The effect of soil moisture on nitrous oxide flux and production pathway in different soil types

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INTRODUCTION

Understanding the mechanisms leading to the emission of the potent greenhouse gas nitrous oxide (N₂O) is essential for accurate flux prediction and for developing effective adaptation and mitigation strategies in response to climate change (1). Even though the knowledge of how N₂O is produced and emitted from soils has advanced over the last several decades (2-4), there still remain surprising grey-areas in our understanding of the underlying mechanisms. One such grey-area is a more precise understanding of how N₂O production pathways (nitrification and denitrification) relate to soil moisture.

RESEARCH OBJECTIVES

With the use of a novel analytical technique (cavity ring down spectroscopy), our objectives are to:
- Precisely quantify the relationship between soil moisture and N₂O production by measuring ¹⁵N²O isotopomers.
- Evaluate the variability in this relationship based on differences in soil nutrient levels, organic matter, and texture.

METHODS

Soil collection and characteristics:
- Soil samples for the 0–10 cm depth were randomly collected at three sites (Dark Brown Chernozems), air-dried and sieved through a 2.00 mm mesh screen.

Soil water holding capacity:
- The soil water holding capacity data were needed (5) to determine the initial range of soil moisture treatments.

Soil incubation study:
- Randomized complete block design with 4 replicates.
- 21.87 cm³ petri dishes were completely filled with 22.0, 24.0, and 26.0 g of soil with bulk densities of 1.01, 1.10, and 1.33 g cm⁻³ for the Sutherland, Asquith, and Bradwell soil associations.
- Treatments established based on gravimetric moisture levels ranged from 20–105% water filled pore space (WFPS).
- Sealed inside 1L mason jars, lids fitted with septa for gas sampling.
- Incubated for 24 hrs in dark, at 21 °C.
- Gas sampled for N₂O and ¹⁵N₂O; analyzed concentrations via GC (Bruker 450) and CRDS (Picarro G5131-i isotopic N₂O analyzer).
- Isotopomers are used to calculate site preference (SP) – this indicates nitrification vs denitrification.

RESULTS & DISCUSSION

Regardless of the dramatically different magnitudes of N₂O flux across each soil type, there were similarities in how soil moisture influenced the relative amount of N₂O (Fig. 1). As N₂O fluxes changed with soil moisture, a mirrored change occurred for SP (Fig. 1).

The δ¹⁵N and δ¹⁸O values decreased during the same soil moisture region that the SP values decreased (Fig. 1).

At soil moisture levels below 53% WFPS:
- Nitrification was the dominated N₂O production pathway: FN = 1

At soil moisture levels exceeding 78% WFPS:
- Denitrification was the dominated N₂O production pathway: FN = 1

CONCLUSIONS

The soil moisture level during the ‘transition zone’ is a key regulation of which pathway dominantly produces N₂O – be it nitrification or denitrification, or a mixture of both.

¹⁵N₂O isotopomers are a powerful technique to more precisely quantify the relationship between soil moisture and N₂O production pathway.

¹⁴N₂O isotopomer results support earlier-known relationships between moisture and N₂O production (2), but can help move beyond inferences towards the quantification of relative source partitions.

REFERENCES


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