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A novel, field based isotope ratio mass spectrometer system to continuously measure N_2 and N_2O emissions in fertilized cropping systems

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Terrestrial denitrification, the reduction of oxidized nitrogen (N) to nitrous oxide (N_2O) and dinitrogen (N_2), is one of the least well-understood processes of the global N cycle. High-frequency measurements of N_2O have significantly improved N_2O flux estimates. However, the temporal coverage of N_2 measurements is usually limited to daily to weekly measurements, which cannot fully account for the high temporal variation of denitrification.
This study introduces a novel, mobile isotope ratio mass spectrometer (IR-MS) coupled to a fully automated chamber system, measuring N_2 and N_2O fluxes in real time at a sub-daily resolution. The new field based IR-MS system was developed by the Queensland University of Technology (QUT) in collaboration with Sercon (Sercon, Crewe, UK) and is housed in an air-conditioned trailer which can be transported to the desired field location. The system was used to investigate the effect of two different fertiliser rates ($K^{15}NO_3$ at 60 atom %, 50 and 100 kg N ha^{-1}) on the magnitude and the N_2:N_2O partitioning of denitrification losses from a sugarcane field in subtropical Australia. The N_2 and N_2O concentration were measured 4 times a day from each chamber over the 7 day monitoring period using a fully automated cycle.
Total denitrification losses (N_2 + N_2O) resulted in 2.05 $\pm$ 0.10 kg ha^{-1} and 5.67 $\pm$ 0.22 kg ha^{-1} for the 50N and 100N treatments, respectively. The main product of denitrification was N_2 for both treatments. However, the N_2:N_2O ratio was lower in the 100N treatment, where higher nitrate (NO_3^-) accumulation likely suppressed the reduction of N_2O to N_2. Based on the standard deviation of atmospheric air samples a method detection limit for N_2 fluxes of 58 g ha^{-1} day^{-1} was calculated (at a NO_3^- ^{15}N pool enrichment of 60%).
These results highlight that sub-tropical sugarcane systems in Australia can be a hotspot for soil denitrification where high emissions of N_2O and N_2 can be expected. They also clearly demonstrate the ability of the new field based IR-MS system to measure N_2 and N_2O emissions from denitrification under field conditions. There is still significant room to improve this system and lower detection limits by further modification of the sampling unit and altering the sampling regime. We conclude that this new system has the potential to significantly improve our understanding of denitrification losses in fertilised cropping systems.