The efficiency and stability of plant litter-C transfer to the Soil Mineral Associated Organic Matter pool

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Introduction

- Soil organic matter stabilization relies in part on the quality of plant litter inputs.
- Plant litter quality may affect both nutrient availability and long-term SOM stabilization through the transfer of C and N to soil fractions that are protected against mineralization by organo-mineral association, henceforth referred to as ‘mineral associated organic matter’ (MAOM).
- Plant litter quality characterizes plants according to their chemical composition. Plant litters with low C/N ratios and low lignin concentrations are considered to be high-quality; and as a result, they are easily metabolized by soil microbes (**Fig. 1**).
- *Cotrufo, et al. (2013)* proposed that high-quality plant litters result in faster and greater SOM stabilization via organo-mineral association because high-quality litters yield more microbial residues per unit of litter input, and microbial residues dominate SOM stabilized via organo-mineral association.

Plant Litter[ŧ]	C:N ratio
Alfalfa	16.5
Oats	22.4
Maize	77.9
Soybean	88.7

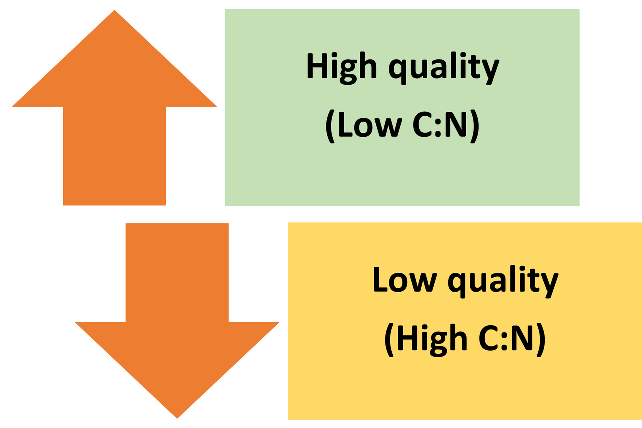


Fig. 1 Plant litter quality rank.
(ŧ) Just aboveground plant litter used, collected at maturity.

Hypotheses

1 High quality plant litters promote more efficient accumulation of MAOM-C and -N than low-quality plant litters.

2 MAOM in soils incubated with high-quality litters has a greater proportion of microbial-derived compounds.

3 Nutrient addition increases the proportion of litter that is transferred to MAOM

4 Neither plant litter quality nor nutrient addition affects the potential mineralization of litter-N accumulated in MAOM-N.

Objective

To isolate the effect of plant litter quality on SOM stabilization.

Methodology

- Long-term laboratory incubation study of 184 day, fully factorial completely randomized design with the following factors:
  - two soil types (sandy loam and silt loam subsoils with low SOM),
  - four plant litters (alfalfa, corn, oats, soybean),
  - two nutrient inputs (with and without).

  Experimental units: 80 samples, including four replicate no-litter controls for each soil*nutrient combination.
- Samples were incubated for four 46-day cycles. At the beginning of each cycle, finely ground plant litter (8.7 g C kg^{-1} dry soil) was added to each sample. At the end of each cycle, any partially decomposed plant litter was removed by air winnowing.

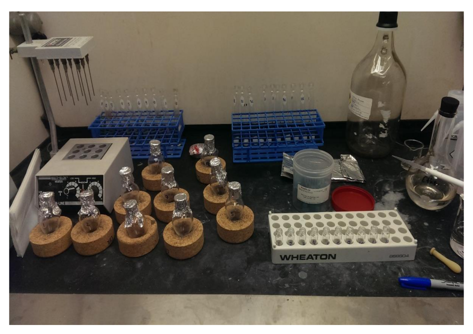
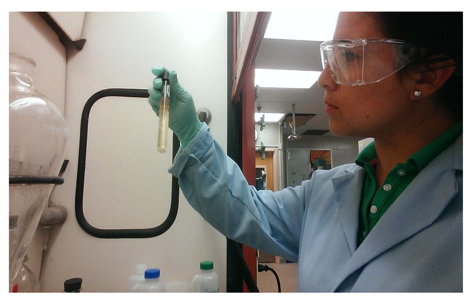


Table 1. Soil physical and chemical properties prior the incubation study.

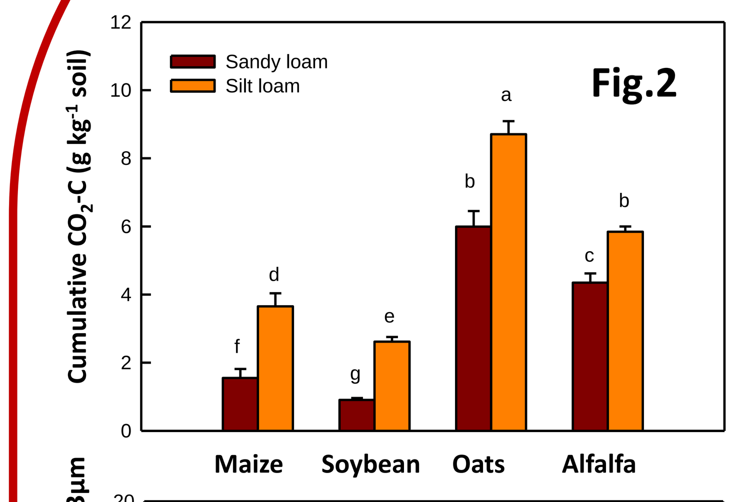
Soil type	Clay (%)	pH (1:1 H2O)	Total Carbon	Total Nitrogen	Total Carbohydrates	C:N ratio
			----------g kg^{-1} soil----------			
Sandy Loam	15.70	7.07	2.48	0.22	1.56	11.46
Silt Loam	31.50	5.12	2.58	0.40	1.81	6.46

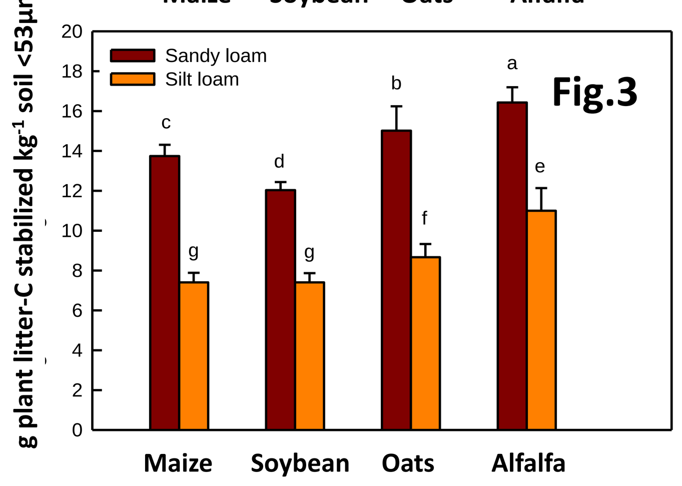
Measurements

- CO_2 flux was frequently measured (0, 1-7d, and every ten days until 46d).
- Plant litter C transfer to stable SOC mineral fine fractions (soil <53 μm) was measured at the beginning and at the end of the incubation by isotopic analysis (δ^{13} C natural abundance using a two-pool isotopic mixing model) as well as calculating the mass transfer of Carbon (C) and Nitrogen (N) (i.e., the increase in soil C and N over the four, 46 day incubation cycles).
- Mineral associated organic matter carbohydrates concentration.
- Potential N mineralization determined after the 186d of the aerobic incubation.



Results





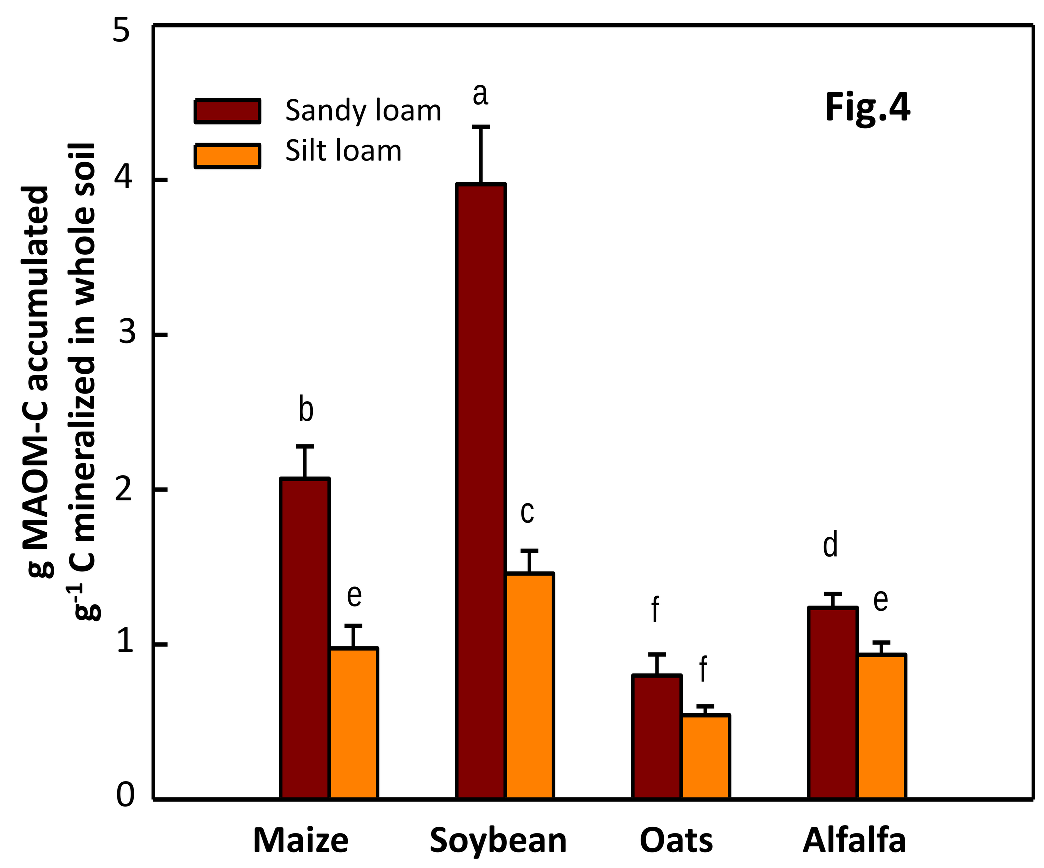


Figure 2, 3, 4. Carbon dynamics in incubated soils after 184d. Carbon mineralization (Fig **1**.), C accumulation in the fine mineral soil fraction (i.e., soil <53um, **Fig. 2**), and C efficiency represented as the ratio of plant litter-C accumulated in the fine mineral soil fraction per unit of C mineralized (**Fig. 3**). Data are mean values (n=8, ± standard error) reported for each plant litter and soil type combination were averaged across the nutrient treatments.

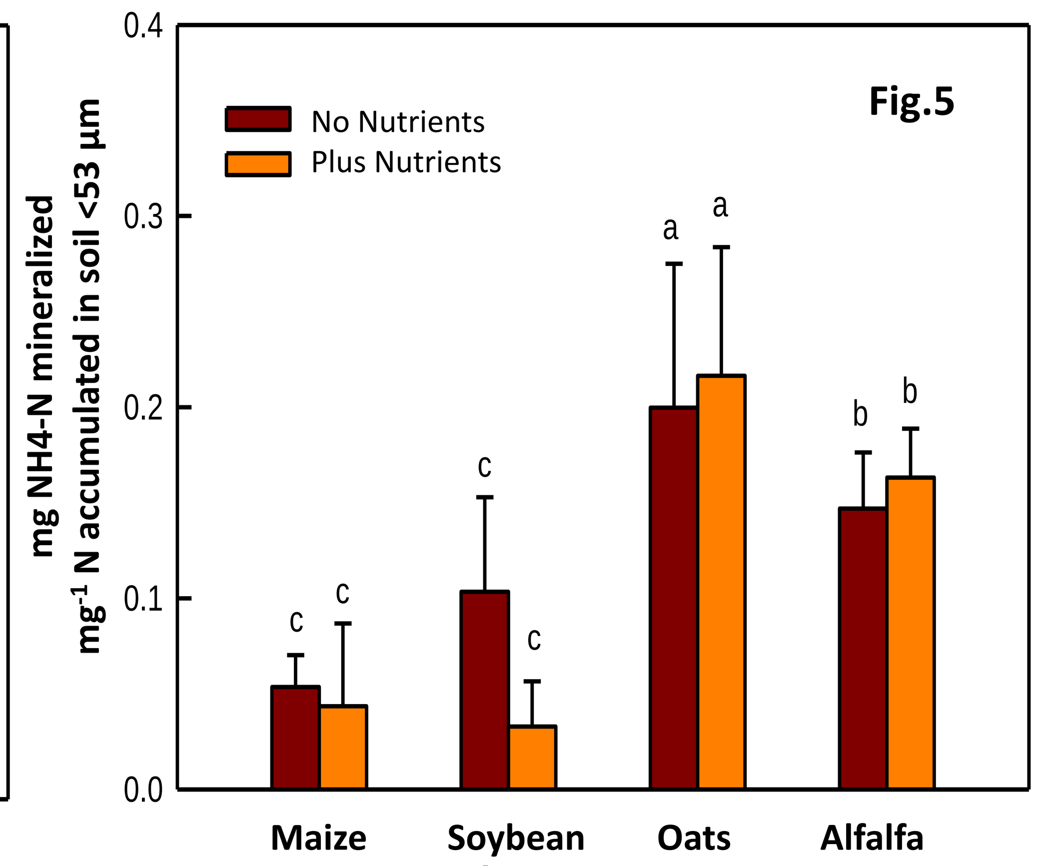


Figure 5. The proportion of potentially mineralized nitrogen relative to the amount of nitrogen accumulated per kg soil <53 μm measured at after the 186d aerobic incubation. Values are based on the average of each treatment (n=8, ± standard error bar).

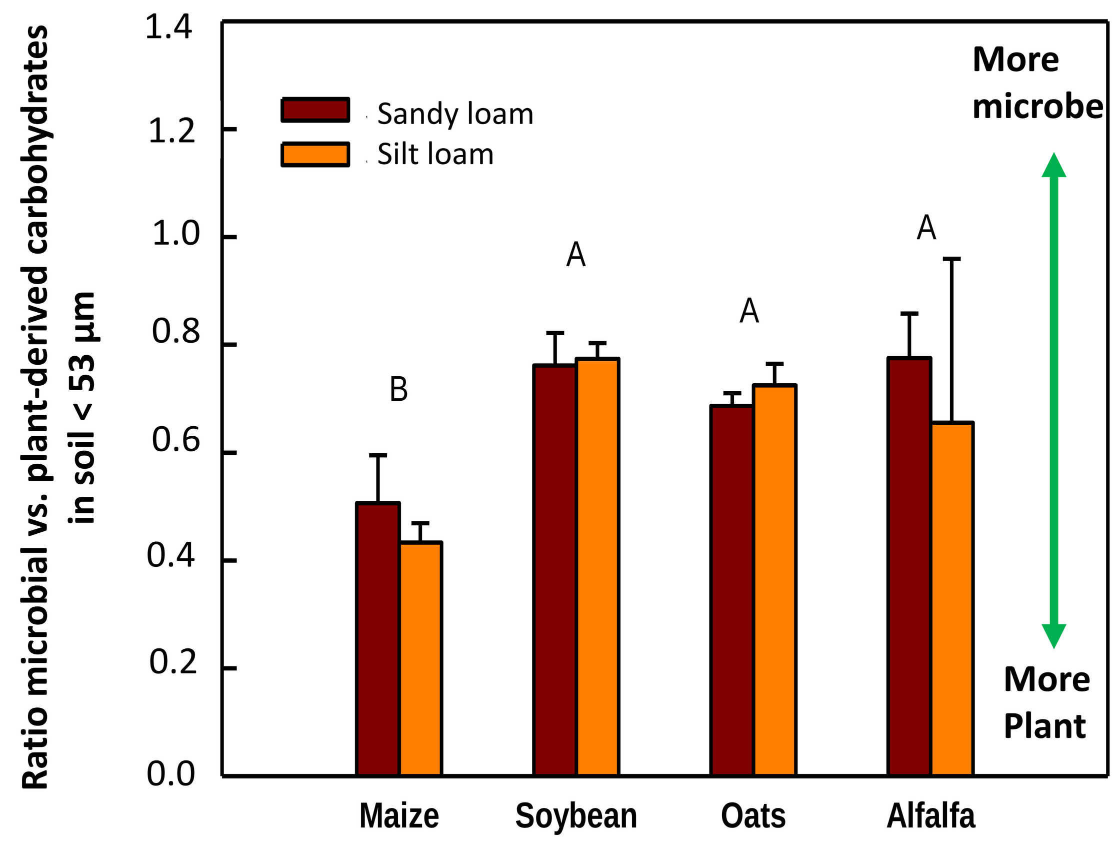


Figure 6. The ratio of microbial versus plant-derived carbohydrates measured in the fine mineral soil fraction (< 53 μm). Values are based on the average of the no-nutrient treatment reported from each plant litter and soil type combination (n=4, ± standard error bar).

(*) Significant differences between plant litter quality marked by different upper case letters (P< 0.05) according to with Tukey’s least significant difference test.

Conclusions

- Soybean and maize litter (i.e., low-quality plant litter) accumulated C more efficiently than oats and alfalfa litter with or without nutrient addition (**Fig. 4**).
- Oats and alfalfa litter (i.e., high-quality plant litter) mineralized **and** stabilized more than soybean and maize litter (**Fig. 1 & 2**).
- The origin of the C accumulated by soybean litter was less plan-derived than that of maize litter (**Fig. 6**). This suggest that soybean N present in the litter favor its decomposition.
- Similar to C mineralization and accumulation in MAOM, the effect of nutrient addition on mineralization of accumulated MAOM-N had an **small effect**, in which no nutrient was 9% greater than nutrient addition (**Fig. 5**).

Acknowledgments

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