EFFECT OF COMBINED USE OF ORGANIC MANURES AND INORGANIC FERTILIZERS ON THE METHANE FLUXES IN RICE CROP (*Oryza sativa*).

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ABSTRACT

Field experiments were conducted to study the effect of combined use of organic manures and inorganic fertilizers on methane fluxes and yield of rice crop production during the year 2015 and 2016. The experiments were conducted in RBD with the following treatments *viz.*, **T_1**- Control (No fertilizer), **T_2**- RDF alone, **T_3** - Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF ha^{-1}, **T_4** - Vermicompost @ 5 t ha^{-1} + 100% RDF ha^{-1}, **T_5** - Pressmud @ 5 t ha^{-1} + 100% RDF ha^{-1}, **T_6** - Poultry Manure @ 5 t ha^{-1} + 100% RDF ha^{-1} , **T_7**- Composted coir pith @ 5 t ha^{-1} + 100% RDF ha^{-1}. The results revealed that application of 100% RDF alone and integration of different organic manures with 100% RDF treatments significantly influenced the grain and straw yield of the rice during the *Thaladi* season of 2015 and 2016. The higher grain yield of 8819 and 9235 kg ha^{-1} and straw yield of 8775 and 9055 kg ha^{-1} were recorded in the treatment supplemented with Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF ha^{-1} (**T_3**) during the *Thaladi* season for the year 2015 and 2016 respectively. Pertaining to the various carbon forms, the higher total carbon of 12.83 and 13.28 g kg^{-1}, Soil organic carbon of 7.8 and 8.6 g kg^{-1} and carbon stock of 13.98 and 15.80 t ha^{-1} were recorded in the treatment supplemented with Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF ha^{-1} (**T_3**) during the *Thaladi* season for the year 2015 and 2016 respectively and the same was superior over all other treatments. With regards to CH_4 emission pattern, the combined application of organic manures and inorganic fertilizers recorded a higher value over control (No fertilizer) and 100% RDF alone applied treatments. A consistent increased pattern of CH_4 emission was noticed from vegetative to reproductive stage and there after CH_4 emission declined at harvest stage of the crop, during the *Thaladi* season of the first and second year of the crop. Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF ha^{-1} (**T_3)** recorded the least value of CH_4 emission at 40, 80 DAS and at harvest 6.46 and 7.01, 9.14 and 9.34 and 4.29 and 4.98 mg m^{-2} h^{-1} respectively for both the years. Apparently a higher value of CH_4 emission of 7.42 and 7.69, 10.19 and 10.10 and 5.80 and 5.28 mg m^{-2} h^{-1} were recorded with the treatment nurtured with pressmud @ 5 t ha^{-1} + 100% RDF (**T_5**) at 40, 80 DAS and at harvest respectively during the *Thaladi* season for the year 2015 and 2016**.**

Key words: Organic manure, Inorganic fertilizers, rice yield, CH_4, SOM, Soil organic carbon.

Introduction

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 (Bálint *et al.*, 2013). US-EPA (2006a) forecast that combined methane emissions from enteric fermentation and manure management will increase by 21% between 2005 and 2020. However, US-EPA (2006a) projects a 16% increase in CH_4 emissions from rice crops between 2005 and 2020, mostly due to a sustained increase in the area of irrigated rice.

The paddy field is considered to be an important anthropogenic CH_4 emission source (Wang et al., 2017). The measurements at various locations of the world show that there are large temporal variations of CH_4 fluxes and that the flux differs markedly with soil type and texture, application of organic matter and mineral fertilizer (Neue and Sass, 1994). The amount and magnitude of CH_4 fluxes varied depends upon various crucial factors *viz.*, climate, characteristics of soil, paddy cultivars, and agricultural management practices, and very particularly by water regimes i.e., pattern of moistening the field. Methane emissions in rice fields can be quite different in different sites, and in seasonal and management types (Wassmann *et al.*, 2000). The major pathways of CH_4 production in flooded soils are the reduction of CO_2 with H_2, with fatty acids or alcohols as hydrogen donor, and the transmethylation of acetic acid or methanol by methane-producing bacteria. Decaying of organic matter in oxygen-deprived environment notably from fermentative digestion of ruminant livestock, rice planted under flooded condition and manures storage are the main sources of CH_4 emissions (Huang *et al*., 2004).

N fertilizers are necessary for increasing crop yields and can have impacts on CH_4 and N2O emissions (Skinner *et al*., 2014; Mai *et al*., 2016). Methane and N_2O emissions depend on N fertilizer type and rate (Traore *et al.*, 2017), Besides, that the CH_4 emission varied with the type of N-form of fertilizer in the soil (Cai *et al.*, 2007) and the amount of N fertilizer applied and their response to the crop yield (Banger *et al.*, 2012). Methane is released to the atmosphere by ebullition, diffusion across the water-air interface and by transport through aerenchyma, well-developed intercellular air spaces which supplies atmospheric oxygen from pores in the leaves, through the plant stems, and to the roots of the rice plants (Nouchi, 1990). In addition to that most probably 90% of the methane emission achieved during the cropping period by diffusive transport through aerenchyma system in the rice plants and the magnitude of these system and its potential varied with the cultivar type (Liou *et al.*, 2003); substrate available and cultivation system (Cheng-Fang *et al.*, 2012). The sources of organic carbon for methanogenic substrates are the primarily rice plants via root exudation, root senescence and plant litter (Holzapfel-Pschorn and Seiler, 1986). Corton et al. (2000) also found that CH_4 emission was low during early stages and increased at the later stages of rice growth. At the later stages, root exudates and the decaying roots become the major carbon source for CH_4 production (Alberto et al., 1996).

The higher value of (3.03 mg m^{-2} day^{-1}) CH_4 emission was recorded in treatments with chemical fertilizer followed by organic fertilizer pellets (2.88 mg m^{-2} day^{-1}), organic fertilizer (1.68 mg m^{-2} day^{-1}) in rice (Pantawat, 2012). The combined application of NPK and Azolla compost had a significant influence on the accumulation of soil carbon (16.93 g kg^{-1}) and capacity of soil carbon storage (28.1 Mg C ha^{-1}) with high carbon efficiency ratio (16.9) and also its application significantly enhanced CH_4 emission (15.66%) carbon storage of soil and improved the ability of grain yield (6.55 Mg ha^{-1}) over other treatments (Adhya *et al.*, 2000). Application of organic C through FYM was eventually increased the GHG emissions (Pathak *et al.*, 2002). Hence, the present investigation was carried out to evaluate the effect of combined use of organic manures and inorganic fertilizers on methane emission and the crop yield of rice.

Materials and Methods

Field experiments were conducted at Ayan Athur Village, Ariyalur District, Tamil Nadu, India, during September 2015 to Jan 2017 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 – 0.45%, total carbon-0.77%, kMnO4-N – 135 kg ha^{-1}, Olsen- P- 13.8 kg ha^{-1}, NH4OAc- K- 163 kg ha^{-1}. The experiments consist of 7 treatments viz., **T_1**- Control, **T_2**- RDF alone, **T_3** - Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF ha^{-1}, **T_4** - Vermicompost @ 5 t ha^{-1} + 100% RDF ha^{-1}, **T_5** - Pressmud @ 5 t ha^{-1} + 100% RDF ha^{-1}, **T6** - Poultry waste manure @ 5 t ha^{-1} + 100% RDF ha^{-1} , **T_7**- Composted coir pith @ 5 t ha^{-1} + 100% RDF ha^{-1}. The treatments were imposed during the month of Sept to Jan of 2015 and 2016. The experiments were conducted in RBD. The rice variety CO49 (R) was chosen for the study. The treatment schedule consisted of organic manures *viz.*, FYM @ 12.5 t ha^{-1}, vermicompost @ 5 t ha^{-1}, poultry waste manure @ 5 t ha^{-1}, pressmud 5 t ha^{-1} and composted coirpith @ 5 t ha^{-1} applied as basally and incorporated 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 during the period of study. Half the recommended dose of nitrogen and potash and the entire dose of phosphorus were applied basally as per the treatment schedule. The remaining dose of nitrogen and potash were applied at the pre flowering stage. The biofertilizers of Azospirillum and Phosphobacteria @ 2 Kg ha^{-1} were applied as a soil application basally. At the time of harvest grain and straw yield were recorded. Post harvest soils after each crop were analyzed for total carbon and expressed as g kg^{-1}, soil organic carbon (Walkey and Black, 1973) and expressed as g kg^{-1}. After harvest of each crop, soil organic carbon stock was worked out with the following formula proposed by (Majumdar *et al.*, 2007).

SOC stock = $\sum$ Profile volume bulk density x SOC content

Measurement of CH_4 fluxes in rice field

CH_4

The experiments were conducted at Ayan Athur village, Ariyalur distirct, in Tamil Nadu. CH_4 fluxes were measured in rice crop during the vegetative, flowering and maturity stages. Li-7700 is a high speed, high-precision open path 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 analyser has a low power requirements of 8 W during normal operation, 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 data removable USB flash card and enabling versatile data output options. Ethernet communication data transfer RS-232 serial communications.

Statistical Analysis

The experimental data were statistically analyzed as suggested by Gomez and Gomez (1976). For significant results the critical difference was worked out at 5 per cent level.

Results

Rice yield attributes Seed and straw yield

The results revealed that the treatments nourished with a judicious combination of different organic manures with inorganic fertilizers positively influenced all yield components *viz.*, number of panicles m^{-2} and number of filled grains $panicle^{-1}$, seed and straw yield of rice over control. The results pertaining to grain and straw yield are presented in table-1. The grain yield ranged from 3818 to 8819 kg ha^{-1} and 3815 to 9235 kg ha^{-1} during the first and second year crop period. Among the treatments, the higher grain yield of 8819 and 9235 kg ha^{-1} were recorded in FYM @ 12.5 t ha^{-1} + 100% RDF ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_3). This was significantly followed by vermicompost @ 5 t ha^{-1} + 100% RDF ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_4) supplemented treatment with a grain yield of 8110 and 8725 kg ha^{-1} during, the *Thaladi* season in the first and second year respectively. The decreasing trend in grain yield were observed in the treatment as follows $T_6 > T_5 > T_7 = T_2 > T_1$ during the *Thaladi* season of the year of 2015 and 2016. Among the organic manures + inorganic fertilizers treated plots, composted coirpith @ 5 t ha^{-1} + 100% RDF ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_7) registered a lower grain yield of 6102 and 6909 kg ha^{-1} and it was on par with RDF alone (T_2) treatment during both the crop period. Control (No fertilizer) plot was recorded the least grain yield of 3818 and 3815 kg ha^{-1} which was inferior to all other treatments imposed with organic manures + 100% RDF during the both years of rice crop.

Pertaining to the straw yield, the values ranged from 4826 to 8775 and 4802 to 9055 kg ha^{-1} during the *Thaladi* season for the year 2015 and 2016 respectively. Among the treatments, a higher straw yield of

8775 and 9055 kg ha^{-1} recorded for FYM @ 12.5 t ha^{-1} + 100% RDF ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1}(T$_3$). This was significantly followed by vermicompost @ 5 t ha^{-1} + 100% RDF ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T$_4$) supplemented treatment with a straw yield of 8244 and 8577 kg ha^{-1} during both first and second year respectively. The decreasing trend in straw yield were observed in the treatment as follows T$_6$ > T$_5$ > T$_7$ = T$_2$ > T$_1$ during the *Thaladi* season for the year of 2015 and 2016. Among the organic manures + inorganic fertilizers supplemented plots, composted coirpith @ 5 t ha^{-1} + 100% RDF ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T$_7$) registered a lower value of straw yield of 6828 and 6909 kg ha^{-1} and it was on par with RDF alone (T$_2$) imposed treatment in both the years of rice crop. Control (No fertilizer) plot recorded the least straw yield of 4826 and 4802 kg ha^{-1} which were inferior to all other treatments during the first and second year rice crop period. Higher values were recorded for all yield attributes *viz.*, number of panicles m^{-2}, number of filled grains panicle^{-1}, grain yield and straw yield in T$_3$ treatment.

Table-1 Effect of combined use of organic manures and inorganic fertilizers on grain and straw yield of rice (2015 and 2016)

Experimental year	**I year**		**II year**	
Treatments	**Grain Yield kg ha^{-1}**	**Straw Yield Kg ha^{-1}**	**Grain Yield kg ha^{-1}**	**Straw Yield Kg ha^{-1}**
T1	3818	4826	3815	4802
T2	6024	6624	6302	6894
T3	8819	8775	9235	9055
T4	8110	8244	8725	8577
T5	6764	7430	7515	7718
T6	7425	7820	8210	8098
T7	6102	6828	6909	7210
S.E(M)	**183.5**	**126.5**	**187.5**	**129.5**
CD(P=0.05)	**391.2**	**269.6**	**401.3**	**277.1**

Treatment Details

T$_1$ - Control(No fertilizers)
T$_2$ - 100% RDF alone
T$_3$ - Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF ha^{-1}
T$_4$ - Vermicompost @ 5 t ha^{-1} + 100% RDF ha^{-1}
T$_5$ - Pressmud @ 5 t ha^{-1} + 100% RDF ha^{-1}
T$_6$ - Poultry waste manure @ 5 t ha^{-1} + 100% RDF ha^{-1}
T$_7$ - Composted coirpith @ 5 t ha^{-1} + 100% RDF ha^{-1}

Effect of INM on SOM, SOC and total carbon content in rice production

The observations recorded on the soil organic matter (SOM), soil organic carbon (SOC) and total carbon in the rice crop during the *Thaladi* season for the year 2015 and 2016 are presented in the Table 2. Addition of organics along with 100% inorganic fertilizers and Azospirillum and phosphobacteria @ 2 kg ha^{-1} showed a positive influence on SOM, SOC and total carbon content over all other treatments. Addition of organic manures combined with inorganic fertilizers significantly increased soil organic matter was recorded over RDF alone and also control imposed treatments. The soil organic matter values ranged from 0.84 to 1.34 and 0.92 to 1.48 % during the first and second year of the rice crop. A higher SOM with a value of 1.34 and 1.48% were recorded in FYM @ 12.5 t ha^{-1} + 100% RDF + Azospirillum and Phophobacteria @ 2 kg ha^{-1}(T_3) treatment during the *Thaladi* season for the 2015 and 2016 respectively. This was significantly followed by the treatment nurtured with vermicompost @ 5 t ha^{-1} + 100% RDF + Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_4) during the *Thaladi* season for the year 2015 and 2016. The decreasing trend in SOM were observed in the treatment as follows $T_6 > T_5 > T_7 > T_2 > T_1$ during the first and second year of the rice crop. The least value of SOM (0.84 and 0.92%) was noticed with the control (No fertilizer) plot during the *Thaladi* season of both the years of rice crop.

Addition of organic manures combined with 100% inorganic fertilizers and Azospirillum and phosphobacteria @ 2 kg ha^{-1} showed its positive influence on soil organic carbon SOC over all other treatments during the *Thaladi* season of both the years of rice crop. Addition of organic manures combined with inorganic fertilizer imposed treatments significantly increased the soil organic carbon content over RDF alone (T_2) and also control (T_1) treatments. The SOC values ranged from 4.9 to 7.8 and 5.4 to 8.6 g kg^{-1}during, the *Thaladi* season of both the years of rice crop. A higher soil organic carbon with a value of 7.8 and 8.6 g kg^{-1} were recorded with FYM @ 12.5 t ha^{-1} + 100% RDF + Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_3) in both the years of rice crop respectively. This was significantly followed by the treatment supplemented with vermicompost @ 5 t ha^{-1} + 100% RDF + Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_4) plot during the *Thaladi* season of both the years of rice crop. The decreasing trend in soil organic carbon were observed in the treatment $T_6 > T_5 > T_7 = T_2 > T_1$ during the *Thaladi* season of both the years of rice crop. The least value of SOC (4.9 and 5.4 g kg^{-1}) recorded with the control (No fertilizer) plot during the *Thaladi* season of both the years of rice crop.

Addition of organic manures along with 100% inorganic fertilizers and Azospirillum and phosphobacteria @ 2 kg ha^{-1} showed its positive influence on total carbon over all other treatments during the *Thaladi* season in both the years of rice crop. Addition of organic manures integrated with inorganic fertilizers significantly increased total carbon content over RDF alone (T_2) and control (No fertilizer) (T_1) imposed treatments during the *Thaladi* season in both the years of rice crop. The total carbon values ranged from 11.47 to 12.83 and 11.28 to 13.28 g kg^{-1} during the first and second year of the crop. A higher total carbon content with a value of 12.83 and 13.28 g kg^{-1} were recorded with FYM @ 12.5 t ha^{-1} + 100% RDF + Azospirillum and Phophobacteria @ 2 kg ha^{-1}(T_3) in both the years of the rice crop respectively. This was significantly followed by the treatment supplemented with vermicompost @ 5 t ha^{-1} + 100% RDF + Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_4) plot during the first and second year of the crop. The least value of total carbon content of (11.47 and 11.28 g kg^{-1}) recorded with the control (No fertilizer) plot during the *Thaladi* season of both the years of rice crop.

Table-2 Effect of combined use of organic manures and inorganic fertilizers on total carbon and soil organic carbon of rice (2015 and 2016)

Experimental year	I Year			II Year		
Treatments	**SOM (%)**	**Soil organic carbon (g kg^{-1})**	**Total carbon (g kg^{-1})**	**SOM (%)**	**Soil organic carbon (g kg^{-1})**	**Total carbon (g kg^{-1})**
T1	0.84	4.9	11.47	0.92	9.8	5.4
T2	0.98	5.7	12.12	1.03	11.3	6.0
T3	1.34	7.8	12.83	1.48	15.8	8.6
T4	1.25	7.3	12.69	1.38	14.9	8.0
T5	1.08	6.8	12.54	1.16	13.8	7.4
T6	1.16	6.3	12.48	1.27	13.2	6.8
T7	1.01	5.9	12.31	1.07	12.4	6.2
S.E(M)	0.02	0.19	0.009	0.03	0.065	0.21
CD(P=0.05)	0.06	0.4	0.02	0.08	0.14	0.45

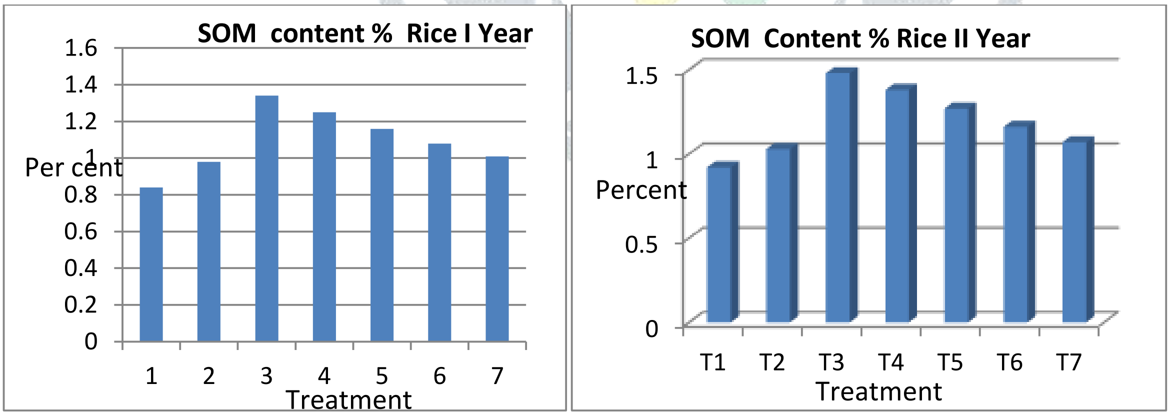
Treatment Details

T_1 - Control(No fertilizers)
T_2 - 100% RDF alone
T_3 - Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF ha^{-1}

T_4 - Vermicompost @ 5 t ha^{-1} + 100% RDF ha^{-1}

T_5 - Pressmud @ 5 t ha^{-1} + 100% RDF ha^{-1}
T_6 - Poultry waste manure @ 5 t ha^{-1} + 100% RDF ha^{-1}
T_7 - Composted coirpith @ 5 t ha^{-1} + 100% RDF ha^{-1}

Figure:1



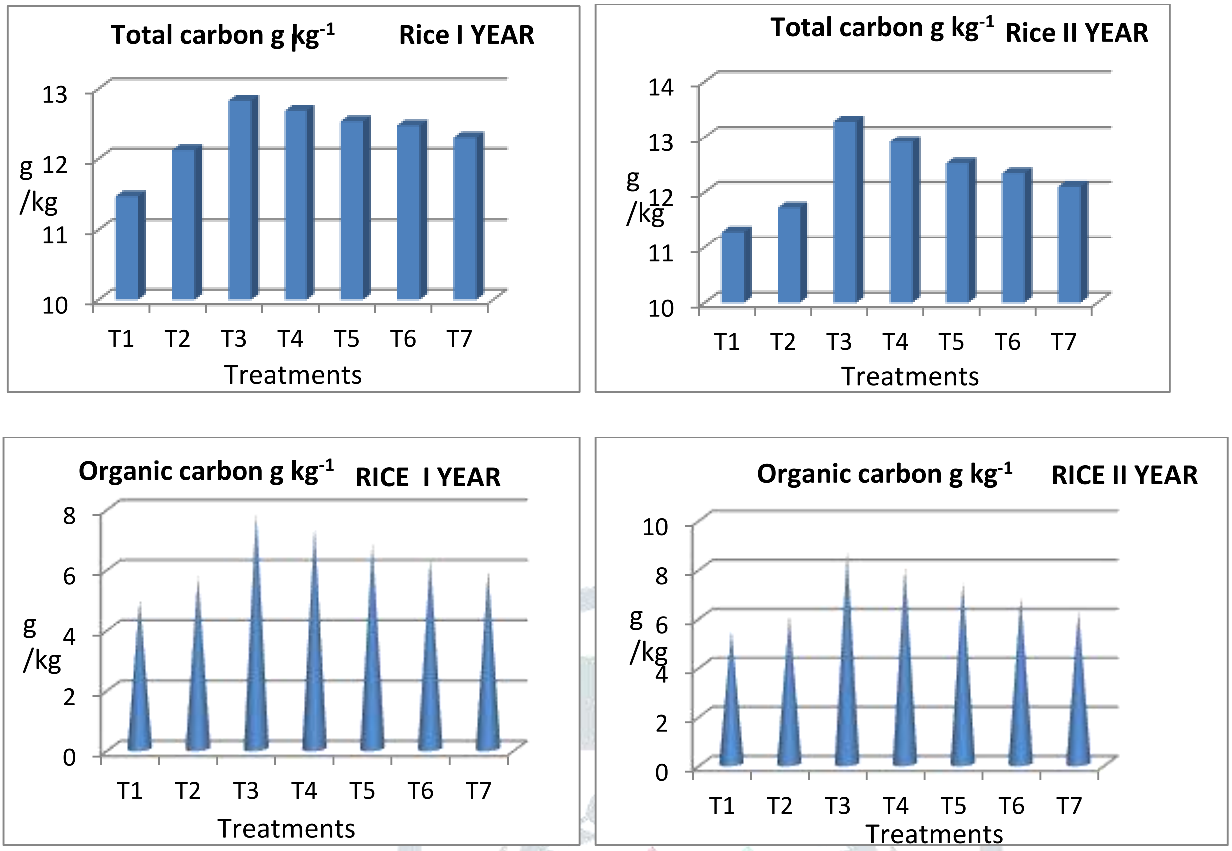
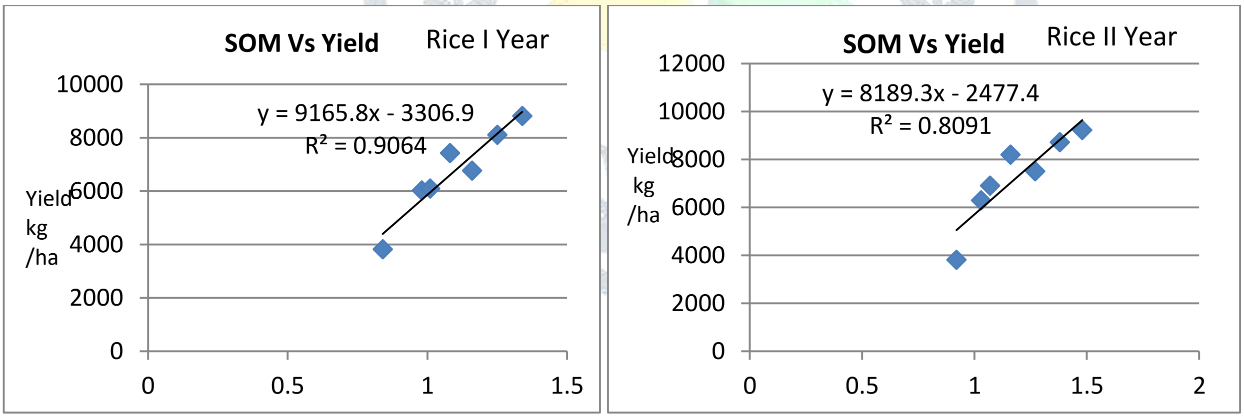
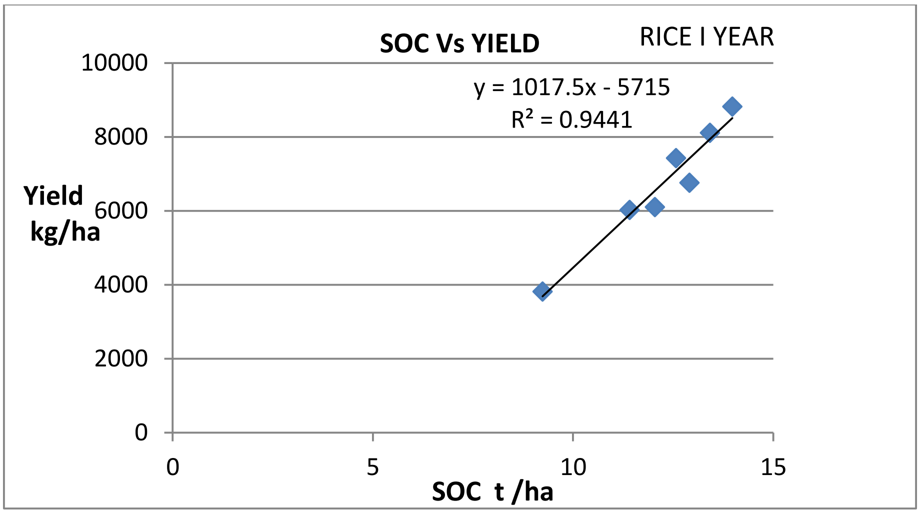


Figure: 2



Relationship between SOM and rice yield for I and II Year

Figure: 3



Relationship between SOC and Rice Yield for I year

Effect of organic manures and Fertilizers on methane fluxes in rice production

The observations recorded on the methane emission on 40DAS, 80DAS and harvest stages of the first and second year crops are presented in the Table 3.

The methane fluxes from the plot nurtured through different organic manures combined with 100% inorganic fertilizers revealed that the methane emission depends upon the season, diurnal variation and during different growth phases of the crop.

The recorded data on methane emission revealed that the diurnal variation coupled with 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 vegetative to reproductive stage and after a declined state of CH_4 emission was observed at harvest stage during the *Thaladi* season of the first and second year of the crop.

The application of FYM @ 12.5 t ha^{-1} integrated with 100% RDF + Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_3) recorded a lower value of 4.4 and 2.06, 7.2 and 1.94 and 2.7 and 1.59 mg m^{-2} h^{-1} CH_4 emission during both the day and night time at 40, 80 DAS and at harvest respectively during the *Thaladi* season of the first year rice crop. Simultaneously, the treatment supplemented with pressmud @ 5 t ha^{-1} + 100% RDF + Azospirillum and Phophobacteria @ 2 kg ha^{-1}(T_5) recorded a higher value of 5.0 and 2.42 and 7.9 and 2.29 and 3.3 and 1.98 mg m^{-1} h^{-1} CH_4 emission in both the day and night time at 40, 80 DAS and at harvest respectively during the *Thaladi* season for the first year rice crop. Among the different organic manures tried in this study, pressmud @ 5 t ha^{-1} integrated with 100% RDF (T_5) received plots exhibit their high potential in the amount of methane exchange to the ecosystem than other organic manures *viz.*, FYM, vermicompost, poultry waste manure and composted coir pith. The similar trend was on CH_4 emission was noticed during the *Thaladi* season of the second year rice crop.

Table-3 Effect of INM on CH_4 emission (mg m^{-2} h^{-1}) in rice I Year

Treatments	CH₄ emission (mg m⁻² h⁻¹)					
	40DAS		80DAS		At Harvest	
	Day	Night	Day	Night	Day	Night
T_1	2.4	1.20	3.0	1.14	2.0	0.96
T_2	2.7	1.56	3.6	1.51	2.3	1.10
T_3	4.4	2.06	7.2	1.94	2.7	1.59
T_4	4.6	2.17	7.5	2.10	2.9	1.62
T_5	5.0	2.42	7.9	2.29	3.2	1.98
T_6	4.7	2.30	7.7	2.11	2.9	1.74
T_7	4.8	2.39	7.8	2.20	3.0	1.89

Treatment Details

T_1 - Control(No fertilizers)

T_2 - 100% RDF alone

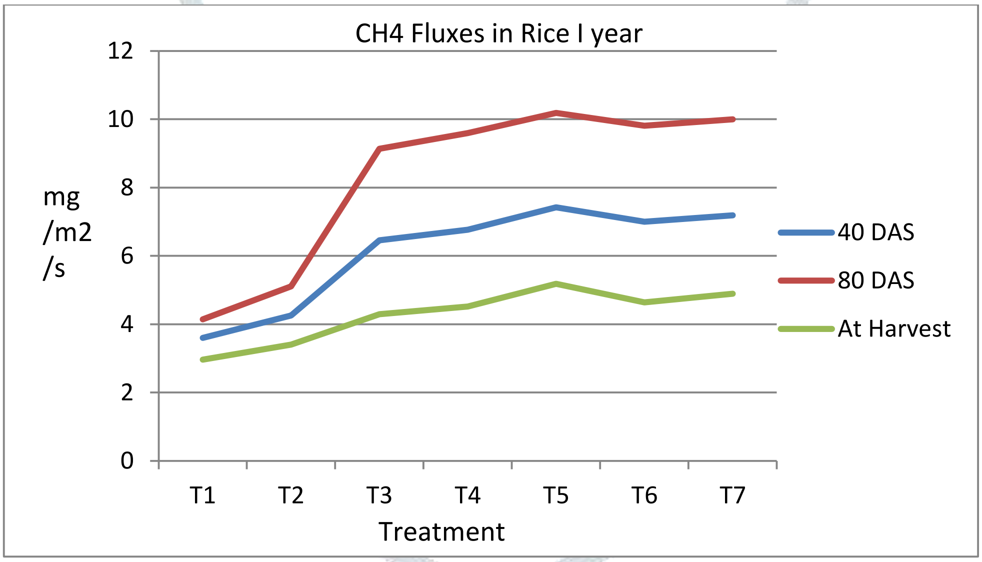
T_3 - Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF

T_5 - Pressmud @ 5 t ha^{-1} + 100% RDF

T_6 - Poultry waste manure @ 5 t ha^{-1} + 100% RDF

T_7 - Composted coirpith @ 5 t ha^{-1} + 100% RDF

Figure: 4



Discussion

Rice yield attributes, grain and straw yield

In the series of study the recorded results evidenced (Tab.1) that an increased grain and straw yield was recorded in FYM @ 12.5 t ha^{-1} + 100% inorganic fertilizers + Azospirillum and Phosphobacteria received plots could be ascribed due to a higher mineralization of nutrients because of improved physical and chemical conditions of the soil, resulting in creating a favourable environment in the soil, which helps the nutrients to be more in the available form, which results in better plant growth. Besides, FYM might have triggered the activity of microorganisms which in turn resulting the synthesis of phytin (Isoinsitolhexa phosphate) *i.e.*, a complex of nutrient like Ca, Mg P containing salt plays a key role in the production of more number of grains and improve the number of filled grains panicle^{-1} reported by Singh and Agarwal, (2001) and Salem (2006). The reciprocation of the overall improvement reflected into a better source- sink relationship, which in turn enhanced the yield and yield attributes in rice. These results were concomitant with the findings of Singh and Singh, (2000), Awad *et al.* (2001), El- Refaee *et al.* (2006).

Effect of INM on SOM, SOC and Total Carbon in rice production

Soil organic matter is known as revolving nutrient fund that supplies mainly carbon, nitrogen and phosphorus. Therefore decline in soil carbon generally decreases crop productivity (Selva Anbarasu *et al.*, 2016). The increased soil organic carbon recorded (Tab.2) in the treatment (T_3) supplemented with FYM @ 12.5 t ha^{-1} + 100% inorganic fertilizers + Azospirillum and Phosphobacteria (Fig.1) was due to the addition of organics improved the physio chemical properties of the soil through the addition of organic matter especially in sandy clay loam soil, paves a way for increased root biomass. Root derived materials are an important DOC source in the soil (Lu et al, 2005). Furthermore about 30 to 60 % of photosynthesized C is allocated to the below ground parts, and as much as 40 to 90% of this substrates enter into the soil in the forms of root exudates, mucilage, sloughed – off cells and decaying roots (Lynch and Whipps, 1990). A significant positive linear relationship of (R^2= 906) and (R^2= 809) soil organic matter and system yield during the both first and second year of the crop (Fig.2) and (R^2= 0.994) between soil organic carbon and system yield (Fig.3) was registered in the first year of rice crop. A positive interaction between the organic manures with inorganic NPK eventually increased all the growth components which attributes, both internal – physiological process and external- phenophase of the crop which in turn accumulation of more photosynthates, shown its positive sign to the microbial activity being a diversified nourishment substrate. The photosynthesized C input into the soil differed among the plant species and the maximum proportion was up to 20%, 64-86% of which was rapidly respired by soil microorganisms and only 2-5% of which incorporated into SOC (Hutsch *et al.*, 2002). Application of organic manure with 100% RDF increased SOC over RDF alone treated plot which might be due to cumulative effect of NPK and organic manure. Furthermore, the increased SOC, could be ascribed to the fact of various C:N ratio of the added organics and their differential rate of decomposition to enhance the total OC of soil which in turn influences the microbial biomass carbon of soil. A similar SOC results were corroborate with the findings of (Rietz and Haynes, 2003)

Effect of organic manures and Inorganic Fertilizers on methane fluxes in rice

The addition of different organic manures combined with 100% inorganic fertilizers revealed that the differences in the methane emission depends upon the season, diurnal variation and during different growth phases of the crop. All the treatments (Tab.3) exhibit increased CH_4 emission (Fig.4) during all growth stages of the crop; especially, peak at midday time and decreased at night time during the *Thaladi* season in both the year of rice crop. Organic fertilization is reported to enhance carbon mineralization resulting in higher CH_4 emission in flooded rice soils (Kimura et al. 2004). Application of different fertilizers in rice soil enhanced the bio available pool of organic carbon and resulted in CH_4 production (Zheng et al., 2007). Addition of organic manures along with inorganic fertilizers proved their positive interaction which resulting in enhancement of microbial activity, furthermore when it coupled with proper moisture regime and sufficient soil temperature showed its magnitude of CH_4 release from the soil most probably peak in the midday time i.e., from 11.00 am to 2.00 pm. An increased trend of methane emission was noticed due to the diurnal variation especially during increased air temperature with respect to various growth stages *viz.*, transplanting, active tillering, booting, flowering and ripening during the *Thaladi* season in both the year crop study. Neue et al. (1994) showed that methane emission rate increased rapidly after sunrise, peaked early in the afternoon, and then declined gradually until they leveled off at night.

Pertaining to the methane emission with respect to various growth stages, a significant increment of methane emission rate was noticed during the growth stage from active tillering to flowering due to temperature hiking and a lower emission rate was noticed from flowering to ripening due to low temperature with high redox potential during the *Thaladi* season in both the years of crop period. Because the conversion rate of substrate to CH_4 production depends on the temperature, it is generally observed that the momentary local emission of CH_4 from the soil to the atmosphere depends on the temperature. These results were concomitant with findings of (Yang and Chang, 1999).

Most methanogenic bacteria are responsible for methane production and grows at a pH range of 6.5–7.5 obviously in the experimental site the soil is nearer to the preferable pH zone for methane producing bacteria to enhance the methane production in both the years of crop period. The optimal pH for methane emission ranges from 6.0 to 7.1 in paddy soil (Wang et al., 1993). Pertaining to the CH_4 emission rate increased with the addition of pressmud @ 5 t ha^{-1} + 100% RDF supplemented plots due to the availability of abundant organic substrates, conducive environment by way of preferable pH for methane producing bacteria, climatic compatibility coupled with production potential of aerenchyma cells of the cultivar comprehensively increase the methane fluxes in rice crop during this period of study. Apparently, the FYM treated plots registered the least CH_4 emission due to more lignin content. This in turn resulted a higher carbon sequestration compared to materials with low lignin content (Brar et al., 2015). Furthermore organic manure like FYM contains more of carbon in recalcitrant form resulting in more C sequestration in soil as it had been already gone under some decomposition before application in agricultural fields (Benbi and Senapati, 2009) and when it integrated with inorganic fertilizers, inorganic N inhibit the activity of methanotrophs. These results were concomitant with findings of (Sass et al., 1991; Wang and Shangguan, 1995; Buendia et al., 1998; Yang and Chang, 1998)

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