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Short-term effect of the nitrification inhibitor DMPP on N-turnover and denitrification losses from two agricultural soils in subtropical Australia

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Intense wetting and drying cycles render agricultural soils in the subtropics prone to nitrogen (N) loss via denitrification, with large pulses of the greenhouse gas nitrous oxide (N_2O) triggered by rainfall. The nitrification inhibitor 3,4-dimethylpyrazole phosphate (DMPP) proved to be effective under subtropical conditions, demonstrating substantial reductions of N_2O emitted from cropping soils. However, DMPP has consistently failed to reduce N_2O emissions from subtropical pasture soils. The aim of this study was therefore to investigate (a) the response of N-transformations and N_2O emissions from a subtropical pasture and a vegetable soil to DMPP, and (b) if the abundance *of nosZ*, the gene encoding the N_2O reductase, can explain N_2O emissions as affected by DMPP.

Soil microcosms were established in centrifuge tubes and fertilised with ammonium nitrate (35 μg g^{-1} soil) with or without DMPP. Labelling either ammonium (NH_4^+), or nitrate (NO_3^-) with ^{15}N at 10 atom% excess enabled the quantification of gross N-transformations using ^{15}N tracer and pool dilution methods. Soil microcosms were incubated at 75% WFPS over two days, and gas samples were taken each day. Gas samples were analysed for $^{15}N_2O$ to split N_2O production into the ammonia oxidation pathway and denitrification. Soil was extracted before and after the incubation for DNA, quantifying the response of *nosZ* abundance to DMPP.

Denitrification was the main source of N_2O production in both soils. The pasture soil emitted more than 1.5 μg N-N_2O g^{-1} soil over two days, exceeding N_2O emissions of the vegetable soil by a factor of 10. This trend was consistent with the high N-transformation rates in the pasture soil, exceeding those of the vegetable soil by a factor $>$10. DMPP reduced gross nitrification by 12 and 60% for the pasture and vegetable soil, respectively. However, DMPP reduced cumulative N_2O emissions from the vegetable soil only. Fertilisation decreased *nosZ* abundance in the pasture soil, regardless of the treatment. The same trend was observed for the fertiliser only treatment from the vegetable soil. DMPP however increased *nosZ* abundance compared to the fertiliser only treatment in the vegetable soil.

Gross N transformation rates identified the pasture soil as the more productive soil regarding soil mineral N supply and demonstrate the magnitude of N_2O emissions as a function of N-turnover. The reduction of *nosZ* abundance after fertilisation in both soils reflects the stimulating effect of fertiliser and water addition on N turnover. Increased NO_3^- production suppresses *nosZ* activity, limiting further reduction of N_2O to dinitrogen (N_2). This mechanism was mitigated by DMPP in the vegetable soil, explaining the significant reduction of N_2O emissions by DMPP. The high N turnover in the pasture soil and the resulting NO_3^- concentration is likely to limit the short-term efficacy of DMPP. The relationship between N_2O emissions and *nosZ* abundance identifies the shift in the N_2:N_2O ratio to N_2 as a key mechanism of N_2O reduction by DMPP. This shift is however driven and limited by soil-intrinsic N-turnover, explaining differences in N_2O reduction by DMPP observed for different soil types in the field.