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INFLUENCE OF SOWING DATE AND IRRIGATION FREQUENCY ON YIELD AND YIELD ATTRIBUTES OF BARLEY (*Hordeum vulgare* L.)

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ABSTRACT

The experiment was conducted at Crop Physiology and Ecology research field and laboratory, Hajee Mohammad Danesh Science and Technology University, Diajpur, during the period of November, 2005 to March, 2006 to study the yield attributes and yield of barley (*Hordeum vulgare* L.) in relation to different sowing dates and irrigation levels. BARI barley 5 was sown with four sowing dates viz., November 1 (S1), November 15 (S2), November 30 (S3) and December 15 (S4), and four irrigations viz., Control (IR0), one irrigation at the tillering stage (IR1), two irrigations one at the tillering stage and one at the booting stage (IR2), and three irrigations, one at the tillering stage, one at the booting stage and one at the grain filling stage (IR3). Most of the yield components i.e., plant height, fertile tiller, spike length, fertile spikelets, 1000-grain weight, grain yield (3.61 t/ha) and HI were found the highest in the plants sown in November 1 with three irrigations and the lowest plant height, fertile tiller, spike length, fertile spikelets, 1000-grain weight, grain yield (1.66 t/ha) and HI were obtained in the crop sown in December 15 with no irrigation (control) while infertile tillers and infertile spikelets showed a reverse result with delay in sowing and control irrigation. It has found that November 1 sowing with three irrigations showed the best performance in respect of growth, yield attributes and yield (3.61 t/ha) of barley.

Key words: *Barley, sowing date, irrigation frequency, yield*

INTRODUCTION

Barley (*Hordium vulgare* L.) belongs to the family gramineae and globally ranked fourth important cereal crop after rice, wheat and maize. Barley is essentially a temperate crop and is grown mainly in the former Soviet Union, Germany, China and United States. In Bangladesh, both in terms of production and acreage, the cultivation of barley is very poor. Presently the crop covers an area of about 6000 acres and produces about 2000 metric tons in this country (BBS, 2007) with a very low average yield of 1.5 tha^{-1} as compared to other barley growing countries having a yield gap of 2.51 tha^{-1} (BBS, 2007). In Bangladesh, the yearly acreage and production of barley have been gradually decreased.

Barley, though a minor cereal of Bangladesh, can play an important role in enhancing the food security of the country as well as in reducing the drainage of foreign currency. Barley is an important crop for direct human consumption and for animal feed. It has several industrial uses also. The most important uses of barley are as grain feed to livestock and poultry and as malt for manufacture of beverages. As a food, barley flour is used in preparing ‘chapaties’. Diluted soup made from barley is used to feed the infants as horlicks, ovaltin, Robinson’s barley, multova etc. These are the baby foods, for which in Bangladesh, several industries and pharmaceutical companies have to import a large amount of barley and malt extract for manufacturing patented baby food and medicine. 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 referred diet after convalescence. Recently, another developing sector like Poultry industry in Bangladesh needs more barley grains to prepare poultry feed. For those

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reasons huge amount of barley grains are imported every year in Bangladesh from different countries.

In Bangladesh barley has been grown as a winter crop. Winter of Bangladesh is short and mild compared to the climate of temperate countries. Therefore, sowing of barley at proper time is very important as yield and yield attributes are decreased with delay in planting (Ahmed *et al*., 2006). Early planted barley produces more tillers and ears/m², heavier grains and higher grain yields than late planted ones. Late sowing might expose the barley crop to higher temperature after reproductive stage resulting reduced number of ears/m² and grains/ear as well as yield (Chowdhury and Wardlaw, 1978). Better grain yield could be obtained when cool temperature prevails during anthesis period.

Efficient water management is one of the most effective means of increasing crop production. Plant development and spikelet formation are readily inhibited by water stress in barley (Oosterhuis and Cartwright, 1983). The crop sown on stored or residual soil moisture generally suffers from moisture stress at different stages of development causing the reduction in growth and grain yield. Indirect problems arising from water deficiency are greater susceptibility to pests and diseases, poor fertilizer use efficiency and possible nutrient imbalance due to impaired water uptake (Lal, 1984). Water deficit at various stages of crop growth has direct effect on crop yield. Severe water deficit at any stage can affect the crop establishment and ultimately the grain yield (Pessarakli *et al*., 2005). Plant heights, number of ears per plant, number of grains per ear, 1000-grain weight are adversely affected by water stress (Abdorrahmani *et al*., 2005). So, the time of sowing and water management in barley bear good importance. Despite the potentiality of increase productivity and high nutritive value of barley, little attention has yet been given to this crop to develop a package of improved management practices required to achieve higher yield of this minor but potential cereal crop in Bangladesh. Therefore, the present investigation was performed to find out the effect of different sowing dates and irrigation levels on yield and yield attributes of barley.

MATERIALS AND METHODS

The experiment was conducted at the Crop Physiology and Ecology research field and laboratory, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period of November 2005 to March 2006 at $25^0 38'$ N latitude and $88^0 41'$ longitude and at the elevation of 34.5m above the sea level (FAO, 1988). The experiment was two factorial randomized complete block design (RCBD) with three replications. The two factors were adopted as: (A) four seeding dates viz., S1: November 1, S2: November 15, S3: November 30 and S4: December 15, and (B) four irrigation levels viz., IRO: no irrigation, IR1: one irrigation at the tillering stage and IR2: two irrigations one at the tillering stage and one at the booting stage and IR3: three irrigations, one at the tillering stage, one at the booting stage and one at the grain filling stage. There were a total of 48 plots having the size of 2.5 m x 2.5m each. The distance between block to block was 1 meter and plot to plot was 0.75 m. The land was uniformly fertilized with 100-86-30-22-3 kg for the supplement of N-P-K-S-Zn ha^{-1} in the form of urea, TSP, MP, Gypsum and Zinc sulfate respectively. In addition, cowdung at the rate of 10 ton ha^{-1} was applied in each experimental unit (BARC, 1997). The seeds of barley were hand sown in rows at about 3 cm depth from the soil surface with the seed rate of 120 kg ha^{-1}. The variety BARI barley 5 was used as planting material in the present study. Irrigation water was applied as per experimental treatment stated earlier. A measured amount of water was applied with a bucket. An equal amount of 6 cm water was applied in each irrigation.

At maturity, ten plants were selected randomly and data were recorded for plant height, fertile tillers per plant, infertile tillers per plant, spike length, number of spikelets per spike, fertile spikelets per spike, infertile spikelets per spike, thousand-grain weight and harvest index. Grain yield was recorded on whole plot harvest basis and calculated as ton per hectare. The collected data were analyzed statistically using the analysis of variance (ANOVA) technique with the help of computer by MSTAT-C program. The treatment means were compared by Duncan's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

A large number of morphological and physiological characters influences yield and yield componets in crop plants. Reduction in yield and yield components of barley due to late sowing and water shortage as well as increase in yield due to optimum time of sowing and irriation were stated by many workers. Crop yield is a complex character depending upon a large number of environmental, morphological and physiological characters. In the present study, yield and yield components were significantly affected by sowing dates and irrigation frequency.

Plant height is an important morphological character directly linked with the productive potential of plant in terms of grain yield. In the present investigation, significant reduction in plant height was noticed due to delay in sowing with no irrigation (Table 1). Among the different treatment combinations, November 1 sowing with three irrigations produced the tallest plant (113.88 cm) which was statistically similar to November 15 seeding with three irrigations (110.91 cm) followed by S2 with IR2 and S3 with IR3. The combination effect of December 15 sowing with no irrigation produced the smallest plant (88.82 cm) which was at par with November 30 sowing with three irrigations (92.00 cm). Similar results were reported by Alam *et al*. (2007) in barley, and Pandit *et al*. (2001) and Sarker and Paul (1997) in wheat.

Number of fertile tillers plant^{-1} is also the most important character which ensures higher yield. Earley sowing with three irrigations increases the number of fertile tillers plant^{-1} as found in the present investigation (Table 1). Among the different treatment combinations November 1 sowing with three irrigations produced the highest number of fertile tillers plant^{-1} (6.00) which was statistically similar to November 15 sowing with three irrigations (5.50) followed by early sowing with two irrigations (5.36). December 15 sowing with no irrigation produced the lowest number of fertile tillers plant^{-1} (2.61) which was at par with November 15 sowing with no irrigation followed by S4 x IR1. These results are in the agreements with Alam *et al*. (2007), Afzal *et al*. (2006) and Bahadur (2008) in barley.

Time of sowing and irrigation levels significantly influenced the number of infertile tillers plant^{-1} in barley (Table 1). The lowest (0.77) number of infertile tillers plant^{-1} was recoded in November 1 sowing with three irrigations and the highest (1.55) number of infertile tillers plant^{-1} was obtained at December 15 sowing with no irrigation. Similar result was observed by Bahadur (2008) in barley.

Spike length was significantly influenced by the interaction effect of sowing time and irrigation frequency (Table 1). Among the different treatments, November 1 sowing with three irrigations produced the longest spike (18.55 cm) which was at par with early sowing with two irrigations (18.16 cm) and mid November sowing with three irrigations (18.12 cm). December 15 sowing with no irrigation produced the shortest spike (15.70 cm) followed by November 30 seeding with no irrigation. The present result was similar to the results of Alam *et al*. (2007) in barley and Rahman and Paul (1998) in wheat.

The number of fertile spikelets spike^{-1} varied significantly due to variation in sowing date and irrigation frequency. Earley sowing with maximum irrigations incresed the number of fertile spikelets spike^{-1} in the present investigation (Table 1). The highest number of spikelets spike^{-1} (49.29) was produced in November 1 sowing with three irrigations. Statistically similar result was recorded in November 15 seeding with three irrigations (47.06). While December 15 sowing with no irrigation produced the lowest number of fertile spikelets spike^{-1} (32.82). Similar result was found in barley by Ahmed *et al*. (2006) and Bahadur (2008).

Table 1. Yield and yield attributes of barley as influenced by sowing date and irrigation frequency

Treatments		Plant height (cm)	Fertile tillers/ plant (No.)	Infertile tillers/ plant (No.)	Spike length (cm)	Fertile spikelets /spike (No.)	Infertile spikelets /spike (No.)	1000-grain weight (g)	Yield (t/ha)	Harvest index (%)
S1	IR0	93.77 h	3.87 d-f	1.01 g	16.94 d-f	38.60 gh	3.22 f-i	39.83 d-g	2.00 jk	21.85 fg
	IR1	105.51 ef	4.68 c	0.91 hi	17.64 bc	43.68 cd	3.07 g-j	43.00 a-c	2.74 f-h	23.68 d-e
	IR2	109.69 b-d	5.36 ab	0.85 ij	18.16 ab	45.65 bc	2.74 jk	43.46 ab	3.23 b-d	26.83 b
	IR3	113.88 a	6.00 a	0.77 j	18.55 a	49.29 a	2.48 k	43.76 a	3.61 a	30.14 a
S2	IR0	93.43 h	3.18 gh	1.21 cd	16.50 e-g	35.82 ij	3.88 b-d	38.71 e-g	1.89 kl	22.35 e-g
	IR1	106.20 c-f	4.00 de	1.11 ef	16.92 d-f	40.36 fg	3.41 e-h	40.64 c-e	2.58 gh	24.78 cd
	IR2	110.15 a-c	4.82 bc	0.99 gh	16.27 cd	43.50 cd	3.12 f-j	43.43 ab	3.15 c-e	27.44 b
	IR3	110.91 ab	5.50 a	0.87 e	18.12 ab	47.06 ab	2.79 i-k	43.54 ab	3.48 b	27.66 ab
S3	IR0	92.00 hi	3.13 e-g	1.15 b	15.95 hi	35.14 j	4.30 ab	37.81 gh	1.85 kl	21.49 g
	IR1	102.93 fg	3.70 d-f	1.24 c	16.35 f-h	39.05 gh	3.80 c-e	38.72 e-g	2.47 hi	23.66 d-f
	IR2	107.06 b-d	4.25 cd	1.14 de	16.68 d-g	40.85 e-g	3.53 d-g	40.26 d-g	2.92 d-f	27.09 b
	IR3	110.10 a-e	4.71 c	1.03 fg	16.90 d-f	42.96 de	2.86 i-k	41.39 a-d	3.27 b-e	27.99 ab
S4	IR0	88.82 i	2.61 h	1.55 a	15.70 i	32.82 k	4.62 a	35.35 h	1.66 l	22.52 e-g
	IR1	100.14 g	3.22 f-h	1.26 c	16.26 g-i	37.65 hi	4.11 bc	38.28 fg	2.24 ij	23.89 c-e
	IR2	105.76 d-f	3.53 e-g	1.19 c-e	16.59 e-g	39.36 f-h	3.54 d-f	40.18 d-g	2.55 g-i	25.60 bc
	IR3	108.18 b-e	3.98 de	1.03 fg	17.10 c-e	41.58 d-f	4.05 h-j	40.97 c-d	2.87 e-g	27.02 b
CV (%)		6.04	8.81	5.31	5.26	8.37	8.82	7.69	7.20	8.50

The figures within a column having same letter(s) do not differ significantly at $P \leq 0.05$ by DMRT (In the treatment column, S1=November 1, S2= November 15, S3=November 30, S4=December 15, IRO= no irrigation, IR1= one irrigation, IR2= two irrigations, IR3= three irrigations).

Sowing time and irrigation showed a significant variation in the number of infertile spikelets spike^{-1} (Table 1). The highest number of infertile spikelets spike^{-1} was produced in December 15 sowing with no irrigation (4.62) and the lowest number of spikelets/spike (2.84) was produced in November1 sowing with no irrigation.

Thousand-grain weight is an important yield component as stated by many workers. In the present investigation, significant combined effect was also found between irrigations and sowing dates in terms of 1000-grain weight (Table 1). The highest 1000-grain weight was observed in crop sown in November 1 with three irrigations (43.76 g) followed by S1 x IR2, S2 x IR3 and S2 x IR2 and the lowest one was in December 15 sowing with no irrigation (35.35 g). Similar results were reported in barley by many workers, such as Ram *et al*. (2004), and in wheat by Borowezak *et al*. (2003) and Afzal *et al*. (2006). Heaviest 1000-grain weight in early sowing with three irrigations was due to tallest plant, maximum fertile tillers per plant, minimum infertile tillers per plant, maximum spike length, highest fertile spikelets per spike and lowest infertile spikelets per spike.
Sowing time and irrigation interacted significantly in grain yield (Table 1). Grain yield also depends on other yield components. The result indicated that the highest grain yield (3.61 t/ha) was found in November 1 sowing with three irrigations applied at tillering, booting and grain filling stages. The lowest grain yield (1.66 t/ha) was noticed in December 15 sowing with no irrigation. In the present investigation, yield and yield components were more or less reduced by late sowing as compared to 1 November and 15 November. Usanova (1985) reported that a delay of 10 days in sowing decreased the yield by 0.5-0.51 t/ha. The main reasons for the yield reduction was low utilization of photosynthetically active radiation during the first 1.5 months after sowing, the decrease in photosynthetic activity of plants during grain filling and maturation, and the acceleration of plant development by 3-6 days which in turn decreased the 1000-grain weight.

The present investigation also supported the result of Nass *et al*. (1975). They reported that yield reduction in late sowing was due to shorter growing period at the vegetative phase and steep rise in temperature at the grain filling stage. High temperatures are known to hasten spike development from floral initiation to anthesis, and also have been found to reduce the number of spikelets per spike (Dawson and Wardlaw, 1989). Frank *et al*. (1992) reported that fertile spikelet number decreased significantly in barley cv. Azure as temperature increased from 16°C to 18°C. High temperature also hastened phenological development (Boonchoo *et al*., 1998). They also found that early sowing induced faster production of tillers and consequently gave higher maximum tillers and tended to accumulate dry matter at a faster rate and provided the highest grain yield led by optimum temperature during the growth period. High temperature at the later stages of growth also reduced grain yield in 30 November (S3) and 1 December (S4) in the present study. High temperature at the later stages of growth (particularly in grain filling period) reduced kernel weight, which resulted lower grain yield. Yield reduction in barley due to water shortage was attributed to reduce productive tillers plant^{-1}, spike length, fertile spikelets spike^{-1} and reduced 1000-grain weight. Moreover, the reduction in yield could be attributed to reduced photosynthetic activity by partial closure of stomata and decrease in supply of CO_2 under water stress condition (Kramer, 1972). On the other hand, seed yield increased with irrigation probably due to positive effect of irrigation for higher number of spikelets spike^{-1}, grains/spike and 1000-grain weight as observed in the present study and also because of optimum moisture helped in proper utilization of nutrients. Similar results were reported by Afzal *et al*. (2006), Borowezak *et al*. (2003), Ahmed *et al*. (2006), and Alam et al. (2007).

Harvest index is the proportion of commercial yield and biological yield. As grain yield was higher in S1 with three irrigation, harvest index was also found to be higher in S1 with three irrigaitons followed by S2 x IR3, S3 x IR3 with same statistical rank in the present investigation (Table 1). Similar results were reported by Afzal *et al*. (2006) and Alam *et al*. (2005).

CONCLUSION

The overall results indicated that the early sowing (November 1) performed better in relation to growth, yield attributes and yield of barley. Three irrigations at early tillering, booting and grain filling stages seemed to be suitable for the same. In conclusion, the early sowing (November 1) with three irrigations (IR3) performed the best for improving the yield of barley. However, further investigations are essential to reach at firm conclusion.

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