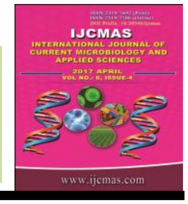
Int.J.Curr.Microbiol.App.Sci (2017) *6*(4): 423-430

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 4 (2017) pp. 423-430**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2017.604.048

A Study of Nitrous oxide Emission from Rice Fields in Tarai Region of Uttarakhand, India

P.P. Singh[1], Rashmi Pawar[2] and R. Meena[3]*

[1]Deptartment of Agromateorology, JNKVV, Jabalpur (M.P.), India
[2]Department of Horticulture, G.B. pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India
[3]Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi- 221 005 (U.P.), India
**Corresponding author*

Keywords

Oxide flux, Growth stages, Rice crop, Methane emission, Nitrous oxide emission.

Article Info

Accepted:
02 March 2017
Available Online:
10 April 2017

A B S T R A C T

A study was conducted at Crop Research Center of G.B. pant University of Agriculture and Technology, Pantnagar in Tarai region of Uttarakhand, India to quantify nitrous oxide emission from rice fields due to the addition of different organic amendments and inorganic fertilizers. The average nitrous fluxes for rice were 0.57, 1.87, 2.37, 3.52 and 1.27 mg m^{-2} h^{-1} from control with crop, farmyard manure (FYM), green manure (GM), straw amendments and sulphur fertilizers, respectively. Among different growth stages of rice transplanting to tillering growth stage nitrous oxide flux was maximum in straw amendment, 5.79 mg m^{-2} h^{-1} while lowest in control 0.53 mg m^{-2} h^{-1}. After that, during tillering highest flux was 3.58 mg m^{-2} h^{-1}, with lowest in control 0.79 mg m^{-2} h^{-1}. During reproductive to ripening growth stage nitrous oxide flux was highest in straw amendments, 2.72 mg m^{-2} h^{-1}, followed by GM amendments, 2.47 mg m^{-2} h^{-1}, FYM amendments, 1.47 mg m^{-2} h^{-1}, sulphurus fertilizers 0.95 mg m^{-2} h^{-1}, and the lowest was in control with crop, 0.35 mg m^{-2} h^{-1}. Lastly ripening to maturity growth stage nitrous oxide flux was highest in GM amendments, 1.69 mg m^{-2} h^{-1}, followed by FYM amendments, 1.18 mg m^{-2} h^{-1}, straw amendments, 0.42 mg m^{-2} h^{-1}, sulphurus fertilizer, 0.43 mg m^{-2} h^{-1}, and the lowest was in control with crop, 0.38 mg m^{-2} h^{-1}. The results indicated that nitrous oxide emission was enhanced by undecomposed organic amendments (straw and green manure) as compared to well-decomposed organic amendments (farmyard manure) and sulphurus fertilizers.

Introduction

Nitrous oxide is an important green house gas and its concentration in atmosphere was estimated as 2.68×10^{-2} mL L^{-1} around 1750. It has increased by about 17% as a result of human alterations in the global N cycle (IPCC, 2001). Nitrous oxide has much greater global warming potential than CO_2. When N_2O reaches the stratosphere, most of it is converted to N_2 through photolytic reaction that converts O_3 into O_2 thereby causing the stratosphere to lose some of its shielding properties against ultra violet rays (Schlesinger, 1997). Nitrous oxide forms in soils primarily during the process of gentrification (Robertson and Tiedje, 1987) and, to a lesser extent, during nitrification

(Tortoise and Hutchinson, 1990). Global annual N_2O emissions from agricultural soils have been estimated to range between 1.9 and 4.2 Tg N, with about half arising from anthropogenic sources (IPCC, 2001). The major factor controlling the flux of N_2O are partial oxygen pressure, soil water status and flooding chemical status of the soil and land use. Nitrous oxide emission of paddy fields at different location in Taiwan was found between 0.20 to 0.17 mg m^{-2} in second crop season. Nitrous oxide emission in first crop season was higher than those in the second crop season because of intermittent irrigation and high temperature at the later growth stage.

Materials and Methods

The experiment was conducted in Kharif season on the Haldi loam soil, which is derived from calcareous alluvium from Shiwalik Mountains. The water table is shallow. The physico-chemical properties of soil are given in Table 1.

Layout and treatment

The experiment was conducted with five treatments and four replications in randomized block design. The treatments were T_{1-} Control with, T_{2-} 100% NPK + FYM, T_{3-} 100% NPK + GM, T_4- 100% NPK + Straw and T_5- 100% NPK + Sulphur. FYM and GM mean farmyard manure and green manure, respectively. The 100% NPK recommended dose for rice was 150:60:40 kg ha^{-1}. The nitrogen provided by FYM, GM and Straw was subtracted from 150 kg N and remaining nitrogen was applied through urea. The nitrogen content of organic amendments is given in table 2. In treatment $T_{5,}$ NPK were given through sulphur containing fertilizers like ammonium sulphate, single super phosphate and potassium sulphate and through, zinc sulphate.

Rice field preparation and transplanting

Harrowing was done twice with the help of harrow and puddling was done with the help of tractor- mounted puddler to prepare the field for rice transplanting. Twenty one days old seedling of rice variety pant Dhan-4 were transplanting at the rate of 2 seedlings per hill. The spacing among hills was 10x20cm. Half dose of nitrogen as per treatment and full dose of phosphorous and potassium were applied as basal dressing during field preparation and pudding and mixed well in the soil remaining half of nitrogen was applied

Collection of gas sample

Gas samples were collected by closed character technique described by Hutchinson and Mosier (1981). Boxes made of acrylic sheets, having dimensions of 50x30x100cm were used for taking the gas samples from plots. An aluminum channel was pre inserted in the field and water was filled in channel, whenever the chamber was placed for collecting the samples to make the set airtight. One mediflex three ways top cock (Eastern Medikit Ltd., India) was fitted at the top of chamber to collect gas samples. Three replicate gas samples were taken from each plot. Height of the headspace was taken for flux calculation.

Analysis of gas sample

The concentration of nitrous oxide was estimated through ECD (Electron Capture Detector), fitted with Porapak N stainless steel column. The temperature for column, injector and detector were kept at 45,120 and 300 ^{0}C, respectively and the pressure of carrier gas (nitrogen) was 5.0 kg/ cm^2. The peak area was measured with microprocessor controlled Nucon 5765 series gas chromatograph with integrator connected to computer. Pre-calibrated standards of nitrous oxide (Scott specialty gas standard, imported and supplied by M/S Sigma- Aldrich) was used. The area of standard nitrous oxide peak was used to calculate the nitrous oxide concentration in the unknown gas sample peaks.

Measurement of nitrous oxide flux

Standard curves were made from the standard samples of know concentrations. Then gas samples gas of unknown concentrations were injected and the peak areas were noted. Using the peak area value and the standard, the concentrations values were taken. To measure flux, the chamber fixed at the experimental site and the change in concentrations in the chamber so formed, with time, was determined by taking triplicate gas samples from the chamber headspace by syringe and transported them to the laboratory for analysis.

Calculation of nitrous oxide flux

The nitrous oxide flux (F) was calculated using the following equation (Mitra *et al.*, 1999).

$$F = [(C_1 - C_O)/t] \times H \times 117.85 \text{ mg m}^{-2} \text{ h}^{-1}$$

Where t is time (minute), initial concentration (ppmv), C_t is final concentration (ppmv), and H is height of head space (m). The derivation of above equation will be as:

Cross sectional area of the chamber
= $A \text{ m}^2$
Height of head space
= H m
Volume of head space
= $A H \text{ m}^3$
N_2O concentration at 0 time
= C_o ppmv
N_2O concentration after time t
= C_t ppmv

Change in Concentration in time t
= $(C_t - C_o)$ ppmv

= $(C_t - C_o)$ µ L/L
Volume of N_2O emitted in time t
= $(C_t - C_o)\ 1^1 \times 1000 \times AHL$.

= $(C_t - C_o) \times AH$ mL.
When t is in minutes then flux (F)
= $[\{C_t - C_o) \times AH]/(A \times t) \text{mLm}^{-2} \text{min}^{-1}$

= $Y \text{ mL m}^{-2} \text{ min}^{-1}$
If Y
= $C_t - C_o \times H\ t$
Then flux nitrous oxide
= $Y \times 44/22400 \text{ gm}^{-2} \text{ min}^{-1}$
Because 1 mL of nitrous oxide
= 44/22400g

= $Y \times 44/22400 \times 1000 \times 60 \text{ mg m}^{-2} \text{ h}^{-1}$
Hence, F
= $C_t - C_o \times H \times 117.857 \text{ mg m}^{-2} \text{ h}^{-1} t$

Results and Discussion

Nitrous oxide flux measurement was carried out up to eighty- two days after transplanting and started from ten days after transplanting of rice. The data on nitrous oxide emission are presented in table 3. The Nitrous oxide emission over the seventy two days period from rice crop was 109.1, 355.6, 450.9,668.5 and 242.2 g ha^{-1} in control with crop, 100% NPK + FYM, 100% NPK +GM, 100% NPK + Straw and 100% NPK + Sulphur treatments. This indicated that highest nitrous oxide emission was in straw treated plots. This is because the addition of un-decomposed organic amendments enhances the nitrous oxide emission. Different growth stages of rice also play an important role in the nitrous oxide emission (Figure 1). It was found that during tillering stage the nitrous oxide flux was maximum in straw amendment *i.e.* 5.79 mg m^{-2} h^{-1} followed by GM amendment *i.e.*

1.45 mg m^{-2} h^{-1}, FYM amendment (1.60) mg m^{-2} h^{-1}, sulphurus fertilizers oxide emission during tillering stage is mainly due to higher vegetative growth of rice crop. Similarly, panicle initiation stage the nitrous oxide flux was highest in straw amendment (3.58) followed GM (2.74), FYM (2.53), sulphurus fertilizers (1.78) and the lowest in control with crop (0.79 mg m^{-2} h^{-1}). During reproductive stage the nitrous oxide flux was in highest straw amendments (2.52) followed by FYM (2.28), GM (2.24) sulphurus fertilizers (1.47) and lowest was in control with crop (0.62 mg m^{-2} h^{-1}) During ripening stage the nitrous oxide flux was 2.72 mg m^{-2} h^{-1} in straw amendment followed by GM (2.47), FYM (1.47), sulphurus fertilizers (0.95) lowest was in control with crop amendment (0.35 mg m^{-2} h^{-1}) During maturing stage the highest nitrous oxide flux was observed in GM amendment (1.69) followed by FYM (1.18), sulphurus fertilizers (0.43), straw (0.42) and lowest was in control with crop i.e., 0.38 mg m^{-2} h^{-1}.

Table.1 Physico-chemical properties of initial soil

Property	Soil depth	
	0-15 cm	**15-30 cm**
EC (d Sm^{-1})	0.10	0.11
Soil p^H(1:2)	7.74	7.87
Organic carbon (%)	1.10	0.82
Available nitrogen (kg ha^{-1})	172.5	106.6
Available phosphorous (kg ha^{-1})	31.4	12.5
Available potassoum (kg ha^{-1})	241.9	156.8

Table.2 Nitrogen content of organic amendments

Organic Amendment	Nitrogen Content(%)	Nitrogen provided to soil (kg ha^{-1})
FYM	0.50	50
Green Manure	0.49	49
Wheat Straw	0.53	53

Table.3 Effect of organic and inorganic sources of nutrients on nitrous oxide gas emission from rice field at different stage

Days after Transplanting (DAT)	**T_1 (Control with crop)**	**T_2 (100% NPK+GM)**	**T_3 (100% NPK+GM)**	**T_4 (100% NPK + Straw)**	**T_5 (100% NPK+ Sulphur)**
10	0.23	1.12	1.33	1.97	0.56
14	0.76	2.66	2.96	7.36	1.67
18	0.58	2.54	2.68	7.19	1.60
22	0.29	2.23	2.70	7.34	1.50
26	0.76	0.42	2.72	7.10	1.26
30	0.62	0.61	2.28	3.75	1.14
Average flux up to Tillering stage	0.54	1.60	2.45	5.79	1.29
34	0.57	0.81	1.93	3.41	1.42
38	0.42	1.01	1.09	3.40	1.65
42	1.02	3.31	3.87	4.77	2.07
46	1.28	4.76	3.89	4.66	2.00
50	0.67	2.76	2.92	1.65	1.75
Average flux up to Panicle initiation stage	0.79	2.53	2.74	3.58	1.78
54	0.65	2.15	1.22	1.63	1.51
58	0.77	2.35	2.79	2.96	1.56
62	0.45	2.34	2.71	2.97	1.35
Average flux up to Reproductive stage	0.62	2.28	2.24	2.52	1.47
66	0.38	1.82	2.63	2.78	1.24
70	0.31	1.12	2.31	2.66	0.65
Average flux up to Ripening stage	0.35	1.47	2.47	2.72	0.95
74	0.18	1.31	1.86	0.18	0.48
78	0.58	1.4	1.64	0.51	0.6
82	0.39	0.84	1.56	0.56	0.21
Average flux up to Maturity stage	0.38	1.18	1.69	0.42	0.43
Over all average	**0.57**	**1.87**	**2.37**	**3.52**	**1.27**

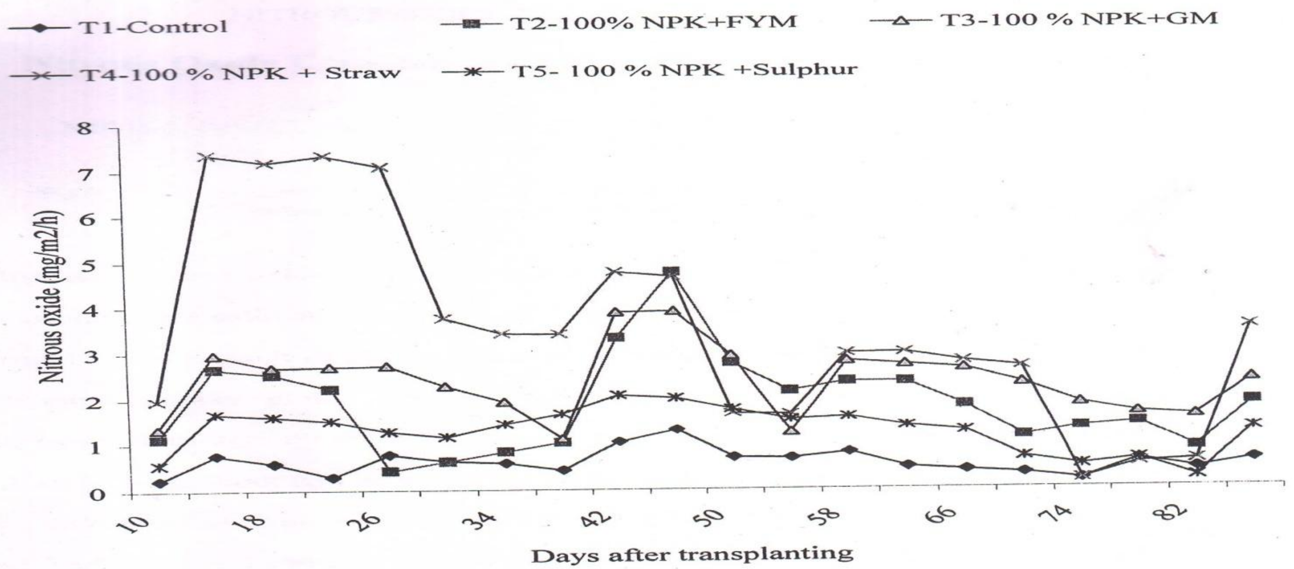


Figure 1. Nitrous oxide flux in rice as affected by different treatments

At ripening and maturity the higher nitrous oxide emission in green manure and FYM treated plots is mainly due to the availability of more mineralized nitrogen after the decomposition of this organic amendment. However, at maturity stage the nitrous oxide emission in straw treated plot is mainly because of exhaustion of nitrogen provided by the straw to the soil. The result showed that nitrous oxide emission was strongly influenced by application of chemical fertilizers (Chen *et al.*, 2002). Seasonal average fluxes of N_2O varied between 0.03 mg N_2O-N m^{-2} d^{-1} under continuous flooding and 5.23 mg N_2O-N m^{-2} d^{-1} under the water regime of F-D-F-M. Both crop residue-induced CH_4, ranging from 9 to 15% of the incorporated residue C, and N_2O, ranging from 0.01 to 1.78% of the applied N, were dependent on water regime in rice paddies. Estimations of net global warming potentials (GWPs) indicate that water management by flooding with midseason drainage and frequent water logging without the use of organic amendments is an effective option for mitigating the combined climatic impacts from CH_4 and N_2O in paddy rice production (Zou *et al.*, 2005). The nitrous oxide fluxes were higher during initiation period of crop growth the availability of mineral nitrogen was high. Then, there was a decrease in fluxes during late tillering stage and early panicle initiation stage. The nitrous oxide fluxes increase again when the top dressing of split dose of fertilizers was done. The nitrous oxide emission was reduced by use of sulphurus fertilizers. This was also reported by (Bufogle *et al.*, 1998). The results also indicated that nitrous oxide emission was enhanced undecomposed organic amendment (straw and green manure) as compared to well-decomposed organic amendment (farmyard manure) and sulphurus fertilizers. The additions of split doses of nitrogen also influenced the nitrous oxide emission. Therefore, the timing of nitrogen application should match the periods when plant requirement of nitrogen is highest. The mid-season drainage and the multiple drainage, with 6.9% and 11.4% reduction in rice yield respectively, had an average methane emission per crop 27% and 35% lower when compared to the local method. Draining with fewer drain days during the flowering period was recommended as a compromise between emissions and yield. The field drainage can be used as an option to reduce methane and nitrous oxide emissions from rice fields with acceptable yield reduction. Mid-season drainage during the rice flowering period, with a shortened drainage period (3 days), is suggested as a compromise between the need to reduce global warming and current socio-economic realities (Touprayoon *et al.*, 2005).

Acknowledgement

The authors are thankful to the Head, Department of Agromateorology, G.B. pant University of Agriculture and Technology, Pantnagar, Uttarakhand for providing necessary facilities to conduct this research work.

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How to cite this article:

Singh, P.P., Rashmi Pawar and Meena, R. 2017. A Study of Nitrous oxide Emission from Rice Fields in Tarai Region of Uttarakhand, India. *Int.J.Curr.Microbiol.App.Sci.* 6(4): 423-430.
doi: https://doi.org/10.20546/ijcmas.2017.604.048