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RAISED BED PLANTING PROVIDES HIGHER YIELD AND LESS WATER INPUTS FOR TRANSPLANTED BORO RICE (*ORYZA SATIVA*) THAN CONVENTIONAL PLANTING METHOD

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ABSTRACT

Introduction of raised bed cultivation system for boro rice production is a major concern nowadays. A field experiment was compare with two cultivation methods: boro (winter, irrigated) rice on raised beds with fertilizer broadcasting and fertilizer broadcasting in conventional planting was conducted in Chuadanga district of Bangladesh. Result showed that fertilizer broadcasting in raised bed increased grain yield of transplanted boro rice up to 15.9% over conventional planting. Fertilizer broadcasting in raised bed planting increased the number of panicle m-2, number of grains panicle-1 and 1000-grains weight of rice than the conventional planting method. Better plant growth attribute was observed in raised bed planting compared to conventional planting. Sterility percentage and weed infestation were lower on fertilizer broadcasting in raised bed than the conventional planting method. Thirty five percent irrigation water and time for application could be saved by fertilizer broadcasting in raised bed than conventional planting. Water use efficiency for grain and biomass production was higher by fertilizer broadcasting in bed planting than the fertilizer broadcasting in conventional method. Similarly, agronomic efficiency of fertilizer broadcasting in bed planting was higher than the fertilizer broadcasting in conventional planting. This study concluded that fertilizer broadcasting in raised bed for boro rice is a new approach to get fertilizer and water use efficiency as well as higher yield and less water input compared to existing agronomic practice in Bangladesh.

Key words: Raised bed planting**,** rice yield, water use efficiency, conventional planting

1. INTRODUCTION

Boro (winter, irrigated) rice is the most important crop in Bangladesh in respect of volume of production. The growing period of boro rice in Bangladesh is December to May. It reveals that due to higher yields, farmer become more interested to bring more area under this crop. Total area under boro crop has been estimated at 48.10 lac hectares in Bangladesh (BBS, 2011).

Raised beds are formed by moving soil from the furrows to the area of the bed, thus raising its surface level. Transplanting of boro rice on raised beds was better than conventional in terms of greater plant height, number of panicle m^{-2}, length of panicle and 1000 grain weight and ultimately higher yield than conventional method (Samar *et al.* 2002). In raised bed system, rice is grown on beds that are kept at saturated by water in furrows in between the beds. While most researchers agreed that bed planting reduced water inputs compared to conventional flooding, reports on its effects on rice yield and water productivity have been diverse (Borrell *et al.* 1997; Thompson 1999; Gupta *et al.* 2002). Tuong (2003) also reported that bed planting reduced water input compared to conventional planting method. Bed planting may also facilitate the establishment of upland crops after rice because beds and furrow improve drainage when rainfall is heavy (Humphreys *et al.* 2004).

Our previous study showed that water use efficiency and grain production were higher in fertilizer broadcasting on raised bed than fertilizer broadcasting in conventional planting for aman rice (Bhuyan *et al.,* 2012a). Likewise, another study showed that foliar split nitrogen fertilizer application on raised bed for transplanted aman rice produced higher yield than conventional cultivation method (Bhuyan *et al.,* 2012b). However, it was not considered for boro (winter, irrigated) rice with fertilizer broadcasting in raised bed than fertilizer broadcasting in conventional method. Therefore, this study was undertaken to determine the effect of fertilizer broadcasting on raised bed than fertilizer broadcasting in conventional planting for boro rice production. It will be hypothesized that fertilizer broadcasting on raised bed receives higher yield and less water inputs than conventional cultivation method.

2. MATERIALS AND METHODS

2.1Geographical location of the experimental site

The field experiment was carried out the farmer field, Chuadanga, Bangladesh, during boro (December-May) season of 2012. Research field was located at 11.5 m above mean sea level. Geographically, it is located at $23^{0}39^{/}$N latitude and $88^{0}49^{/}$ E longitudes.

2.2. Meteorological information during the crop season

The Meteorological data for the cropping season were recorded at local weather station, Chuadanga district of Bangladesh. The rainfall received during the growth period of crop (February-May) total of 128 mm. The mean maximum and minimum temperature were recorded 34.28ºC and 22.03ºC respectively for the cropping season. The relative humidity ranged between 63.8% in the month of March and 71.5% in the month of February.

2.3. Basic soil properties of the experimental site

Soil physical and chemical properties of the experimental site are as below:

Textural class	Silt loam
Soil pH	7.30
OC (%)	0.88
Total N (%)	0.11
Available P (ppm)	5.68
Exchangeable K (meq 100 g^{-1})	0.15
Available S (ppm)	12.10
Available Zn (ppm)	0.22

These properties were measured at regional soil testing laboratory of Soil Resources Development Institute, Jhenidah, Bangladesh.

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2.4. Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The entire experimental area was divided into three block representing three replications to reduce soil heterogenic effects and each block was divided into three unit plots with raised bunds as per treatments. Thus the total number of unit plots was 9. The size of each unit plot was 4 m × 3.5 m. Plots were separated from one another by ails of 0.25 m. Unit blocks were separated from one another by 1 m drains. Treatments were randomly distributed within the blocks.

2.5. Characteristics of rice variety

BRRI dhan28, a high yielding variety of rice was used as the test crop in this experiment. The variety was released for boro season by Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur in 1994 after regional and zonal trial and evaluation. The variety was developed after selection of bread line BR601-3-3-4-2-5, which was obtained from crossing line IR 28 with purbachi. Then the line BR 601-3-3-4-2-5 was released for boro season as BRRI dhan 28. It is a transplant boro rice cultivar with average yield 5.0 t ha^{-1}. Life cycle of this variety ranges from 135 to 140 days, which however may vary due to change in climatic condition.

2.6. Cultural practices of rice

Two fertilizer application methods for comparison of raised bed and conventional planting were established across a soil. The combinations of treatments were fertilizer broadcasting in raised bed, fertilizer broadcasting in conventional planting and control. Two 45 day old seedlings $hill^{-1}$ of BRRI 28, a popular boro (winter, irrigated) rice variety were transplanted on 29th February 2012. The row to row and hill to hill spacing were 25 cm and 20 cm for both beds and flat. Only two rows of rice were planted on each bed and plant density was much higher in the conventional treatment. Fertilizer was applied at the following rates: N=120, P=14, K=36, S=1.0 kg ha^{-1} applied as urea, Triple Super-Phosphate (TSP), Murate of Potash (MP), Gypsum and Zinc sulphate ($ZnSo_4$), respectively. Whole of TSP, MP, gypsum and $ZnSO_4$ were applied at the final land preparation as basal dose in the plots with conventional treatment. In the plots with bed planting treatment, the basal doses were broadcasted before transplanting on top of the beds. Urea was broadcasted in three equal splits at 15, 30, and 50 days after transplanting of rice. Manual weeding was done twice in the transplant boro rice field during growth period. The plots were weeded at 15 and 30 DAT. Weed samples from each plot were collected at the time of weeding for comparing weed population and dry biomass yield of different treatments. The rice was infested by stem borer at tillering stage and rice bug at grain filling stage. Furadon 5G at the rate of 10 kg ha^{-1} was applied at 40 DAT and Malathion 57 EC 5G at the rate of 1 litre ha^{-1} was applied at grain filling stage to control stem borer and rice bug, respectively.

2.7. Plant height and tiller number observation

Randomly selected and tagged 10 plants were used for the measurement of plant height at an interval of 15 days from 15th day after transplanting and ending with just flowering. It was measured from base to tip of the upper leaves of the main stem. Numbers of tiller per plant were counted from one meter row length.

2.8. Leaf area index

Leaf area (cm^2) of the functional leaves obtained from samples drawn for dry matter accumulation study was measured by automatic leaf area meter. Then leaf area of the plants/units is will be worked out by following formula:

Leaf area index (LAI) = Leaf area/Ground area

2.9. Yield attributed characters of rice

Observation regarding the effective tiller per row length was recorded just before harvesting the crop and the average values was used to obtain the effective panicles per meter row length. The length of panicle was taken from the 10 panicles from each plot which were randomly selected just before harvesting and mean were

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calculated. Number of filled and unfilled grains was counted to determine the number grains per panicle. Thousand grains were counted from the grain yield of each plot and weighted with the help of automatic electronic balance.

2.10. Biomass yield and grain yield

Biomass yield and grain yield was taken at harvesting from each plot. All the plants from 1 m length were uprooted and weighed to determine the total biomass yield. Digital grain moisture meter was used to record the moisture of the grain. Finally grain yield was adjusted at 14% moisture using the formula as suggested by Paudel (1995).

Grain yield (t ha^{-1}) at 14% moisture = (100-MC) x plot yield (ton) x 10000(m^2)/ (100-14) x plot area (m^2)

Where, MC is the moisture content in percentage of the grains.

2.11. Harvest index

Harvest index (HI) was computed by dividing grain yield with the total dry matter yield as per following formula.

HI = (grain yield)/ (grain yield + straw yield)

2.12. Irrigated water measurement

Irrigation water was measured by using a delivery pipe and water pan. A plastic delivery pipe was connected from the water pump to the experimental field. A water pan with 300-liter volume was filed by irrigation through the delivery pipe and time required was recorded. Then plots with different methods of planting were irrigated through the delivery pipe and times required were recorded. The amount of irrigation water applied in different plots was calculated as follows:

Amount of water applied per plot=

$$\frac{\text{Volume of water pan (L)} \times \text{Time required to irrigation the plot (sec)}}{\text{Time required filling the water pan (sec)}}$$

2.13. Water use efficiency calculation

Water use efficiency for grain and biomass production was calculated by the following equations:

Water use efficiency for grain production (kg $ha^{-1}cm^{-1}$)

= grain yield (kg ha^{-1})/total water required (cm)

Water use efficiency for biomass production (kg $ha^{-1}cm^{-1}$)

= [grain yield (kg ha^{-1}) + straw yield (kg ha^{-1})]/ total water required (cm)

2.14. Agronomic efficiency of N fertilizer calculation

Agronomic efficiency (A_E) of N fertilizer was calculated by the following equation:

$A_E = GY_{NA} - GY_{N0}/N_R$

Where $GY_{NA=}$ Grain yield (kg ha^{-1}) with addition of nutrient

GY_{N0}= Grain yield (kg ha^{-1}) without addition of nutrient

N_R= Rate of added nutrient (kg ha^{-1})

2.15. Statistical analysis of data

The experiment was conducted using randomized complete block design with three replications for each treatment. Data were analysed following standard statistical procedure and means of treatments were compared based on the least significant difference test (LSD) at the 0.05 probability level. Microsoft Excel was used for tabulation and simple calculation, presentation of table for different comparisons.

3. RESULTS

3.1. Grain yield and yield components

The average yield data in the Table 1 indicated that the grain yield of rice differed significantly with two method of planting. The yield increased by 15.90% in bed planting over conventional planting. Likewise, the

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higher thousand grain weight was observed in bed over conventional planting method. Similarly, the raised bed planting had 10 grains panicle^{-1} more than the conventional planting method. In addition, the panicle number m^{-2} was significantly higher in raised bed over conventional planting method (Table 1).

Table.1: Grain yield and yield components with respect to fertilizer broadcasting in raised bed and fertilizer broadcasting in conventional planting.

Method of Fertilizer application	Yield and yield components			
	panicles m^{-2} (no)	Grains panicle^{-1} (number)	1000 grain wt (gm)	Grain yield (t ha^{-1})
Fertilizer broadcasting in bed planting	470a	116a	24.88	5.10a
Fertilizer broadcasting in conventional planting	430b	106b	21.00	4.40b
LSD at 5%	4.98	3.82	2.60	0.38
Level of significance	**	*	n.s.	*

Where, n.s.,* and ** represents probability of > 0.05, ≤ 0.001 and ≤ 0.01, respectively. Values were means of three replicates.

3.2. Plant growth components

Plant biomass was higher in fertilizer broadcasting on raised bed than conventional flat method (Table 2). The length of panicle was 0.48 cm higher in raised bed planting than the conventional planting method. Interestingly, the plant height at maturity was 0.48 cm higher in conventional planting over bed planting method. However, the sterility percentage was 22.52% higher in conventional planting compared to bed planting. The higher number of grains per panicle was accountable for lower sterility percentage in raised bed. On the other hand the higher sterility in conventional planting might be due to the lower number of grains per panicle. The straw yield in raised had 0.47 t ha^{-1} more than the conventional planting. The higher straw yield produced by bed planting over conventional planting might be due to the higher dry matter accumulation. Moreover, the appraisal of data in Table 2 revealed that the harvest index of different planting method was insignificant. The harvest index was high in bed planting over conventional planting with higher yield.

Table 2: Plant biomass with respect to fertilizer broadcasting in raised bed and fertilizer broadcasting in conventional planting

Method of Fertilizer application	Plant height (cm)	Panicle length (cm)	Non-bearing tiller (number m^{-2})	Sterility (%)	Straw yield (t ha^{-1})	Harvest index
Fertilizer broadcasting in bed planting	85.78	24.58	75b	13.23b	5.39	0.48
Fertilizer broadcasting in conventional planting	87.34	24.10	102a	16.21a	4.92	0.47
LSD at 5%	2.35	1.36	2.62	1.60	0.37	0.00
Level of significance	n.s.	n.s.	**	*	n.s.	n.s.

Where, n.s.,* and ** represents probability of > 0.05, ≤ 0.001 and ≤ 0.01, respectively. Values were means of three replicates.

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3.3. Tiller number and crop growth rate

Different planting method of transplanted boro rice affected the number of tiller m^{-2} (Table 3). In raised bed, the highest tiller production was observed in 40 days after transplanting (DAT). After 50 DAT, the number of tiller was started to declined and continued to 100 DAT. In conventional planting method the highest tiller number was recorded at 40 DAT. The tiller production differed significantly ($P \geq 0.05$) by raised bed over conventional method except 80 and 90 DAT.

Table 3: Effect of tiller production by fertilizer broadcasting in raised bed and fertilizer broadcasting in conventional planting.

Method of Fertilizer application	Tiller (number m^{-2}) at days after transplanting								
	20	30	40	50	60	70	80	90	100
Fertilizer broadcasting in bed planting	80a	218a	247a	209a	170a	154a	144	142	140a
Fertilizer broadcasting in conventional planting	76b	209b	240b	200b	162b	149b	141	139	135b
LSD at 5%	2.07	2.62	2.62	2.07	2.42	1.31	2.07	2.07	2.62
Level of significance	*	**	**	**	**	**	n.s.	n.s.	*

Where, n.s.,* and ** represents probability of > 0.05, ≤ 0.001 and ≤ 0.01, respectively. Values were means of three replicates.

3.4. Leaf area index

In bed planting method, the highest LAI was recorded at 60 DAT (Table 4). From Table 4 it was showed that the early stage of crop growth (20 DAT), the LAI was higher in conventional planting than the bed planting. The highest LAI was observed by conventional planting at 80 DAT. However, LAI differed significantly ($P < 0.01$) between two methods except 40 DAT.

Table 4: Effect of leaf area index by fertilizer broadcasting in raised bed and fertilizer broadcasting in conventional planting.

Method of Fertilizer application	LAI at different DAT				
	20	40	60	80	100
Fertilizer broadcasting in bed planting	0.28b	2.45	5.76a	5.30	3.94
Fertilizer broadcasting in conventional planting	0.42a	2.50	5.03b	5.08	3.85
LSD at 5%	0.00	0.46	0.19	0.29	0.10
Level of significance	**	n.s.	**	n.s.	n.s.

Where, n.s. and ** represents probability of > 0.05 and ≤ 0.01, respectively. Values were means of three replicates.

3.5. Dry matter production

Crops yield depends upon the dry matter production per unit area therefore high production of total dry matter was first pre requisite for high yield. The effects of different treatments in dry matter production are shown on Table 5. At 20 DAT, the conventional planting method produced higher dry matter yield than the bed planting. Likewise, at the last date of measurement (90 DAT) the raised bed planting produced higher dry matter yield than the conventional planting method. From Table 5, it showed that the progressive increase in total dry matter production as crop attained maturity by both planting method.

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Table 5: Effect of dry matter production by fertilizer broadcasting in raised bed and fertilizer broadcasting in conventional planting.

Method of Fertilizer application	Dry matter production (gm m^{-2}) at different days after transplanting (DAT)							
	20	30	40	50	60	70	80	90
Fertilizer broadcasting in bed planting	37b	234b	505	641a	1020a	1121a	1293a	1308a
Fertilizer broadcasting in conventional planting	61a	257a	492	619b	903b	1049b	1282b	1294b
LSD at 5%	2.07	2.62	10.83	2.07	9.44	19.93	2.62	9.44
Level of significance	**	**	n.s.	**	**	**	**	**

Where, n.s. and ** represents probability of > 0.05 and ≤ 0.01, respectively. Values were means of three replicates.

3.6. Crop growth rate

Further, the crop growth rate was highest at 50 to 60 DAT by bed planting (Table 6). The lowest crop growth rate was observed at 80 to 90 DAT by bed planting method. In conventional planting the highest crop growth rate was observed at 50 to 60 DAT. The lowest crop growth rate was recorded at 80 to 90 DAT by conventional planting method. The crop growth rate differed significantly ($P \geq 0.05$) by two planting method except 20-30 and 30-40 DAT.

Table 6: Effect of crop growth rate by fertilizer broadcasting in raised bed and fertilizer broadcasting in conventional planting.

Method of Fertilizer application	Crop growth rate (gm m^{-2} day^{-1}) at different days after transplanting (DAT)						
	20-30	30-40	40-50	50-60	60-70	70-80	80-90
Fertilizer broadcasting in bed planting	19.70	27.10	13.6a	37.9a	10.10b	17.20b	1.50a
Fertilizer broadcasting in conventional planting	19.60	23.50	12.70 b	28.40 b	14.60a	23.30a	1.20b
LSD at 5%	0.39	1.51	0.39	0.38	1.58	1.22	0.26
Level of significance	n.s.	n.s.	*	*	**	**	**

Where, n.s.,* and ** represents probability of > 0.05, ≤ 0.001 and ≤ 0.01, respectively. Values were means of three replicates.

3.7. Weed vegetation

The conventional planting method produced 243 numbers more weeds m^{-2} than the bed planting method (Table 7). As a result the conventional planting method also produced 207.86 kg ha^{-1} more dry mass of weed than the raised bed planting method. Interestingly, dry weed biomass significantly ($P \geq 0.05$) differed between these two methods.

Table 7: Effect of weed growth by fertilizer broadcasting in raised bed and fertilizer broadcasting in conventional planting.

Method of Fertilizer application	Weed vegetation	
	Weed vegetation population (number m^{-2})	Dry biomass (kg ha^{-1})
Fertilizer broadcasting in bed planting	146	137.12b

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Fertilizer broadcasting in conventional planting	389	344.98a
LSD at 5%	1.31	1.38
Level of significance	n.s.	**

Where, n.s. and ** represents probability of > 0.05 and ≤ 0.01, respectively. Values were means of three replicates.

3.8. Irrigation requirement

Different planting method affected the irrigation water requirement .The total irrigation water required by bed planting was 109.82 cm (Table 8). On the other hand the conventional method received 149.00 cm irrigation water. Result showed that the total water savings by bed planting over conventional planting was 35%.

Table 8: Irrigation water savings by fertilizer broadcasting in raised bed and fertilizer broadcasting in conventional planting.

Method of Fertilizer application	Irrigation required (cm)	Rainfall (cm)	Total Irrigation required (cm)	Water saved over conventional method (%)
Fertilizer broadcasting in bed planting	97.02b	12.8	109.82	
Fertilizer broadcasting in conventional planting	136.20a	12.8	149.00	35%
LSD at 5%	2.17	0.21	2.15	
Level of significance	**	n.s.	n.s.	

Where, n.s. and ** represents probability of > 0.05 and ≤ 0.01, respectively. Values were means of three replicates.

3.9. Water use efficiency

In raised bed planting method the water use efficiency for grain and biomass production was 46043 and 95.51 kg ha^{-1} cm^{-1}, respectively (Table 9). On the other hand water use efficiency for grain and biomass production in conventional planting method was 29.53 and 62.55 kg $ha^{-1}cm^{-1}$, respectively. In addition, the water use efficiency for grain and biomass production by bed planting was 57.22% and 52.69% higher over conventional planting.

Table 9: Water use efficiency by fertilizer broadcasting in raised bed and fertilizer broadcasting in conventional planting.

Method of Fertilizer application	Water u Efficiency savings by fertilizer broadcasting in raised bed and fertilizer broadcasting in conventional planting.	
	Water use efficiency for grain production (kg $ha^{-1}cm^{-1}$)	Water use efficiency for biomass production (kg $ha^{-1}cm^{-1}$)
Fertilizer broadcasting in bed planting	46.43a	95.51a
Fertilizer broadcasting in conventional planting	29.53b	62.55b

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LSD at 5%	1.29	2.75
Level of significance	**	**

Where, ** represents probability of ≤ 0.01 .Values were means of three replicates.

3.10. Agronomic efficiency of N fertilizer

The agronomic efficiency of N fertilizer for bed planting was 28.33% (Table 10). Likewise, the agronomic efficiency of N fertilizer for conventional planting was 22.56%. The agronomic efficiency of N fertilizer in bed planting was 25.57 % higher over conventional planting method.

Table 10: Agronomic efficiency of fertilizer by fertilizer broadcasting in raised bed and fertilizer broadcasting in conventional planting.

Method of Fertilizer application	Agronomic efficiency of fertilizer (%)
Fertilizer broadcasting in bed planting	28.33a
Fertilizer broadcasting in conventional planting	22.56b
LSD at 5%	1.85
Level of significance	**

Where, **represents probability of ≤ 0.01. Values were means of three replicates.

4. DISCUSSIONS

4.1. Transplanted boro rice produced higher yield components in raised bed than conventional cultivation method

Transplanted boro rice has 0.71 t ha^{-1} more yield for fertilizer broadcasting in raised bed than fertilizer broadcasting in conventional flat method. Likewise, fertilizer broadcasting in raised bed produced about 3 gm thousand grain weights than fertilizer broadcasting in conventional flat method. Similarly panicle number, grains per panicle was significantly ($P \leq 0.01$ and $P \leq 0.05$) higher in fertilizer broadcasting in raised bed than fertilizer broadcasting in conventional flat method (Table 1). Likewise, Husain *et al*. (2003) found higher number of panicle m^{-2} under raised bed planting than the conventional planting method. This study found that higher number of grains $panicle^{-1}$ was recorded in bed planting. This findings also supported by Husain *et al*. (2004). They observed the higher number of grains $panicle^{-1}$ under raised bed compared to farmers practice. Planting method also effect the 1000 grains weight. In Our study the weight of 1000 grains was higher in raised bed planting than conventional planting method. Our speculation is that the bed planting encouraged proper crop growth and development and assimilate synthesis in the grains. But Husain *et al.* (2004) and Hossain *et al.* (2003) observed higher 1000-grains weight under bed planting compared to the farmers practice. Fertilizer broadcasting in bed produced 15.90% higher grain yield than fertilizer broadcasting in conventional flat method. Nissanka and Bandara (2004) reported that grain yield in raised bed was 9% higher than conventional planting method. Connor *et al.* (2003) demonstrated that bed planting of rice improved grain yield 6.2 % compared to conventional flat method. Likewise, Talukder *et al.* (2010) reported that boro rice in raised planting increased grain yield 14% over the conventional planting method. Similarly, Lauren *et al.* (2013) demonstrated that raised bed increased rice yield by 13 to 16 percent compared to conventional planting. They speculated that raised bed build soil aggregation and provide deeper rooting and better air-water relationship in soils that results improve rice yield. Our speculation is that bed planting cultivation method allowed to the vigorous and healthy growth, development of more productive tillers and leaves ensuring greater resource utilization than conventional planting which contributed to higher grain yield for the transplanted boro rice.

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4.2. Plant growth attributes in transplanted boro rice

Plant growth parameters in transplanted boro rice were significantly ($P \leq 0.05$) higher for fertilizer broadcasting in raised bed than conventional flat method. Panicle numbers were significantly ($P \leq 0.05$) greater in raised bed than conventional flat method (Table 1). Other study conducted by Aslam *et al.* (2008) found that bed planting of rice produced higher number of panicle m^{-2} than conventional planting method. They suggested that lower number of panicle m^{-2} were produced by conventional planting method due to lower availability of nutrients in the submerged field. Likewise, panicle length was 0.48 cm more in fertilizer broadcasting on raised bed than conventional cultivation practice (Table 2). Similar findings were found from other study. El-Bably *et al.* (2008) found that panicle length of rice in bed planting was 1.5 cm more than conventional planting. They stated that higher panicle length in bed planting could be attributed to the varietal differences. Similarly, tiller numbers were significantly ($P \leq 0.05$) greater in fertilizer broadcasting on raised bed than conventional flat method up to 70 days after transplanting (Table 3). Regardless of that crop growth rate were significantly ($P \leq 0.05$) higher in fertilizer broadcasting on raised bed that conventional flat method from 40 to 60 days after transplanting (Table 6). This finding was supported from other study. Mollah (2005) showed that transplanted rice in beds (70 cm wide) produced higher number of tiller and crop growth rate at maturity over conventional planting. He suggested that wider beds (80 and 90 cm wide) could not produce higher number of tiller compared to conventional planting method. However, sterility percentage was significantly ($P \leq 0.05$) higher in fertilizer broadcasting on conventional flat than raised bed planting (Table 2). This result was supported by Javaid *et al.* (2012). They stated that higher sterility percentage in conventional planting was probably due to severe competition of plants for resources on account of higher number of tiller and panicle per unit area.

Speculation in this study is that under bed planting practices the root system is several times longer and deeper enabling them to access for nutrients even in much greater volume of nutrient poor soil. Deeper root growth encouraged higher nutrient absorption subsequently higher assimilation which was favored higher tiller and panicle production than conventional planting. Transplanted of rice in bed planting provided sufficient nutrient for vegetative growth and also for reproductive phase which ultimately leads to increased plant height than conventional planting. The higher percentage of sterility in conventional planting was because of more tertiary tiller production, which bear late flowering. Among them some were fertilized and majority remained un-fertilized due to weak tiller. Rice transplanted under bed planting might have recovered fast enough due to lower transplanting shock and started absorbing nutrients and water to support faster growth and hence higher dry matter production was observed. The better plant growth performance in bed planting could be due to improved soil physical properties, reduced lodging and incidence of disease. On raised beds, border effects allows the canopy to intercepts more solar radiation, it strengthens the straws, and the soil around the base of the plant is drier to prevent crop from lodging which directly contributed to higher plant growth parameter. Raised bed rice planting provided more favorable root-zone conditions exist for plant growth since there is a greater depth of surface soil, and the furrows act as drains, so rapid re-aeration of the root-zone occurs following irrigation or rainfall.

4.3. Raised bed suppressed weed vegetation

Density of weeds in fertilizer broadcasting on bed planting was higher than fertilizer broadcasting in conventional planting method (Table 7). Dry biomass of weeds in fertilizer broadcasting on bed planting were significantly ($P \leq 0.05$) higher over fertilizer broadcasting in conventional planting method (Table 7). This result supported by Karim (2011). He found that the population and dry weight of weeds were less in bed planting than in conventional planting method. Mishra (2004) also reported the same result. He found that furrow irrigated raised bed system reduced the population of weeds. He stated that raised bed caused least soil

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disturbance and hence less emergence of weeds. Further, Hobbs *et al.* (2000) demonstrated that fewer weeds germinated in raised bed planting compared with farmers practice. They suggested that permanent bed planting offered farmers an alternative to herbicide use for weed control since most weeds can be controlled by mechanical cultivation through driving down the furrows. In addition, Hossain *et al.* (2012) found that conventional planting of rice resulted acute weed stress compared to permanent raised bed planting. He suggested that poor crop growth in conventional planting could not compete as well with weeds. Furthermore, Mollah (2005) reported that reduced number of weeds m^{-2} and dry biomass yield were in bed planting compared to conventional planting. He suggested that the low number of weeds in beds might be due to dry top surface of beds that inhibited the weed growth. In contrast, Tuong *et al.* (2004) differed with our findings. They reported that bed planting produced higher weed infestation. They suggested that bed planting increased diversity of weeds flora as a result of differing water regimes for weed germination and establishment. Our speculation is that the most of the crop-growing period, the furrow between beds in bed planting remained inundated that drastically reduced weeds in furrows. The profuse tillering of rice in beds also filled up the top of beds very rapidly keeping a little space for weed growth. Therefore, weed population and biomass yield was lower in beds than conventional planting method. Moreover, at the time of bed preparation, the top soil of the furrow was mulched to the beds, which reduced weeds in furrow. Weed density was reduced in bed compared to conventional planting because of without disturbance and with drier soil; few weeds were germinated or established.

4.4. Broadcasting fertilizer application in raised bed uses irrigation water efficiently over conventional flat method

The irrigation water saved 35% by the fertilizer broadcasting in bed planting over conventional flat method (Table 8). EL- Bably *et al*. (2008) reported that irrigation water applied were 1480 mm and 919 mm for traditional and bed planting respectively. So bed planting method saved 37.9% of irrigation water compared with traditional planting method. These results are in accordance with those reported by Atta (2005), Devivder *et al*. (2005), Atta *et al*. (2006) and Jagroop *et al*. (2007). Water use efficiency for grain and biomass production in bed planting were 57.22% and 52.69% higher over conventional planting method (Table 9). EL-Bably *et al.* (2008) also demonstrated that field water use efficiency (FWUE) of beds increased 65.8% more than traditional planting method .Similar results were reported by Velhaiya *et al*. (2003). Borell *et al.* (1997) found that water savings were 34% of bed planted rice compared to flooded rice. Bouman *et al.* (2007) reported that irrigation water savings of rice transplanted on beds about 37-40% compared to puddle flat transplanted rice. Connor *et al.* (2003) found that water savings of rice in bed planting was 42% over conventional planting. Talukder *et al.* (2010) demonstrated that the raised beds system saved water use by about 30% compared with conventional planting. Findings in this study are also confirmed by Cabangon *et al*. (2005). They reported that rice grown on raised beds reduced irrigation and total water input by as much as 200-500 mm, which amounts to a 20-45% reduction in total water input compared with well watered rice planting method. Thompson *et al*. (2003) found that irrigation water savings of about 14% using raised bed for growing rice compared to flat irrigation design. Beecher *et al*. (2005) demonstrated that total input water use for rice crop cultivation in raised bed was 18.1 $MLha^{-1}$ and 18.7 $MLha^{-1}$ in flat cultivation method. There are many reports of substantial irrigation water savings with rice on beds compared with continuously flooded flat transplanted rice. However, some studies suggest that where similar irrigation scheduling is used, irrigation water use of transplanted rice in beds and puddle flats is similar.

Further, Choudhury *et al.* (2007) reported that total water input (irrigation plus rainfall) varied from 930 mm (raised beds) to 1600 mm (flooded transplanted). Total water input in rice on raised beds was 38–4l % less than in flooded transplanted rice and 32–37% less than in flooded wet seeded rice. For comparison,

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Humphreys *et al.* (2005) reported that reductions in irrigation water use of 12–60% in transplanted or dry-seeded rice on raised beds compared with flooded transplanted rice. Hossain *et al.* (2004) demonstrated permanent bed (PB) reduced irrigation water use by 32% relative to conventionally tilled on the flat (CTF). Our speculation is that bed planting system involves growing rice on raised bed with a shallow water table (about 10 cm below the surface of the beds) by maintaining a shallow water depth in the furrows. The low percolation rates are attributed to shallow water table. This may resulted low water input by bed planting over conventional cultivation of rice. Another probable cause of allowing the soil in raised beds to dry out a little bit more reduced irrigation water inputs than conventional planting. Irrigation water advances faster in untilled soil (bed) than in a tilled soil (conventional) may be another cause of less water input in bed planting method. In addition, the application of fertilizer in bed planting facilitated root growth, which can extract soil moisture from deeper layers. Furthermore, application of fertilizers in raised bed facilitated early development of canopy that covers the soil and intercepts more solar radiation and there by reduces the evaporation component of the evapo-transpiration which contributed less water input in raised bed planting. Water surface have a higher evaporation rate than soil surface. Bed planting reduced the duration that the field flooded may also decreased the amount of evaporation. Bed planting maintained shallow water depth in rice field reduced the hydrostatic pressure which resulted less water loss through percolation.

5. CONCLUSIONS

This research demonstrated that fertilizer broadcasting in bed planting increased yield by 15.90% compared to fertilizer broadcasting in conventional planting for boro (winter, irrigated) rice. Raised bed produced higher panicle number, grains per panicle and thousand grain weights over conventional planting method. Better plant growth parameter of boro rice in bed planting was observed compared to conventional planting. Raised bed planting saved irrigation water by 35% as well as increased irrigation efficiency. Bed planting provided less weed density and dry biomass than conventional planting. These findings concludes that water use efficiency for grain and biomass production was higher in fertilizer broadcasting of bed planting than fertilizer broadcasting in conventional method. The agronomic efficiency of fertilizer was also significantly higher in fertilizer broadcasting of bed planting than the fertilizer broadcasting in conventional method. The potential gains from growing boro rice on raised beds are considered to be associated with better agronomic management than conventional method. It is likely that the raised bed technique will have long term soil physical benefits without sacrificing yield. The incorporation of fertilizer broadcasting in raised bed introduced a new boro rice based farming system offers many advantages. Based on the findings of this experiment, high yielding boro rice (winter, irrigated) crops have been successfully grown on raised bed under fertilizer broadcasting. There is a good prospect of utilization of this technology to benefit the rice farmers. More studies is needed to establish bed planting, a better planting method of boro rice cultivation in Bangladesh as well as other countries in the world. Further study will be conducted to determine the effect of foliar spray of split nitrogen fertilizer application on raised bed as compared to conventional cultivation practice.

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REFERENCES

[1]. Atta YIM, Meleha ME, Tallet A, and Gawish UM 2006 Improving water productivity in rice cultivation with high potential for water saving. The 3rd Arab world region conference, Cairo, 4-11 December, 2006.

[2]. Atta YIM 2005 Strip planting of rice: A new method for increasing water use efficiency under splitting of nitrogen fertilizer. Egyptian Journal of Applied Science **20 (10B)**: 501-511.

[3]. Aslam M, Hussain S, Rahzan M, and Akhter M 2008 Effect of different stand establishment techniques on rice yields and its attribures. Journal of Animal and Plant Science **18**: 21-26.

[4]. BBS 2011. Bangladesh Bureau of Statistics ,Government of the People's Republic of Bangladesh, Agriculture Wing,Parishankhyan Bhaban , E-27/A, Agargaon, Dhaka-1207.

[5]. Beecher G, Thompson JA, Dunn BW and Mathews SK. 2005 Permanent raised beds in irrigated farming systems in the Murrumbidgee / Murray Valleys of NSW.

[6]. Bhuyan MHM, Ferdousi MR and Iqbal MT 2012a Yield and growth response to transplanted aman rice under raised bed over conventional cultivation method. ISRN Agronomy (doi:10.5402/2012/646859).

[7]. Bhuyan MHH, Ferdousi, MR and Iqbal, MT 2012b Foliar spray of nitrogen fertilizer on raised bed increases yield of transplanted aman rice over conventional method. ISRN Agronomy (doi:10.5402/2012/184953).

[8]. Borell AK, Carsid AL, and Fukai S 1997 Improving efficiency of water use for irrigated rice in a semi-arid tropical environment. Field Crops Research **52**: 231-248.

[9]. Bouman BAM, Feng L, Tuong TP, Lu G, Wang H, Feng Y. 2007 Exploring options to grow rice under water short conditions in northern China using a modeling approach. II. Quantifying yield, water balance components and water productivity. Agricultural Water Management **88**:23-33.

[10]. Cabangon RJ, Tuong TP and Janiya. JD 2005 Rice grown on raised beds: effect of water regime and bed configuration on rice yield, water input and water productivity. Evaluation and performance of permanent raised bed cropping systems in Asia, Australia and Mexico edited by C.H. Roth, R.A. Fischer and C.A. Meisner ACIAR Proceedings No. 121 (printed version published in 2005).

[11]. Choudhury BU, Bouman BAM, and Singh A. K. 2007 Yield and water productivity of rice wheat on raised beds at New Delhi, India. Field Crops Research **100(2/3)**: 229-239.

[12]. Connor DJ, Timsina J, andHumphreys, E. 2003 Prospects for permanent beds in the rice wheat system. In Ladha JK, Hill JE, Duxbury JM, Gupta RK, and Buresh RJ (eds) 'Improving the Productivity and Sustainability of Rice-Wheat Systems: Issues and Impacts'. ASA Special Publication 65, 197–210. ASA Inc, CSSA Inc, SSSA Inc, Madison, USA.

[13]. Devinder S, Mahey RK, Vashist KK, and Mahal SS. 2005 Economizing irrigation water use and enhancing water productivity in rice (*Oryza sativa* L.) through bed/furrow planting. Environment and Ecology **23(3)**: 606-610.

[14]. El-Bably AZ, Meleha ME, Abd Allah AA and El-Khoby WM 2008 Increasing Rice Productivity, Water Use Efficiency, Water Saving and Rice Productivity in North Delta, Egypt. The 3rd International Conference on Water Resources and Arid Environments (2008) and the 1st Arab Water Forum.

[15]. Gupta RK , Naresh RK, Hobbs PR and Ladha JK 2002 Adopting conservation agriculture in the rice wheat system of the Indo- Gangetic Plains: new opportunities for saving water. In "water wise rice production". (Eds.BAM Bouman , H Hengsdijk , B hardy, PS Bindraban , TP Tuong , JK Ladha) Los Banos (Philippines): IRRI : 207-222.

[16]. Humphreys E, Gupta R, Meisner C, Timsina J, Beecher HG, Young LUT, Yadvinde-Sing, Gill MA, Zheng Jia Cuo and Tompson JA 2004 Water saving in rice wheat system .Plant Production Science **8(3)**: 231-241.

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Vol.3.Issue.1.2016 (January-March) ISSN:2455-0221(P), 2394-2606(O)
[17]. Humphreys E, Meisner C, Gupta R, Timsina J, Beecher HG, Lu TY, Yadvinder-Singh, Gill MA, Masih I, Guo ZJ, Thomposon JA. 2005 Water savings in rice-wheat systems. Plant Production Science **8**:242-258.

[18]. Hobbs PR, Gupta RK, Ladha JK and Balasubramanian V. 2000 Crop Establishment and Management: New Opportunities. Paper Presented at the International Workshop on Developing an Action Program for Farm-Level Impact on Rice-Wheat Systems of the Indo-Gangetic Plains. 25-27 September 2000. New Delhi, India.

[19]. Hossain MZ, Hossain SMA, Anwar MP, Sarker MRA and Mamun AA 2003 Performance of BRRI Dhan 32 in SRI and Conventional Methods and Their Technology Mixes. Pakistan Journal of Agronomy **2(4):** 195-200.

[20]. Hossain MIC, Meisner JM, Duxbury JG, Lauren MM, Rahman, MM, and Rashid M.H. 2004 Use of raised beds for increasing wheat production in rice-wheat cropping systems. 4th International Crop Science Congress.

[21]. Hossain MI, Karim SMR, Hossain MI, Islam MS, Mandal RI and Tiwary TP. 2012 Weed growth and grain yield in wheat and rice as affected by tillage system and weed management practices in rice-wheat cropping system in Bangladesh. Pakistan Journal of Weed Science Research **18:** 775-783, Special Issue, October, 2012.

[22]. Husain AMM., Chowhan G, Rahman ABMZ, Uddin R, and Barua P. 2004 Report on the system of rice intensification. PETRRA Technology Workshop, BRRI Auditorium, Gazipur. May 23-24. [http://ciifad.cornell.edu/sri/countries/bangladesh/ /bangpetechrep.pdf].

[23]. Jagroop K, Mahey RK,Vashist KK and Mahal SS.2007 Growth and productivity of rice (Oryza sativa L.) and water expense efficiency as influenced by different planting Techniques. Environment and Ecology **25(1):** 235-238.

[24]. Javaid T, Awan IU, Baloch MS, Shah IH, Nadim MA, Khan EA., Khakwani AA, and Abuzar MR 2012 Effect of planting methods on the growth and yield of coarse rice. The Journal of Animal & Plant Sciences**22(2):**358-362.

[25]. Karim, SMR. 2011 Weed growth and grain yield in wheat and rice as affected by tillage system and weed management practices in rice-wheat cropping system in Bangladesh. University of Malaysia Kelantan-Repository Files.URI:hppt://Umkeprint.Umk. edu.my/id/eprint/416.

[26]. Lauren J, Duxbury J, Meisner C, Hossain MI. 2013 Permanent raised beds for the rice wheat cropping system of South Asia. VIVO, Research & Expertise across Cornell, Cornell University.

[27]. Mollah MIU 2005 Effect of bed planting technique on the productivity and resource conservation in rice- wheat cropping system. Department of Agronomy, Bangladesh Agricultural University, Mymensingh, November- 2005.

[28]. Mishra JS 2004 Tillage and weed management - Technical Bulletin-I, National Research Centre for Weed Science, Jabalpur.

[29]. Nissanka SP, and Bandara T. 2004 Comparison of productivity of system of rice intensification and conventional rice farming systems in the dry-zone region of Srilanka. New directions for a diverse planet: Proceedings of the 4th International Crop Science Congress. Brisbane, Australia, 26 Sep. 1 Oct. [http://www.cropscience.org.au/icsc2004/poster/1/2/1177_nissankara.htm].

[30]. Paudel, MN. 1995 Nutrient management for Sulphan buri- 90 rice variety in acid sulfate soil with green leaf manure. M.Sc. Thesis, Asian Institute of Technology, Bankok, Thailand.

[31]. Samar S, Yadav A, Malik RK and Singh H 2002 Long term effect of zero tillage sowing technique on weed flora and productivity of wheat in rice wheat cropping zones of Indo Gangetic plains. In proceedings of International Workshop "Herbicide Resistance Management and Zero Tillage in Rice-Wheat Cropping System" held at CCS HAU, Hisar.

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[32]. Talukder ASMHM., Meisner C A, Sarkar MAR, and Islam MS. 2010 Effect of water management, tillage options and phosphorus rates on rice in an arsenic-soil-water system.19th World Congress of Soil Science, Soil Solutions for a Changing World, 1 – 6 August 2010, Brisbane, Australia.

[33]. Tompson J 1999 Methods for increasing rice water use efficiency workshop proceedings. Yanco (Australlia): CRC for Sustainable Rice Production: 45-46. Thompson J, Griffin D, and North, S. 2003. Improving the water use efficiency of rice. Final report Project No. 1204, Cooperative Research Centre for Sustainable Rice Production, Yanco, New South Wales.

[34]. Tuong TP 2003 Strategies for increasing water productivity in rice irrigation system: water saving irrigation technologies. In proceedings of the international conference on increasing water use efficiency in lowland rice cultivation . September 15-19, 2003. Iksan, Korea. Rural Development Administration, Republic of Korea: 39-65.

[35]. Tuong TP, Bouman BAM, and Mortimer M. 2004 More Rice, Less Water—Integrated Approaches for Increasing Water Productivity in Irrigated Rice-Based Systems in Asia. Crop Science- ICSC2004.

[36]. Vethaiya B, Ladha JK, Gupta KR, Naresh RK, Mehla RS and Yadvinder S 2003 Technology options for rice in the rice wheat system in South Asia. Improving the productivity and sustainability of rice wheat system: issues and impacts proceedings of an international symposium, USA, 22 October, 115-147.