



Phenotypic Screening of Heat-Tolerant Wheat (*Triticum Aestivum* L.) Genotypes

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Abstract: Ten Bread Wheat (*Triticum aestivum* L.) genotypes developed through different breeding techniques (BWM-3, MSH-36, MASR-03, MASR09, MASR07, NIA-10/8, NIA-28/4, DH-25) were evaluated for terminal high temperature stress for yield and yield associated traits. Sarsabz and T.D-1 were used as check varieties. The heat stress was imposed by planting on three different sowing dates. Early sowing (8th November) was used as control. Experiment was conducted in Randomized **Complete Block Design** (RCBD) with three **replications**. The results showed the inhibitory effect of high temperature on most of the yield and yield associated traits. Spike length, grain yield and biological yield were the severely affected traits. 10.3% reduction was found for mean spike length at late sowing (SD-3) and 11.0 % at Normal sowing (SD-2) as compared to early sowing (SD1). Mean spike yield reduced 3.05% at normal sowing to 2.17% at late sowing. 1000 grain weight decreased 40.63% at normal sowing to 37.3% at late sowing. Grains per plant declined 52.2% at normal sowing to 45.2% at late sowing. Grains per plot also reduced 798.3 at normal sowing to 641.3 at late sowing. Over all five genotypes Viz; BWM-3, MSH-36, MASR-09, NIA 10/8 and TD-1 performed better under late sown conditions for grain yield and yield associated traits. These genotypes may further be used in breeding program for developing heat tolerant varieties.

Keywords: Grain yield, Heat-tolerance, Wheat, Late sowing

1. **INTRODUCTION**

Bread wheat (*Triticum aestivum* L.) belongs to Poaceae family (grass family), is a major cereal food crop of the world including Pakistan. Grain yield of wheat in Pakistan is low as compared to various other countries of the world (G.O.P., 2013). The possible reasons for the low crop productivity are environmental stresses.

Among all environmental stresses, high temperature is a main environmental constraints to wheat productivity affecting different growth stages specially anthesis and grain filling stages (Wheeler *et al.*, 2000; Villegas *et al.*, 2015; Rehmani *et al.*, 2016). In our country, terminal heat stress is a major reason of yield decline in wheat due to delayed planting (Villegas *et al.*, 2015; Rehmani *et al.*, 2016). The temperature above normal limits alter the phenotypic, physiological and biochemical behavior of wheat plant. The temperature above 35°C during grain filling period particularly at post-anthesis stage can significantly reduce grain yield of wheat and barley (Randall and Moss, 1990; Ferris *et al.*, 1998). Research studies have proved that the grain quality is also affected due to heat stress (Randall and Moss, 1990). It has been reported that the sowing dates in terms of change temperature are critical for determining appropriate crop yield.

Sial (2005) reported that with delayed planting cause overall shortening of plant height, reduction in number of internodes, days to heading, days to maturity

and grain filling period and ultimately in the reduction of yield and yield components. Singh (2011) studied the effect of high temperature stress on various traits for developing thermo-tolerance in bread wheat variety; he concluded that heat stress severely affects grain yield per pant, biological yield per plant and grain yield per spike under late sown conditions.

The present studies was conducted to evaluate ten wheat advance lines to early and late terminal heat stresses on yield and its associated traits and to select early maturing, heat-tolerant genotypes suitable for late plantings in middle to upper Sindh.

2. **MATERIAL AND METHODS**

Ten genotypes developed through different techniques such as mutations(BWM-3,MSH-36,MASR-03, MASR09,MASR07) conventional breeding(NIA-10/8,NIA-28/4) doubled haploid line (DH-25) and two check varieties (Sarsabz and T.D-1) were evaluated at Nuclear Institute of Agriculture (NIA) Tandojam for terminal high temperature stress.

Heat stress was imposed by sowing crop in different sowing dates (SD) (Fig. 1). Early sowing (8th November) was used as control and compared with Normal sowing (29th November 2014 and Late sowing (21st December) for heat stress.

Experiment was conducted in Randomized Complete Block Design (RCBD) with three replications arranged in plot size of 3.6m² while row length was 5m.

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Row to row distance was maintained at 30 cm. Each genotype was sown in six rows. The experimental field was watered three times. First time water was given before sowing, second time water was given at the time of tillering and third time water was given at the time of heading. The quantitative characters examined were: Number of tillers per m², Plant height (cm) and Spike length (cm) were measured with tap rod. Days to heading, Days to maturity, Days to grain filling, Number of spikelets per spike and Number of Grains per spike were counted. Main spike yield, Biological yield per plot (kg) Weight of 1000 Grains and Grains yield per plant were weighed with digital balance.

Data analysis

The Means of normal and late sowing treatments were compared with early sowing using Duncan's Multiple Rang Test (DMRT) at ($p < 0.05$).

3. RESULTS AND DISCUSSION

The present study was conducted to evaluate response of various wheat genotypes under heat stress planted at three different sowing dates. The results obtained from the studies are presented character wise. Mean numbers of tillers per m² of wheat genotypes exhibited marked reduction (80.31%) at late sowing (SD-3) and (16.6%) at Normal sowing (SD-2) as compared to early sowing (SD1) (Table 1). Significant differences ($p > 0.5$) were observed for number of tillers per m² of wheat genotypes at various planting times (Table 2). At normal sowing three genotypes Viz: MSH-36, NIA 28/4, TD-1 significantly reduced numbers of tillers and at late sowing three genotypes show further decrease in number of tillers. No significant difference was found in genotypes Viz: MASR-09, MASR-07, and DH-25 at normal sowing whereas BWM-3. MASR-09, MASR-07 does not exhibit any significant differences at late sowing. Herbek and Lee (2009) reported fewer tillers or even abortion of initiated tillers under heat and Hozayan and Monem (2010) found 11.20% reduction for spike length. This may be due to decline in chlorophyll content above 30 °C, nitrogen accumulation and starch synthetase activity (Bermner and Rawson, 1978; Hawker and Jenner, 1993; Kropff *et al.*, 1993). Casal *et al.* (1986) and Kasperbauer and Karlen (1986) related numbers of tillers with Phytochrome and radiation quality.

Mean height of wheat genotypes was reduced and 11.5% at Normal sowing (SD-2) and 8.9% at late sowing (SD-3) as compared to early sowing (Table 1). Significant difference ($p > 0.5$) was scored for height of wheat genotypes at various planting times (Table 2). At normal sowing MASR-03 significantly reduced in height and at late sowing five genotypes showed significant decrease in height Viz MASR-03, NIA 28/4.

DH-25, Sarsabz, TD-1. Less significant decrease was found in genotypes Viz: MSH-36, NIA 28/4, and SARSABZ at normal sowing where as MASR-09, NIA 10/8 recorded less significant decrease at late sowing. Irfaq (2005) also observed reduction in plant height of wheat genotypes under terminal heat stress.

The data for percent decrease for days to heading is compiled in (Table 1). Negligible decline of 12.1% was observed at normal sowing (SD-2) and 12.1% at late sowing (SD-3) as compared to early sowing. At normal sowing (SD-2) NIA 28/4, MASR-07 and BWM-3 enjoyed very less number of days for heading as compared to early sowing. At late sowing (SD-3) NIA 28/4, BWM-3, MSH-36 enjoyed fewer days for heading whereas NIA 10/8 and DH-25 enjoyed more days for heading (Table 2). Present findings are close to those of Hakim (2012). He reported 14-19% reduction for the period of days to heading.

The mean maturity time of wheat genotypes slightly reduced at normal sowing (8.6%) where as it was more pronounced at late sowing (91.5%) (Table 1). At normal sowing less number of days to maturity was recorded in genotypes Viz: NIA 10/8, MSH-36, and TD-1, whereas less significant decrease was recorded in NIA 28/4 (Table 2). At late sowing (SD-3) days to maturity significantly reduced for all genotypes, whereas NIA 10/8 and TD-1 had enjoyed fewer days to maturity as compared to early sowing. Reduction in days to maturity is supported by two-year study of Ubaidullah (2006).

The mean grain filling of wheat genotypes at normal sowing (SD-2) reduced 20.15% whereas at late sowing (SD-3) 24.2% reduction was observed (Table 1). The grain filling period is critical for producing high yield, because kernel size and weight are determined during this stage. At normal sowing less number of days to grain filling was recorded in

Table 1. Overall Percent decrease in different phenotypic characters subjected to heat stress

S. No.	Parameters	SD2	SD3
1	No. of Tillers m ²	16.6	80.31
2	Days to Heading	11.5	8.9
3	Plant height	10.7	12.1
4	Days to Maturity	8.6	91.5
5	Days to Grain Filling	20.15	24.2
6	Spike Length	5.9	11.9
7	No. of Spikelets	5.9	12.4
8	No. of Grains per spike	3.7	19.6
9	Main spike Yield	10.02	38.05
10	1000 Grain Weight	13.05	1.34
11	Biological yield	14.5	26.5
12	Grain yield per plant	13.86	91.3

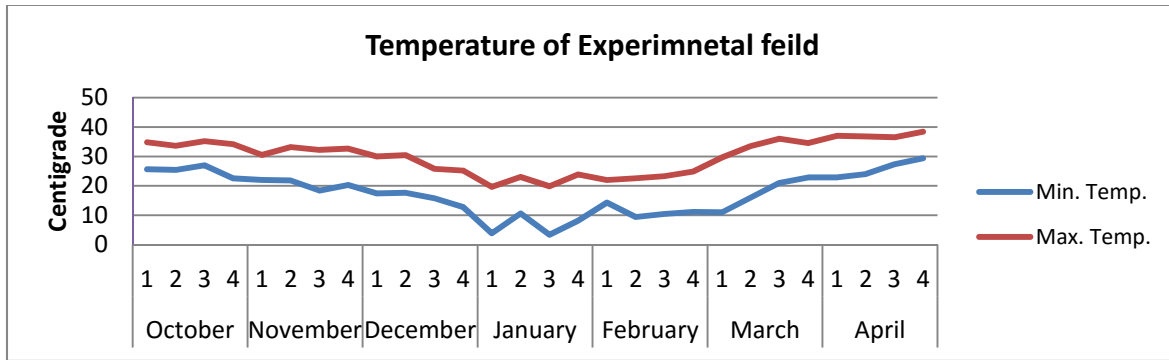


Fig. 1. Minimum and Maximum temperatures of experimental field during October 2014 to April 2015

Table 2. Evaluation of wheat genotypes for No. of Tillers m² Plant height, Days to Heading and Days to Maturity at different planting time

Genotypes	No. of Tillers m ²			Plant height			Days to Heading			Days to Maturity		
	Sd-1	Sd-2	Sd-3	Sd-1	Sd-2	Sd-3	Sd-1	Sd-2	Sd-3	Sd-1	Sd-2	Sd-3
BWM-3	560 A	513.3 A	546.7A	91 BC	88.3BC	85.88 BC	57.7 F	67 B	57.3 A	130.7 C	120.7 EF	113.3 BC
MSH-36	566.7 A	380 BC	354.7 B	89.33 BC	87.0BC	83.10 C	61.3E	67 B	59 A	132 C	119.7 G	112.3 C
MASR-03	441.3 ABC	386.7 BC	374.7 B	100.55 AB	97.43AB	91.11 B	64 D	68.7 B	58.3 A	131 C	119.7 G	111.3 D
MASR-09	366.7 C	357.3C	376.0B	69.99D	67.3D	64.33 D	64.7 D	67.7 B	58.3A	132.3 BC	121 DEF	111 CD
NIA-10/8	530.7 A	400 BC	417.3B	96.66BC	94.9AB	91.21 B	79.3 A	80.3 A	56.3A	135.7 AB	121.7 CD	109.3 D
NIA-28/4	526.7 AB	361.3 BC	386.7B	114.22 A	109.3A	105.88 A	56 G	79 A	59 A	136.7 A	127.7 A	122 A
MASR-07	393.3 BC	402.7 BC	393.3B	71.77 D	69.67D	66.10 D	64.7 D	76.3 A	57.3 A	133.3 AB	122.3 C	113.7 BC
DH-25	480 ABC	465.3 ABC	372.0B	97.77 ABC	92.43BC	88.66 B	73.7 B	77.7 A	60 A	136 A	123.3 B	115.7 B
Sarsabz	461.3ABC	422.7 ABC	380.0B	101.77 AB	98.10AB	91.33 B	63.3 D	70.7 B	59 A	131.3 C	121.3 DE	112.3 C
T.D-1	620 A	434.7 ABC	372.0B	83.33 CD	77.0CD	67.33 D	67.7 C	67.7 B	58.7 A	133.7 AB	120.3 FG	108.7 D

(DMRT at p<0.05)

Table 3. Evaluation of wheat genotypes for Days to Grain Filling, Spike Length No. of Spikelets and No. of Grains per spike at different planting time

Genotypes	Days to Grain Filling			Spike Length			No. of Spikelets			No. of Grains per spike		
	Sd-1	Sd-2	Sd-3	Sd-1	Sd-2	Sd-3	Sd-1	Sd-2	Sd-3	Sd-1	Sd-2	Sd-3
BWM-3	73 B	53.7 A	56 B	12.8 B	11.9 AB	10.3 B	17.5 EF	16.3 D	16.2 BC	51.7 AB	49.1 CDE	42.4 AB
MSH-36	70.7 BC	52.7 AB	53.3 BC	9.7 E	9.1 E	8.9 C	14.6 G	14.9 E	15.7 CD	51 AB	50.1 ABCD	45.7 A
MASR-03	67 CD	50.7 ABC	53.7 BC	12.2 BC	11.5 BC	10.2 B	19.7 ABC	18.3 AB	17.7 A	56.8 A	53.9 AB	44.8 A
MASR-09	67.7 CD	53.3 AB	52.7 BC	11.2 CDE	10.4 D	9.6 BC	17.9 DEF	16.6 CD	15.9 BCD	49.1 AB	46.1 DE	37.6 BCD
NIA-10/8	56.3 F	41.3 E	53 BC	11.7 BCD	10.9 CD	10.1 B	18.6 CDE	17.4 BC	16.7 AB	52.1 AB	48.2 BCDE	41.2 ABC
NIA-28/4	80.7 A	48.7 BCD	63.7 A	11.8 BCD	11.1 BCD	10.2 B	20.1 ABC	18.7 A	17.6 A	54 AB	51.7 ABC	44.2 A
MASR-07	68.7 CD	46 CDE	56.3 B	14.4 A	12.6 A	11.4 A	21 A	19 A	17.6 A	55 A	53.5 A	42.3 AB
DH-25	62.3 E	45.7 DE	53 BC	10.7 DE	10.4 D	8.7 C	19.3 BCD	18.1 AB	15.7 CD	58.9 A	55.3 ABC	37.4 BCD
Sarsabz	68 CD	50.7 ABC	53.3 BC	12 BCD	11.2 BCD	9.4 BC	20.1 AB	18.3 AB	15.9 BCD	54.8 AB	53 C	35.3 CD
T.D-1	66 DE	52.7 AB	50 C	10.7 DE	10.5 D	8.9 C	16.7 F	16.4 D	15.1 D	44.4 B	43.6	34.3 D

(DMRT at p<0.05)

Table 4. Evaluation of wheat genotypes for Main spike Yield, 1000 Grain Weight and Biological yield at different planting time

Genotypes	Main spike Yield			1000 Grain Weight			Biological yield			Grain yield per plant		
	Sd-1	Sd-2	Sd-3	Sd-1	Sd-2	Sd-3	Sd-1	Sd-2	Sd-3	Sd-1	Sd-2	Sd-3
BWM-3	3.26 B	2.9 CD	2.16 AB	47 AB	41.33 AB	36.66 C	4.41 AB	3.92AB	3.41AB	79.7 A	70.7 A	56.7 A
MSH-36	3.42 AB	3.07 ABC	2.36 A	50 AB	41.33 AB	36.33 C	3.16 D	2.83CDE	2.5 CDE	56.8 CD	49.7 CD	41.1 D
MASR-03	3.44 AB	3.13 AB	2.36 A	50.33 AB	44.66 A	35.33C	4.5 AB	3.5AABC	2.75 CDE	56.3 CD	49.2 CD	43.3 BCD
MASR-09	3.28 AB	2.93 BC	2.13 ABC	39 C	38 AB	37 BC	2.83 D	2.67C	2.25 DE	69.1 B	60.2 B	54.8 A
NIA-10/8	3.45 AB	3.03 ABC	2.26 A	39.66 C	38.33 AB	36.33 C	4 BC	3.5ABC	3.08 ABC	58.6 CD	49.7 CD	42.8 CD
NIA-28/4	3.49 AB	3.13 AB	2.33 A	47.33 ABC	42 AB	38 ABC	4.75 A	4.08A	3.58 A	64.9 BC	56.4 BC	46.3 B
MASR-07	3.27 B	3.2 A	2.3 A	39.66 C	38.33AB	40.33 A	3.16 D	2.75DE	2.25 DE	54.9 D	45.4 D	43.7 BCD
DH-25	3.76 A	3.2 A	2.1 ABC	56 A	44 A	39.66 AB	4 BC	3.25BCDE	2.75 CDE	56.7 CD	50.1 CD	44.4 BC
Sarsabz	3.44 AB	3.17 A	1.88 BC	41.33 BC	37 B	35.33 C	4.25 AB	3.42ABCDE	2.75 BCD	53.3 D	44.4 D	40.8 DE
T.D-1	3.08 B	2.7 D	1.86 C	43.33 BC	41.33 AB	38 ABC	3.33CD	2.83CDE	2.83 E	56.7 CD	46.9 D	38.7 E

(DMRT at $p < 0.05$)

times (Table 3). At normal sowing MASR-07, BWM-3, MASR-09 and NIA 10/8 significantly reduced in spike length and at late sowing Sarsabz, TD-1 and BWM-3 showed significant decrease in spike length. Less significant decrease in spike length was observed in genotypes TD-1 and DH-25 at normal sowing whereas MSH-36 recorded showed less significant decrease in spike length at late sowing.

Overall numbers of spikelets per spike of wheat genotypes at reduced 5.9% at normal sowing and 12.4% (Table 1). At normal sowing MASR-07 and Sarsabz significantly reduced in Numbers of spikelets per spike and at late sowing Sarsabz, MASR-07 and BWM-3 showed further significant decrease in spike length. Less significant decrease in number of spikelets per spike was found in genotypes Viz: MSH-36 and TD-1 at normal sowing while MSH-36, BWM-3 and TD-1 were recorded less significant decrease in numbers of spikelets per spike at late sowing (Table 3).

Mean numbers of grains per spike of wheat genotypes were reduced 3.7% at normal sowing SD-2 and 19.6% at late sowing (SD-3) as compared to early sowing (Table 1). Significant difference was recorded for number of grains per spike of wheat genotypes at various planting times (Table 3). At normal sowing two genotypes Viz: NIA 10/8 and BWM-3 significantly reduced their number of grains per spike and at late sowing whereas DH-25 AND SARSABZ showed

further significant decrease. Less significant decrease was found in TD-1, MASR-07, and DH-25 at normal sowing whereas MSH-36, BWM-3 and NIA 28/4 showed with no significant difference at late sowing.

The mean of Main spike yield at exhibited 10.02% decline and 38.05% at late sowing (Table 1). Significant reduction ($p < 0.05$) were observed for Main spike yield (g) (Table 4). At normal sowing DH-25, TD-1, NIA 10/8 significantly reduced for Main spike yield and whereas m further decrease was observed f at late sowing in, TD-1, DH-25. Less significant decrease in Main spike yield was found in MASR-07 at normal sowing while MSH-36, MASR-07 exhibited less significant decrease at late sowing.

As large, dense seeds are considered to be better quality than low weight kernels and responsible for production of stronger tillers and eventually good yield potential. Therefore it is important to calculate 1000 seed weight. Mean 1000 grains weight of wheat genotypes were reduced 13.05% at Normal sowing (SD-2) and 1.34% at late sowing (SD-3) as compared to early sowing. Significant difference was recorded for 1000 grains weight of wheat genotypes at various planting times (Table 4). At normal sowing two genotypes Viz: DH-25, MSH-36 significantly reduced 1000 grains weight and at late sowing three genotypes show further significant decrease in 1000 grains weight Viz DH-25, MASR-03, MSH-36. Less significant decrease in 1000 grains weight was found in MASR-09,

NIA 10/8, and MASR-07 at normal sowing whereas MASR-07, MASR-09 and NIA 10/8 showed significant decrease in 1000 grains weight at late sowing.

Mean biological yield per plot (kg) of wheat genotypes were reduced 14.5% at Normal sowing (SD-2) and 26.5% at late sowing (SD-3) as compared to early sowing (Table 1). Significant difference was recorded for biological yield per plot (kg) among wheat genotypes at various planting times (Table 4). At normal sowing three genotypes Viz: MASR-03, SARSABZ and DH-25 significantly reduced biological yield per plot (kg) and at late sowing three genotypes show significant decrease in biological yield per plot (kg) Viz Sarsabz, MASR-03 and DH-25. Less significant decrease in biological yield per plot (kg) was found in MASR-09 at normal sowing whereas TD-1, MASR-09 and MSH-36 showed significant decrease in biological yield per plot (kg) at late sowing. Present results are consistent with Irfaq (2005) who observed reduction in biological yield of wheat genotypes due to late sowing.

The mean Grain yield per plant reduced 13.86% at normal sowing and 91.3% at late sowing (Table 1). Grain yield per plant of wheat genotypes were recorded with significant reduction at late sowing (Table 4). At normal sowing TD-1, MASR-07 and Sarsabz significantly reduced in grain yield per plant and at late sowing genotypes such as TD-1, BWM-3 and NIA 28/4 showed significant decrease in Grain yield per plant. Less significant decrease in grain yield per plant was found in BWM-3 and DH-25 at normal sowing whereas, MASR-07, MASR-09 and DH-25 recorded less significant decrease in grain yield per plant at late sowing.

It can be inferred from the results that all the yield and yield associated traits are sensitive to terminal heat shock. All the parameters showed decline with increasing sowing dates except days to grain filling and 1000 grain weight. At normal sowing (SD-2) highest reduction was observed in days to grain filling and least reduction was scored for spike length per plant and No. of spikelet per plant. Days to maturity and grain yield per plant were the most affected parameter and 1000 grain weight was the least affected parameter at late sowing (SD-3). Present result is consistent with Abdullah (2007) who found mild decline in 1000-grain weight.

4. **CONCLUSIONS**

Days to grain filling, days to maturity and grain yield per plant are the major parameters to be considered for selection of heat tolerant genotypes. Five genotypes Viz; BWM-3, MSH-36, MASR-09, NIA 10/8

and TD-1 are comparatively heat tolerant therefore may further be used in breeding programmed for developing heat tolerant varieties.

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