Review

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Nitrogen dynamics in flooded soil systems: an overview on concepts and performance of models

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Abstract

Extensive modelling studies on nitrogen (N) dynamics in flooded soil systems have been published. Consequently, many N dynamics models are available for users to select from. With the current research trend, inclined towards multidisciplinary research, and with substantial progress in understanding of N dynamics in flooded soil systems, the objective of this paper is to provide an overview of the modelling concepts and performance of 14 models developed to simulate N dynamics in flooded soil systems. This overview provides breadth of knowledge on the models, and, therefore, is valuable as a first step in the selection of an appropriate model for a specific application.

Supporting information may be found in the online version of this article.

Keywords: nitrogen; dynamic model; flooded soil; flooded rice

INTRODUCTION

Nitrogen (N) fertiliser is applied in flooded rice systems to increase grain production, but not all applied N will be absorbed by the rice crop.[1] The total N loss in fertilised and flooded rice systems can reach up to 50% of the total N applied, and may occur through several pathways, such as ammonia (NH_3) volatilisation, nitrogen oxides (NO_x) emissions from simultaneous nitrification and denitrification, and N leaching.[2–5] Although our aim is to increase grain production, it is also equally important to minimise total N loss from fertilised and flooded rice systems to reduce production costs and negative environmental outcomes.[6,7]

As an alternative to a conventional experimental approach, many semi-physical N dynamics models for simulating N dynamics in flooded soil systems have been developed over the last 30 years.[5,8–16] Simulations of system behaviour by these models under different conditions provide insights into the underlying mechanisms, and are useful in evaluating management practices to reduce N losses and increase grain production. However, the interactive, non-linear and time-varying N processes in flooded soil systems have resulted in models of different complexities. Consequently, model selection for a specific research application is challenging.

Jayaweera and Mikkelsen[17] reviewed the concepts and performance of physically based models developed for the estimation of NH_3 volatilisation in flooded soil systems without a rice crop and in the absence of other N processes; for example, models of Bouwmeester and Vlek,[18] Moeller and Vlek,[19] and Jayaweera and Mikkelsen.[9] Benbi and Richter[20] reviewed the objectives and capabilities of about 20 soil N dynamics models, but the reviewed models were not applied to simulate N dynamics in flooded rice systems. Nieder and Benbi[21] reviewed models of carbon (C) and N dynamics in a soil–plant–atmosphere system, but few models were selected to illustrate different modelling concepts. Giltrap *et al.*[22] and Gilhespy *et al.*[23] specifically reviewed the development and performances of DeNitrification–DeComposition (DNDC) variants, while Keating *et al.*[24] provided an overview on the Agricultural Production Systems Simulator (APSIM).

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