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Article

Performance of wheat, barley and triticale as influenced by irrigation levels and terminal heat stress

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Abstract: Alternative winter cereals should be chosen to cope up with changing climate as wheat is facing drought stress as well as terminal heat stress and resulting drastic yield reduction. Therefore, a field experiment was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November 2012 to March 2013 to find out the performance of wheat, barley and triticale as influenced by irrigation levels and terminal heat stress. The experimental factors comprised of three factors viz. three crop species, two date of sowing (18 November sowing and 24 December sowing) and three irrigation levels (completely irrigated, irrigation till booting and irrigation till flowering). The crop species comprised of wheat (var. BARI Gom-27), barley (var. BARI Barley-2) and triticale (var. BARI Triticale-2). The experiment was laid out in randomized complete block design with three replications. Crop species in 24 December sowing received higher temperature on their reproductive stages than 18 November sowing which could be considered as terminal heat stress. All the yield, yield components and grain dimensions were influenced by crop species, date of sowing, irrigation levels and their interactions. The interaction effect of crop species, date of sowing and irrigation levels showed significant in relation to yield and yield components except number of total tillers/plant, straw yield, biological yield, harvest index and number of grains/m^2. The highest 1000-grain weight and grain yield were obtained from the interaction of wheat, 18 November sowing and completely irrigated condition. Result showed that yield and yield components of wheat, barley and triticale were increased with optimum sowing and completely irrigated condition and decreased with late sowing and less irrigation condition. Compared to optimum sowing, in late sowing condition with less irrigation the yield of wheat crop was reduced drastically than barley and triticale.

Keywords: wheat; barley; triticale; terminal heat stress; irrigation levels

1. Introduction

The impact of climate change induced global warming on agricultural production is a big concern worldwide. It is particularly very important for Bangladesh where agriculture is one of the important sectors of the national economy. Temperature is one of the most important climatic factors that affects growth and development of plants. Temperature above the resistance limit of plants is called heat stress, which tends to decrease the plant's physiological activities (Noohi *et al.*, 2009). Terminal heat stress is a common abiotic factor for reducing the yield of a crop. Poulton and Rawson (2011) reported that temperature in Bangladesh increased over the past two decades by 0.035°C/year. If this trend continues, temperature will increase 2.13°C more than 1990 levels by

2050. Thus, heat is the greatest threat to food security in densely populated Bangladesh. Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of the world. It is primarily a thermo sensitive winter crop. The optimum temperature for the growth and development of spring-wheat is around 20^{o}C (Paulsen, 1994), but the temperature often rises above 30^{o}C before the physiological maturity in many wheat growing countries including Bangladesh, which exposes the crop to chronic heat stress. The optimum sowing time of wheat in Bangladesh ranges between mid November and first week of December (Hossain and Alam, 1986) and over 1% grain yield loss/day occurs for delay after the fifth day of December (Ahmed *et al.,* 1986). It has already been established that heat stress can be a significant factor in reducing the yield and quality of wheat (Stone and Nicolas, 1995). About 80-85% of wheat in Bangladesh is grown after trasplanted aman rice of which 60% of area is planted lately due to delay in harvesting of rice (Badaruddin *et al.*, 1994) and thus the crop frequently encounters high temperature stress during the reproductive stage of growth causing significant yield reduction. The area under wheat cultivation in Bangladesh during 2011-2012 was about 3.58 lakh hectare producing 9.95 lakh tons of wheat with an average yield of 2.78 tons per hectare (BBS, 2012). In the year 2010-2011 the area under wheat cultivation was 3.73 lakh hectare producing 9.72 lakh tons of wheat with an average yield of 2.60 tons per hectare. The wheat production area in 2007-08, 2008-09 and 2009-10 was 4.08, 3.99 and 3.89 lakh hectare, respectively (BBS, 2012). Therefore, the cultivation of wheat decreased in last few years. Farmers' interest on the cultivation of more profitable contemporary crop is considered as of the main reason. In case of late sowing, wheat is a high temperature sensitive crop. As a result the yield of wheat is reduced drastically due to adverse impact of terminal heat stress.

Barley (*Hordeum vulgare subsp. vulgare*) cultivation has to be popularized among the growers in Bangladesh (BARI, 2004). Triticale, (*Triticale hexaploide*) the first successful human-made cereal grain, was deliberately produced in 1875 by crossing wheat with rye. Presently, it is considered as an alternative to wheat or barley as a food grain in areas with unfavorable growing conditions or in low-input systems (Varughese, 1996). Barley and triticale are those crops which have the capability to tolerate heat stress than wheat. In winter season we grow less fodder producing crop in Bangladesh. Therefore, it is needed to explore an alternative which could serve as dual purpose crop like barley and triticale those are used as food, feed or fodder crops like other countries. These crops have also required less irrigation, fertilizers, and insecticides than wheat. Compared to barley and wheat, triticale shows increased yield, tolerance to drought and increased resistance to pests and diseases (Roy and Sarker, 1993). Irrigation plays a vital role in terms of bringing good growth and development of wheat, barley and triticale. Irrigation frequency also has a significant influence on growth and yield of wheat, barley and triticale (Khajanij and Swivedi, 1988). However, to the best of author's knowledge, no work has been carried out to assess the effect of sowing dates and irrigation levels on wheat, barley and triticale. A few research works have been reported on the agronomic aspect of wheat, barley and triticale as affected by different levels of irrigation and high temperature stress. It was, therefore, considered worthwhile to evaluate their effects on the yield and yield components of wheat, barley and triticale.

2. Materials and Methods

2.1. Location and site

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November 2012 to March 2013 to find out the performance of wheat, barley and triticale as influenced by irrigation levels and terminal heat stress. Geographically, the experimental field was located at 24^{o}75′ N latitude and 90^{o}50′ E longitude at an elevation of 18m above the sea level belonging to non-calcareous dark grey floodplain soil under Old Brahmaputra Floodplain Agro-ecological zone-"AEZ 9". The land was medium high with sandy loam texture.

2.2. Soil

The experimental plot was a medium high land with silty clay loam soil having pH 5.80. The physical and chemical properties of the soil were tested in the Agri-Humboldt Soil Testing Lab, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

2.3. Experimental treatment

The experimental factors comprised of three factor namely, crop species, date of sowing and irrigation levels. The crop species comprised of wheat (var. BARI Gom-27), barley (var. BARI Barley-2) and triticale (var. BARI Triticale-2). Date of sowing comprised of 18 November sowing and 24 December sowing. Irrigation levels comprised of three different levels of irrigation viz. completely irrigated, irrigation till booting and irrigation till flowering where completely irrigated means irrigations given at 20 DAS, 45 DAS, 60 DAS. Irrigation till booting means irrigations given at 20 and 45 DAS. Irrigation till flowering means irrigations given at 20 and 60 DAS. The experimental field was laid out in randomized complete block design with three replications.

2.4. Experimental design

The unit plot size was 4 m^2 (2 m × 2 m) and spaces between blocks and unit plots were 1 m and 0.5 m, respectively. Whole amount of recommended dose of triple super phosphate, muriate of potash and gypsum were broadcast in each plot at the time of final land preparation and the fertilizers were mixed thoroughly with soil by spading. The urea was top dressed in three equal splits, one at early tillering stage (28 days after sowing) and the other at booting stage, (46 day after sowing) and reproductive stage (64 days after sowing). Seeds were sown continuously by hand in 20 cm apart rows first on 18 November 2012 and then second on 24 December 2012. Intercultural operations such as weeding and gap filling were done in order to ensure and maintain the normal growth of the crop as and when necessary. At full maturity stage, the crop species were harvested first on 18 March 2013 and then second on 28 March 2013.

2.5. Data collection

2.5.1. Crop phenology

Wheat, barley and triticale showed similar phenology in both sowing dates. When sowing dates are compared, crop species took more days in optimum sowing than late sowing due to prevailing high temperature. Under high temperature in late sowing, crop species completed their life cycle much faster than under normal temperature condition in optimum sowing. In anthesis- maturity stage, crop species were respond to highest temperature and lowest relative humidity than emergence-booting and booting-anthesis in case of both sowing. The highest temperature was countered to barley on anthesis-maturity stage than wheat and triticale in late sowing. Crop species of late sowing were considered to receive terminal heat stress as because of rising temperature up to 31.24 ^{0}C during anthesis to physiological maturity stages.

2.5.2. Yield and yield components

Plot-wise yield and data on yield components were recorded. The parameters recorded were plant height, number of total tillers/plant, numbers of spikes/m^2, spike length, number of total spikelets/spike, number of fertile spikelets/spike, number of non-fertile spikelets/spike, number of grains/m^2, 1000-grain weight, grain yield, straw yield, biological yield and harvest index.

2.6. Statistical analysis

All data were analyzed statistically and mean differences were adjudged by DMRT.

3. Results and Discussion

3.1. Climatic conditions in relation to crop phenology

Wheat, barley and triticale showed similar phenology in both sowing dates. Differences in booting, anthesis and physiological maturity dates were less than 5 days among the crop species (Table 1). When sowing dates were compared, crop species took more days in 18 November sowing (optimum sowing) than 24 December sowing (late sowing). The maximum, minimum, mean temperature during the emergence-booting, booting-anthesis and anthesis-physiological maturity periods were shown in Table 1. Wheat, barley and triticale received higher temperature in late sowing than optimum sowing. The maximum temperature of wheat, barley and triticale from emergence-booting, booting-anthesis and anthesis-physiological maturity ranged from 23.39 to 27.60^{0}C in optimum sowing and 24.93 to 31.24 ^{0}C in late sowing. The optimum temperature for the growth and development of winter cereal is around 20 ^{0}C (Paulsen, 1994). But the temperature often rises above 30 ^{0}C before the physiological maturity in late sowing condition which exposes the crop to terminal heat stress. It is known that terminal heat stress happens only when high temperature lies on reproductive stage of crop. Therefore, it can be said that crop species of late sowing were considered to receive terminal heat stress as because of rising temperature up to 31.24 ^{0}C during anthesis to physiological maturity stages.

3.2. Effect of crop species

In case of crop species all parameters were found significant. The highest plant height (99.38 cm), straw yield (5.67 t/ha), biological yield (7.88 t/ha) and number of grains/m^2 (6079.72) were found from barley (Table 2). These might be for the genetic make- up of the crop species. Number of total tillers/plant (5.46), number of spikes/m^2 (346.76), Spike length (10.21 cm), number of total spikelets/spike (19.75), number of fertile spikelets/spike (19.06), 1000-grain weight (39.52 g) and harvest index (32.72%) were highest in triticale (Table

2). The lowest value for the yield components like plant height (76.14 cm), number of total tillers/plant (4.69), number of spikes/m^2 (271.11), spike length (8.42 cm), number of total spikelets/spike (16.91), number of fertile spikelets/spike (15.87), number of grains/m^2 (5356.33),1000-grain weight (39.46 g), grain yield (2.13 t/ha), straw yield (4.43 t/ha) and biological yield (6.55 t/ha) were found from wheat, number of non-fertile spikelets/spike (0.69) was found in triticale and harvest index (27.65%) was obtained from barley (Table 2). Rahman (2013) also evidenced similar results.

3.3. Effect of date of sowing

The effect of date of sowing was significant for all yield components. 18 November sowing produced higher plant height (94.47 cm), number of total tillers/plant (5.47), number of spikes/m^2 (414.28), spike length (10.33 cm), number of total spikelets/spike (19.03), number of fertile spikelets/spike (18.37), number of grains/m^2 (6424.05), 1000-grain weight (41.68 g), grain yield (2.65 t/ha), straw yield (5.47 t/ha), biological yield (8.13 t/ha) and harvest index (32.85%). Lower value of all those parameters was recorded at 24 December sowing except number of non fertile spikelets/spike. This might be for the adverse impact of terminal heat stress particularly to reproductive stages. This result was similar to Mahboob *et al.* (2005) who reported that delayed planting reduced the days to heading, days to maturity grain filling duration and ultimately showed the reduction in yield and yield components. Hossain *et al.* (2012d) also observe similar results and he reported that in stress condition (late sowing) all genotypes had shorter spikes (18-40%) which ultimately reduced the final yield.

Table 1. Effect of phenology and temperature from emergence to booting (Em-Bo), booting to anthesis (Bo-At) and from anthesis to physiological maturity (At-PM) of wheat, barley and triticale.

Crop Species	Sowing Time	Phenology (days)			Maximum temperature (^oC)			Minimum temperature (^oC)			Mean temperature (^oC)		
		Em-Bo	Bo-At	At-PM	Em-Bo	Bo-At	At-PM	Em-Bo	Bo-At	At-PM	Em-Bo	Bo-At	At-PM
Wheat	Sowing 1	35	12	42	23.39	21.88	27.30	12.98	9.12	14.36	18.19	15.51	20.97
	Sowing 2	36	10	23	24.93	26.75	30.94	11.65	15.61	18.27	18.46	21.20	24.49
Barley	Sowing 1	35	16	42	23.39	22.49	27.45	12.98	9.50	14.49	18.19	16.01	21.08
	Sowing 2	34	14	23	24.67	27.28	31.24	11.41	15.73	18.54	18.20	21.52	24.78
Triticale	Sowing 1	35	16	42	23.39	23.01	27.60	12.98	9.97	14.82	18.19	16.51	21.25
	Sowing 2	34	12	25	24.67	27.73	31.22	11.41	15.22	18.62	18.20	21.50	24.80

3.4. Effect of irrigation levels

The effect of different irrigation levels was significant in relation to all yield components. The highest plant height (93.87cm), number of total tillers/plant (5.31), number of spikes/m^2 (332.93), spike length (9.67 cm), number of total spikelets/spike (19.17), number of fertile spikelets/spike (18.48), 1000 grain weight (39.33 g), no. of grains/m^2 (5670.76), grain yield (2.31 t/ha), straw yield (4.99 t/ha), biological yield (7.30 t/ha), harvest index (31.35%) were obtained from completely irrigated condition (Table 4). Plant height might be increased with increasing irrigation levels and this caused by supplying proper amount of water for vegetative growth. Rahman (2013) found same kind of result in wheat, barley and triticale and Ahamed (2011), Islam (2004), Rao and Agarwal (1984) and Hefni *et al.* (1983) also found in wheat where irrigation plays a positive role in increasing the number of total tillers/plant. Rahman (2013) and BARI (1993) also reported similar result that no. of spikes/m^2 and grain yield was increased when irrigation was increased. Ahamed (2011) and Kabir (2009) also observed that yield was varied significantly due to irrigation treatment on wheat crop. The lowest value of all those parameters was recorded at irrigation at booting except number of non-fertile spikelets/spike (Table 4).

Table 2. Yield and yield components of wheat, barley and triticale.

Crop species	Plant height (cm)	Number of total tillers/ plant	Number of spikes/m^2	Spike length (cm)	Number of total spikelets/ spike	Number of fertile spikelets/ spike	Number of non-fertile spikelets/ spike	Number of grains/m^2	1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
C_1	76.14c	4.69c	271.11c	8.42c	16.91c	15.87c	1.04a	5356.33c	39.46a	2.13c	4.43b	6.55b	32.08ab
C_2	99.38a	5.04b	278.75b	9.49b	18.42b	17.65b	0.77b	6079.72a	35.94b	2.20b	5.67a	7.88a	27.65b
C_3	97.03b	5.46a	346.76a	10.21a	19.75a	19.06a	0.69b	5612.25b	39.52a	2.24a	4.54b	6.78ab	32.72a
CV (%)	3.93	12.22	12.27	18.58	6.98	4.77	15.52	8.08	3.7	9.31	10.88	8.65	7.08
Level of Sig.	**	**	**	**	**	**	**	**	**	**	**	**	**

In a column figures with similar letter do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT.
**indicates significant at 1% level of probability.
C_1 = Wheat, C_2 = Barley and C_3 = Triticale.

Table 3. Effect of date of sowing on yield and yield components of wheat, barley and triticale.

Crop species	Plant height (cm)	Number of total tillers/ plant	Number of spikes/m^2	Spike length (cm)	Number of total spikelets/ spike	Number of fertile spikelets/ spike	Number of non-fertile spikelets/ spike	Number of grains/m^2	1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
S_1	94.47a	5.45a	414.28a	10.33a	19.03a	18.37a	0.66b	6424.05a	41.68a	2.65a	5.47a	8.13a	32.85a
S_2	87.22b	4.68b	183.47b	8.42b	17.68b	16.69b	1.00a	4941.49b	34.94b	1.72b	4.29b	6.01b	28.79b
CV (%)	3.93	12.22	12.27	18.58	6.98	4.77	15.52	8.08	3.7	9.31	10.88	8.65	7.08
Level of Sig.	**	**	**	**	**	**	*	**	**	**	**	**	**

In a column figures with similar letter do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT.
*and ** indicate significant at 5% and 1% level of probability, respectively.
S_1= 18 November sowing and S_2= 24 December sowing

Table 4. Effect of irrigation levels on yield and yield components of wheat, barley and triticale.

Level of Irrigation	Plant height (cm)	Number of total tillers/ plant	Number of spikes/m^2	Spike length (cm)	Number of total spikelets/ spike	Number of fertile spikelets/ spike	Number of non- fertile spikelets/ spike	Number of grains/m^2	1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
I_1	93.87a	5.31a	332.93a	9.67a	19.17a	18.48a	0.69b	5831.90a	39.33a	2.31a	4.99a	7.30a	31.35a
I_2	88.45c	4.80b	266.93c	9.09b	17.53c	16.53c	1.00a	5545.65c	37.73b	2.10b	4.78c	6.88c	30.50b
I_3	90.22b	5.08ab	296.76b	9.37ab	18.38b	17.58b	0.80b	5670.76b	37.88b	2.16ab	4.87b	7.03b	30.60b
CV (%)	3.93	12.22	12.27	18.58	6.98	4.77	15.52	8.08	3.7	9.31	10.88	8.65	7.08
Level of Sig.	**	**	**	**	**	**	**	**	**	*	*	**	*

In a column figures with similar letter(s) do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT.
*and ** indicate significant at 5% and 1% level of probability, respectively.
I_1 = Completely irrigated, I_2 = Irrigation till booting and I_3 = Irrigation till flowering.

Table 5. Effect of interaction of crop species, date of sowing and irrigation levels on yield and yield components.

Interaction (Crop species × date of sowing × irrigation level)	**Plant height (cm)**	**Number of total tillers/ plant**	**Number of spikes/m^2**	**Spike length (cm)**	**Number of total spikelets/ spike**	**Number of fertile spikelets/ spike**	**Number of non-fertile spikelets/ spike**	**1000-grain weight (g)**	**Grain yield (t/ha)**	**Straw yield (t/ha)**	**Biological yield (t/ha)**	**Harvest index (%)**
$C_1S_1I_1$	81.68i	5.50	454.58c	9.35e	18.59e	17.91e	0.68d-h	51.71a	2.98a	5.09	8.08	36.94
$C_1S_1I_2$	75.25k	4.17	272.50f	8.13gh	16.21h	15.28g	0.93b-e	43.36bc	2.31e	4.62	6.94	33.35
$C_1S_1I_3$	78.22j	4.83	351.50e	8.80f	17.17fg	16.40f	0.77c-g	43.89b	2.38e	4.80	7.18	33.15
$C_1S_2I_1$	76.00k	4.83	189.92hij	8.15gh	17.77f	16.69f	1.08bc	32.73e	1.71f	4.03	5.74	29.74
$C_1S_2I_2$	72.33l	4.13	174.17jkl	7.80i	15.05i	13.31h	1.74a	32.52e	1.68f	3.98	5.66	29.63
$C_1S_2I_3$	73.33l	4.70	184.00ijk	8.31g	16.67gh	15.66g	1.01bcd	32.57e	1.70f	4.03	5.73	29.69
$C_2S_1I_1$	109.15a	5.60	436.92c	11.04b	20.17ab	19.73ab	0.43gh	37.58cde	2.85b	6.73	9.58	29.75
$C_2S_1I_2$	101.60c	5.27	353.67e	10.30d	19.03de	18.37de	0.67d-h	37.39cde	2.58d	6.26	8.85	29.21
$C_2S_1I_3$	105.83b	5.43	391.42d	10.74c	19.63bc	19.10bc	0.53fgh	36.88de	2.70cd	6.47	9.17	29.46
$C_2S_2I_1$	96.07de	4.84	165.75kl	8.89f	17.65f	16.72f	0.93b-e	34.82e	1.71f	4.89	6.60	25.96
$C_2S_2I_2$	91.17h	4.49	161.83l	7.97hi	16.82g	15.67g	1.14b	34.35e	1.67f	4.84	6.51	25.71
$C_2S_2I_3$	92.43gh	4.58	162.92l	8.03ghi	17.22fg	16.31f	0.91b-e	34.65e	1.69f	4.86	6.55	25.80
$C_3S_1I_1$	104.33b	6.17	540.92a	11.63a	20.37a	20.03a	0.33h	41.38bcd	2.79bc	5.21	8.00	34.84
$C_3S_1I_2$	97.00d	5.97	440.75c	11.48a	19.50cd	18.83cd	0.67d-h	41.34bcd	2.60d	4.98	7.58	34.31
$C_3S_1I_3$	97.15d	6.10	486.25b	11.48a	20.63a	19.67ab	0.97b-e	41.62bcd	2.69cd	5.08	7.77	34.62
$C_3S_2I_1$	96.00de	4.90	209.50g	8.93f	20.46a	19.78a	0.68d-h	37.73cde	1.79f	4.01	5.81	30.89
$C_3S_2I_2$	93.33fg	4.78	198.67ghi	8.85f	18.57e	17.73e	0.85b-f	37.42cde	1.76f	3.97	5.73	30.82
$C_3S_2I_3$	94.33ef	4.82	204.50gh	8.87f	18.94de	18.31de	0.62e-h	37.65cde	1.78f	4.01	5.79	30.87
CV (%)	3.93	12.22	12.27	18.58	6.98	4.77	15.52	3.7	9.31	10.88	8.65	7.08
Level of Sig.	*	NS	**	**	**	*	*	**	**	NS	NS	NS

In a column figures with similar letter(s) or without letters do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT.
NS, *and ** indicate not significant, at 5% and 1% level of probability, respectively.
C_1 = Wheat, C_2 = Barley and C_3 = Triticale. S_1= 18 November sowing and S_2= 24 December sowing.
I_1 = Completely irrigated, I_2 = Irrigation till booting and I_3 = Irrigation till flowering.

3.5. Interaction effect of crop species, date of sowing and irrigation levels

The interaction effect of crop species, date of sowing and irrigation levels showed significant in relation to yield and yield components except number of total tillers/plant, straw yield, biological yield, harvest index. The highest grain yield (2.98 t/ha) was obtained from the interaction effect with crop species wheat, 18 November sowing and completely irrigated condition. In 24 December sowing the highest grain yield (1.79 t/ha) was obtained from the interaction of crop species triticale, 24 December sowing and completely irrigated condition (Table 5).

4. Conclusions

The following conclusions based on the results of the present study may be drawn-

a) In optimum sowing and completely irrigated condition wheat crop gave higher yield than barley and triticale.
b) But in late sowing condition the yield of wheat and barley reduced drastically than triticale. Because this crops were encountered mostly by terminal heat stress which affected at anthesis and grain filling stage and accelerated maturity and thus significantly reduced grain size, weight and yield. In heat stress condition with completely irrigated condition wheat and barley gave equal yield which was better than less irrigation.
c) Triticale gave better yield in completely irrigated condition than wheat under heat stress condition. Though barley gave lowest yield in late sowing combined with less irrigation but there was least difference between barley and wheat in case of yield Barley gave better yield in optimum sowing than wheat under less irrigation condition.

Based on the results of the present study it can be suggested that in order to obtain higher grain yield, farmers may be advised to sow winter cereal in optimum sowing date and apply complete irrigation. For grain yield wheat crop can be grown with complete irrigation in optimum sowing date. Triticale crop can be introduced for dual purpose like feed and fodder to fulfill the supplementary feed for animal consumption in winter season and it also gave better yield in late sowing condition than wheat. Barley crop also can be introduced where irrigation facilities are limited because barley is a drought tolerant crop. So, triticale or barley or both of them perform better than wheat under heat stress and water limited condition i.e. less irrigation. Before making conclusion, however, further trials with the same treatment combination on different Agro-Ecological Zones (AEZs) of Bangladesh will be useful.

Conflict of interest

None to declare.

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