Influence of Earthworms on C Stabilization and N Dynamics in Irrigated Corn-Tomato Cropping Systems

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Introduction

- The maintenance of soil organic matter (SOM) in agroecosystems is fundamental to long-term sustainability and has important implications for global C cycling.
- Interactions between management practices, soil biota, and soil structure are important in understanding SOM dynamics.
- Earthworms are important processors of plant residues, can mediate soil aggregate formation and may facilitate the stabilization of organic matter in soil aggregates.
- This study explores the influence of earthworms and cropping systems on soil C and N dynamics in soil, and more specifically in soil aggregates.

Hypothesis:

Earthworm activity increases the incorporation of fresh residue C and N into microaggregates within macroaggregates, thus facilitating the long-term stabilization of C in soils

Design & Methods

Study Site
- Field plots located at the Russell Ranch field site, LTRAS (Fig. 1)
- Soil type: Yolo Silt Loam

Treatments
- 3 irrigated corn/tomato farming systems: conventional (Con), low-input legume (Leg), and organic (Org); 3 replicates of each
- 2 worm treatments: plus (+) worm and minus (-) worm

Installation
- Plots were amended with $^{13}C/^{15}N$ labeled cover crop (Leg & Org) or ^{15}N mineral fertilizer (Con) during Spring 2004
- 4 microcosms (20 cm dia. x 30 cm deep and sealed with fine mesh on both ends) were installed in each microplot (Fig. 2) in June 2004
- Electro-shocking used to eliminate pre-existing worm populations (Fig. 3)
- 5 mature *Aporrectodea rosea* added to create + worm microcosms

Sampling
- 4 soil sampling dates in 2004 (3/13, 6/17, 8/2 & 9/21)

Aggregate separations
- Field moist soils dry-sieved through an 8 mm sieve and air-dried
- Wet sieving used to obtain 3 aggregate size fractions (Fig. 4):
  1. > 250 μm (macroaggregates)
  2. 53-250 μm (microaggregates)
  3. < 53 μm (silt and clay fraction)

Microaggregate Isolation
- Sub-samples from macroaggregate fractions were shaken with small bearings above a 250 μm mesh, while a continuous flow of water removed freed microaggregates to prevent further fragmentation
- Further wet sieving of < 250 μm fraction yielded a total of 3 size fractions from the macroaggregates (Fig. 4)
- All fractions analyzed for total C, total N, ^{13}C and ^{15}N

Figure 1: Russell Ranch site

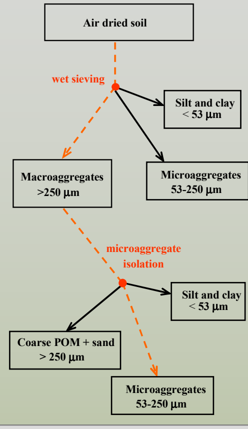
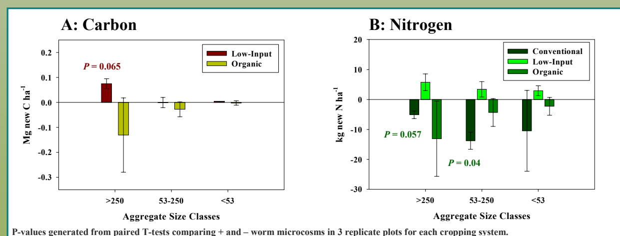


Figure 4: Aggregate fractionation scheme and hypothesized pathway of earthworm mediated organic matter stabilization

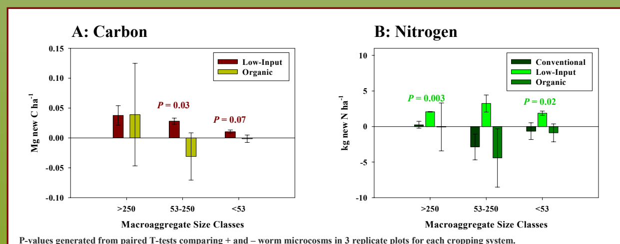
Figure 2: Plot layout & microcosm installation

Figure 3: Electro-shocking microcosms

Key Findings and …



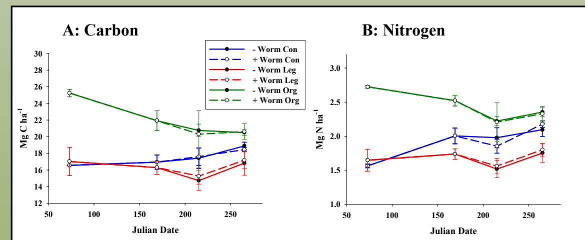
Figures 5A&B: Earthworm influence on C and N incorporation into free soil aggregates. Calculated as the average difference between treatments (plus worm – minus worm).



Figures 6A&B: Earthworm influence on new C and N incorporation into fractions isolated from macroaggregates. Calculated as the average difference between treatments (plus worm – minus worm).

…Discussion

- Earthworms significantly increased new C and N incorporation into the macroaggregate fractions by the final sampling date in the low-input legume system. (Figs. 5 & 6).
- Earthworm activity also resulted in decreased N incorporation into both macroaggregates and free microaggregates in the conventional system (Fig. 5b).
- The contrasting influence of earthworms on N incorporation between the conventional and low-input systems highlights the importance of cropping systems in determining the effect of earthworms and suggests that the form of N applied plays a critical role.
- Increased leaching may account for the decrease in N incorporation observed in the conventional system. Earthworms are known to increase soil porosity and leachate volume, while the relatively mobile nature of the mineral N applied would only facilitate this loss of N.
- Earthworm effects in the organic system may have been masked by high background levels of C and N (Figs. 7A&B) or an increased diversity of organic residues in this system, which could provide earthworms with an alternative and preferential food source



Figures 7A&B: Total C and N in bulk soil

Conclusions

- These results demonstrate that earthworm activity can significantly influence the incorporation of C and N into the soil.
- Cropping systems play a major role in determining the effect that earthworms have on soil C and N dynamics.
- The increased incorporation of new C into microaggregates within macroaggregates indicates the potential for earthworms to play an important role in SOM stabilization.
- Given the relatively low population densities tested and the short duration of this study, the influence of earthworms could be substantial when considered in systems with greater densities or over longer time intervals.

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