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Spring wheat genotypes exhibit physiological and yield potentiality under late sowing conditions in Bangladesh

Md. Monwar Hossain[1], Mohammad Nur Alam*[1], Md. Zaherul Islam[1], Md. Sariful Bin Ekram[2], Rabiul Islam[3], Md. Atiquzzaman[4]

[1]*Wheat Breeding Division, Bangladesh Wheat and Maize Research Institute, Nashipur, Dinajpur, Bangladesh*

[2]*Agricultural Engineering Division, Bangladesh Wheat and Maize Research Institute, Nashipur, Dinajpur, Bangladesh*

[3]*Wheat Breeding Division, Regional Station, Bangladesh Wheat and Maize Research Institute, Jassore, Bangladesh*

[4]*Project Coordinator, LIFT Project, Gram Bikash Kendra, Dinajpur, Bangladesh*

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Abstract

To combat the consequences of climate changes is the great challenges in crop production by mitigating biotic and abiotic factors' effects. Fifty genotypes including control were evaluated at the research farm, Headquarter station, Dinajpur and Regional Station, Jassore of the Bangladesh Wheat and Maize Research Institute. Seeds were sown at Dinajpur and Jassore on 22 December and 18 December, respectively in the Rabi season of 2016-17. Based on the days to heading, days to maturity, plant height, thousand grain weight (TGW) and yield performance; five genotypes exhibited good performance. At Dinajpur days to heading of five genotypes was longer than Jassore, but days to maturity of the genotypes was shorter at Dinajpur than Jassore. TGW of the genotypes at Jassore was more than Dinajpur. The average yield of the genotypes was more at Jassore than Dinajpur. At Jassore the highest yield was exhibited by the Genotype (Gen) 42 (4.23t ha-1) compared to Shatabdi variety (3.89t ha-1), and the lowest by Gen 44 (3.43t ha^{-1}). On the other hand, Gen 12 demonstrated the maximum yield (3.86t ha-1) at Dinajpur compared to Gen 44 (3.51t ha^{-1}), and the lowest by Gen 45 (2.69t ha^{-1}). The earlier sowing of the genotypes at Jassore than Dinajpur, environmental and genetical factors might influence the physiology and yield performances of the genotypes. Need to conduct further trials to search out the final performance of the Gen 12 and Gen 42 which may be the promising variety to mitigate the consequences of climate changes in Bangladesh.

* **Corresponding Author:** Mohammad Nur Alam ✉ mnalam79@yahoo.com

Introduction

Wheat (*Triticum aestivum* L.) is one of the staple food crops of the world. It contributes 40% feeding of the world population, and gives 20% of total food calories and protein in human nutrition intake, and covers 17% crop acreage (Gupta *et al.*, 2008). Food supply in the world substantial increases 70-100% and is requisite to feed an allotment 9 billion people by 2050 (Godfray *et al.*, 2010). Since there is limited feasibility to extend present crop-growing areas, it's an important to increase crop production to secure future food supply (Parry *et al.*, 2011; Reynolds *et al.*, 2011). In the last century, wheat yields have increased significantly due to higher fertilization rates, diseases and pest and management improvement, and also for genetic improvements (Semenov *et al.*, 2012). Towards environmental and climatic changes, wheat crop is very sensitive (Porter and Semenov, 2005). To identify multidisciplinary door and needful to realize how to plants react to abiotic stresses, and to apply this sense in the connection of climate changes are very crucial for plant scientists (Reynolds *et al.*, 2011; Zheng *et al.*, 2012; Martre *et al.*, 2015). The temperature of Bangladesh rises day by day. The annual mean temperature of Bangladesh is 25.75°C, which is expected to rise about 0.21°C by 2050 (Karmakar and Shrestha, 2000). The OECD (2003) estimated a rise in temperature of 1.4°C by 2050 and 2.4°C by 2100 in Bangladesh. Poulton and Rawson (2011) reported that temperature in Bangladesh has increased over the past two decades by 0.035°C/year. If this trend continues, the average temperature of Bangladesh will increase by 2.13°C more than 1990 levels by 2050. Unfortunately, heat stress has become a main environmental factor that is associated with higher temperature (Wahid *et al.*, 2007). Half or total breakdown of the crop as well as anatomy, morphology, biochemistry and physiology causes heat stress. It is a task of the enormity and increases the rate of temperature (Wahid *et al.*, 2007). Terminal heat stress or end-of-season is also probably to gain as for wheat due to rise in global warming in near future (Semenov, 2009). Therefore, to promote heat-tolerant cultivars is necessary in wheat breeding programs (Sikder and Paul, 2010; Mohamed, 2013). The growth and development of wheat variation in response to climatic and environmental changes, it is possible to choose ideo-types with excellent function under incoming climates and environments. High temperature in wheat, greater than 34 °C, swift leaf senescence which has a real impact on grain yield (Alam *et al.*, 2014). Advance leaf senescence reduces the net amount of light intercepted by the crop through shortening the term of grain filling (Asseng *et al.*, 2011). Exceeding 30°C temperature is indicated to cause unusual development both of anthers and ovary which makes floret infertility (Senapati *et al.*, 2019).

From the grain filling stage, temperature above 35°C influences the improvement of the endosperm which limits highest grain weight (Hawker and Jenner, 1993). A major constraint of wheat production in Bangladesh is late planting of T. Aman rice. Due to the late harvesting of T. Aman rice, wheat is mostly planted on last week of November to mid-December, i.e. 2-3 week later after the optimal planting date. Due to late planting, the growth and development stages, particularly grain-filling stage is subjected to hot and humid climate at the second week of February which hastens grain filling period resulting shriveled grain and low yields. So, development of heat tolerant variety is an utmost priority. Therefore, the genotypes under high temperature wheat yield trial were screened to select promising heat tolerant lines that can be exploited in developing heat tolerant wheat variety.

Materials and methods

Location and soil characteristics

The trial was carried out in the *Rabi* season of 2016-17 (December to April) in the research field of Bangladesh Wheat and Maize Research Institute (BWMRI), Dinajpur (23°11' 14.52" N, 89°11' 11.99" E; 10.4 masl), and the Regional Station, BWMRI, Jassore (23°11' 14.52" N, 89°11' 11.99" E; 10.4 masl), Bangladesh (Quayyum, 1994). The soil of the research field of BWMRI belongs to under the Old Himalayan Piedmont Plain designated as Agro Ecological Zone (AEZ) # 1 (FAO/UNDP, 1988), characterized by flood free highland, fine in texture (Sandy loam and Silty loam), poor in organic matter. It is situated in northern part of Bangladesh and geographically the area lies between 25°38´ N and 88°41´ E and 38.20 m above sea level. The soil of the experimental field belongs to under the High Ganges River Floodplain designated as AEZ # 11 (FAO/UNDP, 1988), characterized by predominantly highland and medium highland. Organic matter content in the brown ridge soils is low but higher in the dark grey soils. Soils are slightly alkaline in reaction. General fertility level is low.

Design and experimental procedures

The trial was conducted with fifty genotypes including one control variety (Shatabdi) at Bangladesh Wheat and Maize Research Institute (BWMRI), Dinajpur and Regional Station, BWMRI, Jassore. The experiment was performed in alpha lattice design with two replications. The seeds of each entry were sown under irrigated late sowing condition on 18 December in Jassore and 22 December in Dinajpur of the *Rabi* season 2016-17. The unit plot size was 2.5 m long and 2 rows with row spacing of 20cm in 2-4cm depth. The recommended crop management practices of BWMRI were followed to grow up the crop. Data were recorded based on different agronomic characters. The whole plot was harvested to record grain yield.

Fertilizering and seed treatment

The land was ploughed four times horizontally with tractor and harrow followed by 12-15cm depth. Each of the sub-plots was fertilized @ 100-27-50-20-1-4.5-5000kg ha^{-1} as N-P-K-S-B-Zn-Cow dung. The source of N, P, K, S, B and Zn were used as urea, TSP, MoP, gypsum, boric acid and zinc sulphate, respectively. All of TSP, MoP, gypsum, boric acid, zinc Sulphate, Cow dung and two-third of urea were applied as basal during final land preparation. Seeds were treated with Provax 200 WP@3g/kg seed, a seed-treated fungicide containing Carboxin and Thiram. Research conducted at the indicated that Provax-200 WP is a perfect match for controlling fungi in Bangladesh soil, for achieving excellent seed germina-tion and for protecting wheat cultivars from fungal infection during the seedling stage (BWMRI, 2018). After well preparation of land, seeds @100kg ha^{-1} of each variety/lines were sown continuously in lines 20cm apart in 2-4cm depth.

Other intercultural operations

One-third urea was applied as top-dress at crown root initiation stage followed by first irrigation at 20 DAS (days after sowing). The second irrigation was applied at late booting stage (50 DAS) and another was applied at early grain filling stage (70 DAS). Each sub-plot was kept free from weeds by applying affinity @2.5g/litre water at 27 DAS after 1st irrigation. Nativo was sprayed two times @0.3g/L water, one just before spike initiation and another was applied 15 days after first spray to control Bipolaris leaf blight (BpLB) and blast diseases. Each of genotypes was harvested after its maturity.

Data recording and their processing

The whole plot was harvested, bundled separately, tagged and taken to a threshing floor. The bundles were thoroughly dried under bright sunshine until dried, then weighed and threshed. The threshed grains of each plot were again dried with sunshine, and weighed. Lastly grain yield was expressed into ton/hectare (t ha^{-1}). Thousand grains was counted, weighed, and expressed in gram (g). To obtain the actual yield of all genotypes, grain yield weight was adjusted at 12% moisture by the following equation (BWMRI, 2018):

Yield Adjustment at Standard Moisture: Adjusted yield at expected moisture percent is

$$Y_{adj} = Y_{AC} \times \frac{(100 - M_{AC})}{(100 - M_{ST})}$$

Where, Yadj = Adjusted yield

Y_{AC} = Yield at actual moisture percent

M_{AC} = Actual moisture percent

M_{ST} = Standard moisture percent

Temperature data was recorded regularly by HOBO U12 Family of Data Loggers (MicroDAQ.com) at the meteorological station, Bangladesh Wheat and Maize Research Institute, Nashipur, Dinajpur, Bangladesh and was presented in the Fig. 1 and Fig. 2.

Data was analyzed by MSTAT-C (Russell, 1994). Treatment means were compared for significance by the least significant difference (LSD) test at $p = 0.05$.

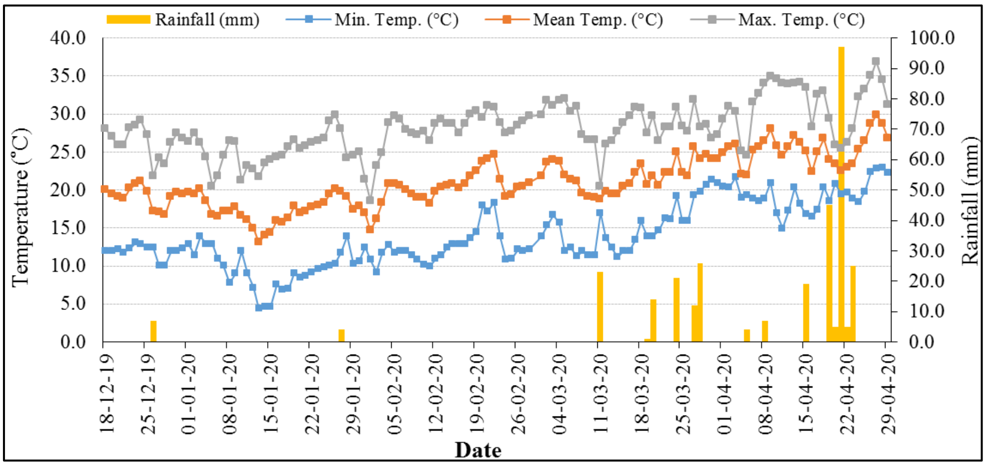

Fig. 1. Meteorological information (Min, Max and mean temperature, and rainfall) during wheat season (18 December 2016 to 29 April 2017) in the Dinajpur location of Bangladesh.

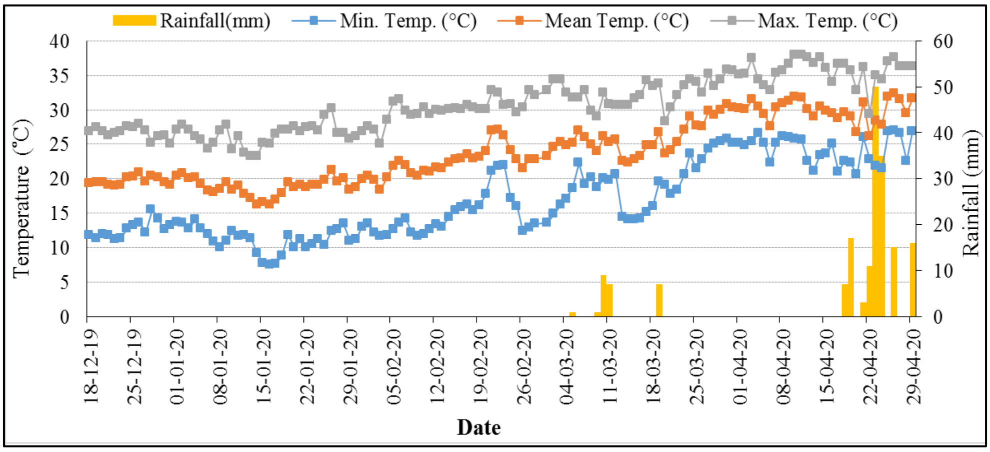

Fig. 2. Meteorological information (Min, Max and mean temperature, and rainfall) during wheat season (18 December 2016 to 29 April 2017) in the Jassore location of Bangladesh.

Results and discussion

Days to heading

Days to heading of various genotypes were significantly different by both locations. In Jassore location days to heading was one day earlier than Dinajpur location (Table 1). The five selected genotypes grown at Jassore also demonstrated earlier heading than those of grown at Dinajpur (Table 2). During seeding to heading in Dinajpur location the minimum, mean and maximum temperature were 11.13, 18.76 and 26.39°C, respectively whereas average rainfall was 11.0mm (Fig. 1). On the other hand, during seeding to heading in Jassore the minimum, mean and maximum temperature were 12.62, 20.11 and 27.60 °C, respectively whereas there had no rainfall (Fig. 2). We found that temperature of Jassore was higher than Dinajpur. It was summarized that higher temperature at Jassore location shortened the life span of spring wheat. The similar result was found by Hossain *et al.* (2019).

Days to maturity

Days to maturity of various genotypes were found significantly different sown at both locations. In Dinajpur location days to maturity was earlier than Jassore location (Table 1 and Table 2). We observed in the Fig. 1 that during seeding to maturity of Dinajpur the minimum, mean and maximum temperature were 12.13, 19.65 and 27.16°C, respectively whereas rainfall was 108.0mm (Fig. 1). Oppositely, during seeding to maturity in Jassore the minimum, mean and maximum temperatures were 14.54, 21.84 and 29.14°C, respectively whereas rainfall was 25.0mm (Fig. 2).

In Jassore seeds were sown on 18 December whereas in Dinajpur seeds were sown on 22 December. Seed sowing earlier time might increase the life span of wheat plant (Fig. 1; Fig. 2) although higher temperature and lower rainfall in Jassore (rainfall 25.0mm) than Dinajpur (rainfall 108.0mm). So the selected five genotypes were more capable to tolerate high temperature. The similar result was found by Hossain *et al.* (2019) and Alam *et al.* (2013).

Table 1. Effect of the locations on physiology and yield attributes of spring wheat genotypes in the *Rabi* season (2016-17) of Bangladesh.

Location	Heading (days)	Maturity (days)	Plant height (cm)	TGW (g)	Yield (t ha^{-1})
Dinajpur	67	98	93	30.08	2.935
Jassore	66	101	91	30.35	3.026
F-test	**	**	**	NS	NS
CV	1.6	0.5	3.9	16.3	13.2
LSD (p=5%)	0.29	0.15	1.01	1.38	110

*Data was analyzed by MSTAT-C (Russell, 1994). Treatment means were compared for significance by the least significant difference (LSD) test at $p = 0.05$.

Table 2. Physiology and yield attributes of spring wheat genotypes were influenced by the locations in the *Rabi* season (2016-17) of Bangladesh.

Genotype	Heading (days)		Maturity (days)		Plant height (cm)		TGW (g)		Yield(t ha^{-1})	
	Din	Jass	Din	Jass	Din	Jass	Din	Jass	Din	Jass
Gen 12	65	63	96	100	95	88	33.9	27.5	3.86	3.88
Gen 19	69	65	100	102	91	88	30.2	34.5	3.40	3.69
Gen 42	69	67	100	102	91	93	28.3	33.0	3.48	4.23
Gen 44	70	68	102	103	97	99	33.1	39.0	3.51	3.43
Gen 45	67	67	98	101	95	94	33.9	35.0	2.69	3.54
Shatabdi	70	64	102	101	97	88	35.0	35.0	3.31	3.89
F-test	**		**		NS		**		**	
LSD	2.08		1.05		7.17		9.78		778	
CV	1.6		0.5		3.9		16.3		13.2	

*Data was analyzed by MSTAT-C (Russell, 1994). Treatment means were compared for significance by the least significant difference (LSD) test at $p = 0.05$.

Effect of the locations on plant height of spring wheat genotypes

Plant height is the important factor to protect the lodging of wheat plants. Plant height of five genotypes of both locations was significantly different. In Jassore plant height is lower than Dinajpur (Table 1 and Table 2). The higher temperature and lower rainfall in Jassore than Dinajpur may lower the plant height (Fig. 1 and Fig. 2). This result is similar to Zhang *et al.* (2013).

Thousand grain weight

TGW is the most important factor of the yield contributing characters. It has the great role to increase/reduce yield of a wheat genotype. TGW of the genotypes were found significantly different sown at both locations (Table 1 and Table 2). In the trial, TGW of wheat genotypes sown at Jassore regional station is comparatively more than Dinajpur regional station (Table 1 and Table 2). The Gen 44 sown at Jassore demonstrated the highest TGW (39.0g) compared to the Gen 45 (35.0g) and Shatabdi (35.0g). At RS, Dinajpur, the Shatabdi variety showed the highest TGW (35g) followed by the gen 12 (33.9g). The seeds sown in the earlier time at Jassore compared to Dinajpur might influence the TGW. The similar results were found by Hossain *et al.* (2018) and Alam *et al.* (2013).

Grain Yield

In the investigation, the yield Jassore and Dinajpur was found statistically significant. At Jassore the highest yield was exhibited by the Gen 42 (4.23t ha-1) compared to Shatabdi variety (3.89 t/ha), and the lowest by Gen 44 (3.43t ha-1).

On the other hand, the gen 12 demonstrated the maximum yield (3.86t ha-1) at Dinajpur compared to the Gen 44 (3.51t ha-1), and the lowest by Gen 45 (2.69t ha-1) (Table 1 and Table 2). In the study, the result summarized that comparatively higher yield was observed at Jassore than Dinajpur (Table 1 and Table 2). The optimum wheat seeding time is in Bangladesh from 15 November to 30 November. Comparatively late sowing after this time lowers the wheat grain yield (BWMRI, 2018). The genetical factor increases the plant growth and yield (Nature, 2005). The earlier sowing of wheat at Jassore than Dinajpur, environmental and genetical factors might influence the yield of the genotype. After further trials, the Gen 12 and Gen 42 may be the promising variety to mitigate the effects of climate changes in Bangladesh, even in the world.

Conclusion

The highest yield was exhibited by the Gen 42 (4.23t ha-1) at Jassore, but 3.48t ha-1 at Dinajpur. On the other hand, the Gen 12 demonstrated the maximum yield (3.86t ha-1) at Dinajpur compared to Gen 44 (3.51t ha-1), but 3.86t ha-1 at Jassore. The earlier sowing at Jassore than Dinajpur, environmental and genetical factors might influence the physiological expressions and yield performances of the genotypes. Need to conduct further trials to search out the final performance of the Gen 12 and Gen 42 which may be the promising variety to mitigate the consequences of climate changes in Bangladesh.

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