Does the legacy of long-term crop rotation influence crop residue decomposition dynamics and potential soil N_2O flux?

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Introduction

Research has demonstrated that including winter wheat and undersown red clover into corn-soybean rotations has the potential to improve soil health indices and crop N use efficiency[1,2]. Yet, the mechanisms that explain these benefits are poorly understood. One explanation is, that by including wheat/red clover in corn-soy rotations, the soil N supply improves or that the soil N cycle 'tightens'.

Photo 1. Elora long-term rotation x tillage trial.

Hypotheses

1. Soil N cycling is regulated by the legacy of long-term crop rotation.
2. Including wheat/red clover in a corn-soy based rotation benefits key soil ecosystem services, such as, (a) reduced potential N losses (N_2O), and (b) increased crop residue decomposition and nutrient turnover.

Experimental Description and Methodology

We focused on a 37-yr old trial located in Elora, Ontario (Photo 1). On a Gray Brown Luvisol, crop rotations and tillage systems are arranged in a split-plot RCBD with four replicates. *Selected rotations studied in 2017:* corn-corn-soy-soy (C**C**SS); corn-corn-soy-winter wheat/red-clover (C**C**SWrc), [crop phase bolded]. Conventional tillage (CT) and no-till (NT) systems were evaluated for each rotation.

^{15}N tracer technique:

- ^{15}N enriched urea was applied to micro-plots in June 2017 to produce enriched crop biomass
- In Oct 2017, ^{15}N natural abundance soil cores (10 cm deep, 8 cm diam.) and enriched plant tissue samples (stover and roots) were collected, dried, sieved, and ground at 2mm (Photos 2 and 3).

Photo 2. Soil core extraction tool

Photo 3. Soil core micro-plot extraction

Soil incubation study:

- 50 g soil microcosms established from natural abundance cores, and mixed with ^{15}N enriched crop residue (1 g stover or 0.2 g root biomass).
- Microcosms incubated for 14 days at 70% water-filled pore space, sealed inside 1L mason jars (Photo 4). Soil and gas samples periodically collected to measure crop residue decomposition dynamics (via ^{15}N mineralization), CO_2, N_2O and $^{15}N_2O$ fluxes.
- Data analyzed using SAS (v. 9.04), ANOVA performed using proc glimmix (laplace method) and alpha at 0.05.

Photo 4. Incubation microcosms

Results and Discussion

Even though the same amount of corn stover (and stover-N) was applied to soil from either rotation, the C**C**SWrc legacy produced significantly higher N_2O fluxes than from the C**C**SS legacy (p=0.0075), regardless of tillage system (Fig. 1).

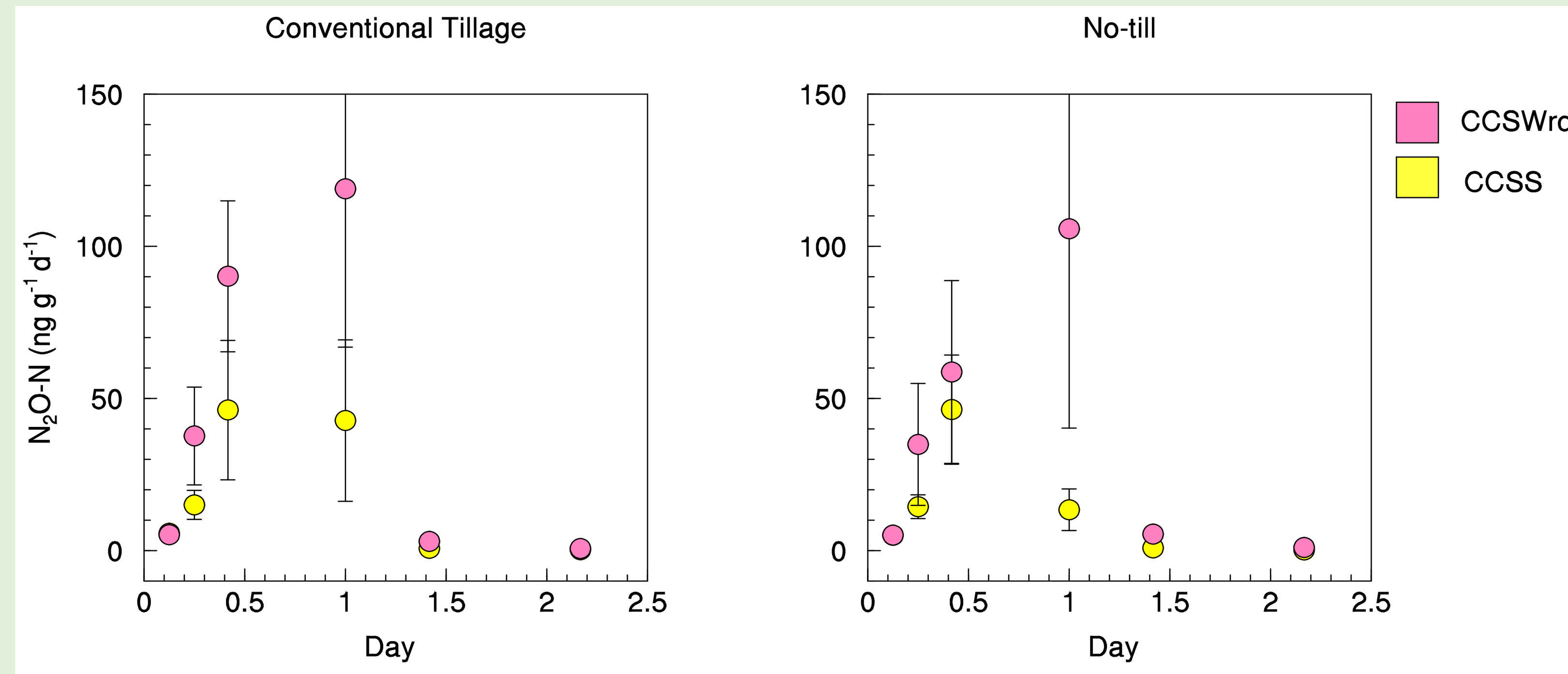

Figure 1. N_2O flux during the first 2.5 days of incubation after corn stover was amended to microcosms containing soil from CT and NT systems that had C**C**SS or C**C**SWrc rotation legacies.

When corn roots were amended to the soil, higher N_2O fluxes were observed from the C**C**SWrc legacy compared to C**C**SS under CT (p<0.0001), but not under NT (p=0.5851) (Fig. 2).

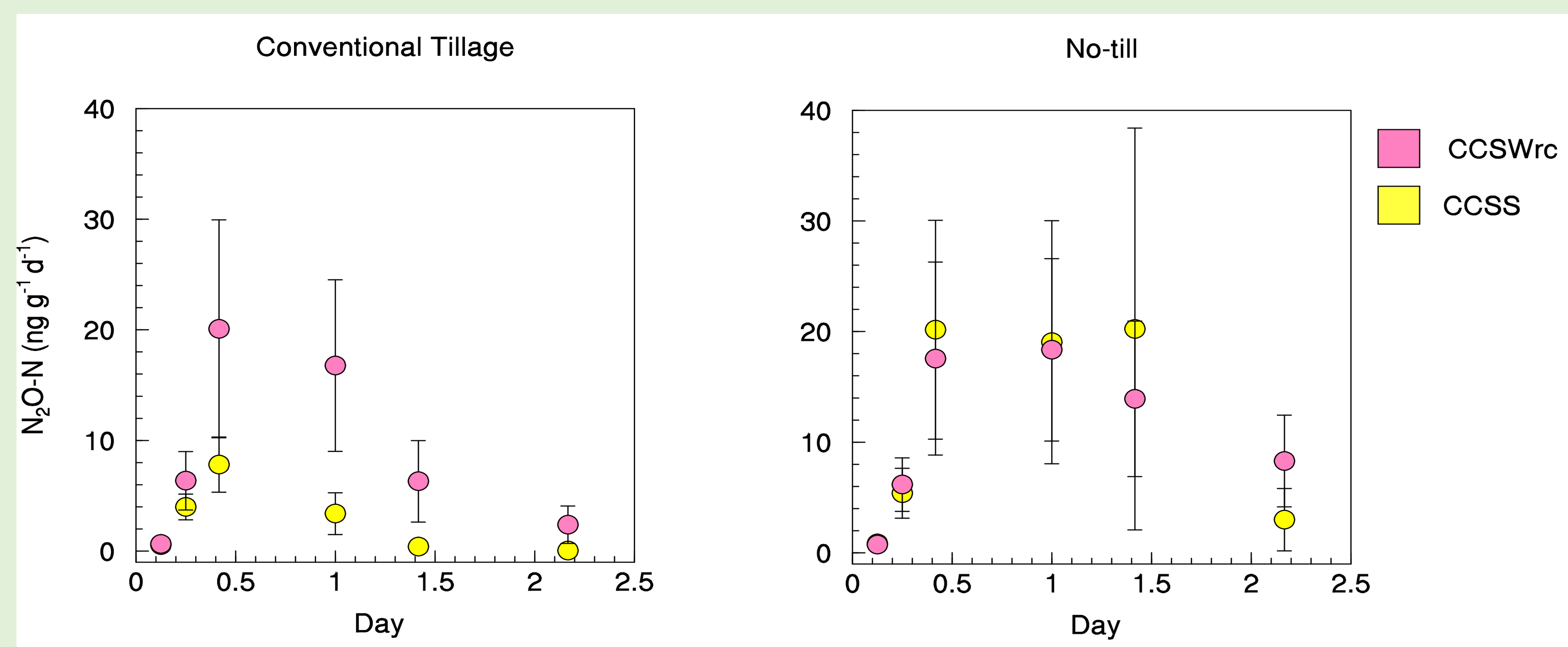

Figure 2. N_2O flux during the first 2.5 days of incubation after corn root was amended to microcosms containing soil from CT and NT systems that had a rotation legacy of C**C**SS or C**C**SWrc.

Using ^{15}N tracer techniques, the source of emitted N_2O was identified. The majority of N_2O from the stover amended treatments was attributed to the stover biomass; however, for the root amended treatments the N_2O was largely soil-derived, indicating soil priming (Fig. 3).

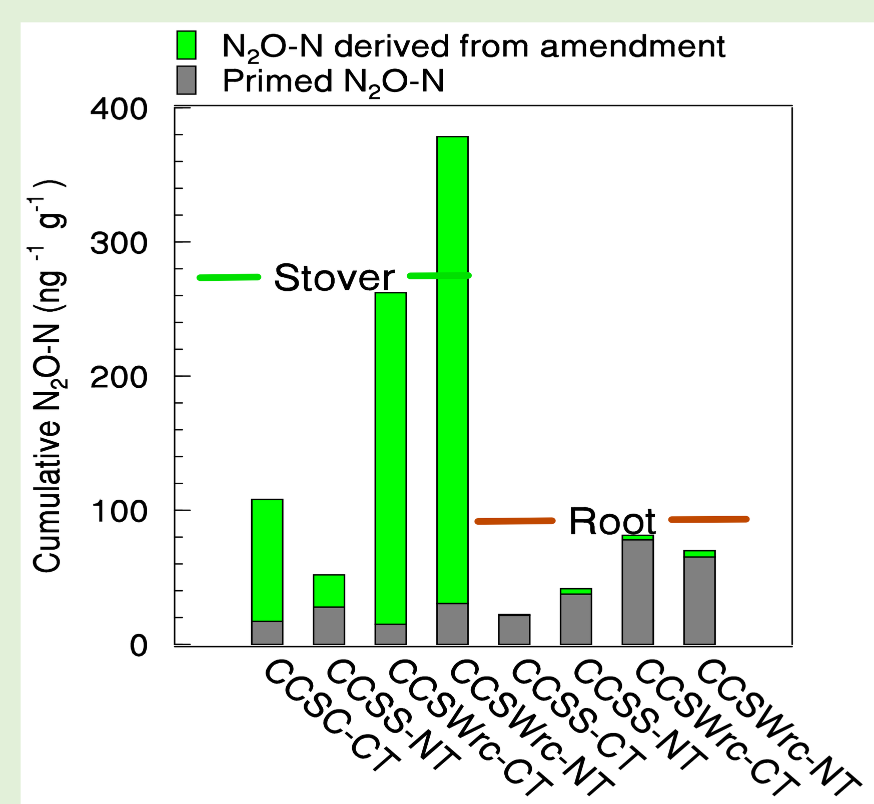

Figure 3. Cumulative amendment-derived and soil N_2O emissions from C**C**SS and C**C**SWrc legacies.

Not only were initial soil inorganic N levels greater under C**C**SWrc than C**C**SS (41-59 vs 26-32 ug g^{-1}, respectively), but 7.9 times more N was mineralized from the corn crop stover (p=0.1195) and 4 times from corn roots (p=0.0508), in the C**C**SWrc legacy than the C**C**SS legacy (Fig. 4).

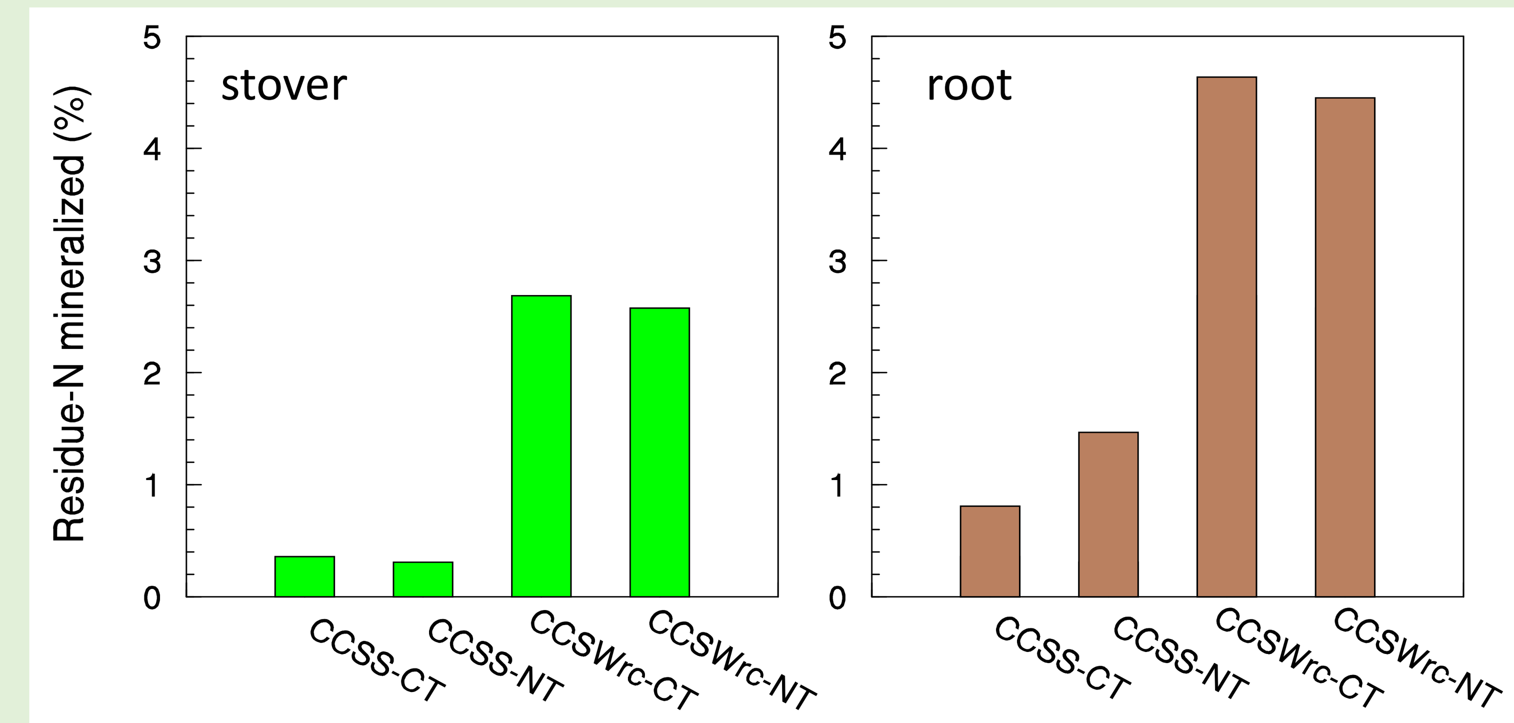

Figure 4. Average percentage of inorganic N (nitrate + ammonium) mineralized from the corn stover or root amendments in C**C**SS and C**C**SWrc soil legacies after 14 d, as calculated using the ^{15}N tracer technique.

Conclusions

Crop residue was processed differently depending on long-term crop rotation legacy, influencing in the way N is cycled in the soil and supporting our first hypothesis. Our results indicate that past soil management may influence present-day biogeochemical processing. When introducing wheat/red clover into a corn-soy rotation, the greater soil inorganic N availability lead to enhanced crop residue-N mineralization, supporting hypothesis 2a). But, in contrary to hypothesis 2b), it may result in increased N_2O fluxes. Moreover, soil N_2O priming seems to be influenced by residue quality inputs. To complement this lab study, further research is being conducted to address the hypotheses at the field scale.

References

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