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INFLUENCE OF NITROGENOUS FERTILISERS AND SEASONAL VARIATION ON METHANE EMISSION IN RICE SOIL ECOSYSTEM

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ABSTRACT

The influence of different sources of nitrogenous fertilisers and seasonal effect on methane emission has been studied at Tamil Nadu Agricultural University Wetland Farm at Coimbatore during *kharif* and *Rabi* seasons, 1996. The results showed that fertilised plots recorded higher emission level than unfertilised plots. The emission level in PK alone (without-N) applied plots is higher during both seasons as compared to nitrogen applied plots. Among the different nitrogenous fertilisers tried, ammonium sulphate was found to reduce the emission level throughout the growing season followed by urea, ammonium chloride and DAP. The sulphur component of ammonium sulphate inhibited methanogenesis in rice rhizosphere. Seasonal variations in methane flux were observed in all treatments. The first peak was observed within 10 days of transplanting and the emission level decreased towards active tillering stage. A second peak of lower magnitude was observed during flowering stage and declined further towards harvest. The magnitude of emission level during *Rabi* season was two to three fold higher as compared to *Kharif* season. The emission level varied with texture of the soil. The light textured soils had lower flux level than heavy textured clay soils.

KEYWORDS: Methane emission, Tropical rice soils, Nitrogenous fertilisers, Seasonal variation

Atomospheric methane is an important greenhouse gas. Its contribution to the global warming is considered to be next to CO_2 (IPCC, 1990). In the troposphere, it also acts as a potential oxidant. Its role in ozone chemistry at stratospheric heights is also well known. Concentration of methane has been increasing over the last decade by about one per cent per year (Black and Rowland, 1988). There are three major sources of methane emission which include wetlands, rice fields and ruminants. There is a large discrepancy in the emission rate of methane from paddy fields (IPCC, 1992). China and India are the major rice growing countries in the world each covering about 30 per cent of the global rice cultivation area. Some measurements of methane flux from paddy fields have been made in the Indian region during the last few years but there are large differneces (Parashar et al., 1991, Lal et al., 1993, Mitra, 1992). Discrepancy in the flux rates appears to be due to (i) different agricultural practices, the types of fertilisers used, soil type, water level etc and (ii) very limited measurements. An experiment was conducted to study the effects of various kinds of fertilisers on methane emission under controlled conditions.

MATERIALS AND METHODS

Field experiments were conducted at Tamil Nadu Agricultural University Wetland Farm during Kharif and Rabi seasons, 1996 in a randomised block design (RBD) with five replications. The nitrogenous fertilisers viz., urea,di-ammonium phosphate (DAP), ammonium chloride were applied to supply 120 kg ha^{-1} of nitrogen to each plots of size $9m^2$ along with recommended levels of phosphorus (36 kg P ha^{-1}) and potassium (36 kg K ha^{-1}). A separate treatment of phosphorus and potassium (PK) alone and a control (without NPK) were also tried. The 120 kg of nitrogen was applied at three important stages of crop growth viz., basal application (50 per cent of recommended N), active tillering (25 per cent of recommended N) and early flowering stage (25 per cent of recommended N) which coincides with 0, 30 and 60 days after transplating (DAT) respectively. The entire quantity of recommended phosphorus and potassium were applied as a basal dressing through muriate of potash and Single Super Phosphate (SSP) respectively.

The sampling procedure and analytical techniques described by Lal et al. (1993) were followed to quantify the methane flux level. Soil samples were collected 1W-AT (Week After Transplanting), tillering, flowering and at harvest stages of the for soil nitrogen fractions and the microbial load of methanogens (Mah, 1980) and sulphate reducers (Postgate, 1981) were quantified. The photosynthetic rate was measured through a portable leaf chamber analyser model ADC II.

RESULTS AND DISCUSSION

Source of Nitrogen

The level of methane emission was maximum (7.26 mg $m^{-2} h^{-1}$) in PK alone (without - N) treatment druing Kharif season followed by DAP, ammonium chloride, urea, control and the lowest emission (3.5mg $m^{-2}h^{-2}$) was recorded at tillering stage with ammmonium sulphate (Table 1). During Rabi season, ammonium chloride recorded maximum emission (25.68 mg $m^{-2} h^{-1}$) followed by PK, DAP, Urea, control and the lowest in ammonium sulphate (12,08 $m^{-2} h^{-1}$) followed by PK, DAP, urea, control and the lowest in ammonium sulphate (12.08 mg $m^{-2} h^{-1}$). Lindau et al. (1990) observed a much lower methane flux under ammonium chloride and urea. Kimura et al. (1992) were of the opinion that ammonium chloride and urea addition as basal fertilisation resulted in higher methane emission than ammonium sulphate. The reason for suppression of methane flux in ammonium sulphate applied plots as compared to ammonium chloride, DAP and urea was due to the sulphur component of the ammonium sulphate. The sulphur addition in the sulphur deficient rice paddies favoured the multiplication of sulphate reducing bacteria (Table 2). The sulphate reducing bacteria were competing with methanogenic bacteria for a common substrates such as organic acids and hydrogen (Westermann and Ahring, 1987). Hence, an increase in the population of sulphate reducers would naturally increase the competition for substrates and resulted in the subdual methanogenic activity. On the other hand, suppression of sulphate reducers would eventually result in increased methane production (Kimura et al., 1991). Besides the sulphte reducers could oxidise methane anaerobically in sulphate reducing zone of anoxic soils. The PK alone recorded higher methane flux during both seasons as compared to other sources of nitrogen. The

Table 1. Effect of sources of nitrogen on methane emission (mg $m^{-2} h^{-1}$)

Treatment	Kharif, 1996					Rabi, 1996				
	1W-AT	T	F	H	Mean	1W-AT	T	F	H	Mean
U + PK	2.32	3.34	7.26	5.79	4.66	14.75	14.64	33.39	6.33	17.28
DAP + PK	6.66	3.86	7.38	7.81	6.43	24.07	20.74	25.70	13.00	20.75
AS + PK	2.45	1.54	5.24	4.78	3.50	7.88	16.78	14.97	8.68	12.08
AC + PK	2.71	4.10	7.70	6.38	5.09	44.69	24.58	21.75	11.69	25.68
PK alone	10.28	4.44	7.58	6.75	7.26	29.24	22.26	21.60	10.77	20.97
Control	2.03	4.47	6.60	4.37	4.37	25.45	14.43	12.99	7.83	15.18
Mean	4.41	3.63	6.88	5.98	-	24.35	18.82	21.73	9.71	-
	CD (P=0.05)					CD (P=0.05)				
Stage	0.24					1.62				
Treatment	0.29					1.98				
Interaction	0.58					3.96				

U- Urea ; DAP - Diammonium phosphate ; AS - Ammonium sulphate ; AC - Ammonium chloride ; PK - Phosphorus and potassium

1W-AT - 1 week after transplanting . T - Tillering stage ; F - Flowering stage ; H - Harvest stage ; $ - Not studied ;

Table 2. Effect of sources of nitrogen on sulphate reducers (x 10^4) in soil

Treatment	Kharif, 1996					Rabi, 1996				
	1W-AT	T	F	H	Mean	1W-AT	T	F	H	Mean
UU + PK	8.4	8.2	8.8	6.4	8.0	11.4	11.9	12.8	6.0	10.5
DAP + PK	8.7	9.2	10.6	8.0	9.1	16.4	18.8	22.4	10.0	16.9
AS + PK	10.8	10.4	11.9	8.4	10.4	18.6	19.4	21.1	10.8	17.5
AC + PK	6.4	6.6	7.0	6.2	6.6	12.2	12.0	13.6	6.4	11.1
PK alone	6.4	6.3	6.9	6.0	6.4	6.2	7.8	9.0	5.4	7.1
Control	6.0	6.2	6.2	5.0	5.9	6.4	6.4	8.2	5.2	6.6
Mean	7.8	7.8	8.6	6.7	-	11.9	12.7	14.5	7.3	-
			CD (P=0.05)					CD (P=0.05)		
Stage			0.4					0.7		
Treatment			0.5					0.9		
Interaction			NS					1.8		

U- Urea ; DAP - Diammonium phosphate ; AS - Ammonium sulphate ; AC - Ammonium chloride ; PK - Phosphorus and potassium

1W-AT - 1 week after transplanting ; T - Tillering stage ; F - Flowering stage ; H - Harvest stage ; NS - Not significant

reason for this was that the ammonium ion in the nitrogen fertilised plots favoured rhizosphere nitrification process which induces methane oxidation. The end product of nitrification, nitrate, might have caused inhibition of methanogenesis, which led to lower flux values in nitrogen fertilised plots as compared to PK alone. In fact ammonium was rapidly oxidized and nitrified in the rhizophere of nitrogen applied plots (Mosier et al., 1990) and this would explain why rice fields fertilised with ammonium chloride and urea showed a lower emission level than no nitrogen plots. The inhibitory effect of NO_3-N which is a product of nitrification in the rice rhizosphere, on methanogenesis had been well documented by Kitada et al. (1993).

Fertilised plots recorded higher flux values than control owing to the increased release of carbohydrates through root exudates which formed the substrate for hihger methanogenic activity. Circerone et al. (1983) have also recorded increased methane flux in paddy soils as compared to control.

SEASONAL VARIATION

The methane flux at 1W-AT was the highest in two out of six treatments during Kharif season and four out of six treatments during Rabi season (Table. 1) followed by a decline at tillering stage in the above treatments. A second peak of lower magnitude at flowering stage was also evident in the above treatments. This could be possible due to release of more root exudates by paddy plant supplying additional substrate for the anaerobic microbes. Contrary to the above, Lal et al. (1993) have reported that a higher magnitude of second peak between 50 to 80 days after transplanting.

The methane emission level during Rabi season was much higher in magnitude as compared to Kharif season (Table. 1). This is obvious that the field in which the Kharif season that conducted was flooded continuously right from June, 1996 and a submerged condition was maintained for more than seven to eight months till the end of Rabi crop. This favoured reduced soil condition (Table 3) which was more conductive for methanogenic activity except for a short while (four to seven days) during the harvest of Kharif season paddy. The field preparation for Rabi crop was started immediately after the harvest of Kharif crop. This prolonged submergence, favoured higher methane emission when fertlisers were added to Rabi corps. Contrary to the above, there was not

Table 3. Effect of sources of nitrogen on redox potential and organic carbon content of soil

Treatment	Redox potential (mv)										Organic carbon content (per cent)									
	Kharif, 1996					Rabi, 1996					Kharif, 1996					Rabi, 1996				
	IW-AT	T	F	H	Mean	IW-AT	T	F	H	Mean	IW-AT	T	F	H	Mean	IW-AT	T	F	H	Mean
U + PK	-200	-222	-214	-154	-198	-230	-220	-232	-182	-216	0.564	0.548	0.530	0.534	0.532	0.664	0.604	0.580	0.592	0.610
DAP + PK	-210	-228	-230	-178	-212	-246	-250	-254	-196	-237	0.580	0.552	0.544	0.536	0.538	0.670	0.610	0.594	0.610	0.608
AS + PK	-200	-210	-200	-160	-193	-222	-230	-232	-176	-215	0.572	0.524	0.526	0.528	0.534	0.652	0.526	0.538	0.572	0.575
AC + PK	-205	-220	-226	-180	-208	-240	-240	-220	-164	-216	0.578	0.530	0.524	0.536	0.538	0.664	0.556	0.556	0.563	0.585
PK alone	-220	-240	-260	-206	-232	-250	-300	-276	-208	-250	0.502	0.486	0.458	0.462	0.486	0.516	0.484	0.480	0.496	0.494
Control	-200	-200	-184	-170	-189	-220	-200	-190	-180	-197	0.400	0.420	0.420	0.424	0.442	0.446	0.430	0.406	0.410	0.423
Mean	-206	-220	-219	-174	-	-234	-234	-234	-184	-	0.533	0.510	0.500	0.503	-	0.602	0.535	0.518	0.541	-
				CD (P=0.05)					CD (P=0.05)					CD (P=0.05)					CD (P=0.05)	
Stage				7					10					0.009					0.015	
Treatment				9					13					0.011					0.018	
Interaction				18					NS					0.022					0.036	

U- Urea ; DAP - Diammonium phosphate ; AS - Ammonium sulphate ; AC - Ammonium chloride ; PK - Phosphorus and potassium
IW-AT - 1 week after transplanting ; T - Tillering stage ; F - Flowering stage ; H - Harvest stage ; NS - Not significant

such continuous submergence prior to Kharif seasons. The field remained dry and fallow immediately after the harvest of Rabi paddy, 1995 for three to four montsh before Kharif paddy 1996. This break in the continuous submergence exposed the soil to oxidised condition. A period of two to three weeks of submergence was again required to attain reduced soil condition during Kharif season for favouring methanogenic activity. This might have caused a reduced initial emission level of lower magnitude during Kharif season. Moreover, the Kharif season trial was conducted in a light textured soil having low clay and more of coarse sand and fine sand than Rabi season trial. The methane produced in a light textured soil having low clay and more of coarse sand and fine sand than Rabi season trial. The methane produced in a light textured soil column might have been subjected to oxidation in the soil itself. The soil organic carbon level in the experimental site (Table 3) which also favoured methane emission. The soil organic carbon had a significant positive correlation with methane emission (r=0.71**) and this was again confirmed in the path coefficient analysis also (0.500).

In this paper the influence of different sources of nitrogen and seasonal variation on methane emission in a tropical indian rice paddies is presented. Fertilisation enhanced the emission level as compared to unfertilised control plots. Addition of nitrogen favoured increased level of methane emission over no nitrogen plots. Among the nitrogen fertilisers tried, the emission level was much lower in ammonium sulphate applied plots and the flux level increased in the order of urea, ammonium chloride and DAP. The methanogenesis was inhibited due to the favourable effect on the multiplication of sulfate reducers in rice soils when nitrogen was added through ammonium sulphate. A strong seasonal influence on methane emission level of two of three fold was observed during Kharif than Rabi seasons. The first peak within 10 days of planting was higher in magnitude than the second peak during flowering stage. The photosynthetic efficiency, soil organic carbon, NH_4-N and NO_3-N had a profound influence on methane emission level.

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