

Effect of Integrated Nutrient Management on the yield performance of T. aman rice

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ABSTRACT

From June to November 2022, we conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, researched how T. aman rice variety cv. BRRI dhan71's yield performance changed when subjected to integrated nutrient management (INM). The experiment consisted of the following treatments- control (no manure and fertilizer) (T_1), the recommended dose of inorganic fertilizer for the cultivars (T_2), tricho-compost @ 5 tha^{-1} (T_3), tricho-compost @ 2.5 tha^{-1} + 50% less of recommended doses of NPKS (T_4), cowdung @ 5 tha^{-1} (T_5), cowdung @ 2.5 tha^{-1} + 50% less of recommended doses of NPKS (T_6), vermicompost @ 5 tha^{-1} (T_7), vermicompost @ 2.5 tha^{-1} + 50% less of recommended doses of NPKS (T_8), bone powder @ 5 tha^{-1} (T_9), bone powder @ 2.5 tha^{-1} + 50% less of recommended doses of NPKS (T_{10}). A three-replica Randomized Complete Block Design (RCBD) was used to set up the experiment. At full maturity, the crop was harvested and data was recorded on many characteristics. The experimental results demonstrated that the yield contributing features and yield of BRRI dhan71 were significantly impacted by integrated nutrition management. The tallest plants (PH) (105.67 cm), maximum total tillers hill⁻¹ (TT) (11.41), maximum effective tillers hill⁻¹ (ET) (9.55), maximum grain panicle⁻¹ (GPP) (118.36), maximum grain yield (GY) (6.48 tha^{-1}), maximum straw yield (SY) (7.55 tha^{-1}), higher biological yield (BY) (14.03 tha^{-1}) was found from T_4 treatment. Tricho compost @ 5 tha^{-1} produced the second highest GY (6.05 tha^{-1}) followed by GY (6.04 tha^{-1}) obtained from T_6 . On the other hand, the lowest GY (4.07 tha^{-1}) was recorded from T_1 , and also lowest PH (94.55 cm), minimum GPP (81.61), lowest SY (4.58 tha^{-1}) and lowest BY (8.65 tha^{-1}) were also recorded from T_1 . Research shows that INM has a significant impact on yield contributing traits and yield of BRRI dhan71.

Keywords: INM; Organic manure; BRRI dhan71; NPKS; Grain yield

Introduction

As the most important food crop, rice (*Oryza sativa* L.) provides sustenance for almost a third of the global population [1]. Rice production has a long history in Bangladesh, an agro-based nation. Agriculture is the backbone of Bangladesh. In FY 2022-23, the agricultural sector contributed approximately 11.38% to the country's GDP and employed roughly 45.33 percent of the entire workforce [2]. In contrast to other countries, Bangladesh's average yields are quite low [3]. After China and India, Bangladesh is the third most prolific rice producer in the world, thanks to its favorable agro-ecological and topographical circumstances. Approximately 10.53 ha and 26.53 mt of rice are harvested in Bangladesh annually [4]. Since boro-T. Aman rice is the most common cropping pattern, intensive rice cropping dominates crop production in Bangladesh. Bangladesh has three different rice growing seasons, known as Aus, Aman, and Boro, based on variations in seasonal conditions. The Boro season, which runs from December to May, yields more than half of the entire production (55.50%), followed by the Aman season, which runs from July to November, with the second-largest production (37.90%), and the Aus season, which runs from April to June, with a small contribution (6.60%) [5]. An estimated 14.96 million metric tons of Aman rice were produced in the fiscal year 2021-2022, a 3.05% increase over the 15.43 million metric tons produced in the fiscal year 2022-2023 [2].

Aman accounts for 45% of the world's rice production. 115 contemporary rice varieties that can be grown in Bangladesh throughout one or more rice growing seasons have been released by the Bangladesh Rice Research Institute (BRRI) [6]. Variety is crucial when it comes to rice production, and BRRI dhan71 is a promising variety among the various T. aman rice cultivars. However, given our nation's growing population, this crop's yield is low [6]. Due to intense population pressure, the area used for rice production is shrinking by nearly 1% annually [7]. These figures show that without significant increases in rice production, Bangladesh, one of the world's most densely populated nations, would have faced a humanitarian disaster. BRRI and farming communities played a crucial part in enabling Bangladesh to produce enough food on its own. Either more cultivable land or a higher yield per hectare are needed to boost rice production in order to feed Bangladesh's growing population. It is challenging to expand the amount of arable land in our heavily populated nation. Thus, raising the yield per acre can boost rice production. Reduced soil fertility is one of the biggest obstacles to raising production in this method. Therefore, efforts should be made to use integrated nutrient management strategies in order to maximize the yield per unit area. The best way to accomplish this goal is to cultivate superior cultivars and manage nutrients properly.

If other production parameters are not restricting, nutrients are the most significant element that contributes to an increase in crop output among those that affect it.

According to reports, chemical fertilizers are currently the most important tool for increasing agricultural productivity. The primary sources of plant nutrients in agricultural soils include inorganic, organic, and biofertilizers [8]. A significant allelopathic relationship was observed between the weed and rice [32]. However, the majority of farmers in our nation rely on inorganic fertilizers. The constant use of inorganic fertilizers damages the physical and chemical characteristics of soil and hastens the loss of organic materials. These days, one of the main causes of environmental contamination is fertilizers. Given their propensity for long-term soil persistence, fertilizers and pesticides are likely to disrupt soil health by influencing the microflora in the soil [9]. When combined with chemical fertilizers, organic manure can greatly increase soil productivity and rice yield [10]. For long-term crop yield and soil fertility in a rice-rice cropping pattern, the combined application of chemical and organic manure is essential [11].

Through the combined use of chemical fertilizer, organic manures, and biofertilizer, among other things, integrated nutrient management (INM) aims to maintain soil fertility, increase sustainable agricultural productivity, and boost farmer profitability. Regrettably, our nation's farmers do not apply fertilizers in the proper dosage. Inappropriate and uneven fertilizer application has a variety of detrimental effects on soil characteristics. When too much nitrogenous fertilizer is used, it can contaminate both surface and groundwater with NO_3 . Heavy metals may be added to soil as a result of using various types of inadequate P and Zn fertilizers. Chemical fertilizers are always costly for agricultural development, particularly in underdeveloped nations like Bangladesh [12]. Even if rice intensity is rising right now, the majority of our soil has an organic matter concentration of less than 1.5% and frequently less than 1%. A worrying issue in Bangladesh these days is the slow loss of soil organic matter, which lowers rice productivity [13]. Evidence from the nation's many AEZs indicates that throughout the past 20 years, the amount of organic matter has decreased by 15 to 30%. Therefore, in this situation, some organic nutrition sources can stop organic matter from becoming depleted. Applying organic fertilizer lowers environmental pollutants and boosts output [14]. To increase soil fertility, this is crucial for encouraging farmers to use more organic fertilizer. The advantages of organic manures, such as vermicompost, tricho-compost, bone powder, and cow dung, are widely recognized. In addition to being excellent nutrient providers, these organic manures help strengthen the soil's physical composition. In addition to NPK, these also have trace elements in modest concentrations, including boron, copper, iron, sulfur, and zinc, as well as a decent number of chemicals that promote development [15].

The natural antifungal agent tricho-compost fights a wide range of harmful fungus, such as *Pythium*, *Sclerotium*, *Phytophthora*, *Rhizoctonia*, *Fusarium*, *Botrytis*, and *Sclerotanomyces*. These fungi are mostly responsible for fungal wilt and soil-borne diseases. Both on its own in organic farming and as part of integrated nutrient management for rice production, vermicompost can be utilized [16-17]. Vermicompost contains all of the nutrients in a form that is easily absorbed by plants, increasing crop output [16-17]. Because of its high nutrient content and positive effects on soil health, it is a great choice for growing rice. Bone meal, or bone powder, is a kind of organic fertiliser made from finely powdered bones of animals, most commonly fish or cattle. It has a high phosphorus content. In order to achieve higher productivity with higher quality rice,

it is necessary to create nutrient management packages that integrate organic and inorganic sources of nutrients. Reduced fertilization costs and increased crop output are the results of well-managed nutrients. Determining the optimal fertilizer rate is crucial for plants to effectively use this element and improve yield performance. Finding the right mix of organic manures and inorganic fertilizers, as well as the optimal rate of application, requires much investigation.

Materials and Methods

Description of the Experimental Site

Location and site

Located at $24^{\circ} 75' \text{N}$ and 90°E , the experimental region has an average elevation of 18 meters above sea level. This area is defined by the Old Brahmaputra Alluvial Soil Tract, which is characterised by non-calcareous dark grey floodplain soil (ARZ-9). Approximately two thousand years ago, the Brahmaputra sediments covered a large portion of the land where the river now flows into the Jamuna Channel [18].

Experimental soil

The soil in the medium-high experimental field has a silt loam texture. The area was above flood level, level, and well-drained. The experimental land's soil had a pH of 6.82, which was essentially neutral. It also had a low amount of organic matter and a low degree of fertility overall. About 0.93% of the soil was organic matter, 0.13% was accessible nitrogen, 26.0 ppm was phosphorus, and 13.90 ppm was sulfur.

Climate

Tropical conditions prevail in the study region. During the kharif season (April to September), it's hot, humid, and rainy, while during the rabi season (October to March), it's mild, sunny, and somewhat dry.

Experimental Treatments

The following ten nutrient management treatments were selected such as: Control (No application of manures and fertilizer) (T_1), Recommended dose (RD) of inorganic fertilizer NPKS for the cultivars ($@55 \text{ kg ha}^{-1}$, 30 kg ha^{-1} , 25 kg ha^{-1} , 15 kg ha^{-1} respectively) (T_2), Tricho-compost @ 5 tha^{-1} (T_3), Tricho-compost @ 2.5 tha^{-1} + 50% less of recommended doses of NPKS (T_4), Cowdung @ 5 tha^{-1} (T_5), Cowdung @ 2.5 tha^{-1} + 50% less of recommended doses of NPKS (T_6), Vermicompost @ 5 tha^{-1} (T_7), Vermicompost @ 2.5 tha^{-1} + 50% less of recommended doses of NPKS (T_8), Bone powder @ 5 tha^{-1} (T_9), Bone powder @ 2.5 tha^{-1} + 50% less of recommended doses of NPKS (T_{10}). BRRI dhan71 was the test rice variety.

Experimental Design and Layout

Three replicates of the experiment were conducted using a RCBD. The treatments were distributed randomly in each of the plots. The experimental setup consisted of 10-unit plots for each replicate. As a result, thirty plots ($2 \times 5 \times 3$). There were 5 m^2 plots in total. There was a 0.5 m separation between plots and a 1.0 m separation between blocks. The experiment's design was finalized on July 20, 2022.

Description of Variety

BRRI dhan71:

Produced in 2014 for the aman growing season, BRRI dhan71 was created by the BRRI, Gazipur. It is a kind that thrives in the humid climate of Bangladesh and produces abundant crops.

BRRI dhan71 has a crop length of 114–117 days. Plant height: 107–106 cm, 1000 grain weight: 24 g. The grain is medium in size and is both long and thin. Being a drought-tolerant cultivar, it matures early. The typical yield of this type is 5.0-6.0 tha^{-1} under normal conditions, 4.0 tha^{-1} under medium drought, and 3.0-3.5 tha^{-1} under severe drought. Water shortage during the reproductive stage, with a parched water table depth greater than 70-80 cm below the surface and reduced soil moisture below 20%, does not impact grain output. Not only that, this type outperforms others when it comes to disease and insect resistance. It is good variety to thrive in drought-prone regions of Bangladesh, ensuring food security in these areas.

Crop Husbandry

Seed collection

The investigated variety's seeds (BRRI dhan71) came from AFL, BAU.

Seed sprouting and Seedling raising

The specific gravity method was used to pick healthy seeds from the collected cultivars. A pail of water was used to soak the chosen seeds for a whole day. The next step was to remove them from the water and place them in gunny bags to encourage sprouting. Nearly all of the seeds were ready for planting after 72 hours, and sprouting began after 48 hours. AFL, BAU was chosen for the rising seeding because of its elevated location. After preparing the land, the seeds were then planted in the well nursery bed on June 22, 2022, after they had sprouted. The seedlings were nurtured with the utmost care by removing weeds and watering the nursery bed at the appropriate times. Power tiller opened the land on July 15, 2022. A tractor ploughed and laddered the field to level it. Tractors then puddled the land. It was weeded and stubble and crop remnants from previous crops removed. The experimental land was laid out on July 20, 2022, according to design.

Fertilization

Plot T_1 was fertilized-free. T_2 received 290 kg urea ha^{-1} , 110 kg TSP ha^{-1} , and 100 kg MoP ha^{-1} as advised by BRRI. Land preparation used one-third urea and all other fertilizers as basal doses. Two top dressings of remaining urea were administered at 30 and 45 DAT. According to treatment, tricho-compost, vermicompost, cow dung, and bone meal were used.

Uprooting and transplanting of seedlings

Uprooting nursery bed seedlings was meticulous. Pre-uprooting water was applied to the nursery beds to make uprooting easier. On 1 August 2022, the seedlings were uprooted without considerable root damage. When uprooted, seedlings were immediately moved to the mainland. On August 1, 2022, three 40-day-old seedlings were transplanted into well-prepared puddled land at 25 cm x 15 cm spacing.

Intercultural operation

Crop growth was carefully monitored. To maximize harvest, these intercultural activities were done. After 7 DAT (days of transplanting), some hills were carefully restored with seedlings from the same source by gap filling. To prevent water and compost from moving across plots, the bund was mended as needed. Early crop establishment was plagued by weeds. To eradicate weeds from plots, pull by hand. Weeding began at 30 DAT. At 45 DAT, the second weeding occurred. When needed, experimental plots were irrigated.

The plots were drained of excess water before 15 days of harvesting to improve crop maturity.

Harvesting & processing

Crop maturity was when 90% of grains were golden yellow. BRRI dhan71 the crop was harvested November 1, 2022. To collect crop and yield data, three hills (1 m x 1 m) were randomly picked from each plot. Each plot's core 1m² was harvested to record grain and straw yields. Each 1m² plot's gathered crop was packed, marked, and carried to threshing floor. Before being weighed into tha^{-1} , the crop was threshed, cleaned, and sun-dried until it reached 14% moisture.

Data Collection

In terms of height (PH) (cm), total tillers (TT) hill⁻¹, effective tillers (ET) hill⁻¹, non-effective tillers (NET) hill⁻¹, length of panicle (PL) (in cm), grain panicle⁻¹ (GPP), sterile spikelets panicle⁻¹ (SPP), 1000-grain weight (TGW) (g), Grain yield (GY) (tha^{-1}), straw yield (SY) (tha^{-1}), biological yield (BY) (tha^{-1}), and harvest index (HI) (%), the data were recorded.

Statistical Analysis:

Data were tabulated and statistically analysed using several factors. Following two factors, ANOVA was used to analyze data. MSTAT-C was used to compute Randomised Complete Block Design (RCBD) and Duncan's Multiple Range Test was used to compare treatment means [19].

Results and Discussion

Impact of INM on rice productivity

Plant height (PH) (cm)

The highest PH (105.67 cm) was recorded in the treatment T_4 , while lowest PH (94.55 cm) was observed by T_1 . Because PH is a heritable trait, it is controlled by the genes of the particular variety. Depending on the variety, plants can grow to different sizes under ideal conditions, but the amount of fertilizer applied can affect how tall the plants get. The outcomes shown here were consistent with those reported by [20-21].

Total tillers hill⁻¹ (TT)

In T_4 , which was statistically comparable to T_7 (11.22) and T_{10} (10.54) treatments, the maximum number of TT was recorded to be 11.41. Figure 1 shows that the lowest total TT value was 8.44 (T_5), which was achieved by treating cowdung with 5 tha^{-1} . Before, we saw TT skyrocket as a result of using more organic and inorganic fertilizers [22-24].

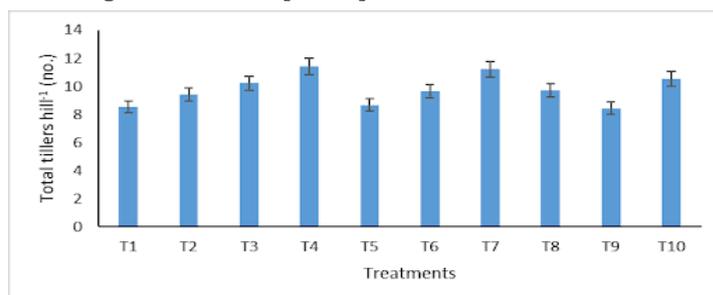


Figure 1: Effect of INM on TT (no). Bar represents standard error of the means

T_1 = Control, T_2 = RD of inorganic fertilizer for the cultivars, T_3 = Tricho-compost @ 5 tha^{-1} , T_4 = Tricho-compost @ 2.5 tha^{-1} + 50% less of recommended doses of NPKS, T_5 = Cowdung @ 5 tha^{-1} , T_6 = Cowdung @ 2.5 tha^{-1} + 50% less of recommended doses of NPKS, T_7 = Vermicompost @ 5 tha^{-1} , T_8 = Vermicompost @ 2.5 tha^{-1} + 50%

less of recommended doses of NPKS, T_9 = Bone powder @ 5 tha^{-1} , T_{10} = Bone powder @ 2.5 tha^{-1} + 50% less of recommended doses of NPKS.

Effective tillers hill⁻¹ (ET)

Various levels of nutrition control had a substantial impact on ET. In the T_4 therapy group, the highest number of ET was 9.55. With values of 8.99, 8.66, 8.33, 8.30, 8.11, and 8 correspondingly, it was statistically comparable to treatments T_{10} , T_3 , T_8 , T_7 , T_2 , and T_6 , according to Figure 2. Figure 2 and Table 1 show that T_9 had a minimum ET of 7.55, which is comparable to T_5 treatment's minimum ET of 7.66. Supplemental nutritional applications have an effect on ET levels, according to the literature [25].

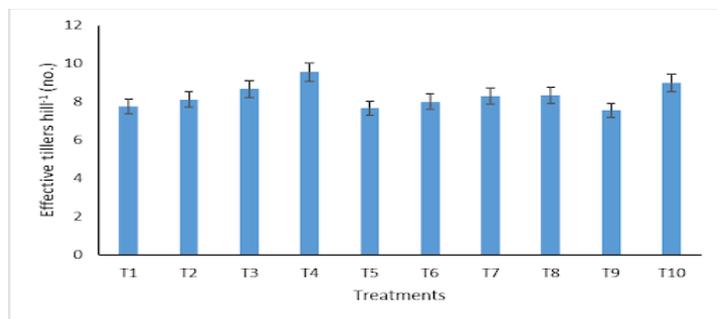


Figure 2: Effect of INM on ET (no). Treatments details are same as Figure 1. Bar represents the standard error of the means

Non-effective tillers hill⁻¹ (NET)

As a result of the various therapies, NET differed considerably. In the T_1 therapy group, the lowest NET value was 0.80. Table 1 shows that the T_7 therapy had the largest number of NET, at 2.91.

Panicle length (PL) (cm)

Statistical analysis did not reveal a significant effect of any nutrition on PL. Treatment with T_8 resulted in the maximum PL (25.18 cm). Table 1 shows that the T_7 treatment (Vermicompost @ 5 tha^{-1}) resulted in the lowest PL of 23.58 cm.

Grains panicle⁻¹ (GPP)

The effects of the various therapies on GPP were highly variable. Figure 3 shows that T_4 , T_6 , and T_8 all had statistically equal maximum GPP values of 118.36, 110.58, and 106.74, respectively, whereas T_1 had the lowest GPP value of 81.61. These results were consistent with those that had been previously reported [24, 26, 27].

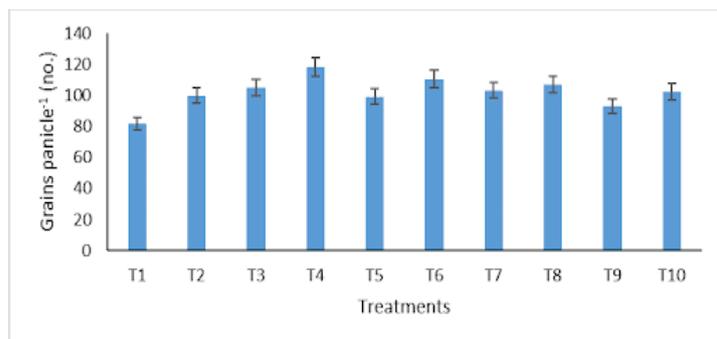


Figure 3: Effect of INM on GPP (no). Treatments details are same as Figure 1. Bar represents standard error of the means

Number of sterile spikelets panicle⁻¹ (SPP)

On SPP, the effects of the various treatments were not statistically significant. Table 1 shows that the number of SPP varied throughout treatments, with the maximum observed in T_7 (12.93) and the lowest in T_2 (9.84).

1000-grain weight (TGW) (g)

On TGW, no treatment had a statistically significant effect. Table 1 shows that the TGW ranged from 24.50 g to 25.08 g, with the lowest value coming from T_5 treatment. It was also found that increasing the application of organic nutrients promoted TGW [27-28].

Grain yield (GY) (tha⁻¹)

Figure 4 shows GY. The highest GY (6.48 tha^{-1}) was obtained in T_4 , which was statistically equivalent to T_3 , T_6 (6.05, 6.04 tha^{-1}). Treatment T_1 had the lowest value (4.07 tha^{-1}). In most cases, trichocompost boosted rice grain production. The results show that tricho-compost is crucial for *T. aman* rice yield. In prior tricho-compost tests, they found the similar result [26, 28, 29].

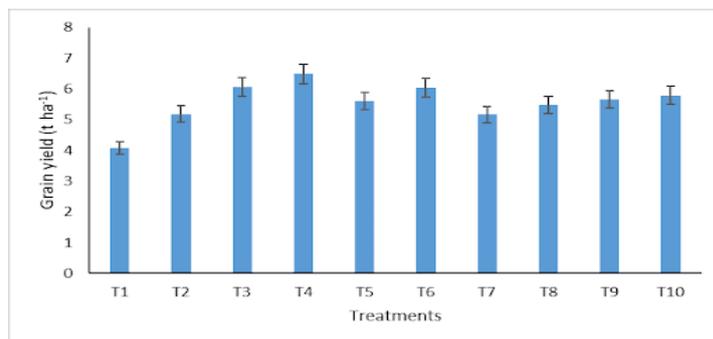


Figure 4: Effect of INM on GY (tha⁻¹). Treatments details are same as Figure 1. Bar represent the standard error of the means

Straw yield (SY) (tha⁻¹)

With respect to SY, INM had a notable impact. The T_4 treatment resulted in the highest SY (7.55 tha^{-1}), while the T_1 treatment yielded the lowest SY (4.58 tha^{-1}) (Figure 5). It could be because there were sufficient nutrients available, which led to improved growth indices and production characteristics. Plants treated with Trichoderma could improve their nutrient uptake, which led to faster growth, stronger roots and shoots, and overall improved plant vitality. This, in turn, increased their carbohydrate and biomass production, as well as their straw yield, all because their photosynthetic rates were higher [30-34].

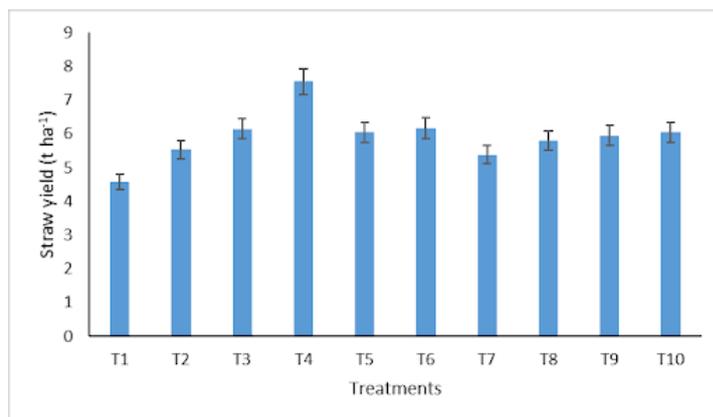


Figure 5: Effect of INM on SY (tha⁻¹). Treatments details are same as Figure 1. Bar represents the standard error of the means

Biological yield (BY) (tha⁻¹)

The impact of INM on BY was substantial. Treatment with T_4 resulted in the highest BY (14.03 tha^{-1}), while therapy with T_1 resulted in the lowest (8.65 tha^{-1}) (Table 1).

Harvest index (HI) (%)

Trichocompost had no discernible effect on the HI. According to Table 1, the T₃ therapy had the highest HI at 49.56%, while the T₄ treatment had the lowest HI at 46.64.

Table 1. Effect of integrated nutrient management (INM) on yield performance of BRRI dhan71

Treatment	PH (cm)	NET (no.)	PL (cm)	SPP	TGW (g)	BY (t ha ⁻¹)	HI (%)
T ₁	94.55d	0.80b	23.91	10.38	24.80	8.65d	47.05
T ₂	102.38abc	1.33b	24.64	9.84	25.07	10.71c	48.35
T ₃	103.44ab	1.54ab	24.35	15.71	24.82	12.20b	49.56
T ₄	105.67a	1.86ab	24.51	12.08	25.06	14.03a	46.64
T ₅	98.00cd	0.99b	23.65	10.85	24.50	11.65bc	48.12
T ₆	100.45bc	1.66ab	24.77	11.58	24.56	12.21b	49.45
T ₇	100.55bc	2.91a	23.58	12.93	24.89	10.55c	48.97
T ₈	102.63ab	1.38b	25.18	11.95	24.61	11.26bc	48.62
T ₉	101.81abc	0.89b	23.68	11.43	24.99	11.61bc	48.74
T ₁₀	104.18ab	1.54ab	23.68	10.59	25.08	11.83bc	48.96
LSD (0.05)	4.45	1.51	1.84	8.48	0.74	1.32	3.09
Level of sig.	**	**	NS	NS	NS	**	NS
CV (%)	2.56	9.28	4.45	8.24	2.74	6.74	3.72

According to DMRT, there is no significant difference between characters in the same column or those without a letter, but there is a substantial difference between characters with different letters.

**= Significant at 1% level of probability, T₁= Control (No application of manures and fertilizer), T₂= recommended dose of inorganic fertilizer for the cultivars, T₃= Tricho-compost @ 5 tha⁻¹, T₄= Tricho-compost @ 2.5 tha⁻¹ + 50% less of recommended doses of NPKS, T₅= Cowdung @ 5 tha⁻¹, T₆= Cowdung @ 2.5 tha⁻¹ + 50% less of recommended doses of NPKS, T₇= Vermicompost @ 5 tha⁻¹, T₈= Vermicompost @ 2.5 tha⁻¹ + 50% less of recommended doses of NPKS, T₉= Bone powder @ 5 tha⁻¹, T₁₀= Bone powder @ 2.5 tha⁻¹ + 50% less of recommended doses of NPKS.

Conclusion

At maturity, INM had a substantial effect on all plant traits, including yield and BRRI dhan71-related ones. With a maximum height of 105.67 cm, highest TT of 11.41, ET of 9.55, GPP of 118.36, GY of 6.48 tha⁻¹, SY of 7.55 tha⁻¹, and higher BY of 14.03 tha⁻¹, the T₄ treatment yielded the most impressive results. Following the GY (6.04 tha⁻¹) from cow dung at 2.5 tha⁻¹ + 50% less of the authorized doses of NPKS, the second-highest GY (6.05 tha⁻¹) was achieved from trichome compost at 5.0 tha⁻¹. The GY, PH, GPP, SY, and BY values were lowest in T₁ (4.07 tha⁻¹), 94.55 cm, 81.61 tha⁻¹, and 4.58 tha⁻¹, respectively. This study suggests that 50% of the prescribed dose of BRRI combined with 2.5 tha⁻¹ tricho-compost may be the best combination for enhancing BRRI dhan71 output during the aman season.

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