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Evaluation of Transplanted Aman Rice by Exploiting and Adjusting Existing Technologies

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Varietal differences are a common occurrence in rice cultivation across Bangladesh. Moreover, the application of appropriate management practices (MP) is essential for optimal rice production. Against this backdrop, a study was conducted at the Agronomy Field Laboratory (AFL) of Bangladesh Agricultural University (BAU), Mymensingh, during the aman season from July to December 2023. The aim was to assess the impact of different varieties and MP on the yield and other related attributes of Transplanted Aman (*T. aman*) rice. The study featured five rice varieties: BR11, BRRI dhan49, BRRI dhan52, BRRI dhan75, and BRRI dhan87 and two MP, namely Farmers' Practices (FP) and Improved Practices (IP). The experimental design was a split plot, with MP as the main plots and varieties as the subplots, replicated three times. The findings indicated

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that both the variety of rice and the MP significantly influenced the yield and yield-related traits. Specifically, the variety BRRI dhan87 showed superior performance, yielding the highest plant height (PH) (116.87 cm), panicle length (PL) (25.33 cm), number of effective tillers (NET) hiil^{-1} (10.33), number of grains panicle^{-1} (NGP) (129.04), 1000 grain weight (TGW) (26.03 g), Biological yield (BY) (11.88 t ha^{-1}), grain yield (GY) (5.69 t ha^{-1}), Harvest index (HI) (47.81%). Under the MP, the IP recorded the highest NET hiil^{-1} (10.47), NGP (119.35), and GY (5.48 t ha^{-1}), showing a 13.14% increase in GY over the FP. The combination of BRRI dhan87 and IP achieved the highest GY (6.31 t ha^{-1}). The study concludes that the highest GY of T. aman rice can be achieved by cultivating BRRI dhan87 with IP, although further trials at various locations are recommended before drawing final conclusions.

Keywords: Rice varieties; farmers' practices; improved practices; grain yield.

1. INTRODUCTION

In Bangladesh, rice (*Oryza sativa* L.) is the most important crop and one of the most delicate agricultural goods for both the local and international markets. The most important product's raw material is rice, which is also used to make some food items in the entire country. Rice is the staple food, with an average annual consumption rate per capita of 144.5 kg year^{-1} [1]. Bangladesh earns about 11.20% of her gross domestic product (GDP) from agriculture [2]. Rice is a tropical crop cultivated in almost all parts of Bangladesh. There are three primary growing seasons exist for rice. Among the rice groups grown our country, T. aman rice in particular covers 5725.91 thousand hectare of land with a production of 15426 thousand MT year^{-1} [2].

Variety plays a crucial role in achieving higher rice yields, influenced by factors such as genotypic characteristics, input demands, growth processes, and the environmental conditions prevalent during the growing season. As a significant genetic factor, variety substantially enhances both the yield and the yield components of a crop. The choice of rice cultivar significantly affects the crop's growth and yield. Yield components include the NET hiil^{-1}, NGP, and TGW, all of which can either increase or decrease overall yield [3,4,5]. The Bangladesh Rice Research Institute (BRRI) has introduced several modern, high-yielding, short-duration aman rice varieties. BR11, BRRI dhan49, BRRI dhan52, BRRI dhan75 and BRRI dhan87 are five of them. In Bangladesh, farmers commonly rely on traditional crop varieties that have been cultivated for generations, particularly in the case of staple crops like rice. However, the overreliance on a limited range of crop varieties leaves agriculture vulnerable to various threats, contributing to decreasing yields [4,6]. Yield gap is one of the major problems in our country. Researcher found many reasons for yield gap in Bangladesh. Use of local varieties and common farmers' practice are vital for decreasing yield. Rural and smallholder farmers of our country are cultivated rice manually. They do not follow proper agricultural practice. Smallholder farmers in our country currently use low yielding native varieties. Farmers apply improper dose of fertilizer and use bund or level their fields insufficiently, weeding is done by improper dose of herbicides with a sub-optimal timing, use irregular spacing with a greater number of seedlings which results in low yield. The country possesses significant potential for the sustainable intensification of rice cultivation. IP have been suggested as a way to boost up rice yield in Bangladesh. IP included the use of modern varieties, proper dose of fertilizers, proper number of seedlings hill^{-1}, proper spacing, regular weed management, pesticides, and irrigation which may increase the yield and yield contributing character of rice. Hence, adopting Improved Practices (IP) can lead to higher yields [7]. The branding of improved MP in rice production has been extensively studied in Southeast Asian countries such as Thailand, Vietnam, Indonesia, Sri Lanka, and Myanmar [8,9]. Additionally, a significant amount of research on improved techniques originates from Sub-Saharan Africa (SSA), particularly in countries like Benin, Cote d'Ivoire, Nigeria, and Senegal [10]. However, Bangladesh has conducted very few research or developed policies on the branding and bundling of these integrated agricultural approaches to increase rice yield.

In Bangladesh yield gap is increasing day by day. Application of improved practices is an essential component of today's modern farming of world crop production. Benedicta *et al.*, [11] found higher grain yield in rice (5.89 t ha^{-1})

against FP (4.15 t ha^{-1}) by following good agricultural practices which is a set of improved FP. Such types of investigations are rare in Bangladesh. Although rice is a crucial global crop, detailed information on the varieties of T. *aman* rice and their responses to MP is limited in the global literature. There is a need for extensive research to identify the most suitable varieties and management systems to achieve satisfactory yields.

2. MATERIALS AND METHODS

2.1 Description of the Experimental Site

The study was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, from July to December 2023 to explore the impacts of variety and MP on the yield and yield attributes of T. aman rice. The experimental site was situated at a latitude of 24°25' N and longitude of 90°50' E, at an elevation of 18 meters above sea level. This area features non-calcareous dark grey floodplain soil from the Sonatola series within the Old Brahmaputra Floodplain, classified under Agro-ecological Zone 9 (AEZ-9) [12]. The soil at the site was slightly neutral with a pH of 6.82, characterized by low organic matter (1.30 %) and fertility. The texture of the soil was silty loam, typical of the Sonatola series in the Old Brahmaputra Alluvial Tract. The locality experiences a tropical climate with high temperatures and heavy rainfall during the kharif season (April to September) and less rainfall with moderately low temperatures during the *rabi* season (October to March).

2.2 Experimental Treatments and Design

The experiment consists of two components. Factor A contains five rice varieties such as: BR11 (V_1), BRRI dhan49 (V_2), BRRI dhan52 (V_3), BRRI dhan75 (V_4), BRRI dhan87 (V_5). Factor B formed, *viz.* Farmers' practices (FP), Improved practices (IP). For collection of different cultural practices used by farmers' a survey was conducted at Boira village near BAU with a semi structured questionnaire. About 50 farmers were interviewed regarding different aspect of T. aman rice cultivation. Then the data generated from questionnaire were accumulated and their average values practices was used in the experiment. For IP the cultivation packages and practices were followed as recommended by Bangladesh Rice Research Institute [13]. The details of MP are presented in Table 1. The experiment was laid out in a split plot design with three replications where main plot factor was management practice and sub plot factor were variety. Thus, total numbers of plots were 30 and each plot size was (4 m x 2.5 m).

2.3 Preparation of Plots and Crop Husbandry

A designated plot was selected for seedling cultivation, where the land was thoroughly puddled using a tractor and subsequently leveled with a ladder. On July 10, 2023, sprouted seeds were uniformly sown in a meticulously prepared nursery bed. Field preparations commenced on July 31, 2023, involving tractor-assisted ploughing followed by laddering. Subsequent to the final land preparation, the field was laid out, and all weeds and stubble were cleared from the plots. For the FP plots, urea, triple super phosphate, and muriate of potash were applied at rates of 200, 50, and 38 kg ha^{-1}, respectively, during the last stage of field preparation. The IP plots received a different fertilizer regimen as recommended by the Bangladesh Rice Research: urea, triple super phosphate (TSP), muriate of potash (MoP), and gypsum ($CaSO_4.2H_2O$) at respective rates of 150, 60, 82, and 33 kg ha^{-1} [13]. All fertilizers, except for urea, were administered during the final land preparation. Urea was applied in three splits at 15, 30, and 45 days after transplanting (DAT). Seedlings, watered a day prior to uprooting, were transplanted at the age of 20 days on August 1, 2023. In FP, three seedlings per hill were planted with spacing of 20 cm between rows and 10 cm between hills. In contrast, IP plots were planted with two seedlings per hill, with 25 cm row spacing and 15 cm hill spacing. Any dead seedlings were replaced after one week via gap filling from the same nursery source. For weed management, IP plots were treated with the pre-emergent herbicide Superhit 500EC at 1L ha^{-1} seven days after transplanting, followed by the post-emergent herbicide Sure WP at 0.2L ha^{-1} fifteen days after transplanting, alongside one manual weeding after 10 DAT. FP plots underwent a single manual weeding session. The experiment proceeded under rainfed conditions without any drainage intervention.

2.4 Harvesting and Data Collection

Crops were harvested at full maturity, identified by the golden yellow coloration of 90% of the grains. Excluding five hills per plot, harvested crops were bundled, tagged, and transported to

Table 1. Description of FP and IP of different cultural practices in T. *aman* rice

Management practice	FP	IP
Crop establishment	Line transplanting with 20 cm x 10 cm spacing	Line transplanting with 25 cm x 15 cm spacing
Number of seedling hill^{-1}	3	2
Fertilizer application	All the fertilizer applied as basal dose.	All the fertilizer except urea applied as basal dose. Three split application urea was done after 15, 30 and 45 DAT.
Fertilizer management (Urea-TSP-MoP-Gypsum-$ZnSO_4$) kg ha^{-1}	(200-50-38-0-0) kg ha^{-1}	(150-60-82-33-2.5) kg ha^{-1}
Weed management	Weeding is done manually by hand. No use of herbicides	One hand weeding with pre and post herbicides was used for weed control

Here, FP- farmers' practices, IP- Improved practices and DAT- days after transplanting

the threshing area. Here, grains and straw were threshed, and the fresh weights were recorded from a standardized 1 m² area at the center of each plot. Following cleaning, grains were weighed with moisture adjusted to 14%. Straw weights were obtained post sun-drying, and both GY and straw yields (SY) per hectare were computed from these measurements. Additional data on crop characteristics were also collected from areas adjacent to the designated 1 m² sampling sites.

2.5 Statistical Analysis

The collected data for various parameters were compiled, tabulated, and subjected to statistical analysis. Analysis of variance (ANOVA) was performed using the R-studio program. Mean differences among treatments were evaluated using Duncan's Multiple Range Test (DMRT) [14].

3. RESULTS AND DISCUSSION

3.1 Effect of Variety on Yield and Yield Contributing Characters of T. *aman* Rice

Varietal differences significantly influenced both yield and yield-related traits. BRRI dhan87 exhibited the highest PH (116.87 cm), NET hill^{-1} (10.33), PL (25.33 cm), NGP (129.04), and TGW (26.03 g), BY (11.88 t ha^{-1}) and HI (47.81) (Table 2). The lowest PH (103.46 cm) was noted in BRRI dhan49, while the lowest values for the NET hill^{-1} (8.17), PL (21.73 cm), NGP (110.30), TGW (21.43 g), BY (10.60 t ha^{-1}) and HI (44.29 %) were observed in BR11 (Table 2). Variability in PH and other agronomic traits among rice varieties is largely determined by genetic differences. For instance, Tahsin et al., [15] noted that the tallest plants were of the variety BR23, while the shortest were BRRI dhan72. Further supporting the genetic influence, Murshida et al., [16] documented variances in the NET hill^{-1} and PL, with BRRI dhan29 showing superior performance in both categories. Additionally, Adhikari et al. [17] highlighted the influence of genetics on grain production metrics, noting the highest NGP and TGW in BRRI dhan50, illustrating the genetic basis for variability in rice yield components.

3.2 Effect of MP on the Yield Contributing Characters and Yield of T. *aman* Rice

The comparative analysis of FP and IP reveals significant differences on the yield contributing characters and yield of rice. IP demonstrated superior performance, with PH (110.17 cm), NET hill^{-1} (10.47), PL (24.07 cm), NGP (119.35), TGW (24.77 g), BY (11.54 t ha^{-1}), and HI (47.48%) all significantly higher than those observed under FP, which recorded 106.37 cm, 7.80, 22.02 cm, 115.03, 21.77 g, 10.58 t ha^{-1}, and 45.00%, respectively. Benedicta et al., [11] also identified a higher NET hill^{-1} (13.7) and TGW (25.87 g) with improved MP compared to FP, which had a TGW of 23.41 g.

3.3 Interaction Effect of Variety and MP on the Yield Contributing Characters and Yield of T. *aman* Rice

The interaction effects of management practices (MP) and variety on various yield contributing characters and yield of rice are presented in the Table 4, showing significant variations. The highest PH (120.58 cm), NET hill^{-1} (11.67), PL (26.74 cm), NGS (135.40), TGW (28.53), BY

(12.96 t ha^{-1}) and HI (48.70 %) was recorded for BRRI dhan87 treated with RDH. The maximum, along with the highest values for was observed in BRRI dhan87 with IP treatment (Table 4). Conversely, the lowest PH (101.00 cm) was found in BR11 with FP. The minimum values for NET hill^{-1} (7.00), PL (20.62 cm), NGS (108.48), TGW (20.51 g), BY (10.30 t ha^{-1}) and HI (42.28%) were recorded in BR11 and FP treatment (Table 4).

Table 2. Effect of variety on the yield contributing characters and yield of T. *aman* rice

Variety	PH (cm)	NET hill^{-1}	PL (cm)	NGP	TGW (g)	BY (t ha^{-1})	HI (%)
V_1	104.98 cd	8.17 d	21.73 c	110.30 d	21.43 c	10.60 c	44.29 d
V_2	103.46 d	9.17 bc	22.92 bc	115.73 bc	23.20 b	10.84 c	46.48 b
V_3	109.50 b	8.50 cd	22.01 bc	114.10 c	22.24 bc	10.62 c	45.72 c
V_4	106.52 c	9.50 ab	23.25 b	116.79 b	23.44 b	11.28 b	46.92 b
V_5	116.87 a	10.33 a	25.33 a	129.04 a	26.03 a	11.88 a	47.81 a
Level of significance	**	**	**	**	**	**	**
CV (%)	12.01	7.48	8.64	5.03	6.70	8.13	7.87

*Here, means with the same letters or without letters within the same column do not differ significantly, **- Significant at 1% level of probability, V_1- BR11, V_2- BRRI dhan49, V_3- BRRI dhan52, V_4- BRRIdhan75 and V_5- BRRI dhan87*

Table 3. Effect of MP on the yield contributing characters and yield of T. *aman* rice

MP	PH (cm)	NET hill^{-1}	PL (cm)	NGP	TGW (g)	BY (t ha^{-1})	HI (%)
FP	106.37 b	7.80 b	22.02 b	115.03 b	21.77 b	10.58 b	45.00 b
IP	110.17 a	10.47 a	24.07 a	119.35 a	24.77 a	11.54 a	47.48 a
Level of significance	*	**	**	*	*	**	**
CV (%)	11.62	5.28	6.38	6.99	5.59	7.43	6.90

*Here, means with the same letters within the same column do not differ significantly, **- Significant at 1% level of probability, *- Significant at 5% level of probability and FP- Farmers' practices; IP- Improved practices*

Table 4. Interaction effect of variety and MP on the yield contributing characters and yield of T. *aman* rice

MP × Variety	PH (cm)	NET hill^{-1}	PL (cm)	NGS	TGW (g)	BY (t ha^{-1})	HI (%)
FPV_1	101.00 de	7.00 e	20.62 d	108.48 g	20.51 e	10.30 d	42.28 g
FPV_2	105.78 cd	7.67 e	21.94 cd	114.92 d-f	21.75 c-e	10.74 c	45.22 ef
FPV_3	103.67 c-e	7.33 e	21.13 cd	113.62 ef	21.18 de	10.32 d	44.70 f
FPV_4	106.22 cd	8.00 de	22.49 bc	115.47 c-e	21.9 cde	10.67 cd	45.89 de
FPV_5	113.16 b	9.00 cd	23.93 b	122.67 b	23.52 bc	10.79 c	46.91 bc
IPV_1	106.96 c	9.33 c	22.83 bc	112.11 f	22.35 c-e	10.96 c	46.29 cd
IPV_2	101.15 e	10.67 ab	23.89 b	116.54 cd	24.65 b	10.94 c	47.74 ab
IPV_3	115.33 b	9.67 bc	22.89 bc	114.59 d-f	23.31 b-d	10.93 c	46.73 b-d
IPV_4	106.82 c	11.00 a	24.01 b	118.11 c	24.98 b	11.90 b	47.95 a
IPV_5	120.58 a	11.67 a	26.74 a	135.40 a	28.53 a	12.96 a	48.70 a
Level of sig.	**	*	*	**	*	**	*
CV (%)	12.01	7.48	8.64	5.03	6.70	8.13	7.87

*Here, means with the same letters within the same column do not differ significantly, **- Significant at 1% level of probability, *- Significant at 5% level of probability, V_1- BR11, V_2- BRRI dhan49, V_3- BRRI dhan52, V_4- BRRI dhan75, V_5- BRRI dhan87, FP- Farmers' practices; IP- Improved practices*

3.4 Effect of Variety on Grain Yield and Straw Yield

GY was significantly affected by the rice variety. Among the varieties tested, BRRI dhan87 exhibited the highest GY of 5.69 t ha^{-1}, whereas BR11 yielded the lowest at 4.73 t ha^{-1} (Fig. 1). In a similar vein, Mahmud et al., [18] and Akondo et al., [5] conducted a study involving seven short-duration T. *aman* rice varieties, namely BRRI dhan33, BRRI dhan39, BRRI dhan49, BRRI dhan56, BRRI dhan57, BRRI hybrid dhan4, and Binadhan-7. Their findings corroborated the observed results, with Binadhan-7 achieving the highest GY of 4.90 t ha^{-1}, while BRRI dhan57 produced the lowest y GY of 3.27 t ha^{-1}. SY was also significantly influenced by variety. Of the five varieties examined, BRRI dhan87 yielded the highest SY at 6.19 t ha^{-1}, whereas BRRI dhan52 recorded the lowest SY at 5.76 t ha^{-1} (Fig. 1). Dola et al., [4] similarly documented variation in SY among different wheat varieties, reporting that BARI Gom-32 achieved the highest SY of 6.61 t ha^{-1}.

3.5 Effect of Management Practices Grain and Straw Yield (t ha^{-1})

GY was significantly affected by the different levels of MP. The highest GY of 5.48 t ha^{-1} was achieved under IP, while the lowest GY of 4.76 t ha^{-1} was recorded under FP (Fig. 2). This finding is consistent with the results of Benedicta et al., [11], who reported that advanced rice cultivation techniques resulted in higher GY ranging from 5.41 to 5.81 t ha^{-1}, compared to yields of 4.15 to 4.84 t ha^{-1} achieved under traditional practices. Notably, the percentage increase in GY with IP over FP was 13.14%. Similarly, SY was significantly influenced by different management practices. The highest SY of 6.05 t ha^{-1} was observed with IP, whereas the lowest SY of 5.81 t ha^{-1} was recorded under FP (Fig. 2). This result aligns with Singh et al., [19], who also reported a higher SY of 6.7 t ha^{-1} under recommended agronomic practices.

3.6 Interaction Effect of Variety and Management Practices on Grain and Straw Yield (t ha^{-1})

The interaction between varieties and different MP significantly influenced GY under the experimental conditions. The highest GY of 6.31 t ha^{-1} was recorded for the combination of BRRI dhan87 with IP, whereas the lowest GY of 4.31 t ha^{-1} was observed for BR11 with FP (Fig. 3). Similarly, the interaction between varieties and nutrient management practices had a significant impact on SY. The highest SY of 6.65 t ha^{-1} was achieved with the combination of BRRI dhan87 and IP, while the lowest SY of 5.71 t ha^{-1} was found with BR11 and FP (Fig. 3).

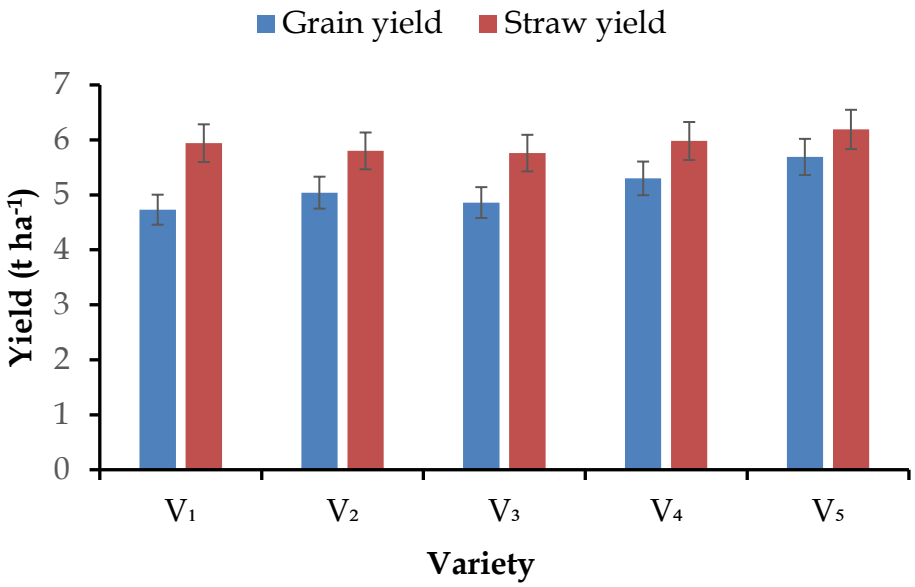

Fig. 1. Effect of variety on Grain yield and straw yield of T. *aman* rice (Vertical bar represents the LSD value at 1% level)

Here, V_1- BR11, V_2- BRRI dhan49, V_3- BRRI dhan52, V_4- BRRI dhan75 and V_5- BRRI dhan87

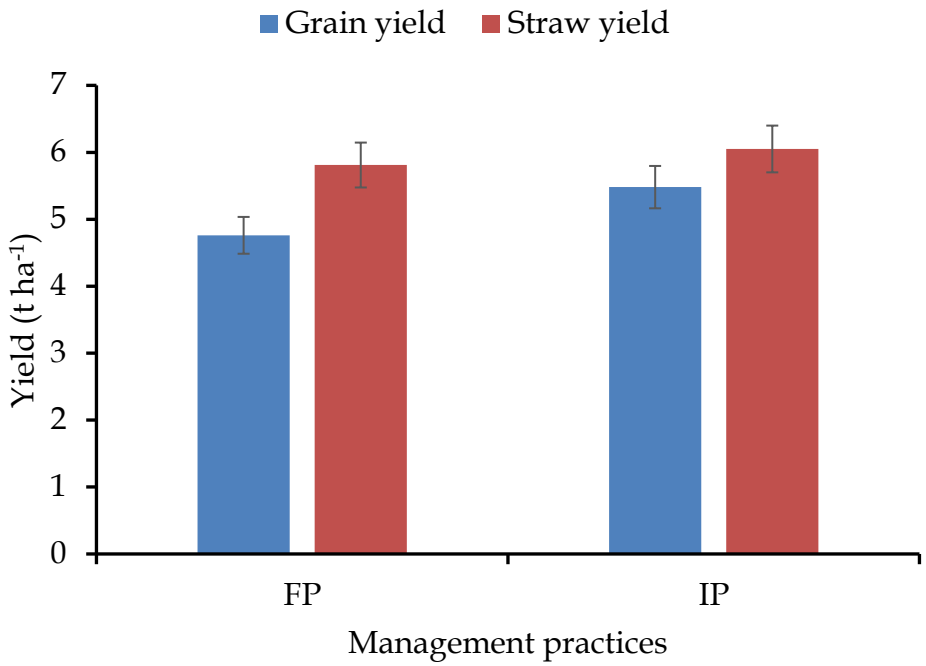

Fig. 2. Effect of MP **on GY and SY of T. *aman* rice (Vertical bar represents the LSD value at 1% level)**

Here, FP- Farmers' practices and IP- Improved practices

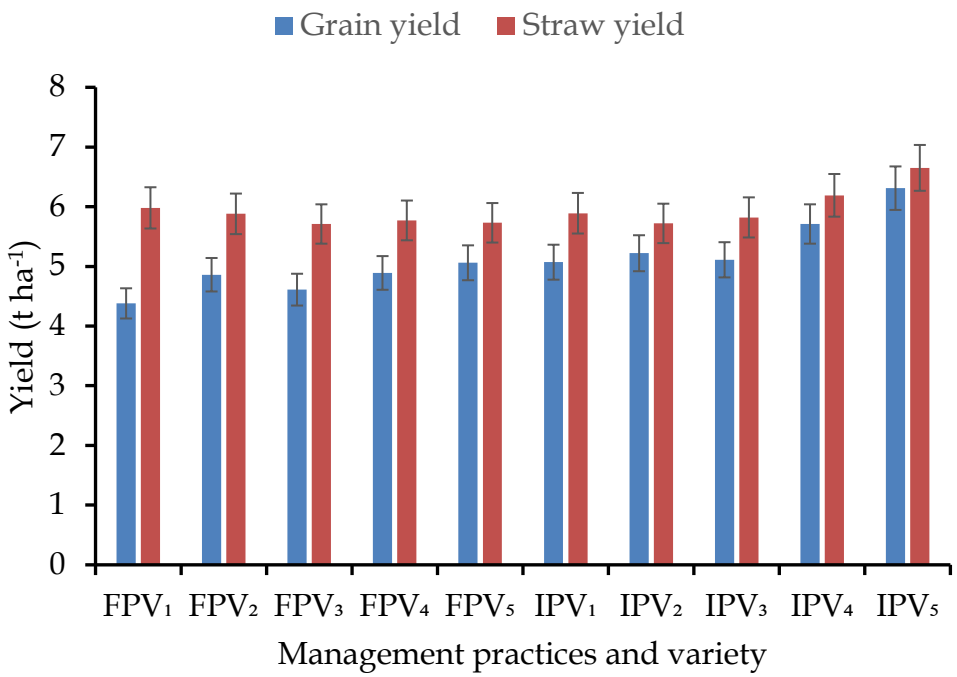

Fig. 3. Effect of variety and MP on GY and SY of T. *aman* rice (Vertical bar represents the LSD value at 1% level)

Here, V_1- BR11, V_2- BRRI dhan49, V_3- BRRI dhan52, V_4- BRRI dhan75, V_5- BRRI dhan87, FP- Farmers' practices and IP- Improved practices

4. CONCLUSION

The study results indicate that BRRI dhan87 is the most effective variety compared to others, while BR11 is the least effective. BRRI dhan87 achieved the highest GY when subjected to IP, which involved a spacing of 25×15 cm, planting 2 seedlings hill^{-1}, and applying a fertilizer regimen of Urea-TSP-MoP-Gypsum-$ZnSO_4$ @ 150-60-82-33-2.5 kg ha^{-1}, respectively, along with hand weeding and pre- and post-emergence herbicide control. This approach resulted in a 13.14% increase in GY compared to FP. The study concludes that the highest GY for T. *aman* rice can be attained by cultivating BRRI dhan87 using these improved practices. However, additional trials at various locations are necessary before making final recommendations.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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