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Performance of some advanced spring wheat lines under optimum and late sown conditions in different regions of Bangladesh

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Abstract. Eleven advanced lines of spring wheat along with check varieties BARI Gom 21, BARI Gom 26, and BARI Gom 32 were evaluated at Bangladesh Wheat and Maize Research Institute (BWMRI), Dinajpur; Regional Wheat Research Center (RWRC) Gazipur; Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Jashore; RWRC, Rajshahi and RARS, BARI, Jamalpur in randomized complete block design (RCBD) with three replications during, November 2017 to March 2018. The trial was conducted under irrigated timely sown (ITS) and irrigated late sown (ILS) conditions. The genotypes were evaluated for yield and yield components, heading, maturity, and disease reaction. The effect of sowing time, location and genotype and their different interaction levels were significant for most traits. Wheat yield was significantly reduced in the ILS condition as compared to the ITS condition. Regarding location, Dinajpur was a better place for wheat production than other tested places. The mean value of the thousand-grain weight (TGW) of all genotypes was higher than all check varieties. Ten produced a higher yield out of eleven genotypes than BARI Gom 26; five produced a higher yield than BARI Gom 32. All the eleven genotypes were out yielded of the check variety BARI Gom 21. The highest yield (4099kg ha^{-1}) was obtained in Dinajpur, and the lowest yield (3108 kg ha^{-1}) was obtained in Jamalpur. Genotypes BAW 1290, BAW 1293, BAW 1317, BAW 1318 showed comparatively better performance in ILS conditions representing that these advanced wheat lines were less affected by terminal heat stress under late sowing conditions.

Keywords: *spring wheat genotypes, grain yield, yield components, early sown, late sown, heat stress*

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1. Introduction

Bangladesh is a densely populated country whose population is increasing, resulting in food demand increasing day by day. Agriculture plays a vital role in the economy and social culture of Bangladesh. Agriculture contributes around 14.23% (2,942,347 million taka) to the country's Gross Domestic Product (GDP) [1]. More than 60% of national employment is involved in the agriculture sector. Wheat is the second important cereal crop in Bangladesh after rice [2], and its consumption trend is increasing. Wheat is an important source of multiple nutrients, and dietary fiber like carbohydrates [3], the protein-containing about 13% vegetable protein is relatively high compared to other major cereals. Therefore, wheat can play an important role in meeting up with increasing food demand.

In 2017, Bangladesh harvested 1.3 million tons from 0.41 million ha of land [4], which is much lower than the annual requirement. Wheat production has been increased in Bangladesh from 1971-72 (around 0.115 million tons) to 1999 (1.9 million tons) [5], and after then it was gradually decreased to 1.3 million tons in 2016-2017 [4]. The cause of this low production is mainly for the reduction of area under wheat cultivation due to compete with other profitable crops like boro rice, maize, potato, and other winter vegetables.

The average yield of existing wheat varieties in Bangladesh is 3.15 t ha^{-1} [4] due to several stresses in Bangladesh. Drought and high temperatures are key stress factors for wheat cultivation. Wheat is affected by heat when it is sown in late condition resulting in yield loss of wheat compared to optimum sowing. Each day delay in sowing of wheat after 30 November onward decreases grain yield at the rate of 36 kg ha^{-1} day^{-1} [6]. Though the timely sowing of wheat is a prime condition to achieve the maximum yield yet there are several constraints (viz., delay in rainfall, unavailability of irrigation water and machinery at the proper time, and sowing of wheat after Aman rice crop) that prevent timely sowing of the crop.

In order to compensate yield losses in wheat due to late sowing, breeders are searching for wheat genotypes having increased heat tolerance traits under late sowing conditions [7,8]. Therefore, wheat genotypes having heat tolerance traits are most desirable for wheat cultivation in this region. In this regard, this trial was conducted to identify heat-tolerant wheat lines for future breeding programs.

2. Materials and Methods

2.1. Design and experimental procedures.

The trial was conducted with eleven promising lines selected from the preliminary yield trial (PYT) in 2016-17 to identify suitable advanced lines for growing in Bangladesh condition. BARI Gom 21, BARI Gom 26, and BARI Gom 32 were used as check varieties in this experiment. The experiment was laid out in RCBD with three replications at six locations (BWMRI, Dinajpur; RWRC, Gazipur; RARS, BARI, Jashore; RWRC, Rajshahi and RARS, BARI, Jamalpur). The trial was set under irrigated timely sown (ITS) and irrigated late sown (ILS) conditions in each location. Seeds were sown continuously in a 5m long 8-rows plot with a row spacing of 20 cm. Sowing dates of all locations are presented in Table 1. The seeding rate was 120 kg ha^{-1} for each advanced line. Before sowing, seeds of all lines were treated with a popular fungicide, Provax-200 WP containing carboxin and thiram (marketed by Hossain Enterprise Bangladesh Ltd. in association with Chemtura Corp., USA). Furadan 5G containing carbofuran (marketed by FMC International S.A. Bangladesh Ltd.) was broadcasted at 15 kg ha^{-1} for controlling soil-borne insects.

Table 1. The sowing dates of the trial in different locations, 2017-2018

Location	Sowing dates	
	ITS	ILS
Dinajpur	20 November 2017	21 December. 2017
Joydebpur	20 November 2017	21 December. 2017
Jashore	26 November 2017	26 December 2017
Rajshahi	20 November 2017	18 December 2017
Jamalpur	20 November 2017	20 December 2017

2.2. Intercultural operation

Recommended fertilizer doses developed by BWMRI such as 100, 27, 40, 20, 1 kg ha^{-1} N, P, K, S, and B, respectively, were applied. Two-thirds of total N and a full amount of the other fertilizers were applied as basal during final land preparation. The remaining one-third N fertilizer was applied immediately after the first irrigation (17 days after sowing, DAS), while second, third, and fourth irrigations were applied at 50, 75, and 85 DAS. At 25 DAS, Mulching and hand weeding was done. Phenological data like days to heading and maturity were recorded during the crop growth stage. The crop was harvested at full maturity on 30 March 2018. Grain yield (GY) and yield contributing characters were measured from the middle 5 rows (5 m^2 area) among 8 rows. The harvested samples from each plot were bundled separately, tagged, and manually threshed on a threshing floor after drying the bundles thoroughly in bright sunshine. GY and TGW were measured at 12% moisture in grain [9].

2.3. Evaluation of disease reactions.

All of these genotypes from different sources, along with checks, were evaluated against bipolaris leaf blight (BpLB) under field conditions of disease development. Leaf blight severity was scored three times on the double-digit scale (00-99), commencing from the water ripe to the early dough stage [10]. Disease data were converted to percent diseased leaf area (% DLA). Wheat blast severity was recorded as a percentage of spike infected and percentage of disease area on the spike.

$$\% \text{ BpLB severity} = D_1/9 \times D_2/9 \times 100$$

where, D_1 = First digit, representing relative disease height, and D_2 = The second digit, indicating disease severity on the foliage
% Disease severity= (% spike incidence/100) * (% diseased area on spike/100) *100

2.4. Statistical analysis

The CropStat program conducted the statistical analysis with an F-test at 1% and 5% levels.

3. Results and Discussion

3.1. Days to heading

At the developmental stage, several physical changes are seen in the plant. When a spike partially appears to emerge from its enclosing sheath is called heading [11]. The effects of sowing time, location, and genotype on days to heading are presented in Tables 2, 3, 4. Significant variations of days to heading were found by sowing time, environment, and genotypes. It was faster in the late sowing than optimum sowing time due to the high temperature in late sowing conditions. Several reports showed similar results [12] where they found that reduction in days to maturity in association with late sowing is the cause of terminal heat stress. In general, all the genotypes took more days to head under normal sowing than late sowing. Regarding the environment, days to the heading of genotypes was earlier in the environmental condition of Gazipur followed by Jashore than other places might be due to the higher temperature in Gazipur and Jashore than other places of the experiment. The difference of days to the heading of wheat genotypes in different sowing and environmental conditions might be due to environmental fluctuation, especially temperature variation, confirmed by several studies [13,14] who showed that crops complete their life cycle much faster at high temperature than in normal temperature conditions. All tested genotypes headed earlier than check variety BARI Gom 21 and BARI Gom 26. Genotype BAW 1295 showed an earlier heading than all check varieties. However, the variations of phenological stages also depend on the genetic makeup of different genotypes [15].

3.2. Days to maturity

Significant effects of sowing time, location, and genotype on days to maturity were observed in this study (Table 2, 3, 4). In late sown conditions, wheat genotypes matured faster than optimum sowing conditions due to the environmental factors, especially temperature, where crops completed their physiological stages more quickly. The results agree with Khan et al. [12], where they found that reduction in days to maturity in association with late sowing is the cause of terminal heat stress. In general, all the genotypes took more days to maturity under normal sowing than late sowing. In the case of location, wheat genotypes matured earlier in Joydebpur, followed by Jashore and Jamalpur. Wheat genotypes took a long time for days to maturity in the location of Dinajpur. A similar result was observed in the study of Hossain et al. [16]. The difference of days to maturity of wheat genotypes in different sowing and environmental conditions might be due to environmental fluctuation. Several reports showed the same results [17,18] where they reported that significantly temperature affects the number of days required to achieve different growth stages in wheat. Genotypes BAW 1317, BAW 1303, BAW 1290, BAW 1293, BAW 1295, and BAW 1296 showed early maturation than two checks, BARI Gom 21 and BARI Gom 26. BARI Gom 32 took less time to maturity. This variation of maturity might be due to different genetic constituents of wheat genotypes. Shahzad et al. [19] also showed that the days to maturity of wheat cultivars vary due to inherent characters between cultivars.

Table 2. Effect of seeding times on phenology, yield attributes, and yield of different advanced wheat lines, 2017-18

Sowing time	Heading (days)	Maturity (days)	Plant height (cm)	Spike m^{-2}	Grains $spike^{-1}$	Thousand-grain weight (g)	Yield (kg ha^{-1})
Irrigated timely sown	62	107	93	324	43	51.2	4367
Irrigated late sown	61	96	88	290	43	42.3	2892
F-test	**	**	**	**	ns	**	**
LSD (0.05%)	0.23	0.29	0.65	6.61	0.61	0.49	70.35
CV (%)	1.9	1.5	3.7	11.2	7.5	5.4	10.1

3.3. Plant height

For crop yield estimation, plant height is an important parameter. In this experiment, plant height was higher in the timely sown condition than the late sown condition (Table 2). Plant height was higher in Dinajpur than in other places. In the ITS condition, plant height was significantly higher than the ILS condition. Irfaq et al. [8] and Shezad et al. [20] also observed a reduction in plant height of different wheat genotypes due to late sowing. Higher plant height was observed in BARI Gom 21. Among tested genotypes, BAW 1317, BAW 1299, and BAW 1293 showed higher plant height than other advanced wheat lines (Table 4); on the other hand, BAW 1297 advanced line was shorter than others tested wheat lines. Plant height variations were due to the genetic makeup of advanced lines as well as location-specific environmental factors.

Table 3. Effects of locations on phenology, yield attributes, and yield of advanced wheat lines, 2017-2018

Location	Heading (days)	Maturity (days)	Plant height (cm)	Spike m^{-2}	Grains $spike^{-1}$	Thousand- grain weight (g)	Yield (kg ha^{-1})
Dinajpur	63	105	97	351	40.9	52.1	4099
Joydebpur	58	95	86	286	41.8	47.6	3741
Jashore	61	102	92	294	43.8	39.9	3469
Rajshahi	64	104	91	315	44.6	48.9	3731
Jamalpur	62	102	87	290	42.5	45.3	3108
F-test	**	**	**	**	**	**	**
LSD(0.05)	0.36	0.45	1.02	10.44	0.97	0.77	111
CV(%)	1.9	1.5	3.7	11.2	7.5	5.4	10.1

Table 4. Effect genotypes on phenology, yield attributes, and yield of advanced wheat lines, 2017-2018

Genotypes	Heading (days)	Maturity (days)	Plant height (cm)	Spike m^{-2}	Grains $spike^{-1}$	Thousand- grain weight (g)	Yield (kg ha^{-1})
BARI Gom 21	67	106	95	328	45	40.7	3359
BARI Gom 26	64	102	90	290	52	41.2	3456
BARI Gom 32	59	99	86	319	41	44.1	3731
BAW 1290	60	100	90	340	38	45.1	3989
BAW 1293	62	101	94	292	40	55.6	3755
BAW 1295	58	101	89	307	40	47.3	3438
BAW 1296	59	101	92	294	40	48.2	3522
BAW 1297	60	102	81	329	38	45.5	3798
BAW 1299	62	103	94	302	41	47.6	3557
BAW 1303	62	100	93	287	48	44.8	3604
BAW 1304	63	102	92	296	46	48.9	3681
BAW 1316	60	103	88	311	42	43.6	3496
BAW 1317	61	101	94	307	42	53.6	3876
BAW 1318	63	104	93	287	47	48.3	3959
F-test	**	**	**	**	**	**	**
LSD(0.05)	0.60	0.77	1.72	17.48	1.62	1.29	186
CV(%)	1.9	1.5	3.7	11.2	7.5	5.4	10.1

Table 5. Effect of seeding time, location, and genotype on spikes m^{-2} in 2017-2018

Entry	Dinajpur		Joydebpur		Jashore		Rajshahi		Jamalpur	
	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS
BARI Gom 21	455	324	277	325	288	403	393	300	332	287
BARI Gom 26	411	288	255	290	234	282	297	263	295	282
BARI Gom 32	444	341	301	189	327	344	380	270	303	294
BAW 1290*	458	355	343	278	346	344	408	230	332	305
BAW 1293	324	264	267	308	249	293	351	280	298	290
BAW 1295	363	315	288	307	269	307	412	253	289	262
BAW 1296	359	285	289	253	233	318	385	242	314	265
BAW 1297*	447	305	334	320	287	320	418	283	315	256
BAW 1299	392	361	282	266	274	319	305	260	284	279
BAW 1303	367	310	277	217	258	281	317	272	296	272
BAW 1304	357	284	268	309	250	307	378	262	282	263
BAW 1316	408	294	290	300	243	304	417	287	296	268
BAW 1317*	348	325	284	313	303	304	333	278	308	275
BAW 1318*	364	284	264	308	259	283	315	223	300	266
F test					**					
LSD(0.05)					55					
CV(%)					11.2					

3.4. Spike number per square meter

Spike number per square meter is one of the critical parameters among yield contributing characters. The present study was significantly affected by sowing time, environmental location, and wheat genotype (Table 2, 3, 4, 5). The maximum spike number m^{-2} was counted at the ITS condition. This result was similar to Shehzad et al. [20], who found that reducing spikes number m^{-2} was related to the delay in sowing. It was also observed that a reduced number of spike m^{-2} was associated with late planting [12]. In the case of location, the highest number of spike m^{-2} was found in Dinajpur (351), followed by Rajshahi. The lowest number of spike m^{-2} was counted at Joydebpur (286). Therefore, Dinajpur was a favorable environment for producing a higher number of spikes compared to Joydebpur. Regarding studied genotypes, the highest spike number m^{-2} was recorded in line BAW 1290 (340) followed by BAW (329), whereas the minimum spike number m^{-2} (287) was produced by BAW 1318 and BAW 1303. In ITS condition, the highest spike number m^{-2} (458), was achieved by the genotype BAW 1290 in the Dinajpur location, and the lowest spike number m^{-2} (233) was counted by the genotype BAW 1296 in the Jashore location. In contrast, in the ILS condition, the highest spike number m^{-2} (361) was achieved by the genotype BAW 1299 in Dinajpur, and the lowest spike number m^{-2} (217), was counted by the genotype BAW 1303 in Joydebpur among the tested genotypes. Variations of spike number m^{-2} were due to the genetic makeup of advanced lines and location-specific environmental factors and sowing times.

Table 6. Effect of seeding time, location, and genotype on thousand-grain weight in 2017-2018

Entry	Dinajpur		Joydebpur		Jashore		Rajshahi		Jamalpur	
	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS
BARI Gom 21	40.9	42.4	48.9	38.4	37.0	25.7	47.2	41.6	50.7	34.6
BARI Gom 26	45.2	37.9	50.0	40.7	42.0	29.0	43.7	37.7	46.1	39.6
BARI Gom 32	55.4	42.4	52.9	41.9	42.0	31.0	52.5	40.1	44.5	38.3
BAW 1290*	54.5	47.5	50.6	39.6	46.3	32.7	47.0	47.6	43.9	41.7
BAW 1293	65.3	55.9	62.0	41.3	57.7	39.0	59.9	52.1	60.5	52.0
BAW 1295	57.0	49.6	52.1	42.0	50.7	35.0	51.9	46.4	47.4	41.0
BAW 1296	61.0	51.3	56.4	40.8	50.7	32.3	52.9	49.4	41.4	45.7
BAW 1297*	59.6	45.0	53.3	41.0	45.0	35.0	47.7	46.2	46.7	35.3
BAW 1299	60.1	47.3	54.9	45.6	50.0	29.7	51.2	47.5	47.3	42.7
BAW 1303	54.1	44.5	52.1	38.0	45.7	31.3	46.3	46.3	48.4	41.6
BAW 1304	59.1	48.6	54.9	43.2	50.0	32.0	49.7	52.7	54.6	44.7
BAW 1316	58.1	48.1	46.1	42.7	45.3	29.7	44.8	38.1	44.6	38.9
BAW 1317*	63.8	55.0	57.9	48.3	52.7	37.7	56.6	53.0	57.7	53.2
BAW 1318*	58.1	52.0	55.8	40.6	51.0	30.7	57.2	51.2	44.7	41.4
F test					**					
LSD(0.05)					4.1					
CV(%)					5.4					

3.5. Thousand-grain weight

In the present study, significantly higher TGW was achieved in the ITS condition than the ILS condition (Table 2). Generally, thousand-grain weight decreases under late sown heat stress conditions, and higher TGW is achieved in optimum sowing time due to maximum individual grain weight that might be due to favorable environmental conditions for crop growth. Considering on environmental location, the highest TGW (52.1 g) was observed in Dinajpur, followed by Rajshahi (48.9 g), and the lowest TGW (39.9 g) was recorded in Jashore (Table 3). Higher TGW was observed in Dinajpur due to prevailing favorable weather conditions during the growth stage of wheat. Genotype BAW 1293 produced the highest TGW (55.6 g), followed by genotype BAW 1304 (48.9 g), and the lowest TGW (40.7 g) was produced by check variety BARI Gom 21 (Table 4). Out of tested eleven genotypes, ten had higher TGW than all three check varieties. In ITS condition, BAW 1293 produced the highest TGW in all locations, followed by BAW 1317 but in ILS condition, BAW 1293 produced the highest TGW in Dinajpur and Jashore, while BAW 1317 produced the highest TGW in Joydebpur, Rajshahi, and Jamalpur. In Dinajpur, Joydebpur, and Jashore, it was observed that all advanced lines gave the highest TGW under ITS condition. While in ILS condition, BAW 1290, BAW 1304 produced higher TGW in Rajshahi, and BAW 1296 gave higher TGW in Jamalpur. In late sowing, reduced grain weight might be due to high-temperature domination during the milk and grain filling stage. Wardlaw [21] has suggested that a reduction in grain weight is caused by high temperature during pre and post-anthesis under field conditions. High temperature and a shortage of soil moisture (drought) in late sowing reduced individual grain weight, which finally affected 1000-grain weight due to faster heading and abnormal maturity.

Table 7. Effect of seeding time, location, and genotype on grain yield (kg ha^{-1}) in 2017-2018

Entry	Dinajpur		Joydebpur		Jeshore		Rajshahi		Jamalpur	
	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS
BARI Gom 21	4624	2413	4098	3340	4511	2108	3583	2625	3982	2200
BARI Gom 26	5664	2419	4286	3371	4222	1826	4475	2575	3373	2249
BARI Gom 32	6024	3492	3971	3351	4477	3017	4200	2817	3251	2707
BAW 1290*	5755	3331	4713	3460	4704	2791	4917	3125	4047	3049
BAW 1293	4999	3208	4429	3039	3950	2796	4858	3175	3753	3342
BAW 1295	5044	2401	4074	3101	3542	2914	4533	2792	3338	2640
BAW 1296	4901	2967	3714	3125	3884	2653	4483	3133	3422	2933
BAW 1297*	5427	2527	3998	3258	4433	2685	4250	2917	3287	2176
BAW 1299	4795	3065	4732	3321	3885	2588	4667	3067	3227	2227
BAW 1303	5156	2592	4384	3251	4290	2641	4883	2625	3378	2835
BAW 1304	5144	3029	4074	3378	4388	2832	4508	3117	3595	2740
BAW 1316	5097	2975	4069	3444	4362	2717	3900	2642	3373	2384
BAW 1317*	5316	3403	3617	3334	4921	2829	5192	2983	4062	3104
BAW 1318*	5714	3301	4678	3951	4576	2595	4817	3608	3720	2629
F test					**					
LSD(0.05)					589					
CV(%)					10.1					

3.6. Grain yield

The effects of seeding time, location, genotype on grain yield are presented in Tables 2, 3, 4, 7. The higher yield (4367 kg ha^{-1}) was achieved under the ITS condition compared to the ILS condition (Table 2). The poor grain yield of wheat in ILS may be assigned to a decrease in spike m^{-2} and TGW. Late sown wheat faced high-temperature stress in field conditions, followed by drought, causing significant yield reduction. Several reports showed similar results [22,23]. Among the location, a higher yield (4099 kg ha^{-1}) was achieved at Dinajpur, followed by Joydebpur (3741 kg ha^{-1}) and Rajshahi (3731 kg ha^{-1}). The lowest yield was recorded at Jamalpur (3108 kg ha^{-1}) (Table 3). The higher grain yield in Dinajpur due to the prevailing long duration of winter compared to other places that helped wheat crops to proper growth. The highest yield was achieved in BAW 1290, followed by BAW 1318 and BAW 1317. The higher yields of these wheat advanced lines assigned to a higher number of spikes m^{-2} and 1000 grain weight. In Dinajpur, BARI Gom 32 produced the highest yield (6024 kg ha^{-1}) followed by BAW 1290 (5755 kg ha^{-1}), BAW 1318 (5714 kg ha^{-1}) under ITS condition, and the lowest yield (2403kg ha^{-1}) was produced in BAW 1295 under ILS condition. In Joydebpur, the highest yield was recorded in BAW 1299 (4732 kg ha^{-1}), followed by BAW 1290 (4713 kg ha^{-1}) under ITS, and the lowest yield was recorded in BAW 1295 (3101 kg ha^{-1}) under ILS condition. In Jeshore, the highest yield was recorded in BAW 1317 (4921 kg ha^{-1}) under ITS condition, and the lowest yield was recorded in BARI Gom 26 (1826 kg ha^{-1}) under ILS condition. The highest yield was achieved in BAW 1317 (5192 kg ha^{-1}) at Rajshahi under ITS condition, and the lowest yield was recorded in BARI Gom 26 (2575 kg ha^{-1}) under ILS condition. The highest yield was achieved in BAW 1317 (4062 kg ha^{-1}), followed by BAW 1290 (4047) at Jamalpur under ITS condition, and the lowest yield was observed in BAW 1297 (2176 kg ha^{-1}) under ILS condition at the exact location. In Joydebpur, genotype BAW 1290, BAW 1304, BAW 1316, BAW 1318 gave a higher yield than all three check varieties in ILS. In Jashore at ILS, all tested genotypes gave a higher yield than two checks BARI Gom 21 and BARI Gom 26 but gave a lower yield than another check BARI Gom 32. At late sown condition, BAW 1290, BAW 1293, BAW 1296, BAW 1297, BAW 1299, BAW 1304, BAW 1317, BAW 1318 showed better performance check varieties in Rajshahi. Regarding Jamalpur, BAW 1290, BAW 1293, BAW 1296, BAW 1303, BAW 1304, BAW 1317 showed better performance than all three check varieties in ILS. The grain yield of all genotypes in late sown conditions was reduced compared to the timely sown conditions in all locations. It has been shown that all the genotypes produced lower grain yield as a result of late sowing [23]. Genotypes BAW 1290, BAW 1293, BAW 1317, BAW 1318 showed comparatively better performance in ILS conditions representing that these advanced wheat lines were less affected by terminal heat stress under late sowing conditions. In general, our results agree with those of Khan et al. [12], Bala and Sikder [23], who found that delay in sowing is directly associated with the consistent reduction in grain yield.

3.7. Percent yield losses due to late sowing and disease reactions

The highest yield loss due to late seeding was recorded in both check variety BARI Gom 26 (44%) and BARI Gom 21 (39%) (Table 8). All tested genotypes lost their yield less than two check varieties BARI Gom 21 and BARI Gom 26, at late sowing. A minor yield loss was found in genotype BAW 1296. Regarding percent diseased leaf area (%DLA), BAW 1295, BAW 1303, BAW 1316, BAW 1317, BAW 1318 showed less %DLA than check varieties BARI Gom 26 and BARI Gom 32. In blast severity, the highest severity was observed in BARI Gom 26 (91.7%). Genotypes BAW 1296, BAW 1297, BAW 1299, BAW 1304, and BAW 1318 showed lower severity than all check varieties.

Table. 8. Mean yield, disease reaction, and percent yield losses due to late seeding in 2017-2018

Genotypes	Irrigated timely sown (ITS)	Irrigated late sown (ILS)	Percent loss due to late seeding	Percent diseased leaf area (DLA)	Percent blast severity at Jashore in ILS
BARI Gom 21	4160	2537	39	14	20.2
BARI Gom 26	4404	2488	44	60	91.7
BARI Gom 32	4385	3077	30	49	34.6
BAW 1290*	4827	3151	35	77	43.6
BAW 1293	4398	3112	29	55	34.8
BAW 1295	4106	2770	33	16	33.9
BAW 1296	4081	2962	27	66	13.6
BAW 1297*	4279	2713	37	67	7.3
BAW 1299	4261	2854	33	63	11.9
BAW 1303	4418	2789	37	45	29.2
BAW 1304	4342	3019	30	62	7.4
BAW 1316	4160	2832	32	18	33.8
BAW 1317*	4622	3131	32	25	36.0
BAW 1318*	4701	3217	32	32	12.0

Conclusion

This study considers the overall performance over locations, seeding times, and genotypes and their different interactions on yield, yield contributing characters, phenology, and disease reactions. It can be concluded that all advanced lines are better in irrigated timely sowing than irrigated late sowing conditions, and it can be said that Dinajpur is the best place for wheat cultivation among these five locations. Genotypes BAW 1290, BAW 1293, BAW 1317, BAW 1318 showed comparatively better performance in ILS conditions representing that these advanced wheat lines were less affected by terminal heat stress under late sowing conditions.

Conflicts of interest: There is no conflict of interest.

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