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SIMULATION OF METHANE AND NITROUS OXIDE EMISSIONS BY DNDC MODEL IN LOWLAND RICE AMENDED BY BIO- AND INDUSTRIAL WASTE

P. P. Padhi*, Vijayakumar S. and P. Bhattacharyya

Division of Crop Production, ICAR-NRRI, Cuttack-753006, Odisha, India

**Corresponding author email: padhi.purbasha@gmail.com*

The DNDC (De Nitrification and De Composition) model is a process based simulation model and a powerful assessment tool which could predict carbon and nitrogen dynamics in soil as well as in plant. In DNDC, the details of management (e.g., tillage, crop rotation, manure modification, fertilization, irrigation, and weeding) have been defined and identified with the different biogeochemical processes (e.g., crop growth, soil water infiltration, decomposition, nitrification, denitrification etc.).Calibration and validation against observed records is a necessary first step of model establishment. If observed value agree well with the simulated value, we can assume that the model simulates precisely considering the biogeochemical activities. The emissions of GHGs (methane, nitrous oxide) could be simulated in rice and the effects of amendments including fertilizers, manures, wastes etc., also could be modelled. In this study we try to simulate and validate the methane and nitrous oxide emissions from lowland rice as affected by different bio- and industrial wastes.

METHODOLOGY

The DNDC model has been calibrated and validated for GHGs emissions in lowland rice in eastern India. The DNDC model was calibrated against the treatments in rice included, (i) T_1- urea (60 kg N ha^{-1}); (ii) T_2 - rice straw + urea (1:1 N basis) (30 kg ha^{-1} each from two different sources). The *kharif* season data for calibration were taken from the published literature (Bhattacharyya *et al.*, 2012). The model was validate against the field data set of CH_4 and N_2O emission from the lowland rice amended by bio- and industrial wastes during 2018 and 2019 *kharif* from experimental field of NRRI, Cuttack with two different treatments i.e. (i) RDF; 80:40:40:: N:P_2O_5:K_2O kg ha^{-1} (ii) RDF + rice straw-incorporation (5t ha^{-1}). The simulations were also done with another three different treatments i.e. (i) RDF; nitrogen through ammonium sulphate (as a substitute of neem coated urea), (ii) RDF + phosphogypsum (2t ha^{-1}) (iii) RDF + rice straw-compost (5t ha^{-1}).

RESULTS

In calibration, the observed emission of CH_4 during the growing season in T_1 and T_2 were 92.6 and 115.4 kg ha^{-1}, while the simulated emissions were 91.9 and 117.4 kg ha^{-1}, respectively. Emissions of N_2O were 1.00 and 0.84 kg ha^{-1} under both the treatments (NPK and NPK + straw), while the simulated values were 0.73 and 0.61 kg N_2O ha^{-1}. In all the cases the deviation of the simulated values from the observed values were less than 5% in methane. However, in case of N_2O the deviations were 17 and 15%, in NPK and NPK + straw treatment, respectively,

During validation and simulation, the methane emission was followed similar patterns in RDF as well as in other amended plots although the magnitude of emissions varied. Our observed data suggested a significant reduction in seasonal methane emission in both the *kharif* seasons of 2018 and 2019 in lowland rice ecology by application of phosphogypsum and ammonium sulphate. The DNDC model also well simulated the methane emission in both the treatments. The higher sulphate content of phosphogypsum might be the reason for lower emission as it prevents the CH_4 formation due to a stronger competition for substrates (hydrogen or acetate) between sulphur reducing

Table 1: Observed and simulated values of yield, N uptake and GHG emission in lowland rice (*kharif* 2011).

Parameters	NPK			NPK + Rice straw		
	Observed(O)	Simulated(M)	Deviation (%)	Observed	Simulated	Deviation (%)
Grain yield (t ha^{-1})	5.13	5.14	0.19	5.57	5.58	0.17
Crop N uptake (kg ha^{-1})	142	141	0.7	154	153	0.6
Seasonal CH_4 emission (kg ha^{-1})	92.6	91.9	0.7	115.4	117.4	1.7
Seasonal N_2O emission (kg ha^{-1})	1.00	0.83	17	0.84	0.71	15

bacteria (SRB) and methanogens in rice soils. The simulated methane emission by the DNDC model in rice straw-incorporation and rice straw-compost treatment was also well fitted with the observed values in both the *kharif* seasons of 2018 and 2019.

CONCLUSION

There are uncertainties in estimation of GHG emissions from different rice ecologies because of its diverse soil and climate conditions. Moreover, various crop management practices, water and fertilizer management for example, play a major role in the emission. What is Indian agriculture's real contribution to GHG emissions could be answered precisely by using simulation models. Validating and evaluating the performance of DNDC in simulating the CH_4 and N_2O emissions in side-by-side field trials of various management treatments is the necessary first step in determining the applicability of the model for quantifying GHGs mitigation potentials of alternative practices and for upscaling to a larger spatial scales. The output from these works would be helpful to formulate the management strategies for mitigating the greenhouse gases emission from rice-based cropping systems.

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