The Fate of Our Nitrogen: Influence of Root Exudates on MAOM Nitrogen Dynamics

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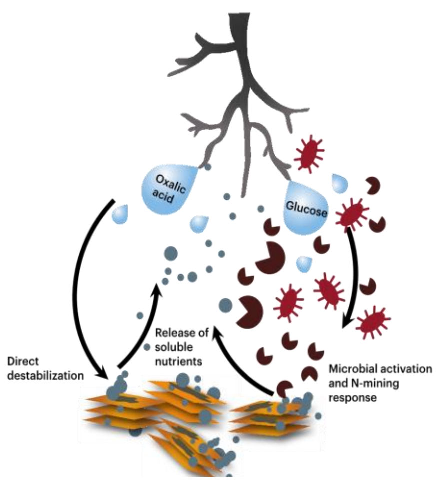
Introduction

- Mineral-associated organic matter (MAOM) is a key intermediary between organic matter N pools
- MAOM holds >75% of agricultural soil N
- MAOM contains a rapidly-cycling "reactive" or new fraction of MAOM-N
- Enrichment in fertilizer, plant- and microbial-derived N products
- Microbes transform nutrients between pools influenced by root exudation



Jilling et al. (2018) depiction of the main pathways of MAOM mobilization.

Objective: Assess the potential for exudates and bio-stimulants to mobilize and render plant-available N from old vs new MAOM and POM

Driving questions:

1) Does the exudate or bio-stimulant preferentially mobilize newly formed or old MAOM? MAOM N or POM N?

2) Does the exudate or bio-stimulant result in MAOM and POM N moving primarily into different pools (i.e. DON vs MBN vs Mineralized N)?

Design/Methods

1) Label grass with/ ^{15}N

Grow ryegrass with and w/out ^{15}N

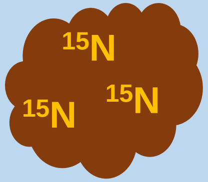
2) Isolate MAOM

Soil size fractionation through 53 µm sieve to isolate MAOM from a silty clay loam Mollisol

3) Label MAOM w/ ^{15}N

Incubate dry ryegrass with and w/out ^{15}N with MAOM

4) Isolate ^{15}N MAOM



Repeat step 2 to isolate the newly ^{15}N labeled MAOM

5) Assemble 3 experimental soils

3 parts sand, 2 parts MAOM with or w/out POM

6) Apply Interventions

1) Corn root exudates **2)** Bio-stimulant **3)** Glucose **4)** Oxalic acid **5)** Water control

Interventions applied once a week for 3 weeks

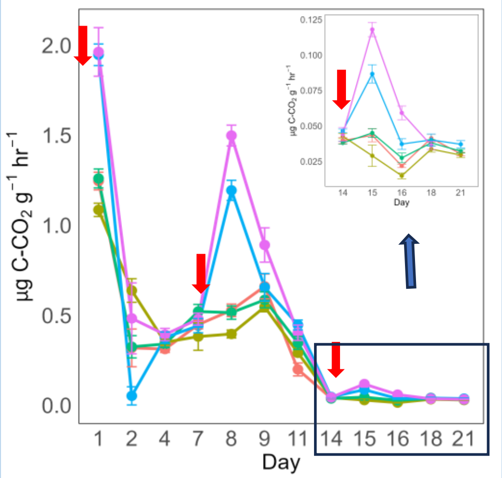
*Exudates normalized for carbon input

Preliminary Results

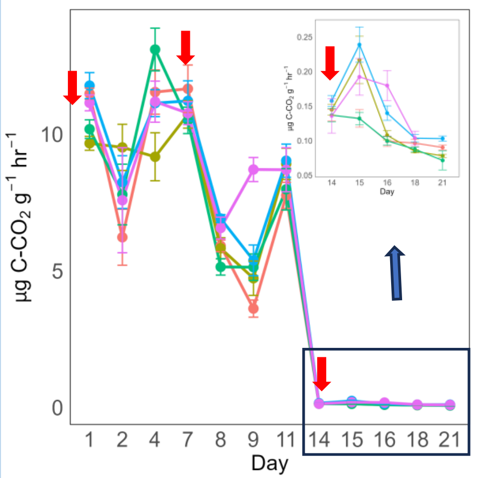
Without POM, glucose and oxalic acid greatly increase respiration but with POM interventions had little effect relative to the control

↓ = Time of application (day 0, 7, and 14), respiration on day 7 and 14 taken prior to application

Treatment: ^{15}N-MAOM



Treatment: ^{15}N-MAOM + ^{14}N POM



glucose ● oxalic acid ● bio-stimulant ● exudate ● control ●

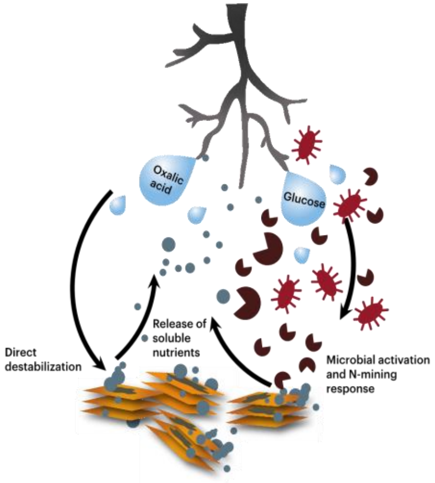
Next Steps

To be quantified next, MAOM ^{15}N, POM ^{15}N, DO ^{15}N, microbial biomass ^{15}N, NH_4 & NO^3, hydrolytic and peroxidative enzymatic activity.

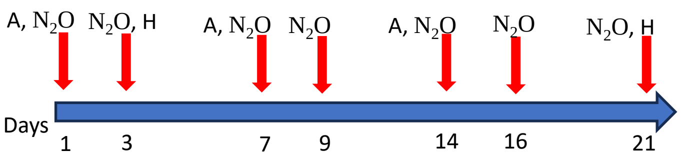
Should we measure something else? Are there considerations we should make quantifying any of these pools or enzymes?

Acknowledgments

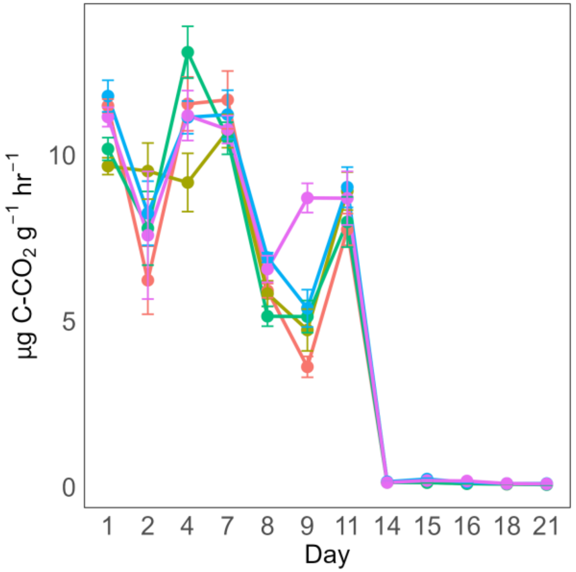
Syngenta Group and NH Agricultural Experimental Station for funding.



Timeline



A = application, N2O = N2O measurement, H = harvest



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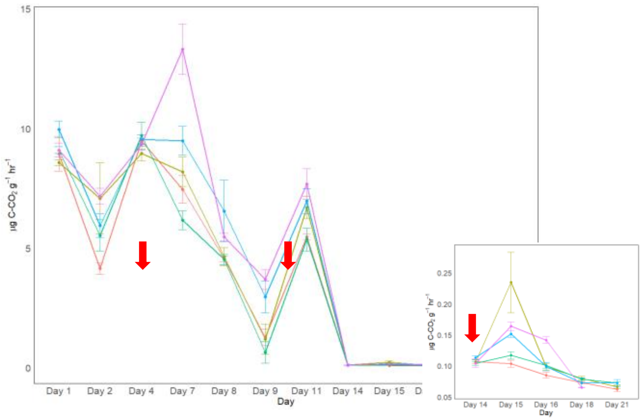

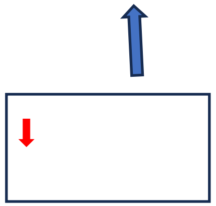

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Treatment: ^{14}N-MAOM + ^{15}N-POM
Pools Investigated: POM-N *vs* unlabeled MAOM (new + old)

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1. University of New Hampshire Durham, NH 2. Center for Soil Biogeochemistry and Microbial Ecology

Introduction

Mineral-associated organic matter (MAOM) is a key intermediary between soluble and particulate organic matter (POM) N pools

MAOM holds >75% of agricultural soil N

MAOM contains a rapidly-cycling "reactive" fraction of MAOM-N

high quality (i.e., low C/N ratio) and enrichment in fertilizer, plant- and microbial-derived N products

microbes are the hub of this system, interacting with plants, transforming nutrients between these pools

thus controlling nitrogen supply to plants over growing seasons or longer

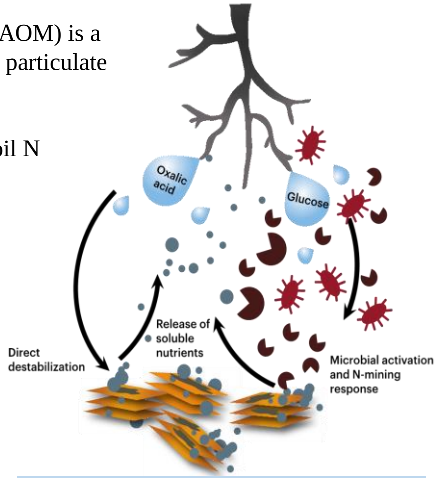


Figure 1) Jilling et al. (2018) Depiction of the main pathways of MAOM mobilization.

bjective: Assess the potential for two Syngenta bio-products to mobilize and nder plant-available N from old vs new MAOM and POM by exploring whether e product acts on organic matter through direct desorption or indirect microbial mulation.

riving questions:

Does the bio-product/exudate preferentially mobilize newly formed or old AOM? MAOM N or POM N?

Does the bio-product/exudate added result in MAOM and POM N moving marily into different pools (i.e. DON vs MBN vs Mineralized N)?

Do bio-products act primarily as an indirect (through stimulation of microbial tivity, like a simple sugar) or direct (direct desorption of SOM molecules, like an ganic acid) mobilizer of carbon and nitrogen from the MAOM pool?

How do these bio-products/exudates influence CO_2 and N_2O emissions?

Acknowledgments/References

NH Agricultural Experimental Station and Syngenta for funding.

Design/Methods

1). Grow ryegrass with and w/out 15N

2). Soil size fractionation through 50 um sieve to isolate MAOM

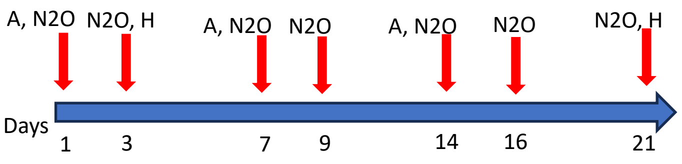
3). Incubate dry ryegrass with and w/out 15N with MAOM

4. Repeat step 2 to isolate the newly 15N labeled MAOM

5. Assemble 3 experimental soil

5 interventions applied once a week for 3 weeks
1) Extracted root exudate **2)** bio-stimulant product **3)** Glucose **4)** Oxalic acid **5)** Water control

Timeline



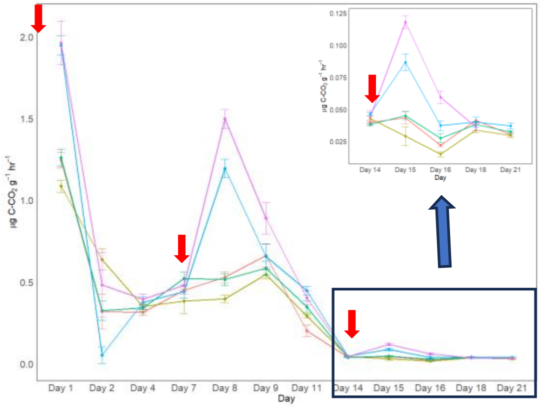
A = application, N2O = N2O measurement, H = harvest

3 x isotope treatments	5 x interventions	Harvests & Reps
1) ^{15}N-MAOM + ^{14}N POM 2) ^{14}N-MAOM + ^{15}N-POM 3) ^{15}N-MAOM alone	1) root exudate 2) bio-stimulant 3) Glucose 4) Oxalic acid 5) Water control	x 2 harvests (2 and 21 days) x 5 reps = 150 total

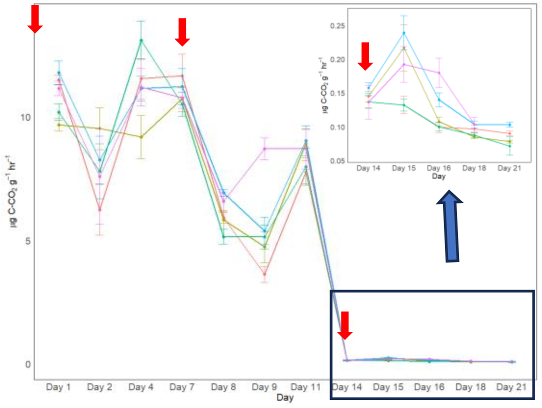
Preliminary Results

W/out POM glucose and oxalic acid greatly increase respiration

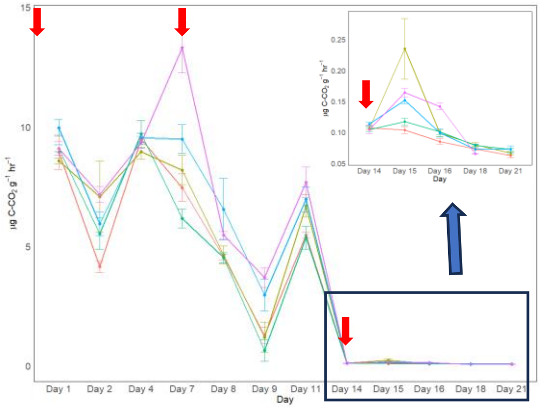
In the presence of POM, increases in respiration seem mainly do to the "belch effect" if influenced by applications at all



Treatment: ^{15}N-MAOM
Pools Investigated: Old *vs* **new MAOM-N** w/out POM



Treatment: ^{15}N-MAOM + ^{14}N POM
Pools Investigated: New MAOM-N *vs* unlabeled SOM (older MAOM + POM)



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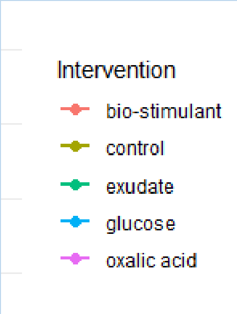
Pools Investigated: POM-N *vs* unlabeled MAOM (new + old)



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The Effects of Grass Legume Bi-culture Defoliation on Soil Microbial Communities and Physico-chemistry

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1. Department of Natural Resources, University of New Hampshire Durham, NH 2. Center for Soil Biogeochemistry and Microbial Ecology (Soil BioME)

Introduction

-Bi-cultures provide forage for livestock.

-Legumes decrease the need for external N inputs[1] due to their associated N fixing bacteria

-Legumes can improve soil quality metrics like organic matter, nitrogen, water holding capacity, soil aggregation compared to monocultures

-Defoliation disturbance through grazing and or haying can alter growth aboveground and belowground and root exudation[6,] below-ground N fluxes[7]

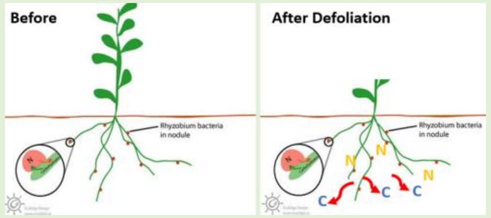


Figure 1. Defoliation increasing carbon and nitrogen flux belowground

Appropriately managing defoliation could enhance the benefits of grass legume bi-cultures

Overarching question: How does defoliation management intensity effect soil physico-chemistry and microbial communities?

Objective: Survey soil physico-chemistry and microbial communities under defoliation frequency and severity treatments applied to grass legume bi-cultures

Design/Methods

-6 orchard grass (ORC) legume bi-cultures, alfalfa, red and white clover, and birdsfoot trefoil in a ratio of 30% legume + 70% ORC , and mixtures at 30% to 70% and 70% to 30% ratios

-Crossed cutting schedule 5 cuts and 3 cuts per year and cutting height 5cm (severe) and 10cm (moderate)

-sampled after 3 years

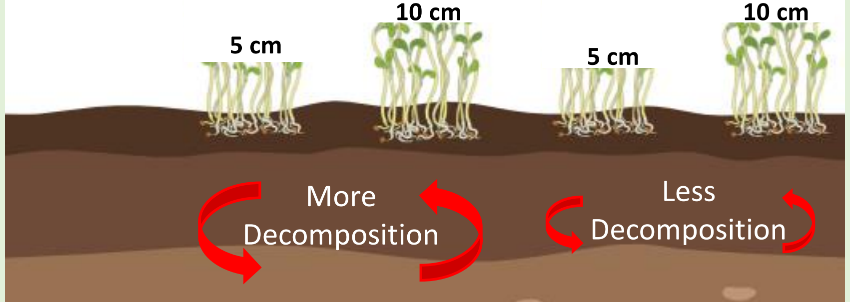
Figure 2. Grass legume bi-culture

Soil metrics were altered most by cutting frequency, but often depended on cutting severity. Bi-culture type explained no variation in soil metrics.

Water holding capacity (WHC) ↑ Gravimetric water content (GWC) ↑ — 5 Cuts/Year

Root biomass ↑ — 3 Cuts/Year

	5 Cuts/Year 5 cm	5 Cuts/Year 10 cm	3 Cuts/Year 5 cm	3 Cuts/Year 10 cm
WHC	a	ab	b	ab
Root Biomass	b	b	a	a
Total Carbon	a	ab	b	ab
GWC	a	ab	b	ab
Microbial Biomass C	ab	ab	b	a



Possible explanation: **Increased soil metrics under more frequent cutting are due to increased root decomposition and exudation. This effect is increased with more severe cutting signifying a greater plant response.**

Figure 3. Green arrows indicate metric is greater under corresponding cut frequency. Shared letters between treatments signify no statistical difference.

Bacterial community composition was altered by cutting severity and frequency and correlated with soil physico-chemistry, but few differences in C and N cycling genes were observed.

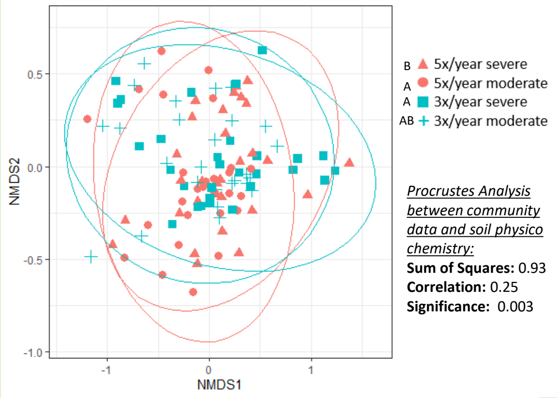


Figure 4. nMDS ordination of 16S amplicon sequence data, where each point represents a community from a sample. Shared letters (legend) signify no statistical difference. Measured soil metrics explain ~25% of the variation in microbial communities.

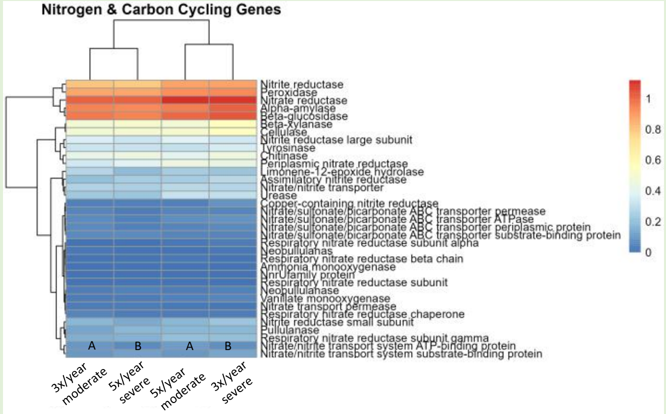


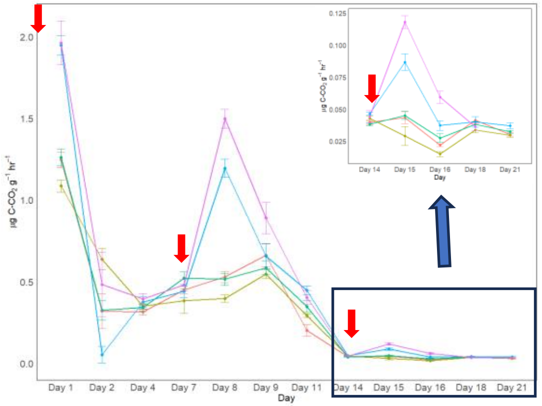
Figure 5. Relative abundance of key carbon and nitrogen cycling genes across treatments. Higher abundances are indicated by red and lower abundances by blue. Shared letters represent no statistical difference between treatments for a given gene.

Conclusions

Increased cutting frequency and to a lesser degree increased severity may improve soil quality metrics. While microbial community composition varied by treatment, the shifts were not substantial. Further, other than nitrate transport system ATP-binding protein, there were no changes in the relative abundance of key C and N cycling genes. Shifts in soil health metrics may have more to do with increased rates of biogeochemical transformations rather than changes in the pathways of transformations.

Acknowledgments/References

NH Agricultural Experimental Station for funding. Nathan Alexander, 2021 UNH Soil Ecology class.



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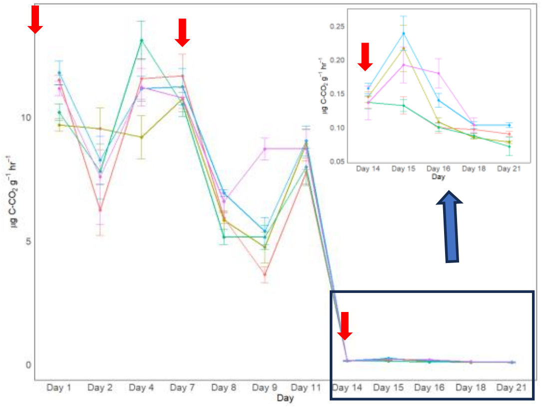

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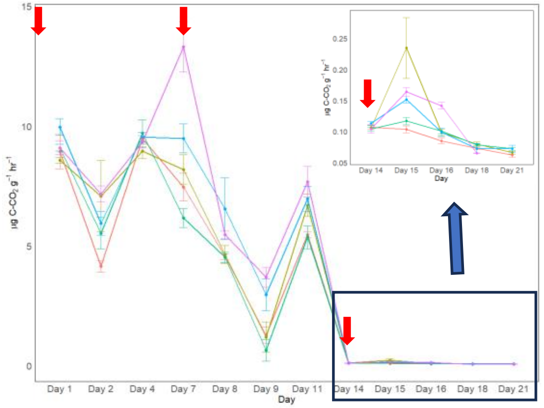

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