.30	104.00	22.30	17.65
Sundar	123.00	103.25	19.75	16.00
Sehar-2006	123.50	106.00	17.50	14.17
Lasani	126.80	102.25	24.55	19.36
AS-2002	128.30	107.00	21.30	16.60
Kiran-95	129.30	108.00	21.30	16.47
TJ-83	130.50	109.00	21.50	16.47
Mean	126.33	105.66	20.70	16.38

Days to senescence:

Leaf senescence is the progressive loss of green leaf area that occurs during reproductive development of a crop (Nood' en, 1988). The breakdown of thylakoid components is also accelerated by heat stress, leading to leaf senescence (Harding *et al.*, 1990). Days to senescence ranged from 28.25 in genotypes Lasani to 38.00 in Sehar-2006 at normal sowing period. In the case of late sowing date, days to senescence ranged from 16.50 in genotype Lasani to 22.25 in Sundar genotype. Due to stress, overall (44.56 %) reduction was observed with late sowing. The decrease percent for days to senescence among genotypes ranged from 29.92 to 55.26%. Genotypes Sehar-2006 and AS-2002 showed highest reduction in days to senescence (55.26 and 51.79%, respectively) (Table 5). Only one genotype Sundar exhibited less reduction (29.92%), showing its worthiness in stress conditions hence can further be exploited for variety of breeding experiments.

Table 5. The Mean difference and reduction (%) in days to senescence due to high temperature

Genotypes	Days to senescence		Difference	Decrease (%) in high temperature
	Normal temperature	High temperature		
V3	34.00	18.00	16.00	47.05
V5	35.00	18.75	16.25	46.42
Sundar	31.75	22.25	9.50	29.92
Sehar-2006	38.00	17.00	21.00	55.26
Lasani	28.25	16.50	11.75	41.49
AS-2002	34.75	16.75	18.00	51.79
Kiran-95	32.25	19.00	13.25	41.08
TJ-83	34.25	20.75	13.50	39.41
Mean	33.53	18.62	14.91	44.56

Biological yield plant⁻¹ (g): With respect to biological yield plant⁻¹, wheat genotypes showed different response for this trait at various planting dates. Maximum biological yield plant⁻¹ was observed in V3 (162.40g) and minimum was observed in Sundar (123.90g) at normal temperature. In the case of high temperature, the maximum biological yield plant⁻¹ was observed in Sehar-2006 (71.53g) and minimum was observed in AS-2006 (53.50g). Above mentioned wheat varieties which showed maximum biological yield plant⁻¹ at the both sowing dates could be further utilized in breeding programs in order to improve bread wheat genotypes so the high biological yield can be obtained. The decrease percentage due to stress for biological yield plant⁻¹ among genotypes was ranged from 47.26 to 60.31%. Genotypes Sundar and Sahar-2006 showed the lowest reduction (47.26 and 47.29%, respectively) in biological yield plant⁻¹ (Table 6), demonstrating that these genotypes possess potentiality for being used in stress breeding. Irfaq *et al.* (2005) and Laghari *et al.* (2012) also found a great reduction in the biological yield of all the wheat genotypes tested in their experiments.

Table 6. The Mean difference and reduction (%) of biological yield plant⁻¹ (g) due to high temperature.

Genotypes	Harvest index (%)		Difference	Decrease (%) in high temperature
	Normal temperature	High temperature		
V3	19.29	12.01	7.28	37.73
V5	19.73	14.06	5.67	28.73
Sundar	19.86	13.72	6.14	30.91
Sehar-2006	21.34	15.42	5.92	27.74
Lasani	20.87	14.07	6.80	32.58
AS-2002	24.90	13.14	11.76	47.22
Kiran-95	21.46	15.06	6.40	29.82
TJ-83	22.39	15.02	7.37	32.91
Mean	20.76	14.06	6.70	32.27

Harvest index (%): Considering the trait harvest index (%), significant difference for harvest index (%) was observed among all genotypes at normal planting date (Table 12). Harvest index ranged from 19.29 in V3 to 24.90 in AS 2002 genotypes. The average harvest index % of all eight genotypes was 20.76. In the case of high temperature, the harvest index % ranged from 12.01 in V3 to 15.42 in Sehar-2006 genotypes. The average harvest index of all eight genotypes was 14.06%. Overall 32.27% reduction was observed with late sowing, indicating the drastic effect of heat on this trait. The decrease percent for harvest index among genotypes was ranged between 27.74 and 47.22%. Genotype Sehar-2006 showed the lowest reduction of 27.74% in harvest index (Table 7).

Table 7. The Mean difference and reduction (%) of harvest index % due to high temperature.

Genotypes	Biological yield plant ⁻¹		Difference	Decrease (%) in high temperature
	Normal temperature	High temperature		
V3	162.40	64.45	97.95	60.31
V5	152.80	69.95	82.85	54.22
Sundar	123.90	65.30	58.60	47.29
Sehar-2006	135.65	71.53	64.12	47.26
Lasani	141.25	65.15	76.10	53.87
AS-2002	123.15	53.50	69.65	56.55
Kiran-95	143.00	69.65	73.35	51.29
TJ-83	128.85	66.90	61.95	48.07
Mean	138.87	65.80	73.07	52.35

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