

## Original Research Article

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## Combating Nitrous Oxide Emission from Rice Field Using Soil Amendments

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Rice cultivation is constantly blamed to be a contributor to climate change through the release of greenhouse gases to the atmosphere especially nitrous oxide, where nitrogenous fertilizers are used injudiciously. A step towards reducing the GHGs emission, an experiment was conducted with eight different soil amendments combinations viz., recommended dose of Fertilizers (RDF), fly ash, biochar, gypsum, Silica Solubilizing Bacteria (SSB), fly ash + SSB, biochar + SSB, gypsum + SSB were studied. Gas collection was done using chambers and samples were analyzed using Gas chromatography. Nitrous oxide emission was observed at active tillering, panicle initiation, 50 per cent flowering and maturity stages. During the crop growth, application of fly ash+ SSB had reduced emission rate followed by fly ash and gypsum + SSB. Higher nitrous oxide emission was found with the treatment of RDF followed by RDF + SSB, biochar, biochar + SSB and gypsum. From the study, it was concluded that application of fly ash + SSB did reduce the nitrous oxide emissions over the application of other soil amendments in rice field.

### Introduction

Rice being an important food crop of Asia supplies 35 to 60 per cent of the calories of 2.7 billion Asians (Pingali *et al.*, 1997). Cultivation of rice in India is mainly concentrated in delta areas, river valleys, and low lying coastal areas. Food and Agriculture Organization (FAO) set its 2015 production forecast as 158.2 million tonnes (FAO Rice Market Monitor, April 2016). Owing to the influence of the El Niño phenomenon, during 2016 season, FAO anticipates 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, Tamil Nadu, 14th Executive Committee Meeting, National Food Security Mission, Department of Agriculture, Tamil Nadu, Nov, 2014). At present rice production is reported to be a contributor to climate change, through the release of greenhouse gases to the atmosphere such as nitrous oxide emissions. There is a need for action on climate change, but global warming has not

been reduced to safe levels. Scientists around the world are tracking over a warming, exceeding 2°C by 2100 (IPCC, 2014), which would have far reaching consequences for 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<sub>2</sub>. Compared to other sectors, agriculture contributes disproportionately heavily to the emissions of methane and nitrous oxide, possibly in the 40-60% range. Soils with nitrogen fertilizers release nitrous oxide, the most potent greenhouse gas. While agriculture releases significant amount N<sub>2</sub>O to the atmosphere, it can potentially be decreased by improving crop management (Smith *et al.*, 2007). The problem starts where the major food driver is pointed as the major source of a greenhouse gas that needs attention towards emission reductions. A pace over reducing the nitrous oxide 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 (T<sub>1</sub>), fly ash (T<sub>2</sub>), biochar (T<sub>3</sub>), gypsum (T<sub>4</sub>), silica solubilizing bacteria (T<sub>5</sub>), flyash + silica solubilizing bacteria (T<sub>6</sub>), biochar + silica solubilizing bacteria (T<sub>7</sub>), gypsum + silica solubilizing bacteria (T<sub>8</sub>). 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.

Collection of gas samples was done continuously for a week at critical stages of crop growth viz., active tillering, panicle initiation, flowering and maturity stages.

### Estimation of nitrous oxide

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

## Results and Discussion

Influence of soil amendments on nitrous oxide emission from rice field is depicted in Table 1.

The nitrous oxide emission was found increasing towards maturity stage, as aeration is obtained during the harvesting stage. During the crop growth, significantly higher

nitrous oxide emission was noted in RDF (2.7 kg/ha) and RDF + SSB (2.5 kg/ha).

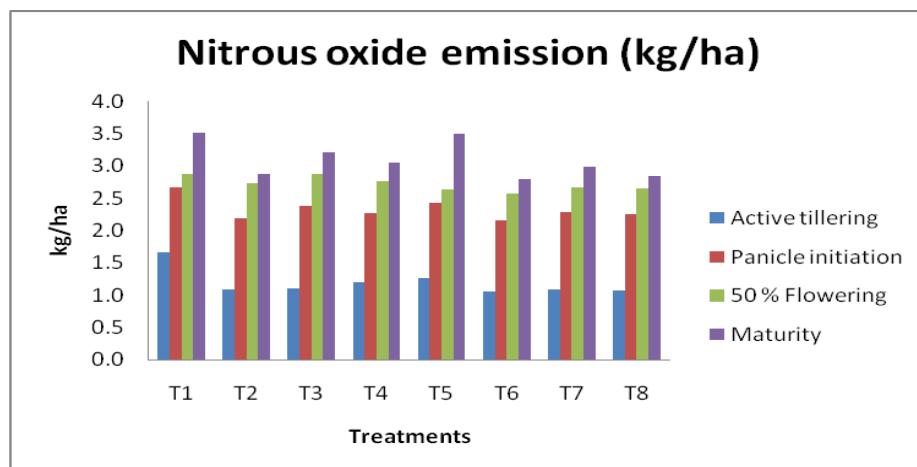
Lower nitrous oxide values were observed in applications of Fly ash + SSB (2.1 kg/ha), Gypsum + SSB (2.2 kg/ha) and Fly ash (2.2 kg/ha) in all stages. Applications of Biochar (2.4 kg/ha), Biochar + SSB (2.3 kg/ha) and Gypsum (2.3 kg/ha) contributed to less nitrous oxide emissions than SSB.

**Table.1** Nitrous oxide emissions in four stages under different treatments (kg/ha)

Treatment	Active Tillering (kg/ha)	Panicle Initiation (kg/ha)	50% Flowering (kg/ha)	Maturity (kg/ha)	Average (kg/ha)
RDF alone	1.7	2.7	2.9	3.5	2.7
Flyash	1.1	2.2	2.7	2.9	2.2
Biochar	1.1	2.4	2.9	3.2	2.4
Gypsum	1.2	2.3	2.8	3.0	2.3
SSB	1.3	2.4	2.6	3.5	2.5
Flyash + SSB	1.1	2.2	2.6	2.8	2.1
Biochar + SSB	1.1	2.3	2.7	3.0	2.3
Gypsum + SSB	1.1	2.3	2.7	2.8	2.2

\*RDF was applied in all the treatment combinations

**Fig.1** Nitrous oxide emissions in four stages under different treatments (kg/ha)



Nitrous oxide from rice field is mainly due to excess application of N fertilizer and faulty method and times of application of N (Nelson *et al.*, 2012) in addition to drying of rice fields

frequently during cropping season. This could be possible reason for increasing nitrous oxide emission towards maturity. There are investigations that focus on reducing the GHG

emission by handling standard agronomic practices (Yadav *et al.*, 2013) and soil amendment. 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<sub>2</sub> equivalent emissions, thus contributing to minimize global warming (Ferreira *et al.*, 2003).

Above results from the field study on nitrous emissions over application of soil amendments concluded that nitrous emissions could be reduced by the application of Fly ash + SSB, Gypsum + SSB and Flyash, biochar, biochar + SSB and Gypsum than the application of recommended dose of fertilizers. The soil amendments were found to help in reducing the nitrous oxide emissions from rice crop fields.

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