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Synergistic Benefits of Combined Application of Manures and Chemical Fertilizers: Enhancing Growth and Yield of Rice and Wheat

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Authors' contributions

This work was carried out in collaboration among all authors. Author MRI conceived the experiment, and author MMR devised the methodology. Author SKR, MS student, conducted both lab and field work. Other authors contributed to study design, data curation, statistical analysis, and visualization. Authors RAT and SP drafted the initial manuscript. All authors reviewed and endorsed the final version. All authors read and approved the final manuscript.

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ABSTRACT

The incorporation of compost and manure with chemical fertilizer has become a key concern to sustain soil fertility. Because the nutrients are continuously depleting from the soil and consequently creating a risk to preserving soil health.

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Aims: This study assesses the response of different doses of cowdung (CD), municipal solid waste compost (MSWC), oil cake (OC), and poultry manure (PM), incorporated with fertilizers on the growth, yield and protein content of BRRI dhan49 rice and BARI Gom-24.
Study Design: RCBD with 8 treatments and 3 replications.
Place and Duration of Study: Field experiment and nutrient analysis were carried out at Bangladesh Agricultural University (BAU), Mymensingh. Wheat was grown during the rabi season from October 2018 to March 2019. Again, rice was cultivated during kharif II season from August 2019 to December 2019 on the same field. Then the laboratory analysis was performed till June 2020.
Methodology: Eight treatments i.e., T_0 Control (no fertilizer), T_1 Recommended Fertilizer Dose, T_2 (CD + NPK), T_3 (MSWC + NPK), T_4 (OC + NPK), T_5 (PM + N), T_6 (MSWC + N), T_7: (CD + OC) were accommodated. Data on the growth parameters including grain and straw yields were documented after the harvest of the fully matured crop simultaneously determining the nitrogen (N) and protein content.
Results: Adoption of various combinations of compost and manures with fertilizer accorded an increase in yield contributing characters as well as the N and protein content. Integrating MSWC @ 10 t ha^{-1}+N projected the highest grain yield (7.11 t ha^{-1} in rice; 4.84 t ha^{-1} in wheat) and straw yield (8.8 t ha^{-1} in rice; 5.55 t ha^{-1} in wheat). It also promisingly secured the highest protein content compared to all other treatments.
Conclusion: The appliance of MSWC @ 10 t ha^{-1} with the recommended dose of N may be endorsed for rice and wheat cultivation in the AEZ-9 region and retaining the physicochemical properties of Old Brahmaputra Floodplain soils.

Keywords: Compost; municipal solid waste compost; growth; N uptake; protein content; yield.

1. INTRODUCTION

Rice dominates Bangladesh's agriculture, covering 80% of cropped land and serving as a primary income source for millions of farmers. In 2022-23, rice spanned 11.55 million hectares, yielding 35.85 million MT. Wheat, the second major cereal, covered 310 thousand hectares and produced 1.10 million MT during the same period [1]. Fertilizers boosted cereal production since the Green Revolution, meeting food demands for a growing population. However, excessive, and imbalanced NPK fertilizer use for intensive cereal cultivation has led to soil related complications like acidification, organic matter (OM) depletion, soil structural degeneration, and declining in biological activity as well as soil fertility [2] which is leading to an overall deterioration of soil health. Crop yields have stagnated despite widespread fertilizer use over the previous decades [3]. Nutrient management is now a major concern, leading farmers to combine manure and compost with chemical fertilizers for better results.

Using organic and inorganic fertilizers together may boost agricultural production. Organic fertilizer incorporation dramatically decreases soil acidity, upgrades soil nutrients level, and lifts soil urease and catalase activities as well as soil nutrient levels [4]. Applying modified municipal solid waste composts (MSWC) had a lasting impact on the soil, leading to higher levels of nitrogen N, P, K, and S content [5]. Applying poultry manure to the soil could raise soil fertility [6], restock organic content, reduce costs of cultivation, and increase farmer profitability [3].

Chemical fertilizers contribute to 59%-69% of rice yields. Combining them with organic sources can boost yields by 0.78%-117% and enhance soil carbon storage [7] Click or tap here to enter text. Fazily [8] found relying solely on inorganic fertilizers led to micro-nutrient deficiencies. Sheoran et al. [9] showed using only organic manure reduced wheat yields, emphasizing its inadequacy for meeting the nutrient demand. The study aims to assess the response of BRRI dhan49 and BARI Gom-24 to cow dung, municipal solid waste compost, poultry manure, oil cake, and fertilizers, studying their effects on nutrient content and uptake.

2. MATERIALS AND METHODS

2.1 Experimental Site and Soil

The experiment was conducted at Bangladesh Agricultural University (BAU) Soil Science Field Lab (24.0°N, 90.0°E), featuring a subtropical climate with high temperatures and rainfall during kharif II (rice season) and lower rainfall in Rabi (wheat season). The soil type is medium-high land and non-calcareous dark gray floodplain soil with specific characteristics, including pH 6.87, OM 1.27%, total N 0.15%, available P 12.21 ppm, exchangeable K 0.14 (me/100 g soil), available S 10.10 ppm, and cation CEC 15.00 (me/100 g soil).

2.2 Experimental Design and Treatments

Eight treatments were employed for both rice and wheat, each involving distinct combinations of chemical fertilizers, viz., urea, triple superphosphate, and muriate of potash. Nutrient amounts (N, P, K, S) were determined for each plot (Table 2.) and applied based on treatments. Randomized Complete Block Design (RCBD) with 8 treatments (Table 1.) and 3 replications were practiced. Plots measured 4×2.5 m^2 with 0.5 m spacing between plots and 1 m between blocks, and the plot size was same for rice and wheat.

Manures (cow dung, compost, poultry manure, oil cake) were mixed during land preparation. For rice, urea was split thrice: 15 DAT, 35 DAT (maximum tillering), and after 60 DAT (panicle initiation).

For wheat, urea was split twice: during land preparation and before booting stage.

2.3 Sowing and Transplanting

BRRI dhan49, a high-yielding rice variety, was chosen. 40-day-old seedlings from BAU's Soil Science Field Lab were transplanted at 20×20 cm spacing. Intercultural practices like irrigation, weeding, and pesticide application were employed. Grain and straw yields were recorded from randomly selected hills and a 10 m^2 area.

BARI Gom-24 (Prodip) wheat seeds were obtained from Wheat Research Centre (WRC), BARI, Nashipur, Dinajpur, and sown at a rate of 125 kg ha^{-1} in rows, covered by hand. Row distance was 20 cm, and furrow depth was 6 cm. A border crop of wheat was established around the field.

2.4 Crop Governance

After transplanting 5-6 cm water was maintained in the rice field throughout the growth period.

Wheat received two irrigations, at 21 days after sowing (DAS) during crown root initiation (CRI), and 52 DAS (heading stage). Weeding and pest management were carried out for both crops when required.

2.5 Data Collection on Plant Growth Parameters

The height of 5 plants $plot^{-1}$ and the panicle length as well as spike length of 10 selected plants $plot^{-1}$ were randomly measured in cm. Total No. of effective tillers $hill^{-1}$, 1000-grains $plot^{-1}$ were recorded accordingly. Grain and straw yields along with harvest index were recorded plot wise.

Table 1. There were 8 treatments including control as follows

Treatment	Inorganic Fertilizer (kg ha^{-1})					Organic Fertilizer (t ha^{-1})			
		N	P	K	S	CD	MSWC	PM	OC
T_0: (Control)	-	-	-	-	-	-	-	-	-
T_1: (RDF)	RFD	120	30	60	15	-	-	-	-
T_2: (CD + NPK)	NPK of RFD	120	30	60	-	5.00	-	-	-
T_3: (MSWC + NPK)	NPK of RFD	120	30	60	-	-	5.00	-	-
T_4: (OC + NPK)	NPK of RFD	120	30	60	-	-	-	-	2.00
T_5: (PM + N)	N of RFD	120	-	-	-	-	-	3.00	-
T_6: (MSWC + N)	N of RFD	120	-	-	-	-	10.0	-	-
T_7: (CD + OC)	N of RFD	120	-	-	-	2.50	-	-	1.0

RFD = recommended fertilizer dose, CD = cow dung, MSWC = municipal solid waste compost, OC = mustard oil cake, and PM = poultry manure

Table 2. Nutrient content of the applied organic fertilizers [5]

Organic manure	N (%)	P (%)	K (%)	S (%)
Cow dung	1.07	0.57	0.54	0.32
Municipal Solid Waste Compost	1.14	0.23	0.87	0.27
Oil Cake	4.70	1.06	0.91	0.93
Poultry Manure	1.33	0.80	0.89	0.42

N = nitrogen, P = phosphorous, K = potassium, S = sulphur

2.6 Sample Preparation and Analysis

Grain and straw samples were oven-dried (65°C for 24 hours), ground, and stored in desiccators. Total N was analyzed using the micro-Kjeldahl method [10].

2.7 Yield Estimation

The yields were expressed as t ha^{-1} on 14% moisture basis. Biological yields were calculated by $Biological\ Yield = Grain\ Yield + Straw\ Yield$, and harvest index was calculated in % by

$$\%\ Harvest\ Index\ (HI) = \frac{Grain\ yield}{Biological\ yield} \times 100.$$

2.8 Nitrogen and Protein Content

The uptake of N by grain and straw was calculated using the following formula [11],

Nitrogen uptake (kg ha-1) = Yield (kg ha-1) × Nitrogen Concentration (%) /100

Again, the protein contents of rice grain were calculated by multiplying the percent N content by 6.25. The protein contents were expressed in percentages. According to [12]. Formula for calculating protein content,

Protein content (%) = N content in grain (%) × 6.25

2.9 Statistical Analysis

Data were analyzed statistically by F-test to examine the treatment effects and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT) [13] and ranking was indicated by letters.

3. RESULTS

3.1 Effects of Compost, Manure, and Fertilizers on Plant Growth

The growth of BRRI dhan49 and BARI Gom-24 was influenced significantly due to application of urea-N, compost, poultry manure, oil cake and fertilizers in different combinations.

3.1.1 Plant height

Plant height variations of rice and wheat with significant differences are depicted in Fig. 1. Throughout the experiment, rice plant height followed the order: $T_3 > T_6 > T_4 > T_1 > T_5 > T_2 > T_7 > T_0$ (Fig. 1). The maximum height was T_3 (91.61 cm) and it was statistically similar to T_6, T_4, and T_1, while T_0 had the minimum height of 62.62 cm. Again, the sequence of wheat plant height was as follows: $T_6 > T_1 > T_7 > T_5 > T_4 > T_3 > T_2 > T_0$ (Fig. 1). T_6 and T_1 exhibited the maximum heights at 86.2 cm and 84.29 cm, respectively, whereas T_0 recorded the minimum height at 73.43 cm.

3.1.2 Tillering and panicle/spike length

The application of MSWC had a noticeable impact on tillering of both rice and wheat (Fig. 2), which is a crucial factor linked to panicle/spike density and grain yield. The highest count of effective tillers hill^{-1} of rice (13.66) were observed in treatment T_2 involving the application CD @ 5 t ha^{-1} along with full N, P, K. It was statistically similar to T_3, T_1, T_6, T_7, and T_4 where control treated plants displayed minimal tillering (Fig. 2). In case of wheat, T_6 (MSWC @ 10 t ha^{-1} + N) treated plants were superior for tillering, but T_1 was significantly higher over others including the inferior performance of T_0. T_4, T_5, and T_7 have given statistical similar results. The highest spike length (9.45 cm) of wheat was obtained in T_6 (Fig. 2) which was significantly higher over T_7, T_5, and T_1. The longest panicle (21.2 cm) was observed in T_2 but there was no statistical difference except control (14.49 cm).

3.1.3 Number of grain and 1000-grain weight

Grain parameters of BRRI dhan49 and BARI Gom-24 were considerably impacted by the application of compost, manure, and fertilizers in different combinations. The maximum number of filled grains of rice (151.33 grains panicle^{-1}), and wheat (78.67 grains spike^{-1}) was resulted from the application of T_6 (Fig. 3). For rice, it was statistically similar to T_1, T_3, T_5 and T_4. Both the crops witnessed the minimum production of filled grain when treated with control.

1000-grain weight of wheat was superior in T_6 treated plants (46.91 g) which was identical to T_1 (46.5 g). Except control, there was no significant difference among the treatment means of 1000-grain weight of rice (Fig. 3). 1000-grain weight of rice ranked the height position for T_6 as well.

3.2 Effects of Compost, Manure, and Fertilizers on Yield Parameters

Organic fertilizers give a better and balanced combination of nutrients to plants, particularly micronutrients, which boost yields. If crop plants can absorb sufficient N, P, and K before the panicle-initiation stage, they would produce a good yield. The results in Fig. 4 express that the grain yield, straw yield, and biological yield of rice has been increased significantly due to the application of treatments in different combinations. Application of recommended dose of N with municipal solid waste compost produced the highest grain yield of 7.11 t ha^{-1} as recorded in the treatment T_6 (MSWC @ 10 t ha^{-1} + N). T_1, T_3, T_7, T_5 and T_4 were statistically similar in producing grain yield of rice (Fig. 4). On the other hand, the lowest grain yield of 3.78 t ha-^{1} was noted in the control treatment. The percent increase in grain yield of rice over control due to different treatments of compost, poultry manure, oil cake and fertilizers ranged from 43.37% to 88.09% and the maximum increase was noted in the treatment T_6. The municipal solid waste compost supplied enough nutrients during the vegetative stage to ensure a good yield. At the same time, T_6 also produced the highest straw yield of 8.8 t ha^{-1} and the treatments T_3, T_1 and T_7 were statistically similar to T_6. The lowest straw yield of 4.98 t ha-^{1} was noted in T_0. The straw yield of rice increased 42.97% to 92.97% over control due to different treatments and which was maximum in T_6. Similarly, a wide variation in the biological yield of rice due to different treatments was observed. The maximum 15.91 t ha^{-1} and minimum 8.76 t ha^{-1} value on biological yield of rice were recorded in the treatments T_6 and T_0, respectively. The percent increase of biological yield of rice over control ranged from 43.15% to 90.86% and all the treatments recorded significantly higher biological yield over the control treatment. Consequently, the highest Harvest Index (44.69%) was recorded in T_6 (Fig. 4).

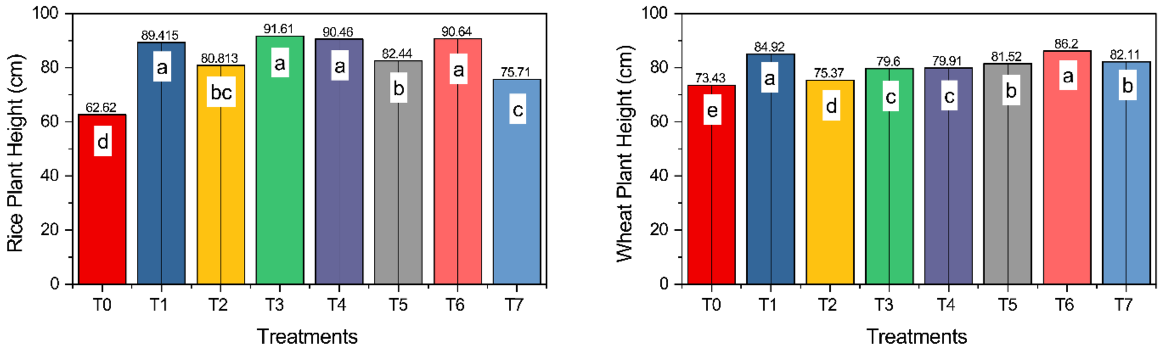

Fig. 1. Effect of organic and inorganic fertilizers on plant height
(Data are mean, n = 3; p ≤ 0.05), significant over control

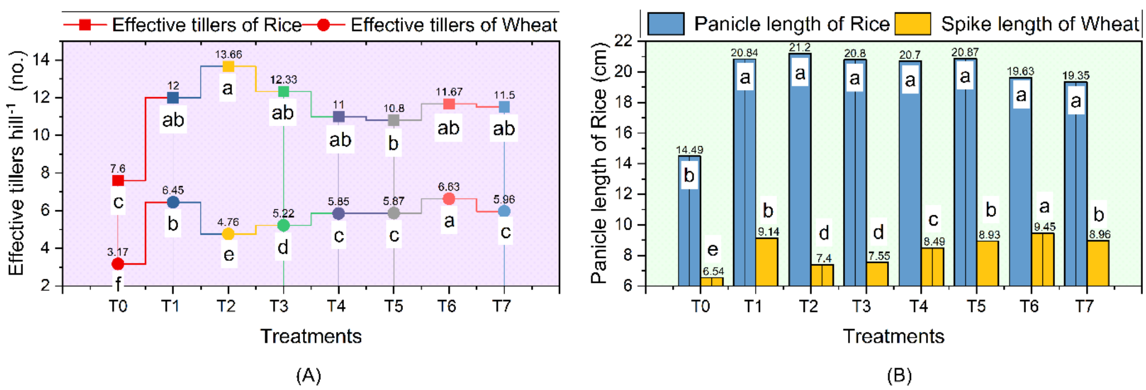

Fig. 2. Effect of organic and inorganic fertilizers on tillers hill^{-1} and panicle/spike length
(Data are mean, n = 3; p ≤ 0.05), significant over control

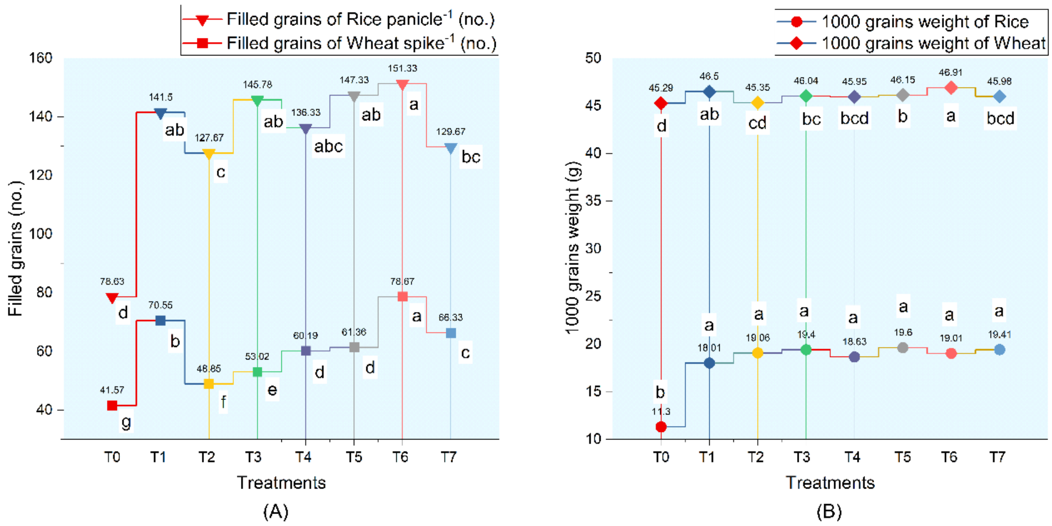

Fig. 3. Effect of organic and inorganic fertilizers on grains
(Data are mean, n = 3; p ≤ 0.05), significant over control

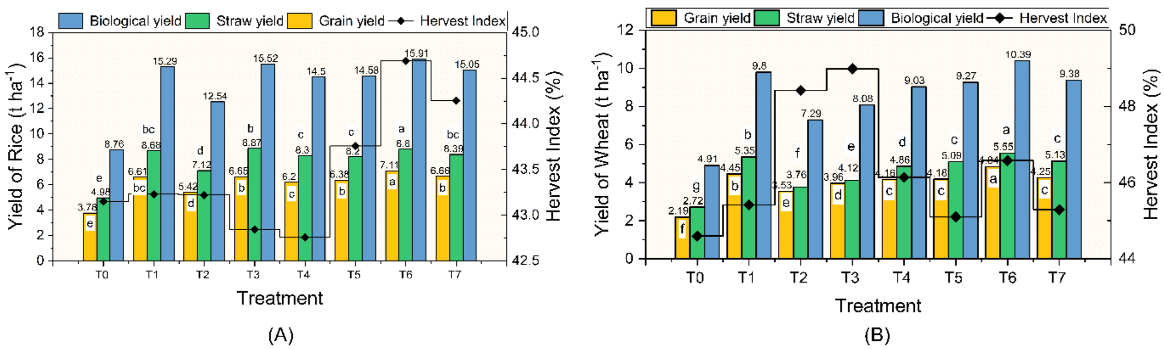

Fig. 4. Effect of organic and inorganic fertilizers on yields
(Data are mean, n = 3; p ≤ 0.05), significant over control

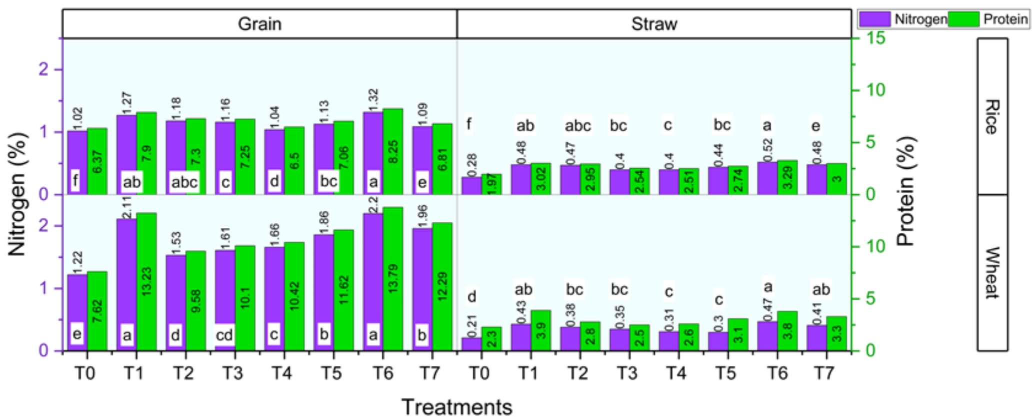

Fig. 5. Effect of organic and inorganic fertilizers on N and protein content
(Data are mean, n = 3; p ≤ 0.05), significant over control

Grain yield, straw yield, and biological yield of wheat has been increased significantly due to the application of treatments in different combinations (Fig. 4). Adding recommended dose of N with municipal solid waste compost produced the highest grain yield of 4.84 t ha^{-1} as recorded in the treatment T_6 (MSWC @ 10 t ha^{-1} + N). T_4, T_5, and T_7 were statistically similar to produce wheat grain yield (Fig. 4). On the other hand, the lowest grain yield (2.19 t ha-^{1}) was noted in the control treatment. Different treatments of compost, poultry manure, oil cake and fertilizers lead to the percent increase (61% to 121%) in grain yield of wheat over control and the maximum increase was noted in the treatment T_6. Subsequently, T_6 accounted for the highest straw yield (5.55 t ha^{-1}) while the lowest straw yield (2.72 t ha-^{1}) was generated in T_0. The straw yield of wheat increased 38% to 104% over control and which was maximum in T_6. Similarly, the biological yield of wheat also varied widely due to several treatment applications being observed. T_6 and T_0 treatments respectively produced the maximum 10.39 t ha^{-1} and minimum 4.91 t ha^{-1} value on biological yield. The percent increase of biological yield over control ranged from 48% to 111% and all the treatments recorded significantly higher biological yield over the control. However, the highest Harvest Index (49%) was recorded in T_3 (Fig. 4).

3.3 Effects of Compost, Manure and Fertilizers on Nitrogen and Protein Content

The detailed percentage of Nitrogen and protein in grain and straw for the both crops presented in Fig. 5. N content in rice grain increased significantly due to the application of different compost, manure, and fertilizers (Fig. 5). The highest N content (1.32%) was observed in T_6 (MSWC @ 10 t ha^{-1} + N) treated grains which was statistically similar to T_1 and T_2 (Fig. 5). The lowest result, 1.02% was observed in T_0 (control). The N content in rice grain was comparatively higher than that of rice straw. All the treatments recorded significantly higher N content in rice straw compared to the control. The treatment T_6 had the highest N content (0.52%) in rice straw, which was statistically equivalent to the treatments T_1 and T_2. The minimum N content in rice straw (0.28%) was noted in control. The protein content of rice grain and straw has risen immensely (Fig. 5). The highest protein content in grains (8.25%) and straw (3.29%) was witnessed in T_6 treated plants. It was statistically equal to T_1 and T_2.

In the case of wheat, the findings indicate that all treatments resulted in significantly higher N content and protein content compared to the control group (Fig. 5). Wheat grain harvested from T_6-treated plot showed the highest N content (2.2%), statistically similar to T_1. Similarly, T_6 recorded the highest N content (0.47%) in straw, akin to T_1 and T_7. Additionally, T_6-treated wheat grain had the highest protein content (13.79%), akin to T_1. Correspondingly, wheat straw protein was also higher (3.8%) in T_6-treated plants which was statistically similar to T_1 and T_7. T_0 resulted in the lowest N and protein content of wheat (Fig. 5). Both the N and protein content was higher in grain in comparison with straw. All the treatments recorded significantly higher protein as well as N-content over control.

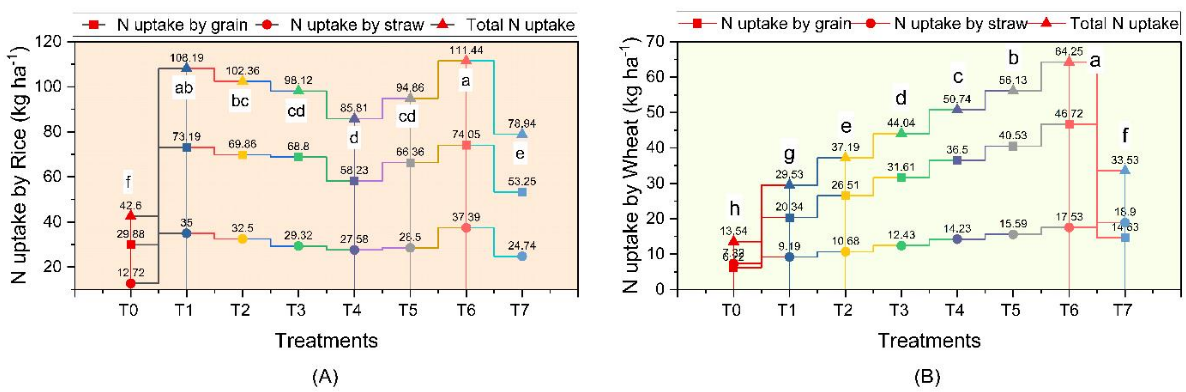

Fig. 6. Effect of organic and inorganic fertilizers on N uptake by rice and wheat
(Data are mean, n = 3; p ≤ 0.05), significant over control

3.4 Effects of Compost, Manure, and Fertilizers on Nitrogen Uptake

The results presented in Fig. 6, indicate that the N uptake by rice grain differed with the maximum result (74.05 kg ha^{-1}) noticed in the treatment T_6. The minimum N uptake (29.88 kg ha^{-1}) was observed in the T_0. In the case of rice straw, the maximum N uptake (37.39 kg ha^{-1}) was obtained also in T_6 and the minimum N uptake (12.72 kg ha^{-1}) was recorded in the control treatment (T_0). Followingly, the highest value for the total N uptake was reported in the treatment T_6 (111.44 kg ha^{-1}) and it was minimum for T_0 (42.6 kg ha^{-1}). Higher N uptake was observed in all the treatments over the control (Fig. 6).

Total nitrogen uptake by wheat plants due to different treatments of compost, poultry manure, oil cake and fertilizers varied widely and ranged between 13.54 kg ha^{-1} and 84.25 kg ha^{-1} Fig. 6). Here MSWC treatment accounted for the largest total N uptake. The superior result for both N uptake by wheat grain (46.72 kg ha^{-1}) and straw (17.53 kg ha^{-1}) was recorded for T_6. In a similar way, the poor result was obtained from the control (Fig. 6).

4. DISCUSSION

Plants get back their replenishing nutrients from three major sources e.g., inorganic, organic and bio-fertilizers [14]. Organic fertilizer decomposes gradually, acting as a prolonged nutrient source, influencing plant growth traits. The supplementation of compost to chemical fertilizer bumps the biomass and grain production of both rice and wheat by enhancing the OM status and soil physical, chemical properties [15].

Significant variations in the growth of BRRI dhan49 and BARI Gom-24 were observed as a result of applying different combinations of urea-N, compost, poultry manure, oil cake, and fertilizers. The application of MSWC simultaneously enriches the physical, chemical and biological properties of soil [16]. It stands out in promoting plant growth due to its balanced nutrient composition, diverse microbial population, and soil structure improvement, ensuring the optimal conditions for enhanced plant development compared to other compost types. Along with the recommended dose of fertilizer, incorporation of MSWC at different doses significantly increases the plant height (Fig. 1). It enhances the root and shoot biomass, which positively influences the growth characters of cereals such as plant height. Sultana et al. [17] obtained the highest plant height in rice applying MSWC. Again, it is also reported that Gypsum @25% combining with microbial enriched MSWC compost can enhance the height of rice and wheat plant [18]. The use of compost combined with chemical N fertilizer substantially boosts rice crop tillering. The application of MSWC not only had a discernible effect on plant height but also significantly influenced tillering in both rice and wheat (Fig. 2). This is particularly noteworthy as tillering plays a pivotal role in determining panicle/spike density and ultimately, grain yield. The increase in tiller numbers, resulting from the optimal nutrient availability facilitated by MSWC application, indicates improved nutrient absorption because of better root development and enhanced carbohydrate translocation which leads to increased yields. Singh et al. [18] demonstrated comparable outcomes for wheat. Jarin et al. [16] also observed positive impact of MSWC on the spike length of wheat through mixing it with the full recommended dose of fertilizer, *Rhizobium* and *Trichoderma*. However, Rice tillering was mostly influenced by CD @ 5 t ha^{-1} along with full N, P, K. In evidence with Ismael et al. [19] stated that beef cattle manure and poultry manure incorporating with urea effectively enhances tillering of rice. The longest panicle (21.2cm) was observed in T_2 and the result is supported by Oahiduzzaman et al. [20] who marked the maximum panicle length by applying CD @ 5.5 t ha^{-1}. Furthermore, the application of MSWC resulted in the highest number of filled grains for rice and wheat (Fig. 3). In T_6 treated plants, both wheat and rice exhibited superior 1000-grain weights. Singh et al. [17] and Sultana et al. [17] also recognized that MSWC along with N can enhance the number of field grain and 1000-grain weight of rice and wheat.

Organic fertilizers provide a well-rounded nutrient combination, including essential micronutrients, which effectively enhance yields in plants. Adequate absorption of N, P, and K by crop plants before the panicle-initiation stage significantly contributes to achieving optimal yields. There is a linear positive relation between biomass production and Yield. The efficacy of organic fertilizers, particularly municipal solid waste compost, in enhancing rice yield components is illustrated in Fig. 4. MSWC @ 10 t ha^{-1} + N resulted in the highest grain yield, straw yield, and biological yield, with a maximum Harvest Index. The result is supported by Sultana et al. [17]. She stated that 50% MSWC combining with 50% fertilizer can enhance the amount of grain and straw yield of rice ensuring 104% grain yield and 95% straw yield benefits over control. Similarly, Fig. 4 highlights significant increases in grain yield, straw yield, and biological yield of wheat with various treatment combinations. T_6 (MSWC @ 10 t ha^{-1} + N) resulted in the highest grain yield, straw yield, and biological yield. The highest Harvest Index (49%) was recorded in another MSWC involved treatment *viz.* T_3. The result is supported by Cherif et al. [21]. Jarin et al. [16] evident that MSWC combining with 100% recommended dose of fertilizer, *Rhizobium* and *Trichoderma* can increase grain (371%) and straw yield (345%) of wheat.

The potential of MSWC to boost the availability of naturally existing soil nutrients by promoting greater biological activity. This process maximizes the nitrogen (N) and protein content, thereby enhancing soil fertility. N content in rice grain significantly increased with the application of different compost, manure, and fertilizers (Fig. 5). The highest N content of rice grain and straw were observed in T_6 which resulted in the highest protein content. The slow release of organic nitrogen from MSW compost accelerated the nitrogen content in the crop. Sultana et al. [17] reported that combined application of MSWC with inorganic fertilizer can produce the highest grain N content (1.35%) and protein content (8.44%) in rice. In wheat, both grain and straw harvested from the T_6-treated plot exhibited the highest nitrogen content. Furthermore, they displayed the highest protein content. The result is supported by Singh et al. [18], He reported that a reduced gypsum dose combined with enriched MSW compost, exhibited the highest N content (1.25%) in grain, and a parallel trend was observed in wheat straw.

Fig. 6 demonstrates variations in nitrogen uptake by rice grain and straw, with the highest uptake observed in MSWC @ 10 t ha^{-1}+N treatment. Consequently, this treatment recorded the highest total nitrogen uptake. In wheat plant, MSWC treatment emerged as the leader, contributing significantly to the total N absorption, showcasing excellence in both wheat grain and straw. Conversely, the control group yielded less favorable results, as depicted in Fig. 6. The results are in line with the work carried out by Singh et al. [18].

5. CONCLUSION

Interest in organic manure combined with chemical fertilizers has surged due to environmental concerns. Organic fertilizer provides organic matter, slow-release nutrients, and micronutrients, while chemicals offer fast-acting nutrients, resulting in improved nutrient balance. Municipal Solid Waste Compost includes more readily accessible micro- and macronutrients, which plants can take up more quickly. The use of MSWC with recommended dose of N likely enhanced plant growth and increased yields of BRRI dhan49 and BARI Gom-24. It also secured higher N and protein content in plants. Considering soil fertility and yield, MSWC @ 10 t ha^{-1} with fertilizer N may be recommended for profitable rice and wheat cultivation in the Old Brahmaputra Floodplain soils.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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