Bangladesh Rural Development Studies, 26(1), 2023 (01-12)

Bangladesh Rural Development Studies (BRDS)
ISSN 1019-9624; Web: www.rda.gov.bd

Comparative study on mechanical system of rice intensification (MSRI) and system of rice intensification (SRI) with different fertilizer rates in Aus season

Samsul Huda Soyeb[1*], Md. Tanjil Anwary[1], Abdullah Al Mamun[1]

[1]Rural Development Academy (RDA), Bogura, Bangladesh.

ARTICLE INFO

Keywords:
MSRI
SRI
Tricho-compost
Yield
Aus rice

Received: 22 May, 2023
Revised: 10 June, 2023
Accepted: 14 June, 2023

***Corresponding Email:**
samsulhuda191@gmail.com

ABSTRACT

*A field experiment was conducted at the Rural Development Academy (RDA), Bogura, Bangladesh's research field during the Aus season. This experiment was set up to evaluate two planting methods, system of rice intensification (SRI) planting method and mechanical transplantation in system of rice intensification (MSRI) planting method, against three rice (**Oryza sativa**) varieties named BRRI dhan 48, BINA dhan 19, and BRRI dhan 98, with the application of two types of fertilizer, traditional fertilizer dose and recommended fertilizer, by the Soil Resource Development Institute (SRDI). The experiment was laid out in a randomized block design with three replications. MSRI had the highest yield parameters, including plant height, effective tiller, panicle length, grain per panicle, 1000 grain weight, and crop yield. Two additional treatments were experimented with for tricho-compost application along with recommended fertilizers against BRRI dhan 48 and BINA dhan 19. It was observed that the best results come from using tricho-compost along with the recommended fertilizer in the MSRI transplantation method for the production of rice.*

How to Cite: Soyeb, S. H., Anwary, M. T., & Mamun, A. A. (2023). Comparative study on mechanical system of rice intensification (MSRI) and system of rice intensification (SRI) with different fertilizer rates in Aus season. *Bangladesh Rural Development Studies, 26*(1), 01-12.

Introduction

Bangladesh is an agriculture dominated country, with 70% of the territory being agricultural land (World Bank, 2014). Rice is a major staple food crop in Bangladesh. Bangladesh is the world's fourth largest per capita rice consumer and producer (FAO, 2015). Rice is the dominant crop in the country, and it covers three-fourths of all cropland area and contributes 70% of calories consumed (Majumder et al., 2016). There are three major cropping seasons in Bangladesh, namely Aus, Aman, and Boro. Aus is typically planted in March–April and harvested in June–July, which corresponds with the hot summer season (March–May). Aus rice occupies only about 11.15% of the total cropped area, where modern varieties cover only 10.23% and local varieties cover 0.92% (BBS, 2021). Only 8.73% of total production comes in Aus season and currently the total area and production of Aus rice are 3.22 million acres and 3.33 million MT (BBS, 2021). The Aus rice area and production has been decreasing continuously compared to Boro, which is the dominant rice crop in

Bangladesh. Boro rice cultivation fully depends on irrigation, and the pressure of ground water is increasing day by day and ground water level is depleting. Aus rice requires only 5% supplement irrigation, thus pressure on ground water is minimum compared to Boro (Rahman, N. M. F. et al., 2016). It is critical to prioritize the cultivation of Aus rice over Boro rice in order to ensure the country's long-term food security. The population of Bangladesh is projected to reach 179.00 million by 2030, and it will increase further to 192.57 million in 2050. Bangladesh accounts for 2.1 percent of the world population (UN, 2019). Due to the drastic population growth, the country will demand more rice production in the future. But the arable land area of the country is even decreasing over time due to increasing demand for residential and industrial use (Hasan et al., 2013). While the population and food demand are both growing, rice production is becoming unstable due to climate change impacts rice cultivation. Organizations such as BRRI, BINA, IRRI, and others have recently brought to light rice varieties with high yield and climate change tolerance. The varieties of rice and their cultivation are affected by the climatic differences from region to region. It is estimated that rice cultivation and production will decrease by almost 51% during the next century due to global climate change. Agricultural performance, on the other hand, contributes to global warming, accounting for 10-14% of total global greenhouse gas emissions and 18% of total methane discharged from paddy rice fields (Hussain et al., 2020). Therefore, moderation and adaptation strategies such as alternate wetting and drying, intercropping with short-term vegetation, limiting chemical fertilizers by precise farming, the usage of rice cultivars with low methane emissions, improved tillage, farm mechanization and developing an integrated rice farming system are needed to hinder greenhouse gas emissions from rice fields. A new technique of plant management, bio-fertilizer application, and water management with resultant high yields in rice production was found in Madagascar in 1983 by Father Henri de Laulan'e, a French Jesuit priest, and later propagated worldwide by the Cornell International Institute for Food, Agriculture, and Development. This method, named "System of Rice Intensification" (SRI) today, is deliberated to save water yet achieves a high yield compared to the conventional method (Thakur et al., 2010; Chapagain and Yamaji, 2009). Stoop et al. (2002) reviewed the SRI method practiced around the world, explaining how high yields are achieved through SRI's key principles through a range of environmental factors and agronomic management practices, including variety selection.

Farm mechanization is required for the profitability of agriculture. It is apparent that mechanization has positive impression and execution to increase productivity and profitability of rice producers. Therefore, the contribution of mechanized farming on progressive farm level production and efficiency has yet to be analyzed in the country context. The purpose of the study is to assess the production of rice under different methods of rice plantation, fertilizer application among different varieties of rice in Aus season. In this article, first, we present the quantitative data results of rice yield and finally, the test results are discussed in comparison with the interactive effect of fertilizer, methods, and varieties which is followed by the conclusions. The main objective of this study is to compare the efficacy of SRI and MSRI based on different varieties and fertilizer rates.

Materials and methods

In this study, we used System of Rice Intensification (SRI) techniques in two ways: one is the plantation of seedlings in the field with the help of manual labor (SRI), and another was by using a mechanical rice transplanter (MSRI). These techniques were synchronized with two fertilizer application methods. The parent organization of the rice variety provides the general fertilizer rate in one method, and SRDI provides the recommended dose of fertilizer after testing a soil sample in the other. A comparative study of SRI and MSRI in Aus growing rice would aid in understanding the constraints and opportunities of Aus rice, thereby guiding policy development.

Study area

The experiment was carried out in the research plot of the Rural Development Academy (RDA), Bangladesh demonstration field, from April 12 to July 26, 2022. The site is located between latitude 24.70 N and longitude 89.39 E and is 20 m above the mean sea level. The study area has a subtropical monsoon climate characterized by huge fluctuations in rainfall, air temperature, and humidity. The following weathers are recorded in the study area: humid summer from March to June, rainy monsoon season from June to October, and winter from November to March. The daily average temperature is 24.8 °C, where the average maximum and minimum temperatures are 34.6 °C and 11.9 °C in summer and winter, respectively. The mean total annual rainfall in the study site is 1610 mm (Islam & Shamsad, 2009). Rainfall is distributed from April to October, and July is the highest rainfall month of the year. The predominant soil type is sandy loam, with a pH value ranging from 5.5 to 6.5.

Field preparation

Rice field was tilled twice, and after the first till, organic fertilizer was applied. Then the field was irrigated and puddled thoroughly.

Transplantation method

Two types of transplanting practices for SRI were done in the field. T_1 represents SRI implementation by manual labor force, while T_2 represents SRI implementation using mechanized rice transplanter machine. In both methods, seedlings were transplanted at 30x30 cm spacing. Here, T_1 is the System of Rice Intensification with manual transplantation by manual labor; T_2 was the Mechanized System of Rice Intensification method by mechanical rice transplanter; and T_3 represented MSRI transplantation where tricho-compost was applied. Seedlings were transplanted 12 days after growing on a seedling tray for MSRI, and 2/3 of the seedlings were planted per hill in both systems.

Variety of rice

Three different UFSHI (HYV) varieties of Aus rice were collected from BRRI and BINA to test the suitability of the respective varieties in the Aus growing season. They were marked as V_1, V_2, and V_3, where V_1 representing BRRI 48; V_2 representing BINA 19; and V_3 representing BRRI 98.

Fertilizer dose

General fertilizer rates were provided by the parent organization of the rice variety that farmers use traditionally. In another method, soil sample was collected from the field and tested in Soil Resource Development Institute lab Bogura and lab recommended fertilizer application dose was used as F_1 and F_2, where F_1 = traditional and F_2 = recommended by the Soil Resource Development Institute (SRDI).

Treatments/ experimental design

The experiments were placed in Randomized Block Design (RBD) with three replications for a total of 12 treatments. The treatments represented as $T_1V_1F_1$, $T_1V_1F_2$, $T_1V_2F_1$, $T_1V_2F_2$, $T_1V_3F_1$, $T_1V_3F_2$, $T_2V_1F_1$, $T_2V_1F_2$, $T_2V_2F_1$, $T_2V_2F_2$, $T_2V_3F_1$ and $T_2V_3F_2$. Two additional treatments were included with for tricho-compost application along with the recommended fertilizer. Those treatments were $T_3V_1F_2$ and $T_3V_2F_2$. T_1 = SRI with manual transplantation by manual labor; T_2 = MSRI method; T3 = MSRI + trico-compost along with recommended fertilizer; V_1 = BRRI 48; V_2 = BINA 19; and V_3 = BRRI 98; and F_1 = fertilizer traditional; and F_2 = recommended fertilizer by SRDI after the test. Plots using the T_1 transplant method cover 40 m^2 area, while plots using the T_2 treatment cover 396 m^2 area.

Weed/ pest management

Weed was controlled by mechanical weeder machine primarily. Manual laborers were used to clear weeds when plants got matured.

Agronomic measurement

The experimental plots were planted at a general spacing of 30 x 30 cm using a mechanical transplanter by running lengthwise of the field on the puddled and leveled surface. The seedlings were transplanted within 30 minutes after uprooting, and 3-7 seedlings were placed in each hill. The water level in the field was kept at 2 cm only to prevent seedlings from floating. Four to five seedlings per hill and young seedlings of 8-12 days old from quality seeds ensure vigorous seedling growth, absolute field establishment, a uniform plant population and accelerated growth rate, pest and disease resistance, and uniform maturity at harvest. Most importantly, a high-quality seed with a germination rate of more than 90% was chosen. Rice straw was used as a cover material over the trays for retention of soil moisture.

The collected data was tested by ANOVA (Analysis of Variance) using R statistical software. Later, LSD test was conducted to identify the differences in development among different treatments. Biometrical observation was carried out on plant height, effective tiller, length of panicle, grain/panicle and 1000 grain weight.

Plant height: The height of plants from five randomly selected plants was measured using the meter rule from the base of the plant to the growing tip.

Number of effective tillers: The number of tillers per square meter was taken by counting the number of tillers on five (5) randomly selected plants.

Number of grains per panicle: Numbers of filled and unfilled grains were counted to determine the number of grains per panicle of the sampled 20 panicles

1000-grain weight: Thousand grains were counted from the randomly separated grain yield of a plot and weighed with the help of a portable automatic electronic scale.

Crop yield: Crop yield was measured by weighing the rice grains from 10m^2 areas of a plot, and the data was converted to kg per hectare.

Harvesting

Combined Harvester machine was used to harvest the crops plot by plot. Agronomic measurements were done before harvesting.

Results and Discussions

Two rice production methods, MSRI and SRI, were tested in RDA, Bogura. It was observed that MSRI method had a significant advantage over SRI method. Considering yield and yield contributing characteristics for traditional fertilizer (F_1), the MSRI method had greater panicle length, effective tillers, length of panicle, grains per panicle and crop yield than the SRI method in the cases of BRRI dhan 48, BINA dhan 19, and BRRI dhan 98 (Table 1). We found that the MSRI method applied in BRRI dhan 98, BRRI dhan 48, and BINA dhan 19 showed the highest plant heights of 102.33 cm, 101.4 cm, and 98.67 cm, respectively. In consideration of effective tillers, length of panicle, and grains per panicle, we observed the best results for the MSRI method in BRRI dhan 98 and the lowest results for the SRI method in BRRI dhan 48. In terms of the parameter 1000 grains weight, the optimum results in the MSRI method were for BRRI dhan 98 and BRRI dhan 48, which were 24.63 g and 23.77 g, respectively. If we compared these two methods, MSRI method yielded 10.3 cm higher plant height for BRRI dhan 48, 6.97 cm higher plant height for BINA dhan 19, and 13.07 cm higher plant height for BRRI dhan 98.

Considering effective tiller, length of panicle, and grain per panicle for BRRI 48, the MSRI method yielded 12 more effective tillers per hill, 11.1 cm higher length of panicle, and 40 more grains per panicle than that of the SRI method. (Table:1)

In terms of effective tiller, panicle length, and grain per panicle for BINA dhan 19, the MSRI method produced 12.33 more effective tillers per hill, 5.3 cm longer panicle length, and 36 more grains per panicle than the SRI method.(Table:1)

In consideration of effective tiller, length of panicle, and grain per panicle for BRRI 98, the MSRI method yielded 13.67 more effective tillers per hill, 10.73 cm higher length of panicle, and 50 more grains per panicle than that of the SRI method (Table 1).

The undermentioned Fig. 1 demonstrates the mean yield of rice in kg per hectare of different varieties of rice under SRI and MSRI

Table 1: Comparative data of variety and transplantation method with respect to traditional fertilizer

	Variety	Method	Plant height (cm)	Effective tillers/ hill	Length of panicle (cm)	Grains per panicle (no.)	1000 grain weight (g)	Crop yield (kg/ ha)
Traditional Fertilizer (F_1)	BRRI dhan 48	SRI	91.1	11	20.4	89	23.77	2795
		MSRI	101.4	23	31.5	129	23.77	2984
	BINA dhan 19	SRI	91.7	11.67	20.5	96	24.5	2262
		MSRI	98.67	24	25.8	132	24	2536
	BRRI dhan 98	SRI	89.26	11	21	92.67	24	2190
		MSRI	102.33	24.67	31.73	142.67	24.63	2647

transplantation method in terms of traditional fertilizer dose (F_1). The chart indicate MSRI practice of BRRI 48 (V_1T_2) has shown better result than others having a value of 2984 kg/ha. It is closely followed by SRI practice of BRRI 48 (V_1T_1) and the lowest yield of rice is observed in SRI of BRRI 98 (V_3T_1**).**

Recently, The result of various rice establishment techniques was evaluated in Bangladesh and the utmost grain efficiency (54.8 q ha^{-1}) was observed under the adaptation of rice intensification method followed by mechanical transplantation (MSRI) (49.8 q·ha–1), planting a sprouted seed with SRI marker (45.2 q ha^{-1}), line transplanting (44.9 q ha^{-1}), manual transplanting (39.6 q ha^{-1}) and least productivity of grain (39.50 q ha^{-1}) (Rahaman, et al., 2022). The mechanical transplanting altogether elevated grain yield around 23%, 37%, and 63%, straw yield around 17%, 14% and 22%, and natural yield around 20%, 24%, and 39% over manual transplanting, dry direct seeding, and direct seeding of sprouted rice in puddled conditions, separately. Similar research finding were also reported by (Tejeswara Rao et al., 2020); MSRI method in paddy recorded 20.76% yield over normal transplanting method of paddy cultivation during both Kharif seasons at Visakhapatnam district of Andhra Pradesh.

Considering yield characteristics for recommended fertilizer (F_2), the MSRI method had greater panicle length, effective tillers, length of panicle, grains per panicle, and crop yield than the SRI method in the cases of BRRI dhan 48,

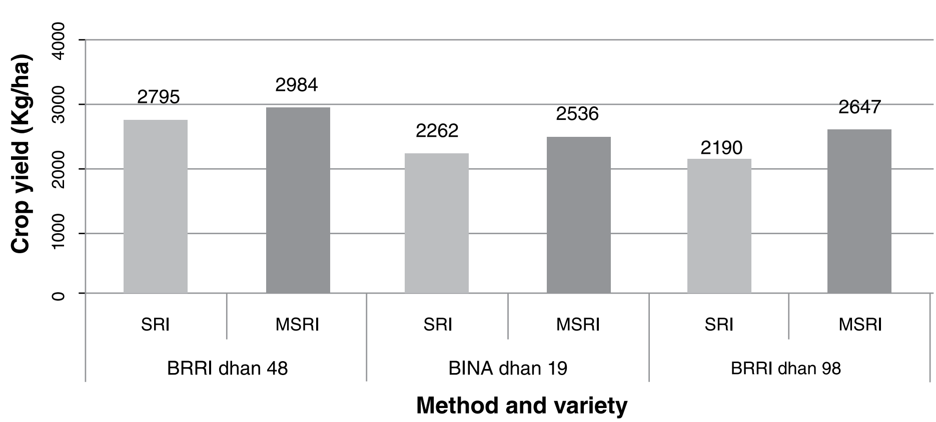

Figure 1: Comparison of crop yield for traditional fertilizer dose (F_1) in variety and methods (kg/ha)

Table 2: Comparative data of variety and transplantation method with respect to recommended fertilizer

	Variety	Method	Plant height (cm)	Effective tillers per hill	Length of panicle (cm)	Grains per panicle (no)	1000 grain weight (g)	Crop yield (approx.) (kg/ha)
Recommended Fertilizer (F_2)	BRRI dhan 48	SRI	95.6	10	20.53	90.67	24.49	2780.71
		MSRI	101.4	25	33.83	144	23.91	2910.80
	BINA dhan 19	SRI	95.27	11	20.6	96.67	24.76	2430.54
		MSRI	98.5	25	25	126	24.49	2846.28
	BRRI dhan 98	SRI	89.5	10.33	20.93	97	24.62	2655.40
		MSRI	101.93	23.67	29.97	134	24.33	2740.00

BINA dhan 19, and BRRI dhan 98 (Table 2). It was found that the MSRI method applied in BRRI dhan 98, BRRI dhan 48, and BINA dhan 19 showed the highest plant heights of 101.93 cm, 101.4 cm, and 98.5 cm, respectively. In consideration of effective tillers, length of panicle, and grains per panicle, we observed the best results for the MSRI method in BRRI dhan 48. In terms of the parameter 1000 grains weight, the optimum results in the SRI method were observed for BINA dhan 19 and BRRI dhan 98, which were 24.76 g and 24.62 g, respectively. If compared these two methods, MSRI method yielded 5.6 cm higher plant height for BRRI dhan 48, 3.23 cm higher plant height for BINA dhan 19, and 12.43 cm higher plant height for BRRI dhan 98.

Considering effective tiller, length of panicle, and grain per panicle for BRRI 48, the MSRI method yielded 15 more effective tillers per hill, 13.3 cm higher length of panicle, and 53.33 more grains per panicle than that of the SRI method.

Compared to effective tiller, length of panicle, and grain per panicle for BINA dhan 19, the MSRI method produced 14 higher effective tillers per hill, 4.4 cm higher length of panicle, and 29.33 more grains per panicle than that of the SRI method.

Considering tiller, length of panicle, and grain per panicle for BRRI 98, the MSRI method yielded 12.43 more effective tillers per hill, 13.34 cm higher length of panicle, and 37 more grains per panicle than that of the SRI method.

Fig. 2 shows the mean yield of rice in kg/ha of different varieties of rice under SRI and

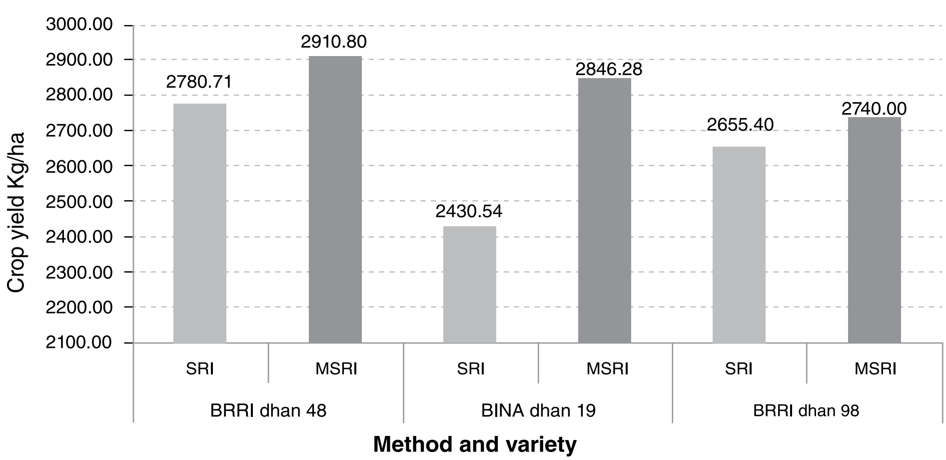

Figure 2: Comparison of crop yield for recommended fertilizer dose (F_2) in variety and methods (kg/ha)

Table 3: Comparative data of variety and transplantation method with respect to recommended fertilizer along with tricho-compost

	Variety	Method	Plant height	Effective tiller	Panicle/ hill	Grain/ panicle	1000 grain weight (gm)	Crop yield (approx.) (kg/ha)
Recommended Fertilizer (F_2)	BRRI 48	Tricho-compost + MSRI	117	20	23	168	28.48	4808.38
		MSRI	101.4	25	33.83	144	23.91	2910.8
		SRI	95.6	10	20.53	90.67	24.49	2780.71
	BINA 19	Tricho-compost+ MSRI	106	25	27	198	25.38	3924.61
		MSRI	98.5	25	25	126	24.49	2846.28
		SRI	95.27	11	20.6	96.67	24.76	2430.54

MSRI transplantation methods in terms of the recommended fertilizer dose (F_2). The figure indicates the MSRI method practice for BRRI 48 (V_1T_2) has better results than others, with a mean yield of 2984 kg/ha. It was closely followed by MSRI management practice for BINA 19 (V_2T_2), and the lowest yield of rice (2430.54 kg/ha) was observed for SRI management practice for BINA 19 (V_2T_1).

In the cases of BRRI dhan 48 and BINA dhan 19, MSRI method along with tricho-compost had increased panicle length, effective tillers, length of panicle, grains per panicle, and crop yield than the MSRI and SRI methods for recommended fertilizer (F_2) as shown in Table 3. It was found that the MSRI method along with tricho-compost applied in BRRI dhan 48 and BINA dhan 19 showed the highest plant heights of 117 cm and 106 cm, respectively. In consideration of effective tillers, length of panicle, and grains per panicle, we observed the best results for the MSRI method in BINA dhan 19. In terms of the 1000 grain weight parameter, we found the best results in the MSRI method with tricho-compost for BINA dhan 19, which was 28.48 gm, which was higher than the rest of the group. If compared, all of these methods, MSRI method with tricho-compost produced 15.6 cm higher plant height for BRRI dhan 48 and 7.5 cm higher plant height for BINA dhan 19 than that of the SRI method.

Considering effective tiller, length of panicle, and grain per panicle for BRRI 48, the MSRI method with tricho compost produced 5 fewer effective tillers per hill, 2 cm longer length of panicle, and 24 more grains per panicle than that of the MSRI method as shown in Table 3.

The MSRI method along with tricho-compost yielded the same effective tillers per hill, 10.83 cm less length of panicle, and 72 more grains per panicle compared to effective tiller, length of panicle and grain per panicle for BINA dhan 19.

Fig. 3 shows the mean yield of rice in kg/ha of different varieties of rice under SRI and MSRI transplantation methods in terms of recommended fertilizer dose (F_2) and trichocompost application. It shows that the tricho-compost+MSRI practice of BRRI 48 (V_1T_3) produced more rice 4808.38 kg/ha than others, while the tricho-compost +MSRI practice of BINA 19 produced the least 3924.61 kg/ha. The SRI of BINA 19 (V_2T_1) had the lowest rice yield 2430.54 kg/ha.

The effects of *Trichoderma* seedling treatment with SRI management were compared to SRI without *Trichoderma* application in a tropical environment, Nepal (Khadka, R. B., & Uphoff, N. 2019). It was found that the yield increase with *Trichoderma* treatments across all trials was 31% higher than that of untreated plots (4.9 vs. 4.5 mt ha-1). With *Trichoderma* treatment,

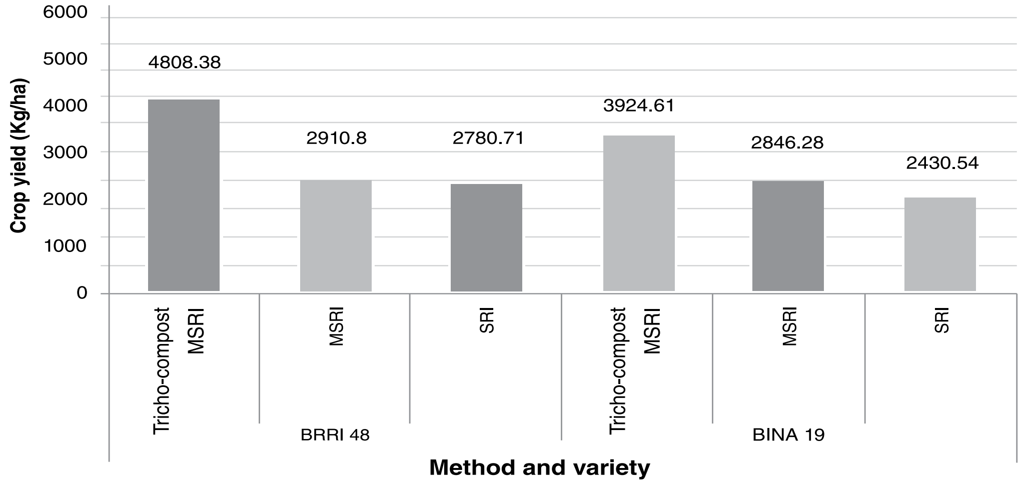

Figure 3: Comparison of crop yield for recomended fertilizer dose (F_2) in variety and methods with tricho-compost application (kg/ha)

yields compared with non-treated plots were 24% higher with organic SRI (6.38 vs. 5.13 mt ha-1) and 52% higher with non-organic SRI (6.38 vs. 3.53 mt ha-1). With regard to varietal differences, under SRI management, *Trichoderma* inoculation of the improved variety Sukhadhan-3 led to a 26% higher yield (6.35 vs. 5.04 mt ha-1), and with the heirloom variety Tilkidhan, the yield was 41% higher (6.29 vs. 4.45 mt ha-1) (Khadka, R. B., & Uphoff, N. 2019). Similar research finding were also reported by Nahar et al., (2010) and it was clarified that yield enhances in tricho-compost treated plots over un-amended control were 63.4%, 51.7% and 45% higher in some vegetables.

Table 4 describes the interactive effect of fertilizer and variety analysing some descriptive statistics. In analysis, it shows that there was no significant difference among the treatment means of V_1F_2, V_2F_2, and V_1F_1 in consideration to plant height. But these treatment methods are significantly different from V_3F_1, V_2F_1 and V_3F_2 when considering plant height. There is no significant difference among the treatment methods with respect to the parameter of grain or panicle. In consideration of a 1000 grain weight, the treatment mean V_1F_1 is significantly different from all other treatment means. In consideration of overall parameters such as plant height, effective tiller, panicle/hill, and grain/

Table 4: Interaction effect of fertilizer and variety on vegetative growth and yield of Aus rice

Treatment means	Plant height	Effective tiller	Panicle/hill	Grain/panicle	1000 grain weight
V_1F_2	98.500 a	17.500 a	27.183 a	117.33 a	24.200 ab
V_2F_2	96.883 ab	18.000 a	22.800 c	111.33 a	24.627 a
V_1F_1	96.267 ab	17.167 a	25.950 a	109.33 a	23.773 b
V_3F_1	95.800 b	17.833 a	26.233 a	117.67 a	24.627 a
V_3F_2	95.717 b	17.000 a	25.450 ab	115.50 a	24.480 a
V_2F_1	95.200 b	17.833 a	23.150 bc	114.00 a	24.280 ab
Standard Error	1.24	0.83	1.20	4.94	0.26
CV%	2.58	1.72	2.48	10.24	0.53
Critical T value 2.074					

Table 5: Interaction effect of fertilizer and methods on vegetative growth and yield of Aus rice

Treatment means	Plant height	Effective tiller	Panicle/hill	Grain/ panicle	1000 grain weight
T_2F_1	100.81 a	24.000 a	29.689 a	134.56 a	24.156 b
T_2F_2	100.61 a	24.556 a	29.600 a	134.67 a	24.244 ab
T_1F_2	93.46 b	10.444 b	20.689 b	94.78 b	24.627 a
T_1F_1	90.70 c	11.222 b	20.533 b	92.78 b	24.298 ab
Standard Error	1.01	0.68	0.98	4.03	0.21
CV%	2.10	1.40	2.03	8.36	0.43
Critical T value 2.074					

panicle, it is observed that the better result is in V_1F_2 (recommended fertilizer in BRRI dhan 48), followed by V_2F_2 (recommended fertilizer in BINA dhan 19), and V_3F_2 (recommended fertilizer in BRRI dhan 98).

CV= The coefficient of variation, Means followed by the same letter (s) within a column do not differ significantly whereas means with dissimilar letter differ significantly according to the least significant different (LSD) test.

Table 5 shows the interactive effect of fertilizer and transplantation method. There is no significant difference between T_2F_1 and T_2F_2 in consideration of the parameters of plant height, effective tiller, panicle/hill, and grain/panicle. As a result, the better results in the treatment mean of T_2F_2 (recommended fertilizer in MSRI transplantation method) were followed by the treatment mean of T_2F_1 (traditional fertilizer in MSRI transplantation method), followed by T_1F_2 (SRI transplantation with recommended fertilizer), and T_1F_1 (SRI transplantation with traditional fertilizer).

CV= The coefficient of variation, Means followed by the same letter (s) within a column do not differ significantly whereas means with dissimilar letter differ significantly according to the least significant different (LSD) test.

The interactive effect between variety and method are shown in Table 6 considering to the following parameters such as plant height, effective tiller, panicle/hill, grain/panicle, and 1000 grains weight, respectively:

Plant Height: From the table, it is observed that there is significant difference among treatment means. V_1T_3 treatment mean is showing better results than others. Plant height was highest with V_1T_3 as 117.00 whereas the lowest

Table 6: Interaction effect of variety and methods on vegetative growth and yield of Aus rice

Treatment means	Plant height	Effective tiller	Panicle/hill	Grain/ panicle	1000 grain weight
V_1T_1	93.35 c	10.500 d	20.467 d	90.17 d	24.133 b
V_2T_1	93.50 c	11.333 d	20.533 d	96.33 d	24.627 c
V_3T_1	89.38 d	10.667 d	20.833 d	94.83 d	24.627 c
V_1T_2	101.42 b	24.167 b	32.667 a	136.50 c	23.840 b
V_2T_2	98.58 c	24.500 b	25.417 bc	129.00 c	24.280 b
V_3T_2	102.13 b	24.167 b	30.850 a	138.33 c	24.480 b
V_1T_3	117.00 a	20.00 c	23.83 c	168.00 b	28.48 a
V_2T_3	106.00 b	25.00 a	27.00 b	198.00 a	25.38 ab
Standard Error	1.24	0.83	1.20	4.94	0.26
CV%	2.58	1.72	2.48	10.24	0.53
Critical T value 2.074					

number of plant height was observed as 89.38 with V_3T_1.

Effective Tiller: It is observed from the table that there is significant difference among treatment means in terms of number of effective tiller. Better result was shown by V_2T_3 treatment mean. Effective Tiller was highest with V_2T_3 as 25.00 whereas the lowest number of Effective tiller was observed as 10.500 with V_1T_1.

Panicle/hill: It is observed from the table that there is significant difference among treatment means in terms of number of panicle per hill. Better result was observed in V_1T_2 followed by V_3T_2 treatment mean. Panicle/hill was highest with V_1T_2 as 32.667 and the lowest number of Panicle/hill was observed as 20.467 with V_1T_1.

Grain/panicle: It is observed from the table that there is significant difference among treatment means in terms of number of grain/panicle. The treatment mean of V_2T_3 shows significantly higher value of 198.00 than others whereas the lowest number of grain/panicle was observed as 90.17 in V_2T_1.

1000 grain weight: There is significant difference between the treatment means of 1000 gm grain weight. It was highest with V_1T_3 (Tricho-compost along with recommended fertilizer in BRRI dhan 48) as 28.48 followed by V_2T_3 (Tricho-compost along with recommended fertilizer in BINA dhan 19) as 25.38 and lowest number of 1000 grain weight was observed as 24.627 with V_2T_1 and V_3T_1.

CV= The coefficient of variation, Means followed by the same letter (s) within a column do not differ significantly whereas means with dissimilar letter differ significantly according to the least significant different (LSD) test.

Doni et al., (2018) found the grain yield parameter of Trichoderma-inoculated rice plants was 30% increased than that from the uninoculated SRI control plots, which simply as a result of changes in management practices produced rice yields that were twice the current average in Malaysia. Similarly, Aravindan et al., (2016) carried out an experiment to evaluate the efficacy of seed treatment with different Trichoderma spp. isolate against leaf blast in four rice varieties; Swarna, IR-64, Samba Mahsuri, and Sahbhagi dhan under upland rice conditions at Almora and Hazaribag. Trichoderma spp. (isolate Th-3) treated seed of Samba Mahsuri (57%) showed highest plant height percentage followed by Tv-12 isolate with Samba Mahsuri (44%) as compared to control. It additionally increases root length (51–93%), general quantity of leaves (6-60%), tillers (3-41%), panicles (4–39%), flag leaf length (2-30%) and panicle length (5–32%) comparison to untreated control.

Tricho-compost has high nutrient values which can be used effectively as fertilizer or soil amended and this fertilizer also can minimize the application of organic fertilizer. Moreover, integrated application of fertilizer or combination of Tricho-compost and NPK showed comparatively better results and gave the highest yield. So, Tricho-compost can play a vital role in consumption of chemical fertilizer or increasing of soil fertility and this integrated approach can contribute to improve crop production. The mechanized system of rice intensification is one of the best practices for improving rice production with low input and maximum output (yield).

Conclusion

Mechanized system of rice intensification (MSRI) is comparatively easier, less time-consuming and more effective than manual planting in SRI due to laborer non-availability and higher wages for skilled laborers. On the basis of biometric analysis of the overall parameter (such as plant height, effective tiller, panicle/hill, grain/panicle, grain weight, and crop yield), the MSRI transplantation method is considerably better than the SRI transplantation method. But it was observed that the best results come from using tricho-compost along with the recommended fertilizer in the MSRI transplantation method. Cost-benefit analysis was not executed in this research. A similar further research can be conducted by other researchers with the intention to evaluate proper adoptable cultivation method. Results reported so far are not conclusive enough to understand these complex effects and can be contradictory to one another.

Hence, there appears the necessity to undertake further investigations.

References

Aravindan, S., Yadav, M. K., & Sharma, P. (2016). Biological control of rice blast disease with Trichoderma spp. under upland rice system. *ORYZA - An International Journal on Rice*, *53*(2), 167-173.

Bangladesh Bureau of Statistics (BBS). (2021). *Yearbook of Agricultural Statistics of Bangladesh*. Government of Bangladesh.

Chapagain, T., & Yamaji, E. (2009). The effects of irrigation method, age of seedling and spacing on crop performance, productivity and water-wise rice production in Japan. *Paddy Water Environment*, *8*, 81-90. https://doi.org/10.1007/s10333-009-0187-5

Doni, F., Zain, C. R. C. M., Isahak, A., Fathurrahman, F., Anhar, A., Mohamad, W. N. A. W., ... & Uphoff, N. (2018). A simple, efficient, and farmer-friendly Trichoderma-based biofertilizer evaluated with the SRI Rice Management System. *Organic Agriculture*, *8,* 207-223. https://doi.org/10.1007/s13165-017-0185-7

Food and Agriculture Organization (FAO). (2002). *FAO rice information*. Vol. 2.

FAO. (2015). *Food and Agriculture Organization of the United Nations Statistics Division (FAOSTAT)*. https://doi.org/10.4135/9781483346304.n170

Hussain, S., Huang, J., Huang, J., Ahmad, S., Nanda, S., Anwar, S., ... & Zhang, J. (2020). Rice production under climate change: adaptations and mitigating strategies. *Environment, climate, plant and vegetation growth,* 659-686. https://doi.org/10.1007/978-3-030-49732-3_26

Islam, M. S., & Shamsad, S. (2009). Assessment of irrigation water quality of Bogra district in Bangladesh. *Bangladesh Journal of Agricultural Research*, *34*(4), 507-608. https://doi.org/10.3329/bjar.v34i4.5836

Khadka, R. B., & Uphoff, N. (2019). Effects of Trichoderma seedling treatment with System of Rice Intensification management and with conventional management of transplanted rice. *PeerJ*, *7*, e5877. https://doi.org/10.7717/peerj.5877

Majumder, S., Bala, B. K., Arshad F. M., Haque, M. A., & Hossain, M. A. (2016). Food security through increasing technical efficiency and reducing postharvest losses of rice production systems in Bangladesh. *Food Security, 8*(2): 361-374. https://doi.org/10.1007/s12571-016-0558-x

Nahar, M. S., Rahman, M. A., Ilias, G. N. M., Rahaman, M. A., Yasmin, L., Afroz, M., ... & Miller, S. A. (2010). Effect of Tricho-compost on soil borne diseases and production of some vegetable crops. *Bangladesh Journal of Plant Pathology*, 26(1/2), 1-7.

N M F Rahman, M M Hasan, M I Hossain, M A Baten, S Hosen, M A Ali and M S Kabir. Forecasting Aus Rice Area and Production in Bangladesh using Box-Jenkins Approach, *Bangladesh Rice Journal*. 20 (1): 1-10, 2016. https://doi.org/10.3329/brj.v20i1.30623

Pun, I., & Yamaji, E. (2014). Comparative study of the structural development of rice, Plants by SRI and non-SRI methods in a lysimeter experiment (unpublished manuscript).

Rahaman, H., Rahman, M. M., Islam, A. K. M. S., Huda, M. D., & Kamruzzaman, M. (2022). Mechanical rice transplanting in Bangladesh: Current situation, technical challenges, and future approach. *J. Biosystems Engineering, 47*, 417–427. https://doi.org/10.1007/s42853-022-00161-x

Rao. K. T., Kumar, P. B. P., & Chandrayudu, E. (2020). Mechanized system rice intensification (MSRI) in rice cultivation at Visakhapatnam district of Andhra Pradesh. *Internat. Plant Science, 15*(2): 135-138. https://doi.org/10.15740/has/ijps/15.2/135-138

Stoop, W.A., Uphoff, N., & Kassam, A. (2002). A review of agricultural research issues raised by the system of rice intensification

(SRI) from Madagascar, Opportunities for improving farming system of resource-poor farmers. *Agricultural System*, *71*, 249-274. https://doi.org/10.1016/s0308-521x(01)00070-1

Thakur, A. K., Rath, S., Patil, D. U., & Kumar, A. (2010). Effects on rice plant morphology and physiology of water and associated management practices of the system of rice intensification and their implication for crop performance. *Paddy Water Environment*, *9*, 13-24. https://doi.org/10.1007/s10333-010-0236-0

World Bank. (2014). Agricultural insurance in Bangladesh: Promoting access to small and marginal farmers.