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Effect of terminal high temperature imposed by late sowing on phenological traits of wheat (*Triticum aestivum* L.)

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Abstract

With a views to observe the effect of prevailing air temperature at irrigated late sowing (ILS) conditions on phenological traits of advanced wheat genotypes and to identify heat tolerant genotypes, the trial was carried out in the research field of Wheat Research Centre, Bangladesh Agricultural Research institute (BARI), Nashipur, Dinajpur in the season of 2011-12. The treatments were four dates of sowing viz. 30 Nov (D_1), 15 Dec (D_2), 30 Dec (D_3), 14 Jan (D_4) and four genotypes viz. BARI Gom 26 (V_1), BAW 1051 (V_2), BAW 1120 (V_3), BAW 1141(V_4) . The genotypes V_2, V_3, and V_4 were taken as tested genotypes and V_1 as check. The design was split-plot with three replications. In ILS conditions, the genotypes phased high temperature stress that significantly reduced the duration of booting, heading, anthesis and physiological maturity stages of all genotypes compared as irrigated timely sowing (ILS, D_1) condition since those faced 21 to 25.8^{o}C average mean temperature during booting to physiological maturity stages from 19 February to 09 April, 2012 (10 days interval minimum and maximum temperature was averaged). All genotypes sown on 30 Nov. and 15 Dec. produced yield more than 4 t ha^{-1} but produced less than 4 t ha^{-1} in other ILS conditions except BAW 1141 seeded on 30 December. Considering overall performance, BAW 1120 and BAW 1141 may be cultivated up to 15 December and 30 December to get yield 3.34 t ha^{-1} and 4.15 t ha^{-1}, respectively as heat tolerant genotypes.

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Introduction

The release of heat tolerant wheat variety is demand of time in Bangladesh due to global warming or climate change. Optimum time of wheat seeding is 15 to 30 November in our country but it can delay up to 7 December in Northern part of Bangladesh due to cool weather compared as that of other parts of the country. Generally, the farmer of our country cultivates wheat in *Rabi* season after harvesting of T. *aman* rice. This rice cultivation fully depends on natural rainfall. Due to lack of timely or sufficient rainfall, T. *aman* rice can't be planted in time. Ultimately harvesting is done lately. So farmers can't sow wheat seeds in optimum time. Most of the farmers sow wheat seeds on last 15 days of December. In late sowing condition, wheat crop faces high temperature stress. Heat stress lowers the grain yield significantly. Researchers have pointed out that wheat yield is considerably affected by sowing date (Chio *et al.*, 1992; Liszewski, 1999; Michiyama *et al.*, 1998; Pecio and Wielgo, 1999). In fact, due to variation of sowing time the air temperature varies widely that affects the phenology of crop plants. On the other hand, Genetic diversity for heat tolerance in cultivated wheat is well established (Midmore et al., 1984; Al-Khatib and Pausen, 1990; Reynolds *et al.,* 1994). Different in photosynthesis under heat stress have been shown to be associated with a loss of chlorophyll and a change in the a:b chlorophyll ratio due to premature leaf senescence (Al-Khatib and Paulsen, 1984; Harding *et al.,* 1990). Under heat stress, wheat crop completes its life cycle much faster than under normal temperature conditions (Reynolds *et al.,* 1985). If the crop has a short duration consequently, it gets fewer days to accumulate assimilates during life cycle and biomass production is reduced. Reproductive processes are remarkably affected by high temperature in most plants, which ultimately affect fertilization and post-fertilization processes leading to reduce crop yield (Wahid *et al.*, 2007). Wheat Research Center (WRC), BARI developed some suitable variety (s) having heat tolerant which can be grown after harvest of T. *aman* rice. Recently, some advanced genotypes have been identified by Barma, *et al.*, (2008). As plant responses to high temperature varies with plant species, varieties, locations and phenological stages, it is essential to observe the performance of advanced genotypes of wheat in respect of phonological traits. Therefore, the trial was undertaken to find out heat tolerant suitable genotype (s) for growing in late sowing condition.

Materials and method

The experiment was carried out in the research field of Wheat Research Centre, BARI, Nashipur, and Dinajpur in the season of 2011-12. The research materials and method are described below:

Design and treatment

The experiment was laid out in split-plot design with three replications. Four genotypes viz. BARI Gom 26 (V_1), BAW 1051 (V_2), BAW 1120 (V_3) and BAW 1141 (V_4) were allocated in the sub-plots, and four sowing dates viz. 30 Nov (D_1), 15 Dec (D_2). 30 Dec (D_3), 14 Jan (D_4) in the main-plots. The unit size of plot was 4×5 m.

Fertilizer and application method

In Zoo condition, land was ploughed five times horizontally with power tiller. Each of the main-plots was fertilized @ 100-27-50-20-1.25-1-5000 kg ha^{-1} as N-P-K-S-Zn-B-Cow dung. The source of N, P, K, S, Zn and B were Urea, TSP, MoP, Gypsum, Zinc sulphate and Boric acid, respectively. All of fertilizers and 2/3 rd of urea were applied as basal during final land preparation.

Seeding

After well preparation of land, seeds @ 120 kg ha^{-1} of each variety/lines was sown followed by continuously line sowing in 20 cm apart. Before sowing seed, it was treated with Provax 200 WP @ 3 g/Kg seed.

Intercultural operations

Rest urea was applied as top dressing at CRI stage followed by first irrigation. The plot was kept free from weeds by spraying herbicide (named affinity) @ 2.5 g/L water after first irrigation. Mulching was done at 28 days after sowing (DAS). Two irrigations were applied during late booting and early grain filling stages, respectively. No plant protection measures were needed.

Data record and analysis

Data on days to booting, heading, anthesis, physiological maturity, yield and yield contributing characters were recorded. Each genotype was harvested after at maturity. Recorded data were analyzed statistically followed by MSTATC and the means were separated by the Lsd at 5% level of probability.

Table 1. Effect of Genotypes and Sowing times on different phenological stages and yield of wheat.

Treatments x Genotypes	Booting	Heading	Anthesis	Physiological Maturity	Yield (t ha^{-1})
V_1	56	66	71	98	3.66
V_2	56	65	70	97	3.8
V_3	58	67	71	99	3.89
V_4	54	64	67	95	4.24
Lsd $_{(0.05)}$	1.06	1.37	1.37	0.6	0.14
CV (%)	2.2	2.5	2.1	0.8	0.6
Dates of Sowing (D)					
Sowing dates	Booting	Heading	Anthesis	Physiological Maturity	Yield (t ha^{-1})
D_1	59	70	76	107	5.44
D_1	58	67	72	102	4.38
D_3	55	64	67	94	3.52
D_4	53	61	65	86	2.26
Lsd $_{(0.05)}$	1.17	1.74	1.74	1.24	0.62
CV (%)	2.1	2.7	2.3	1.3	1.6

V_1 = BARI Gom 26 D_1 = 30 Nov DAS = Days after Sowing
V_2 = BAW 1051 D_2 = 15 Dec Lsd = Least Significance Difference
V_3 = BAW 1120 D_3 = 30 Dec CV = Co-efficient of Variance
V_4 = BAW 1141 D_4 = 14 Jan

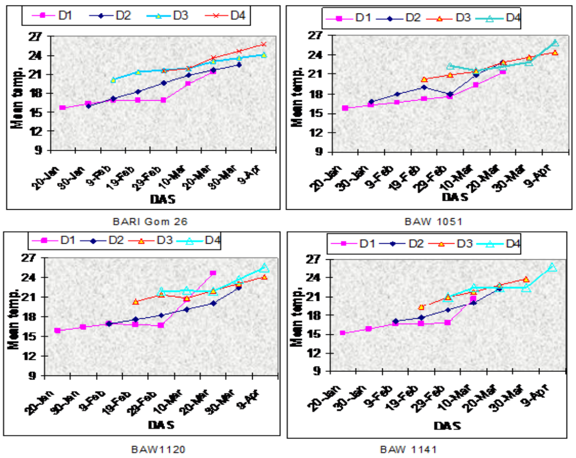

Fig. 1. Temperature (Mean) fluctuation during booting to physiological maturity different genotypes at different sowing dates.

Air temperature effect on genotypes

Among the genotypes BAW 1141 was produced the highest yield (4.24 t ha^{-1}), although this genotype completed its phenological traits; booting, heading, anthesis and physiological maturity stages within the shortest period i.e. 54, 64, 67 and 95 DAS, respectively. Because it can't tolerate high temperature and bipolaris leaf blight disease of wheat. It was observed that BAW 1120 took more days to last those phonological stages compared as other genotypes, but its yield (3.89 t ha^{-1}) was less than that of BAW 1141. Because it is more susceptible to bipolaris leaf blight disease of wheat than BAW 1141 although it can tolerate high temperature. On the contrary, BARI Gom 26 furnished its booting, heading, anthesis and physiological maturity stages 56, 66, 71 and 98 DAS, respectively within more days compared as V_2 and V_4, but its yield (3.66 t ha^{-1}) was the lowest of all. Although BAW 1051 required more days compared as BARI Gom 26 and BAW 1141, it was ranked in the third position among the genotypes in respect of yield (3.8 t ha^{-1}) produced (Table1). It is said that life span varies genotypes to genotypes of wheat, and reduces or hampers the yield production of wheat genotypes. Similar result was also observed by Nahar, *et al.* (2010). So, it was observed that BAW 1141 is the best genotype among all genotypes in respect of yield and short time life cycle.

Result and discussion

The results of studied characters were presented in the tables 1 and Table 2, and Fig.1. Findings of these phenological traits were explained below under the sub headings.

Table 2. Effect of interaction between genotypes (V) and dates of sowing (D) on various phenological stages and yield of wheat.

Sowing date X Genotypes	Booting	Heading	Anthesis	Physiological Maturity	Yield (t ha^{-1})
D_1xV_1	60	71	78	110	5.14
D_1xV_2	58	70	76	106	5.44
D_1xV_3	59	72	77	108	5.53
D_1xV_4	56	68	72	103	5.66
D_2xV_1	57	67	73	102	4.28
D_2xV_2	57	67	71	102	4.32
D_2xV_3	59	68	72	104	4.41
D_2xV_4	56	64	69	99	4.52
D_3xV_1	55	64	67	95	3.3
D_3xV_2	56	63	67	94	3.29
D_3xV_3	57	66	68	96	3.34
D_3xV_4	53	63	64	92	4.15
D_4xV_1	52	62	66	85	1.94
D_4xV_2	53	61	65	86	2.16
D_4xV_3	55	63	67	88	2.29
D_4xV_4	50	58	63	85	2.64
Lsd ($_{0.05}$)	*2.12*	*2.75*	*2.75*	1.24	*0.29*
CV (%)	2.2	2.5	2.1	0.8	0.6

Air temperature effect on sowing dates

The highest yield (5.44 t ha^{-1}) was produced at normal sowing time *i.e.* 30 November. The lowest yield (2.26 t ha^{-1}) was produced at very late sowing *i.e.* 14 January. In normal sowing condition, different phenological stages *i.e.* booting, heading, anthesis and physiological maturity were required more days (59, 70, 76 and 107 DAS, respectively) than other sowing dates (Table 1). This period (booting to physiological maturity stage) prevailed from 20 January to 29 February and temperature was 15.7 to 21.6^{o}C (Fig.1). Different genotypes sown on 14 January were needed fewer days to complete booting, heading, anthesis and physiological maturity stages (53, 61, 65 and 86 DAS, respectively) compared as other sowing dates. This period was from 29 February to 9 April and temperature was about 21 to 25.8^{o}C. Various genotypes sown on 15 and 30 December also performed better (Yield 4.38 t ha^{-1}) and good (3.52 t ha^{-1}), respectively. It was observed that life span of wheat was decreased with increasing temperature remarkably. Under high temperature conditions, earlier heading is advantageous in the retention of more green leaves at anthesis, leading to a smaller reduction in yield (Tewolde *et al*., 2006). Growth chamber and greenhouse studies suggest that high temperature is most deleterious when flowers are first visible and sensitivity continues for 10-15 days. Among the reproductive phases fertilization (13 days after anthesis) is one of the most sensitive stages to high temperature in various plants (Foolad, 2005). It is observed that high air temperature shortens different phonological stages of wheat and low temperature lengthen those of wheat. Similar result was observed by Nahar, *et al*. (2010). So it is decided that wheat may be sown up to 15 December to get Maximum yield (≥4 t ha^{-1}) and even on 30 December to produce optimum yield (≥3 t ha^{-1}).

Interaction effect of genotypes and sowing times on various phynological stages and yield of wheat

BAW 1141 sown on 30 November producing the maximum yield (5.66 t ha^{-1}) in all of sowing times compared as other lines/variety (Table 2) although its different phenological stages *i.e.* booting, heading, anthesis and physiological maturity (56, 68, 72 and 103 DAS, respectively) was the shortest period of all. It was observable that BARI Gom 26 sown on 30 November gave the lowest yield (5.14 t ha^{-1}) though its duration of different phenological stages was the longest period (60, 71, 78 and 110 DAS, respectively) of all lines. Sown on 15 December, BAW 1141 yielded best (4.41 t ha^{-1}). It can be cultivated up to 30 December since it yielded 4.15 t ha^{-1} grains. Continual heat stress is defined by a mean daily temperature of over 17.5 ^{o}C in the coolest month of the season (Fischer and Byerlee, 1991). It is opined that sequential late sowing conditions (With increasing temperature) reduced the duration of different phenological stages resulted decreasing the yield potentiality of all wheat genotypes (Table 2) as temperature was prevailing 17.6 to 25.8 ^{o}C from 19 February to 09 April (Fig. 1). Heat stress (high temperature, 21 to 25.8^{o}C) reduced the duration of different phenological stages of BAW 1141. It might be sown up to 30 December to achieve optimum yield (4.15 t ha^{-1}). Another genotypes might be sown to grow yield of >4.0 t ha^{-1} on 15 December and get yield >3.0 t ha^{-1} on 30 December.

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