Cattle slurry amended with nitrification inhibitors: effects on nitrous oxide, dinitrogen and methane emissions

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Introduction In recent decades, a very intensive dairy farming system has been developed in northern Portugal. Considering the appreciable amounts of slurry generated and the small farm areas for spreading, this activity involves large annual inputs of N with the risk of undesirable consequences for the environment. Emission of greenhouse gases from agricultural sources, such as N_2O (originating from nitrification and denitrification) and CH_4, therefore need to be reduced. The aim of this laboratory experiment was to evaluate the effectiveness of two nitrification inhibitors (dicyandiamide (DCD) and 3,4-dimethylpyrazole phosphate (DMPP)) in reducing nitrification and subsequent denitrification after being added to cattle slurry.

Materials and methods Nitrification inhibitors were added along with sieved (4 mm) cattle slurry to a sieved (2 mm) arable soil (Cambisol) collected from the 0-20cm layer and incubated under simulated autumn conditions for Portugal of temperature (12h day/12h night cycle of 20/10ºC) and water content (90% field capacity). Soil mineral N analyses gave: 0.86 mg NH_4^+-N and 4.62 mg NO_3^--N (/kg dry soil). Total N of the slurry was 0.13% (fresh basis). Treatments, with three replicates, consisted of a control (without slurry), slurry treated with DCD (at 5% slurry-N), slurry treated with DMPP (at 1% slurry-N) and slurry only. Slurry was applied at the equivalent of 70 m^3 /ha (~90 kg N/ha). An automated laboratory incubation system permitted direct, independent measurements of N_2O, N_2 and CH_4 fluxes, which were measured approximately every 2 h over a period of 36 d. After 32 days incubation, (phase 1, nitrifying conditions), the O_2 supply to the incubation system was removed to induce anaerobic conditions in the soils (phase 2, denitrifying conditions).

Results During phase 1, N_2O emissions were only evident in soil receiving slurry without inhibitors, with peak emissions on days 15-17 (~ 0.22 kg N/ha per d). There were clear diurnal patterns in emissions that were highly correlated with temperature. There were no discernible emissions of N_2, and CH_4 was only emitted during the first 4.5 d from the slurry-treated soils. Significantly greater amounts of CH_4 were emitted from soil receiving slurry +DCD (0.31 kg C) compared with slurry only treatment (0.18 kg C). In phase 2, there were much greater amounts of N_2O from soil receiving slurry only and control treatments (~1.0 kg N/ha per d) compared with soils receiving slurry plus inhibitors (~0.1 kg N/ha per d). During this phase, emissions of N_2 were greatest with the two inhibitor treatments, reaching 1.0-1.5 kg N/ha per d with no emissions of CH_4. Considering the results of both phases, the amounts of gaseous N emitted were 4.8, 5.8, 3.9 and 4.5 kg N/ha from the control, slurry-only, slurry +DCD and slurry +DMPP treatments, respectively.

Conclusions Results show that, relative to the slurry only treatment, the N_2O emissions were 62%, 4% and 10% from soils receiving the control, slurry +DCD and slurry +DMPP treatments, respectively. Considering the total N flux emitted, the differences between treatments were less evident (83%, 68% and 78%, respectively). Nevertheless, nitrification inhibitors provided important reductions in N emissions, particularly when considering effects on global warming. However, the amounts of CH_4-C emitted from the slurry plus inhibitor treatments were greater than those from the slurry only treatment (with DCD exceeding DMPP emissions by 29%) and this needs to be set against the apparent benefits of inhibitors.