Methane emission in irrigated rice soils of Punjab

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Methane emission measurements were recorded from the organic and inorganic fertilizer treatments managed at the site under rice–wheat rotation in Punjab. Urea–N significantly increased methane emission and application of 8 t wheat straw ha^{-1} with 120 kg N maximized methane emission to 57.3 mg m^{-2} h^{-1}.

INCREASED agricultural productivity over the past 50–100 years has also contributed significantly towards the increase in the concentration of greenhouse gases, viz. CO_2, CH_4 and N_2O. Of these, methane is the most important because of its infra-red absorption capacity, which is thirty times greater than that of CO_2 though its atmospheric concentration is about 200 times lesser[1]. Methane is biologically produced under strict anaerobic process and its emission from wetland rice agriculture has been estimated up to 170 Tg yr^{-1}, which accounts for approximately 26% of global anthropogenic budget[2]. Large variations and uncertainty in observed methane emission rates from the paddy field amongst different sites or treatments have been reported[3–5]. Keeping this in view, a field study was conducted to take a series of measurements of methane emission in the different treatments of crop residues and inorganic fertilizer management in Punjab. In this paper we report the first results of the measurements from Punjab.

The experiment was conducted at Punjab Agricultural University Research Farm in Ludhiana, at the site where wheat and rice crops were grown in rotation and their residues managed. The soils were sandy loam with soil pH 7.9 (1:1 soil/water). The experiment had five treatments, viz. control, wheat straw applied @ 8 t ha^{-1} before rice transplanting + N (WS + N 120), application of wheat straw @ 4 t ha^{-1} before rice transplanting and rice straw @ 4 t ha^{-1} before wheat sowing + N (WS + RS + N 120), rice straw applied @ 8 t ha^{-1} before wheat sowing + N (RS + N120) and urea–N applied @ 120 kg ha^{-1} (N 120). Rice nursery (variety PP 106) of twenty-five days old was transplanted in the above treatments on 11.06.1993. Nitrogen through urea was applied in two equal instalments, half at the time of transplanting, and the rest was broadcasted 4 weeks after transplantation. Four close top glass chambers (18 cm wide and 34 cm heigh), with permanently installed base unit, were placed in each treatment having four replications. Plots were of the size 8 × 3 m and were irrigated, having 7 cm standing water, four hours before sampling. At the inception of each sampling, zero time (9 a.m.) gas samples were collected within the base unit. Chamber tops were immediately sealed to the base unit and head space gas samples were removed after two hours (11 a.m.), after the air was mixed by a manual gas mixer. Pressure control consisted of 1.5 m of plastic tubing (1 mm ID) which was used to maintain an equilibrium gas pressure between inside and outside chambers. Samples were removed from each chamber through serum caps and collected gas samples were properly sealed and transferred to the laboratory for immediate analysis.

Chrom-Packard gas chromatograph (438 A model) equipped with flame ionization detector was used to detect methane. Gas chromatograph was run by keeping flow rate of N_2, H_2 and air as 20 ml min^{-1}, 25 ml min^{-1} and 235 ml min^{-1} respectively. The temperatures of the oven, detector and the injector were 80°C, 120°C and 100°C respectively. A glass column of 2 m length, with internal diameter 1/4″ and thickness of 2 mm containing parapak-T (80–100 Mesh) was used to detect methane in the sample. Standard gas methane (All Tech. Associates, USA) was used for comparison. Evolved methane was estimated by using the closed chamber equation[6].

$F = (V/A)\ \Delta c/\Delta t$, where F is the methane gas flux, V the volume of the head space chamber air, A the chamber soil surface area and $\Delta c/\Delta t$ is the change in methane concentration per unit of time. The data were subjected to CRBD analysis.

The methane emission rates from the rice fields in the 'kharif' of 1993 were observed from July 6, 1993 to September 17, 1993. Gas samples were drawn on 26, 33, 46, 53, 60, 69, 75, 93 and 99 days after transplantation. Comparison of results obtained for different treatments reveals that application of fertilizer N significantly increased methane emission from 15.7 to 22.5 mg m^{-2} h^{-1}. The treatment RS + N did not cause any additional methane emission compared to the application of N alone. However, application of 4 t ha^{-1} rice straw to wheat and 4 t ha^{-1} wheat straw (WS + RS + N) to rice increased the mean methane emission from 22.5 to 34.0 mg $m^{-2}h^{-1}$. Maximum methane (57.3 mg m^{-2} h^{-1}) was emitted from plots receiving 8 t ha^{-1} wheat straw with 120 kg N ha^{-1}. It has been observed that the addition of wheat straw raised the mean methane value of methane emission by 34.8 mg m^{-2} h^{-1} over 22.5 mg m^{-2} h^{-1} of fertilizer N treatments.

Methane emission trend fluctuated (Figure 1) during a growing season, the first peak in methane emission appearing on 33 day after transplanting (DAT) and 2nd peak on 75th DAT. On 33 DAT, methane emission was maximum as compared to other periods of sampling. There was a decrease on 93 DAT with a small increment on 99 DAT. Methane emission varied from 0.6 to 57.5, 0.9 to 93.9, 9.6 to 76.0, 28.7 to 131.3 and 4.6 to 58.1 in treatments, viz. control, N 120, WS + RS + N and RS + N respectively.

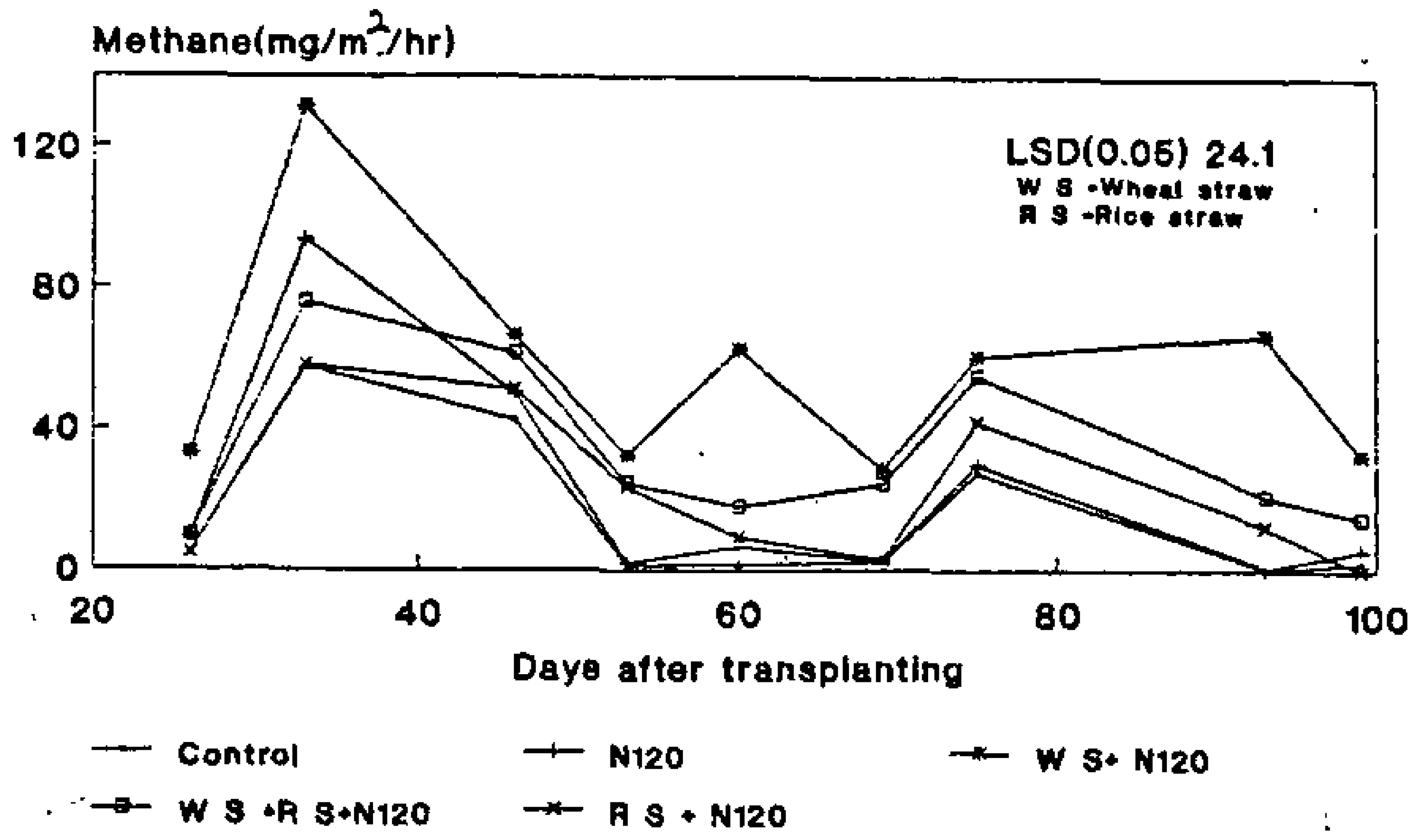

Figure 1. Methane emission as affected by different residues management practices.

Methane emission during the rice growing season was highest twice during investigation, forming two peaks in most of the treatments (Figure 1). But the treatment with 8 t wheat straw ha^{-1} showed three peaks. The first peak was observed in June, 2nd peak in middle of July and 3rd in August by Yagi and Minami[7], but in the present studies first peak was observed in the middle of July. The first methane peak may be due to the enhanced availability of root exudates and development of root gas transport system[8,9], but the present investigations were carried out at the site under rice–wheat rotation where the rice and wheat residues have been managed and obviously making more availability of carbon substrate to anaerobes for maximizing methane production. Addition of straws to the flooded rice paddies has shown dramatic increase in methane emission with type, quantum and pattern of residues incorporated into the soil. This has also been observed by other investigators[8,10]. The second peak may be due to the decay of roots besides the remaining residue sources.

Methane emission rates ranged between –0.20 and 66 mg m^{-2} h^{-1} in kharif season[3], and the methane emission was 80 mg m^{-2} h^{-1} in the green leaf manure treatment[11]. In the present studies, control plots emitted methane @ 15.7 mg m^{-2} h^{-1} and in the treatments where different residues were incorporated at different rates and blends, it was in the range of 24.1 to 57.3 mg m^{-2} h^{-1}.

As is evident, methane emissions in most of the treatments were maximum in the first half of the growing season in Punjab. Some workers have assumed that active methane emission occurred during a 15-day period[12], while others have assumed 30 days[13] for calculating total methane emission from the area. Our study suggests that such assumptions are not appropriate. Methane emission varies with sites and different treatments are needed to be taken care of while computing total methane emission of the area. Further recycling of crop residues for substitution of nutritional requirements, and also inorganic fertilizer are needed to be evaluated for the methane production, so that emission of methane to the atmosphere is regulated, if not completely ceased.

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Layering of the Earth's crust and upper mantle – An evidence from gravity anomalies over India

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Studies on the propagation of seismic waves revealed that the Earth, in general, possesses a layered structure; the boundaries between successive layers being characterized by abrupt changes in seismic wave velocities and hence the densities. Local variations in the depths of these discontinuities, among other things, produce gravity anomalies whose wavelengths are dependent on their depths from the surface of the earth. Spectral analysis is a powerful tool to find the ensemble average depths of horizontal (approximately) boundaries between rock units of different