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Simulated efficiency of DMPP applications in reducing N_2O emissions from Australian N-fertilized rainfed wheat cropping systems

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Abstract: The atmospheric concentration of nitrous oxide (N_2O), one of the major greenhouse gases, increased from the pre-industrial value of 270 ppb to 332 ppb (v/v) in 2019, with 70% of the increase occurring since 1970 (IPCC, 2021). The agricultural sector contributes about 74% and 80% of all anthropogenic N_2O emissions in Australia (Department of Environment, 2014) and in the world (IPCC, 2014), respectively. Approximately 70% of N_2O emissions are associated with microbial nitrification and denitrification.

The use of nitrification inhibitors (NIs) is a promising strategy for reducing N_2O emissions from both nitrification and denitrification processes. However, the efficacy of NIs in reducing N_2O emissions has varying degrees (0–92%) as shown from field studies (e.g. Schwenke and Haigh, 2019). The objectives of this study were therefore to use the APSIM model to assess the long-term effects of the DMPP, a nitrification inhibitor, on N_2O emissions. The model was calibrated and validated against the data from eight field experiments (30 treatments) conducted in 6 sites cross the northern grain region (NGR) in Australia. A series of long-term scenarios embracing a range of N fertiliser rates (0–250 kg N ha^{-1} applied as urea), climatic regions and soil textures were simulated for exploring the effects of DMPP on N_2O emissions rainfed wheat cropping systems in the NGR.

Results indicate that APSIM predicted soil moisture, NH_4^+-N and NO_3^--N and N_2O emissions with moderate to high accuracy (R^2 = 0.30–0.85). Observed differences between the N treatments and N+DMPP treatments in soil NH_4^+ and NO_3^- and daily N_2O emissions were also predicted with moderate to high accuracy (R^2 = 0.30–0.77). Results of the long-term simulation indicated that the efficiency of DMPP in reducing N_2O emissions varies with N fertilizer rates with the substantial inter-annual variations in each simulation site. The highest average efficiency in each site is found at the fertilizer rate, which is just lower than the optimal fertilizer N rate to achieve the maximum grain yield. This study highlights the importance of considering fertilizer-N rates and seasonal conditions when nitrification inhibitors (such as DMPP) is adopted in making the optimal agricultural management regimes for improving the profitability and environmental sustainability of wheat industry across contrasting environments.

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