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The combined effect of organic and inorganic fertilizers on the growth and yield of T. Aman rice in the T. aman-Mustard-Boro cropping pattern

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Abstract

A study was conducted at Bina Sub-station Nalitabari, Sherpur Farm from June to October 2022 to investigate the effect of combining organic and inorganic fertilizers on rice growth and yield. It followed a randomized block design with three replications and a unit plot size of 3m×4m.The experiment consisted of five treatments: T_1 100% STB ($N_{90}P_{15}K_{75}S_{12}Zn_2$), T_2 (85% CF+ 5t/ha cow dung), T_3 (85% CF+ 4t/ha vermicompost), T_4 (70% CF+ 5t/ha cow dung), and T_5 (70% CF+ 2t/ha vermicompost). The objective was to assess their impact on the growth, yield, and yield-contributing characteristics of the BINAdhan-17 rice variety. The study found that combining inorganic fertilizer with 2t/ha of vermicompost resulted in the highest yield. Chemical fertilizer (CF) with organic sources increased yield. The tallest plants were in T_1 (104.9cm), while the shortest was in T_4. The highest grain yield was in T_3 (5.9t/ha), and lowest in T_4 (4.7t/ha).When combining 4t/ha of vermicompost with 85% CF (77kg N, 13kg P, 64kg K, 12kg S, 2kg Zn), the parameters of tillers per plant, panicle length, filled grains per panicle, 1000-grain weight, grain yield, and straw yield were maximized.Based on these findings, it can be concluded that Using high-quality rice varieties and incorporating compost, alone or with chemical fertilizers, increases yields compared to full inorganic fertilizer. The study emphasizes the importance of judicious organic and chemical fertilizer application for significantly enhancing rice yields.

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Introduction

Rice plays an important role as a staple cereal crop in the nutritional intake of a considerable portion, around 75%, of the global population. In Ghana, rice has gained prominence as a significant staple food, ranking second only to maize. Restoring fertility in agricultural soils is dependent on the use of inorganic, organic, and biofertilizers as essential sources of plant nutrients. (Rahman *et al.*, 2019). The major plant nutrition sources for refilling agricultural soils are inorganic, organic, and bio-fertilizers.

A large portion of the daily caloric intake of more than 2.5 billion people globally comes from rice because of its highly valued abundance of carbohydrates (Belder *et al.*, 2004; Metwally *et al.*, 2011). Additionally, it provides around 49% and 69%, respectively, of the recommended consumption for women and children of dietary zinc (Arsenault *et al.,* 2010). In Ghana, where there are 28.2 million people, the average yearly intake of rice is 35kg. It was anticipated to rise to 40 kilograms per person by 2020. The entire amount of rice consumed in the nation was 1.0 million metric tons, but only 450,000 MT of domestic production was available to satisfy this need (GAIN, 2018). Ghana's average rice production, 2.43t/ha, is significantly lower than that of nations like South Korea (7.00t/ha) and Japan (6.22t/ha).

The use of inorganic, organic, and bio-fertilizers in agricultural activities is essential for restoring soil nutrients (Masarirambi*et al.*, 2012). According toresearch, it is insufficient to attain sustained production by only using inorganic or organic sources (Satyanarayana *et al.*, 2002). Nitrogen-based inorganic fertilizers, in particular, can have a detrimental effect on soil quality and increase insect problems (Siavoshi*et al.*, 2011). However, organic fertilizers by themselves might not be able to supply enough nutrients. However, mixing chemical and organic fertilizers increases nutrient accessibility for plant uptake, encourages microbial activity, and improves nutrient utilization efficiency (Moharana*et al.*, 2012). Therefore in order to produce optimal yields and preserve soil health, a mixture of organic and inorganic fertilizers must be used to increase soil productivity (Rama *et al.*, 2012). Cow dung, chicken manure, crop leftovers, and compost are examples of organic fertilizers that not only boost grain yields but also enhance the physical, chemical, and biological characteristics of the soil (Hussainy, 2019). However, overuse of nitrogen fertilizers, whether chemical or organic, can be hazardous to soil and human health since extra nitrogen turns into dangerous nitrates (Mukherjee, 2013).

Environmental harm results from intensive soil exploitation brought on by rising food demand (Martey, 2018). According to research by Barker and Herdt (1985), inorganic fertilizers can increase rice grain production by 25%. There are issues with the long-term detrimental effects of continued inorganic fertilizer usage on the soil's composition and health, though (Ghosh & Bhat, 1998). Reduced soil productivity is caused, especially in rice paddy areas, by the excessive use of chemical fertilizers (FFTC, 1994). Increased use of organic fertilizers is essential for promoting sustainable food production.

In this situation, the present study has been conducted at Bina Sub-station Nalitabari, Sherpur to study the combined effect of organic and inorganic fertilizers on the growth and yield of T. Aman rice in the T. aman-Mustard-Boro cropping pattern with the following objectives:

I. To investigate the effect of combining organic and inorganic fertilizers on the growth and yield of rice, specifically evaluating the impact on the BINAdhan-17 rice variety.

Materials and methods

The study was conducted at Bina-substation, Nalitabari, Sherpur, from June 2022 to September 2022. The experiment consisted of five treatments: T_1 100% STB ($N_{90}P_{15}K_{75}S_{12}Zn_2$), T_2 (85% CF+ 5t/ha cow dung), T_3 (85% CF+ 4t/ha vermicompost), T_4 (70% CF+ 5t/ha cow dung), and T_5 (70% CF+ 4t/ha vermicompost). The experimental soil had a sandy loam texture with sand content of 58%, silt content of 32%, and clay content of 10%. The soil characteristics included a pH of 5.70, organic carbon content of 0.89%, total nitrogen content of 0.12%, available phosphorus content of 6.90 mgkg-1 soil, exchangeable potassium content of 22.78 ppm, and available sulfur content of 9.68 ppm. The climate of the area is subtropical.

Experimental Design and Analysis

The experiment was designed using a Randomized Complete Block Design (RCBD) with three replications. Each plot had a size of 3m × 3m, covering an area of 9 m2. A distance of 0.5 m was maintained between adjacent plots, while a distance of 1 m was maintained between blocks. The collected data were subjected to statistical analysis using the STAR program (Russell, 1994). Mean differences between treatments were compared using the least significant difference (LSD) test at a significance level of 5%.

Experimental Materials

The rice variety used in the experiment was Binadhan-17, developed at the Bangladesh Institute of Nuclear Agriculture (BINA) and recommended for the Aman season. The seedlings were raised using the wet bed method, with a seed bed prepared on June 25, 2022. The seedlings, which were 20 days old and 95% germinated, were carefully uprooted from the nursery and transplanted on July 14, 2022. Planting involved placing one or two seedlings per hill, with a line-to-line spacing of 20cm and plant-to-plant spacing of 20cm. Any missing hills were filled with additional seedlings within one week of transplantation. Prior to planting, the land was prepared by plowing with a power tiller, saturating the soil with irrigation water, and conducting successive plowing and cross-plowing. The experimental plot was cleared of any unwanted residues, leveled, and divided into unit plots as per the experimental design.

Methods of studying parameters

Biological yield: Biological yield was calculated by using the following formula: Biological yield= Grain yield + straw yield 2.7

Harvest index (%): Harvest index is the relationship between grain yield and biological yield. It was calculated by using the following formula: HI (%) = 100 Biological yield Grain yield × 2.8 Statistical analysis.

Results and discussions

Plant height

There are significant differences in plant height among treatments. Significant variations were observed in the plant height of rice when the field was incorporated with different doses of vermicompost (Table 2). The tallest plant (104.87cm) was recorded from the T_1 treatment which was 100% chemical fertilizer, Not significantly different from T_2 and T_3 treatments and the lowest plant height (100.2cm) was recorded from the T_4 treatment which was 70% chemical fertilizer with 4t/ha cow dung. Vermicompost might have increased the soil moisture content, soil porosity, and other factors that enhance plant growth resulting the taller plants. The variation in plant height due to different nutrient sources can be attributed to variations in the availability of major nutrients. Chemical fertilizers provide readily soluble nutrients that are quickly available to plants through the soil solution. On the other hand, nutrient availability from organic sources relies on microbial action and the improved physical condition of the soil. These findings are consistent with the research conducted by Sarker *et al.* (2004).

Number of tiller/ plant

The number of tillers per plant ranged from 14.7 to 11.7. T_3 (14.7) had the most tillers per plant, which was exactly the same as the T_2 treatment (13.7) (Table 2). The T_4 treatment had the fewest tillers per hill (11.67), consisting of 5 tons per hectare of cow dung and 70% chemical fertilizer. Plants receive more balanced nourishment, including micronutrients, from organic sources like cow dung. Vermicompost's balanced diet may have helped the plants' tillers work more effectively. The findings of this study are consistent with Miller's (2007) investigation, and Rakshit*et al.*, (2008) also provide credence to it.

Table 1. Physicochemical properties of the experimental plot.

Physicochemical properties	Value
Soil pH	5.78
Soil texture	Sand- 58% Silt-32% Clay-10%
Textural Class	Sandy loam
OC (%)	0.89
Total N (%),	0.12
Available P (ppm)	6.90
Exch. potassium (ppm)	22.78
Available S (ppm)	1.68

Table 2. Mean performance in plant height, Tiller/plant, panicle/plant, filled grain/plant, 1000 seed weight, grain yield, and straw yield of BINAdhan-17 rice variety at different levels of fertilizer application.

Treatments	Plant Height (cm)	Tiller/plant (No.)	Panicle length (cm)	Filled grain/plant (No.)	1000 seed Weight (gm)	Grain Yield (tons/ha)	Straw Yield (t/ha)
T_1	104.9a	13.4b	23.8ab	154.4a	22.4a	5.4abc	6.23bc
T_2	103.5a	13.7ab	24.3ab	156.3a	22.5a	5.8ab	6.74ab
T_3	103.3a	14.7a	25.1a	156.7a	22.6a	6.0a	7.02a
T_4	100.2b	11.7c	21.1c	145.1b	21.8b	4.8c	5.48d
T_5	102.6ab	12.7bc	23.3bc	151.5ab	22.4a	5.2bc	5.93cd
CV (%)	6.4	5.0	5.7	5.2	4.1	6.5	6.2
SE(±)	1.2	0.5	0.7	2.8	0.2	0.3	0.3
Sig. Level	*	**	*	*	*	*	*

Common letter (s) within the same column do not differ significantly at 5% level of significance analyzed by DMRT. *=Significant (p≤5%).

Table 3. Correlation matrix.

	Plant Height (cm)	Tiller/plant (No.)	Panicle length (cm)	Filled grain /plant (No.)	1000 seed Weight (gm)	Gr. Yield (t/ha)	Str. Yield (t/ha)
Plant Height (cm)	1						
Tiller/plant (No.)	0.72***	1					
Panicle length (cm)	0.80***	0.97***	1				
Filled grain/plant (No.)	0.86***	0.93***	0.98***	1			
1000 seed Weight (gm)	0.85***	0.90***	0.98***	0.98***	1		
Gr. Yield (t/ha)	0.68***	0.97***	0.96***	0.96***	0.91***	1	
Str. Yield (t/ha)	0.65**	0.97***	0.94***	0.94***	0.88***	0.97***	1

Panicle length (cm)

The panicle length of rice was significantly influenced by different doses of chemical fertilizers and vermicompost (Table 2). The T_3 treatment, which received a specific dose of vermicompost, exhibited the highest panicle length (25.1cm), similar to the panicle lengths observed in the T_2 (24.3cm) followed by T_1 (23.8cm) treatments. Conversely, the T_4 treatment displayed the lowest panicle length (21.1cm). This result suggests that the balanced nutrient supply from vermicompost may have contributed to the enhancement of panicle length. The use of different doses of chemical fertilizers combined with vermicompost demonstrated significant variation in rice panicle length.

Filled grains/plant

The number of filled grains, an important component of rice yield, was significantly affected by the T_3 treatment (Table 2). The T_3 treatment exhibited the highest number of filled grains per panicle, with 156 grains, while the lowest number was observed in the T_4 treatment (145 grains). These results indicate that the different fertilizer applications resulted in significant variations in the number of filled grains in the T_3 treatment. Additionally, the T_3 treatment showed the maximum number of filled grains per panicle, which was statistically similar to the numbers observed in the T_1 and T_2 treatments.

1000 seed weight (gm)

The weight of 1000 seeds in grams varied from 22.6gm to 21.8gm (Table 2). The maximum weight was found in T_3 (22.6gm) which was statistically significant with T_1, T_2, and T_5. The lowest seed weight was found in T_4 (21.8gm) treatment.

Grain yield (ton/ha)

The use of vermicompost resulted in significant variations in the grain yield of rice. The highest grain yield was obtained from the T_3 (6 ton/ha) treatment, which involved 85% chemical fertilizer with 4 tons/ha of vermicompost (Table 2). This yield was not significantly different from the T_2 treatment. On the other hand, the lowest grain yield was observed in the T_4 treatment, which involved 70% chemical fertilizer with 5 tons/ha of cow dung. Previous studies by Ram *et al.* (2000) and Singh *et al.* (2001) have also shown that the application of organic matter can lead to an increase in grain yield. Significant variations in grain yield were observed at different doses of 85% chemical fertilizer with 4 tons/ha of vermicompost. The integration of organic sources and inorganic fertilizers demonstrated yield advantages compared to the use of chemical fertilizers alone. This could be attributed to the availability of nutrients for a shorter period, as inorganic nitrogen may undergo processes such as volatilization, denitrification, and leaching, leading to reduced nutrient availability.

Straw yield (ton/ha)

There are significant variations observed in straw yields among the treatments. Straw yields were ranging from 7.02 tons/ha to 5.48 tons/ha (Table 2). The highest straw yield was found in the treatment T_3 (7.02tons/ha) which is not statistically different from T_2. The lowest straw yield was found in the treatment T_5 (5.08t/ha).

Conclusion

In conclusion, the study examined the combined effect of organic and inorganic fertilizers on the growth and yield of T. Aman rice. Significant variations were observed in plant height, number of tillers per plant, panicle length, filled grains per plant, 1000 seed weight, grain yield, and straw yield among the different fertilizer treatments. The integration of vermicompost with chemical fertilizers resulted in taller plants, increased tillering, longer panicles, a higher number of filled grains, and improved grain yield. The use of organic and inorganic fertilizers in combination demonstrated advantages over sole chemical fertilizer application, highlighting the importance of nutrient balance and availability for optimal rice production. Incorporating organic sources like vermicompost can contribute to sustainable food production and soil health. Further research is warranted to optimize fertilizer dosages and assess long-term environmental implications.

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