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ESTABLISHED RICE RATOON FOR IMPROVING CROPPING INTENSITY AND INCOME

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Abstract

Transplanted *aman* rice suffers from frequent flash flood damage in northern Bangladesh and thus grain yield decreases. An experiment was conducted at the RDRS Farm, Rangpur, Bangladesh to evaluate production opportunity and income generation from growing ratoon rice in between *boro* and *aman* seasons during May to July in fallow land as additional harvests. Ratoon seedlings of ACI-2 *boro* hybrid rice was transplanted and tested against the performance of conventional transplanted BR11 and BRRI dhan46. BR11 gave higher grain yield and profit than ratoon cropping. However, ratoon crop required only 75-80 days for maturity. Thus, it would be possible to incorporate rice ratoon cropping in fallow lands immediately after harvest of *boro* rice in April-May as additional crop. After harvests of the ratoon rice, farmers can grow traditional *aman* varieties as conventional practice. If ratoon of ACI-2 (hereafter ratoon rice)-BRRI dhan46 cropping system is practiced then total grain yield from the system was 8.42 t ha^{-1}, which was almost double than conventional BR11 or BRRI dhan46 cultivation. Total net income of *boro* and ratoon rice-BRRI dhan46 system was also higher (Tk 55,090 ha^{-1}) compared to traditional BR11 *aman* rice cultivation (Tk 35,802 ha^{-1}). The overall result indicated that just immediate after *boro* rice harvests, growing rice from ratoon seedlings of ACI-2 followed by BRRI dhan46 in *aman* season provided higher net profit than traditional cultivation of BR11. The result also implies that growing rice by using ratoon seedlings can ensure three harvests (*boro* rice-ratoon rice-*aman* rice) in the same year instead of growing two traditional rice (*boro* rice-*aman* rice) crops in a year with additional net profit of Tk 19,288 ha^{-1} $year^{-1}$. Moreover, use of rice ratoon seedlings might help farmers in intensification of crop in flash flood prone areas of the country.

Keywords: Profitability, ratoon tillers, lean season, productivity.

Introduction

Rice, a principal food crop, plays an important role in Bangladesh in terms of food security. Its demand is also increasing because of increased total population in the country. This principal crop grows almost year-round and faces different natural calamities of variable intensities. The damages from natural disasters have been increased because of climate change (CC) impacts. The effects of climate change have greatly endangered the farmlands in recent years in Bangladesh. The frequency of flood has increased in recent years (Biswas

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et al., 2019) and it destroys rice crop partially or completely in almost every year, especially in late August to early September. This late flood reduces *aman* rice (monsoon rice) yield seriously and sometimes food crisis become unavoidable for the marginal farmers. To overcome food deficit, there remains no way but to increase food production. Growing additional rice crop from ratoon seedlings of *boro* rice can play an important role under such situations.

Rice ratooning is not a new practice with farmers. Its usefulness has been studied in many countries such as India, United State of America, the Philippines, China, Swaziland, Thailand and Taiwan (Nakano and Morita, 2007). The main reasons of nurturing rice ratoon are the reduction in growth duration, less labor and water requirements than the main crop (Oad *et al.,* 2002; Negalur *et al*., 2017). Actually, the advantage of rice ratooning in some areas could be an avenue of additional returns. Besides, the cultivable land is decreasing over the years (Kabir *et al*., 2015) because of urbanization and industrialization indicating that it is not possible to increase rice cultivation area in Bangladesh but possible to increase per unit production sustainably.

Agricultural sustainability is based on the principle that our present need should be met without compromising the needs of the future generations. This indicates that the quality of land and natural resources are to be maintained or improved. We have to use them in such a way that it can be utilized sustainably in future. Moreover, social, economic and environmental sustainability are the necessary components of true sustainable agriculture (Brodt *et al*., 2011). Although natural resources are declining in many parts of the country because of intense cropping along with labor and energy crisis for modern agriculture, we have to produce more rice to feed our people. Rice ratooning (Negalur *et al*., 2017) could be one of the avenues of increased rice production. The production cost of rice ratooning is lower than that of the main crops due to the minimized cost for land preparation, transplantation, crop maintenance, and grain yield could be 50% of the main crops (Bollich *et al*., 1988; Sarian, 2013). We hypothesize that rice production could be improved in northern Bangladesh through rice ratooning.

It was found that about 30-64% of total cultivable lands in northern region of Bangladesh are cultivating rice twice in a year. One is irrigated rice (*boro* season) and other one is transplanted *aman*. Farmers usually transplant *boro* seedlings in late December to January and harvest in mid-April to early May, and they generally transplant *aman* rice in the same land at the end of July. The period between *boro* and *aman* rice remains fallow for two and a half months. Farmers may utilize this period by growing any suitable crop depending on land type and family demand. Growing ratoon rice (transplanting ratoon tiller), a prospective technology for providing three harvests (*boro*–ratoon rice–*aman*) in a year. Therefore, this study was conducted to find out the performance of ratoon – seedling transplanted rice in comparison to normal rice cropping, and also the profitability of *boro*-ratoon rice-*aman* cropping system.

Materials and Methods

Ratoon rice seedlings transplanting

Within 3 to 5 days of harvesting irrigated *boro* rice in late April to May, new tillers developed from the left-out rice plants. They were allowed to grow for 10-15 days followed by separation of the nodes and transplanted as seedlings in the study plot. A medium high land was selected as flood free land for conducting the experiment.

Field plot management

The experiment was conducted at the RDRS (a development NGO) Farm, Rangpur, Bangladesh in 2016 and 2017. In 2016, the experiment was laid out in a randomized complete block design (RCBD) with five replications. The unit plot size was 5 m×5 m. Fertilizer rate was selected based on existing literature (Islam *et al*., 2014) with slight modifications. During land preparation, fertilizers were applied at 50, 80, 45 and 5 kg ha^{-1} as TSP, MoP, Gypsum and Zinc sulphate, respectively along with 3,000 kg ha^{-1} cow dung.

The *boro* rice variety ACI-2 was harvested on 5 May 2016 and ratoon rice tillers (ACI-2) was planted on 22 May 2016. Three to four ratoon tillers per hill were transplanted like rice seedlings at of 25×15cm spacing. After 10-15 days of planting, the short and thin panicle emerged from the ratoon tillers, which were removed with scissors. Urea was top dressed twice at the rate of 85 kg/ha at 10 days and 30 days of planting ratoon tillers. The field was maintained weed free for first 40 days of planting. Generally, there was sufficient rainfall during this period and no irrigation water was provided. Need based supplementary irrigation was provided in the seedbed. Expected panicles began to come out after 40 to 45 days of ratoon tillers planting. The crop was ready to harvest at 75 to 78 days after planting.

In the same way, 35-day-old seedlings of BR11 were transplanted on 27 July 2016 as per conventional practices followed by the farmers. Urea was top dressed twice at the rate of 85 kg ha^{-1} at 15 days and 40 days of planting. The field was maintained weed free for first 50 days of planting.

In 2017, the same experiment was repeated but with one additional treatment to accommodate BRRI dhan46. Similar to first season trial, ratoon rice was established on 18 May 2017. BR11 rice plot was established on 29 July 2017 as a conventional practice in *aman* season.

The ratoon rice seedlings were harvested on 05 August 2017 and in the same plot BRRI dhan46 was transplanted on 09 August 2017 as a conventional system in wet season (*Kharif-II*). Ten hills were collected from each treatment for determination of yield components. Grain and straw yields were recorded on whole plot basis. Grain moisture was measured by Satake moisture meter and grain yields were adjusted at 14 moisture content. Straw yields were recorded after repeated sun drying at constant weight. Economic analysis was done to find out income of ratoon rice cropping compared to traditional rice culture and calculated marginal rate of returns. Labor price was fixed based on contract, though it is much lower than conventional labor marketing. Moreover, fixed cost was not considered because it is applicable both for the ratoon and conventional rice cultivation methods.

Statistical analysis

Yield and yield component data were analyzed for analysis of variances in CropStat for Windows (http://bbi.irri.org/products). Means were compared following LSD at 5% level of probability.

Results and Discussion

Performance of ratoon rice and traditional rice in 2016

Yield and yield components of ratoon rice and BR11 did not vary significantly (Table 1) indicating that transplanting of ratoon rice seedlings can provide satisfactory grain yield compared to conventionally grown rice culture. Moreover, growing rice in between *boro* and *aman* seasons can ensure somewhat food security even if *aman* rice is partially or fully damaged because of flash flood, which generally occur in low lying areas of Bangladesh. However, BR11 gave statistically insignificant higher grain (4.81 t ha^{-1}) and straw (5.01 t ha^{-1}) yields compared to ratoon rice. Almost similar grain yield of BR11 was reported by Rahman *et al.* (2008). The relatively better performance of BR11 in *aman* season was due to higher number of tillers hill^{-1} (13), higher number of panicles hill^{-1} (12), higher number of grains in a panicle (157) and lower number of sterile spikelet panicle^{-1} (30). Sadeghi (2011) and Ranawake *et al*. (2013) observed that the number of effective tillers and number of grain panicle had direct effect on grain yield per plant. Faruq *et al*. (2014) also reported that grain yield per plant was significantly and positively correlated with number of tillers hill, number of effective tillers per hill, grains panicle and thousand-grain weight.

Economic analysis of ratoon rice and BR11 in 2016

The economic analysis of ratoon rice production as compared with traditional BR11 rice cultivation is shown in (Table 2). Production cost of conventionally cultured BR11 was Tk 38,124/- ha^{-1}. On the other hand, it was Tk 37,890/- ha^{-1} for ratoon rice. Total gross income of BR11 in *aman* season from grain and straw was Tk 77,225 ha^{-1}, where total net profit was Tk 39,101/-. In the same way, the total gross income of ratoon rice from grain and straw was Tk 69,400/-, and total net profit was Tk 31,510/-. So, it is found that the net benefit of BR11 in *aman* season as traditional rice culture was higher (Tk 39,101/-) compared to ratoon rice (Tk 31, 510/-). As economic return depends on grain and straw yields mainly, net profit was also affected. Surek (2002) and Ghosh *et al.* (2004) mentioned that effective tillers number

Table 1. Yield and yield components of ratoon rice and BR11 rice variety in 2016

Treatment	Plant height (cm)	Tiller hill^{-1} (no.)	Panicle hill^{-1} (no.)	Grains panicle^{-1} (no.)	Sterile spikelet panicle^{-1} (no.)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Ratoon rice (ACI-2)	94.16	11	11	144	34	4.35	4.15
BR11	104.72	13	12	157	30	4.81	5.00
LSD (0.05)	10.67	1.97	2.99	39.99	5.96	0.73	1.40
CV (%)	9.50	6.10	15.10	15.20	10.70	9.10	17.50

Table 2. Cost of production, income and net profit in growing BR11 as conventional culture and ACI-2 as ratoon rice in 2016

Items A. Cost of production (Tk ha^{-1})	Ratoon crop	Conventional culture
1. Rice seeds 37 kg × Tk 45 kg^{-1}	-	1665/-
2. Tiller separation (75 labors × Tk 100 $labor^{-1}$ and planting	9970/-	-
3. Seedbed preparation, seeding and nursing seedbed	-	1235/-
4. Main land preparation (including rent of power tiller)	4947/-	4940/-
5. BRRI recommended fertilization (basal dose)	7320/-	7410/-
6. Seedlings up-rooting and transplantation	-	3708/-
7. Unexpected panicle cutting	2470/-	-
8. 1st top-dress of urea	1034/-	1037/-
9. 2nd top-dress of urea	1034/-	1037/-
10. 3rd top-dress of urea	-	1037/-
11. Pesticides and herbicides spray	1235/-	2470/-
12. Supplementary irrigation	1235/-	2470/-
13. Weeding	2470/-	4940/-
14. Harvesting, carrying, threshing, cleaning, sun drying and storing	6175/-	6175/-
Total cost	37,890/-	38,124/-
B. Income		
Grain yield (kg ha^{-1})	4,350/-	4,815/-
Grain price (Tk kg^{-1})	15/-	15/-
Income from grain (Tk.)	65,250/-	72,225/-
Straw yield (kg ha^{-1})	4,150/-	5,000/-
Income from straw (Tk. 1 kg^{-1})	4,150/-	5,000/-
Total income (Grain & Straw)	69,400/-	77,225/-
C. Net profit (B –A)	31,510/-	39,101/-

and grain number per $panicle^{-1}$ affected by the environmental and cultivation factors which have great effect on grain yield. Significant positive correlation of grain yield per plant was observed with most of the yield related traits in main and ratoon crop (Faruq *et al*., 2014). Oad *et al*. (2002) observed fewer effective tillers in ratoon crop compared to main crop.

Performance of ratoon rice based cropping and conventional rice culture in 2017

Grain and straw yields of rice were significantly affected by rice culture techniques (Fig. 1). Cultivation of ratoon rice followed by BRRI dhan46 in the same year gave in total 8.42 t ha^{-1} grain yield and 9.05 t ha^{-1} straw yields compared to BRRI dhan46 (grain 4.32 t ha^{-1} and straw 4.65 t ha^{-1}) and BR11 (grain 4.81

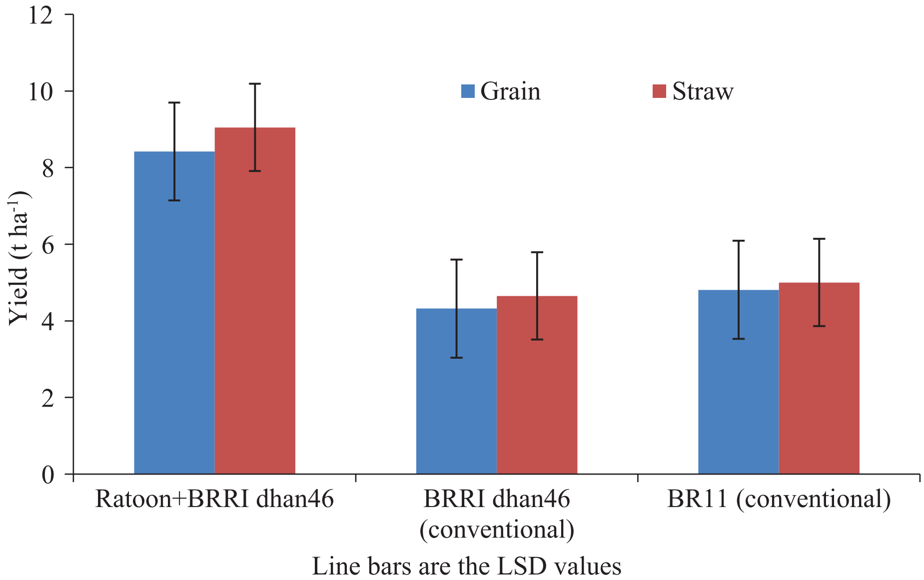

Fig. 1. Grain and straw yields as influenced by ratoon and conventional rice cropping.

t ha^{-1} and straw 5.00 t ha^{-1}) as conventional culture. Das *et al.* (2009) reported almost similar results. Such high yield is highly desirable when our food demand is increasing in Bangladesh.

Economic analysis of ratoon rice and conventionally cultured rice in 2017

Production costs and net profits for growing rice in ratoon and conventional culture are shown in Table 3. Total costs of production were 42,365/-, 37,840/-, 41,298/- and 80,205/-Tk ha^{-1} for ratoon rice cropping, conventionally grown BRRI dha46 and BR11 and ratoon rice-BRRI dhan46 double cropping system, respectively. The corresponding net profits were 23,540/-, 31,550/-, 35,802/- and 55,085/- Tk ha^{-1}, respectively. These results showed that growing double rice (ratoon rice-BRRI dhan46) is the most profitable one followed by conventionally cultured BR11 and BRRI dhan46. The least profit was obtained from ratoon rice-based cropping as single venture in a season. Our findings clearly indicate that ratoon-BRRI dhan46 (double rice) system can be disseminated as technology for improving rice productivity in Rangpur regions, where flash flood damages *aman* rice crop frequently.

The additional cost per hectare for ratoon rice-BRRI dhan46 system was Tk 37,840/- where total cost was Tk 80,205/- compared with ratoon rice production cost (Tk 42,365/-). The value of rice under ratoon rice-BRRI dhan46 system as double crop was increased by Tk 55,090/- due to an additional grain yield (4.3 t ha^{-1}) and straw yield (4.65 t ha^{-1}) compared to ratoon rice alone. It is shown that the marginal rate of return was higher with ratoon-BRRI dhan46 system (183%) as compared with only ratoon rice.

Table 3. Cost of production, income and net benefit of growing rice under ratoon rice and conventional system

Items A. Cost of production	Ratoon rice (ACI-2)	BRRI dhan46 conventional	BR11 Conventional	Ratoon-BRRI dhan46 system
1. Rice seeds 37 kg × Tk. 48	-	1,776/-	1,776/-	1,776/-
2. Tiller separation (75 labors × Tk.120) partial time	9,000/-	-		9,000/-
3. Seedbed preparation, seeding the seeds and nursing the seedbed	-	1,450/-	1,450/-	1,450/-
4. Main land preparation including rent of power tiller	6,100/-	6,100/-	6,100/-	12,200/-
5. Basal Fertilizer doses (BRRI recommendation)	7,415/-	7,415/-	7,415/-	14,830/-
6. Seedlings up-rooting and transplantation	-	5,074/-	5,074/-	5,074/-
7. Tiller transplantation (*Kushi*)	3,700/-	-	-	3,700/-
8. Unexpected flower cutting	2,960/-	-	-	2,960/-
9. 1st time urea top-dress	1,100/-	1,100/-	1,100/-	2,200/-
10. 2nd time urea top-dress	1,100/-	1,100/-	1,100/-	2,200/-
11. 3rd time urea top-dress	-	-	1,100/-	-
12. Pesticides and Herbicides spray	1,850/-	1,850/-	2,588/-	3,700/-
13. Supplementary irrigation	-	1,850/-	2,470/-	1,850/-
14. Weeding	2,965/-	3,950/-	4,950/-	6,915/-
15. Rice harvesting, carrying, threshing, cleaning, sunning and storing	6,175/-	6,175/-	6,175/-	12,350/-
Total cost ((Tk. ha^{-1})	42,365/-	37,840/-	41,298/-	80,205/-
B. Income				
Grain yield (Tk ha^{-1})	4.1/-	4.3/-	4.8/-	8.4/-
Grain price (Tk kg^{-1})	15/-	15/-	15/-	15/-
Income from grain (Tk ha^{-1})	61,500/-	64,740/-	72,000/-	126,240/-
Straw yield (kg ha^{-1})	4.4/-	4.6/-	5.1/-	9.0/-
Straw price (Tk kg^{1})	1/-	1/-	1/-	1/-
Income from straw (Tk ha^{-1})	4,400/-	4,650/-	5,100/-	9,050/-
Total income	65,900/-	69,390/-	77,100/-	135,290/-
C. Net profit (B-A)	23,540/-	31,550/-	35,802/-	55,085/-

Marginal Rate of Return (MRR)

Treatments	Marginal Cost	Marginal Income	MRR (%)
Ratoon rice vs ratoon-BRRI dhan46 system	37,840/-	69,390/-	183
BRRI dhan46 vs ratoon-BRRI dhan46 system	42,365/-	65,900/-	156
BR11 vs ratoon-BRRI dhan46 system	38,907/-	58,190/-	150

The additional cost per hectare of ratoon rice-BRRI dhan46 system was Tk 42,365/- where total cost was Tk 80,205/- compared with BRRI dhan46 production cost as Tk 37,840/-. The value of rice under ratoon rice-BRRI dhan46 system as double crop was increased by Tk 55,090/- compared to BRRI dhan46 alone. It is also found that the marginal rate of return was higher with ratoon rice-BRRI dhan46 system (156%) as compared with only BRRI dhan46.

The additional cost per hectare of ratoon rice-BRRI dhan46 system was Tk 38,907/- where total cost was Tk 80,205/- compared to BR11 production cost as Tk 41,298/-. The value of rice under ratoon rice-BRRI dhan46 system as double crop was increased by Tk 55,090/- compared to the only BR11. It is found that the marginal rate of return was higher with ratoon rice-BRRI dhan46 system (150%) as compared with only BR11 production alone.

Conclusion

As food demand is increasing and cultivable land areas for growing crops are decreasing in Bangladesh, more food needs to be produced from unit land areas for maintaining food security of the country. Our efforts to grow rice by utilizing ratoon seedlings after *boro* crop harvest indicated that *boro*-ratoon rice-*aman* system can provide additional yields, about 4.0 t ha^{-1} than *boro*-*aman* rice system. Moreover, the tested system was economically viable, about Tk. 19,000 additional profit than traditional cropping system. Since flash flood damages *aman* rice crops are very common in northern region of Bangladesh, growing rice from boro ratoon seedlings before usual aman rice cropping can provide the growers a safe window of additional rice harvests. Our findings showed that if this technology is extended in suitable areas of the country, total rice production could be increased greatly.

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