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EFFECT OF SOWING DATE, IRRIGATION LEVEL AND VARIETY ON YIELD ATTRIBUTES, YIELD, CONSUMPTIVE WATER USE AND WATER USE EFFICIENCY OF BARLEY (*Hordeum vulgare* L.)

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ABSTRACT

The experiment was conducted to study the yield attributes, yield, consumptive water use and water use efficiency of barley (*Hordeum vulgare* L.) in relation to different sowing date and irrigation level. Two barley varieties, namely, BARI Barley 5 and BARI Barley 6 were tested for the above-mentioned parameters. Barley was sown in four sowing dates viz., November 1(S_1), November 16(S_2), December 1(S_3) and December 16 (S_4) and four irrigations, viz., control (I_0), one irrigation at the tillering stage (I_1), two irrigations, one at the tillering and one at the booting stages (I_2) and three irrigations, one at the tillering, one at the booting and one at the grain filling stages (I_3) were given. All the yield components i.e. plant height, number of fertile tillers/plant, number of fertile spikelets/spike, spike length, 1000-grain weight, straw yield, grain yield and HI were highest in S_2. The lowest values were found in S_4. With some exceptions, highest plant height, number of fertile tillers/plant, number of fertile spikelets/spike, spike length, 1000-grain weight, straw yield, grain yield and HI were observed in three irrigations. The highest consumptive use of water (CUW) was recorded in S_1 which was at par with S_2 and the lowest was in S_4. The highest CUW was recorded in I_3 followed by I_2 and I_1. The lowest CUW was recorded in the rainfed crops (I_0). The S_2 plants had the highest water use efficiency (WUE) which was at par with S_3 and the lowest was in S_4 which was at par with S_1. The highest WUE was recorded in the non-irrigated plants (I_0) followed by I_1 and I_2. The lowest WUE was exhibited in three irrigations (I_3).

Keywords: Sowing Date, Irrigation Level, Yield Attributes and Water Use Efficiency

INTRODUCTION

Barley (*Hordeumvulgare*L.) is the world's 4th most important cereal crop and it has the potential to become one of the important crops in Bangladesh. Barley though a minor crop of the country, can play an important role in enhancing the food security of the country and in drainage of foreign currency. This crop has several industrial uses also. Diluted soup made from barley is used to feed the infants as horlicks, ovaltine, Robinson's barley, Alberta barley, Hamilton's barley flour, pancake mix, viva, multova etc. Barley grain contains starch (61.8%), protein (13.1%), insoluble fiber (10.8%) moisture (7.55%), soluble fiber (4.85%), pentosan (4.28%), β-D glucan (4.26%), lipid (2.92%) and ash (1.89%) (Helm *et al.*1999). Foods prepared from barley are useful for diabetic and high blood pressure patients. It is suggested that barley could be therapeutic diet for diabetic patients, a good diet for kidney patients and the referred diet after convalescence (Ikegami *et al.* 1991). Recently, another

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developing sector of Bangladesh "Poultry industries" needs more barley grains. For those reasons huge amount of barley were imported every year in Bangladesh from different countries. Proper land preparation, optimum time of sowing, recommended fertilizer doses, proper irrigation schedule and seed rates are not usually practiced to raise this crop.

Yield and yield attributes are decreased with delay in planting (Ahmed *et al.* 2006). Early planted crops had more tillers and ears, heavier grains and higher grain yields than the late planted barley (Knapp and Knapp 1978). Late sowing might expose the barley crop to higher temperature at the reproductive stage resulting in reduced number of ears and number of grains/ear as well as yield. Efficient water management is one of the most effective means of increasing crop production. With the available facility of irrigation, productivity of the barley can be increased by timely sowing and irrigating the most promising varieties. Crop yields under dry land condition are related to seasonal rainfall, water use efficiency, can be substantially improved by crop management practices (Harris *et al*. 1991). The winter rainfall in Bangladesh is very low, which is frequently insufficient for successful barley production. This is because water deficit barley plants fail to develop properly on account of retardation in photosynthetic and metabolic activities resulting in decreased number of tiller and spike production, decreased number of seeds/spike and reduced seed size (Chaudhary and Sharma 2003). Inadequate water supply, often result in disruption of physiological process. Tillering, booting and heading are adversely affected by water stress at the early growth stage and dry matter partition, leaf area indices, crop growth rate also affected with water deficit condition (Baheri *et al.* 2005).

Yield loss of the crop can be minimized by proper irrigation and planting the crop in time. The present study was set up to find out a suitable combination of date of sowing and irrigation level for better growth, development and yield of barley under field condition. Therefore, the present study was undertaken to find out the effect of sowing dates and irrigation levels and varieties on productivity, consumptive water use and water use efficiency in barley.

MATERIALS AND METHODS

The experiment was conducted at the Crop Physiology and Ecology Field Laboratory, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during the period from November, 2015 to April, 2016. The experimental field was a medium high land sandy loam textured soil belonging to agro-ecological zone-1 (AEZ-1). The pH of the soil was 6.1. The experimental site was located at $25^0 38^/$ N and $88^0 41^/$ E longitude and at the elevation of 34.5 m above the sea level. The experiment was laid out in a split-split plot design with 3 replications. The irrigations were assigned in the main plots, date of sowing was in the sub plot and the barley variety was assigned in the sub–sub plots. The unit plot size was 2.5 m X 2 m having a plot to plot distance of o.5 m. The treatments included three sets of factors. Factor A. Irrigations: i) No irrigation (control) - I_0 ii) One irrigation (30 mm) (25 DAS i.e., at the tillering stage) - I_1 iii) Two irrigations (30+30 =60 mm) (25 and 45 DAS i.e., one at the tillering stage and another at the booting stage) - I_2 iv) Three irrigations (30+30+30 =90 mm) (25, 45 and 65 DAS i.e., one at the tillering stage, one at the booting stage and one at the grain filling stage)- I_3. Factor B. Date of sowing: i) 1 November(S_1) ii) 16 November(S_2) iii) 1 December(S_3) iv) 16 December(S_4) and factor **C.** Barley variety**:** i) BARI Barley 5 (Hulled) ii) BARI Barley 6 (Hull-less). The land was fertilized with 180 kg urea,125 kg TSP, 100 kg MP and 100 kg Gypsum per hectare and cowdung at the rate of 5t/ha (BARC 1997).

Determination of soil moisture: Soil samples were collected from each plot with an auger up to 1 meter depth of soil for determining soil moisture content before sowing and after

harvest of the crop. Soil moisture was determined gravimetrically up to l m depth of soil profile from 5 soil layers (0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm and 80-100 cm) before sowing of seeds and at the final harvest with the help of an auger. The moisture content values were used to compute consumptive water use (CWU) according to the following formula proposed by Dastane (1972).

$$\text{Consumptive use of water (mm)} = IR + ER + \sum_{i=1}^{n} \frac{Mb_i - Me_i}{100} \times A_i \times D_i$$

Here,

IR= Irrigation water, ER= Rainfall, Mb_i= Moisture percentage at the beginning of the season of the ith layer of the soil profile, Me_i= Moisture percentage at the end of the season of the ith layer of the soil profile, D_i= Depth of ith layer of the soil profile within the root zones, n= Number of soil layers in the root zone and A_i=Specific density of soil.

Tostudy the growth pattern, total dry matter production (TDM), crop growth rate(CGR),leaf area index(LAI) and net assimilation rate(NAR) were determined during different growth period by using standard methods (Radford,1965).

YIELD AND YIELD COMPONENTS

At the time of harvesting, 5 random plants were used for recording data on yield attributes. The experimental plots were harvested separately at full maturity. The central 5 rows of crops were harvested for collecting data on yield. Harvest index(HI) and water use efficiency were calculated as follows. Harvest index was calculated by dividing economic yield by biological yield of the plant in each plot and by multiplying with 100 and expressed in percentage.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Water use efficiency (WUE): Water use efficiency was calculated as follows-

$$\text{WUE} = \frac{\text{Grain yield (kg/ha)}}{\text{Consumptive use of water (mm)}} \times 100$$

Statistical analysis: All the necessary parameters recorded were analyzed statistically. A program called Microsoft Excel 2000 was used for the spreadsheet analysis and numerical calculations. All the recorded data were statistically analyzed following the ANOVA technique and the significance of mean differences were adjusted by Duncan's New Multiple Range Test, DMRT (Gomez and Gomez 1984) with the help of computer package M-STAT.

RESULTS AND DISCUSSION

Total dry matter: Date of sowing significantly influenced total dry matter at all the growth stages(Table 1). Both BARI Barley 5 and BARI Barley 6 produced the highest TDM in November 16 sowing (S_2) which was followed by November 30 sowing (S_3) and the lowest TDM was recorded in December 16 sowing (S_4). Irrigation treatment significantly influenced total dry matter production at most of the growth stages except 20 and 30 DAS. Significant irrigation effect was noticed at 40 DAS and onward.(Figure 5 and Tables 1 and 2). Starting from 40 DAS, the highest TDM was recorded in three irrigations (I_3)which was at par with I_2.The lowest TDM was observed in no irrigation (I_0) treatment. Between the two varieties, BARI Barley 6 produced higher TDM than BARI Barley 5(Table 1).

Table 1. Effect of sowing time, irrigation and variety on TDM (g/m^2)of barley

Treatment	Days after sowing (DAS)								
	20	30	40	50	60	70	80	90	100
a) Sowing time									
S_1	18.049b	68.589b	147.905c	316.547c	512.001c	783.305c	998.371c	1167.522b	1252.965b
S_2	20.127a	73.277a	165.13a	349.755a	566.426a	871.312a	1110.663a	1242.083a	1320.825a
S_3	18.916b	67.993b	154.854b	325.75b	532.854b	818.48b	1045.642b	1167.159b	1234.303b
S_4	16.735c	61.754c	138.356d	291.481d	477.049d	732.619d	932.45d	1042.554c	1096.106c
b) Irrigation									
I_0	18.616a	48.592b	98.17d	201.314c	326.316c	506.492c	661.839c	742.114c	790.066c
I_1	18.211a	70.47a	152.957c	318.04b	508.664b	771.691b	964.502b	1096.343b	1166.26b
I_2	18.834a	75.139a	172.777b	376.961a	620.864a	955.732a	1220.545a	1379.355a	1464.108a
I_3	18.166a	77.412a	182.339a	387.219a	632.486a	971.801a	1240.24a	1401.505a	1483.766a
c) Variety									
BARI Barley 5	16.923b	64.257b	144.595b	305.011b	490.791b	757.156b	970.506b	1098.131b	1172.642b
BARI Barley 6	19.990a	71.55a	158.527a	336.755a	553.374a	845.702a	1073.057a	1211.528a	1279.458a
CV (%)	9.73	11.83	8.28	5.85	5.50	5.38	6.67	6.53	8.89
Level of sig.	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.05

Leaf area index (LAI): Date of sowing significantly influenced LAI at all the growth stages (Table 2). The S_2 plants had the highest LAI followed by S_3 and the lowest LAI was recorded in S_4 which was at par with S_1. Irrigation levels had significant effect on LAI at all the growth stages except at 20 and 30 DAS. LAI increased with increasing levels of irrigation. The highest LAI was observed in three irrigations (I_3) and the he lowest LAI was found in rainfed barley crop (I_0).The highest LAI was observed at 60 DAS and continued till 70 DAS and then declined sharply.

Table 2. Effect of sowing time, irrigation and variety on leaf area index (LAI) of barley

Treatment	Days after sowing (DAS)								
	20	30	40	50	60	70	80	90	100
a) Sowing time									
S_1	0.446c	0.967c	1.743c	2.393c	3.06c	2.759c	2.113c	1.415c	0.569c
S_2	0.538a	1.142a	2.074a	2.869a	3.703a	3.274a	2.606a	1.683a	0.663a
S_3	0.504b	1.083b	1.931b	2.696b	3.436b	3.081b	2.395b	1.581b	0.631b
S_4	0.456c	0.966c	1.734c	2.422c	2.99c	2.99b	2.138c	1.413c	0.562c
b) Irrigation									
I_0	0.478a	0.72d	1.44c	1.868c	2.267c	2.085c	1.588c	1.105c	0.554c
I_1	0.482a	0.961c	1.853b	2.453b	3.019b	2.839b	2.092b	1.586b	0.604b
I_2	0.493a	1.202b	2.04a	3.002a	3.906a	3.56a	2.761a	1.687a	0.606b
I_3	0.493a	1.275a	2.148a	3.057a	3.997a	3.62a	2.811a	1.715a	0.661a
c) Variety									
BARI Barley 5	0.490a	0.987b	1.819a	2.517b	3.232b	2.931b	2.288b	1.538a	0.641a
BARI Barley 6	0.482a	1.092a	1.921a	2.674a	3.362a	3.121a	2.338a	1.508a	0.571b
CV (%)	8.58	8.27	10.07	6.07	8.01	6.76	6.95	8.85	11.39
Level of sig.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05

Starting from 20 DAS, higher LAI was observed in BARI Barley 6 up to 80 DAS and thereafter higher LAI was recorded in BARI Barley 5 (Table 2).

Crop growth rate (CGR): The crops sown within November and early December showed higher CGR than the late sowing(Table 3). With some exceptions, the plants of both S_3 and S_1 showed more or less similar CGR throughout the growth period in both the years. The highest CGR was observed at 60-70 DAS in all the sowings in both the varieties. Irrigation levels had significant effects on CGR at all the growth stages except at maturity (90-100 DAS). The highest CGR was observed in I_3 which was statistically similar with I_2 (Figure 11 and Tables 7 and 8)and the lowest CGR was observed in the rainfed condition (I_0).. During most of the growth stages, significantly higher CGR was observed in BARI Barley 6 and at the end of the growth period (90-100 DAS) relatively higher CGR was observed in BARI Barley 5 (Tables 7 and 8). The highest CGR of 29.233 g/m^2/day and 26.637 g/m^2/day were observed in BARI Barley 6 and BARI Barley 5 at 60-70 DAS(Table 3).

Table 3. Effect of sowing time, irrigation and variety on CGR (g/m^2/day) of barley

Treatment	Days after sowing (DAS)							
	20-30	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**80-90**	**90-100**
a) Sowing time								
S_1	5.053a	7.931bc	16.769b	19.642bc	27.13ab	21.507a	16.915a	8.544a
S_2	5.314a	9.184a	18.255a	21.876a	30.489a	23.935a	13.142ab	7.874a
S_3	4.908ab	8.686ab	17.09b	20.71ab	28.563ab	22.716a	12.152b	6.714a
S_4	4.461a	7.702c	15.313c	18.556c	25.557b	21.983a	11.01b	5.855a
b) Irrigation								
I_0	2.998b	4.957c	10.314c	12.50c	18.018c	15.535c	8.028b	6.795a
I_1	5.226a	8.248b	16.286b	19.286b	26.303b	19.281b	13.184ab	6.992a
I_2	5.588a	9.804a	20.418a	24.392a	33.487a	26.481a	15.881a	8.475a
I_3	5.925a	10.493a	20.408a	24.606a	33.931a	26.844a	16.127a	8.226a
c) Variety								
BARI Barley 5	4.713b	8.053b	15.892b	18.729b	26.637b	21.335b	12.762b	7.451a
BARI Barley 6	5.155a	8.698a	17.821a	21.663a	29.233a	22.736a	13.847a	6.793b
CV (%)	8.52	7.68	6.64	6.08	9.12	8.07	7.42	8.75
Level of sig.	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01

Net assimilation rate (NAR): NAR was significantly influenced by sowing time at 20-30, 40-50, 50-60 and 80-90 DAS (Table 4). Highest NAR values were found for S_1 followed by S_2 and the lowest NAR values were found in S_3 and S_4). Irrigation levels showed significant effects on NAR at 20-30, 40-50 and 50-60 DAS, the highest NAR was in two and three irrigations and the lowest was in the control (I_0). NAR did not differ significantly in both the varieties(Table 4).

Yield contributing characteristics: Plant height, number of fertile tillers/plant, number of fertile spikelets/spike and spike length was significantly influenced by both sowing time and irrigation level (Table 5). Early sowing produced the tallest plant than the late sowing. The highest plant height, maximum number of fertile tillers/plant, fertile spikelets/spike and highest spike length was observed in the plants sowing in 16 November (S_2) which was at par with S_1. The shortest plant height, fewer number of fertile tillers/plant, fertile spikelets/spike and shortest spike length were produced in December 16 sowing (S_4).

Table 4. Effect of sowing time, irrigation and variety on NAR (g/cm^2/day) of barley

Treatment	Days after sowing (DAS)							
	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
a) Sowing time								
S_1	0.749a	0.596a	0.805a	0.761a	0.929a	0.890a	0.964a	0.916a
S_2	0.658b	0.580a	0.736b	0.724b	0.868a	0.819a	0.606b	0.748a
S_3	0.643b	0.587a	0.737b	0.674c	0.872a	0.837a	0.606b	0.686a
S_4	0.622c	0.580a	0.735b	0.684c	0.857a	0.795a	0.627b	0.572a
b) Irrigation								
I_0	0.510c	0.483c	0.628c	0.613b	0.830a	0.860a	0.608a	0.617a
I_1	0.659b	0.610b	0.765b	0.716a	0.905a	0.795a	0.725a	0.724a
I_2	0.705a	0.623a	0.822a	0.712a	0.899a	0.844a	0.732a	0.828a
I_3	0.728a	0.627a	0.797a	0.703a	0.893a	0.842a	0.737a	0.752a
c) Variety								
BARI Barley 5	0.664a	0.584b	0.729b	0.658b	0.865a	0.827a	0.705a	0.731a
BARI Barley 6	0.687a	0.602a	0.777a	0.714a	0.898a	0.844a	0.737a	0.730a
CV (%)	8.98	7.66	10.24	8.87	7.12	8.08	7.08	9.87
Level of sig.	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.05

Table 5. Effect of sowing time, irrigation and variety on yield components, grain yield, CUW and WUE of barley

Treatment	Plant height (cm)	No. of fertile tillers/ plant	No. of infertile tillers/ plant	No. of fertile spikelets/ spike	No. of infertile spikelets/ spike	Spike length (cm)	Extrusion length (cm)
a) Sowing time							
S_1	92.415ab	4.65b	1.281a	41.483b	3.528c	18.290a	2.85a
S_2	93.962a	5.126a	0.914c	43.565a	3.094d	18.113a	2.479b
S_3	89.72bc	4.30c	1.083b	40.541b	3.908b	17.658ab	2.336c
S_4	88.578c	3.324d	1.268a	38.176c	4.232a	17.351b	2.194d
b) Irrigation							
I_0	81.068c	3.331d	1.301a	36.367c	4.238a	16.401c	1.941d
I_1	89.502b	4.163c	1.185b	40.172b	3.746b	17.861b	2.296c
I_2	95.988a	4.822b	1.127c	42.878a	3.617b	18.354ab	2.628b
I_3	98.118a	5.084a	0.933d	44.347a	3.161c	18.795a	2.992a
c) Variety							
BARI Barley 5	103.087a	3.985b	1.210a	40.81b	3.245b	19.626a	2.807a
BARI Barley 6	88.368b	5.15a	1.177a	45.167a	4.505a	17.865b	2.369b
CV (%)	6.99	7.59	7.03	6.97	6.72	6.22	6.44
Level of sig.	0.01	0.01	0.01	0.05	0.02	0.01	0.01

The tallest plant, the maximum number of fertile tillers/plant, fertile spikelets/spike and highest spike length was produced by three irrigations each by 30mm, i.e., one at the tillering stage, one at the booting stage and one at the grain filling stage)- I_3 which was statistically identical to two irrigations each by 30mm, i.e., one at the tillering stage and another at the booting stage) - I_2 and the lowest plant height was found in no irrigation (I_0). Between the two varieties, BARI Barley 5 gave maximum values for the above characteristics than BARI Barley 6 (Table 5). The interaction effect between sowing time and irrigation level was also found to be significant. Among the different treatment combinations, November 16 sowing (S_2) with three irrigations (I_3) produced the tallest plants, the maximum number of fertile

tillers/plant, fertile spikelets/spike and highest spike length followed by $S_1 \times I_3$, $S_3 \times I_3$ and $S_4 \times I_3$. The lowest values were recorded in the combination of December 1 and December 16 sowing with no irrigation ($S_4 \times I_0$, $S_3 \times I_0$).

Table 5a. Effect of sowing time, irrigation and variety on yield components, grain yield, CUW and WUE of barley

Treatment	1000- grain wt (g)	Straw yield (kg/ha)	Grain yield (kg/ha)	HI (%)	CUW (mm)	WUE (kg/ha/mm)
a) Sowing time						
S_1	36.97c	8531.589a	2791.832c	24.533c	372.345a	8.427b
S_2	39.835a	8519.076a	3082.374a	26.664a	368.461ab	9.676a
S_3	38.512b	8436.690b	2914.421b	25.335b	359.147bc	9.253a
S_4	36.195c	7892.867c	2485.312d	23.875d	352.055c	7.961b
b) Irrigation						
I_0	35.34d	6576.572d	1960.328d	23.038c	156.781d	12.612a
I_1	37.448c	7989.526c	2689.527c	25.259b	293.944c	9.29b
I_2	38.683b	9285.027b	3224.405b	25.801ab	434.555b	7.425c
I_3	40.04a	9529.096a	3399.679a	26.308a	566.729a	5.99d
c) Variety						
BARI Barley 5	41.837a	8280.089b	3113.696a	27.190a	371.356a	9.004a
BARI Barley 6	37.707b	8736.413a	2868.442b	24.532b	354.649b	8.655b
CV (%)	4.30	12.38	9.05	5.69	10.99	7.31
Level of sig.	0.01	0.05	0.01	0.01	0.05	0.01

1000-grain weight and straw yield, grain yield and HI were highest in the plants sowing in 16 November (S_2) which was at par with S_1 (Table 5 and 5a). The lower values for the 1000-grain weight, straw yield, grain yield and HI were recorded in December 16 sowing (S_4). 1000-grain weight, straw yield, grain yield and HI were highest in the three irrigations (Table 5) each by 30mm, i.e., one at the tillering stage, one at the booting stage and one at the grain filling stage)- I_3 which was statistically identical to two irrigations each by 30mm, i.e., one at the tillering stage and another at the booting stage) - I_2 and the lowest 1000-grain weight, straw yield, grain yield and HI were found in no irrigation (I_0). Between the two varieties, BARI Barley 5 gave maximum values for the 1000-grain weight, straw yield, grain yield and HI than BARI Barley 6. The interaction effect between sowing time and irrigation level was also found to be significant. Among the different treatment combinations, November 16 sowing (S_2) with three irrigations (I_3) produced the highest 1000-grain weight, straw yield, grain yield and HI tallest plants followed by $S_1 \times I_3$, $S_3 \times I_3$ and $S_4 \times I_3$. The lowest values were recorded in the combination of December 1 and December 16 sowing with no irrigation ($S_4 \times I_0$, $S_3 \times I_0$) (Table 6 and 6a).

Consumptive use of water (CUW): The amount of total water consumption decreased with late sowing. The highest CUW was recorded in S_1 which was at par with S_2. Significantly lowest water consumption was recorded in S_4 (Table 5a). The irrigation schedules exhibited significant influence on CUW of barley. The total amount of water consumption increased with increasing irrigation frequencies. The highest CUW was recorded in I_3 followed by I_2 and I_1. The lowest CUW was recorded in rainfed barley crops (I_0) (Table 5a). BARI Barley 5 consumed more water (CUW) than BARI Barley 6. In case of interaction effects, the highest CUW was recorded in the crops sown in November 16 (S_2) with three irrigations (I_3) which was at par with $S_1 \times I_3$ and the lowest CUW was recorded in $S_3 \times I_0$ which was statistically similar with $S_4 \times I_0$, $S_2 \times I_0$ and $S_1 \times I_0$ (Table 6a).

Water use efficiency (WUE): The S_2 and S_3 plants had the highest WUE and the lowest WUE was recorded in S_4 plants which was at par with S_1 (Table 5a). Irrigation levels also had significant effect on WUE of barley in both the years. WUE values decreased with the increasing irrigation frequencies. The highest WUE was recorded in the non-irrigated plats

Table 6. Interaction effect of sowing time and irrigation on yield components, grain yield, CUW and WUE of barley

Interaction	Plant height (cm)	No. of fertile tillers/ plant	No. of infertile tillers/ plant	No. of fertile spikelets/ spike	No. of infertile spikelets/ spike	Spike length (cm)	Extrusion length (cm)
$S_1 I_0$	85.97de	3.335f	1.48a	36.323gh	4.045cd	16.525cd	2.245g
$S_1 I_1$	90.285b-e	4.22d	1.335bc	40.198c-f	3.57ef	18.565ab	2.655de
$S_1 I_2$	94.591abc	5.26b	1.265bc	43.397a-d	3.445fg	18.785ab	3.04b
$S_1 I_3$	98.815ab	5.785a	1.045d	46.013ab	3.05h	19.285a	3.46a
$S_2 I_0$	84.27ef	4.035d	1.035d	38.492efg	3.527fg	16.65cd	1.95ij
$S_2 I_1$	93.105a-d	4.835c	0.94e	42.818bcd	3.135h	17.81abc	2.31fg
$S_2 I_2$	98.48ab	5.82a	0.913e	45.957ab	3.03h	18.81ab	2.645de
$S_2 I_3$	99.995a	5.815a	0.768f	46.993a	2.685i	19.18a	3.01bc
$S_3 I_0$	76.095g	3.44ef	1.24c	35.988gh	4.53b	16.5cd	1.84jk
$S_3 I_1$	88.977cde	4.165d	1.125d	40.115c-f	3.995cd	17.625bc	2.175gh
$S_3 I_2$	95.61abc	4.69c	1.078d	42.157cde	3.86de	17.94abc	2.488ef
$S_3 I_3$	98.197ab	4.905bc	0.89e	43.903abc	3.248gh	18.565ab	2.84cd
$S_4 I_0$	77.935fg	2.515g	1.45a	34.663h	4.85a	15.93d	1.73k
$S_4 I_1$	85.64def	3.43ef	1.34b	37.558fgh	4.285bc	17.445bc	2.045hi
$S_4 I_2$	95.272abc	3.52ef	1.25bc	40.003def	4.135cd	17.88abc	2.34fg
$S_4 I_3$	95.465abc	3.83de	1.03d	40.478c-f	3.66ef	18.15ab	2.66de
CV (%)	6.99	7.59	7.03	6.97	6.72	6.22	6.44
Level of sig.	0.01	0.01	0.01	0.05	0.02	0.01	0.01

Table 6a. Interaction effect of sowing time and irrigation on yield components, grain yield, CUW and WUE of barley

Interaction	1000 seed wt (g)	Straw yield (kg/ha)	Grain yield (kg/ha)	HI (%)	CUW (mm)	WUE (kg/ha/mm)
$S_1 I_0$	34.708gh	6655.837de	1917.684ef	22.473gh	166.285h	11.587b
$S_1 I_1$	36.448efg	8115.352bc	2636.395cd	24.633ef	288.1fg	9.16c
$S_1 I_2$	37.557c-f	9585.703a	3231.231b	25.255cde	450.95d	7.162ef
$S_1 I_3$	39.167bcd	9769.466a	3382.018b	25.77b-e	584.045ab	5.798gh
$S_2 I_0$	37.43def	6644.604de	2130.606e	24.425ef	157.565h	13.539a

$S_2 I_1$	39.6bc	8080.956bc	2921.347c	26.774abc	262.205g	11.157b
$S_2 I_2$	40.61ab	9567.566a	3513.215ab	27.451ab	451.57d	7.766de
$S_2 I_3$	41.7a	9783.177a	3764.328a	28.007a	602.505a	6.242fgh
$S_3 I_0$	36.183efg	6642.253de	2003.763ef	23.202fgh	146.69h	13.779a
$S_3 I_1$	38.193cde	8035.294bc	2746.22cd	25.434cde	306.355f	8.97cd
$S_3 I_2$	39.198bcd	9350.967ab	3374.895b	26.098b-e	426.255de	7.929de
$S_3 I_3$	40.475ab	9718.249a	3532.805ab	26.606a-d	557.29b	6.334fgh
$S_4 I_0$	33.04h	6363.596e	1789.258f	22.055h	156.585h	11.542b
$S_4 I_1$	35.552fg	7726.504cd	2454.145d	24.195efg	319.115f	7.873de
$S_4 I_2$	37.367def	8635.873abc	2778.277c	24.399ef	409.445e	6.843efg
$S_4 I_3$	38.82bcd	8845.495abc	2919.566c	24.851def	523.075c	5.587h
CV (%)	4.30	12.38	9.05	5.69	10.99	7.31
Level of sig.	0.01	0.05	0.01	0.01	0.05	0.01

(I_0) followed by I_1 and I_2.and the lowest WUE was exhibited in three irrigations (I_3). Higher WUE was recorded in BARI Barley 5 than BARI Barley 6. In case of interaction effects, the highest WUE was observed in the crops sown in November 16 (S_2) with no irrigation (I_0) which was followed by $S_1 \times I_0$ and $S_4 \times I_0$and the lowest WUE was recorded in the crops sown in December 16 (S_4) with three irrigation levels (I_3) (Table 6a).

CONCLUSION

The overall results of the present investigation indicated that barley sown in November 16 can perform better for yield and yield contributing characteristics as well as growth parameters. Other sowings like, November 1 and December 16 may be harmed by weather and climatic hazards. Application of two irrigations at 45 and 65 days after sowing (DAS) or three irrigations at 25, 45 and 65 DAS increased crop growth, water consumption, yield contributing characters, grain and straw yield of barley. Higher number of fertile tillers/plant, fertile spikelets/spike and straw yield were in BARI Barley 6. Whether higher spike length, 1000-grain weight, grain yield, HI, CUW and WUE were observed in BARI Barley 5. Therefore, to get higher yield, both the varieties (BARI Barley 5 and BARI Barley 6) may be recommended for sowing at the mid-November with two and (if possible) three irrigations in the northern region of Bangladesh.

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