INT. J. BIOL. BIOTECH., 13 (1): 101-106, 2016.

ASSESSMENT OF ELITE WHEAT GENOTYPES FOR HEAT STRESS ON THE BASIS OF YIELD CONTRIBUTING TRAITS

Munaiza Baloch[1], Abdul Wahid Baloch[1], Zubair Ahmed Shaikh[1], Samia Arain[1], Muhammad Jurial Baloch[1], Muhammad Azeem Asad[2], Gul Muhammad Baloch[1], M. Ali[3] and Abdul Majeed Baloch[4]

[1]*Department of Plant Breeding & Genetics, Sindh Agriculture University, Tandojam, Pakistan.*
[2]*Nuclear Institute of Agriculture, Tandojam, Pakistan.*
[3]*Department of Biotechnology, Sindh Agriculture University, Tandojam, Pakistan.*
[4]*Department of Horticulture, Sindh Agriculture University, Tandojam, Pakistan.*
Corresponding author's email: munaizabaloch@yahoo.com

ABSTRACT

In comparison to other nations, wheat grain yield in our country is comparatively lower as it is badly affected by numerous biotic and abiotic stresses. Considering the abiotic stresses, heat stress is one of main issues which causes a great reduction in production in Pakistan. The present research was focused on the evaluation of the performance of elite wheat genotypes at normal and late sowing dates. For this purpose, eight wheat genotypes were sown in a randomized complete block design having three replications at the experimental farm of Nuclear Institute of Agriculture, Tandojam. The data was observed on five quantitative traits including spike length (cm), spikelets spike^{-1}, grain weight spike^{-1}, grains spike^{-1} and 1000 grain weight. The analysis of variance of all the genotypes at normal and high temperature exposed significant differences at P≤0.01 for all the characters, indicating the trustworthiness of used materials for future breeding experiments in order to improve bread wheat at normal and stress conditions. Low reduction in mean performance at high temperature for the traits spike length, grain weight spike^{-1}, grains spike^{-1} and 1000-grain weight was demonstrated by the cultivars AS-2002, Sehar-2006, Sundar and Kiran-95, respectively. The above mentioned elite wheat genotypes may prove better crop resources for heat stress breeding in wheat crop.

Key-words: Bread wheat, delayed planting, heat stress, yield traits

INTRODUCTION

Wheat, *Triticum aestivum* L., belongs to poaceae family and is considered as main food crop of the country. As staple diet of the majority of the people, it engages a larger area of the country. Wheat has been played an important role in the advancement of civilization and is accepted as the king of cereals. Being the primary source of staple food, it has been broadly cultivated and prefer to consume in Pakistan (Bhatti and Soomro, 1996). With respect to its contribution to the country, it contributes 10.0 and 2.1 percent to the value added in agriculture and GDP, respectively. Talking about area under wheat cultivation has declined to 9180 thousand hectares in 2014-15 from previous year's area of 9199 thousand hectares that displays a reduction of 0.2 percent. The wheat production stood at 25.478 million tonnes during 2014-15, demonstrating a decrease of 1.9 percent over the preceding year's production (25.979 million tonnes). The decline in production was associated with extended winter season and exceptional rains during the months of April and May which caused damages to grain at harvesting time (GOP, 2014).

Late planting undesirably distress wheat grain yield (Mehboob *et al.*, 2005) which might be associated to grain insubstantiality because of high temperature injury during reproductive growth (Wardlaw, 2002). Terminal heat stress reduces the period for grain filling, starch production gets disturbed in the endosperms of the seeds and encourage early maturity which results shrinking of kernels and eventually low grain weight obtained (Nageswara *et al.*, 2001). Nevertheless, substantial variations exist among wheat genotypes in terms of grain yield reduction under late sowing conditions (Okuyama *et al.*, 2005; Khan *et al.*, 2007; Sohail et al., 2014). The ability of the wheat cultivars to tolerate high temperature stress is correlated with improved leaf chlorophyll and low canopy temperature maintenance (Lopes and Reynolds, 2010). The genotypes which show tolerance against high temperature can play a vital role to increase wheat productivity. The current study was conducted to assess wheat genotypes for their potential to tolerate high temperature at normal and stress conditions.

MATERIALS AND METHODS

The present study was composed of eight wheat cultivars (Sundar, V3, Saher-2006, V5, Lasani, AS-2002, Kiran-95 and TJ-83) and was carried out at the experimental farm of Plant Breeding and Genetics Division, NIA, Tandojam. The effects of heat stress was assessed on five yield related traits (spike length, spikelets spike^{-1}, grain weight spike^{-1}, grains spike^{-1} and 1000-grain weight) of bread wheat. The plant material was examined in two sowing date's i.e. normal planting (15th November) and late planting (15th December) during growing season of 2012-13. The current experiment was carried out in randomized complete block design having three replications. 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).

RESULTS AND DISCUSSION

Metrological observations

Day-to-day meteorological data were recorded for minimum and maximum temperatures during whole wheat growing season (2012-13) at the experimental site that is illustrated in figure 1. The high temperature was observed during the sowing of experiment in the second week of November. The temperatures was low in the months of December and January, which persisted up, to first week of February. At grain filling time, during the month of March, temperature exceeded from 30^{0} C which reached to 38^{0}C at ripening stage.

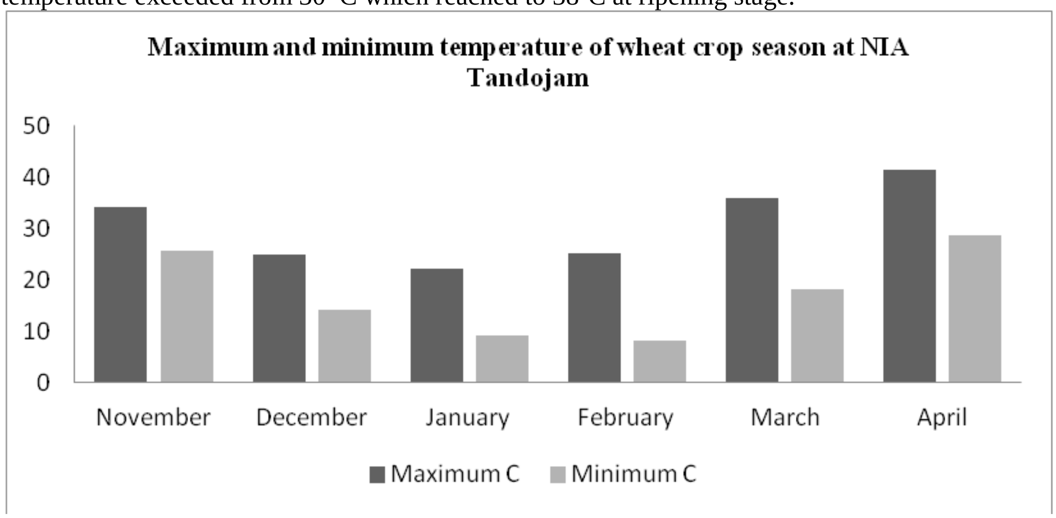

Fig. 1. Maximum and minimum temperature of wheat season, 2012-2013.

Analysis of variances

The mean squares of all the traits among the tested genotypes at normal and high temperature exhibited a significant differences ($P \leq 0.01$), representing the existence of excessive genetic variability among the genotypes (Table 1a and 1b). Results on overall mean performance of the studied traits are discussed in following paragraphs.

Spike length (cm)

Spike length is a trait of great interest since bigger spike is contemplated to set more grains, resulting in greater grain yield plant^{-1}. Maximum spike length was recorded in Kiran-95 (14.15 cm), while smaller spike length was observed in Lasani (11.22 cm) at normal temperature. However, maximum spike length was also recorded in Kiran-95 (11.15 cm), while smaller spike length was observed in Lasani (9.50 cm) at high temperature. The decrease percent for spike length among genotypes ranged from 5.77 to 30.74%. Two genotypes AS-2002 and Sundar showed less reduction (5.77 and 11.10%, respectively). Genotype TJ-83 showed the highest reduction of 30.74% in spike length (Table 2). Hozayan and Monem (2010) found in their finding that reduction reached from 4.05 to 19.94% for plant height, 6.48 to 21.33% for spikes number/0.25 m^2, 5.00 to 6.22% for spike length, 1.54 to 31.65% for spike weight, 4.48 to 33.73% for grain weight spike^{-1}, 4.05 to 18.92% for spikelets number spike^{-1}, 2.26 to 5.85%

for grain spike ratio and 14.39 to 26.84% for 1000-grain weight compared with those of plants sown at suitable date. Overall reduction of 17.56% was recorded for spike length due to late sowing in our study which is close the reported value.

Table 1a. Mean squares of wheat genotypes under normal temperature.

Source of variation	Mean squares					
	D.F.	Spike length	Spikelets $spike^{-1}$	Grain weight $spike^{-1}$	Grains $spike^{-1}$	1000-grains weight
Replications	2	0.565	0.034	0.024	123.526	2.774
Genotypes	7	5.247**	3.899**	4.570**	360.031**	98.853**
Error	14	0.230	0.106	0.153	20.061	4.780
Total	23					

**= significant at 1%

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

Source of variation	Mean squares					
	D.F.	Spike length	Spikelets $spike^{-1}$	Grain weight $spike^{-1}$	Grains $spike^{-1}$	1000-grains weight
Replications	2	0.182	0.476	0.057	29.468	81.650
Genotypes	7	1.499**	10.511**	3.371**	152.805**	90.353**
Error	14	0.107	0.518	0.042	9.742	33.809
Total	23					

**= significant at 1%

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

Genotypes	Spike length (cm)		Difference	Decrease (%) in high temperature
	Normal temperature	High temperature		
V3	13.45	11.07	2.38	17.69
V5	13.35	10.35	3.00	22.47
Sundar	12.61	11.12	1.40	11.10
Sehar-2006	12.80	10.93	1.87	14.60
Lasani	11.22	9.50	1.72	15.32
AS-2002	11.25	10.60	0.65	5.77
Kiran-95	14.15	11.15	3.00	21.20
T.J-83	14.12	10.80	3.32	30.74
Mean	12.87	10.70	2.16	17.36

Table 3. The Mean difference and reduction (%) in spikelets spike^{-1} due to high temperature.

Genotypes	Spikelets spike^{-1}		Difference	Decrease (%) in high temperature
	Normal temperature	High temperature		
V3	23.50	22.90	0.60	2.55
V5	22.50	21.90	0.60	2.55
Sundar	21.80	20.55	1.25	5.73
Sehar-2006	22.10	21.35	0.75	3.39
Lasani	21.00	18.75	2.25	10.71
AS-2002	20.30	18.50	1.80	8.86
Kiran-95	22.30	19.80	2.50	11.21
T.J-83	23.30	21.25	2.05	8.79
Mean	22.10	20.67	1.47	6.72

Table 4. The Mean difference and reduction (%) in grain weight spike^{-1} (g) due to high temperature

Genotypes	Grain weight spike^{-1}		Difference	Decrease (%) in high temperature
	Normal temperature	High temperature		
V3	2.87	1.28	1.59	55.40
V5	2.99	1.33	1.66	55.51
Sundar	3.31	1.27	2.04	61.63
Sehar-2006	3.42	1.54	1.88	54.97
Lasani	3.59	1.39	2.20	61.28
AS-2002	3.57	1.37	2.20	61.62
Kiran-95	3.81	1.49	2.32	60.89
T.J-83	3.73	1.43	2.30	61.66
Mean	3.41	1.39	2.02	59.12

Table 5. The Mean difference and reduction (%) in grains spike^{-1} due to high temperature.

Genotypes	Grains spike^{-1}		Difference	Decrease (%) in high temperature
	Normal temperature	High temperature		
V3	61.70	43.65	18.05	29.25
V5	63.40	43.90	19.50	30.75
Sundar	70.90	52.25	18.65	26.30
Sehar-2006	68.80	48.85	19.95	28.99
Lasani	60.00	37.65	22.35	37.25
AS-2002	62.65	38.80	23.85	38.06
Kiran-95	77.30	39.15	38.15	49.35
T.J-83	71.85	39.95	31.90	44.39
Mean	67.07	43.02	24.05	35.54

Table 6. The Mean difference and reduction (%) 1000-grain weight due to high temperature.

Genotypes	1000- Grain weight		Difference	Decrease (%) in high temperature
	Normal temperature	High temperature		
V3	46.56	29.54	17.02	36.55
V5	47.17	30.94	16.23	34.40
Sundar	46.75	24.50	22.25	47.59
Sehar-2006	49.80	31.57	18.23	36.60
Lasani	59.90	37.15	22.75	37.97
AS-2002	57.02	35.78	21.24	37.25
Kiran-95	49.32	38.58	10.74	21.77
T.J-83	51.98	36.40	15.58	29.97
Mean	51.06	33.05	18.01	35.27

Spikelets spike^{-1}

Spikelets spike^{-1} is also an important trait in wheat, as more number of spikelets spike^{-1}, the more number of the grains spike^{-1}, consequently higher the grain yield plant^{-1}. Maximum number of spikelets spike^{-1} was recorded in V3 (23.50) and minimum spikelets spike^{-1} was observed in AS-2002 (20.30) at normal temperature. At high temperature, the maximum number of spikelets spike^{-1} was recorded in V3 (22.90), whereas less spikelets spike^{-1} was observed in AS-2002 (18.50) (Table 3). The decrease percent for number of spikelets spike^{-1} among genotypes ranged from 2.55 to 11.21%. Genotypes V3, V5 and Sehar-2006 showed less reduction in number of spikelets spike^{-1} (2.55, 2.53 and 3.39 %, respectively). Considering the reduction percentage for this trait, it is obvious that our findings show some interesting results under stress conditions hence these genotypes which showed low reduction at delayed planting in number of spikelets^{-1} spike may prove valuable genetic stock in future breeding programs. Contrary to our results, Fischer (1984) reported that when growth resources are limited by heat stress, the size of plant organs such as leaves, tillers and spikes is also reduced. According to Shafiq (2004), early sowing enhanced germination per unit area, plant height, spikelets spike^{-1}, grains spike^{-1} and 1000-grain weight over late sowing.

Grain weight spike^{-1} (g)

With regards to grain weight spike^{-1}, the maximum main spike yield was recorded in Kiran-95 (3.81 g), while minimum weight of main spike yield was observed in V3 (2.87 g) at normal temperature. In the case of high temperature, the maximum main spike yield was recorded in Sehar-2006 (1.54 g) and minimum main spike yield was observed in V3 (1.28 g). The decrease percent for main spike yield among genotypes ranged from 54.97 to 66.66% (Table 4). Genotype Sehar-2006 showed less reduction (54.97%) in main spike yield, indicating that this genotype could be reliable plant material to develop high temperature tolerance genotypes. The effect of high temperatures on wheat genotypes typically results in severe reductions of yield and its associated components e.g., kernel weight (Wieg and Cuellar, 1981). Acevedo *et al*. (1991) penned that a rise of one degree in mean temperature during grain filling period may resulted in a reduction of 4 percent in grain weight.

Grains spike^{-1}

Grains spike^{-1} is also a key trait in wheat breeding; it directly involves enhancing the grain yield plant^{-1}. Grains spike^{-1} ranged from 60.00 in Lasani to 77.30 in Kiran-95 genotypes at normal sowing date. Maximum (52.25) and minimum (37.65) grains spike^{-1} was produced by Sundar and Lasani genotypes at high temperature. The decrease percent for grains spike^{-1} among genotypes ranged from 26.30 to 49.35%. Genotypes Kiran-95 and T.J-83 showed the highest reduction of 49.35 and 44.39%, respectively, in grains spike^{-1} (Table 5). These findings are supported by those of Hanson (2001), who reported significant variation in number of grains spike^{-1} with sowing dates. The possible reasons could be due to suitable temperature during seed development and more number of branches palnt^{-1} with more productive spikes, and thus resulted in greater number of grains spike-^{1}. Sial *et al*. (2005) reported reduction in grain numbers due to late sowing and temperature stress.

1000-grain weight (g)

Seed index is one of the more important yield contributing traits, it also increases yield at great level. The maximum 1000-grain weight was recorded in Lasani (59.90 g), while minimum 1000- grain weight was found in V3

(46.56 g) and mean of all six genotypes for 1000- grain weight was obtained 51.06 g at normal sowing date. In the case of late planting, the maximum 1000-grain weight was recorded in Kiran-95 (38.58 g), while minimum 1000-grain weight was observed in Sundar (24.50 g) and average of all genotypes for 1000- grain weight was remained 33.05 g at late sowing date. Overall (35.27 %) reduction was observed with late sowing (Table 6). The decrease percent for 1000-grain weight among genotypes ranged from 21.77 to 47.59 %. The genotype Kiran-95 showed less reduction (21.97%) in 1000-grain weight (Table 10). Abdullah *et al.* (2007) reported that characters i.e. 1000-grain weight, test weight and flour yield dropped significantly with delayed sowing.

REFERENCES

Abdullah, M., A. Rehman, N. Ahmad and I. Rasul (2007). Planting time effect on grain and quality characteristics of wheat. *Pak. J. Agri. Sci.,* 44 (2): 200-202.

Acevedo, E., M. Nachit and G. Ortiz-Ferrara (1991). Effect of heat stress on wheat and possible selection tools for use in breeding for tolerance. In: D.A. Saunders (ed.). Wheat for the non-traditional warm areas, pp. 401-421. Mexico, DF. CIMMYT.

Bhatti, I.M. and A.H. Soomro. 1996. Agriculture inputs and field crop production in Sindh (2nd Rev. Ed.). Directorate General, Agriculture Research Sindh, Hyderabad, Sindh, Pakistan. PP. 95-107.

Fischer, R.A (1984). Physiological limitations to producing wheat in semitropical and tropical environments and possible selection criteria. In pages 209-230, Wheat for more tropical environments: A proceedings of the international symposium. Mexico, D.F.: CIMMYT.

GOP. 2014. Area and Production of Major Kharif and Rabi Crops. Economic Survey of Pakistan (2014-15), Ministry of Food and Agriculture; Federal Bureau of Statistics, Government of Pakistan, Islamabad.

Hanson, B. (2001). Planting date influence on yield and agronomic traits of hard red spring wheat in northeastern North Dakota. Langdon Res. Ext. Center NDSU Agric. Report.

Harding, S.A., J.A. Guikema and G.M. Paulsen (1990). Photosynthetic decline from high temperature during maturation of wheat I: Interaction with senescence process. *Plant Physiol.,* 92: 648–653.

Hozayan, M. and A.A.A. Monem (2010). Alleviation of potential impact of climate change of wheat productivity using arginine under irrigated Egyptian agriculture, Options mediteranenes. Economic of drought and drought preparedness in climate change context, 95-100.

Khan, M.I., M. Tila, F. Subhan, M. Amin and S.T. Shah (2007). Agronomic evaluation of different bread wheat (*Triticum Aestivum* L.) genotypes for terminal heat stress. *Pak. J. Bot.,* 39(7): 2415-2425.

Lopes, M.S. and M.P Reynolds (2010). Partitioning of assimilates to deeper roots is associated with cooler canopies and increased yield under drought in wheat. *Funct. Plant Biol.,* 37(2): 147–156.

Mahboob, A.S., A. Arain, S. Khanzada, H. Mazhar, M. Naqvi, D. Umar and N. A. Nizamani (2005).Yield and quality parameters of wheat genotypes as affected by sowing dates and high temperature stress. *Pak. J. Bot.,* 37(3): 575-584, 2005.

Nageswara, R.C., H.S. Talwar and G.C. Wright (2001) Rapid assessment of specific leaf area and leaf nitrogen in Peanut (*Arachis hypogaea* L.) using a chlorophyll meter. *J. Agron. Crop Sci.,* 186 (3):175–182.

Okuyama, L.A., F.L. Carlos and B.N.J. Fernandes (2005). Grain yield stability of wheat genotypes under irrigated and non-irrigated conditions. *Braz. Arch. Biol. Technol.,* 48(5): 697-704.

Shafiq, H.M (2004). Modeling growth, radiation use efficiency and yield of wheat at different sowing dates and nitrogen levels under arid conditions of Bhawalpur. M.Sc. (Hons.) Thesis, University of Agriculture, Faisalabad-Pakistan.

Sial, M.A., M.A. Arain, S. Khanzada, M.H. Naqvi, M.U. Dahot, N.A. Nizamani (2005). Yield and quality parameters of wheat genotypes as affected by sowing dates and high temperature stress. *Pak. J. Bot.,* 37:575-58.

Sohail, M., I. Hussain, R. Din, S.K. Tanveer, M. Qamar and S.H. Abbas (2014). Physio-agronomic traits evaluation of wheat genotypes for adaptability under rainfed conditions. *Sarhad J. Agric.,* 30(2): 151-156.

Wardlaw I.F. and C.W. Wrigley (1994). Heat tolerance in temperate cereals: an overview. *Aust. J. Plant Physiol.,* 21: 695-703.

Wieg, C.L. and J.A. Cuellar (1981). Duration of grain filling and kernel weight of wheat as affected by temperature. *Crop Sci.,* 21: 95-101.

(*Accepted for publication December 2015*)