Source-process Partitioning of Soil N_2O and CO_2 Production: Nitrogen and Simulated Exudate Additions

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Background

- Greenhouse gas emissions from agriculture account for 12% of total anthropogenic emissions globally[1].
- 60% of anthropogenic N_2O comes from agricultural soil[2].
- Soil organic matter can be primed by plant root exudates or nitrogen fertilizer, altering N_2O and CO_2 emissions.
- Understanding source partitioning of CO_2 & N_2O emissions from soil is integral for quantification of SOM priming.
- Process partitioning of N_2O fluxes can lead to better mitigation strategies.

Study Objective

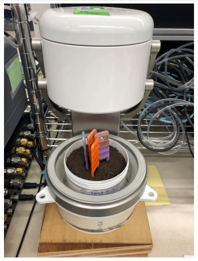
To quantify and partition N_2O and CO_2 sources and N_2O processes to understand how simulated root exudate and nitrogen fertilizer interplay to induce SOM priming effects.

Materials and Methods

- Upper 15 cm of soil collected from continuous barley rotation in Breton, Alberta.
- **Soil properties:** Texture: silty loam, C/N: 11, Available N: 8.7 mg N kg^{-1}, DOC: 11.95 g C kg^{-1}.
- **Lab incubation experimental design:** RCBD with 10 treatments, 4 replicates.
- **Artificial root exudate:** 60% glucose, 40% malonic acid labelled with 99 atom % ^{13}C. Applied at 0, 6.2 or 12.5 mg C kg^{-1} soil day^{-1}.
- **Nitrogen fertilizer:** Urea labelled with 5 atom% ^{15}N. Applied at 0 or 53 mg N kg^{-1} soil.
- **Flux measurements:** non steady state, automated chambers, Picarro cavity ring down spectroscope & Aerodyne quantum cascade laser spectroscope.

Experimental Setup

Exudate Application (mg C kg^{-1} soil)	N Fertilizer (53 mg N kg^{-1} soil)	No N Fertilizer
0	0F	0NF
6.2	0.5F	0.5NF
12.5	1F	1NF



Results

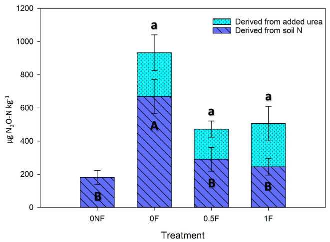


Fig 1. Cumulative N_2O emissions (μg N_2O-N kg^{-1} soil) for select treatments separated by source.

- Source priming determined by difference in soil N-derived N_2O between the control (0NF) and treatments.
- Significant positive priming in 0F treatment (no exudate, with fertilizer).
- Addition of root exudate (0.5F & 1F treatments) reduced positive priming.

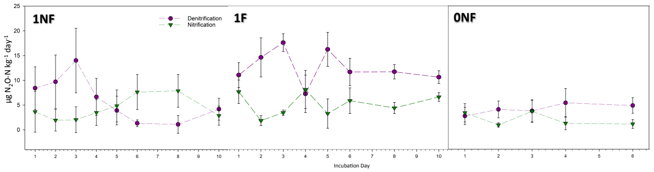


Fig 2. Average daily emissions (μg N_2O-N kg^{-1} day^{-1}) partitioned into source processes, i.e., nitrification and denitrification.

- Denitrification was dominant in all treatments during first 4 days.
- During incubation days 5 to 10, denitrification was positively primed in the 1F treatment and negatively primed in the 1NF treatment.
- Nitrification was positively primed in the 1F treatment.

Results (con't)

- Source priming determined by difference in soil C-derived CO_2.
- Labile carbon additions as exudate induced positive priming relative to the control.
- Addition of labile nitrogen reduced positive SOM priming relative to unfertilized counterparts.

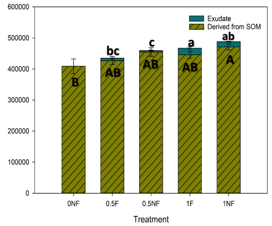


Fig 3. Cumulative CO_2-C fluxes (μg CO_2-C kg^{-1}) over the duration of the incubation.

Conclusions

- No single mechanism can explain the different patterns of priming of SOM in response to exogenous inputs of exudate (labile C) and nitrogen. Multiple priming mechanisms may be occurring simultaneously.
- Addition of nitrogen fertilizer increased the fluxes of N_2O and positive SOM-N priming to produce N_2O, both of which were reduced when labile C was applied.
- Nitrogen and carbon additions altered the magnitude and proportion of N_2O formed via nitrification and denitrification.
- Addition of labile carbon increased CO_2 fluxes and SOM priming to generate CO_2, but addition of nitrogen fertilizer reduced both when applied concurrently.

Acknowledgments

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Bibliography

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[2]Wang, Qihui, et al. "Data-driven estimates of global nitrous oxide emissions from croplands." National Science Review 7.2 (2020): 441-452.