A nutrient-centric view of rhizosphere priming: Corn mediation of cover crop litter decomposition and nitrogen cycling

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Background

Plants can influence many soil processes through rhizosphere-microbe interactions, including rhizosphere effects on soil organic matter decomposition (rhizosphere priming). Rhizosphere priming research has largely focused on the relative magnitude of plant-mediated impacts on soil organic matter decomposition. Plant roots exhibit a high degree of plasticity in response to nutrient patches in the soil yet we lack an understanding of whether plants mediate the decomposition of recent litter inputs of varying quality.

Understanding rhizosphere effects on litter decomposition may offer an opportunity to improve the synchrony of nitrogen mineralization and plant nitrogen uptake.

We hypothesized that:

- the presence of growing corn roots would increase the decomposition rate of cover crop litter
- corn mediation of decomposition would differ by litter quality
- increased corn belowground carbon (C) allocation would correlate with increasing litter nitrogen (N) uptake by corn
- excluding roots from litter would reduce the mediation effect and would reduce corn N uptake from litter

Research approach

We tracked the C and N from corn (*Zea mays*), soil organic matter, and cover crop litter in a greenhouse study after 7 weeks of corn growth.

Cover crop litter was produced by growing rye (*Secale cereale*) and red clover (*Trifolium pratense*) in a greenhouse and fertilizing with ^{15}N-enriched fertilizer. Treatments included: Litter type (clover, rye or a mixture of clover-rye); Litter roots or shoots; Litterbag mesh size (2mm or 35um) that were buried in each of 4 replicate pots with and without corn plants (Fig. 1A).

Pots were filled with a mixture of sand and soil that had a 20+ year history of C_3 grasses. This allowed the use of C stable isotopes to differentiate between C_4 corn-derived and C_3 cover crop and soil organic matter sources in soil respiration measured using cavity ring-down spectroscopy. Corn shoot biomass, microbial biomass, and dissolved organic N were analyzed for total N and ^{15}N concentration to track the fate of cover crop litter N (Fig. 1B).

A) B)

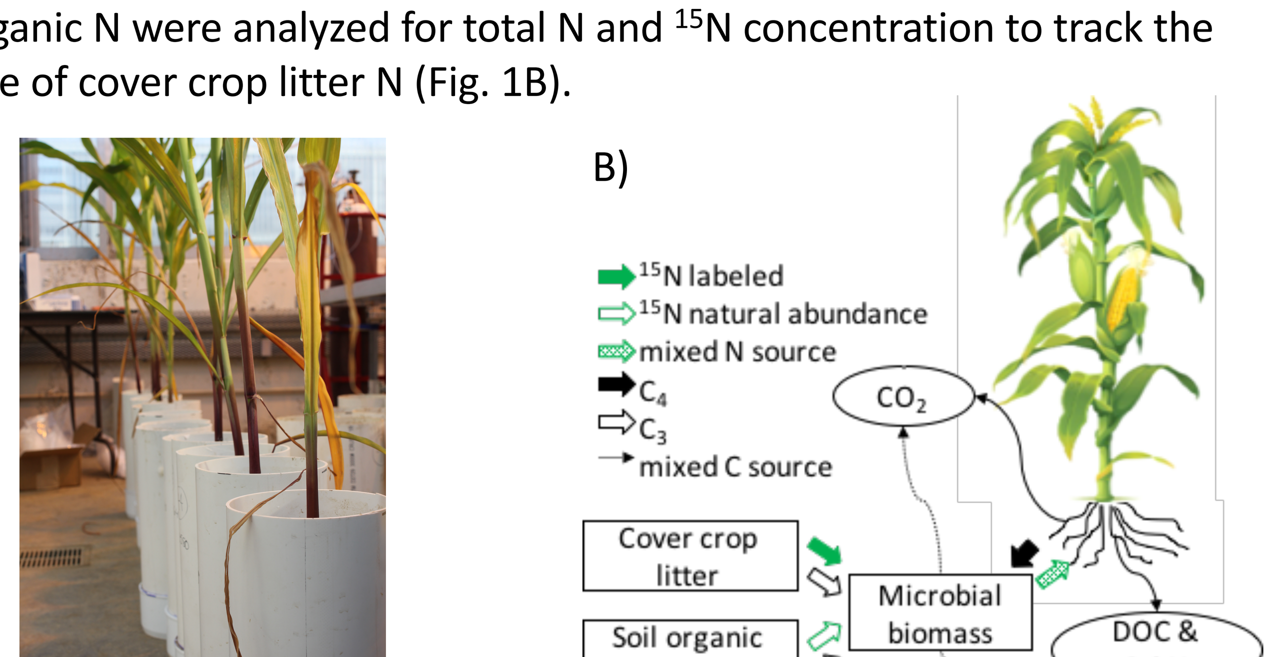

Figure 1. A) Greenhouse pots with and without corn. B) Pools and fluxes of carbon and nitrogen measured using ^{13}C and ^{15}N stable isotope methods.

Corn plants increased cover crop litter decomposition rates

Table 1. Starting litter quality and N added per pot. Rye shoots had the highest N concentration.

Litter type		initial %N	C:N	N added (mg/bag)	N added (mg/pot)
Clover	shoot	2.58	19.9	0.21	0.40
Clover	root	2.48	19.7	0.20	
Mix	shoot	2.8	18.4	0.22	0.38
Mix	root	2.0	24.9	0.16	
Rye	shoot	2.98	16.8	0.24	0.36
Rye	root	1.57	30.1	0.13	

The presence of corn plants increased the rate of N loss from decomposing litter and the corn effect was greatest for clover litter (Fig. 2). Shoot litter decomposed faster than root litter (% mass lost, p=0.0002).

While clover litter decomposed faster than rye litter (% mass lost, p=0.03), rye litter had a greater proportional N loss than mixed litter (Fig. 2).

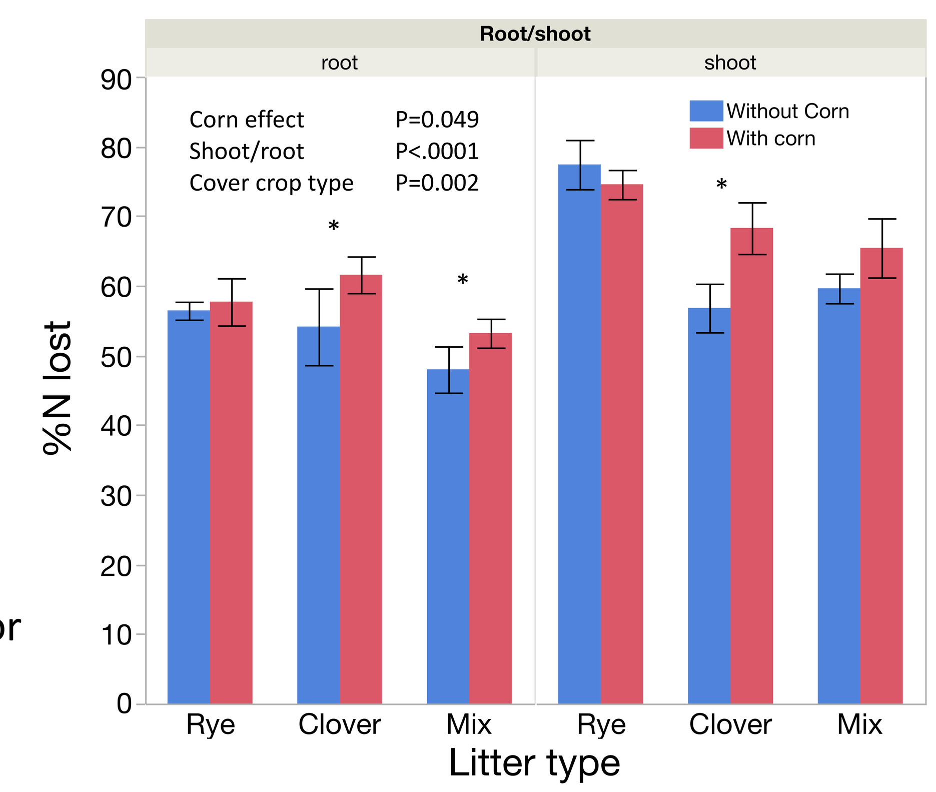

Figure 2. Corn increased the rate of N loss from clover roots and shoots and mixed clover/rye litter roots.

Excluding roots decreased litter decomposition rates

Excluding roots from cover crop litter decreased litter decomposition rates and corn acquisition of litter N. The mesh size effect was greatest for clover litter (Fig. 5).

While excluding roots from litter did not affect microbial biomass, excluding roots did reduce both soil DOC and DON relative to pots with 2mm mesh litterbags (Fig. 6).

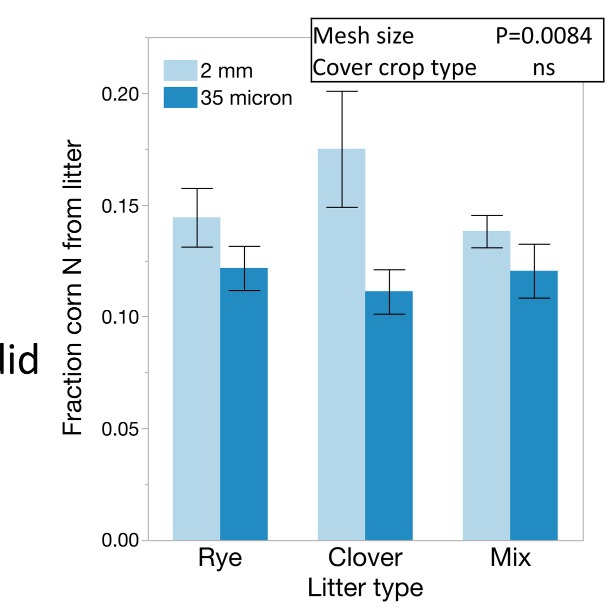

Figure 5. Corn accessed more litter N when roots could enter litterbags.

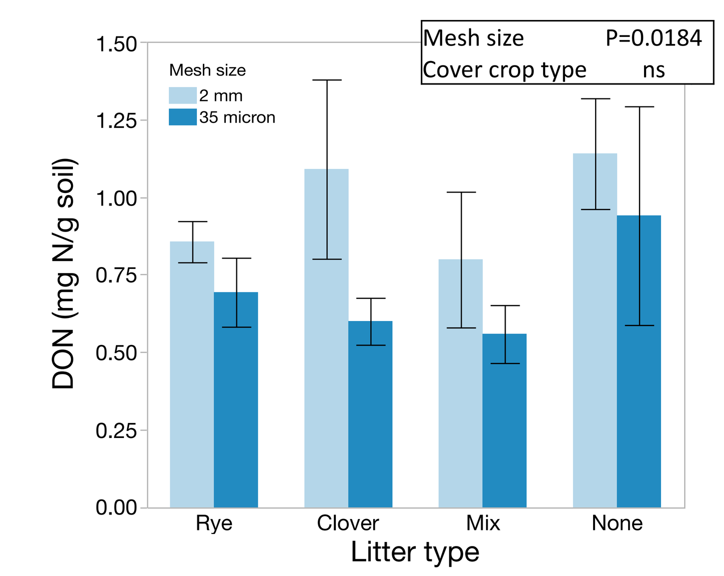

Figure 5. Dissolved organic N was greater in soils with 2mm mesh litterbags.

Corn increased belowground C when grown with cover crop litter

Corn plants responded to cover crop litter by increasing root and shoot allocation relative to pots without cover crop litter. While shoot biomass was greatest for corn in pots with clover litter, corn aboveground N uptake was greater in the absence of cover crop litter than with clover litter (Fig. 3).

Corn plants increased soil respiration relative to pots without corn. This increased respiration was due to corn-derived root respiration and not the priming of soil organic matter decomposition (Fig. 4).

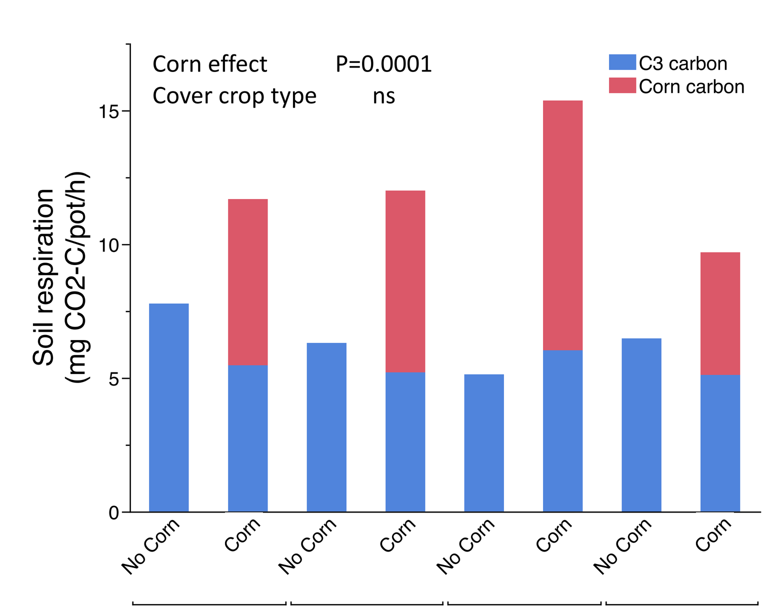

Figure 4. Corn increased the rate of soil respiration, but did not increase respiration derived from decomposing soil organic matter or cover crop litter.

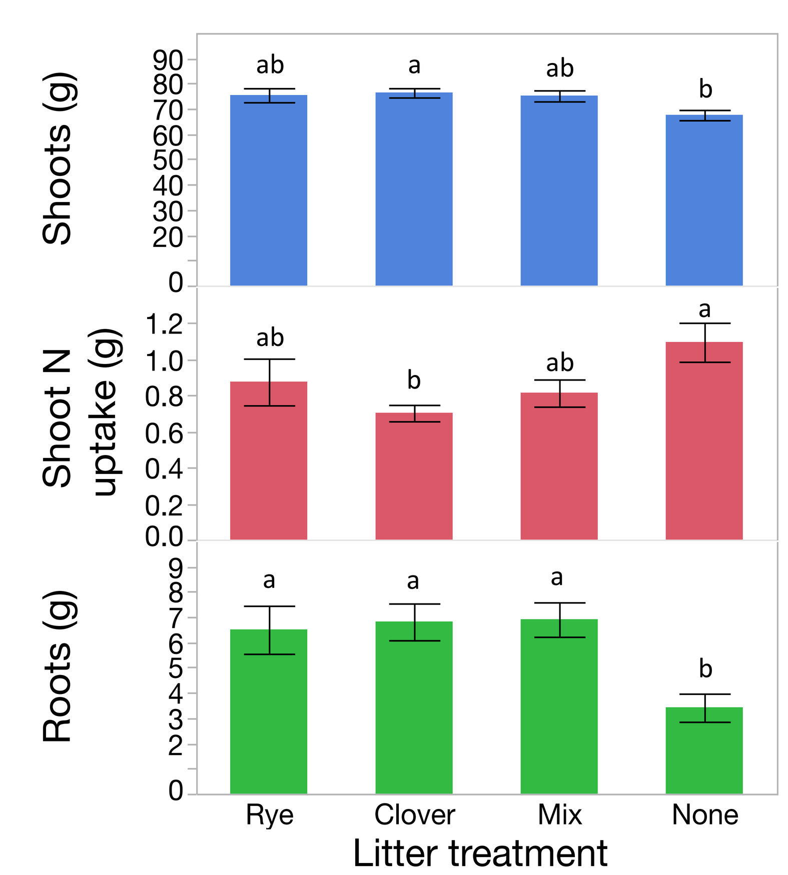

Figure 3. Corn above and belowground biomass was greater when grown in pots with cover crop litter. This did not correspond with increasing aboveground N uptake.

Conclusions

From this study and previous field studies (Rosenzweig et al. 2017), we have found consistent evidence of corn priming the decomposition cover crop litter, but limited evidence of corn priming the decomposition of total soil organic carbon pools.

These results suggest that plant mediation of litter decomposition is influenced by litter type. In both field and greenhouse studies, corn increased the decomposition rate of clover, but not rye litter.

In addition, direct contact between litter and plant roots increased the priming effect on litter decomposition.

Together these results suggest that crops can shift belowground carbon allocation in response to litter patches, which in turn stimulates increased decomposition rates and crop nitrogen acquisition.

Acknowledgements

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Literature cited

Rosenzweig, S. T., Schipanski, M. E., & Kaye, J. P. 2017. Rhizosphere priming and plant-mediated cover crop decomposition. Plant and Soil 417: 127-139.

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