<u>*Original Research Article*</u>

INM-A potential way of farming in reduction of CH_4 and CO_2 emission in rice- sunflower sequential cropping system

ABSTRACT

Aim: To find out the CH_4 and CO_2 emission pattern and the considerable amount of SOC sequestered by using different organic sources in sandy clay loam soil.

Study Design: Randomized Block Design

Place and Duration of the study: Field experiments were conducted at Ayan Aathur Village, Ariyalur District, Tamil Nadu, India, from September 2016 to Jan 2017 and September 2017 to January 2018 for I and II crops respectively in sandy clay loam soil. The field is geographically situated at 11°23'N latitude, 79°29'E longitude, and an altitude of +26 m MSL.

Methodology: The different sources of organic manures viz., FYM @ 12.5 t ha^{-1}, vermicompost, pressmud, poultry manure, and composted coirpith are @ 5 t ha^{-1} applied as basally and incorporated along with Azospirillum and phosphobacteria @ 2 kg ha^{-1} as a soil application. A nutrient schedule of 150:50:50 kg N, P, and K ha^{-1} was followed throughout the period of study for rice crop. An open path LICOR analyzer 7700 and 7500 for CH_4 and CO_2 to find the CH_4 and CO_2 fluxes during the period of study through calibration of eddy covariance fluxes emissions were calculated.

Results: The data revealed that the combined application of RDF along with FYM @ 12.5 t ha^{-1} reduced the CH_4 emission by 13.6 and 15 % over other organic sources in rice whereas, the CO_2 emission by 54.4 and 53.8% and 61.5 and 53.9 % over other organic sources in rice and sunflower respectively. Concomitantly, the SOC increased by 6.8 and 7.5% in rice and 4,7 and 4.4% in sunflower over other organic sources.

Keywords**:** Carbon dioxide, GHG's, Global warming, Methane, and Organic carbon.

INTRODUCTION

Global warming is a part of climate change and one of the most predominant environmental issues across the world due to the wide range of GHG's emissions. Worldwide agricultural practices have the prospective to influence methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O) emissions, the potent greenhouse gases (GHG) by contributing around 20-30% of the earth's global warming radiative force (1). In the agriculture sector, rice is a predominant crop that meets 70 percent of the world's population feed mostly grown in warm climates, and higher temperatures increase the amount of methane emitted (2). As world food demand continues to grow, rice yields will need to increase by around 28% by 2050 to match demand, further increasing emissions (3). Especially, the paddy field is considered to be an important anthropogenic CH_4 emission source (4). The amount and magnitude of CH_4 fluxes varied depending upon various crucial factors *viz.,* climate, characteristics of soil, paddy cultivars, and agricultural management practices, and very particularly by water regimes i.e., the pattern of moistening the field. Though agriculture is the largest contributor to GHGs, an urgent call to mitigate/reduce the CH_4 and CO_2 emissions paves the way to increase the accumulation of organic carbon in the soil biota. Reduction of CH_4 and CO_2 could be achieved through several practices such as tillage, précised nutrient management, and irrigation management.

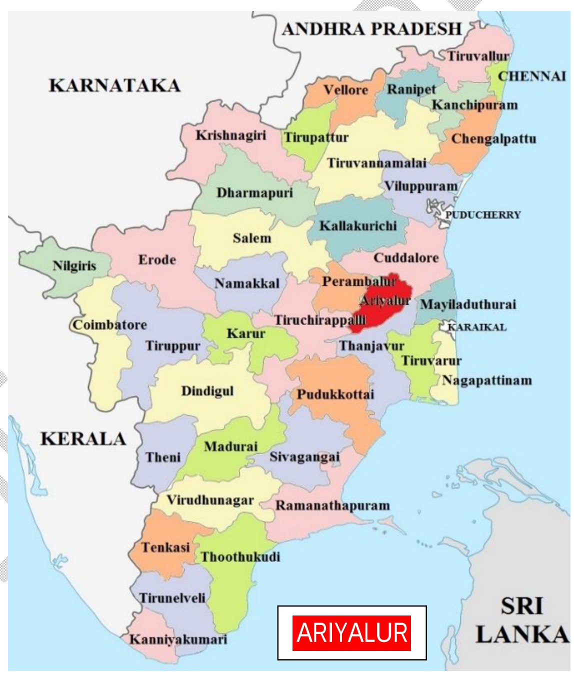
To know the impact of these factors on nutrient management field experiments were conducted to study the significance of cartel use of organic manures and inorganic fertilizers on methane and carbon dioxide fluxes and yield of the rice crop during the years 2016 and 2017. The experiments were conducted in RBD with 7 treatments. With regards to the CH_4

and CO_2 emission pattern, the combined application of organic manures and inorganic fertilizers recorded a lesser value over other INM-applied treatments.

MATERIALS AND METHODS

Field experiments were conducted at Ayan Aathur Village, Ariyalur District, Tamil Nadu, India, from September 2016 to Jan 2017 and September 2017 to January 2018 for I and II crops respectively in sandy clay loam soil. The field is geographically situated at 11°23'N latitude, 79°29'E longitude, and an altitude of +26 m MSL. The experimental soil had a pH of 7.8, EC- 0.46 dSm^{-1}, organic carbon - 0.49%, total carbon-0.77%, $KMnO_4$-N - 135 kg ha^{-1}, Olsen- P- 13.8 kg ha^{-1}, NH_4OAc- K- 163 kg ha^{-1}.

SITE MAP



Map 1 :

The experiments consist of 7 treatments viz., $\mathbf{T_1}$- Control, $\mathbf{T_2}$- RDF alone, $\mathbf{T_3}$ - Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF ha^{-1}, $\mathbf{T_4}$ - Vermicompost @ 5 t ha^{-1} + 100% RDF ha^{-1}, $\mathbf{T_5}$ - Pressmud @ 5 t ha^{-1} + 100% RDF ha^{-1}, $\mathbf{T_6}$ - Poultry waste manure @ 5 t ha^{-1} + 100% RDF ha^{-1}, $\mathbf{T_7}$- Composted coir pith @ 5 t ha^{-1} + 100% RDF ha^{-1} for rice and additionally SSP @ 40 kg ha^{-1} for organic amendment-imposed treatments for sunflower. The experiments were conducted in RBD. As per the treatment schedule appropriate sources of organic manures viz., FYM @ 12.5 t ha^{-1}, vermicompost, pressmud, poultry manure, and composted coirpith are @ 5 t ha^{-1} applied as basally and incorporated along with Azospirillum and phosphobacteria @ 2 kg ha^{-1} as a soil application. A nutrient schedule of 150:50:50 kg N, P, and K ha^{-1} was followed throughout the period of study. The major nutrients viz., N, P, and K were supplemented through urea (46% N), DAP (18% N and 46% P_2O_5), and muriate of potash (60% K_2O) respectively. Half of recommended nitrogen and potash and the entire dose of phosphorus were applied basally as per the treatment schedule. Five hills of rice crop were chosen at random within each net plot and tagged for recording bio-metric and need-based other observations both in soil and plant were taken at various stages of crop.

LICOR CH_4 ANALYZER

CH_4 fluxes were measured in rice crops during the vegetative, flowering, and maturity stages. Li-7700 is a high-speed, high-precision methane Analyzer designed to use in eddy covariance flux and atmospheric monitoring applications. It uses wavelength modulation Spectroscopy (WMS) to make high-speed precise measurements of methane concentrations at ambient pressure and temperature. It is designed to withstand environmental extremes expected during outdoor deployment, with data output up to 20 Hz bandwidth. The CH_4 analyzer has a low power requirement of 8 W during normal operation, and withstands outdoor environmental extremes, with a temperature range from -25°C to 50°C without damage or calibration shifts. Analog input channels to integrate sonic anemometer, wind speed (U, V, and W), and sonic temperature (T_s) data with CH_4 and CO_2 data removable USB flashcard and enabling versatile data output options. Ethernet communication data transfer RS-232 serial communications.

CALIBRATION OF LI-COR 7700

Li – 7700 calibrations offset and sensitivity was checked before and offsetting zero span gases in a balance of air with CH_4 accuracy greater than the gases that are free of volatile organic compounds other than methane. Removed the radiation shield and installed the calibration to ensure that it seals around the top and bottom openings to connect the ‘zero gas” (0 ppm CH_4 in the air). Allow for 10 to 30 minutes for calibration depending on the flow rate.

LICOR CO_2 ANALYZER

The LI-7500A is a high-performance, non-dispersive, open-path infrared CO_2 and H_2O Analyzer designed for use in eddy covariance flux measurement systems. Three components of wind velocity (U, V, and W) and temperature were measured with a sonic anemometer (Hs, Gill) while the densities of CO_2 and water vapour were measured with an open-path CO_2/H_2O Analyzer (LI-7500A). The sensor heads of the sonic anemometer and the IRGA were mounted all most at a height of 3.0 m above the ground, where the direction of the sonic anemometer was 180 ± 1°. The horizontal distance between the two sensor heads was 0.16 m, and the data from the sonic anemometer and the IRGA were sampled at 10 Hz and stored in CR 100 data logger (CR 100, Campbell, S/N1396) which was retrieved using a compact flash card.

CALIBRATION OF LI-7500A IRGA

IRGA was new, before installing it was calibrated two times during calibration offset, and sensitivity was checked before and after setting Zero and the span of the IRGA following the instruction manual (LI-COR, 2001). CO_2 span gas (344.1 ppm and 488.7 ppm) was supplied from cylinders. The calibration was done in a laboratory maintaining a room temperature of 27°C during calibration.

Fig.1 LICOR CH_4 and CO_2 Analyzer

RESULTS AND DISCUSSION

The results revealed that the treatment nourished with FYM@ 12.5 t ha^{-1} with RDF positively influenced all yield components *viz*., number of panicles m^{-2} and number of filled grains panicle^{-1}, grain and straw yield of rice over other organic amended treatments which are presented in Table-1. Among the organic manures + inorganic fertilizers treated plots, composted coir pith @ 5 t ha^{-1} + 100% RDF ha^{-1} registered a lower grain and straw yield of 6506 and 7019 kg ha^{-1} and it was on par with RDF alone treatment during both the crop period.

About the SOM and SOC (Table.1), the same increasing trend was observed during the crop period. Among the organic manures + RDF supplemented plots, composted coir pith @ 5 t ha^{-1} + 100% RDF ha^{-1} registered a lower value of SOM (1.04%) and pressmud @ 5 t ha^{-}1+ 100 RDF ha^{-1} SOC of (6.1 g ka^{-1}) than other imposed treatments of rice crop. The increased soil organic carbon is due to the addition of organic manures which improved the Physico-chemical properties of the soil, especially in sandy clay loam soil. This subsequently paves way for increased root biomass. Root-derived materials are an important DOC source in the soil (Lu *et al.*, 2005). Furthermore, positive interaction between the organics with inorganic NPK eventually increased the overall growth components which attribute to both the internal-physiological process and external- phenophase of the crop which in turn leads accumulation of more photosynthates shows a positive sign to the increased microbial activity from diversified nourishment substrate. The photosynthesized C act as an effective input into the soil differed among the plant species in which, 64-86% was rapidly respired by soil microorganisms and only 2-5% of which incorporated into SOC (Hutsch *et al*., 2002).

EFFECT OF INM ON CH_4 AND CO_2 FLUXES IN RICE–SUNFLOWER PRODUCTION

The observations registered on the methane and carbon dioxide emission on 40, and 80 DAS and at harvest stages of the rice crop are depicted in Table 2. The methane and carbon dioxide fluxes from the plot nourished through different organic manures combined with 100% inorganic fertilizers revealed that the methane emission depends upon the season, diurnal variation, and different growth phases of the crop. The recorded data on methane emission revealed that the diurnal variation coupled with the continuous flooding pattern of irrigation had a marked influence on CH_4 ecosystem exchange at all growth stages during, the *Thaladi* season in both the years of rice crop. All the treatments exhibit their consistent increased pattern of CH_4 emission was noticed from the vegetative to the reproductive stage and after a declined state of CH_4 emission was observed at the harvest stage during the *Thaladi* season of the rice crop.

Table-1 Effect of INM on grain, straw yield, SOM, and SOC of rice

Experimental year	**Crop duration 2016-2018**			
Treatments	**Grain Yield kg ha^{-1}**	**Straw Yield Kg ha^{-1}**	**SOM %**	**SOC g Kg^{-1}**
Control (No fertilizers)	3818	4814	0.88	5.2
100% RDF alone	6163	6759	1.01	5.9
FYM @ 12.5 t + 100 % RDF	9027	8915	2.82	8.2
VC @ 5 t + 100% RDF	8418	8411	1.32	7.7
Pressmud @ 5 t + 100% RDF	7140	7574	1.12	6.1
PM @ 5 t + 100% RDF	7818	7959	1.22	7.1
CCP @ 5 t + 100% RDF	6506	7019	1.04	6.6
S.E(m)	187.5	129.5	0.02	0.19
CD(P=0.05)	401.3	277.1	0.06	0.40

VC- Vermicompost, PM- Poultry manure waste, CCP- Composted Coir Pith, RDF- Recommended Dose of Fertilizer

The application of FYM @ 12.5 t ha^{-1} integrated with 100% RDF recorded a lower methane fluxes value of 4.7 and 2.3, 7.0 and 2.0, and 3.2 and 1.8 mg m^{-2} h^{-1} CH_4 emission and carbon dioxide value of -0.11 and 0.06, -0.06 and 0.12 and -0.12 and 0.07 m mol m^{-2} s^{-1} during both the day and night time at 40, 80 DAS and at harvest respectively during the *Thaladi* season of the rice crop. Simultaneously, the treatment supplemented with press mud @ 5 t ha^{-1} + 100% RDF recorded significantly a higher value of 5.4 and 2.6 and 7.9 and 2.3 and 3.9, and 2.2 mg $m^{-1}h^{-1}$ CH_4 emission, and the treatment with CCP @ 5 t ha^{-1} + 100% RDF recorded the higher carbon dioxide emission of -0.08 and 0.08, -0.04 and 0.14 and -0.11 and 0.09 m mol m^{-2} s^{-1} in both the day and night time at 40, 80 DAS and at harvest respectively during the *Thaladi* season of the rice crop. Among the different organic manures tried, press mud @ 5 t ha^{-1} integrated with 100% RDF received plots exhibit their high potential in the amount of methane and CCP exhibits a high potential of CO_2 exchange to the ecosystem than other organic manures *viz.,* FYM, vermicompost, poultry waste manure, and composted coir pith. Compared to FYM other organic manures showed an increasing trend of CH_4 emission throughout the period. This might be due to the high resistant capacity of organic manure against decomposition due to the high C:N ratio which will be escaped through ebullition. Besides, the higher amount of CH_4 emission at the reproductive stage of the crop in all treatments might be due to the production of more sloughed-off root tissues coupled with root exudates increasing the methanogenesis which paves a way for increased CH_4 emission Lu *et al.* (2000), Eusuf *et al.* (2011). In the case of CO_2 emission, the emission pattern of CO_2 proved that the initial stage of the crop released more amount *i.e.,* on 40 DAS, and decreased amount of emission at 80 DAS i.e., at the reproductive stage and also further declining trend was observed at harvest stage in all respective treatments. These results corroborate the findings of Cai (1999) narrated that the addition of organic manure could increase CO_2 emission no matter of the aerobic and anaerobic conditions in paddy soils.

Table-2 Effect of INM on CH_4 and CO_2 emission in Rice (Compiled mean average of 2 years data)

Treatments	CH_4 emission (mg m^{-2} h^{-1})						CO_2 emission (m mol m^{-2} s^{-1})					
	40 DAS		80 DAS		At Harvest		40 DAS		80 DAS		At Harvest	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Control (No fertilizers)	2.6	1.3	3.4	1.1	2.2	1.1	-0.13	0.04	-0.10	0.06	-0.13	0.04
100% RDF alone	2.9	1.6	3.7	1.4	2.9	1.3	-0.12	0.06	-0.08	0.11	-0.12	0.07
FYM @ 12.5 t + 100 % RDF	4.7	2.3	7.3	2.0	3.2	1.8	-0.11	0.06	-0.06	0.12	-0.12	0.07
VC @ 5 t + 100% RDF	4.9	2.4	7.4	2.1	3.4	1.9	-0.10	0.07	-0.05	0.13	-0.11	0.08
Pressmud @ 5 t + 100% RDF	5.4	2.6	7.9	2.3	3.9	2.2	-0.09	0.09	-0.04	0.15	-0.10	0.09
PM @ 5 t + 100% RDF	4.9	2.5	7.7	2.2	3.6	1.9	-0.10	0.07	-0.05	0.13	-0.12	0.08
CCP @ 5 t + 100% RDF	5.1	2.6	7.8	2.2	3.7	2.1	-0.08	0.08	-0.04	0.14	-0.11	0.09
S.E(m)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

VC- Vermicompost, PM- Poultry manure waste, CCP- Composted Coir Pith, RDF- Recommended Dose of Fertilizer

Fig.2 Effect of INM on Carbon Dioxide emission in Rice

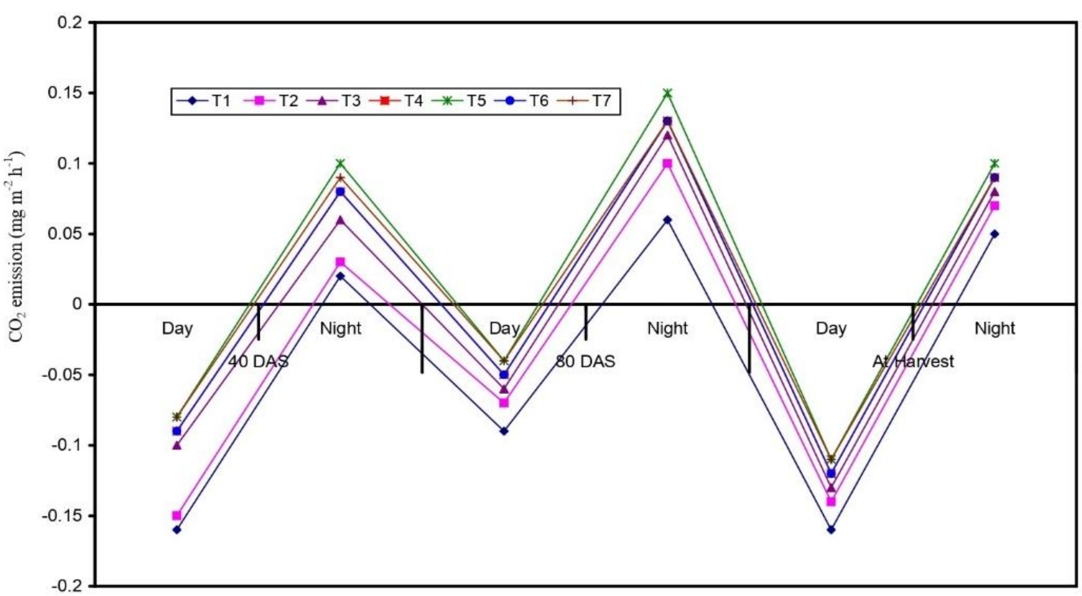
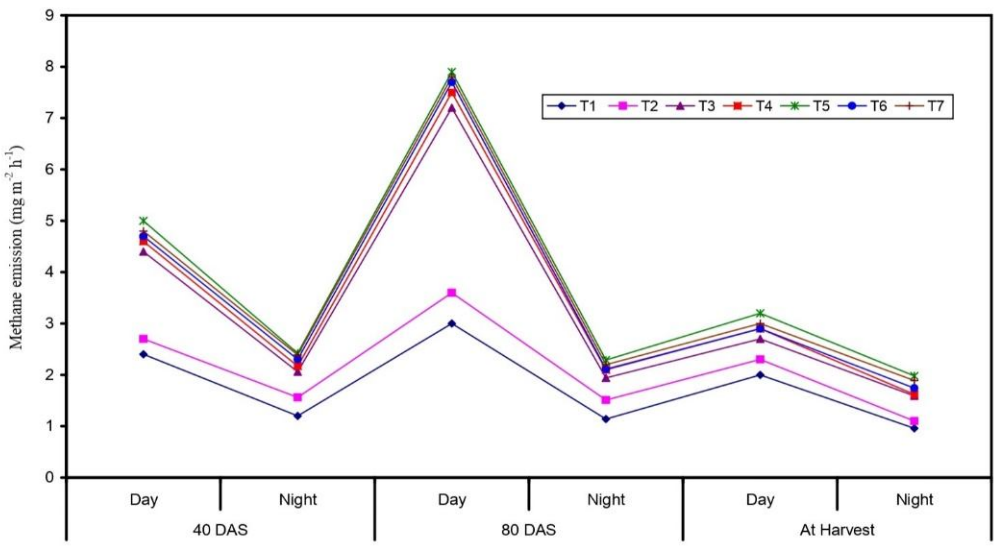


Fig.3 Effect of INM on Methane emission in Rice



CONCLUSIONS

1. The least CH_4 and CO_2 emission values were acquired in one of the INM practices through FYM @ 12.5 t ha^{-1} along with 100% RDF in rice.
2. Higher CH_4 and CO_2 emission values were obtained in the INM practice through Pressmud 5t ha^{-1} along with 100% RDF in rice.
3. Though the lesser CH_4 and CO_2 emission values were attained in the RDF alone practice it is important to consider long-run sustainability of soil fertility and the system production.
4. Probably it is proven by higher SOC and SOM accumulation in the INM practice through FYM @ 12.5 t ha^{-1} along with 100% RDF which paves attain a higher grain and straw yield in rice.

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