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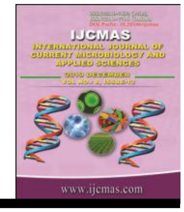

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Soil Amendments as GHGs Curtailers in Rice Fields

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A B S T R A C T

Rice cultivation is being focused as a prime contributor to climate change due to the release of greenhouse gases into the atmosphere. In aspect to study the reduction of the GHGs emission, experiment trial was conducted with eight different soil amendment combinations viz., recommended dose of Fertilizers (RDF), fly ash, Biochar, Gypsum, Silica Solubilizing Bacteria (SSB), fly ash + SSB, Biochar + SSB, Gypsum + SSB. Gas collection was done at different crop growth stages using open bottom chambers and analyzed with Shimadzu GC-2014 gas chromatograph. Methane emission was observed less in applications of Fly ash (40.5 kg/ha), Fly ash + SSB (43.7 kg/ha) and Gypsum + SSB (45.5 kg/ha). Low levels of nitrous oxide emission were seen in applications of Fly ash + SSB (2.1 kg/ha), Gypsum + SSB (2.2 kg/ha) and Fly ash (2.2 kg/ha). Higher nitrous oxide and methane emission was found with the treatments of RDF, SSB, Biochar, Gypsum and Biochar + SSB. From the study, it was concluded that application of fly ash + SSB and fly ash did reduce the GHGs emissions on higher percentage over the application of other soil amendments in rice field.

Keywords

Climate change, Greenhouse gases, Emission reduction

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Introduction

Rice being an important food crop of Asia contributes 35 to 60 per cent of the calories of 2.7 billion Asians (Pingali *et al.,* 1997Delta areas, river valleys, and low lying coastal areas are the major rice producing areas in India. Food and Agriculture Organization (FAO) set its 2015 production forecast as 158.2 million tonnes (FAO, 2016).Settling to the influence of the El Niño phenomenon, during 2016 season, FAO anticipated production in India improve to 158.4 million tonnes, up 2 per cent from 2015 expectations. Tamil Nadu ranks fifth position in rice production in India with an area of 21 lakhs ha, with a production of 92 lakh M.T. (Metric Tonnes) and a productivity of 4381 kg/ha (Department of Agriculture, 2014). In the current scenario, rice production is reported to be a contributor to climate change, through the release of greenhouse gases to the atmosphere.

There is a need for action on climate change, but global warming has not been reduced to safe levels. Scientists are overseeing a warming, exceeding 2°C by 2100 (IPCC, 2014), which would have far reaching consequences on food security, fresh water availability and the frequency and intensity of storms.

Nitrous oxide is one among the prominent greenhouse gases, being 298 times potential enough as CO_2. Compared to other sectors, agriculture contributes heavily towards40-60% emissions of methane and nitrous oxide. Soils with nitrogen fertilizers are prone to release nitrous oxide.

While agriculture releases significant amount N_2O to the atmosphere, it can efficiently be decreased by improving crop management (Smith *et al.,* 2007). Methane (CH_4) stands second in the place of major greenhouse gas, with a global warming potential (GWP) 25 times that of carbon dioxide (CO_2). Methane is estimated to be responsible for 25 per cent of the anticipated warming (Forster *et al.,* 2007). It is biogenically sourced from the anaerobic decay of organic matter.

Increased food demand may force the rising levels of methane gas to 50 per cent higher levels by 2020(Bouman, 1991). Nevertheless, Carbon dioxide is the major greenhouse gas to be understood at a larger cause. Subrahmanyam Desiraju *et al.,* (2008) formulated a general rule that for every 75 ppm increase in CO_2 concentration, rice yield found to be increased by 0.5 ton per hectare, but yield would get decreased by 0.6 ton per hectare for every 1°C increase in temperature. Gerald *et al.,* (2009) reported that based on impact of climate change on agriculture by 2050, the rice price would increase between 32 and 37 per cent. They also showed that yield losses in rice could be between 10 and 15 per cent.

The problem starts where the major food production is indicated as the major source of a greenhouse gas and needs attention towards emission reductions. A headway towards reducing the GHGs emissions can be done with application of soil amendments to the rice crop field.

Materials and Methods

Field experiment

A field experiment was conducted in Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu during *Rabi* (2015-16) season. The short duration rice variety CO(R) 51 was used in RBD with three replications and eight treatments viz., recommended dose of fertilizers alone (RDF), fly ash, biochar, gypsum, silica solubilizing bacteria (SSB), flyash + SSB, biochar + SSB, gypsum + SSB. Recommended dose of fertilizers (RDF) of NPK at 150: 50: 50 kg/ha, flyash at 20 t/ha, biochar at 10 t/ha, gypsum at 500 kg/ha and silica solubilizing bacteria (SSB) at 12.5 kg/ha were the dosages applied. RDF was a default component in all the treatment combinations.

Application of soil amendments

Soil amendments and silica solubilizing bacteria were applied a day prior to transplanting into the plots with respective doses as given in treatment details.

Collection of air samples

Gas samples were collected from the field using static closed chamber technique (Jain *et al.*, 1999). As described by Khosa *et al.*, (2010) each chamber was placed on the soil surface with 4-5 cm inserted into the soil, 10 minutes prior to each sampling for equilibration to reduce the disturbance so as to minimize the disturbance to the sampling site. Care was taken not to disturb the vegetation during the whole measurement program. After covering the plants with the chamber, four air samples were collected in Tedlar bags starting with zero time and subsequent sampling at an interval of 15 minutes using syringe and one way valve pump. As described by Jayadeva *et al.*, (2009), the air samples were collected in the morning (09:00-10:00 hours) and in the evening (14:00-15:00 hours) and the average of morning and evening fluxes were used as the flux value for the day.

Estimation of GHGs

The gas samples were analyzed in a Shimadzu GC-2014 gas chromatograph equipped with FID.

Results and Discussion

The effect of soil amendments on GHGs emission from rice field is indicated in Table 1. In case of methane emission, higher emission was noted in RDF (54.9 kg/ha), and SSB (53.2 kg/ha). Lower methane values were seen in applications of Fly ash (40.5 kg/ha), Fly ash + SSB (43.7 kg/ha) and Gypsum + SSB (45.5 kg/ha). Applications of Biochar + SSB (46 kg/ha), Biochar (46.9 kg/ha) and Gypsum (47.5 kg/ha) also contributed to less methane. Emission reduction percentage from Table 1 states that Fly ash (26.2 %), Fly ash + SSB (20.5 %) and Gypsum + SSB (17.2 %) are efficient in reducing methane emissions. Although lesser to the above amendments, biochar + SSB (16.3 %), Gypsum (13.4 %) and biochar (14.6 %) did have reduced methane emission rates than RDF and SSB (3 %) applications (Figure 1).

During the crop growth, significantly higher nitrous oxide emission was (Table 1) noted in RDF (2.7 kg/ha) and SSB (2.5 kg/ha). Lower nitrous oxide values were seen in applications of Fly ash + SSB (2.1 kg/ha), Gypsum + SSB (2.2 kg/ha) and Fly ash (2.2 kg/ha). Applications of Biochar (2.4 kg/ha), Biochar + SSB (2.3 kg/ha) and Gypsum (2.4 kg/ha) contributed to less nitrous oxide emissions than SSB. Emission reduction percentage from Table 1 states that Fly ash + SSB (20.4 %), Gypsum + SSB (18.3 %) and Fly ash (17.7 %) are efficient in reducing nitrous oxide emissions. Although lesser to the above amendments, biochar + SSB (16.2 %), Gypsum (14 %) and biochar (11.2 %)did have reduced nitrous oxide emission rates than RDF and SSB (8.8 %) applications (Figure 2).

Carbon di oxide has a different way of results (Table 1, Figure 3) compared to the nitrous oxide and methane emissions. Higher amounts of carbon dioxide release was found in Fly ash + SSB (56.8 t/ha), Gypsum + SSB (54.9 t/ha), Biochar + SSB (t/ha) and Gypsum (51.6 t/ha) applications. Whereas RDF (41.3 t/ha) and SSB (45.6 t/ha) had the lower rates of carbon dioxide emission. Fly ash (48.8 t/ha) and Biochar (46.8 t/ha) have contributed to more carbon dioxide than RDF and SSB.

Methane oxidation into carbon di oxide could be the reason for reduced methane emissions (Cicerone *et al.*, 1981; Oremland1988). Gypsum reduces CO_2-C equivalent emissions as in words of (Denier *et al.*, 2002; Ali *et al.*, (2007). Biochar acts as a slow C release source (Wardle *et al.*, 2008) can minimize the methane emissions.

Table.1 Greenhouse gases emissions under different soil amendments

Treatment	Methane emission (kg/ha)	Methane Percentage Reduction (%)	Nitrous oxide emission (kg/ha)	Nitrous oxide Percentage reduction (%)	Carbon di oxide emission (t/ha)	Carbon di oxide Percentage increase (%)
RDF alone	54.9		2.7		41.3	
Flyash	40.5	26.2	2.2	17.7	48.8	18.3
Biochar	46.9	14.6	2.4	11.2	46.8	13.4
Gypsum	47.5	13.4	2.3	14.0	51.6	25.1
SSB	53.2	3.0	2.5	8.8	45.6	10.4
Flyash + SSB	43.7	20.5	2.1	20.4	56.8	37.5
Biochar + SSB	46.0	16.3	2.3	16.2	52.2	26.4
Gypsum + SSB	45.5	17.2	2.2	18.3	54.9	33.1

*RDF was applied in all the treatment combinations

Fig.1 Methane emission

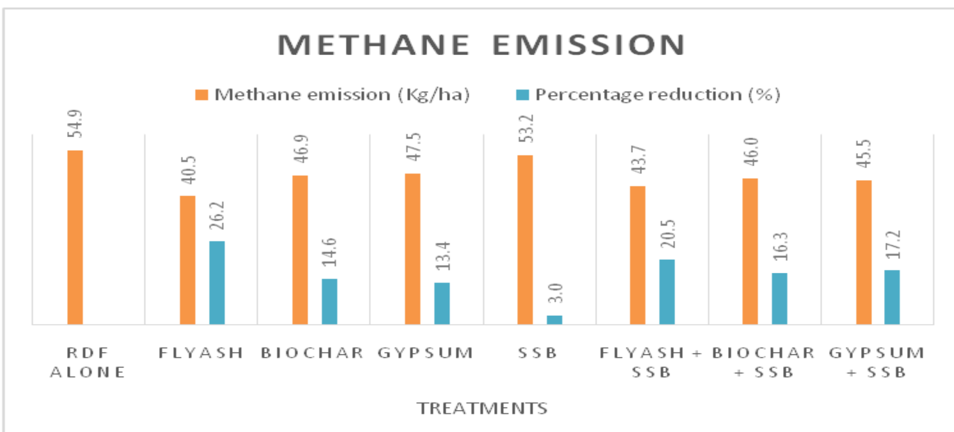


Fig.2 Nitrous oxide emission

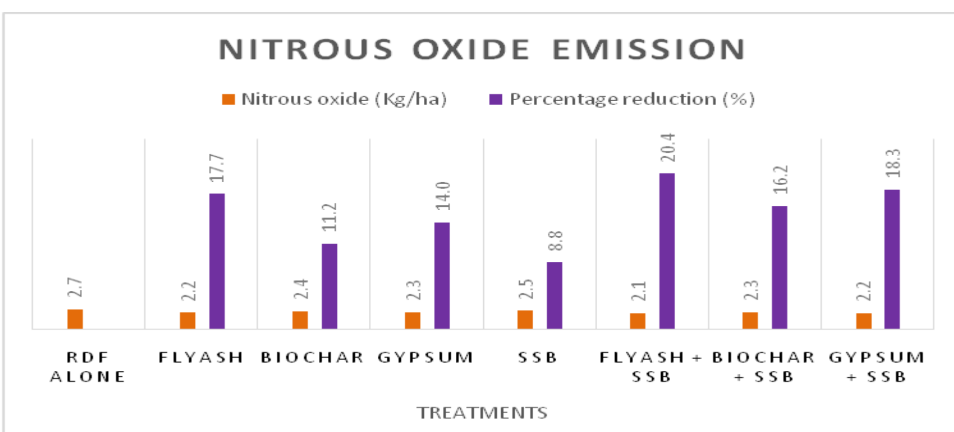
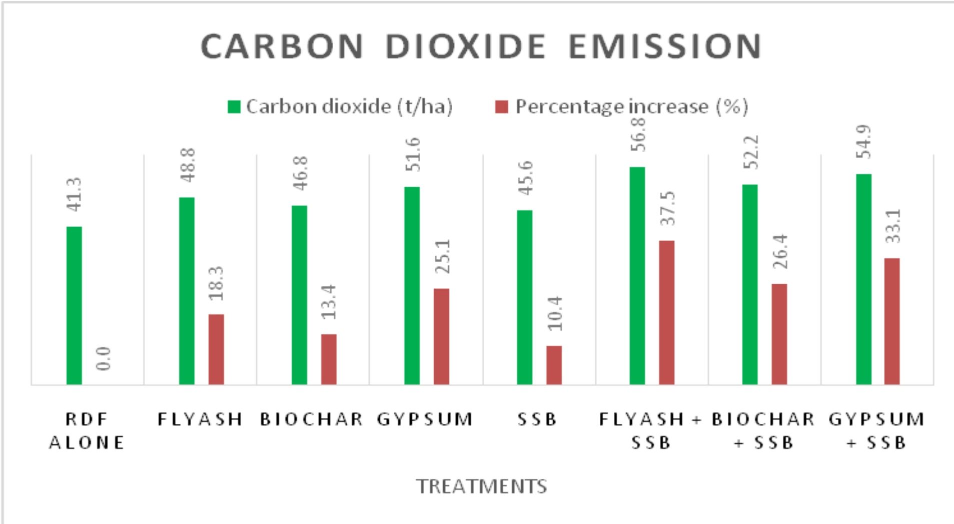


Fig.3 Carbon dioxide emission



The increased iron and manganese compounds in fly ash and gypsum acts as electron acceptors and thereby, suppress CH_4 emission during rice cultivation (Ali *et al.*, 2009). The same level of results could be observed in this research also.

Nitrous oxide from rice field is mainly due to excess application of N fertilizer and faulty method and times of application of N in addition to drying of rice fields frequently during cropping season (Nelson *et al.*, 2012). There are investigations that aim on reducing the GHG emission by handling standard agronomic practices and soil amendment (Yadav *et al.*, 2013). The study has also met out the same purpose of reducing nitrous oxide emission. Use of fly-ash as soil ameliorant in place of lime could lead to reduction in CO_2 equivalent emissions, thus contributing to minimize global warming (Ferreira *et al.*, 2003).

There are some aerobic microbes in rice soil itself that are capable of sinking methane. Such transformation of methane to carbon dioxide by the oxidation process is carried out by methanotropic bacteria (Schutz *et al.*, 1990).

Conrad and Rothfuss (1991) have observed that about 80 per cent of the potential diffusive CH_4 flux through the soil-water interface was oxidized in the oxic surface layers. So this could further increase the amount of carbon dioxide than the methane gas which is more potent compared to the former. This could be the possible reason for increased carbon di oxide emissions.

The results from the field study on application of soil amendments over GHGs emissions concluded that emissions could be reduced by the application of fly ash + SSB, flyash, gypsum + SSB, biochar + SSB, biochar and gypsum than the application of recommended dose of fertilizers and SSB. The soil amendments were found to help in reducing the GHGs emissions from rice crop fields.

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