#228-11

Effects of Agricultural Management Systems On Gaseous Carbon Losses From Corn Root Residue

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Background

It is widely recognized that root residue contributes more to stable soil carbon pools than shoot residue, but the dynamics of the root residue carbon pool have not been studied across a broad range of agricultural management systems. The objective of this research was to determine the effect of management systems on the turnover of corn root residue C. The research was conducted on soils with a long term record of management ranging in tillage type and frequency, fertilizer form and quantity, and rotation length.

Hypotheses:

1) We expected that the root residue carbon would comprise a smaller proportion of the total CO_2 flux in management systems with higher background SOM levels (i.e. 4 yr. > 2 yr. rotations).
2) Tillage was expected to decrease physical protection of soil C, thereby increasing rates of overall soil organic matter decomposition. Correspondingly we expected high tillage systems to show higher emissions of labeled root residue C than low tillage systems.

Approach

Design:

We used stable isotope labeling to trace the decomposition of recent root residue in order to improve our understanding of how management systems influence the decomposition of recent root residue C. We estimated the turnover of root residue carbon (C) as the cumulative growing season emission of root residue C (as CO_2) divided by the initial estimate of root biomass C in the soil.

In half of the microplots, developing corn plants were labeled with ^{13}C-CO_2. Microplots (1 m^2) containing ^{13}C labeled roots were compared with microplots that received no ^{13}C label, but which otherwise received identical treatment during corn development. This allowed us to trace the decomposition of the ^{13}C labeled root residue over the following growing season. Static chamber flux measurements were taken at 2-3 week intervals from May through October. Flux measurements from each plot were integrated to calculate the cumulative growing season C emissions. Samples were analyzed by gas chromatography and isotope ratio mass spectrometry. This experiment was replicated in 2005 and 2006 on separate sets of plots.

Recent C Sources in Microplots:

- root-labeled: ^{13}C labeled root residue + non-labeled shoot residue
- non-labeled: Non-labeled root residue + non-labeled shoot residue

Study site:

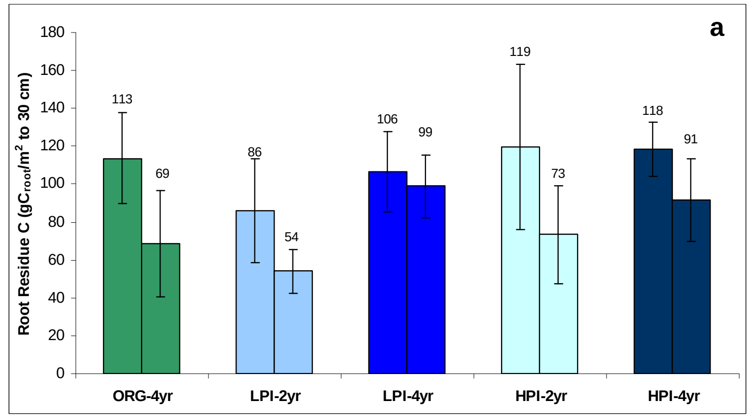
- University of Minnesota: Southwest Research and Outreach Center (Lamberton, MN), 44° 14' N, 95° 19' W
- Under continuous management since 1989
- Soils: calcic and aquic Hapludolls and typic Endoaquolls

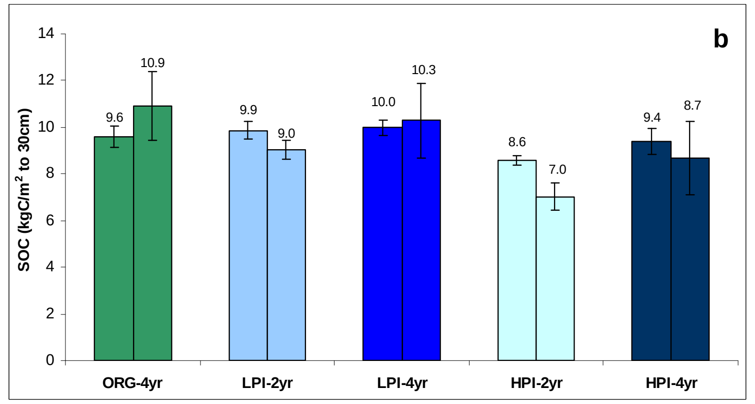
Five management systems:

*****See companion poster for additional information (poster #228-10)*

-HPI-2yr, corn/soybean, higher fertilization and tillage
-HPI-4yr, corn/soybean/oats-alfalfa/alfalfa, higher fertilization and tillage
-LPI-2yr, corn/soybean, lower fertilization and tillage
-LPI-4yr, corn/soybean/oats-alfalfa/alfalfa, lower fertilization and tillage
-ORG-4yr, corn/soybean/oats-alfalfa/alfalfa, manure fertilization, highest tillage frequency, no cover crop (equivalent to ORG-CC on poster #228-10)

Results





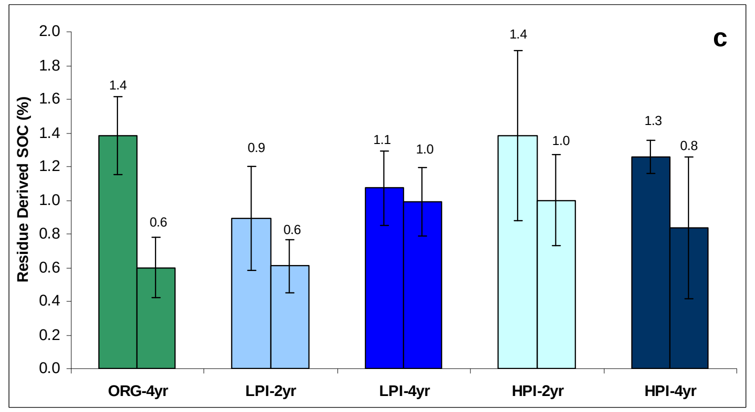


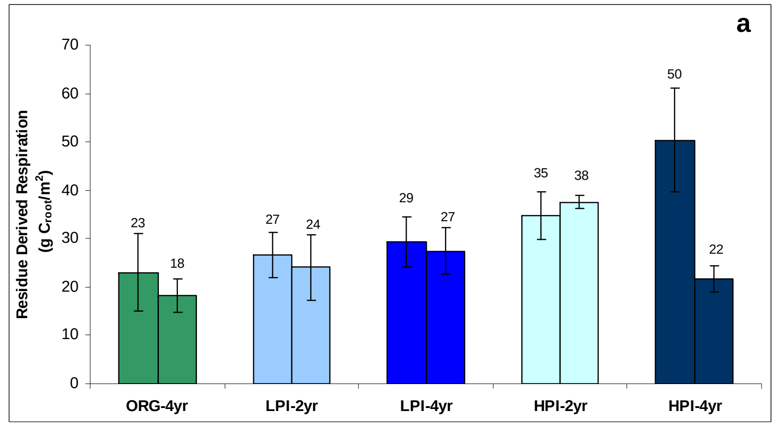
Figure 1. Root residue biomass and soil organic C for the spring of 2005 and 2006. The two years are shown as adjacent bars for each management system. In all figures, unless noted, each bar represents the average and s.e. for each management system, n = 3 (per year).

a) Estimates of initial root biomass C in the soil, g C_{root}/m^2.

b) Total SOC levels, 0-30cm, kg C/m^2.

c) Fraction of total SOC that is residue derived, (%).

• No significant differences among management systems were detected for parameters shown in Fig 1a or 1c. There is a trend of higher root residue C in 4 yr. rotations than in 2 yr. rotations. There was significantly higher SOC content in the 4 yr. rotation systems than in the 2 yr. rotation systems (p = 0.06). This trend is especially clear in 2006.



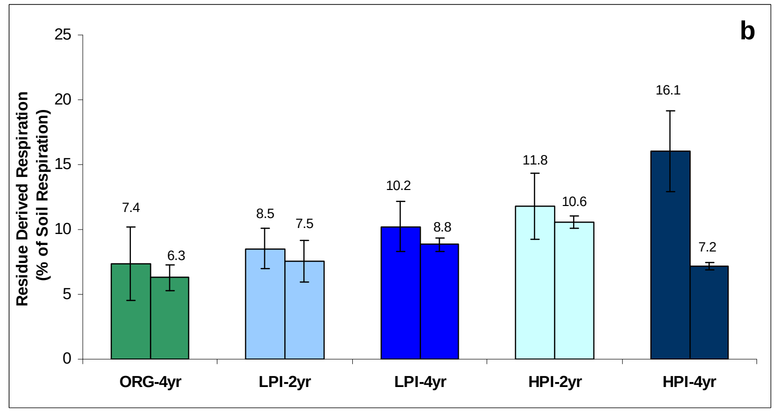


Figure 2.

a) **Cumulative residue derived respiration over the growing season.** Reported as grams of residue derived C respired per square meter, (g C_{root}/m^2).

b) **Percent of soil respiration that was root residue derived.** Calculated as the cumulative root derived C respired / cumulative soil C respired. Soil respiration was very similar among management systems meaning that patterns observed in Fig. 2a are maintained.

• 2005 and 2006 results were highly consistent for each management system with the exception of HPI-4yr.

• No significant management system differences were detected for these parameters in either year.

Field site and sampling apparatus, spring 2005.

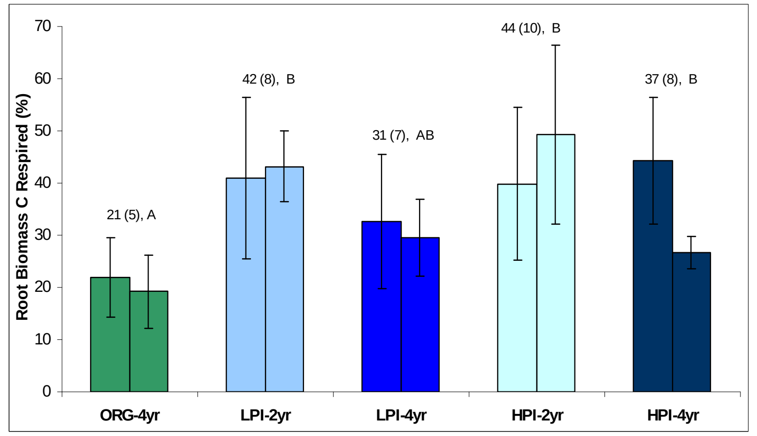


Figure 3. Percent of initial root biomass C respired by the end of the growing season.

• Each bar represents a management system average, n = 3 (per year). Values and significance levels above each management system represent the 2005 and 2006 average and s.e., n = 6.

• High variability is due in part to the uncertainty in our estimates of initial root biomass C (Fig. 1a).

Summary

There are several noteworthy patterns which emerge when 2005 and 2006 data are combined in order to assess management system effects on root residue C cycling. These patterns suggest that rotation length has an important influence on rates of root C turnover.

Root Biomass C: Root C inputs to SOM were greater in 4 yr. than 2 yr. rotations and greater in HPI than in LPI systems.

SOC: Soils in 4 yr. rotations had higher SOC content than in 2 yr. rotation systems, (p = 0.06). This was particularly true for the HPI management system, and clearer in the 2006 data (data from D. Allan *et al.*, see poster #228-10).

Cumulative Root C Respired:

• The quantity of root residue C respired was highest in HPI, followed by LPI, while in ORG systems we measured the lowest cumulative respiration of root residue C (Fig. 2a).

• The percent of respired C that was residue derived followed the same pattern, HPI > LPI > ORG (Fig. 2b).

• For both parameters, 2 yr. rotations showed lower root C losses and also a lower fraction of respired C that was root residue derived compared to 4 yr. rotations (Fig. 2b). HPI-4yr is the exception to this pattern because of the large difference between 2005 and 2006 measurements.

Percent of Root Residue Respired:

• Root residue C turnover was highest in the 2 yr and HPI-4yr soils. Turnover was lowest in the LPI-4yr and ORG-4yr management system soils. Turnover of root residue C is significantly lower in the ORG-4yr system than in all other systems, with the exception of the LPI-4yr system (Fig 3).

• There was a marginally significant effect of rotation length on root residue C turnover (p = 0.06). The average residue C turnover was lower in 4 yr. rotation systems (ORG-4yr, LPI-4yr, HPI-4yr) than in 2 yr. rotation systems (LPI-2yr, HPI-2yr) (Fig. 3).

Conclusions

• Across all management systems, respiration of root residue C accounted for up to 16% of the cumulative amount of C respired from soils over the growing season (Fig. 2b).

• Over one growing season, the percent of root residue C respired ranged from 21 ± 5 to 44 ± 10% of the initial root biomass C (Fig. 3).

• Emissions of root residue C, and the fraction of C emissions that was residue derived, were greater in 4 yr. than 2 yr. rotation systems.

• Turnover of root residue C, in contrast, is higher in 2 yr. than in 4 yr. rotation systems. This difference reflects the relative abundance of root C in the soil (Figs. 1 and 3).

• Overall, management systems had a smaller effect on root residue C cycling than expected, but our results in combination with those of D. Allan *et al.* (poster #228-10), indicate that the turnover of root C is faster in 2 yr. rotation systems than in 4 yr. rotation systems.

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