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Impact of Paddy Straw Incorporation along with Different Fertilizer Doses on Mineral N Dynamics and GHG Emissions

Ch. Ravali [a++*], G. Jayasree [b#], K. Sammi Reddy [c†], G. Pratibha [d‡] and S. Triveni [e^]

[a] SR University, Warangal, India.
[b] Department of Soil Science and Agril. Chemistry, College of Agriculture, PJTSAU, Hyderabad, India.
[c] ICAR-NIASM, Baramati, Maharashtra, India.
[d] Division of NRM, CRIDA, Hyderabad, India.
[e] Department of Microbiology and Bio Energy, College of Agriculture, PJTSAU, Hyderabad, India.

Authors' contributions

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

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ABSTRACT

Aim: An incubation experiment was conducted, which aimed to investigate NH4+ and NO3- release pattern and GHG emissions as influenced by paddy residue decomposition over 120 days.
Study Design: Completely randomized block design.

[++] *Assistant Professor;*
[#] *Senior Professor and University Head;*
[†] *Director;*
[‡] *Principal Scientist;*
^ *Professor and Univ. Head;*
**Corresponding author: E-mail: ch.ravali@sru.edu.in;*

Place and Duration of Study: The study was conducted at Agrometerology laboratory, CRIDA, Hyderabad. The experiment was conducted between 2021-22.
Methodology: Sampling was performed at 2, 4, 6, 8, 10, 20, 30, 45, 60, 75, 90, 105 and 120 days after incubation (DAI). The treatments included control (T1), soil + N (T2), paddy residue + 100% RDN (Recommended dose of Nitrogen) - 33:33:33 (T3), paddy residue + 100% RDN - 43:23:33 (T4), paddy residue + 100% RDN - 43:33:23 (T5), paddy residue + 10% extra RDN - 43:23:33 (T6). Fertilizer N was applied in three splits (first at initiation of experiment, second and third at 30 and 60 DAI respectively). RDN used in the study was 240 kg ha-1 (i.e., maize).
Results: Residue incorporation along with inorganic fertilizer significantly influenced NH4+ - N and NO3- - N, as well as GHG emissions. After addition of each split, there was an increase in NH4+ - N and NO3- - N contents. Significantly higher NH4+ - N and NO3- - N was recorded in T6, compared to other treatments. The cumulative CO2 and N2O emissions were significantly higher in paddy residue + 10 % extra RDN – 43:23:33 i.e., 296.63 µg C g-1 of soil and 1.81 µg N g-1 of soil respectively, while lowest (42.59 µg C g-1 of soil and 0.09 µg N g-1 of soil respectively) was observed in control.

Keywords: Residue incorporation; Cumulative emissions; NH4+ - N; NO3- - N; Residue decomposition; inorganic fertilizer; cattle feed; rice straw; soil fertility.

1. INTRODUCTION

Rice stands out as the predominant crop residue producer in Asia, contributing to a substantial 826 million tons, which makes up 84% of the world's total production. Traditionally, rice straw is harvested from fields in South Asia for utilization as cattle feed and various other purposes. On an average, rice crop residues contain 0.7% N, 0.23% P and 1.75% K. Therefore, the amount of NPK in rice crop residues produced is about 22.13×10^6 and 26.26×10^6 t year^{-1} in Asia and the world, respectively [1]. From the perspective of farmers, burning is perceived as the most suitable method for rice straw disposal, not only due to its cost-effectiveness but also for its effectiveness as a pest control measure [2].

The rapid decomposition of soil organic matter, leading to a swift loss of nitrogen, poses a significant challenge in maintaining soil fertility and raises environmental concerns. The application of water-soluble nitrogen fertilizers results in increased levels of available nitrogen, surpassing plant requirements, particularly early in the crop growth season. This nitrogen excess has the potential for leaching, contributing to NO_x gases generation, including nitrous oxide (N_2O), a greenhouse gas associated with global warming. The likelihood of N_2O production from soil is contingent upon favorable denitrification conditions, such as temperature, soil moisture, organic carbon levels and pH, emphasizing the intricate interplay between nitrogen management and environmental impacts [3].

A synchrony between soil N availability and plant N requirement is highly essential and also serves as an important factor contributing to increase N plant uptake and grain yields. As the most rice residue is being burnt before taking up the succeeding crop, it is leading to release GHG emissions and environmental hazards. So, efficient management of rice residue is of major concern. Residue incorporation serves as one of the best residue management options, which improves soil fertility and reduces environmental pollution.

The C/N ratio of organic material is commonly considered as a pivotal factor in predicting net nitrogen (N) immobilization or mineralization during the decomposition of residues. The quality of the residue plays a crucial role in influencing decomposition, thus it carefully manages the balance between N mineralization and immobilization. Hence, strategically incorporating low-quality crop residues (residues having C:N ratio > 30:1) along with application of nitrogen fertilizer holds promise for effectively curbing nitrogen losses [4]. The initial decline in mineral nitrogen (N) status, due to immobilization resulting from the incorporation of crop residues with a high carbon-to-nitrogen (C/N) ratio, may contribute to a reduction in subsequent nitrous oxide (N_2O) emissions. When the residues are incorporated along with inorganic fertilizer, immobilization followed by re-mineralization of mineral N occurs, which means that, after the initial immobilization, the mineral N is released back into the soil. Many previous studies proved that when wheat straw is incorporated along with inorganic N fertilizer, there was initial N mineralization, followed by release of N in later stages [5].

Agricultural management practices exert profound influence on soil CO_2 emissions through modifications in the soil environment, encompassing parameters such as soil aeration, pH levels, moisture content, temperature and C/N ratios. These inherent characteristics of soil environment plays a pivotal role in modulating microbial activity and the decomposition mechanisms which are responsible for the conversion of plant-derived carbon into organic matter and subsequent release of CO_2. Crop residues with high C:N ratio, when incorporated into soil, C mineralization occurs, which also leads to GHG emissions. Therefore, we conducted an incubation study, to examine the release patterns of NH_4^+-N and NO_3^- - N and also to investigate the GHG emissions (CO_2, CH_4 and N_2O), after incorporation of paddy straw with various changed split doses of inorganic nitrogen, throughout the incubation period.

2. MATERIALS AND METHODS

2.1 Soil and Crop Residues

The soil used for incubation study was collected from B block of college farm, College of Agriculture, Rajendranagar, PJTSAU, which is located in Rangareddy district of Telangana state at an altitude of 542.6 m above mean sea level (78^{0}23' °E longitude and 17^{0}19' N latitude).The weekly mean maximum temperature during the crop growth period in *Rabi* 2020-21 ranged from 29.5 ^oC to 38.1^oC with an average of 34.9^oC, while the weekly mean minimum temperature ranged from 11.2^oC to 25.3^oC with an average of 19.3^oC. The soil was collected from the maize experimental field. Soil samples were combined, homogenized, sieved (2 mm), pre-incubated, and residues were collected, oven dried at 65 ^oC in a hot air oven, and crushed with a willey mill before sieving through a 2 mm sieve. The residues were then characterized using appropriate techniques (Table 1). The texture of soil was sandy clay loam, with pH of 7.9, EC of 1.14 dSm^{-1}, organic carbon of 0.72% and had a C:N ratio of 16:1.

2.2 Incubation

The experiment was conducted by taking 100 g of the soil in 150 ml plastic cups and the soil was kept at field capacity by adding 13 ml of distilled water and kept in dark for 10 days for pre-incubation. Pre-incubation was done prior to the start of incubation experiment to initiate microbial activity in the soil.

After pre-incubation, 0.18g powdered paddy straw was mixed with soil as per treatments and urea was added along with distilled water into the soil. After treatment imposition, the beakers were incubated at room temperature for 120 days.

The entire experiment was repeated so as to collect greenhouse gas emissions from one set and second set was used to monitor mineralization with destructive sampling at given intervals. The samples were used for analysis of NH_4^+- N, NO_3^+- N, C:N ratio and available N . The constant soil moisture content of the experiment was maintained throughout the experimental period. Details of treatments is mentioned in Table 2.

The treatments were replicated thrice and were laid out in Completely Randomized Design (CRD) Sampling was done on 2, 4, 6, 8, 10, 20, 30, 45, 60, 75, 90, 105, 120 days after incubation.

Table 1. Properties of paddy residue used in the lab study

S.No.	Particulars	Values
1	Lignin (%)	24.7
2	Cellulose (%)	35.0
3	Hemicellulose (%)	13.6
4	Total C (%)	48.98
5	Total N (%)	0.66
6	C:N	74.21
7	ADF (%)	43.6
8	Ash (%)	15.53
9	Proteins (%)	4.12
10	Total phenols (mg GAE / 100 g)	31.03

Table 2. Treatment details

T_1	Control (Soil only without residue and nitrogen)
T_2	Soil + RDN in normal 3 splits (33:33:33)
T_3	Crop residue incorporation + RDN in normal 3 splits (33:33:33)
T_4	Crop residue incorporation + 100 % RDN but with changed quantities *i.e.*,43:23:
T_5	Crop residue incorporation + 100 % RDN but with changed quantities *i.e.*,43:33:23
T_6	Crop residue incorporation + 10 % extra N with changed quantities during crop growth *i.e.*, 43:33:33

**Note: Rate of paddy straw added to 100g soil was based on top residue available from the kharif crop that is possible to deploy in succeeding rabi (maize) crop*

NH_4^+, NO_3^- and GHG emissions: Ten grams of soil was shaken with 100 ml of 2 M KCl for an hour and filtered. Then the filtrate was steam distilled in presence of 0.2 g MgO. The distillate was collected in 4% boric acid containing mixed indicator was titrated with standard sulphuric acid (0.02 *N*) as described by Chivenge et al [6] and expressed in mg kg^{-1}. After removal of NH_4-N^+ from the sample, the distillation flask was removed and then 0.2 g Devarda's alloy was added immediately and steam distillation was performed. The distillate was collected in 4% boric acid containing mixed indicator was titrated with standard sulphuric acid (0.02 *N*) as described by Chivenge et al [6] and expressed in mg kg^{-1}.

100g of soil (2mm sieved) was taken in plastic cups to which urea (as per treatments) and paddy residue (0.18g) was added. Then bulk density was adjusted to 1mg m^{-3}. Moisture was added to bring the soil samples to FC. Constant moisture content of the set was maintained in the soil throughout the experiment. Plastic cups were positioned within a gallon jar, with a small amount of water at the bottom of the jar to maintain soil moisture. Gas samples were collected using an airtight three-way stopcock syringe (60 ml capacity) from the headspace of the jar and then injected into pre-evacuated extainer vials at specific intervals of 2,4,6,8,10,20,30,45,60,75,90 and 120 days after incubation (DAI) for analysis using an autoanalyzer. The concentrations of N_2O, CO_2 and CH_4 gases were simultaneously analyzed using a modified gas chromatography instrument (Bruker 450) equipped with three detectors: FID, ECD, and TCD. Nitrous oxide was separated by two stainless steel columns (column-1: 1 m length, 2.2 mm i.d.; column-2: 3 m length, 2.2 mm i.d.) packed with 80–100 mesh porapack Q and detected by ECD. Carbon dioxide was separated by a single stainless steel column (2 m length, 2.2 mm i.d.) packed with 50–80 mesh porapack Q, and then hydrogen reduced CO_2 to CH_4 in a Nickel catalytic converter at 37.5°C, with CH_4 being detected by FID. The oven temperature was set at 55°C, the ECD operated at 330°C, and the FID at 220°C, respectively. Regular opening of the jars occurred at specified intervals to prevent CO_2 buildup. During the experiment, the CO_2 concentration was kept below 5%. The jars were opened, and the cups were briefly placed outside before being returned to the jars. Subsequently, the jars were flushed with ambient air for one minute.

The GWP of different treatments was calculated using the following equation [7], where the GWP for CO_2 is taken as 1.

$$GWP = CH_4 \times 21 + N_2O \times 298$$

2.3 Statistical Analysis

All the data was subjected to statistical analysis using OPSTAT software. The critical difference for assessing the significance of treatment means was computed at a 5% level of probability.

3. RESULTS AND DISCUSSION

The effect of different nitrogen fertilizer doses along with paddy straw application on changes in mineral N status (NH_4^+ and NO_3^-) for each split dose of fertilizer was studied for 120 days, where the sampling was done on 2,4,6,8,10,20,30,45,60,75,90,105 and 120 DAI. The NH_4^+ and NO_3^- content in soil under incubation was significantly influenced by different nitrogen fertilizer doses along with paddy straw application, throughout the incubation period (Table 3, 4 and Fig. 1).

Ammoniacal nitrogen (NH_4^+ - N): After application of first split dose of nitrogen along with paddy residue, the sampling was done on 2, 4, 6, 8, 10, 20 DAI (Fig. 1a). Here only basal dose of nitrogen was given. On day 2, application of paddy residue + 10 % extra RDN – 43:23:33

(T_6) recorded significantly higher NH_4^+ - N (117.60 mg kg^{-1}) , followed by soil +N (T_2) *i.e.*, 102.00 mg kg^{-1} which was on par to paddy residue + 100 % RDN - 43:23:33 (T_4) and control (T_1) where the ammoniacal nitrogen was 97.00 and 97.00 mg kg^{-1} respectively. The lowest NH_4^+ - N was recorded in paddy residue + 100 % RDN - 33:33:33 (T_1) *i.e.,* 85.27 mg kg^{-1}. From day 1 to day 8, there was an increase in NH_4^+ - N content in all treatments except control (T_1) and soil + N (T_2), where the NH_4^+ - N content increased upto 10th day and later decreased throughout the incubation period. However in all the sampling dates after day 2, upto day 8 (4,6,8 DAI), T_6 recorded significantly higher NH_4^+ - N (156.60, 174.13, 185.00 mg kg^{-1} respectively). After day 8, the NH_4^+ - N shown a decreasing trend upto day 30. T_6 recorded significantly higher NH_4^+ - N from day 10 to day 30.

The effect of second split dose application on NH_4^+ - N was studied from 30th day to 60th DAI *i.e.,* second split application was done on 30th day after the application of first split. The sampling was done on 30, 45 days after the application of second split. Among all the treatments, paddy residue + 10 % extra RDN – 43:23:33 (T_6) recorded significantly higher NH_4^+ - N and the lowest NH_4^+ - N was recorded in control (T_1). The NH_4^+ - N in T_6 on 30th day was 85.47 mg kg^{-1}, later it was increased to 94.53 mg kg^{-1} on 45th day.

The effect of third split dose application on NH_4^+ - N was studied from 60th day to 120th DAI *i.e.,* third split application was done on 60th day after the application of first split. The sampling was done 60, 75, 90, 105, 120 days after incubation. Here all the three split doses were applied. Results indicated that the NH_4^+ - N content increased from day 60 to day 75 and later it has decreased upto 120th day. The paddy residue + 10 % extra RDN - 43:23:33 (T_6) recorded highest NH_4^+ - N and paddy residue + 100 % RDN - 43:33:23 (T_5) recorded lowest NH_4^+ - N. There was approximately 22.48 % decrease in NH_4^+ - N content from day 75 to day 120.

Increase in N concentration increased mineral N status. Application of fertilizer along with rice straw increased mineral-N (NH_4^+-N + NO_3^-–N) concentration compared with no-straw [8]. Initial increase in NH_4^+-N after the application of N fertilizer along with rice straw, from day 2 to day 8 might be due to increased ammonification. Thereafter NH_4^+-N showed a decreased trend which might be due to immobilization, as the rice straw had high C:N ratio (73:1), which caused immobilization. After the application of second split, there was slight increase in NH_4^+-N upto 45th day, which is due to increased mineralization and this continued even after application of third split (*i.e.,* upto 75th day) and later it has decreased due to increase in the nitrification.

Nitrate Nitrogen (NO_3^- - N): The NO_3^- - N content on day 2 was higher in paddy residue + 10 % extra RDN - 43:23:33 (T_6) *i.e*., 69.17 mg kg^{-1} which was on par to paddy residue + 100 % RDN - 43:33:23 (T_5) *i.e.,* 67.00 mg kg^{-1}, while the lowest NO_3^- - N was recorded in control (T_1) *i.e*., 43.67 mg kg^{-1} (Fig. 4.1b). From day 4 to day 20, T_6 recorded higher NO_3^- - N at all the sampling dates. The NO_3^- - N content has shown an increasing trend from day 2 to day 20 and later it showed a decreasing trend upto day 30, in all the treatments except in soil + N (T_2), where there was increase in NO_3^- - N upto 30th day. The NO_3^- - N ranged from 65.23 to 87.83 mg kg^{-1} from day 1 to day 20.

The effect of second split dose application on NO_3^- - N content was studied from 30 to 60 DAI. On day 30, significantly higher NO_3^- - N was observed in soil + N (T_2) *i.e*., 89.33 mg kg^{-1}. and the lowest NO_3^- - N was recorded in control (T_1) *i.e.,* (60.33 mg kg^{-1}). After the application of second split, the NO_3^- - N increased from day 30 to day 45, the increase was approximately 44.79 %.

The effect of third split dose application on NO_3^- - N content was studied from 60 to 120 DAI. On day 60, significantly higher NO_3^- - N was observed in soil + N (T_2) *i.e*., (98.99 mg kg^{-1}), while the lowest NO_3^- - N was recorded in paddy residue + 100 % RDN - 43:33:23 (T_5) *i.e.,* (75.17 mg kg^{-1}). The NO_3^- - N increased from 60 to 90 DAI and later it had decreased from 90th to 120th day. Compared to T_6, on an average, 60.80 % of lower NO_3^- - N was recorded in control (T_1) throughout the incubation period, after third split application.

The NO_3^- - N was significantly higher in T_6, where extra nitrogen was applied. After the application of first split, from day 2 to day 20 there was increase in NO_3^- - N which is due to increased nitrification in those days. The aerated conditions and the moisture conditions in soil favoured multiplication of nitrifiers, which inturn enhanced nitrification process [9]. After 20th day, there was slight decrease in NO_3^- - N status, which was later increased after the application of second split dose *i.e.,* on 30th day. This increase in NO_3^- - N status is due to increase in total mineral nitrogen due to application of second split dose. Then from day 30 onwards NO_3^- - N status increased upto day 45, after which third split dose was applied. The NO_3^- - N status continued to increase upto the end of incubation period. This is due to continuous nitrification process of nitrogen from both fertilizer nitrogen as well as the nitrogen from residue decomposition. Among all the treatments containing nitogen, soil + N (T_2) recorded highest NO_3^- - N by the end of the experiment. This may be attributed to the apparent immobilization of nitrogen in the treatments where both paddy straw and nitrogen were applied [10].

3.1 GHG emissions

3.1.1 CO_2 emissions

The data indicated that, in all the treatments, after addition of only fertilizer or fertilizer along with residue, there was increase in CO_2 emissions (Fig. 2a). CO_2 emissions decreased upto day 4, after which CO_2 emissions increased and reached peak on day 6, later CO_2 emissions decreased upto day 20. After day 20, the CO_2 emissions increased and reached peak on day 30. After day 30, upto day 45, CO_2 emissions have decreased and from day 45 to day 60, CO_2 emissions have increased and reached peak on day 60. From day 60 to day 75, CO_2 emissions decreased and almost reached a constant value upto the end of the incubation.

The cumulative CO_2 emissions (Fig. 2b) were significantly higher in paddy residue + 10 % extra RDN – 43:23:33 (T_6) *i.e.*, 296.63 µg C g^{-1} of soil (Table 5 and Fig. 3). The lowest cumulative CO_2 emissions were observed in control (T_1) *i.e.,* 42.59 µg C g^{-1} of soil. The addition of residue enhanced carbon source and energy which had boosted microbial activity and lowered soil redox potential, there by increased CO_2 emissions in all treatments containing residue. Similar results were reported by Guopeng et al [11], who reported that, in a 100 days incubation experiment, incorporation of rice residue significantly increased soil CO_2 emissions.

3.1.2 CH_4 emissions

The methane emissions decreased from day 2 to day 4, the increased upto day 6, later decreased upto day 8 and then increased upto day 10, after which the methane emissions decreased upto day 30 (Fig. 4a). On day 30, after addition of second split, methane emissions increased and reached peak upto day 45, after which there was a decrease upto day 90, then increased upto day 105 and later methane emissions decreased upto day 120. The treatments did not differ significantly (Fig. 4b) with respect to cumulative CH_4 emissions (Table 5 and Fig. 3). The incubation study was conducted under aerobic conditions, which is very unfavourable condition for the emission of methane. So in all the treatments, the methane emissions was very limited, which did not make any significant difference.

3.1.3 N_2O emissions

The N_2O emissions reached peak on day 6, after which there was a decrease upto day 10 and almost reached zero from 10^{th} day to 20^{th} day (Fig. 5a). From day 20, there was increase in N_2O emissions upto 30^{th} day, where it reached peak (reached maximum). After 30^{th} day, there was decrease upto 45^{th} day. From 45^{th} day, the N_2O emissions increased and reached peak on 60^{th} day and later it has decreased upto 120^{th} day.

The cumulative N_2O emissions (Fig. 5b) were significantly higher in paddy residue + 10 % extra dose of N (1.81 µg N g^{-1} of soil), followed by paddy residue + 100 % RDN (43:23:33) *i.e.,* 1.77 µg N g^{-1} of soil. The lowest cumulative N_2O emissions were observed in control (T_1) *i.e.,* 0.09 µg N g^{-1} of soil (Table 5 and Fig. 3).

The incorporated straw stimulated N_2O emissions by providing readily available C as an energy source for dentirifiers. Our results were in line with studies conducted by Li et al [12] and Guardia et al [13], who reported that residues with high C:N ratio, when incorporated into soil along with inorganic fertilizer, increased N_2O emissions via enhanced dentitrification after fertilization. The increased nitrogen dose in paddy residue + 10 % extra dose of N (T_6) treatment increased the nitrogen substrate and thus increased N_2O emissions [14]. Another reason might be rice residue incorporation/retention increases soil respiration which creates anaerobic microsites and promotes multiplication of denitrifiers, enhancing denitrification process, thereby increases N_2O emissions [15]. The higher dose of nitrogen in the first split lowered C:N ratio, increased N mineralization and increased availability and accessibility of substrates to microbes and the residues created anaerobic conditions which encouraged the growth and multiplication of denitrifiers in soil, thus promoting N2O formation [16].

Table 3. Effect of different fertilizer doses employing paddy straw on NH4+- N (mg kg-1) during incubation

Treatments	Days of Incubation												
	2	**4**	**6**	**8**	**10**	**20**	**30**	**45**	**60**	**75**	**90**	**105**	**120**
Control (T_1)	97.00	103.33	104.67	106.00	117.67	81.33	76.67	73.00	74.33	70.33	69.67	57.00	47.00
Soil + N (T_2)	102.00	105.33	108.00	110.67	115.00	107.78	91.67	86.67	92.67	84.33	76.33	68.33	58.33
Paddy straw + RDN-33:33:33 (T_3)	85.27	99.80	117.93	121.00	109.27	87.73	77.70	84.23	94.83	124.50	104.87	96.17	86.17
Paddy straw+ RDN-43:23:33 (T_4)	97.00	121.93	138.27	140.53	114.87	96.20	57.80	77.20	90.67	122.33	108.00	91.67	84.17
Paddy straw + RDN - 43:33:23 (T_5)	93.73	119.33	140.87	143.17	118.53	99.73	79.00	86.83	78.80	95.17	81.73	72.87	66.60
Paddy straw + 10% extra RDN - 43:23:33 (T_6)	117.60	156.60	174.13	185.00	174.23	132.57	85.47	94.53	106.83	140.67	126.67	113.47	108.13
C.D. (5 %)	5.93	8.54	8.97	12.81	8.88	6.66	6.73	5.31	5.54	4.54	5.46	4.68	4.97
SE(m) ±	1.90	2.74	2.88	4.11	2.85	2.14	2.16	1.71	1.78	1.46	1.75	1.50	1.59
SE(d)	2.69	3.88	4.07	5.82	4.03	3.02	3.05	2.41	2.51	2.06	2.48	2.13	2.25

Table 4. Effect of different fertilizer doses employing paddy straw on NO3-- N (mg kg-1) during incubation

Treatments	Days of Incubation												
	2	**4**	**6**	**8**	**10**	**20**	**30**	**45**	**60**	**75**	**90**	**105**	**120**
Control (T_1)	43.67	46.00	46.00	52.00	61.00	72.33	60.33	50.00	46.67	45.00	44.00	43.00	40.00
Soil + N (T_2)	46.00	54.00	55.00	58.00	72.00	83.00	89.33	93.33	98.99	101.00	107.00	110.00	120.33
Paddy straw + RDN-33:33:33 (T_3)	58.13	61.17	62.00	68.67	70.83	80.33	68.17	71.67	85.13	112.00	116.00	103.00	94.33
Paddy straw+ RDN-43:23:33 (T_4)	62.50	64.27	69.50	73.83	75.83	82.17	66.13	67.33	87.17	119.67	114.33	102.33	93.67
Paddy straw + RDN - 43:33:23 (T_5)	67.00	71.00	72.67	74.50	77.17	84.17	69.00	73.50	75.17	97.83	97.00	90.00	81.37
Paddy straw + 10% extra RDN -43:23:33 (T_6)	69.17	72.50	74.17	76.83	81.17	87.83	71.50	77.50	88.17	123.83	124.83	113.17	107.83
C.D. (5 %)	4.66	4.58	4.57	3.56	3.62	2.67	3.09	5.22	7.11	4.02	5.85	7.08	4.57
SE(m) ±	1.50	1.47	1.47	1.14	1.16	0.86	0.99	1.68	2.28	1.29	1.88	2.27	1.47
SE(d)	2.11	2.08	2.07	1.62	1.64	1.21	1.40	2.37	3.23	1.83	2.65	3.21	2.07

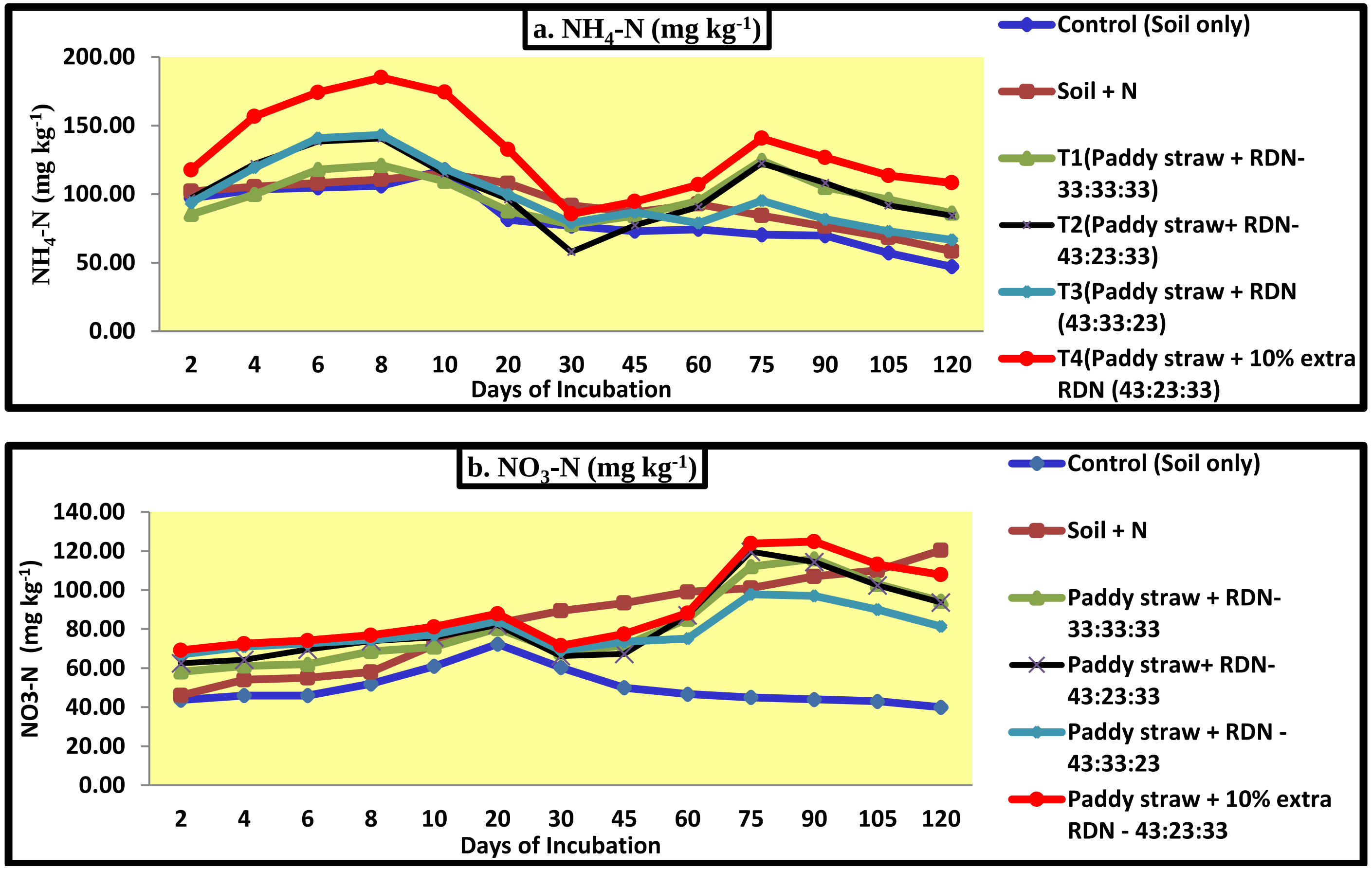
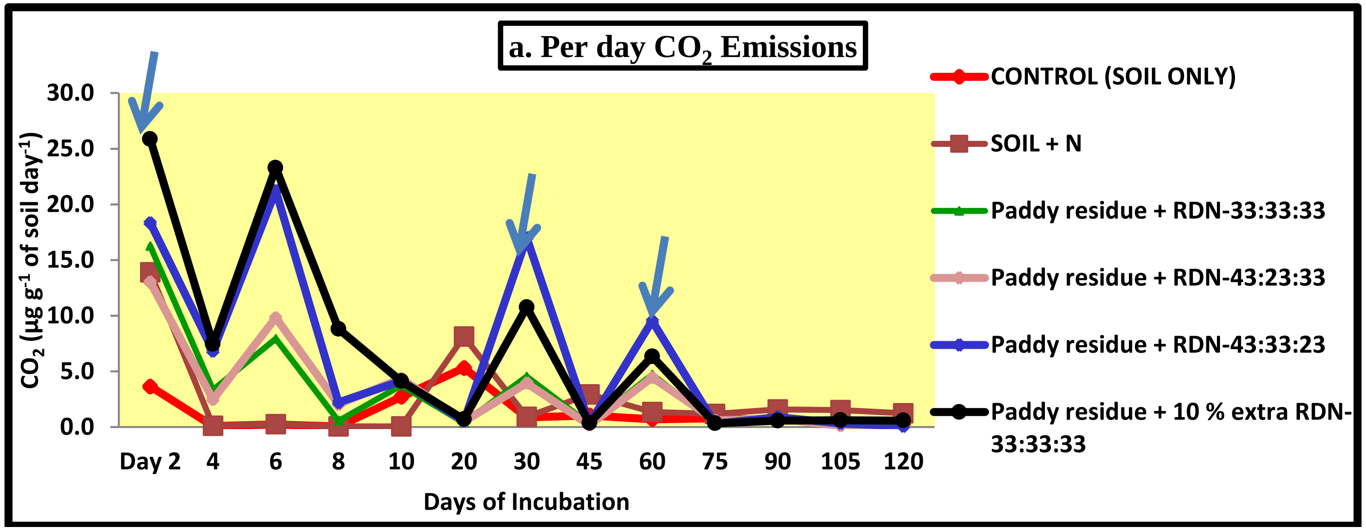


Fig. 1. Effect of different fertilizer doses employing paddy straw on inorganic N fractions during incubation



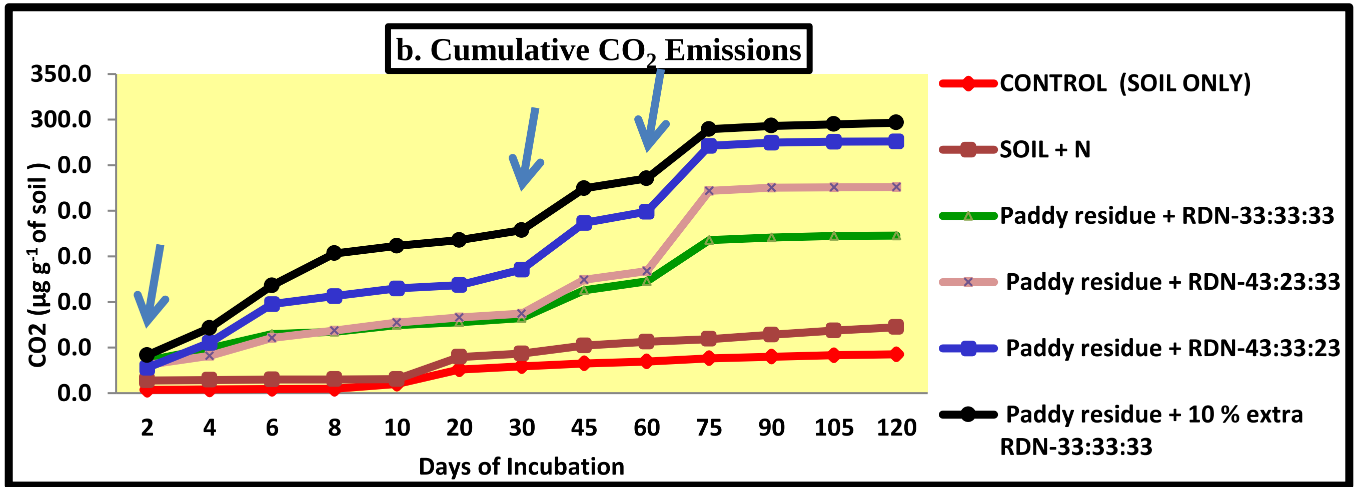
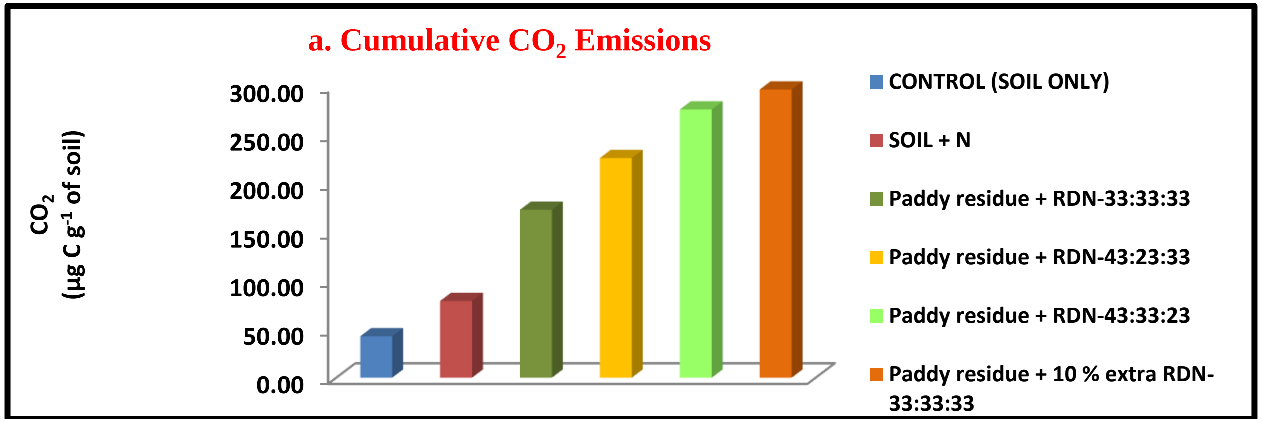
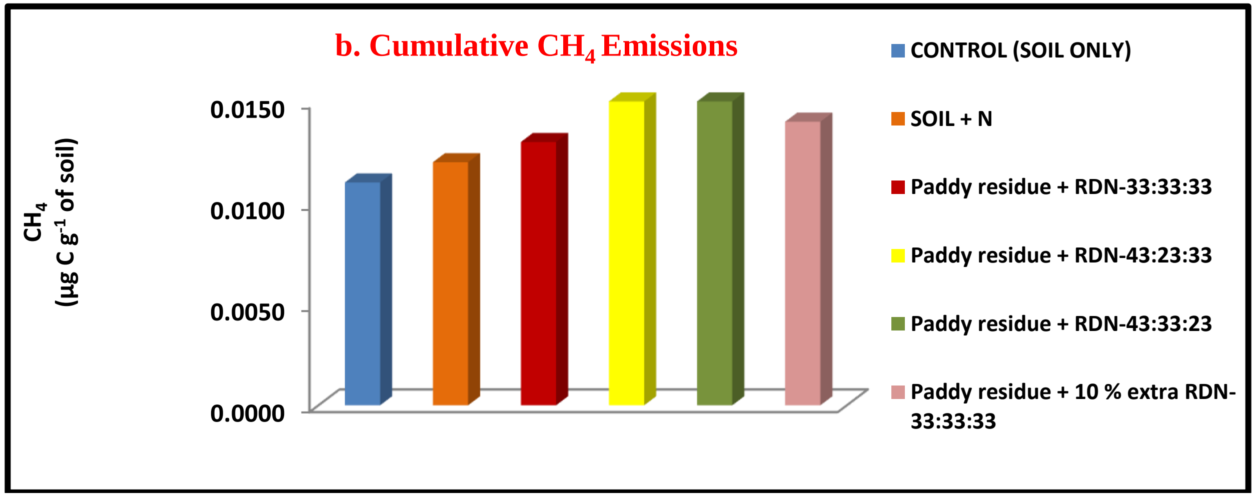


Fig. 2. Effect of different fertilizer doses employing paddy straw on CO_2 emissions during incubation

Note: Arrows indicates split application of N fertilizer


a. Cumulative CO_2 Emissions
CO_2 (µg C g^{-1} of soil)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
CONTROL (SOIL ONLY)
SOIL + N
Paddy residue + RDN-33:33:33
Paddy residue + RDN-43:23:33
Paddy residue + RDN-43:33:23
Paddy residue + 10 % extra RDN-33:33:33


b. Cumulative CH_4 Emissions
CH_4 (µg C g^{-1} of soil)
0.0150
0.0100
0.0050
0.0000
CONTROL (SOIL ONLY)
SOIL + N
Paddy residue + RDN-33:33:33
Paddy residue + RDN-43:23:33
Paddy residue + RDN-43:33:23
Paddy residue + 10 % extra RDN-33:33:33

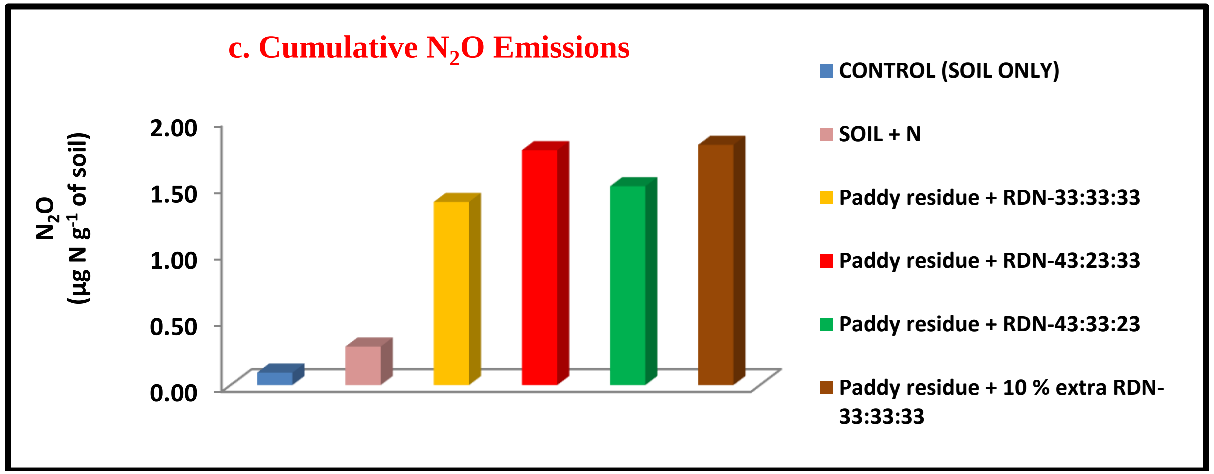
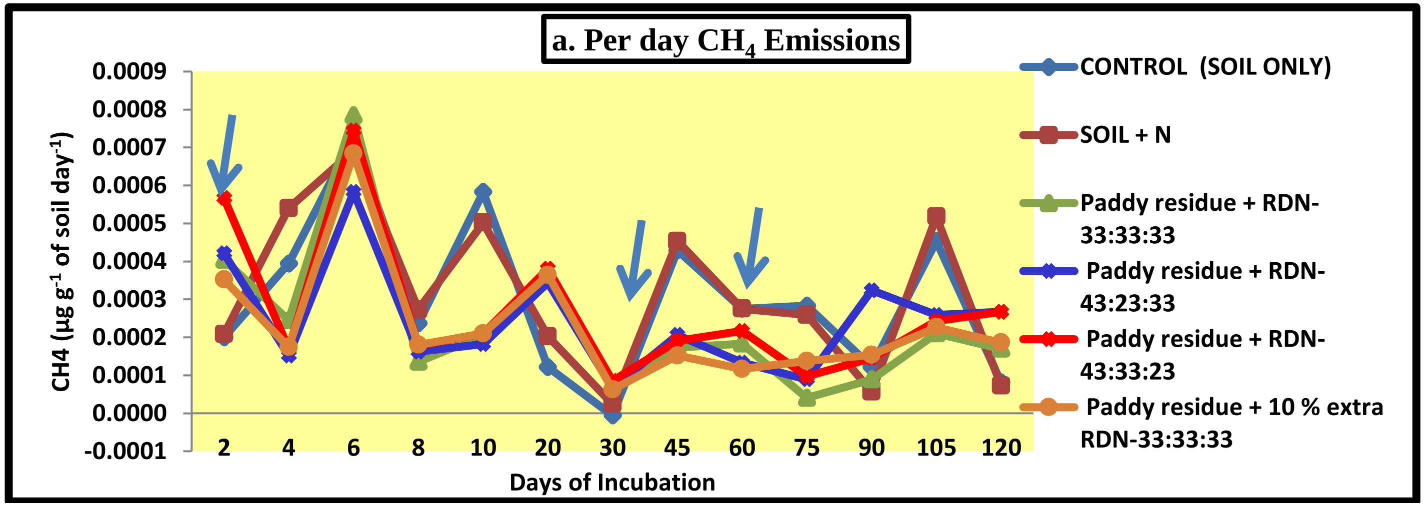


Fig. 3. Effect of different fertilizer doses employing paddy straw on cumulative emissions during incubation



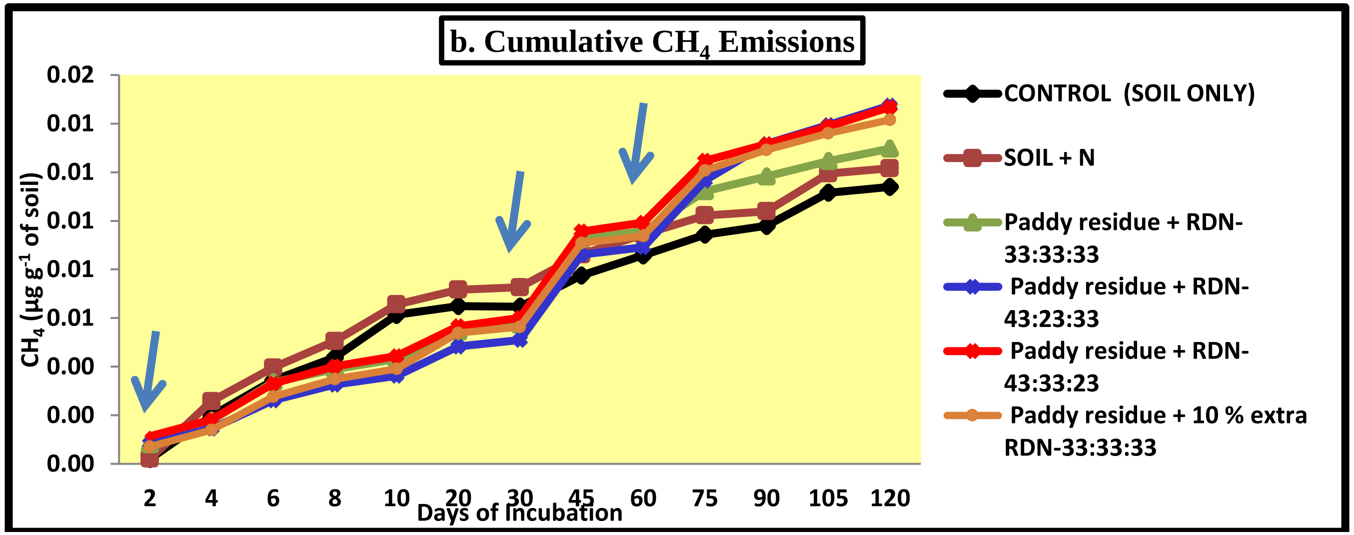
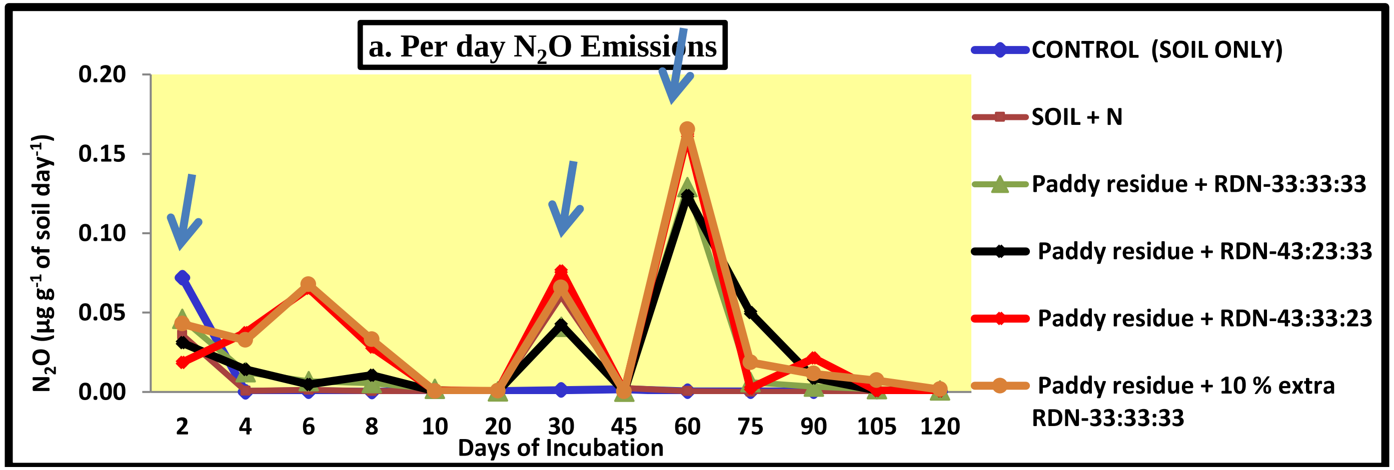


Fig. 4. Effect of different fertilizer doses employing paddy straw on CH_4 emissions during incubation

Note : Arrows indicates split application of N fertilizer



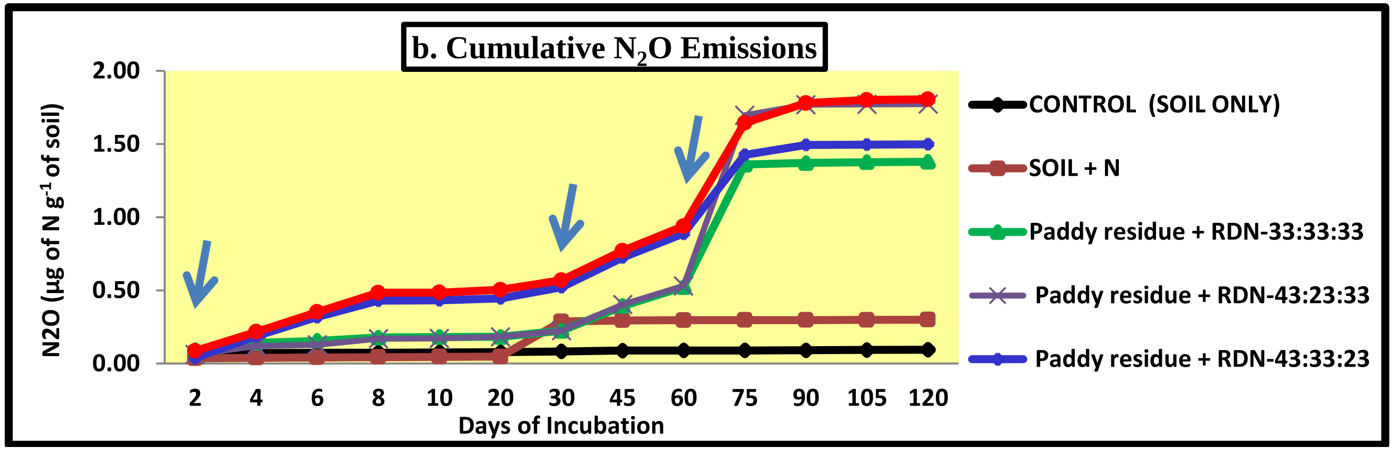


Fig. 5. Effect of different fertilizer doses employing paddy straw on N2O emissions during incubation

Note : Arrows indicates split application of N fertilizer

Table 5. Effect of different fertilizer doses employing paddy straw on cumulative GHG emissions during incubation

Treatment	Cumulative CO_2 Emissions (µg C g^{-1} of soil)	Cumulative CH_4 Emissions (µg C g^{-1} of soil)	Cumulative N_2O Emissions (µg N g^{-1} of soil)
Control (T_1)	42.59	0.011	0.09
Soil + N (T_2)	78.97	0.012	0.29
Paddy straw + RDN- 33:33:33 (T_3)	172.81	0.013	1.38
Paddy straw+ RDN-43:23:33 (T_4)	226.09	0.015	1.77
Paddy straw + RDN -43:33:23 (T_5)	276.05	0.015	1.50
Paddy straw + 10% extra RDN - 43:23:33 (T_6)	296.63	0.014	1.81
C.D.	9.05	NS	0.04
SE(m) $\pm$	2.90	0.001	0.01
SE(d)	4.11	0.001	0.02

4. CONCLUSION

Our observation showed that, from day 1 to 8, NH_4^+ -N content increased in most treatments, except control and soil + N. After application of each split dose of fertilizer, there was increase in release of NH_4^+ -N content in all the treatments. Paddy residue + 10% extra RDN - 43:23:33 treatment recorded significantly higher NH_4^+ -N content. Approximately 22.48% decrease in NH_4^+ -N content from day 75 to day 120. On day 2, paddy residue + 10% extra RDN - 43:23:33 had higher NO_3^--N. Second split application on day 30 increased NO_3^--N. From day 30 to 45, NO_3^--N increased by approximately 44.79%. Third split application from day 60 to 120 showed variations among treatments, with soil + N recording the highest on day 60. Cumulative CO_2 emissions significantly higher in paddy residue + 10% extra RDN – 43:23:33, lowest was observed in control. Cumulative CH_4 emissions showed no significant differences among treatments. Cumulative N_2O emissions was significantly higher in paddy residue + 10 % extra dose of N and was lowest in control. Our results suggest that, incorporation of crop residues along with inorganic fertilizer serves as best residue management practice compared to residue burning, in croplands. It increases N availability, besides improving soil fertility and decreasing GHG emissions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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