Reprint **ISSN 1991-3036 (Web Version)**

International Journal of Sustainable Crop Production (IJSCP)

(***Int. J. Sustain. Crop Prod.***)

Volume: 18 **Issue: 2** **November 2023**

Int. J. Sustain. Crop Prod. 18(2): 07-16 (November 2023)

EFFECT OF SUPPLEMENTAL IRRIGATION ON THE PERFORMANCE OF TRANSPLANTED AMAN RICE VARIETIES AT DINAJPUR REGION

M.T.R. READ, F. MOHAMMAD, M.A. HASAN AND M.M. BAHADUR

An International Scientific Research Publisher

Green Global Foundation©

Web address: http://ggfjournals.com/e-journals archive

E-mails: editor@ggfjournals.com and editor.int.correspondence@ggfjournals.com

ISSN-1991-3036 (Online)
Int. J. Sustain. Crop Prod. 18(2):07-16(November 2023)

EFFECT OF SUPPLEMENTAL IRRIGATION ON THE PERFORMANCE OF TRANSPLANTED AMAN RICE VARIETIES AT DINAJPUR REGION

M.T.R. READ[1*], F. MOHAMMAD[1*], M.A. HASAN[2] AND M.M. BAHADUR[2]

[1]MS Student; [2]Professor, Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh.

Accepted for publication on 10 September 2023

ABSTRACT

Read MTR, Mohammad F, Hasan MA, Bahadur MM (2023) Effect of supplemental irrigation on the performance of transplanted aman rice varieties at Dinajpur region. *Int. J. Sustain. Crop Prod.* 18(2), 7-16.

An experiment was carried out to evaluate the effect of supplemental irrigation on the performance of T. aman rice varieties at the Crop Physiology and Ecology Research Field, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from July to November 2018. The experiment was laid out in a split-plot design with three replications. The experiment comprised two sets of treatments: two water regimes (i.e., Rainfed condition and supplemental irrigation condition) were assigned in main plots and four rice varieties (i.e., BRRI dhan56, BRRI dhan72, BRRI dhan71 and BRRI dhan62) were assigned in sub-plot. Half of the plots were exposed under rainfed conditions and the remaining half plots were irrigated at 60 and 75 days after transplanting. Data were collected on plant height, number of leaves per hill, number of tillers per hill, SPAD value on different days after transplanting, leaf area, and number of filled and unfilled grains per panicle, panicle length, 1000-grain weight, grain and biological yields. All the growth and yield contributing characters and yield of all T. aman rice were increased due to the application of supplemental irrigation over rainfed conditions. Among the varieties, significantly higher plant height, leaf area, leaf dry weight, tillers per hill, filled spikelets per panicle and panicle length due to supplemental irrigation contributed to higher yield in BRRI dhan56 and BRRI dhan71.

Key words: *irrigation; rice; T. aman varieties; yield performance*

INTRODUCTION

As a global food, rice (*Oryza sativa* L.) is the staple food and has a large influence on human nutrition and food security all over the world. Rice is second to wheat in terms of area but as food rice is most important since it provides more calories than any other cereals. In Bangladesh, food security has been and will remain a major concern because food requirement is increasing at an alarming rate due to the increasing population. The projected supply and demand balance showed that the country will require 34-35 million tons of food grain by the year 2020 while the supply would be 27-33 million tons (Shahabuddin *et al.* 1999).

The edaphic and climatic conditions of Bangladesh are favorable for rice cultivation throughout the year. However, the yield per unit of rice at the farmer's level is much lower than the potential yield. The average yield of rice is 2.29 t ha^{-1} (BBS 2013) which is quite lower compared to that of many other countries like China, Japan, Korea and the USA where yields are 6.30, 6.60, 6.30 and 7.04 t ha^{-1}, respectively (FAO 2013). Although Bangladesh ranks 4th in the production of rice (FAO 2002), it ranks 39th in yield (IRRI 1995). The reasons for the low yield of rice are mainly associated with the lack and use of modern varieties, judicious management of fertilizers, irrigation and other intercultural operations. Variety plays an important role in rice production. The use of local cultivars is one of the most important reasons for low yield because the yield of a particular variety may decrease due to cultivation for several years. Among the different management practices, special emphasis should be given to irrigation. Thus, the selection of potential variety and proper management of irrigation can play a crucial role in increasing grain yield and national income.

The crop production in Bangladesh is dominated by intensive rice cropping covering about 80% of the arable land and the most dominant cropping pattern is boro, T. aman rice. Rice is grown in Bangladesh under diverse ecosystems like irrigated, rainfed and deep water conditions in three distinct seasons namely aus, aman and boro. The production efficiency of rice depends on favourable climatic conditions particularly temperature, soil moisture level and sunshine hours. Successful crop cultivation largely depends on proper water management during the greater part of the growth period of the crop. Water plays a vital role in the growth yield and nutrient uptake of rice plants. Insufficient water rigorously affects the germination of seeds, cell division, tillering and nutrient uptake of the plants. Nutrients from the soil reach the surface of roots by mass flow and diffusion processes. Mass flow and diffusion processes are again positively correlated with the moisture content of the soil. The movement of nutrients through the plant body is also associated with soil water contents. So, optimum supply of water is one of the most important factors in rice production. Rice plants need adequate moisture throughout their life cycle. In tropical Asia on average, a total of 1245 mm of water is required for the complete growth cycle of rice. This total can be split into 40 mm for seedling nursery, 200 mm for land preparation and 1000 mm for satisfying the needs during the whole growing period (Sattar 2004). In Bangladesh, Aman rice is generally cultivated under rainfed conditions during the period from July to December. The rainfall distribution pattern in this period is not uniform. Bangladesh receives about 95% of the total annual rainwater (203 cm) during the months from April to October. This quantity of water can support the safe yield of rice crops.

*Corresponding author & address: Md. Tareq Rahman Read, Faruk Mohammad; E-mail: mtrriadiubat@gmail.com, satu.hstu@gmail.com
Md. Tareq Rahman Read[1], Faruk Mohammad[1], Dr. Md. Abu Hasan[2], Dr. Md. Maniruzzaman Bahadur[2]

At the early part of the growing season (i.e. up to the maximum tillering stage), rainwater can meet the crop water demand for rice. After October, rainfall ceases or is irregular and not sufficient for the potential yield of rice and most of the aman rice remains at the panicle initiation to the flowering stage. RRDI (1999) observed that rice is most susceptible to water stress during the reproductive stage. Water deficit at the reproductive stage has the reduction number of effective tillers, panicle length, number of spikelets per panicle and percentage of filleds pikelets (BRRI 1992). If irrigation water is not supplied on those farms, ice yields will be reduced markedly. It is disappointing to note that most of the farmers do not usually irrigate aman rice even if the farm has access to irrigation water. This may be due to ignorance of technology and/or the higher cost of modern irrigation facilities. It was found that supplemental irrigation significantly increased rice yields over rainfed conditions. Moreover, it was suggested that supplemental irrigation should be supplied precisely at the peak period of crop growth which may provide a better yield of this crop (Sattar 2003).

All the varieties do not require equal amounts of water in the aman season and did not respond uniformly to supplemental irrigation. Under the circumstances, it is important to find out the most suitable rice variety for rainfed and supplemental irrigated conditions. However, in our country, ample research work has not been conducted on the comparative varietals performance of transplant aman rice under-rainfed and supplemental irrigated conditions.

With the above views in mind, the present piece of research work was conducted to achieve the following objectives to investigate the effect of supplemental irrigations on the morphological and physiological traits of different T. aman varieties and find out the effect of supplemental irrigation on the yield performance of T. aman rice and to study the response of different varieties to supplemental irrigation.

MATERIALS AND METHODS

Details of the methodology of the study followed during the research period are presented in this chapter.

Location and duration

The experiment was conducted at Crop Physiology and Ecology Research Field, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from July to November 2018.

Soil and Climate

The experimental field was a medium-high land belonging to the non-calcareous dark grey floodplain soil under the agro-ecological zone (AEZ-1) of the Old Himalayan Piedmont Plain. The soil is sandy loam under the Order Inceptisol. The experimental site is situated in the sub-tropical region characterized by heavy rainfall during the months from May to September and scant rainfall in the rest of the year. It has a complex relief pattern. Deep, rapidly permeable sandy loams and sandy clay loams are predominant in this region. They are strongly acidic in topsoil and moderately acidic in subsoils; low in weatherable K minerals. Seven general soil types occur in the region, of which non-calcareous brown floodplain soils, black terai soils, and non-calcareous dark grey floodplain soils predominate. Organic matter contents are generally higher than in most floodplain soils of Bangladesh. The natural fertility of the soil is moderate but well-sustained. Soil fertility problems include rapid leaching of N, K, S, Ca, Mg and B. Most of Panchagarh and Thakurgaon districts and the northwestern part of Dinajpur district are included in this zone.

Preparation of seedbed and seedlings raising

A well-puddled piece of land was selected for seedlings raising. Weeds and stubbles were removed. Then the sprouted seeds of selected varieties were sown in the seedbed on July 12, 2018, and covered with a thin layer of fine earth. Adequate carewastaken to raise healthy seedlings.

Land preparation

The mainland preparation commenced in August 2018 for the cultivation of T. aman rice. The land was prepared by repeated ploughing with a power tiller. Every ploughing was followed by laddering to have a good tilth. All kinds of weeds and stubbles of the previous crops were removed from the field. After leveling the experimental plot was laid out as per treatment and design. Finally, the individual plot was cleaned and leveled with a wooden plank before transplanting. The land was thus ready for transplanting of seedlings.

Experimental treatments

The experiment comprised two sets of treatments: two water regimes (i.e., Rainfed condition and supplemental irrigation condition) were assigned in main plots and four rice varieties (i.e., BRRI dhan56, BRRI dhan72, BRRI dhan71 and BRRI dhan62) were assigned in sub-plot.

Experimental design and layout

The experiment was conducted in a split-plot design with three replications. The unit plot size was 2 m x 2 m. The distance between plots was 0.5 m and block to block distance was 1.5 m. The two growing conditions were placed in the main plots as main plot treatments whereas four rice varieties were placed randomly in the sub plots as sub plot treatments.

Application of fertilizers

Recommended doses of fertilizers were applied to each plot. Fertilizers such as Urea, TSP, MOP, Gypsum and Zinc Sulphate were used as sources for N, P, K, S and Zn, respectively. The full doses of all fertilizers except urea were applied as basal doses to the individual plot during final land preparation. Urea was top dressed in three (3) equal splits at 15, 30 and 45 days after transplanting (DAT). The doses of fertilizers with their source are mentioned in Table 1.

Table 1. The recommended doses of fertilizers with their source

Nutrient element	Source	Dose (Kg ha^{-1})
N	Urea (46%)	75
P	TSP (20%)	15
K	MPO (50%)	45
S	Gypsum (18%)	10
Zn	Zinc Sulphate (Zn 36%, S 18%)	1.5

Source: BARC, 2005

The uprooting of seedlings and transplanting

Thirty-day-old seedlings were uprooted carefully from the seedbed in the morning and then transplanted on the same day in the main field on August 10, 2018. The spacing was 20 cm x 20 cm and three seedlings were transplanted in each hill.

Intercultural operations

Intensive cares were taken during the growing period to ensure adequate growth and development of the crop. Intercultural operations were done as follows:

Gap filling

Seedlings in some hills died off and these were replaced by seedlings from the same source.

Weeding

The experimental plots were infested with some common weeds which were removed twice by hand weeding.

Control of insects and diseases

A few stem borers were noticed in the field which was controlled by using Curaterr 5G (a) 9.88 kg ha^{-1}. There was no serious incident of disease in the field and therefore, no chemical was applied to the field for controlling pathogens.

Data collection from plant samples

Plant height

The plant height in cm at 45, 55, 65, and 75 days after transplanting and at harvest was measured from the ground level to the top of the panicle for each plot. Plants of 5 hills were measured and averaged.

Number of leaves per hill

The number of leaves per hill at 45, 55, 65, and 75 days after transplanting and at harvest was counted and the data were recorded from 5 hills and the mean value was counted and recorded.

Number of tillers per hill

The number of tillers per hill at 45, 55, 65, and 75 days after transplanting and at harvest was counted and the data were recorded from 5 hills the mean value was counted and recorded and the total numbers of tillers per hill, the total number of effective tillers per hill were recorded.

SPAD value

SPAD value was taken from the middle portion of the flag leaf of five main shoots at 50, and 60 days after transplanting and at harvest using a SPAD meter (Model: MINOLTA, CHLOROPHYLL METER, SPAD-502, JAPAN).

Leaf area

Leaf area at 65 days after sowing and harvest was measured from leaf length and leaf breadth from 5 selected plants and then averaged as leaf area/plant in cm^2. Actual leaf area was calculated by multiplying leaf length × leaf breath× 0.75.

Number of filled and unfilled grains per panicle

Five panicles were taken at random hill and the filled and unfilled spikelet panicle-1 were counted and averaged.

Panicle length

The measurement of panicle length in cm was taken from the basal node of the rachis to the apex of each panicle. Each observation was an average of 5 hills.

1000-grain weight

The weight of 1000 grains from each plot was weighed after sun drying by an electrical balance.

Grain and biological yields (g/m^2)

Grain and straw yields were recorded for each plot after sun drying. The grain yields were expressed as tha^{-1} on a 14% moisture basis.

Data analysis

The data were analyzed by partitioning the total variance with the help of a computer by using the MSTAT program. The treatment means were compared using DMRT at P ≤ 1% level.

RESULTS AND DISCUSSION

Pant height

Plant height was not significantly influenced by the interaction of water regimes and rice varieties at 45 and 55 days after transplanting but the interaction was significant at 65 and 75 DAT (Fig. 1). In general, the height of the plant increased with the advancement of time after transplanting and also due to supplemental irrigation compare to rainfed condition.

At 45 days after transplanting, the tallest plant (104.22 cm) was observed in BRRI dhan72 with supplemental irrigation condition which was statistically similar in BRRI dhan56 with supplemental irrigation followed by BRRI dhan56 with rainfed, BRRI dhan72 with rainfed and BRRI dhan62 with supplemental irrigation condition. The shortest plant (85.55 cm) was observed in BRRI dhan62 with rainfed followed by BRRI dhan71 with rainfed conditions.

At 55 days after transplanting, the tallest plant (119.77 cm) was observed in BRRI dhan56 with supplemental irrigation condition which was followed by BRRI dhan56 with supplemental irrigation followed by BRRI dhan71 with supplemental irrigation that was statistically similar to BRRI dhan72 with supplemental irrigation. The shortest plant (100.44 cm) was observed in BRRI dhan62 with rainfed followed by BRRI dhan62 with supplemental irrigation conditions that were statistically similar to BRRI dhan71 with rainfed and BRRIdhan72 with rainfed conditions.

At 65 days after transplanting, the tallest plant (132.88 cm) was observed in BRRI dhan72 with supplemental irrigation condition which was statistically similar in BRRI dhan71 with supplemental irrigation and BRRI dhan56 with supplemental irrigation condition. The shortest plant (105.99 cm) was observed in BRRI dhan62 with rainfed condition that was statistically similar to BRRI dhan62 with supplemental irrigation condition followed by BRRI dhan71 with rainfed and BRRI dhan72 with rainfed condition.

At 75 days after transplanting, the tallest plant (144.34 cm) was observed in BRRI dhan71 with supplemental irrigation condition which was followed by BRRI dhan72 with supplemental irrigation, BRRI dhan56 with supplemental irrigation condition and BRRI dhan71 with rainfed condition. The shortest plant (108.33 cm) was observed in BRRI dhan62 with rainfed condition that was statistically similar to BRRI dhan62 with supplemental irrigation condition followed by BRRI dhan71 with rainfed and BRRI dhan56 with rainfed condition.

The higher vegetative growth under a higher level of irrigation was probably due to the higher photosynthesis rate and its proportionate partitioning towards vegetative growth under this treatment. Previously, Panigrahi *et al*. (2012) showed similar findings of a decrease in vegetative growth of deficit-irrigated plants. The minimum growth of the plants was observed in rainfed treatment.

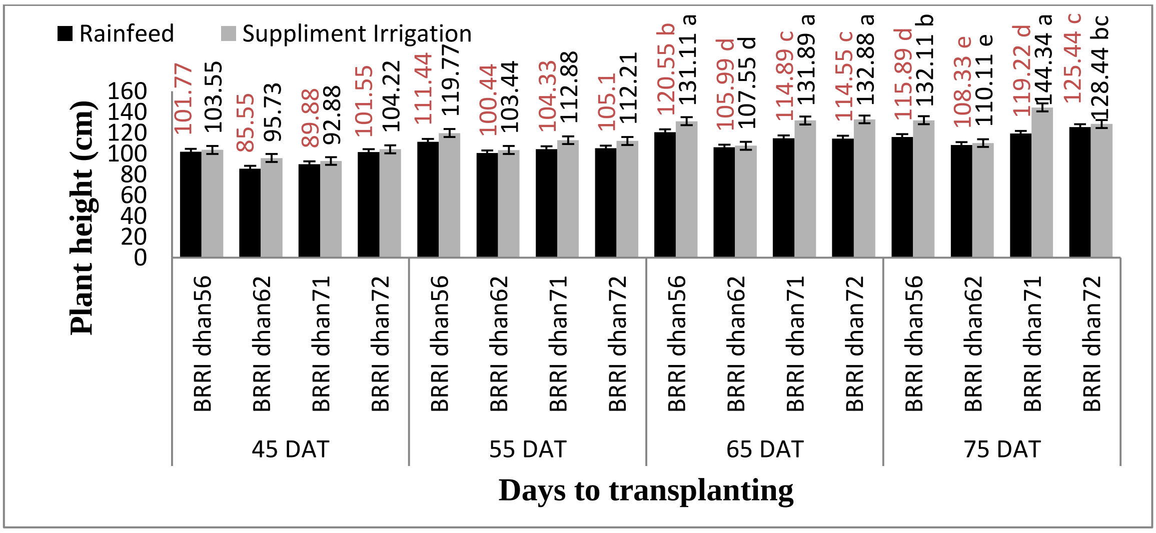

Fig. 1. Effect of supplement irrigation on plant height of different T. aman rice varieties on different days after transplanting

Number of tillers per hill

The number of tillers per hill was not significantly influenced by the interaction of water regimes and rice varieties at 45 and 55 days after transplanting but the interaction was significant at 65 and 75 DAT (Fig. 2). In general, the number of tillers per hill decreased with the advanced of time after transplanting and increased due to supplemental irrigation compare to rainfed condition. At 45 days after transplanting, the highest number of tillers per hill (21.66) was observed in BRRI dhan62 with supplemental irrigation conditions. The lowest number of tillers per hill (17.88) was observed in BRRI dhan56 with rainfed conditions.

At 55 days after transplanting, the highest number of tillers per hill (23.11) was observed in BRRI dhan62 with supplemental irrigation condition which was followed by BRRI dhan72 with supplemental irrigation, BRRI dhan62 with supplemental irrigation and BRRI dhan72 with rainfed condition. The lowest number of tillers per hill (14.55) was observed in BRRI dhan71 rainfed which was followed by BRRI dhan56 with the rainfed condition which was statistically similar to BRRI dhan56 with supplemental irrigation and BRRI dhan71 with supplemental irrigation condition.

At 65 days after transplanting, the highest number of tillers per hill (20.44) was observed in BRRI dhan72 with supplemental irrigation condition which was statistically similar to BRRI dhan62 with supplemental irrigation followed by BRRI dhan62 with the rainfed condition, BRRI dhan72 with rainfed condition and BRRI dhan56 with rainfed condition. The lowest number of tillers per hill (13.67) was observed in BRRI dhan71 with rainfed conditions which was statistically similar in BRRI dhan56 with rainfed conditions.

At 75 days after transplanting, the highest number of tillers per hill (18.33) was observed in BRRI dhan62 with supplemental irrigation condition which was statistically similar with BRRI dhan72 with supplemental irrigation, BRRI dhan62 with rainfed condition followed by BRRI dhan72 with rainfed condition and BRRI dhan71 with supplemental irrigation condition. The lowest number of tillers per hill (13.22) was observed in BRRI dhan71 with rainfed conditions which was statistically similar in BRRI dhan56 with rainfed conditions.

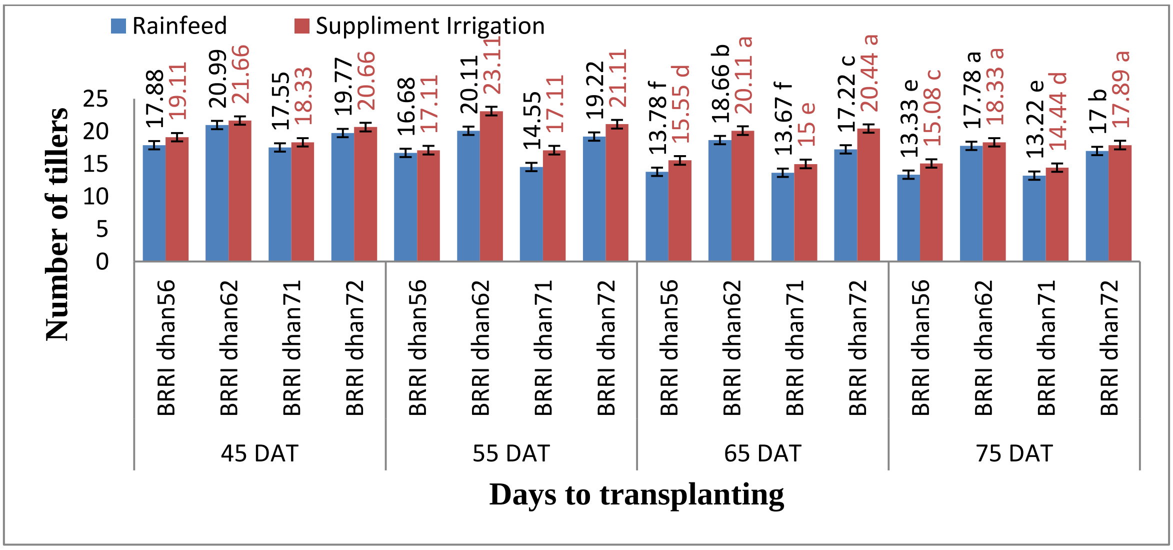

Fig. 2. Effect of supplemental irrigation on the number of tillers per hill of different T. aman rice varieties on different days after transplanting

Number of leaves hill^{-1}

The number of leaves per hill was not significantly influenced by the interaction of water regimes and rice varieties at 45, 55, 65 and 75 days after transplanting (Fig. 3). In general number of leaves per hill decreased with the advancement of the time after transplanting and increased due to supplemental irrigation compare to rainfed condition.

At 45 days after transplanting, the highest number of leaves per hill (126.66) was observed in BRRI dhan62 with supplemental irrigation condition which was followed by BRRI dhan56 with supplemental irrigation, BRRI dhan62 with rainfed condition, BRRI dhan71 with supplemental irrigation, BRRI dhan72 with supplemental irrigation and BRRI dhan72 with rainfed condition. The lowest number of leaves per hill (83.1) was observed in BRRI dhan71 with rainfed conditions followed by BRRI dhan56 with rainfed conditions.

At 55 days after transplanting, the highest number of leaves per hill (109.44) was observed in BRRI dhan62 with supplemental irrigation condition and the lowest number of leaves per hill (82.22) was observed in BRRI dhan71 with rainfed condition.

At 65 days after transplanting, the highest number of leaves per hill (99) was observed in BRRI dhan62 with supplemental irrigation condition and the lowest number of leaves per hill (74.77) was observed in BRRI dhan56 with rainfed condition.

At 75 days after transplanting, the highest number of leaves per hill (95.55) was observed in BRRI dhan72 with supplemental irrigation condition and the lowest number of leaves per hill (69) was observed in BRRI dhan56 with rainfed condition.

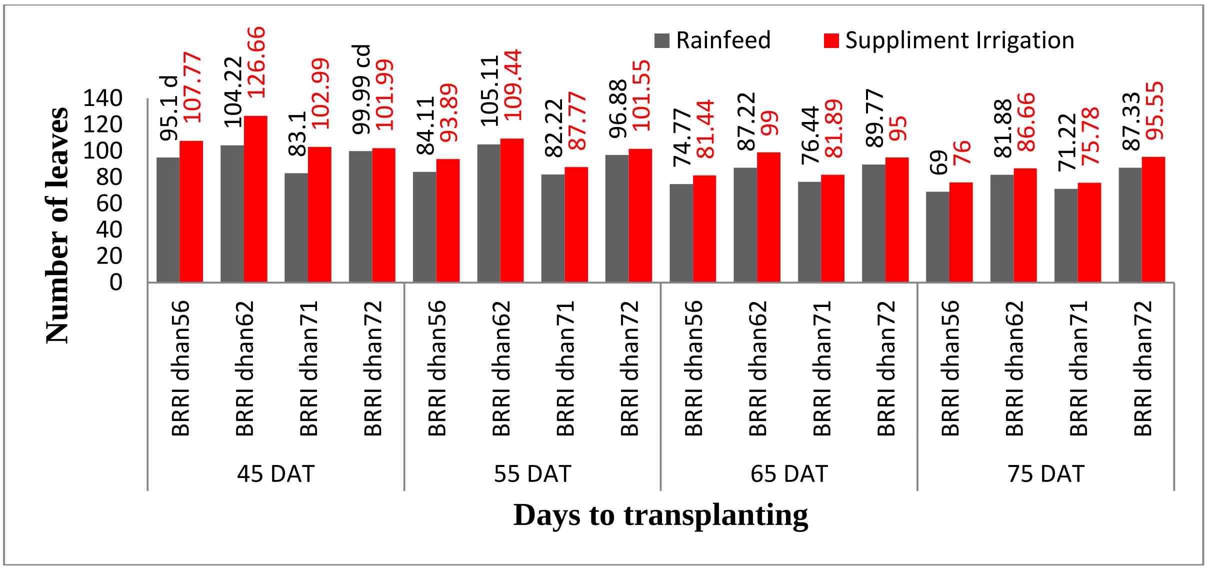

Fig. 3. Effect of supplemental irrigation on the number of leaves per hill of different T. aman rice varieties on different days after transplanting.

SPAD value

The interaction of water regimes and rice varieties did not significantly influence SPAD value 60 and 75 days after transplanting (Fig. 4). In general SPAD value was increased due to supplemental irrigation compared to rainfed conditions. At 60 DAT, the highest SPAD value (39.66) was observed in BRRI dhan62 with supplemental irrigation condition and the lowest SPAD value (34.5) was observed in BRRI dhan56 with rainfed condition. At 75 DAT, the highest SPAD value (42.26) was observed in BRRI dhan62 with supplemental irrigation condition and the lowest SPAD value (33.2) was observed in BRRI dhan56 with rainfed condition.

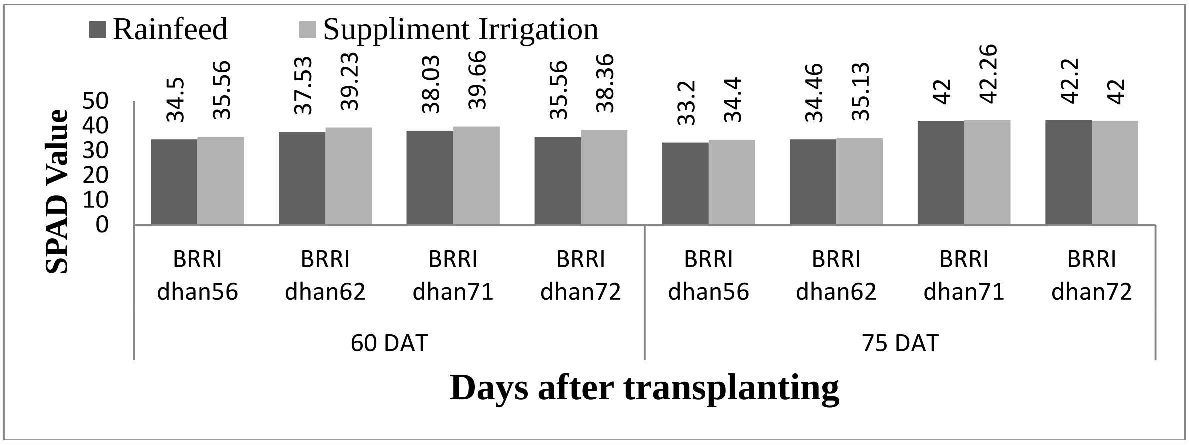

Fig. 4. Effect of supplemental irrigation on SPAD value of different T. aman rice varieties at 60&75DAT

Leaf area per hill

The interaction effect of water regimes and rice varieties on leaf area per hill was found significant (Table 1). At rainfed conditions, BRRI dhan72 produced the highest leaf area (3654.53 cm^2) which was followed by BRRI dhan56 (3018.9 cm^2) and BRRI dhan71 (2951.34 cm^2). BRRI dhan62 produced significantly the lowest leaf area (2436.92 cm^2). Due to supplemental irrigation leaf area per hill was increased in all rice varieties. However, the magnitude of the increment was not the same for all rice varieties. The increment was 2.35% in BRRI dhan56, 1.97% in BRRI dhan72, 7.35% in BRRI dhan71 and 239.22% in BRRI dhan62.

Leaf dry weight

The interaction effect of water regimes and rice varieties on leaf area per hill was found significant (Table 1).

Table 1. Effect of supplemental irrigation on leaf area per hill, leaf dry weight and Plant height at harvest of different T. aman varieties

Variety	Growing condition	Leaf area per hill		Leaf dry weight		Plant height at harvest	
		Cm^2	% change	g	% change	cm	% change
BRRI dhan56	Rainfed	3018.9 c		0.203 a		130.33	
	Supplemental	3089.98 bc	+2.35	0.208 d	-2.46	133.46	+2.40
BRRI dhan72	Rainfed	3654.53 a		0.190 ab		150.13	
	Supplemental	3726.85 a	+1.97	0.182 b	-4.21	153.40	+2.17
BRRI dhan71	Rainfed	2951.34 c		0.173 b		129.00	
	Supplemental	3168.32 b	+7.35	0.208 a	+20.23	131.46	+1.90
BRRI dhan62	Rainfed	2436.92 d		0.124 d		109.73	
	Supplemental	3392.76 ab	+39.22	0.145 c	+16.93	111.33	+1.45
Level of significance		**		**		NS	
CV%		5.23		4.32		7.12	

In a column, values followed by a similar letter(s) did not differ significantly by the DMRT test at p ≤ 5%

At rainfed conditions, BRRI dhan56 produced the highest leaf dry weight (0.203 gm) which was statistically similar to BRRI dhan72 (0.190 gm) followed by BRRI dhan71 (0.173 gm). BRRI dhan62 produced significantly the lowest leaf dry weight (0.124 gm). Due to supplemental irrigation leaf dry weight was increased in all rice varieties except BRRI dhan62 leaf dry weight was reduced. However, the magnitude of the increment was not the same for all varieties. The increment was 2.46% in BRRI dhan56, 20.23% in BRRI dhan71 and 16.93% in BRRI dhan62.

Plant height at harvest

Plant height at harvest was not significantly influenced by the interaction effect of water regimes and rice varieties (Table 1). In general, the height of the plant increased due to supplemental irrigation (111 cm-153 cm) compared to rainfed conditions (109.73 cm - 150 cm).The increment was 2.40 % in BRRI dhan56, 2.17 % in BRRI dhan72, 1.90% in BRRI dhan71 and 1.45 % in BRRI dhan62.

Tillers per hill

The interaction effect of water regimes and rice varieties on tillers per hill at harvest was found significant (Table 2). At rainfed conditions, BRRI dhan62 produced the highest tillers (19.33) which was followed by BRRI dhan72 (17.66) and BRRI dhan71 (16.73). BRRI dhan62 produced significantly the lowest effective tillers (16.33). Due to supplemental irrigation tillers per hill were increased in all rice varieties. However, the magnitude of the increment was not the same for all rice varieties. The increment was lower in BRRI dhan62 (6.88%) and BRRI dhan56 (11.02%) and higher in BRRI dhan72 (13.98%) and BRRI dhan71 (23.90%).

Effective tillers per hill

The interaction effect of water regimes and rice varieties on effective tillers per hill was found significant (Table 2). At rainfed conditions, BRRI dhan72 produced the highest effective tillers (16.13) which was statistically similar to BRRI dhan62 (16.13) and BRRI dhan56 (14.60). BRRI dhan71 produced significantly the lowest effective tillers (12.46). Due to supplemental irrigation effective tillers per hill were increased in all rice varieties. However, the magnitude of the increment was not the same for all rice varieties. The increment was 10.95% in BRRI dhan56, 5.39% in BRRI dhan72, 13.40% in BRRI dhan71 and 10.35% in BRRI dhan62. Similar results were achieved by Chowdhury *et al.* (1993) and Islam and Gretzmacher (2000).

Table 2. Effect of supplemental irrigation on tillers per hill at harvest, effective tillers per hill and filled spikelets per panicle of different T. aman varieties

Variety	Growing condition	Tillers per hill at harvest		Effective Tillers per hill at harvest		Filled spikelets per panicle	
		Number	% change	Number	% change	Number	% change
BRRI dhan56	Rainfed	16.33 e		14.60 d		165.33 e	
	Supplemental	18.13 d	+11.02	16.20 c	+10.95	177.13 d	+7.13
BRRI dhan72	Rainfed	17.66 d		16.13 c		176.73 d	
	Supplemental	20.13 b	+13.98	17.00 b	+5.39	191.53 b	+8.37
BRRI dhan71	Rainfed	16.73 e		12.46 e		186.66 c	
	Supplemental	20.73 a	+23.90	14.13 d	+13.40	194.60 a	+4.25
BRRI dhan62	Rainfed	19.33 c		16.13 c		100.60 g	
	Supplemental	20.66 ab	+6.88	17.80 a	+10.35	116.30 f	+15.60
Level of significance		**		**		**	
CV%		3.56		6.85		7.52	

In a column, values followed by a similar letter (s) did not differ significantly by the DMRT test at P ≤ 5%

Filled spikelet per panicle

The interaction effect of water regimes and rice varieties on filled spikelet per panicle was found significant (Table 2). At rainfed conditions, BRRI dhan71 produced the highest filled spikelet per panicle (186.66) which was followed by BRRI dhan72 (176.73) and BRRI dhan56 (165.33). BRRI dhan62 produced significantly the lowest spikelet per panicle (100.60). Due to supplemental irrigation filled spikelet per panicle were increased in all rice varieties. However, the magnitude of the increment was not the same for all rice varieties. The increment was 7.13% in BRRI dhan56, 8.37% in BRRI dhan72, 4.25% in BRRI dhan71 and 15.60% in BRRI dhan62. Yang *et al.* (1994) reported that water deficit at the reproductive stage has a reduction number of spikelet panicles.

Unfilled spikelets per panicle

The interaction effect of water regimes and rice varieties on unfilled spikelets per panicle was found significant (Table 3). At rainfed conditions, BRRI dhan72 produced the highest unfilled spikelets (81.40) which was followed by BRRI dhan71 (41.93) and BRRI dhan62 (15.33). BRRI dhan56 produced significantly the lowest unfilled spikelets (22.46). Due to supplemental irrigation unfilled spikelets per panicle was decreased in all rice varieties. However, the magnitude of reduction was not the same for all rice varieties. The reduction was lower in BRRI dhan56 (8.01%) and BRRI dhan62 (16.11%) and higher in BRRI dhan72 (33.66%) and BRRI dhan72 (31.17%). Kabir *et al.* (2001) and Tao Long *et al.* (2004) reported that variety and supplemental irrigation had a significant effect on the sterile spikelets panicle-1.

Panicle length

The interaction effect of water regimes and rice varieties on panicle length was found significant (Table 3). At rainfed conditions, BRRI dhan71 produced the longest panicle length (30.53 cm) which was followed by BRRI dhan71 (28.63 cm) and BRRI dhan72 (28.36). BRRI dhan62 produced significantly the shortest panicle length (25.40 cm). Due to supplemental irrigation panicle length was increased in all rice varieties except BRRI dhan71. However, the magnitude of the increment was not the same for all rice varieties. The increment was 2.36% in BRRI dhan56, 7.76% in BRRI dhan72 and 8.26% in BRRI dhan62. Uddin (2004) reported that panicle length was significantly influenced by variety and Islam *et al.* (1994) found that panicle length was significantly influenced by supplemental irrigation.

Table 3. Effect of supplemental irrigation on un-filled spikelets per panicle, panicle length and thousand-grain weight of different T. aman varieties

Variety	Growing condition	Un-filled spikelets per panicle		Panicle length		Thousand-grain weight	
		Number	% change	cm	% change	g	% change
BRRI dhan56	Rainfed	22.46 e		28.36 cd		48.947	
	Supplemental	20.66 e	-8.01	29.03 c	+2.36	49.046	+0.20
BRRI dhan72	Rainfed	81.40 a		28.36 cd		54.590	
	Supplemental	54.00 b	-33.66	28.63 c	+0.94	55.800	+2.21
BRRI dhan71	Rainfed	41.93 c		30.53 b		49.869	
	Supplemental	28.86 d	-31.17	32.90 a	+7.76	50.799	+1.86
BRRI dhan62	Rainfed	15.33 f		25.40 e		50.383	
	Supplemental	12.86 f	-16.11	27.50 d	+8.26	52.700	+4.59
Level of significance		**		**		NS	
CV%		5.62		4.70		7.56	

In a column, values followed by a similar letter (s) did not differ significantly by the DMRT test at P ≤ 5%

Thousand-grain weight

The interaction effect of water regimes and rice varieties on thousand-grain weight was not significant (Table 3). Due to supplemental irrigation thousand grain weights was increased in all rice varieties compared to rainfed condition. However, the magnitude of the increment was not the same for all rice varieties. The increment was 0.20% in BRRI dhan56, 2.21% in BRRI dhan72, 1.86% in BRRI dhan71 and 4.59% in BRRI dhan62. Similar results were reported by Reddy and Flokkeri (1979).

Grain yield per square meter

The interaction effect of water regimes and rice varieties on grain yield per square meter was found significant (Table 4).

Table 4. Effect of supplemental irrigation on grain yield per square meter and Biological yield per square meter of different T. aman varieties

Variety	Growing condition	Grain yield per square meter		Biological yield per square meter	
		g	% change	gm	% change
BRRI dhan56	Rainfed	558.33 e		2750.33 e	
	Supplemental	755.00 b	+35.22	3566.66 c	+ 29.68
BRRI dhan72	Rainfed	696.33 d		3538.00 c	
	Supplemental	732.33 c	+5.16	4386.00 a	+ 23.96
BRRI dhan71	Rainfed	764.66 b		3339.33 d	
	Supplemental	917.66 a	+20.00	3929.00 b	+ 17.65
BRRI dhan62	Rainfed	434.00 g		2696.00 e	
	Supplemental	470.33 f	+ 8.37	2883.66 e	+ 6.96
Level of significance		**		**	
CV%		7.25		5.85	

In a column, values followed by a similar letter (s) did not differ significantly by the DMRT test at P ≤ 5%

At rainfed conditions, BRRI dhan72 produced the highest grain yield per square meter (764.66 gm) which was followed by BRRI dhan72 (696.33 gm) and BRRI dhan56 (558.33 gm). BRRI dhan62 produced the lowest grain yield per square meter (434.00 gm). Due to supplemental irrigation grain yield per square meter was increased in all rice varieties compared to rainfed conditions. However, the magnitude of the increment was not the same for all rice varieties. The increment was 35.22% in BRRI dhan56, 5.16% in BRRI dhan72, 20.00% in BRRI dhan71 and 8.37% in BRRI dhan62. Similar findings were observed by Spanu *et al.* (2004) who indicated that grain yields were satisfactory both in quantity and quality under well-watered conditions.

Biological yield per square meter

The interaction effect of water regimes and rice varieties on biological yield per square meter was not found significant (Table 4) but all the varieties produced higher biological yield under supplemental irrigation stress conditions (2883.66 g-4386.00 gm) compared to rainfed conditions (2750.33-3538.00 gm). However, the magnitude of the increment was not the same for all rice varieties. The increment was 29.68% in BRRI dhan56, 23.96% in BRRI dhan72, 17.65% in BRRI dhan71 and 6.96% in BRRI dhan62. Islam *et al.* (1994) reported that moisture stress resulted in total dry matter.

CONCLUSION

A significant interaction in biological yield was found among the varieties due to water regimes. Biological yield increased due to due to supplemental irrigation. From the overall results, it may be concluded that yield and yield-contributing characteristics and yield of all T. aman rice was increased due to the application of supplemental irrigation over rainfed conditions. BRRI dhan56 and BRRI dhan71 respond better to supplemental irrigation.

REFERENCES

BARC (Bangladesh Agricultural Research Council) (2005) Fertilizer Recommendation Bangladesh Guide. BARC Soils Publication No. 45, BARC, Dhaka, 1-254.

BBS (Bangladesh Bureau of Statistics) (2013) Yearbook of Agricultural statistics. Stat. Div. Ministry of Planning, Govt.People's Repub. Bangladesh. pp. 59-67.

BRRI (Bangladesh Rice Research Institute) (1992) Annual Report for 1991. Bangladesh Rice Res. Inst. Joydebpur, Gazipur. pp.8-9.

Chowdhury MJU, Sarker AU, Sarker MAR, Kashem MA (1993) Effect of variety and number of seedlings hill-1 on the yield and its components on late transplanted aman rice. *Bangladesh J. Agril. Sci*. 20(2), 311-316.

FAO (Food and Agriculture Organization) (2002) Production Year Book.Food and Agricultural Organization of the United Nations. Rome. pp.76-77.

FAO (Food and Agriculture Organization) (2013) FAO Statistical Yearbook. Food and Agricultural Organization of the United Nations. Rome. pp.157-162.

IRRI (International Rice Research Institute) (1995) World Rice Statistics 1993-94. Intl. Rice Res. Inst., Manila, Philippines. pp.2-19.

Islam MT, Gretzmacher R (2000) Screening of some transplanted aman rice cultivars under water stress condition. *Bangladesh J. training and dev*. 13(1 and 2).

Islam MT, Salam MA, Kauser M (1994) Effect of soil water stress at different growth stage of rice on yield components and yield progress. Agric. 5:151-156.

Kabir MH, Rahman MS, Hossain SMA (2001) Effect of plant spacing and variety/advanced line on the crop characters.yield and yield component of boro rice. *Bangladesh J. Crop. Sci.* 12(1-2), 139-144.

Panigrahi P, Srivastava AK, Huchche AD (2012) Effects of drip irrigation regimes and basin irrigation on Nagpur mandarin agronomical and physiological performance. Agricultural Water Management, Volume 104,pp 79-88.

Reddy SR, Flokkeri SB (1979) Soil water and weed management for direct seeded rice grown on irrigated soils in North-Western India. Ind. *J. Agric. Sci.* 49(6), 427-433.

RRDI (Rice Research and Development Institute) (1999) Netscape-Effect of water deficit. Department of Agriculture, Batalagoda, Ibbagamuwa, Srilanka.

Sattar MA (2003) Training manual on supplemental irrigation of T. Aman draught elimination. Irrigation Water Management Division, Bangladesh Rice Research Institute (BRRI), Gazipur. Bangladesh.

Sattar MA (2004) Water Management in Rice Production. Handout preparation for rice production training programme, Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh.

Shahabuddin QS, Uddin MZ, Hossin M (1999) Determinants of rice supply and demand in Bangladesh: recent trend and projection. Social Sci. Div., Intl. Rice Res. Inst., Philippine. Discussion Paper Series No. 99-102.

Spanu A, Murtas A, Ledda L, Ballone F (2004) Comparison of rice varieties subjected to non-continuous irrigation. Informatore Agrario. 60(18), 61-64.

Tao Long X, Wang X, Huang XI, MinShaoand K, Cheng S (2004) Effects of soil moisture content on physiological activity of rice root system during grain filling stage. China National Rice Research Institute. Hangzhou, China. Scientia-Agricultura-Sinica. 2004. 37(11), 1616-1620.

Uddin B (2004) Effect of variety and age of seedlings on the yield attributes and yield of transplant aman rice. M.S. Thesis. Dept. of Agronomy, Bangladesh Agril.Univ. Mymensingh.pp.51-52.

Yang C, Hsiang W, Isiang WM (1994) Growth and yield of rice as affected by water deficits. *Chinese J. Agrometerology*, 1:143-150.