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Research Article

Foliar Spray of Nitrogen Fertilizer on Raised Bed Increases Yield of Transplanted Aman Rice over Conventional Method

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Bed planting with foliar nitrogen fertilizer application of rice production systems is very new, and research on it is still at introductory phase. Influence of foliar application of nitrogen fertilizer on growth and yield of transplanted aman rice and evaluation of water and fertilizer application efficiency of rice-fallow-rice cropping system were investigated under raised bed cultivation method. Results showed that foliar spray in bed planting method increased grain yield of transplanted aman rice up to 9.33% over conventional method. Foliar nitrogen fertilizer application in bed planting method increased the number of panicle m^{-2}, number of grains $panicle^{-1}$, and 1000-grain weight of rice than the conventional method. Sterility percentage and weed infestation were lower at foliar nitrogen fertilizer application in bed planting method than the conventional method. Thirty-nine percent of irrigation water and time for application could be saved through foliar nitrogen spray in bed planting than conventional method. Water use efficiency for grain and biomass production was higher by foliar nitrogen fertilizer application in bed planting than conventional method. Likewise, agronomic efficiency of foliar nitrogen fertilizer application in bed planting method was higher than the conventional method. This study concluded that foliar nitrogen spray in bed planting method is a new approach to get fertilizer and water use efficiency as well as higher yield compared to existing agronomic practice in Bangladesh.

1. Introduction

Foliar spray of fertilizer did not only increase the crop yields but also reduced the quantities of fertilizer applied through soil. Foliar application can also reduce the lag time between application and uptake by the plant [1]. The use of foliar fertilizing in agriculture has been a popular practice within farmers since the 1950s, when it was learned that foliar fertilization was effective. Radioisotopes were used to show that foliar-applied fertilizers passed through the leaf cuticle and into the cells [2]. Various studies have shown that a small amount of nutrients (nitrogen, potash, or phosphate) applied by foliar spraying increases significantly the yield of crops [3–10].

In fact, foliar fertilization does not totally replace soil-applied fertilizer but it does increase the uptake and hence the efficiency of the nutrients applied to the soil. This application technique is especially useful for micronutrients but can also be used for major nutrients like N, P, and K basically because the amount applied at any time is small and thus it requires several applications to meet the needs of a crop. The increased efficiency reduces the need for soil-applied fertilizer, reduces leaching and run-off of nutrients, reducing the impact on the environment of fertilizer salts [11–13].

Little information is available about the effects of foliar nitrogen fertilizer application on yield and growth response of transplanted aman rice under raised bed over conventional method. Foliar application of nitrogen fertilizer may be the most effective means for maximizing yield of rice. Our previous study showed that water use efficiency and grain production were higher in raised bed than conventional cultivation method [14]. However, it was not considered for foliar spray of nitrogen fertilizer in raised bed than conventional method. Therefore, this study was undertaken to determine the effect of foliar nitrogen fertilizer spray on raised bed over conventional cultivation method. It was hypothesized that foliar fertilizer spray on raised bed receives higher fertilizer use efficiency and yield than conventional cultivation method.

2. Materials and Methods

2.1. Experimental Site and Soil. The experiment was conducted at the farmer's field in Chuadanga, Bangladesh, during transplanted aman rice growing period. The soil of the experiment plot was silt loam with pH 7.30.

2.2. Cultivator. The aman rice variety SORNO was used as an experimental crop, because this variety is widely using by the farmers in the experimental area.

2.3. Experimental Design. The experiment was laid out in a randomized complete block design with three replications. The combination of treatments was randomly distributed in the plots within a block. The unit plot size was 8 m^2 (4 m × 2 m).

2.4. Land Preparation. The land was prepared conventionally. The final land preparation was done by ploughing and cross-ploughing by two wheel power tiller with two laddering before two days of transplanting. One day before transplanting, the plots were laid out as per experimental design.

2.5. Bed Preparation. Raised bed and furrows were made manually by spade following the conventional land preparation. According to the treatments 60 cm (centre to centre of furrows) width bed was made. For the 60 cm bed, the top of the raised bed was 35 cm, and furrow between beds was 25 cm. The beds were made one day before transplanting the plots according to layout of the experiment. The heights of beds were 15 cm (Figure 1).

2.6. Fertilizer Application. The crop was fertilized with N, P, K, S, and Zn at the rates of 66, 5, 18, 6, and 0.5 kg ha^{-1}, respectively [15]. The sources of N, P, K, S, and Zn were urea, TSP, MP, gypsum, and $ZnSO_4$, respectively. All of the TSP, MP, gypsum, and $ZnSO_4$ were applied at the time of final land preparation as basal dose in the plots with conventional treatment. In the plots with bed planting treatments, the basal doses were applied before transplanting on the top of the beds. The urea was top dressed in three equal splits at 15, 30, and 50 days after transplanting (DAT) in conventional plot. The urea spray volumes were prepared by mixing 2 kg of urea in 100 L of water as per treatment. The foliar spray was 2% at 38 kg ha^{-1}. The plots were sprayed during late afternoon hours when wind speed was less than 10 km hr^{-1}.

2.7. Transplanting of Seedlings. Thirty-day-old seedlings were uprooted from the seedbed without making any injury to them and transplanted on the same day. Two to three seedlings hill^{-1} were transplanted maintaining row spacing of 25 cm and plant to plant spacing of 15 cm. Irrigation water was applied one day before transplanting between the furrows of bed to make the soil soft.

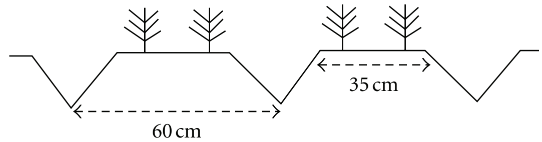

Figure 1: Two rows of rice on the top of the beds (TPR).

2.8. Irrigation. Though transplant aman rice was a rain fed crop, supplemental irrigation was needed for preparation of the plots with conventional treatment and for the bed planting of all plots. Another supplemental irrigation was done for all plots at flowering stage of rice.

2.9. Weeding. Manual weeding was done twice in the transplant aman 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.

2.10. Pest Control. The rice was infested by stem borer at tillering stage and by rice bug at grain filling stage. Furadan 5G at the rate of 10 kg ha^{-1} was applied at 40 DAS, and Malathion 57 EC 5G at the rate of 1 L ha^{-1} was applied at grain filling stage to control stem borer and rice bug, respectively.

2.11. Water Use Efficiency Calculation. Water use efficiency for grain and biomass production was calculated by the following equations:

$$\begin{aligned}
&\text{water use efficiency for grain production } \left(\text{kg ha}^{-1}\text{ cm}^{-1}\right) \\
&\quad = \frac{\text{grain yield } \left(\text{kg ha}^{-1}\right)}{\text{Irrigation required (cm)}} \\
&\text{water use efficiency for biomass production } \left(\text{kg ha}^{-1}\text{ cm}^{-1}\right) \\
&\quad = \text{grain yield } \left(\text{kg ha}^{-1}\right) + \frac{\text{straw yield } \left(\text{kg ha}^{-1}\right)}{\text{Irrigation required (cm)}}.
\end{aligned} \tag{1}$$

2.12. Crop Harvesting. Rice was harvested and threshed by using pedal thresher.

2.13. Agronomic Efficiency of Fertilizer. Agronomic efficiency (AE) of fertilizer was calculated by the following equation:

$$\text{AE} = \text{GY}_{\text{NA}} - \frac{\text{GY}_{\text{N0}}}{\text{N}_{\text{R}}}, \tag{2}$$

where GY_{NA} = grain yield (kg/ha) with addition of nutrient, GY_{N0} = grain yield (kg/ha) without addition of nutrient, and N_{R} = Rate of added nutrient (kg/ha).

2.14. Statistical Analysis of Data. The experiment was conducted by randomized complete block design replicated with three replications. All statistical analysis was conducted through t-test.

3. Results

3.1. Grain Yield and Yield Components. The yield increase by foliar spray in bed planting over conventional method was 9.33%. A similar finding was also found in panicles, grains per panicle, and 1000- grain wt (gm). Foliar spray in bed planting had more than 22 panicle number m^{-2}, 25-grain number per panicle, and 0.22 gm in 1000-grain wt than conventional method (Table 1).

3.2. Other Plant Attributes. Planting method affected plant height, panicle length, nonbearing tillers m^{-2}, sterility percentage, straw yield, and harvest index of rice. Plant height, panicle length, and harvest index were higher by foliar nitrogen fertilizer spray in bed planting than conventional method. On the contrary, nonbearing tillers m^{-2}, straw yield, and sterility percentage were higher in conventional method than foliar spray in bed planting. Likewise, lower number of nonbearing tillers m^{-2} was recorded by foliar spray in bed planting treatments than conventional method. Foliar spray in bed planting significantly reduced the sterility percentage compared to conventional method. In bed planting sterility was lower. The lower sterility might be accountable for higher grains in bed planting. Bed planting resulted in higher harvest index than conventional method (Table 2).

3.3. Tiller Production. Transplanting of aman rice under different planting method affected the number of tillers m^{-2} of rice. The increasing trend of tiller m^{-2} was continued to 50 DAT. At 50 DAT both foliar spray in bed planting method attained the highest number of tiller m^{-2} and then started declining up to 100 DAT. However, both method differ significantly ($P \leq 0.01$) from 20 to 100 days after transplanting (Table 3).

3.4. Leaf Area Index. Planting method affected the leaf area index (LAI) of transplant aman rice recorded at different days after transplanting (DAT). Plant-to-plant distance in rows also influenced the leaf area index measured at different stages of crop growth. The highest leaf area index was achieved at 60 DAT by foliar spray in bed planting method. After 60 DAT the leaf area index started to decline and continued to 100 DAT by foliar spray. It was also revealed that at early stage of crop growth the leaf area index by foliar spray in bed planting treatments was lower than conventional method. The highest LAI achieved in conventional method was 80 DAT. After 80 DAT the LAI started to decline and continued to 100 DAT by conventional method. However, LAI differs significantly ($P \leq 0.01$) between two methods from 20 to 40 DAT (Table 4).

3.5. Dry Matter Production. Planting method affected the dry matter production of transplanted aman rice recoded at different days after transplanting (DAT). In the first date of measurement (20 DAT), it was observed that the conventional method produced higher dry matter yield than foliar nitrogen spray in bed planting. Likewise, at the final date (100 DAT), highest dry matter production was also recorded in conventional method than foliar spray in bed planting method. However, dry matter production differs significantly ($P \leq 0.01$) at different days after transplanting (DAT) in both planting method (Table 5).

3.6. Crop Growth Rate. At the initial stage (20 to 40 DAT), the crop growth rate (CGR) by foliar spray in bed planting is lower than conventional method. The greatest crop growth rate was observed in 60 to 70 DAT by foliar spray in bed planting method. On the other hand the highest crop growth rate was observed in 50 to 60 DAT by conventional flat plot. The lowest CGR was observed at 20 to 30 DAT by both planting method. However, crop growth rate significantly ($P \leq 0.01$) differed between both planting methods at all DAT except 60 to 70 DAT (Table 6).

3.7. Weed Population. Weed population and dry biomass were greatly influenced by different planting methods of transplanted aman rice. The foliar spray in bed planting method reduced weed population resulting in lower dry biomass than conventional planting. The conventional method had significantly ($P \leq 0.01$) higher weed vegetation than raised bed method (Table 7).

3.8. Irrigation Water. Amount of water required for different irrigations differed remarkably between the conventional and bed planting methods. The conventional method received the higher amount of water at every irrigation, and total amount was 142.66 cm. The total amount of irrigation water received by foliar spray in bed planting was 102.47 cm. Result showed that total water saving by foliar spray in bed over conventional method was 39% (Table 8).

3.9. Water Use Efficiency. Water use efficiency for grain and biomass production by foliar spray in bed planting was 45.67 kg ha^{-1} cm^{-1} and 91.75 kg ha^{-1} cm^{-1}, respectively. In contrast, water use efficiency for grain production and biomass production in conventional planting was 30.63 kg ha^{-1} cm^{-1} and 65.11 kg ha^{-1} cm^{-1}, respectively. However, water use efficiency for grain production and biomass production by foliar spray bed planting over conventional was 49% and 40.88%, respectively (Table 9).

3.10. Agronomic Efficiency of Fertilizer. Agronomic efficiency of fertilizer (AE) by foliar spray in raised bed was 93.82%. On the other hand AE for conventional planting was 43.67%. Agronomic efficiency of fertilizer by foliar spray in raised bed was significantly ($P \leq 0.01$) higher than the conventional planting method (Table 10).

Table 1: Grain yield and yield components with respect to foliar spray in bed and conventional method.

Method of fertilizer application	Yield and yield components			
	Grain yield (t ha^{-1})	Panicles m^{-2} (no)	Grains $panicle^{-1}$ (no)	1000-grain wt (gm)
Foliar spray of fertilizer in raised bed	4.68	298a	165a	23.10
Fertilizer broadcasting in conventional planting	4.37	276b	140b	22.88
LSD at 5%	0.26	3.34	4.98	1.32
Level of significance	n.s.	**	**	n.s.

Where ** represents probability of ≤0.01 and n.s. represents probability of >0.05. Values were means of three replicates. In a column figures with same letter do not differ significantly whereas figures with dissimilar letters differ significantly ($P \leq 0.01$).

Table 2: Plant biomass with respect to foliar spray in raised bed and conventional method.

Method of fertilizer application	Plant height (cm)	Panicle length (cm)	Nonbearing tiller (no·m^{-2})	Sterility (%)	Straw yield (t ha^{-1})	Harvest index
Foliar spray of fertilizer in raised bed	91.34a	24.67	46b	9.28b	4.72	0.49
Fertilizer broadcasting in conventional planting	86.38b	24.30	59a	12.41a	4.92	0.47
LSD at 5%	1.57	0.33	2.07	0.46	0.21	0.00
Level of significance	**	n.s.	**	**	n.s.	n.s.

Where ** represents probability of ≤0.01 and n.s. represents probability of >0.05. Values were means of three replicates. In a column figures with same letter do not differ significantly whereas figures with dissimilar letters differ significantly ($P \leq 0.01$).

Table 3: Effect of tiller production by foliar spray in raised bed and conventional method.

Method of fertilizer application	Tiller (no·m^{-2}) at days after transplanting								
	20	30	40	50	60	70	80	90	100
Foliar spray of fertilizer in raised bed	73b	171b	309b	302b	296b	291b	287b	282b	279b
Fertilizer broadcasting in conventional planting	88b	205a	371a	363a	354a	349a	344a	339a	336a
LSD at 5%	2.07	2.07	9.44	3.34	4.63	13.09	2.07	2.62	2.07
Level of significance	**	**	**	**	**	**	**	**	**

Where ** represents probability of ≤0.01 and n.s. represents probability of >0.05. Values were means of three replicates. In a column figures with same letter do not differ significantly whereas figures with dissimilar letters differ significantly ($P \leq 0.01$).

Table 4: Effect of leaf area index by foliar spray in raised bed and conventional method.

Method of fertilizer application	LAI at different DAT				
	20	40	60	80	100
Foliar spray of fertilizer in raised bed	0.175b	2.38b	5.32	5.05	3.83a
Fertilizer broadcasting in conventional planting	0.38a	2.47a	4.92	4.97	3.78b
LSD at 5%	0.001	0.001	0.31	0.04	0.00
Level of significance	**	**	n.s.	n.s.	*

Where *, **, and n.s. represent probability of ≤0.001, ≤0.01, and >0.05, respectively. Values were means of three replicates. In a column figures with same letter do not differ significantly whereas figures with dissimilar letters differ significantly ($P \leq 0.01$).

Table 5: Effect of dry matter production by foliar spray in raised bed and conventional method.

Method of fertilizer application	Dry matter production (g m^{-2}) at different days after transplanting (DAT)								
	20	30	40	50	60	70	80	90	100
Foliar spray of fertilizer in raised bed	36b	90b	242b	383a	576b	802b	913b	1094b	1198b
Fertilizer broadcasting in conventional planting	64a	127a	251a	350b	621a	851a	1062a	1190a	1260a
LSD at 5%	2.07	2.07	2.07	4.98	19.63	2.07	15.18	5.93	4.98
Level of significance	**	**	**	**	*	**	**	**	**

Where * and ** represent probability of ≤0.001 and ≤0.01, respectively. Values were means of three replicates. In a column figures with same letter do not differ significantly whereas figures with dissimilar letters differ significantly ($P \leq 0.01$).

Table 6: Effect of crop growth rate by foliar spray in raised bed and conventional method.

Method of fertilizer application	Crop growth rate ($g\,m^{-2}\,day^{-1}$) at different days after transplanting (DAT)							
	20–30	30–40	40–50	50–60	60–70	70–80	80–90	90–100
Foliar spray of fertilizer in raised bed	5.4b	15.2a	14.1a	19.3b	22.6	11.1b	18.1a	10.4a
Fertilizer broadcasting in conventional planting	6.3a	12.4b	9.9b	27.1a	23	21.1a	12.8b	7b
LSD at 5%	0.46	0.41	0.13	0.29	1.87	0.13	1.03	1.00
Level of significance	*	**	**	**	n.s.	**	**	**

Where *, **, and n.s. represent probability of ≤0.001, ≤0.01, and >0.05, respectively. Values were means of three replicates. In a column figures with same letter do not differ significantly whereas figures with dissimilar letters differ significantly ($P \leq 0.01$).

Table 7: Effect of weed growth by foliar spray in raised bed and conventional method.

Method of fertilizer application	Weed vegetation	
	Weed vegetation population ($no \cdot m^{-2}$)	Dry biomass ($kg\,ha^{-1}$)
Foliar spray of fertilizer in raised bed	115b	107.8b
Fertilizer broadcasting in conventional planting	380a	337a
LSD at 5%	4.72	2.75
Level of significance	**	**

Where ** represents probability of ≤0.01. Values were means of three replicates. In a column figures with same letter do not differ significantly whereas figures with dissimilar letters differ significantly ($P \leq 0.01$).

4. Discussion

4.1. Foliar Spray in Bed Planting Method Produces Higher Biomass and Yield Than Conventional Method. The number of panicles m^{-2} was significantly ($P \leq 0.01$) higher in bed planting over conventional method. The difference of panicles number was 22 m^{-2} between these methods (Table 1). Bed planting method produced significantly ($P \leq 0.01$) higher grains panicle than conventional method. Likewise, Borrell et al. [16] found that panicles number m^{-2} in rice plant for raised bed planting and flooded method was 228 and 210, respectively. They also found that panicle number per plant in raised bed and flooded methods was 2.3 and 2.0, respectively. They speculated that the raised bed method has the potential to better utilize water and nutrients than conventional methods. This may result in higher panicle number per plant by foliar spray in raised bed than conventional method.

Planting method showed significant ($P \leq 0.01$) effect on plant height of transplant aman rice. Foliar spray in bed planting attends significantly higher plant height than conventional method. The lower plant height in conventional method indicated that the poor growth of plant might influence the grain yield and yield components. Likewise, planting method significantly influenced the number of nonbearing tillers of transplanted aman rice. Foliar spray in bed planting treatments irrespective of bed widths and plant rows per bed significantly ($P \leq 0.01$) reduced nonbearing tillers as compared to the conventional method. Similarly, planting method also affected sterility percentage of transplant aman rice. From the data presented in Table 2, it was revealed that foliar spray in bed planting system greatly reduced the sterility of transplanted aman rice compared to the conventional method. The low sterility in bed planting system might be the basis of higher grains panicle^{-1}, which directly added the grain yield. The results presented in Table 2 showed that the higher harvest index (HI) was obtained by foliar spray in bed, and lower HI was obtained by conventional method. The higher and lower HI resulted due to higher and lower grains yield.

Foliar spray in bed planting method had 0.31t ha^{-1} higher rice production over conventional method (Table 1). The yield increased by bed planting in transplant aman rice compared to conventional method was also reported by Hobbs and Gupta [17], Balasubramanian et al. [18], Meisner et al. [19], and Jat and Sharma [20]. Likewise, Tang et al. [21] also reported that bed planting method significantly increased rice yield by 6.7% compared with traditional cropping technique. Moreover, Ockerby and Fukai [22] confirmed that yields of rice grown on raised beds were greater than rice grown in conventional method. They advised that effective N fertilizer utilized by rice paddy plants influenced better rice production in raised bed system. Another study speculated that potential agronomic advances of beds include improved soil structure due to reduced compaction through controlled trafficking and reduced water logging condition is responsible for improved rice production [23].

Weight of 1000 grains was also higher in foliar spray in bed planting than conventional method (Table 1). Yadav et al. [24], Zhongming and Fahong [25], and Meisner et al. [19] reported similar results. Likewise, Choudhury et al. [26] found that 1000 grains per g in flat bed and raised bed were 20.0 and 20.5, respectively. They speculated that higher grain production in raised bed than flat method could be due to management and geometry of bed, less weed population, and better crop establishment.

4.2. Foliar Spray in Bed Planting Method Has Less Weed Growth Than Conventional Method. Weed production was

Table 8: Irrigation water savings by foliar spray in bed planting of rice production over conventional method.

Method of fertilizer application	Water required at different times of irrigation (cm)					Water saved over conventional method (%)
	Land preparation	Transplanting	Reproductive stage	Rainfall	Total	
Foliar spray of fertilizer in raised bed	—	6.35	43.62	52.50	102.47b	
Fertilizer broadcasting in conventional planting	13.06	6.20	70.90	52.50	142.66a	39%
LSD at 5%	—	0.37	0.00	1.03	2.62	
Level of significance	n.s.	n.s.	n.s.	n.s.	**	

Where ** and n.s. represent probability of ≤0.01 and >0.05. Values were means of three replicates. In a column figures with same letter do not differ significantly whereas figures with dissimilar letters differ significantly ($P \leq 0.01$).

Table 9: Water use efficiency by foliar spray in raised bed and conventional method.

Method of fertilizer application	Water use efficiency savings by foliar spray in bed planting of rice over conventional method	
	Water use efficiency for grain production (kg/ha·cm)	Water use efficiency for biomass production (kg/ha·cm)
Foliar spray of fertilizer in raised bed	45.67a	91.73a
Fertilizer broadcasting in conventional planting	30.63 b	65.11b
LSD at 5%	1.85	5.04
Level of significance	**	**

Where ** represents probability of ≤0.01. Values were means of three replicates. In a column figures with same letter do not differ significantly whereas figures with dissimilar letters differ significantly ($P \leq 0.01$).

Table 10: Agronomic efficiency of fertilizer by foliar spray in bed and conventional plot.

Method of fertilizer application	Agronomic efficiency of fertilizer (%)
(i) Foliar spray of fertilizer in raised bed	93.82a
(ii) Fertilizer broadcasting in conventional planting	43.67b
LSD at 5%	5.26
Level of significance	**

Where ** represents probability of ≤0.01. Values were means of three replicates. In a column figures with same letter do not differ significantly whereas figures with dissimilar letter differ significantly ($P \leq 0.01$).

significantly ($P \leq 0.01$) lower in foliar spray in bed planting than conventional method. Likewise, existing weed vegetation was significantly ($P \leq 0.01$) lower in raised bed planting than conventional method (Table 7). Singh et al. [27] found that total weed dry weight and weed density were lower in raised bed planting method as compared to conventionally puddle transplanted rice. Similarly, Singh et al. [28] also found lower weed biomass in raised beds than the conventional method. They speculated that the low number of weeds in beds might be due to dry top surface of beds that inhibited the weed growth. However, our speculation is that, at the time of bed preparation, the top soils of the furrows were mulched to the raised beds, which drastically reduced the weeds in furrow. Another probable cause was that the soil was not disturbed in the zero tillage systems under bed planting method. Another speculation is that this difference of weed growth between bed planting and conventional method may be due to agronomic management practices. In bed planting method, rice plants were grown in wet conditions while in conventional methods, rice plants were grown under standing water condition. This difference in weed growth between these two methods could also have been due to the contrasting weed flora and soil moisture conditions of fields. Likewise, Hobbs [29] opined that bed planting method reduces weed growth compared with conventional flat-bed planting method. He also suggested that bed planting provides additional options to farmers for controlling weeds. Similarly, Jat et al. [30] suggested that planting of crops on raised bed systems reduces weed competition over conventional method. By adopting raised bed system, fertilizers are banded close to the rows enhancing crop accessibility to nutrient and competitiveness over weeds. The higher fertilizer use efficiency through better placement of fertilizer and faster drying of the top portion of raised bed is responsible for reduced infestation.

4.3. Input Water Use. The differences in total water use between these two methods were 39% higher in conventional over foliar spray in bed planting method for the entire cropping period (Table 8). Similarly, Thompson et al. [31] grew rice on both raised beds and flat layout in small plots. They found that irrigation water savings were of about 14% using beds compared with flat layout. Studies in the USA have also shown considerable water saving with furrow-irrigated rice on raised bed over conventional flooding method [32]. Likewise, Beecher et al. [33] found that water use in flat and raised bed methods was 18.7 and 15.1 ML ha^{-1}, respectively. They recommended that there is a good scope for saving water while maintaining yield on suitable rice soil through the use of raised beds. In another study, Boulala et al. [34] speculated that, compared to conventional method, the introduction of the raised bed planting system resulted in higher soil resistance to the penetration in the upper soil profile. This may protect deep percolation of irrigation water in the field. Regardless of that, Fahong et al. [35] suggested that the better performance of raised bed over conventional methods was considered to be due to reduced water logging, improved soil physical properties, reduced lodging, and decreased incidence of disease. However, our speculation is that the advantages come from the fact that irrigation water advances faster on bed planting soil than in a tilled soil and less water percolation loss in bed planting method over conventional method.

5. Conclusion

This study concludes that foliar spray in raised beds increased rice yield by 9.33% when compared with conventional tillage on the flat. Raised bed also reduced irrigation water requirement by 39% as well as increased irrigation efficiency. This finding concludes that water use efficiency for grain and biomass production was higher in foliar spray in bed planting than by the conventional method. The agronomic efficiency of fertilizer was also significantly higher in foliar spray of bed planting than the conventional method. The potential gains from growing rice production on raised beds are considered to be associated with better agronomic management than conventional method. Also, the crust problem on the soil surface was eliminated and soil physical status was greatly improved in bed planting plot over conventional flat system.

Based on the findings of this single season experiment, high yielding aman rice (depends on both irrigation and rainfall) crops have been successfully grown on raised bed under foliar spray; however, this research needs further validation. In this perspective, further study is under way to investigate yield and growth response of transplanted boro rice (completely depends on irrigation) under conventional and foliar spray on bed planting method.

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