Research Article

Effect of Soil Amendments on Methane Emission and Rice Productivity nearby the Dingaputa Haor area of Netrokona District, Bangladesh

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Abstract

An experiment was conducted nearby the Dingaputa haor area of Netrokona District during boro season. The aim of the study was to find out the most suitable soil amendment for reducing CH₄ emission and maximizing the yield attributes of BRRI dhan58. In this experiment six treatments, such as T₁: 100% recommended dose of urea (220 kg ha⁻¹), T₂: 50% Urea+Vermicompost (4 tha⁻¹), T₃: 50% Urea+Azolla incorporated (4 tha⁻¹), T₄: 25% Urea+Azolla incorporated (4tha⁻¹)+ Vermicompost (4 tha⁻¹), T₅: 25% Urea+Azolla incorporated (6 tha⁻¹)+Vermicompost (2 tha⁻¹), T₆: 25% Urea+Azolla incorporated (6 tha⁻¹)+Azolla dual cropping (1tha⁻¹) with Cyanobacterial mixture were used. At 14 DAT, CH₄ flux was very low and no significant differences were observed among the treatments. At 70 DAT, CH₄ emissions peaked in all treatments where highest peak was recorded (30.39 mgm⁻²h⁻¹) in treatment T₆ and the lowest was recorded (16.38 mgm⁻²h⁻¹) in T₂. The highest grain yield (6.50 th⁻¹) was found in the treatment T₄ while lowest grain yield (5.37 th⁻¹) was found in the treatment T₃. After rice harvest the soil properties such as soil pH, total nitrogen, organic carbon, phosphorus, potassium and sulphur was found 6.94, 0.16%, 1.58%, 14.52 ppm, 0.10 meq 100g⁻¹ and 9.65 ppm respectively. Considering all the above parameters it may be concluded that, the application of 25-50% of the recommended Urea along with Azolla incorporated (4tha⁻¹) and Vermicompost (4tha⁻¹) amendment could be suitable for maximizing of rice yield and reducing CH₄ emission.

Keywords: Methane emission; Azolla; Vermicompost; Soil amendments

Introduction

Bangladesh is an agricultural country and rice is the main food crop. Rice has been growing over 25 million hectares of land under irrigated and rain fed conditions, which cover about 84% of total cropped area in Bangladesh. The pressure on Bangladesh land resources to produce more rice will aggravate in the coming years due to increasing population and demand for food. Rice demand would increase by 25% to keep pace with population growth [1]. Rice is produced at least twice in the same crop field in Bangladesh. High fertilizer responsiveness is an essential criterion for a high yielding rice varieties and nitrogen is one of the major nutrient elements for crop production that can contribute a lot for higher yield of rice [2]. In case of Rice Fallow-Rice cropping pattern, one rice crop is fully irrigated (Boro rice) and another is mostly rainfed (T. Aman rice). The flooded rice paddy has been identified as one of the most important sources of anthropogenic CH₄ emission. The CH₄ is an important greenhouse gas (with a 21-fold higher global warming potential than CO₂ over a 100-year time horizon, [3], which has been reported to account for 95% of total CO₂ equivalent emissions from paddy fields [4]. The differences in plant growth duration among rice cultivars affected the total seasonal CH₄ emission from flooded soil. Combination of various factors such as the supply of organic matter, inherent characteristic, depth of water level, size of the root space and oxidation rate in the rhizosphere have also been identified to affect the CH₄ flux from various rice cultivars. To date no systematic study on organic fertilizers have been conducted to determine an optimum organic fertilizer management

practice to maintain a high yield of rice grain while reducing CH₄ emissions to a minimum [5]. The CH₄ is produced in soils by the microbial breakdown of organic compounds in strictly anaerobic conditions at redox potential less than -150 mV [6]. There are two major sources of methane emissions, one is natural source and another is anthropogenic source. More than 50% of the global annual CH₄ emission is of anthropogenic origin [3]. It is reported that irrigated rice accounts for more than 75% of global rice production and these rice fields are one of the major sources of CH₄ gas [7]. Since irrigated rice remains continuously flooded most of the time during growing season, this creates the ideal condition for CH₄ emission. Recent estimates of CH₄ emission from rice fields show that its rate varies within the range of 39 and 112 Tg CH₄ year⁻¹ which is equivalent to 6 to 18% of total global CH₄ flux [7]. A statistical analysis of the CH₄ emission fluxes from rice fields in Asia showed that the average CH₄ flux during the growing season is significantly affected by water management, organic matter application, soil organic carbon content, soil pH, and climate [8]. It is also influenced by soil type, weather, tillage management, residues, fertilizers, and rice cultivar. Therefore, manipulation of this factor can help reduce CH₄ emission. Thus, several studies were conducted to mitigate CH₄ emission in rice fields through soil and water management [9]. Cyanobacteria play an important role in maintenance and buildup of soil fertility, consequently increasing rice growth and yield as a natural bio-fertilizer [10]. The agricultural importance of cyanobacteria in rice cultivation is directly related with their ability to fix nitrogen and other positive effects for plants and soil [11,12]. The beneficial effect of cyanobacteria in decreasing the headspace concentration of methane (CH₄) by increasing dissolved oxygen concentration which enhance the methane oxidation at source is also reported [10]. Blue Green Algae (BGA) reduce methane (CH₄) flux without reducing rice yields that can be used as a practical mitigation option for minimizing the global warming potential of rice ecosystem. Considering such thing this study was undertaken to find out the effects of soil amendments on CH₄ emission during rice cultivation; to determine the soil properties after rice harvest and to determine the growth and yield of rice under different soil amendments.

Materials and Methods

The experiment was carried out during boro season (December 2015 to April 2016). The study was undertaken nearby the Dingaputa haor area located between the latitudes of 24°52' N to 24.86°N and between the longitudes of 90°58' E to 90.96°E in the Mohongonj Upazilla, Netrokona District under the Mymensingh division of Bangladesh. BRRI dhan-58 was used as the test crop. This variety was developed by BRRI (Bangladesh Rice Research Institute).

Experimental Design

The experimental design was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The experimental field was divided into 3 blocks with 6 treatments. Thus, the total numbers of unit plots were 18.

The area of each plot was 10m² (4m × 2.5m). There was 100 cm drain surrounding of each unit of the plot. The total area of the experimental plot was 18 plots × 10 m² = 180 m² (Figure 1).

Fertilizer application

Standard recommended doses of fertilizers were used in the experimental plots. At the time of final land preparation nitrogenous fertilizer in the form of urea (prilled) was applied as basal dose at the rate of 220 kg ha⁻¹ and amounts of urea was applied in 2 equal splits at 30 and 60 days after transplanting. Organic fertilizers were applied after making sub-plots at the time of final land preparation according to the design (Tables 1-3).

Analytical techniques of gas sample collection

Gas samples were collected by using the closed-chamber method [13] during the rice cultivation. The dimensions of close chamber were 62 × 62 × 112 cm³. Three chambers were installed in each experimental plot. Gas sample was collected at different growth stages to get the CH₄ emissions during the cropping season. Gas sample was collected in 50 ml gas-tight syringes at 0, 10- and 20-minutes intervals after chamber placement over the rice planted plot. The samples were analyzed for CH₄ by using gas chromatograph equipped with an FID (flame ionization detector). The analysis column used a stainless-steel column packed with Porapak NQ (Q 80-100 mess). The concentration difference between 0, 10 and 20 min give the total emission occurred when gas chamber

Before Transplantation		After Transplantation	
Fertilizer	Dose (kg ha ⁻¹)	Fertilizer	Dose (kg ha ⁻¹)
Vermicompost	2 ton ha ⁻¹	Urea	220
Vermicompost	4 ton ha ⁻¹		
Azolla incorporated	4 ton ha ⁻¹	Azolla dual cropping	1 ton ha ⁻¹
Azolla incorporated	6 ton ha ⁻¹		

Table 1: Fertilizer doses as applied to the experimental plots.

Fertilizer doses during cultivation	Fertilizer doses after Transplantation
<ul style="list-style-type: none"> Vermicompost Azolla incorporated 	<ul style="list-style-type: none"> Urea: 1st Time (10-15 DAT) 2nd Time (30-45 DAT) 3rd Time (50-60 DAT) Azolla dual cropping

Table 2: Treatment schedule.

Organic amendments	Nutrient content (%)			
	TN (%)	OC (%)	OM (%)	C:N
Vermicompost	1.1	14.67	26.41	14:1
Azolla	1.26	12.51	22.52	10:1

Source: Humboldt Laboratory, Department of Soil Science, BAU, Mymensingh.

Table 3: Composition of some selected soil amendments.

Legend: Treatments: 6; Replication: 3; Total number of plot: 18; Plot length: 4.0 m; Plot width: 2.5 m; Plot area: 10 m² Peripheral drain: 1m (each side); Internal drain: Block to block: 1 m and Plot to plot: 0.5 m

Figure1: Layout of the experimental field.

was closed. The temperature of column, injector and detector were adjusted at 60°C, 120°C, and 220°C, respectively. Methane emission from the paddy field was calculated from the increase in CH₄ concentrations per unit surface area of the chamber for a specific time interval. A closed-chamber equation [14] was used to estimate methane fluxes during rice cultivation.

Estimation of methane emission

Methane emission from the paddy field was calculated from the increase in CH₄ concentrations per unit surface area of the chamber for a specific time interval. A closed-chamber equation [14] was used to estimate methane fluxes during rice cultivation.

Calculation of CH₄ flux:

$$F = \rho \cdot (V/A) \cdot (\Delta C / \Delta t) \cdot 273/T$$

Where

F= methane flux (mg m⁻² hr⁻¹)

ρ= gas density (0.714 mg CH₄ m⁻³)

V= volume of the chamber (m³)

A= surface area of chamber (m²)

ΔC/Δt= rate of increase of methane gas concentration in the chamber (mg m⁻³ hr⁻¹)

T= 273+mean temperature in chamber (°C)

Statistical analysis

The findings were analyzed by partitioning the total variance with the help of computer by using MSTAT program. The treatment means were compared using Duncan's New Multiple Range Test (DMRT) as outlined by [15].

Result and Discussion

A field experiment was carried out to find out the results of the study regarding the effect of different soil amendments on total CH₄ emission and rice productivity.

Effect of soil amendments on CH₄ emission

CH₄ emission rate was significantly affected by different soil amendments (Figure 2). CH₄ emission was recorded 0.88 to 2.48 mg m⁻² h⁻¹ at 14 DAT where no significant differences were observed among the treatments. Similarly, at 28 DAT or active tillering stage, CH₄ emission ranged from 6.12 to 12.94 mg m⁻² h⁻¹ where treatment T₆ showed the highest (12.94 mg m⁻² h⁻¹) and treatment T₂ showed the lowest (6.12 mg m⁻² h⁻¹) CH₄ emission. At 49 DAT or panicle initiation stage, treatment T₆ and T₂ further showed the highest and lowest CH₄ emission (17.64 mg m⁻² h⁻¹ and 9.90 mg m⁻² h⁻¹ respectively). Similar trend was observed at 70 DAT. At 70 DAT, CH₄ emissions peaked in all treatments where highest peak was recorded (30.39 mg m⁻² h⁻¹) found in the treatment T₆ and the lowest (16.38 mg m⁻² h⁻¹) was recorded in T₂. Finally, at 91 DAT or ripening stage treatment T₆ and T₂ further showed the highest and lowest CH₄ emission at 18.27

Figure 2: Trends of CH₄ gas emission during BRRI dhan58 cultivation.

mg m⁻² h⁻¹ and 11.73 mg m⁻² h⁻¹ respectively. The highest percentage of CH₄ emission (30.39%) occurred when the rice plots were treated with 25% Urea+6 ton azolla incorporated ha⁻¹+1 ton azolla dual cropping ha⁻¹ with cyanobacterial mixture(T₆) and the lowest percentage of emission was obtained (0.88%) in those plots which were treated with 50% Urea + 4 ton vermicompost ha⁻¹ (T₂). Therefore, this result revealed that the azolla with cyanobacterial mixture application as organic amendment was responsible for increasing CH₄ emission in rice field as compared to urea or vermicompost. In the study on an average, CH₄ emission rate during rice cultivation followed the sequences: T₆ > T₃ > T₁ > T₅ > T₄ > T₂. [4] studied that the application of azolla incorporated and other organic fertilizers increases CH₄ emission than that from inorganic fertilizers application. CH₄ emission increased with increasing amounts of rice straw and a peak in CH₄ emission at the end of the reproductive stage was observed in all fields receiving rice straw. Total CH₄ emissions ranged from 4.04 to 40.8 g CH₄ m⁻² per growing season and emissions were 2-10-fold greater than from fields with no rice straw [4]. Methane emission was higher during flowering to maturity stages which dropped during later stages before harvesting. Ali MA, et al (2012) [16] Reported that, 25% recommended urea + Azolla Cyanobacteria (1 tha⁻¹) decreased CH₄ emission by 11% in low land rice field and rice grain yield was increased by 8%.

Effect of soil amendments on soil properties

Soil redox potential (Eh): The effect of soil amendments on soil redox potential is presented in Figure 3. From the Figure it is found that the redox potentials significantly decreased with the progress of time and plant growth stages. Eh ranged from -42.87 to -92.40 mV at 14 DAT, -98.23 to -171.33 mV at 28 DAT, -186.33 to -227.00 mV at 49 DAT, -196.00 to -238.33 mV at 70 DAT and 131.00 to -174.00 mV at 91 DAT. At 14 DAT or initial tillering stage, the significant value of Eh was found in T₂ (-42.87 mV) and T₄ (-92.40 mV) where (T₂) 50% Urea + Vermicompost (4 t ha⁻¹) showed the less reduction of Eh (-42.87 mV) and treatment T₄ (25% Urea + Azolla incorporated (4 t ha⁻¹) + Vermicompost (4 t ha⁻¹) showed the highest reduction of Eh (-92.40 mV). At

28 DAT or active tillering stage, less reduction of Eh was observed from the 50% Urea + Vermicompost (4 t ha⁻¹) in treatment T₂ and more reduction of Eh (-171.33 mV) was found in treatment T₄ while lowest reduction of soil redox potential of Eh (-98.23 mV) in the treatment T₂. At 49 DAT or panicle stage, highest and lowest Soil redox potential (Eh) was found 186.33 mV and -227.00 mV, respectively in the treatments of T₂: (50% Urea+4 ton Vermicompost ha⁻¹) and T₆: (25% Urea + Azolla incorporated (6 t ha⁻¹) + Azolla dual cropping (1 t ha⁻¹) with Cyanobacterial Mixture). At 70 DAT or flowering stage, treatment T₄ showed the higher capability to reduce the soil redox potential (-238.33 mV) which was not significantly differed (196.00 mV) from T₅ (25% Urea + Azolla incorporated (6 t ha⁻¹) + Vermicompost (2 t ha⁻¹). Finally, at 91 DAT or ripening stage, the above significant variation range of Eh revealed that, the lowest (-131.00 mV) and highest (-174.00 mV) reduction of Eh were recorded from the T₆ and (196.00 mV) by T₄. From the above result, it is found that the application of Azolla cyanobacteria as soil amendments significantly reduced the soil redox potential (Eh). Similar trends of changes in soil Eh was reported by [13]. In this study soil redox potential value (Eh) showed follow the sequence: T₂ > T₄ > T₅ > T₁ > T₃ > T₆.

Soil pH after harvest of rice: With the application of soil amendments pH range of post-harvest soil was significantly influenced (Table 4). It was evident that, the higher pH value (6.94) was found in the treatment T₆ (25% Urea + Azolla incorporated (6 t ha⁻¹) + Azolla dual cropping (1 t ha⁻¹) with Cyanobacterial Mixture) and the lower (6.63) was found in the treatment T₂: 50% Urea + Vermicompost (4 t ha⁻¹). Phy C, et al (2014) [17] Reported that the soil amendments application had significant effect on soil pH.

Total Nitrogen: Total Nitrogen content ranged from 0.13 to 0.16% and varied due to the effect of different soil amendments. Table 5 represented that treatments T₄, T₅ and T₆ was most effective for contributing the TN content in soil as compared to other treatments. Kamara A, et al. (2015) [18] Also reported that the Azolla treated soils improved the chemical properties of soil as well as the N content compared to the control or other treated soil.

T₁: 100% recommended dose of urea (220 kg ha⁻¹)
T₂: 50% Urea + Vermicompost (4 t ha⁻¹)
T₃: 50% Urea + Azolla incorporated (4 t ha⁻¹)
T₄: 25% Urea + Azolla incorporated (4 t ha⁻¹) + Vermicompost (4 t ha⁻¹)
T₅: 25% Urea + Azolla incorporated (6 t ha⁻¹) + Vermicompost (2 t ha⁻¹)
T₆: 25% Urea + Azolla incorporated (6 t ha⁻¹) + Azolla dual cropping (1 t ha⁻¹) with Cyanobacterial Mixture.

Figure 3: Changes in soil redox potential (Eh) during BRRI dhan58 cultivation.

Treatments	Chemical properties of post-harvest soil						
	pH	Total N (%)	Organic carbon (%)	Organic matter (%)	Phosphorus (ppm)	Potassium (meq/100g)	Sulphur (ppm)
T ₁	6.83b	0.13	1.29b	2.32b	14.12a	0.07b	7.87abs
T ₂	6.63c	0.13	1.45c	2.61c	10.40b	0.09ab	7.11abc
T ₃	6.87b	0.13	1.43b	2.57b	14.34a	0.10a	8.13abc
T ₄	6.68a	0.14	1.57a	2.83a	14.52a	0.10a	9.65a
T ₅	6.79b	0.15	1.47b	2.65b	10.16b	0.08ab	5.59c
T ₆	6.94a	0.16	1.58a	2.84a	14.27a	0.07b	8.89ab
LSD _(0.05)	0.184	0.056	0.097	0.178	0.389	0.018	2.837
CV (%)	3.28	17.32	3.90	3.84	1.77	24.05	20.84
Level of significance	**	NS	**	**	*	NS	*

**= Significant at 1% level of probability and NS= Not significant

CV= Co-efficient of variation and LSD= Least significant difference

Table 4: Effect of soil amendments on chemical properties of post-harvest soil

Organic Carbon: Organic carbon varied from 1.29 to 1.58% where the lowest amount of organic carbon was found from those soils which were not treated by any organic amendments (only 100% recommended dose of urea) while treatment T₆ showed the higher percentage of OC (1.58%). This result revealed that only Azolla and cyanobacteria as soil amendment can be produced more OC in soil compared to urea fertilizer and similar observation was also found by [19,20] (Tables 5).

Organic Matter: Organic matter ranged from 2.32 to 2.84% where the lowest amount of OM was found from those soils which were not treated by any organic amendments (only 100% recommended dose of urea). This result was in agreement with the research work of [19] who also found that the Azolla and cyanobacteria treated soils improved the OM content compared to the control or without Azolla treated soil.

Available Phosphorus: The higher content of phosphorus (14.52 ppm) was recorded from the treatment T₄ while T₅ and T₂ treatment produced statistically lower content of P (10.16 ppm and 10.40 ppm respectively) (Table 6). Kamara A, et al. (2015) [18] Stated that the application of organic fertilizers improved available phosphorus and cation exchange capacity in soils.

Exchangeable Potassium: The ranges of K content were 0.07 to 0.10 meq 100g⁻¹ while the highest content was found from those soils the treatments T₃ and T₄ respectively while, the lowest content (0.07 meq 100g⁻¹) was obtained from T₁ but they were statistically identical due to non-significant variation (Table 6).

Available Sulphur: The higher content of sulphur (9.65 ppm) was recorded from the treatment T₄ while T₅ treated soil produced lowest content of sulphur (5.59 ppm). Kimetu

(i)	pH	:	6.3
(ii)	Organic carbon (%)	:	1.03
(iii)	Total nitrogen (%)	:	0.17
(iv)	Available phosphorus (ppm)	:	13.9
(v)	Available potassium (ppm)	:	16.3
(vi)	Exchangeable potassium (ppm)	:	0.28

Source: Laboratory Test: Department of soil Science, BAU, Mymensingh -2202.

Table 5: Chemical characteristics of pre-sowing soil

Sand (2-0.05mm):	32%
Silt (0.05-0.002mm):	62%
Clay (<0.002):	08%
Textural class:	Silt loam

Source: Humboldt Laboratory, Department of Soil Science, BAU, Mymensingh

Table 6: Physical properties of pre-sowing soil (0-15 cm depth) of the experimental site

JM, et al (2008) and Mosier AR, et al. (1998) [21,22] Also reported that phosphorus, K, Ca, S and magnesium (Mg) concentrations were not affected or decreased on plots with the longest continuous cropping history where organic amendments were utilized.

Effect of soil amendments on growth and yield contributing characters

Plant height: The plant height ranged from 99.33 (T_2 : 50% Urea + Vermicompost (4 t ha⁻¹) to 103.00 cm (T_4 : 25% Urea + Azolla incorporated (4 t ha⁻¹) + Vermicompost (4 t ha⁻¹) and did not vary significantly in different soil amendments. Rani R, et al. (2002) [23] Also conducted a pot experiment in a glass house of Varanasi in Uttar Pradesh to assess the rice production to different combination of vermicompost and nitrogen treatments significantly increased plant height.

Number of panicle hill⁻¹: The number of panicle hill⁻¹ did not vary significantly due to different soil amendments (Table 7). Number of higher (14.67) and lower (13.00) panicle ranged from T_4 and T_1 , respectively. This result revealed that all the treatments of the present study were produced statistically same number of panicles hill⁻¹.

Number of grains panicle⁻¹: The number of grains panicle⁻¹ ranged from 123.7 to 128.3 where the highest number of grains panicle⁻¹ was obtained in treatment T_2 and the lowest was recorded in treatment T_6 . Similar results also found by [24] that recorded as the application of nitrogen with organic fertilizers increased grains number and significantly improve the grain quality (Table 7).

Weight of 1000-grain: Weight of 1000-grain and it was ranged from 23.40g to 24.02 g. In the present study, it was found that 1000-grain weight was showed non-significant variation due to the application of soil amendments. Hoque MA (1999) [25] Also reported that application of organic and inorganic fertilizers increased the 1000-grain weight of rice.

Grain yield and Straw yield: Significantly grain yield (ha⁻¹) and straw yield (ha⁻¹) influenced by the use of different soil amendments. From the Table 7, it was observed that,

the highest grain yield (6.50 t ha⁻¹) was found in treatment T_4 and highest straws yield (8.70 t ha⁻¹) found in the same treatment. Similarly, lowest grain yield (5.37 t ha⁻¹) was found in the treatment T_3 and lowest straws yield (7.37 t ha⁻¹) was found in the treatment T_3 . Ali MA, et al. (2012) [26] Reported that, 25% recommended urea+ Azolla Cyanobacteria (1 t ha⁻¹) increased rice grain yield by 8% in low land rice field. Khan MA, et al. (2007) [26,27] also observed that combined application of NPK and organic fertilizers significantly increased the grain and straw yield of rice.

Harvest Index (HI %)

With the application of different soil amendments grain harvest index significantly influenced (Table 7). Harvest Index (HI) of different soil amendments influenced in different way at different stages of BRRI dhan58. It was evident that the higher harvest index (44.71%) was found in the treatment T_4 and the lower (41.67%) was found with the use of T_3 . In case of rice production, it was found that organic amendments increased the yield of rice than control treatment.

Conclusions

From the obtained results it was found that the CH₄ emission was significantly varied from 0.88 mg m⁻² h⁻¹ to 2.48 mg m⁻² h⁻¹ at 14 DAT where no significant differences were observed among the treatments. Similar trend of results was also found at 48 DAT while it was ranges from 6.12 mg m⁻² h⁻¹ to 12.94 mg m⁻² h⁻¹ in treatment T_6 . The highest CH₄ flux was observed in T_6 treatment and where the lowest CH₄ flux was recorded in treatment T_2 . However, methane emission showed the highest peak at 70 DAT in all treatments. The highest amount (30.39 mg m⁻² h⁻¹) of CH₄ emission flux was observed in treatment T_6 (25% Urea + Azolla incorporated (6 t ha⁻¹) + Azolla dual cropping (1 t ha⁻¹) with Cyanobacterial mixture) within the 70 DAT while the lowest (16.38 mg m⁻² h⁻¹) was recorded in the treatment T_2 (50% Urea + Vermicompost (4 t ha⁻¹). After rice harvest the value of soil properties such as soil pH, total nitrogen, organic carbon, phosphorus, potassium and sulphur was observed 6.94, 0.16%, 1.58%, 14.52 ppm, 0.10 meq 100g⁻¹

Treatments	Plant height (cm)	No. of panicles hill ⁻¹	Number of grains panicle ⁻¹	Weight of 1000-grain(g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	Harvest index (%)
T ₁	102.7	13	127.0bc	23.85	5.45c	7.63b	42.08b
T ₂	99.33	14	128.3ab	23.58	5.93b	7.92b	42.89b
T ₃	102	13.33	125.7c	23.45	5.37c	7.37b	41.67b
T ₄	103	14.67	128.3a	24.02	6.50a	8.70a	44.71b
T ₅	101.3	13.67	124.3c	23.4	5.63a	7.42b	42.75b
T ₆	101.3	14.33	123.7c	23.4	6.00b	7.45b	43.16a
LSD _(0.05)	2.435	1.503	1.391	1.002	2.32	2.83	1.428
CV (%)	1.35	6.43	0.62	2.39	4.34	4.19	1.87
Level of significance	NS	NS	**	NS	**	**	*

*, **= Significant at 5% and 1% level of probability, respectively and NS=Not significant
CV= Co-efficient of variation and LSD=Least significant difference

Table 7: Effect of soil amendments on growth and yield contributing characteristics of BRRI dhan58.

and 9.65 ppm, respectively in T₆, T₄ and T₃ treatments. Considering the CH₄ emission trend during rice cultivation the treatments sequence may be ranked as T₆> T₃> T₁> T₅> T₄> T₂. On the other hand, on the basis of grain yield the treatments may be ranked as T₄> T₆> T₂> T₅> T₁> T₃. Considering all the above parameters it may be concluded that the application of 25-50% of the recommended Urea along with Azolla incorporated (4 t ha⁻¹) and Vermicompost (4 t ha⁻¹) amendment could be suitable for maximizing of rice yield and reducing CH₄ emission. From the knowledge of this experiment, rice fields enriched with different soil amendments are the significant source of plants nutrients. Now rice growers would be able to select the suitable soil amendments for rice cultivation considering the negative effect of CH₄ gas emission from rice field. It would also help the farmer to select easily the different soil amendments which can give more production on the availability to them. As a result, rice production could be increased through utilization of suitable soil amendments while CH₄ gas emission could be controlled from rice field. Considering the above facts of the present study, the following recommendation may be suggested:

- Further study may be needed to ensure the studied performance in another AEZ-9 area for observing the adaptability.
- Different suitable soil amendments may be needed to include for further study to make sure the present findings of the study.

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