

# Heat Accumulation, Nutrient Content and Yield of Wheat (*Triticum Aestivum L.*) Varieties in Bangladesh

M A K Mian<sup>1\*</sup>, A A Begum<sup>2</sup>, J Hossain<sup>3</sup>, M A A Khan<sup>3</sup> and M R Karim<sup>3</sup>

<sup>1</sup>Principal Scientific Officer, Bangladesh

<sup>2</sup>Senior Scientific Officer, Bangladesh

<sup>3</sup>Scientific Officer, Bangladesh Agricultural Research Institute, Bangladesh

\*Corresponding author: M A K Mian, Principal Scientific Officer, Bangladesh



## ARTICLE INFO

Received: 📅 January 13, 2021

Published: 📅 January 29, 2021

**Citation:** M A K Mian, A A Begum, J Hossain, M A A Khan, M R Karim. Heat Accumulation, Nutrient Content and Yield of Wheat (*Triticum Aestivum L.*) Varieties in Bangladesh. Biomed J Sci & Tech Res 33(3)-2021. BJSTR. MS.ID.005416.

**Abbreviations:** GDD: Growing Degree Day; HUE: Heat Use Efficiency; BARI: Bangladesh Agricultural Research Institute; DAS: Days After Sowing; PTI: Phenothermal index;

## ABSTRACT

An experiment was conducted with twelve BARI wheat varieties at Regional Agricultural Research Station, Ishwardi, Pabna during two consecutive years of 2016-2017 and 2017-2018 in Bangladesh. Selected wheat varieties were BARI Gom-21, BARI Gom-23, BARI Gom-24, BARI Gom-25, BARI Gom-26, BARI Gom-27, BARI Gom-28, BARI Gom-29, BARI Gom-30, BARI Gom-31, BARI Gom-32 and BARI Gom-33 as treatment. Phenological duration and Growing Degree Day (GDD) showed variation among the wheat varieties. BARI Gom-26, BARI Gom-27, BARI Gom-28, BARI Gom-29, BARI Gom-30, BARI Gom-31, BARI Gom-32 and BARI Gom-33 were found more suitable as heat tolerant varieties in respect of higher heat use efficiency (2.71-3.09 kg/ha/GDD) producing higher grain yield (4.98-5.47 t/ha) associated with better yield components. Grain yield was positively correlated with Heat Use Efficiency (HUE) ( $r=0.86$  at  $p<0.01$ ) and effect of HUE on grain yield was about 74% ( $Y=1.6248+1.2383x$ ,  $R^2 = 0.74$ ). BARI Gom-21, BARI Gom-23, BARI Gom-25, BARI Gom-26 BARI Gom-30 and BARI Gom-33 were identified as protein (13.13-14.75%) rich varieties. Content of N (1.85-2.36%), P (0.03-0.16%), K (0.32-0.54%), S (0.22-0.37%), Ca (0.51-0.67%), Na (0.09-0.15%) and B (5.12-7.39 ppm) noticed variation among the varieties. BARI Gom-25 and BARI Gom-26 were found as Zn (35-38 ppm) and Fe (123-126 ppm) rich but BARI Gom-31 was found as Zn (35-38 ppm) rich wheat varieties.

**Keywords:** Phenological Duration; Growing Degree Day (GDD); Protein; Nutrient; Yield; Wheat

## Introduction

Wheat is a widely adapted cereal food crop grown in temperate, warm and humid, dry and cool environments Hakim, et al. [1]. The crop is cultivated worldwide Tahir, et al. [2] and as a staple food over 60 countries Nipa, et al. [3] with an increasing demand day by day. In Bangladesh condition, wheat is a second cereal food grain after rice. Wheat cultivation area covers about 330348 hectares of land with an annual production of 1016811 tones in Bangladesh [4]. Bangladesh has experienced in climate change effect as the global warming. Under climate change situation winter is becoming shorter and temperature is rising Mian, et al. [5]. Generally wheat grows after *Taman* rice following *Taman*-Wheat cropping pattern in Bangladesh Mian, et al. [6]. Consequently, high temperature stress at the terminal of growing season usually constrains

crop yield potential as the stress coincides with the grain filling period of wheat Tahir, et al. [2]. Temperature is the single most important climatic factor affecting the growth and development of crop plant. It also influences different physiological process in the plant system. High temperature affects phenology, growth and yield of crop Mian, et al. [5]. Due to variation of air temperature, heat accumulation (Growing Degree Day: GDD) in crop plant and phenological development is always changing Mian, et al. [7]. More accumulation of heat unit (GDD) is an important phenomenon of heat tolerant varieties of wheat Mian, et al. [8]. Heat tolerant varieties get long phenological duration for heading (flowering) and physiological maturity. Consequently, more heat unit (GDD) accumulation occurs in longer duration of vegetation phase as well

as reproductive phase of wheat Mian, et al. [8]. Heading or flowering starts after accumulation of certain amount of heat unit in a specific variety in an ideal environment without any stress. Heat tolerant varieties are more preferable to wheat grower in Bangladesh due to delay harvesting of *Taman* rice. *Boro* rice is a major crop and it is competitive to wheat in winter season in Bangladesh. Wheat cultivation requires less cost as compared to *boro* rice.

The crop also requires less water as compared to *boro* rice. Thus, wheat cultivation can save underground water use as compared to *boro* rice cultivation in Bangladesh condition. Being a major source of starch and energy, wheat also provides substantial amounts of protein, minerals, fat, calcium, iron, carotene, vitamin B-1, vitamin B-2 and other phytochemicals which are essential or beneficial for human and animal health [9]. Wheat grain protein concentration is an important determinant of wheat quality for human nutrition but very often overlooked to improve it Muelber, et al. [10]. Nutrient content in wheat varied significantly due to change of environment as the change of sowing dates Pan, et al. [1,11]. Protein content increased with the increase of maturity period of wheat Hossain, et al. [12]. Protein percent (%) in wheat flour increased with the increase of temperature Muelber, et al. [10]. There exists a relationship between nutrient content in wheat with the change of environment Pan, et al. [11]. Grain yield is positively correlated with GDD to heading duration and maturity duration Al-Karaki [8,13]. Bangladesh Agricultural Research Institute (BARI) has developed a good number of modern wheat varieties. Research on nutritional status of wheat was done for some earlier developed varieties Hakim, et al. [1,3]. However, there is a little research work regarding heat accumulation and nutrient content of wheat varieties in Bangladesh condition. Therefore, the study was undertaken to observe the heat accumulation and nutrient content of BARI wheat varieties in Bangladesh condition.

## Materials and Method

The experiment was conducted at Regional Agricultural Research Station, Ishwardi, Pabna (Latitude 24.16° N and Longitude 89.45° E) during two consecutive years of 2016-2017 and 2017-2018 in Bangladesh. Twelve BARI wheat varieties viz., BARI Gom-21, BARI Gom-23, BARI Gom-24, BARI Gom-25, BARI Gom-26, BARI Gom-27, BARI Gom-28, BARI Gom-29, BARI Gom-30, BARI Gom-31, BARI Gom-32 and BARI Gom-33 were selected as treatment. The experiment was conducted in a RCB design with 4 replications. Unit plot size was 6m × 5m. Crop was sown in 20 November in both the year of 2016 and 2017. Seeding was done in continuous line maintaining 20 cm line to line distance and 4-5 cm depth using seed rate of 120 kg/ha. Nutrients were applied @ 160-35-90-20-3-1.5 kg/ha of N-P-K-S-Zn-B [14-18]. All nutrients including 2/3 of N were applied at final land preparation and the rest 1/3 N was top dressed at CRI stage. Three irrigation was done at 20, 50 and 80 Days After Sowing (DAS). Different varieties were harvested at different dates on the basis of physiological maturity. Heading duration (first

flowering time) was recorded. Data on yield components and yield were recorded. Nutrients concentration in grain were determined following the standard laboratory procedures (N by Micro Kjeldahl method, P by modified Olsen method, K by flame photometer from digest, S by turbid metric method, B by CaCl<sub>2</sub> extraction method; Zn, Ca and Fe by atomic absorption spectrophotometer). Protein content was calculated from laboratory analyzed N concentration in grain. Protein content and Growing Degree Day (GDD) were computed using the following formulae.

Protein content (%) = N% × 6.25, Where

N = Nitrogen and 6.25 is the converting factor for protein calculation.

$$GDD = \sum \left( \frac{\text{Maximum Temperature} + \text{Minimum Temperature}}{2} - \text{Base Temperature} \right)$$

Where

Base Temperature for wheat is 5°C.

Heat Use Efficiency (HUE) and Phenothermal index (PTI) were calculated after Akhter et al. [19] as follows.

$$\text{Heat use efficiency (HUE)} = \frac{\text{Grain Yield (kg / ha)}}{\text{GDD}}$$

$$\text{Phenothermal index (PTI)} = \frac{\text{GDD}}{\text{Growing duration (day)}}$$

There was no significant difference from year to year about the studied parameters of wheat. Hence, the paper has been written with the pooled values of the parameters.

## Results and Discussion

### Phenological Duration and Heat Accumulation

Heading duration varied significantly among the varieties of wheat (Table 1). Longer heading duration (67 day) was noticed in BARI Gom-33 followed by BARI Gom-21 (66 day), BARI Gom-23 (65 day), BARI Gom-27 (65 day) and BARI Gom-31 (65 day) while the shorter duration was found in BARI Gom-25 (61 day) and BARI Gom-30 (62 day) (Table 1). Variation of heading duration was also observed in different genotypes of wheat [15]. Maturity duration significantly varied to different varieties requiring the highest value for BARI Gom-33 (115 day) followed by BARI Gom-21 (114 day) and BARI Gom-23 (114 day) but the lowest (110 day) value was obtained for BARI Gom-25, BARI Gom-28 and BARI Gom-30 (Table 1). Variation of maturity duration occurred due to genetical inheritance and its interaction with environment specially temperature. Similar results also have been reported by other investigators Mian, et al. [8,15,16]. Significant variation of Growing Degree Day (GDD) for heading was observed among the varieties showing the highest value in BARI Gom-33 (1248) followed by BARI Gom-21 (1229), BARI Gom-23 (1210) and BARI Gom-31 (1210) and giving the lowest value in BARI Gom-25 (1134) and BARI Gom-30 (1153) (Table 1). More heat accumulation (GDD)

occurred in BARI Gom-33 (1248), BARI Gom-21 (1229), BARI Gom-23 (1210) and BARI Gom-31 (1210) due to longer duration of heading as compared to other varieties (Table 1). The GDD for maturity noticed significant variation among the varieties (Table 1). The highest GDD was found in BARI Gom-33 (1913) followed by BARI Gom-21 (1884) and BARI Gom-23 (1884) while giving the lower value (1768) in BARI Gom-25, BARI Gom-28 and BARI Gom-30 (Table 1). Variation of heat accumulation occurred among the varieties due to variation of duration of physiological maturity. Longer physiological maturity duration (day) enhanced to more heat accumulation (GDD) in wheat. Similar results also have been described by other investigators Kumar [17,18]. The GDD might be varied or reduced in a variety due to some stress condition when the crop got forced maturity receiving shorter physiological maturity

period. The results are in agreement with the observation of Kumar [17], and Mian, et al. [8]. Heat Use Efficiency (HUE) showed variation among the varieties giving the highest value (3.03-3.09 kg/ha/GDD) in BARI Gom-28 and BARI Gom-30 but the lowest value (2.56-2.69 kg/ha/GDD) in BARI Gom-21 BARI Gom-23 BARI Gom-24 and BARI Gom-25 (Table 1). Grain yield was positively correlated with heat use efficiency (HUE) ( $r=0.86$  at  $p<0.1$ ) and effect of HUE on grain yield was about 74% ( $Y=1.6248+1.2383x$ ,  $R^2 = 0.74$ ). Phenothermal Index (PTI) was found the highest (16.63 GDD/day) in BARI Gom-33 which was identical with those of BARI Gom-21 and BARI Gom-23 but the lowest (15.83 GDD/day) was found in BARI Gom-32 (Table 1). The results are in agreement with the observation of Akhter, et al. [19].

**Table 1:** Phenological duration, heat accumulation (GDD) and protein content of wheat varieties (Pooled values of 2016-2017 and 2017-2018).

Variety	Heading Duration (day)	Maturity duration (day)	GDD for Heading	GDD for Maturity	HUE (kg/ha/GDD)	PTI(GDD/ day)	Protein Content (%)
BARI Gom-21	66	114	1229	1884	2.58	16.53	13.69
BARI Gom-23	65	114	1210	1884	2.56	16.53	13.63
BARI Gom-24	64	112	1191	1826	2.69	16.3	11.56
BARI Gom-25	61	110	1134	1768	2.69	16.07	13.5
BARI Gom-26	63	112	1172	1826	2.95	16.3	13.13
BARI Gom-27	65	112	1210	1826	2.89	16.3	11.75
BARI Gom-28	60	110	1115	1768	3.03	16.07	12.25
BARI Gom-29	64	112	1191	1826	2.94	16.3	12.94
BARI Gom-30	62	110	1153	1768	3.09	16.07	14.75
BARI Gom-31	65	111	1210	1797	2.77	16.19	12.63
BARI Gom-32	63	108	1172	1710	2.93	15.83	12.63
BARI Gom-33	67	115	1248	1913	2.71	16.63	13.69
LSD <sub>(0.05)</sub>	1.91	3.73	22	41	0.13	0.25	0.41
CV(%)	2.07	2.31	1.27	1.43	3.22	1.07	2.35

Note: HUE: Heat use efficiency, PTI: Phenothermal index.

### Protein Content

Protein content was found significantly different among the varieties (Table 1). Protein content was calculated the highest in BARI Gom-30 (14.75%) also showing higher values (13.13-13.69%) in BARI Gom-21, BARI Gom-23, BARI Gom-25, BARI Gom-26 and BARI Gom-33 whereas the lowest value (11.75%) was in BARI Gom-27 (Table 1). Higher protein content occurred due to higher nitrogen (N %) concentration in the grain of wheat varieties (Table 2). Nitrogen concentration in grain varied due to variation of nitrogen uptake efficiency since it was a varietal character. Nitrogen and protein content among the wheat varieties might also be varied due to interaction of varieties and environmental factors Pan, et al. [1,11]. Variation of protein content in different wheat varieties also has been reported by other investigators Hakim, et al. [1,3].

### Nutrient Content

Concentration of N, P, K, S and Zn was found variation among the varieties (Table 2). Nitrogen concentration was found higher (>2.02%) in all varieties except BARI Gom-24, BARI Gom-27, BARI Gom-28 while the highest value was found in BARI Gom-30 (2.36%) (Table 2). Concentration of P noticed higher value (>0.10%) in all varieties except in BARI Gom-21, BARI Gom-23, BARI Gom-24 while the highest value was observed in BARI Gom-27 (0.16%). Concentration of K was found the highest in BARI Gom-33 (0.54%) followed by BARI Gom-32 (0.51%) but the lowest in BARI Gom-30 (0.32%) while other varieties gave intermediate values (0.40-0.47%) (Table 2). The S concentration was observed the highest in BARI Gom-33 (0.37%) followed by BARI Gom-31 (0.31%) while other varieties showed closer values ranged 0.22 -0.29% (Table 2).

Concentration of Zn was found higher (38 ppm) in BARI Gom-25, BARI Gom-26 followed by BARI Gom-31 (35 ppm) and the lowest in BARI Gom-21 (31 ppm) (Table 2). These nutrient concentration was also found variation in wheat varieties by Nipa et al. [3]. Concentration of Ca, Fe, Na and B was found variation among the varieties (Table 3). Concentration of Ca was found the highest (0.67%) in BARI Gom-31 and BARI Gom-33 followed by BARI Gom-29 (0.65%) while giving the lowest value in BARI Gom-24 (0.51%) (Table 3). Concentration of Fe was obtained the highest (123-126 ppm) in BARI Gom-25 and BARI Gom-26 but other varieties gave lower values (<96 ppm) while the lowest value was found in BARI Gom-24 (56 ppm) (Table 3). Concentration of Na was obtained the highest (0.15%) in BARI Gom-27 followed by BARI Gom-25 (0.14%) and BARI Gom-28 (0.14%) but the lowest value was found in BARI Gom-30 (0.09%) (Table 3). Concentration of B showed significant variation among the varieties giving higher values (6.03-7.39 ppm) in most of the varieties except BARI Gom-21 (5.12 ppm) and BARI Gom-25 (5.32 ppm) (Table 3). Variation of nutrient concentration in different genotypes of wheat also has been reported by other investigators Hakim, et al. [1,3].

**Table 2:** Concentration of N, P, K, S and Zn in wheat varieties (Pooled values of 2016-2017 and 2017-2018).

Variety	N (%)	P (%)	K (%)	S (%)	Zn (ppm)
BARI Gom-21	2.19	0.08	0.41	0.29	31
BARI Gom-23	2.18	0.06	0.4	0.24	32
BARI Gom-24	1.85	0.03	0.4	0.24	33
BARI Gom-25	2.16	0.11	0.41	0.26	38
BARI Gom-26	2.1	0.12	0.45	0.24	38
BARI Gom-27	1.88	0.16	0.46	0.26	26
BARI Gom-28	1.96	0.1	0.45	0.22	34
BARI Gom-29	2.07	0.14	0.47	0.29	32
BARI Gom-30	2.36	0.13	0.32	0.26	32
BARI Gom-31	2.02	0.14	0.4	0.31	35
BARI Gom-32	2.02	0.14	0.51	0.28	32
BARI Gom-33	2.19	0.13	0.54	0.37	33
LSD (0.05)	0.0376	0.0018	0.0096	0.0069	0.97
CV (%)	1.23	1.09	1.52	1.77	2.04

**Table 3:** Concentration of Ca, Fe, Na and B in wheat varieties (Pooled values of 2016-2017 and 2017-2018).

Variety	Ca (%)	Fe (ppm)	Na (%)	B (ppm)
BARI Gom-21	0.57	75	0.14	5.12
BARI Gom-23	0.6	85	0.13	7.24

BARI Gom-24	0.51	56	0.12	6.03
BARI Gom-25	0.57	123	0.14	5.32
BARI Gom-26	0.63	126	0.13	6.43
BARI Gom-27	0.6	80	0.15	7.24
BARI Gom-28	0.63	72	0.14	7.06
BARI Gom-29	0.65	87	0.12	7.31
BARI Gom-30	0.6	96	0.09	7.25
BARI Gom-31	0.67	87	0.11	7.39
BARI Gom-32	0.62	91	0.13	6.47
BARI Gom-33	0.67	91	0.12	7.08
LSD <sub>(0.05)</sub>	0.0127	3.31	0.0053	0.55
CV (%)	1.44	2.59	3.08	5.67

### Yield Component and Yield

Spikes/m<sup>2</sup> was significantly the highest in BARI Gom-30 (389/m<sup>2</sup>) which was identical with those in BARI Gom-23 (359/m<sup>2</sup>), BARI Gom-26 (369/m<sup>2</sup>), BARI Gom-28 (360/m<sup>2</sup>) and BARI Gom-33 (363/m<sup>2</sup>) while the lowest in BARI Gom-24 (327/m<sup>2</sup>) (Table 4). Variation of spikes/m<sup>2</sup> among the genotypes also has been reported by [20]. Grains/spike showed significant variation among the varieties producing the highest values (48-50) in BARI Gom-24, BARI Gom-27, BARI Gom-30, BARI Gom-32 and BARI Gom-33 but the lowest (36) value in BARI Gom-23 (Table 4). Weight of 1000-grain was found significantly the highest (44-46 g) in BARI Gom-24, BARI Gom-26 and BARI Gom-31 but the lowest (36 g) in BARI Gom-27 (Table 4). Similar results also have been reported by [20]. Significantly the highest grain yield (5.01-5.47 t/ha) was obtained from BARI Gom-26, BARI Gom-27, BARI Gom-28, BARI Gom-29, BARI Gom-30, BARI Gom-32 and BARI Gom-33 which were identical to each other while the lowest grain yield (4.75-4.98 t/ha) was observed in rest of the varieties (Table 4). The highest yield was mainly contributed by the cumulative effects of spikes/m<sup>2</sup>, grains/spike and 1000-grain weight. Yield potentially depends on genetical make-up of the varieties but yield potentiality expression occurred by its interaction with the environment. The results are in agreement with the findings of Mian et al. [8] and [20]. Straw yield was found the highest (6.80-7.21 t/ha) in all the varieties except BARI Gom-21, BARI Gom-24 and BARI Gom-25 where straw yield ranged 6.57-6.61 t/ha (Table 4). Significant variation of harvest index (HI%) was noticed among the varieties exhibiting the higher values (43.19-43.77) in later developed varieties (BARI Gom-28, BARI Gom-29, BARI Gom-30, BARI Gom-31, BARI Gom-32 and BARI Gom-33) than those of earlier developed varieties of wheat. Variation of harvest index mainly depends on dry matter partitioning into the grain during grain growth period. Similar results also have been reported by Mian [21].

**Table 4:** Spikes/m<sup>2</sup>, grains/spike, 1000-grain weight, grain yield, straw yield and harvest index (HI) of wheat varieties (Pooled value of 2016-2017 and 2017-2018).

Variety	Spikes/m <sup>2</sup>	Grains/Spike	1000-Grain Weight (g)	Grain Yield	Straw Yield	HI (%)
	(no.)	(no.)		(t/ha)	(t/ha)	
BARI Gom-21	345	39	42	4.87	6.61	42.13
BARI Gom-23	359	36	40	4.82	6.86	41.65
BARI Gom-24	327	48	44	4.91	6.57	42.47
BARI Gom-25	337	45	42	4.75	6.61	41.82
BARI Gom-26	369	47	46	5.39	7.18	42.69
BARI Gom-27	357	48	36	5.28	7.15	42.57
BARI Gom-28	360	47	40	5.35	7.04	43.19
BARI Gom-29	358	46	40	5.37	7.05	43.25
BARI Gom-30	389	49	42	5.47	7.21	43.77
BARI Gom-31	349	45	46	4.98	6.81	43.66
BARI Gom-32	358	50	41	5.01	7.11	43.21
BARI Gom-33	363	49	41	5.19	6.8	43.28
LSD (0.05)	29.72	2.81	3.08	0.37	0.47	0.88
CV(%)	5.77	4.25	5.12	5.11	6.29	1.42

## References

- Hakim MA, Hossain A, Silva JA T, Zvolinsky VP, Khan MM (2012) Yield, protein and starch content of twenty wheat (*Triticum aestivum* L.) genotypes exposed to high temperature under late sowing condition. *JSR J Sci Res* 4(2): 477-489.
- Tahir NS, Ali A, Ijaz MR, Ansari, N Iqbal (2015) Genotypes profiling of seed storage proteins in wheat (*Triticum aestivum* L.). *Iranian J Sci and Technol* 39: 567-572.
- Nipa FN, Saha BK, Chowdhury MA H, Hassan MN (2013) Varietal influence on nutrient contents and their uptake by wheat. *J Bangladesh Agril Univ* 11(2): 221-226.
- (2019) BBS (Bangladesh Bureau of Statistics). *Statistical Year Book of Bangladesh 2019*. Statistics Division, Ministry of Planning p. 147.
- Mian MA K, Islam MR, Hossain J (2016) Sowing time and air temperature: a functional yield model of lentil. *Bull Inst Trop Agr Kyushu Univ* 39: 53-64.
- Mian MA K, Begum AA, Saha RR (2019) Functional relationship between grain yield and spikes per square meter of wheat as influenced by seed rate under late sown condition. *Bangladesh Agron J* 22(1): 105-113.
- Mian MA K, Islam MR (2010) Phenological development, growth and yield of lentil genotypes under prevailing temperature at varying sowing time. In *International Seminar on Climate Change and Environmental Challenges of 21<sup>st</sup> Century (7-9 December 2010)*. Univ of Rajshahi Bangladesh p. 4-22.
- Mian MA K, Islam MR, Hossain J (2013) Development of yield model of wheat under late sown irrigated condition. In *Annual Research Report*. Agronomy Division. Bangladesh Agricultural Research Institute. Gazipur pp. 20-24.
- (2018) AIS (Argil Information Service). *Krishi Diary* (In Bangla). Department of Argil Extension Khamarbari, Dhaka pp. 114-119.
- Muelbert AE, Baker TR, Dexter KG, Lewis SL, Brienen RJ W, et al. (2019) Compositional response of Amazon forests to climate change. *Global change biology* 25(1): 39-56.
- Pan J, Zhu Y, Cao W, Dai T, Jiang D (2006) Predicting the protein content of grain in winter wheat with meteorological and genotypic factors. *Plant Prod Sci* 9(3): 323-333.
- Hossain J, Khan AA, Islam AA, Islam MR, Mian MA K, et al. (2016) Phenology, growth, yield and protein content of wheat as influenced by foliar application of nitrogen. *J Biological Sci* 17: 142-150.
- Al Karaki GN (2012) Phenological development-yield relationships in durum wheat cultivars under late-season high-temperature stress in a semiarid environment. *International Scholarly Research Notices* 10: 7.
- (2012) BARC (Bangladesh Agricultural Research Council). *Fertilizer recommendation guide (2012)*. Bangladesh Agril. Res. Coun. Farmgae, Dhaka, p. 88.
- (2018) BARI (Bangladesh Agricultural Research Institute). Development of heat tolerant wheat genotypes. In *Annual Report*. Wheat Res. Centre (WRC). Bangladesh Agril. Res. Inst. Gazipur, p. 31-33.
- (2017) BARI (Bangladesh Agricultural Research Institute). Development of heat tolerant wheat genotypes. In *Annual Report*. Wheat Res. Centre (WRC). Bangladesh Agril. Res. Inst. Gazipur, p. 36-38.
- Kumar R, Hahajan G (2013) Effect of weather in relation to dates of sowing and verities on productivity of wheat (*Triticum aestivum* L.). *IJPS (International J Plant Sci)* 8(2): 322-325.
- Mian MA K, Begum AA, Khanum MM, Saha RR (2020) Estimation of temperature coefficient of wheat for adjusting proper sowing time. In *Annual Research Report*. Agronomy Division. Bangladesh Agricultural Research Institute. Gazipur pp. 217-226.
- Akhter MT, Mannan MA, Kundu PB, Paul NK (2015) Effect of different sowing dates on the phenology and accumulation of heat units in three rapeseeds (*Brassica campestris* L.) varieties. *Bangladesh J Bot* 44(1): 97-101.
- (2016) BARI (Bangladesh Agricultural Research Institute). Development of heat tolerant wheat genotypes. In *Annual Report*. Wheat Res. Centre (WRC). Bangladesh Agril. Res. Inst. Gazipur p. 26-30.
- Mian MA K (2008) Performance of maize oriented cropping patterns under different nutrient management. Ph.D. Dissertation. Depart. Agronomy. Bangladesh Agril. Univ, Mymensingh p. 54-58.

ISSN: 2574-1241

DOI: 10.26717/BJSTR.2021.33.005416

M A K Mian. Biomed J Sci & Tech Res



This work is licensed under Creative Commons Attribution 4.0 License

Submission Link: <https://biomedres.us/submit-manuscript.php>



#### Assets of Publishing with us

- Global archiving of articles
- Immediate, unrestricted online access
- Rigorous Peer Review Process
- Authors Retain Copyrights
- Unique DOI for all articles

<https://biomedres.us/>