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GRAIN GROWTH OF WHEAT UNDER PREVAILING AIR TEMPERATURE

M.A.K. Mian[1], M.R. Islam[2], J. Hossain[2] and M.A.Aziz[1]

Agronomy Division, BARI, Joydebpur[1] and RARS, Ishwardi[2]
Bangladesh Agricultural Research Institute, Joydebpur, Gazipur 1701

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Abstract

An experiment was conducted at the Regional Agricultural Research Station, Ishwardi, Pabna in two consecutive years of 2010-2011 and 2011-2012 to quantify the effect of temperature on phenological duration and grain growth of wheat. Temperature variation was created by changing sowing date (15 November=S_1, 30 November=S_2, 15 December=S_3 and 30 December=S_4). Results revealed that reproductive phase was more sensitive to high temperature as compared to vegetative phase of wheat. Reproductive phase reduced from 54 to 37 days in 2010-2011 and from 64 to 34 days in 2011-2012 as influenced by higher air temperature under late sowing. Duration of reproductive phase was strongly and negatively correlated with mean air temperature (r=-0.64 to -0.96 at p<0.01). Maximum grain growth (49.12-50.18 mg grain^{-1}) was recorded at 55 days after anthesis in 30 November sowing in both the years. Grain growth was negatively correlated (r=-0.80 at p<0.01) with mean air temperature during grain growth period. Grain yield was the highest (4560-6080 kg ha^{-1}) in 30 November sowing, afterwards it reduced in both the years. Grain yield was negatively correlated (r=-0.70 at p<0.01) with mean air temperature of grain growth period. Rising of air temperature at grain filling stage subjected to reduced grain yield of wheat. Effect of temperature on grain yield of wheat can be explained about 88% by the function of $Y= -14910+ 2069X-52.67X^2$ (R^2 = 0.88). Rising of one degree (°C) temperature above optimum (19.64 ^{0}C) grain yield reduced @ 53 kg ha^{-1} (0.98%).

Introduction

Wheat is an important cereal crop in Bangladesh covering an area of 436814 ha with an annual production of 1347926 metric tons (BBS, 2016). Wheat is winter season crop in Bangladesh. But winter is becoming shorter due to climate change and global warming. It is estimated that temperature would be increased about 1.4°C by 2050 and 2.4°C by 2100 in Bangladesh (OECD, 2003). Therefore, wheat production may be reduced. As the global warming, temperature has significant effect on crop production. Due to global warming, environmental scientists have given research emphasis on temperature effect and other weather elements. Bangladesh has experienced climate changed effect due to global warming (Karim, 2015). Winter is coming shorter and temperature is rising in winter affecting the winter crops in Bangladesh (Mian *et al.,* 2016). Wheat requires different temperatures at different stages of plant growth and development. The optimum temperature for wheat ranges from 20° to 25° C. Temperature above 30 ^{0}C at grain filling stage leads the crop to forced maturity and retards grain formation resulting yield loss (Uddin *et al.*, 2015).

Rising of air temperature in later part of winter affects the grain development and reduces grain growth resulting lower yield of wheat (BARI, 2016). Sometimes, farmers cannot sow wheat timely due to excess soil moisture or standing crop of T. *aman* rice in the field. Consequently, delay sowing of wheat frequently subjects to high temperature stress in grain filling stage. On this account, farmers harvest lower yield of wheat (BARI, 2016). Temperature is the single most important climatic factor that affects the growth and development of crop plant (Mian *et al.,* 2013). It also influences the other different physiological process of the crop plant. Temperature affects root and shoot growth, nutrient uptake, water absorption, photosynthesis, respiration, transpiration, translocation of photosynthate and other metabolic functions in the plant system (Ali and Sarker, 2016). High temperature affects phenology, growth and yield of wheat (Chakrabarti *et al.* 2013). Different planting time and year to year temperature variation would affect the grain growth and grain yield of wheat. The present study was undertaken to quantify the effect of temperature on phenology and grain growth of wheat under late sown irrigated condition.

Materials and methods

The experiment was conducted at the Regional Agricultural Research Station, Ishurdi, Pabna during the *rabi* season of 2010-2011 and 2011-2012. The experiment was laid out in a RCB design with four replications. Unit plot size was 6 m × 5 m. Soil texture of the experimental site was sandy loam. Wheat var. BARI Gom-26 was used as test crop in the experiment. The treatment was 15 November= S_1, 30 November= S_2, 15 December= S_3 and 30 December= S_4. The crop was fertilized with 80-35-55-20-1.2 kg ha^{-1} of N-P-K-S-B. All nutrients including 2/3 of N were applied as basal. Rest of 1/3 of N was top dressed at CRI stage. Three irrigations were applied at CRI, booting and grain filling stages. Weed control was done at 25 days after emergence by spading in between rows. No disease and insect control is needed. Data on duration of phenological phases, grain weight at 5 days interval starting from 20 days after anthesis, grain yield, and daily air temperature were recorded. Air temperature was calculated on the basis average of daily maximum and minimum temperature. Crop was harvested on 25 March, 1 April, 2 April and 4 April respectively in 2011 and on 15 March, 22 March, 28 March and 7 April, respectively in 2012. Data were analyzed and presented in Tables and Figures. Optimum temperature was estimated using the functional model as below (Mian *et al.*, 2011).

$Y=a + bx- cx^2$
Y=Grain yield of wheat (dependent variable)
a=intercept (constant)
x=mean air temperature (independent variable)
b and c are the rates of change of grain yield due to change of air temperature
Optimum temperature for maximum grain yield of wheat (Yw)= (-b)/2c

Results and Discussion

Effect of sowing date and air temperature on phenological duration

Phenological duration is changed due to change of sowing date (Table 1). Duration of vegetative phase was found maximum (68 days) in 30 November sowing but minimum (34-37 days) in 30 December sowing in both the years. Duration of reproductive was longer (54-64) in 15 November sowing; afterwards it decreased chronologically with the shortest (34-37 days) in 30 December sowing. Field duration was exhibited higher (112-122 days) in earlier sowing as compared to later sowing. Similar results also have been reported by Ali and Sarker (2016). Phenological duration showed negative correlation with air temperature (Table 2). Duration of reproductive phase showed strong and negative correlation (r=-0.64 to -0.96 at $p< 0.01$) with air temperature in both the years. Field duration also exhibited strong and negative correlation (r=-0.82 to -0.93 at $p< 0.01$) with air temperature in 2010-2011 and 2011-2012. Correlation between duration of vegetative phase and air temperature was very weak but negative (Table 2). The results are in agreement with the findings of others (Wheeler *et al.,* 1996 and Mian *et al.,* 2013).

Effect of sowing date and air temperature on grain growth

Effect of sowing date on grain growth has been presented in Fig.1 and Fig.2. Sowing in 15-30 November exhibited higher trend of grain growth in both the years (Fig. 1 and Fig. 26) as compared to later sowing. Grain growth was maximum (49.12-50.18 mg $grain^{-1}$) in 30 November sowing followed by 15 November sowing while the lowest in 30 December sowing in both the years. Grain growth showed negative and strong correlation ($r=0.80$ at $p<0.01$) with air temperature (Table 2). The results indicated that grain growth reduced due to higher temperature in late sown condition of wheat. Similar results also have been described by Khan and Aziz (2015), and (Uddin *et al*., 2015).

Effect of sowing date and air temperature on grain yield

Grain yield was the highest (4560-6080 kg ha^{-1}) in 30 November sowing and the lowest in 30 December sowing in both the years (Table 4). The results expressed that grain yield reduced in later sowing as compared earlier sowing. Grain yield showed negative and strong correlation ($r= -0.71$ to -0.79 at $p<0.01$) with air temperature (Table 4). The results revealed that rising of air temperature at later sowing reduced grain growth resulting poorer grain yield of wheat. The results are in agreement with the reports of BARI (2014) and BARI (2016). Effect of temperature on grain yield of wheat can be explained about 88% by the function of $Y=-14910+ 2069X -52.67X^2$ (R^2 = 0.88) (Fig. 3). By using the function it was estimated that rising of one degree (°C) temperature above optimum (19.64 ^{0}C) grain yield reduced @ 53 kg ha^{-1} (0.98%). Similar results also have been described by Chakrabarti *et al.* (2013).

Conclusion

Reproductive phase as well as field duration of wheat would be reduced as influenced by air temperature at later sowing (after 30 November). Grain growth was higher in 30 November sowing and it was negatively correlated ($r=-0.80$ at $p<0.01$) with mean air temperature. Rising of one degree (°C) temperature above optimum (19.64 ^{0}C) grain yield would be reduced @ 53 kg ha^{-1} (0.98%).

Table 1. Phenological duration of wheat under different sowing dates (2010-2011 and 2011-2012)

Year	Sowing date	Vegetative phase (days)	Reproductive phase (days)	Field duration (days)
2010-2011	15 November	58	54	112
	30 November	68	45	113
	15 December	63	39	102
	30 December	56	37	93
2011-2012	15 November	56	64	122
	30 November	68	45	114
	15 December	65	38	105
	30 December	64	34	98
Mean	-	62	45	107
STDEV	-	5	10	10

Table 2. Effect of air temperature on phenological duration of wheat (2010-11and 2011-2012)

Year	Correlation between	Correlation co-efficient (r)
2010-2011	Duration of vegetative phase and air temperature	-0.26NS
	Duration of reproductive phase and air temperature	-0.96**
	Field duration of and air temperature	-0.93**
2011-2012	Duration of vegetative phase and air temperature	-0.14NS
	Duration of reproductive phase and air temperature	-0.64**
	Field duration of and air temperature	-0.82**

** indicates significant at 0.01 level of probability, NS = not significant

Table 3. Effect of air temperature on grain growth of wheat (2010-2011 and 2011-2012)

Year	Sowing date	Air Temperature ^0C (Reproductive Phase)	Grain wt. (mg grain^{-1})	Correlation co-efficient (r)
2010-2011	15 November	18.60	48.22	-0.74**
	30 November	22.86	50.18	
	15 December	24.09	42.57	
	30 December	25.14	39.21	
2011-2012	15 November	20.16	47.50	-0.69**
	30 November	23.17	49.12	
	15 December	24.42	42.45	
	30 December	26.42	39.24	
Mean	-	23.11	44.81	-0.80**
STD	-	2.59	4.46	
Combined of 2010-2011 and 2011-2012	-	-	-	

** indicates significant at 0.01 level of probability

Table 4. Effect of air temperature on grain yield of wheat (2010-2011 and 2011-2012)

Year	Sowing date	Air Temperature ^0C (Reproductive Phase)	Grain yield (kg ha^{-1})	Correlation co-efficient (r)
2010-2011	15 November	18.60	5920	-0.79**
	30 November	22.86	6080	

	15 December	24.09	4380	
	30 December	25.14	3580	
2011-2012	15 November	20.16	4200	-0.71**
	30 November	23.17	4560	
	15 December	24.42	4040	
	30 December	26.42	3000	
Mean	-	23.11	4470	-0.70**
STD	-	2.59	1064	
Combined of 2010-2011 and 2011-2012	-	-	-	

** indicates significant at 0.01 level of probability

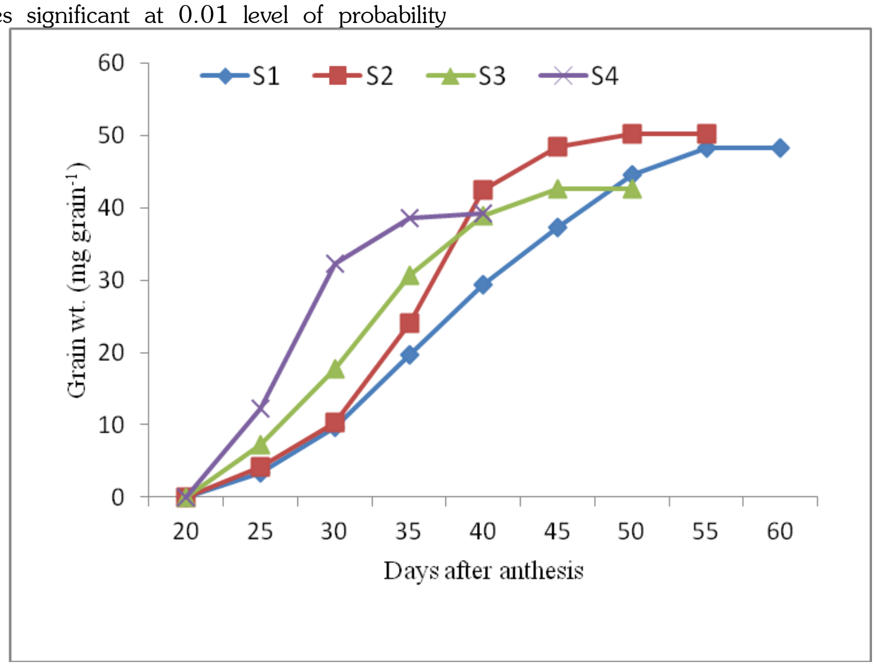

Fig. 1. Grain growth of wheat as affected by different dates of sowing (S_1 =15 November, S_2= 30 November, S_3=15 December and S_4=30 December) in 2010-2011

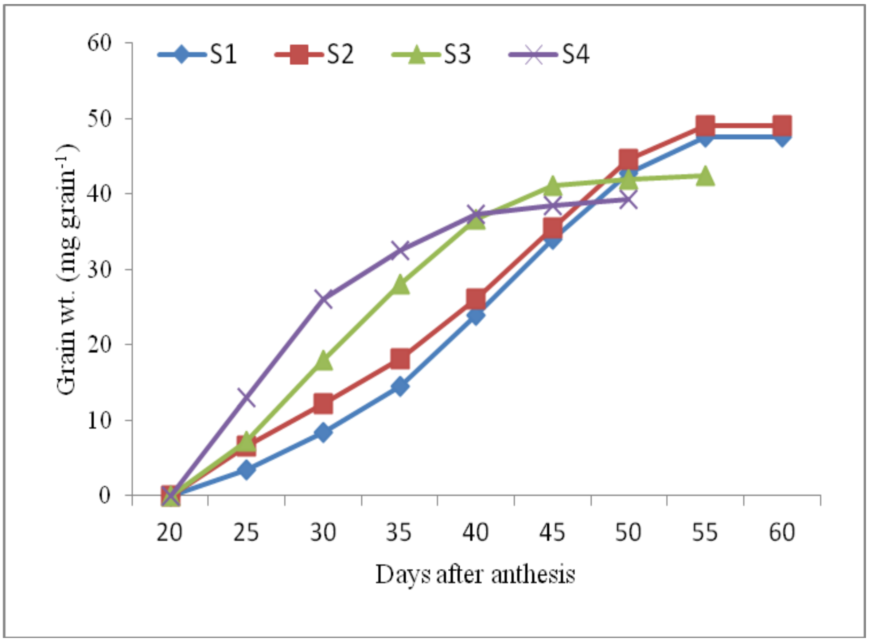

Fig. 2. Grain growth of wheat as affected by different dates of sowing (S_1 =15 November, S_2= 30 November, S_3=15 December and S_4=30 December) in 2011-2012

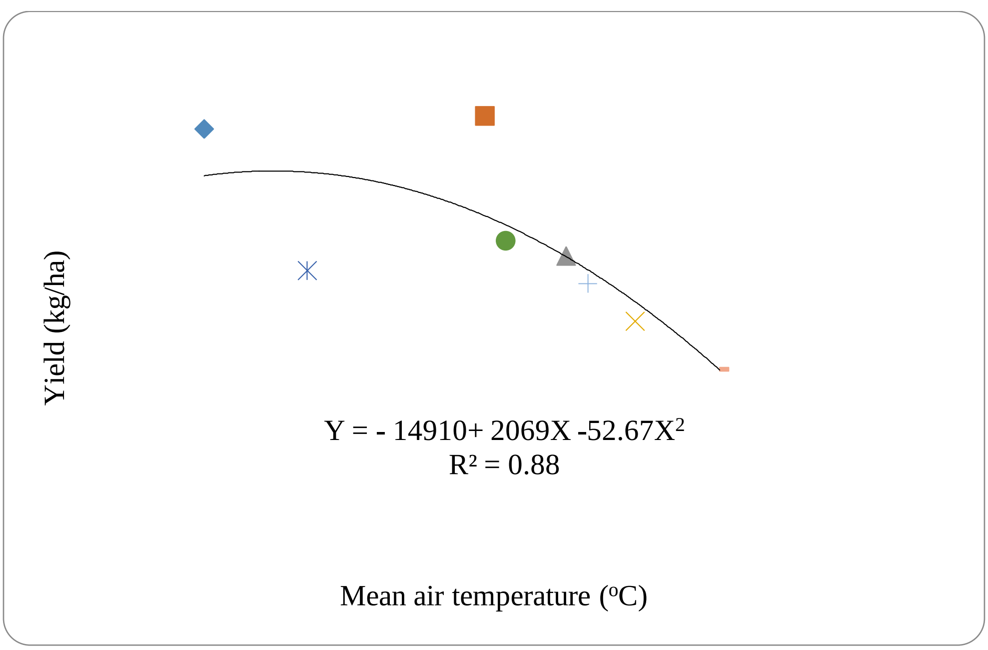

Fig. 3. Functional relationship between air temperature and grain yield of wheat

Reference

Ali, M. Z. and M. A. I. Sarker. 2016. Effect of sowing time based temperature variation on growth, yield and seed quality of gardenpea. In: Unfavourable Ecosystem. Crop Production under high temperature and drought stress. Agronomy Division, Bangladesh Agril. Res. Int. Gazipur 1701. Pp. 1-7.

BARI (Bangladesh Agricultural Research Institute). 2014. Interaction effect of different locations, dates of sowing and genotypes on yield contributing characters and yield of wheat. In: Annual Report. Wheat Res. Centre. Bangladesh Agril. Res. Int. Nashipur, Dinajpur. Pp. 115-116.

BARI (Bangladesh Agricultural Research Institute). 2016. Development of yield model of modern wheat varieties under late sown heat stress environment. In: Annual Report. Wheat Res. Centre. Bangladesh Agril. Res. Int. Nashipur, Dinajpur. Pp. 110-119.

BBS (Bangladesh Bureu Statistics). 2016. Yearbook of Agril. Statistics-2015. Bangladesh Bur. Stat. Ministry of Planning. Govt. People's Republic of Bangladesh. Pp.78-81.

Chakrabarti, B., S. D. Singh, V. Kumar, R. C. Harit and S. Misra. 2013. Growth and yield response of wheat and chickpea crops under high temperature. Indian J. Plant Physiol. 18: 7-14.

Karim, M. A. 2015. The challenge of increasing climate variability to climate smart agriculture in Bangladesh. In: Souvenir, 14th Confer. Bangladesh Soci. Agronomy. Bangladesh Agril. Res. Council. Farmgate Dhaka 1215. Pp. 25-36.

Khan, M. S. A and M. A. Aziz. 2015. Impact of sowing date induced temperature and management practices on development events and yield of mustard. Bangladesh Agron. J. 18(2): 45-52.

Mian, M. A. K., M. R. Islam, J. Hossain, M. S. Alam. 2011. Estimation of nutrient level of mustard in charland. Bangladesh Agron. J. 14 (1-2): 27-32.

Mian, M. A. K., M. R. Islam, J. Hossain and M. S. Alam. 2013. Assessing Agro-climatological model of summer mungbean. In: International Confer. on crop management in changing climate. Univ. Faisalabad. Pakistan. P. 135.

Mian, M. A. K., M. R. Islam and J. Hossain. 2016. Sowing time and air temperature: A functional yield model of lentil. Bull. Inst. Trop. Agr. Kyushu Univ. 39: 53-64.

OECD (The Organization for Economic Co-operation and Development). 2003. Rising food prices: Causes and consequences. 9 P. Available online: *http://www.oecd.org/dataoecd/54/42/ 40847088.pdf* [Accessed on the 20 January 2009].

Uddin, R., M. S. Islam, M. J. Ullah, P. K. Hore and S. K. Paul. 2015. Grain growth and yield of wheat as influenced by variety and sowing date. Bangladesh Agron. J. 18(2): 97-104

Wheeler, T. R., T. D. Hong, R. H. Ellis, G. R. Batts, J. I. L. Morison and P. Hadley. 1996. The duration and rate of grain growth, and harvest index, of wheat (*Triticum aestivum* L.) in response to temperature and Co_2. J. Exp. Bot47: 623-630.