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LATE SOWING AND IRRIGATION CUTBACK EFFECTS ON YIELD AND ECONOMIC PERFORMANCES OF DRY DIRECT SEEDED *BORO* RICE

M.M. Rahman*, A. Hadi and M.A. Salam

Department of Agronomy, Bangladesh Agricultural University, Mymensingh

ABSTRACT

Dry direct seeding (DDS) is a water saving rice cultivation technology. The sowing of dry direct seeded rice in *boro* season is generally delayed when grown under the T. *aman* rice – *Rabi* crops – DDS *boro* rice pattern. An experiment was conducted at the Agronomy Field of Bangladesh Agricultural University, Mymensingh to study the effect of sowing date and irrigation schedule on growth and yield of DDS *boro* rice. The experiment used two sets of treatments (a) two sowing dates viz. 22 February and 13 March; and (b) six irrigation regimes viz. no irrigation, one irrigation at 25% Field Capacity (FC), two irrigations at 25% FC and 1 week after (WA) 25% FC, three irrigations at 25% FC, 1WA 25% FC and 2 WA 25% FC, four irrigations at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3 WA 25% FC and one irrigation at 3 weeks after 25% FC and the treatments were arranged in a split-plot design with three replications allocating sowing dates into the main plot and irrigation schedule into the subplots. BRRI dhan58 was used as test crop. The result showed that grain yield of the crop did not differ significantly for sowing on 13 March and 22 February. The study revealed that BRRI dhan58 sown on 13 March with four irrigations applied at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3 WA 25% FC produced the highest economic return and hence it is concluded that the sowing date of *boro rice* could be delayed up to 13 March with four irrigations.

Keywords: Irrigation regime, field capacity, water saving, *boro* rice, grain yield, economic return

INTRODUCTION

In Bangladesh, transplanting seedlings onto puddle land is the most common way of establishing rice. Puddle transplanted rice (PTR) technique demands more labor and irrigation water. Under this conventional method, rice production in the *boro* (winter)

* Corresponding author: rahmanag63@bau.edu.bd

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season is threatened by shortage of labor, rising wage rates and water scarcity. As rainfall is so limited throughout the *boro* season, irrigation is the must for rice farming (Acharjee et al., 2017). Additionally, the need for power and diesel is being increased by irrigation for *boro* rice (Sattar et al., 2009). The main obstacles to the viability of traditional puddle transplanted *boro* rice farming are thus the lack of water and labor. The profit margins of PTR in *boro* season have been slashed because of high water inputs and labor costs (Pandy and Velasco, 1999). *Boro* rice under puddled transplanted irrigated system uses 3000-5000 liters of water for every kilogram of rice produced. Dry direct seeded rice (DDSR) technology has just recently emerged as a competitive substitute for the puddle transplanting approach (Rahman, 2019). Rice grown in the DDS technique produces higher or similar yields than rice grown in the PTR system while consuming 50- 60% less irrigation water (Rahman and Masood, 2014). No standing water is kept in a dry direct seeded system from sowing to panicle initiation but standing water (3-5cm) is maintained from panicle initiation (PI) to blooming or milking stage. Thus, water conservation in the DDS system is primarily achieved by avoiding puddling and preserving aerobic soil conditions from sowing to PI stage. In this arrangement, water loss due to seepage, percolation and evaporation is minimal. As a result, dry direct seeding requires less water and uses water more efficiently than transplanted rice (Liu et al., 2015). In addition to being an excellent water-saving technology, the DDS for *boro* season also lowers production costs, saves money on power and diesel, and reduces soil and environmental pollution. This approach eliminates the need for seedbed preparation, seedling care in the seedbed, seedling pulling, transportation, and transplanting procedures. Additionally, direct seeded rice may reach maturity 7 to 10 days earlier than transplanted rice (Rahman et al., 2009). By requiring less irrigation, the dry direct sowing method would minimize greenhouse gas emissions and arsenic poisoning of the soil and rice. According to reports, crops that have been poisoned with irrigated water absorb significant concentrations of arsenic through their roots, straw, and grain, which then enters the food chain. A million kilograms of arsenic are thought to be added to Bangladesh's fertile soil each year via shallow aquifer irrigation, primarily in paddy fields (FAO, 2017).

Among the numerous cropping patterns in Bangladesh, T. *aman* rice - Fallow – *Boro* rice is the most dominant one. In this pattern, land remains fallow in between *aman* rice and *boro* rice. Farmers can easily cultivate *rabi* crops during this period and thereby cropping intensity can be increased. Therefore, T. *aman* - *Rabi* crops - *Boro* rice pattern can be easily adopted for increased cropping intensity, diversity and farm income. Cultivation of *boro* rice after a rabi crop could lead to late planting of *boro* rice especially when *rabi* crops are expected to have a long duration. In general, *boro* rice is transplanted during mid-December to mid-January and directly sown during mid-January to mid-February (Uddin, 2019). Under the context of water scarcity, PTR system of *boro* cultivation can be easily replaced by DDS system as it has many other advantages. DDS system generally requires 4-6 irrigations during the vegetative phase of rice. However, it is imperative to know the response of DDS rice to irrigation regime during vegetative phase to optimize irrigation requirement. To maximize output while utilizing the least amount of water, the current study was conducted with the goal of examining the impact of late sowing and irrigation regime on growth and yield of dry direct seeded *boro* rice.

MATERIALS AND METHODS

Description of the study site

The experiment was conducted at the Agronomy Field of Bangladesh Agricultural University, Mymensingh during February-July 2021 to study the effect of sowing date and irrigation regimes on yield performance of late sown dry direct seeded *boro* rice variety BRRI dhan58. The experimental field was located at an elevation of 18m above the sea level. The experimental field belongs to non-calcareous dark grey floodplain soil under the Sonatala series of the Old Brahmaputra Floodplain Agro-ecological Zone (AEZ-9). The experimental field was a medium high land with moderate drainage condition. The soil was silty loam in texture having pH 6.50, 1.29% organic matter, 1.0% total N, 16.72 ppm available P, 0.12 ppm exchangeable K and 14.2 ppm available Sulphur. The bulk density, particle density and porosity of the soil were 2.60 g/cc, 1.35 g/cc and 46.67%, respectively. The climate of the locality is sub-tropical in nature and is characterized by high temperature and heavy rainfall during *Kharif* season (April-September) and scanty rainfall associated with moderately low temperature during *rabi* season (October-March). The daily average air temperature, total rainfall, sunshine hours and evaporation during the experimental period have been presented in Fig. 1.

Experimental treatment, design and layout

Two sets of treatments included in this experiment are (a) date of sowing viz. 22 February (D_1) and 13 March 2021 (D_2) and (b) six irrigation regimes viz. no irrigation (I_0), one irrigation at 25% field capacity (25%FC; I_1), two irrigations at 25% FC and at 1 week after 25% FC (I_2), three irrigations at 25% FC, at 1 and at 2 weeks after 25% FC (I_3), four irrigations at 25% FC, 1, 2 and 3 weeks after 25% FC (I_4), and one irrigation at 3 weeks after 25% FC (I_5). The experiment was laid out in a spilt-plot design with three replications. Sowing dates were allocated into the main plot and irrigation regime into the sub plots. Thus, there were 36 plots in the experiment and the unit plot size was 10 m^2 (4 m ×2.5 m).

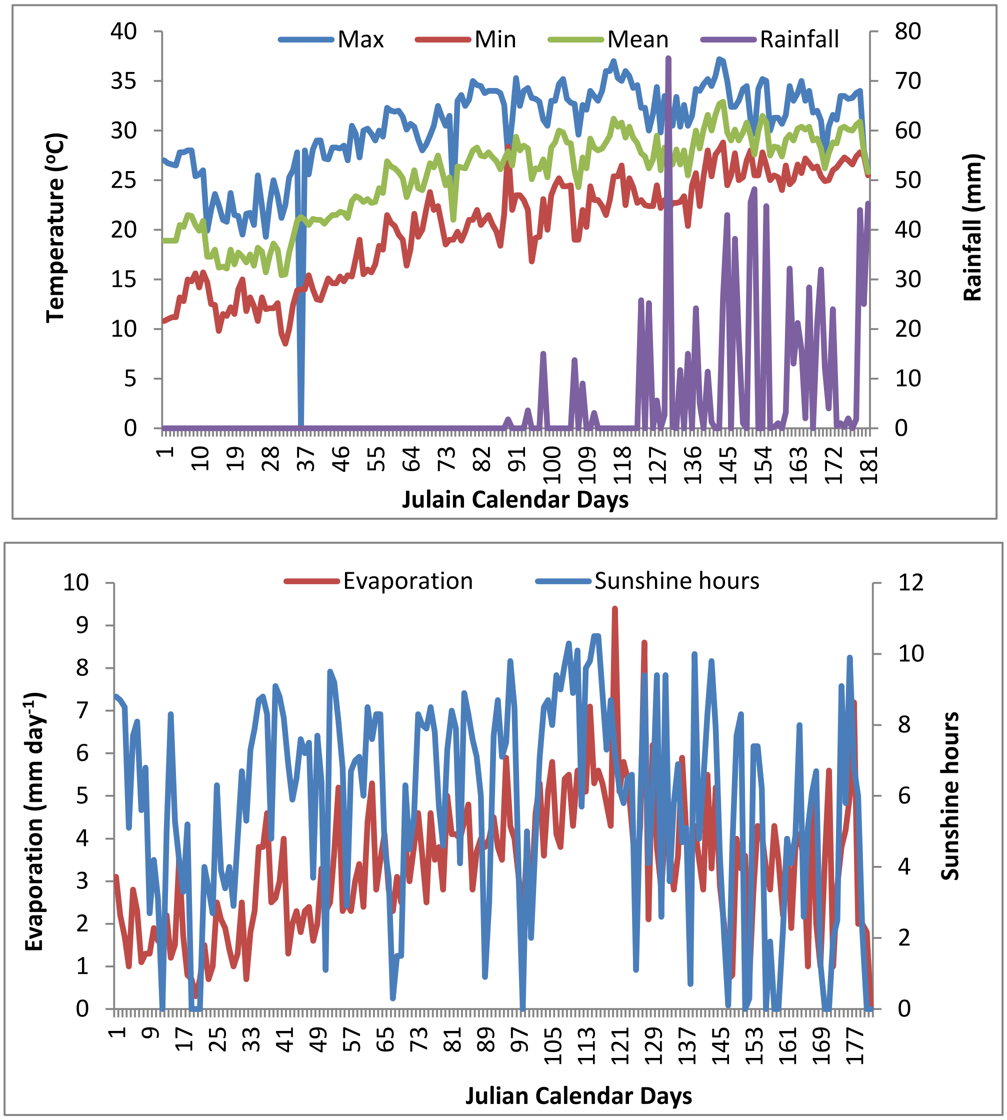

Figure 1. Daily average (a) temperature and rainfall and (b) sunshine hours and evaporation of the experimental site during 01 January to 30 June 2021

Crop husbandry

Seeds of rice variety BRRI dhan58 were hydro-primed by soaking in water for 24 hours at room temperature and then incubated for 30 hours at 35 ^{0}C. Then the primed seeds were directly sown onto the dry cultivated land in two different sowing dates as per experimental specification at 15cm × 25cm in 3-5cm depth allocating 4 seeds hill$^-$

^{1}. The field was fertilized at the rate of 325, 100, 130, 115 and 4 kg ha^{-1}of urea, triple super phosphate, muriate of potash, gypsum and Zinc sulphate (monohydrate) respectively as per recommendation of FRG (2012). The whole amount of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied as basal dose at the time of final land preparation. Urea was top dressed in three equal splits at 15, 30 and 45 days after sowing (DAS). A pre-emergence herbicide Panida 33 EC (Pendimethalin) was applied at 3 DAS @ 50 ml 10 L^{-1} and weeding was done thrice at 30, 45 and 60 DAS. Insecticide carbofuran @ 33 kg ha^{-1} was applied twice to control the rice stem borer. Polythene lining was done around the bunds in each plot to protect water inflow and outflow.

Sampling, harvesting and processing

The crop was harvested at maturity when 90% of the grains became golden yellow in color. Five hills (excluding border hills) were randomly selected from each unit plot and uprooted before harvesting for data recording on yield parameters. For recording data on grain and straw yield the crop was harvested from central 3.0 m^{-2} area (2.0 m × 1.5 m). The harvested crops of individual plot were bundled, properly tagged and then brought to threshing floor. The grains and straws were dried in the sun and finally the grain yield was adjusted at 14% moisture basis and converted to t ha^{-1}.

Data recording

Field capacity and soil moisture content: The field capacity is the amount of water retained in the soil after all the excess water at saturation has been drained out (Rai et al., 2017). It was measured by taking soil samples from the field after 2 days of saturation and the soil sample was oven dried at 105 ^{o}C for 48 hours. The moisture content of soil (P_w) was calculated by oven-dry weight basis by using the following formula.

$$Pw = \frac{W1 - W2}{W2} \times 100$$

Where,

W1 = weight of wet soil sample

W2 = weight of dry soil sample

The soil moisture content at field capacity was 35.3%. The Management Allowable Depletion (MAD) of soil moisture at which irrigation to be applied was scheduled to be at 25% of field capacity and that condition of field reached at 26.1% soil moisture content. The soil moisture content of the rice field was monitored at 7 days interval by collecting soil samples from three selected spots of the field. The soil moisture content at different day after sowing was noted and presented in Fig. 2.

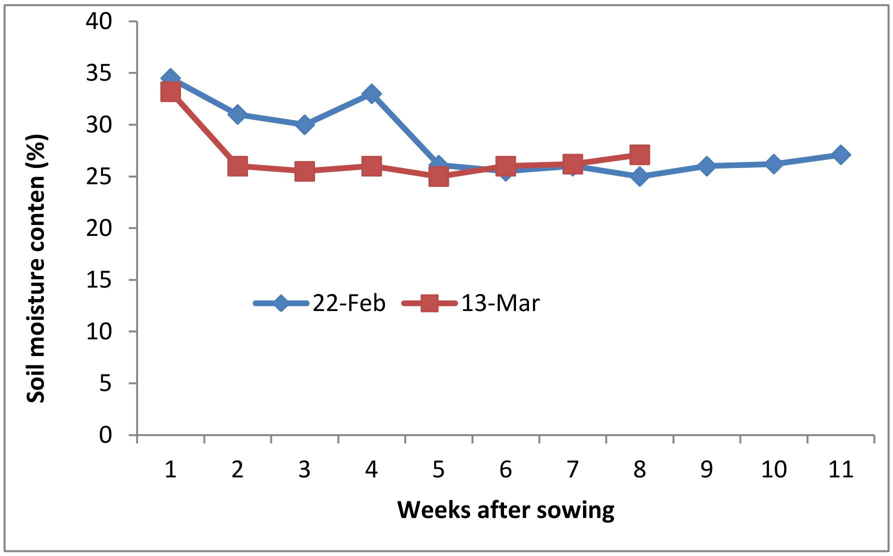

Figure 2. Soil moisture content at different weeks after sowing of dry direct seeded rice in 2021

Economic Analysis

Costs for all heads of expenditure were recorded for studying the economic performance of the DDS *boro* rice under different sowing dates and irrigation regimes. The non-material input costs, material input costs, overhead costs and fixed costs were recorded to estimate the total costs of production (TCP) per hectare. Gross return (GR), gross margin (GM) and benefit cost ratios (BCR) were also calculated. Gross margin (GM) was obtained by deducting total variable cost (TVC) from gross return (GR) (Barnard and Nix, 1999). Benefit Cost Ratio (BCR) was calculated using the following formula:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross Retun}}{\text{Total cost of production}}$$

Statistical Analysis

The collected data were compiled and tabulated in proper form and were subjected to statistical analysis. Data were analyzed using the analysis of variance (ANOVA) technique with the help of computer package program STATISTIX-10 and mean differences were adjudged by LSD Test.

RESULTS AND DISCUSSION

Effect of sowing date

Sowing date had no significant effect on plant height, number of total, effective and non-effective tillers hill^{-1}, numbers of sterile spikelets panicle^{-1}, 1000-grain weight, grain yield and straw yield but had significant effect on panicle length and number of grain panicle^{-1} (Table 1 and 2). The crop sown on 13 March produced higher number of grains panicle^{-1} (88.46) than 22 February sown crop (78.18). On the other hand, 22 February sown crop gave longer panicles (22.09 cm) than 13 March sown crop (20.78 cm). It was noted that the number of grains panicle was higher for 13 March sowing but number of effective tiller was higher in 22 February sown crop (Table 1 and 2). Thus, it may be revealed that the yield did not differ due to the differential effects of the yield contributing characters in response to sowing dates.

Table 1. Effect of sowing date on plant height, tiller production and panicle length of dry direct seeded *boro* rice var. BRRI dhan58

Sowing dates	Plant height (cm)	No. of total tillers hill-1	No. of effective tillers hill-1	No. of non-effective tillers hill-1	Panicle length (cm)
22 February	89.94	21.81	17.86	3.95	22.09 a
13 March	96.21	19.52	16.83	2.69	20.78 b
Level of significance	NS	NS	NS	NS	*
LSD0.05	8.443	2.792	1.261	1.873	0.579
CV%	6.32	9.42	5.07	39.34	1.89

In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per LSD test; NS = Not significant; * = Significant at 1% level of probability,

Table 2. Effect of sowing date on yield contributing characters and yield of dry direct seeded *boro* rice var. BRRI dhan58

Sowing dates	Filled grain panicle^{-1} (no.)	Unfilled grain panicle^{-1} (no.)	Thousand grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
22 February	78.18 b	12.89	19.24	4.75	5.91
13 March	88.46 a	13.41	19.41	5.09	5.99
Level of significance	**	NS	NS	NS	NS
LSD0.05	2.861	3.841	0.485	0.890	0.499
CV%	2.39	20.22	1.75	14.74	5.85

In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per LSD test; NS = Not significant; ** = Significant at 1% level of probability,

Effect of irrigation regime

Irrigation regime had significant effect on number of total tillers hill^{-1}, number of effective tillers hill^{-1}, number of grains panicle^{-1}, 1000-grain weight, grain yield and straw yield but not on plant height, number of non-effective tillers hill^{-1}, panicle length and sterile spikelet panicle^{-1} (Table 3 and 4). The highest number of total tiller hill^{-1} (23.32) was found with I_3 (three irrigations at 25%FC, 1 weeks after 25%FC and 2 weeks after 25%FC) while the lowest one was found with I_0 (No irrigation). The second highest number of total tiller hill^{-1} was found with I_5 (22.0) and it was statistically at par with I_2 (21.23). The number of effective tiller hill^{-1} was the highest with I_3 (18.59), that was statistically similar with I_1, I_2 and I_5 and the lowest value was found with I_0 (15.87). The highest number of grains panicle^{-1} was found with I_4 (92.62) and the lowest value was found with I_0 (72.05). The second highest value was found with I_3 which was statistically at par with I_2 (85.32) and I_1 (83.53). The highest 1000-grain weight (19.89 g) was found with I_4 (four irrigations at 25% FC, 1, 2, 3 and 4 weeks after 25%FC), which was statistically similar with I_3 (19.61 g). The lowest grain weight was found with I_0 (18.63 g). The highest grain yield (6.0 t ha^{-1}) was found with I_4 which was statically similar with I_3 (5.44 t ha^{-1}). The lowest grain yield was noted in I_0 (3.71 t ha^{-1}). The similar trend was noted for straw yield (Table 4). The highest value was noted in I_4 (6.32 t ha^{-1}) which was similar with I_3 (6.09 t ha^{-1}).

Table 3. Effect of irrigation schedule on plant height, tiller production and panicle length of dry direct seeded *boro* rice var. BRRI dhan58

Irrigation schedule	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	Panicle length (cm)
I_0	91.12	17.86 e	15.87 c	1.99	21.17
I_1	92.01	20.27 c	17.32 abc	2.95	21.58
I_2	92.78	21.23 b	17.42 abc	3.81	21.62
I_3	93.31	23.32 a	18.59 a	4.73	21.53
I_4	93.37	19.32 d	16.79 bc	2.53	21.80
I_5	92.27	22.00 b	18.17 ab	3.83	20.88
Level of significance	NS	***	*	NS	NS
LSD0.05	2.997	0.826	1.650	1.835	1.148
CV%	2.67	3.32	7.90	45.91	4.45

In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per LSD test; NS = Not significant; ** = Significant at 1% level of probability; *** = Significant at 0.1% level of probability; I_0=No irrigation; I_1 =One irrigation at 25% Field Capacity (FC); I_2= Two irrigations at 25% FC and 1 week after (WA) 25%FC; I_3 = Three irrigations at 25% FC, 1 WA 25% FC and 2 WA 25% FC; I_4=Four irrigations at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3WA25% FC; I_5=One irrigation at 3 weeks after 25% FC

The lowest straw yield was observed in I_0 (5.72 t ha^{-1}) which was at par with I_1, I_2 and I_5. The result indicated that the water stress may adversely affect yield and related attributes. The present study showed that four irrigations resulted highest grain yield of 6.0 t ha^{-1} while no irrigation gave the lowest grain yield of 3.71 t ha^{-1}. In case when only one irrigation applied at 25% FC, the yield was reduced by 1.09 t ha^{-1} but when only one irrigation was applied at 3 weeks after 25% FC reduced yield by 1.53 t ha^{-1}. The yield reduction for two and three irrigation plots were 0.94 and 0.56 t ha^{-1}, respectively. The result also revealed that the lowest grain yield was produced with no irrigation (I_0) plot, which was similar with the plots one irrigation only at the late vegetative stage (I_5). All other irrigation treatments gave significant higher yield than these I_0 and I_5 treatments.

Table 4. Effect of irrigation schedule on yield contributing characters and yield of dry direct seeded *boro* rice var. BRRI dhan58

Irrigation schedule	Filled grain $panicle^{-1}$ (no.)	Unfilled grain $panicle^{-1}$ (no.)	Thousand grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
I_0	72.05 d	8.97	18.63 d	3.71 d	5.72 b
I_1	83.53 bc	13.22	19.29 bc	4.91 bc	5.90 b
I_2	85.32 b	11.17	19.32 bc	5.02 bc	5.91 b
I_3	87.17 b	15.50	19.61 ab	5.44 ab	6.09 ab
I_4	92.62 a	14.87	19.89 a	6.00 a	6.32 a
I_5	79.23 c	15.13	19.20 c	4.47 c	5.78 b
Level of significance	***	NS	***	**	*
LSD0.05	5.438	4.899	0.358	0.582	0.372
CV%	5.42	30.94	1.54	11.48	5.28

In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per LSD test; NS = Not significant; ** = Significant at 1% level of probability; *** = Significant at 0.1% level of probability; I_0 = No irrigation; I_1 = One irrigation at 25% Field Capacity (FC); I_2 = Two irrigations at 25% FC and 1 week after (WA) 25%FC; I_3 = Three irrigations at 25% FC, 1 WA 25% FC and 2 WA 25% FC; I_4 = Four irrigations at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3WA25% FC; I_5 = One irrigation at 3 weeks after 25% FC

Thus the result clearly showed that water stress during early vegetative phase is less detrimental than that imposed at late vegetative stage. The yield reductions in case of no irrigation, one irrigation, two irrigation and three irrigation plots were mainly attributed to the reduction in number of grain panicle and grain weight. Thus, it is better to use three or four irrigations during vegetative phase and it could be started at the point when soil moisture is depleted at 25% of the field capacity.

Interaction effect of sowing date and irrigation regime

The result showed that there was no significant interaction effect of sowing date and irrigation regime on plant height, number of effective tiller hill^{-1}, number of non-effective tiller hill^{-1}, panicle length, number of grains panicle^{-1}, number of sterile spikelet panicle^{-1}, grain yield, straw yield, but had significant effect on number of total tiller hill^{-1} and 1000-grain weight (Table 5 and 6). The crop sown on 22 February with four irrigations ($D_1 \times I_4$) gave the highest number of total tiller hill^{-1} which was statistically similar with those of $D_1 \times I_1$, $D_1 \times I_2$, $D_1 \times I_3$, $D_2 \times I_3$ and $D_2 \times I_4$ (Table 5).

Table 5. Effect of interaction between sowing date and irrigation schedule on plant height, tiller production and panicle length

Interaction	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	Panicle length (cm)
$D_1 \times I_0$	90.53	17.93 de	17.57	0.36	20.63
$D_1 \times I_1$	93.10	21.83 abc	18.00	3.83	21.70
$D_1 \times I_2$	88.13	22.58 abc	18.02	4.83	20.73
$D_1 \times I_3$	89.37	23.17 ab	18.77	4.4	19.83
$D_1 \times I_4$	88.52	24.83 a	19.17	5.66	21.03
$D_1 \times I_5$	89.97	20.50 bcde	17.75	2.75	20.73
$D_2 \times I_0$	91.70	17.78 e	15.40	2.38	21.70
$D_2 \times I_1$	98.09	18.71 de	16.25	2.46	21.70
$D_2 \times I_2$	97.43	19.87 cde	16.83	3.04	22.57
$D_2 \times I_3$	95.17	20.83 abc	16.89	3.94	21.93
$D_2 \times I_4$	98.10	21.81 abc	17.33	4.48	22.03
$D_2 \times I_5$	96.77	18.13 de	16.17	1.96	22.87
Level of significance	NS	*	NS	NS	NS
LSD0.05	8.793	2.853	2.395	2.881	1.564
CV%	2.67	3.32	7.90	45.91	4.45

In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per LSD test; NS = Not significant ; * = Significant at 5% level of probability; D_1 = 10 February D_2 = 01 March;; I_0 = No irrigation; I_1 = One irrigation at 25% Field Capacity (FC); I_2 = Two irrigations at 25% FC and 1 week after (WA) 25%FC; I_3 = Three irrigations at 25% FC, 1 WA 25% FC and 2 WA 25% FC; I_4 = Four irrigations at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3WA25% FC; I_5 = One irrigation at 3 weeks after 25% FC

It was noted that the plots having no irrigation (I_0) produced the lowest grain yield which was similar to that of I_5 (one irrigation given at 3 weeks after 25% FC). In case of 1000-grain weight, the highest weight was achieved (Table 6) for D_1 × I4 (20.06 g) which was statistically similar with $D_1 \times I_3$ (19.78 g), $D_2 \times I_2$ (19.45 g), $D_2 \times I_3$ (19.44 g) and $D_2 \times I_3$ (19.73 g). The lowest 1000-grain weight was found with no irrigation plots both for both 22 February (18.21 g) and 13 March (19.05 g) sowings. The yield characters responded in a similar way due to irrigation in both the sowing dates, indicating that water availability is the key factor in harnessing higher yield of *boro* rice under dry direct seeded system. Therefore, delayed sowing would not affect grain yield of rice in DDS system if water supply is adequate.

Table 6. Effect of interaction between sowing date and irrigation schedule on yield contributing characters and yield of dry direct seeded boro rice var. BRRI dhan58

Interaction	Filled grain panicle^{-1} (no.)	Unfilled grain panicle^{-1} (no.)	Thousand grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
D1 × I0	67.17	10.67	18.21 e	3.46	5.59
D1 × I1	78.67	12.83	19.18 cd	4.71	5.87
D1 × I2	80.26	8.73	19.19 cd	5.10	5.95
D1 × I3	81.66	15.67	19.78 ab	5.32	6.13
D1 × I4	87.56	14.83	20.06 a	5.90	6.32
D1 × I5	73.83	14.60	19.04 d	4.28	5.64
D2 × I0	77.00	7.27	19.05 d	3.97	5.90
D2× I1	88.40	13.60	19.39 bcd	4.88	5.92
D2 × I2	90.37	13.60	19.45 abcd	5.16	5.86
D2 × I3	92.66	15.33	19.44 abcd	5.56	6.05
D2 × I4	97.67	14.90	19.73 abc	6.10	6.31
D2 × I5	84.63	15.77	19.36 bcd	4.67	5.93
Level of significance	NS	NS	*	NS	NS
LSD0.05	7.442	7.142	0.633	0.893	0.659
CV%	5.42	30.94	1.54	10.65	5.28

In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per (DMRT); NS = Not significant ; ** = Significant at 1% level of probability; D_1 = 10 February D_2 = 01 March;; I_0 = No irrigation; I_1 = One irrigation at 25% Field Capacity (FC); I_2 = Two irrigations at 25% FC and 1 week after (WA) 25%FC; I_3 = Three irrigations at 25% FC, 1 WA 25% FC and 2 WA 25% FC; I_4 = Four irrigations at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3WA25% FC; I_5 = One irrigation at 3 weeks after 25% FC

Economic Performance

Table 7. Economic performance of dry direct seeded boro rice var. BRRI dhan58 in response to sowing dates and irrigation schedule

Sowing date	Irrigation schedule	TVC (tk. ha^{-1})	TCP (tk. ha^{-1})	GR (tk. ha^{-1})	GM (tk. ha^{-1})	BCR
22 February	I_0	79425	108396	131750	52325	1.22
	I_1	80925	109971	170650	89725	1.55
	I_2	82425	111546	182750	100325	1.64
	I_3	83925	113121	190250	106325	1.68
	I_4	85425	114696	208600	123175	1.82
	I_5	80925	109971	156600	75675	1.42
13 March	I_0	79425	108396	148600	69175	1.37
	I_1	80925	109971	176000	95075	1.60
	I_2	82425	111546	184100	101675	1.65
	I_3	83925	113121	197050	113125	1.74
	I_4	85425	114696	214550	129125	1.87
	I_5	80925	109971	169750	88825	1.54

Here, Total cost of production (TCP) includes total variable cost (TVC) and fixed cost (FC) per hectare. Total variable cost includes: Land preparation = 8000 tk, Fertilizer application = 1600 tk, Seed sowing = (25*400=10000 tk), Cost per irrigation = 1500 tk, Weeding and herbicide = 4000 tk, Harvesting = 12000 tk, Post-harvest operation = 8000 tk, Seed cost = 3000 tk, Fertilizer cost = 17425 tk, Pesticide = 2000 tk, Gross return (GR) includes return from grain and straw (Grain @30000 tk t-1 and Straw @5000 tk t -1), Fixed cost (FC) includes: Interest on operation cost = 5% of TVC and Rental value of land = 25000 tk ha^{-1}. GM = Gross margin and BCR = Benefit cost ratio. D_1 = 10 February D_2 = 01 March; I_0 = No irrigation; I_1 = One irrigation at 25% Field Capacity (FC); I_2 = Two irrigations at 25% FC and 1 week after (WA) 25%FC; I_3 = Three irrigations at 25% FC, 1 WA 25% FC and 2 WA 25% FC; I_4=Four irrigations at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3WA25% FC; I =One irrigation at 3 weeks after 25% FC.

Economic analysis (Table 7) showed that highest cost of production (114696 tk ha^{-1}) required with four irrigations given at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3 WA 25% FC (I_4) for both 22 February (D_1) and 13 March (D_2) sowings. The highest gross return was found for sowing on 13 March (214550 tk ha^{-1}) and sowing on 22 February (208600 tk ha^{-1}) in combination with four irrigations. The crop sown on 22 February and 13 March in combination with four irrigations gave the highest gross margins-123175 tk ha^{-1} and 129125 tk ha^{-1}, respectively. The highest benefit cost ratio (BCR) with four irrigations (I_4) given at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3 WA 25% FC for 22 February and 13 March sowing were1.82 and 1.87, respectively.

CONCLUSION

The study revealed that grain yield of BRRI dhan58 under dry direct seeded system did not vary significantly for sowings on 22 February and 13 March. The crops grown with four irrigations given at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3 WA 25% FC gave the highest grain yield which was statistically similar to that for three irrigations given at 25% FC, 1 WA 25% FC and 2 WA 25% FC. The result also exposed that BRRI dhan58 cultivated by sowing on 13 March and given with four irrigations at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3 WA 25% FC resulted the highest economic return. It can thus be concluded that maximum grain yield and economic return from cultivation of BRRI dhan58 could be obtained by delaying sowing up to 13 March and applying with four irrigations at 25% FC, 1 WA 25% FC, 2 WA 25% FC and 3 WA 25% FC under dry direct seeded system.

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