The role of mineral-N in the decomposition of residues, microbial C and N cycling, and formation of soil organic matter

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Introduction

•Many nutrient cycling models assume that residue decomposition is controlled by the C to N ratio, and therefore residue-C and -N are considered closely linked.

•Recent studies suggest that under N-fertilization and N-deposition, mineral-N may preferentially be used in the formation of stable soil organic matter compared to residue-N.

•We conducted a study to determine if residue quality, with and without the addition of mineral-N, affects the cycling of C and N through the soil microbial biomass, and consequentially controls the formation of stable soil organic matter.

•In a second study we followed the fate of labeled residue-C with and without mineral-N additions.

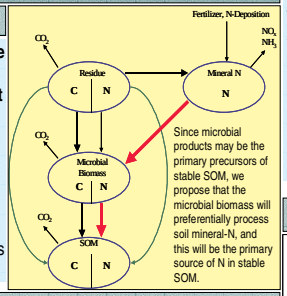
Experiment 1: Labeled Microbial Biomass

Hypothesis & Objectives

H_0: Mineral-N addition will increase the cycling of C through the microbial biomass. This effect will be greatest with high C:N residue.

O1.) How do mineral-N additions affect microbial C and N cycling with added residue of different C:N ratios?

O2.) Are residue-C and N assimilated proportionally by the microbial biomass upon mineral-N additions?



Since microbial products may be the primary precursors of stable SOM, we propose that the microbial biomass will preferentially process soil mineral-N, and this will be the primary source of N in stable SOM.

Methods

Label soil microbial biomass:

•Added ^{13}C-glucose and $(^{15}NH_4)_2SO_4$

•Incubate 2 days at 55% water holding capacity

Inputs:

•Rice residue and urea

•Normalized for N

•**Low C:N = 45:1; Mid C:N = 62:1, High = 99:1**

Group I Controls	Group II Mineral-N	Group III Residues	Group IV Combinations
Soil Only	Urea	Low C:N residue	Low C:N residue + urea
No Soil		Middle C:N residue	Middle C:N residue + urea
		High C:N residue	High C:N residue + urea

Experiment Incubation:

•40 days at 25°C at 55% water holding capacity

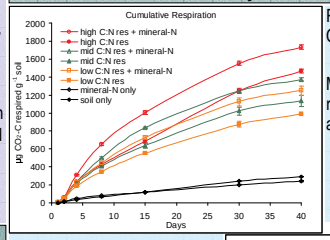
Analyses:

ι Initial t_0 and Final t_{40}: microbial biomass atom% ^{13}C and atom% ^{15}N (chloroform fumigation-incubation, analysis by GC-IRMS)

ι Days 1,2,4,8,15,30,40: gas sampling for ^{13}C-CO_2

Results and Discussion

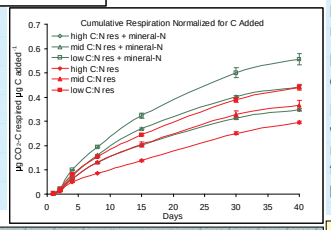
Objective 1



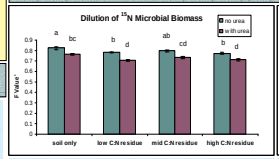
Respiration highest for high C:N, followed by mid and low.

Mineral-N addition increased respiration the same magnitude across all C:N residues.

Microbial respiration highest when low C:N residue is added.



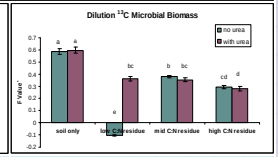
Objective 2



$$F_N = \frac{atom\%^{15}N_{final} - atom\%^{15}N_{background}}{atom\%^{15}N_{initial} - atom\%^{15}N_{background}}$$

•Pattern and change the same across C:N ratios

•Dilution depends on amount of N added, no difference whether it came from residue-N or urea-N



$$F_C = \frac{atom\%^{13}C_{final} - atom\%^{13}C_{background}}{atom\%^{13}C_{initial} - atom\%^{13}C_{background}}$$

•Little difference in MBC pool dilution among treatments

•Slightly more dilution in high C:N residue treatments

Experiment 2: Labeled Inputs *(in progress)*

Hypothesis & Objectives

H_0: Fertilizer-N contributes more to stable SOM formation than residue-N.

O1.) Determine if addition of fertilizer-N leads to more stable SOM formation than without.

O2.) Determine if fertilizer-N is the predominant N-source in stable SOM when both are present.

Methods

Inputs:

•$(NH_4)_2SO_4$ mineral-N source

•$^{13}C^{15}N$-labeled and unlabeled rice straw

Group I Controls	Group II Mineral-N	Group III Residues	Group IV Combinations
Soil Only	^{15}N-Mineral N	$^{13}C^{15}N$-Residue	$^{13}C^{15}N$-Residue + Mineral N
		Unlabeled Residue	Unlabeled Residue + ^{15}N-Mineral N

Experiment Incubation:

•90 days at 25°C at 55% water holding capacity

Analyses:

ι Days 1,2,4,6,15,30,60, 90: gas sampling for ^{13}C-CO_2

ι Microbial biomass δ^{13}C and atom% ^{15}N (chloroform fumigation-extraction) *(in progress)*

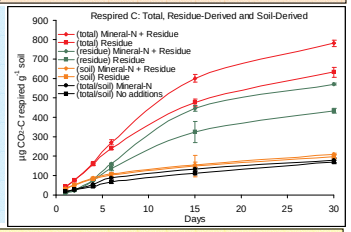
ι SOM fractionation into light fraction, humic, fulvic and humin after 90 days *(in progress)*

Preliminary Results and Discussion

No soil priming from mineral-N or residues.

Mineral-N increases mineralization of residue-C.

Fractionation of SOM after 90 days will test whether this increase in respiration signifies a stimulation of the microbial biomass that will produce more stable SOM.



Summary & Conclusions

Experiment 1

•Mineral-N additions increased soil respiration regardless of residue quality

•Microbial respiration increased with residue addition in the order Low C:N > Mid C:N > High C:N on a g^{-1} C added basis

•Residue-C and residue-N were not linked through the microbial biomass upon mineral-N addition.

•The decoupling of residue-C and -N through the microbial pool may suggest a direct role of mineral-N additions in the cycling and sequestration of C.

Experiment 2

•Soil-derived respiration was unaffected by treatments (no priming)

•Mineral-N additions increase respiration of residue-C

•Whether this increased respiration results in more stable SOM formation will be determined by fractionations after 90 days.