Influence of earthworm activity on C stabilization in organic versus conventional irrigated tomato systems

Steven J. Fonte[1], Johan Six[1], Chris van Kessel[1], and Paul F. Hendrix[2]

[1]Department of Agronomy and Range Science, University of California, Davis

[2]Institute of Ecology, University of Georgia, Athens

Introduction

- The maintenance of soil organic matter in agricultural ecosystems is imperative to the long-term sustainability of soils and global C dynamics.
- To further our understanding of soil C dynamics, a number of studies have investigated the role of the soil matrix and the influence of different management practices on soil structure and soil biota.
- Earthworms are important processors of detritus, can incorporate large quantities of organic matter into the soil, and can mediate macroaggregate and microaggregate formation.
- The relevance of this process for long-term C sequestration under field conditions remains unclear.
- Earthworm abundance and diversity are generally greater in reduced-till organic farming systems compared to conventional systems.

Overall hypothesis: Increased earthworm abundance and diversity in organic tomato-based farming systems under conservation tillage management leads to a greater carbon stabilization within microaggregates compared to standard tilled conventional farming systems.

Specific hypotheses:

H1: Organic farming practices in combination with conservation tillage practices further increases earthworm abundance and diversity compared to tilled organic and conventional farming systems.

H2: Increasing earthworm abundance and diversity leads to an increase in the incorporation of fresh residue C into stable microaggregates leading to a long-term stabilization of C in organic farming systems

Experimental Design

Study Site

- Field plots (Figure 1) will be installed in irrigated corn/tomato systems at the LTRAS/SAFS field site

Treatments

- 3 corn/tomato farming systems (conventional, low input-legume, and organic)
- 2 soil tillage regimes (standard and conservation till)
- 2 worm treatments (ambient and zero worm)
- Zero earthworm microplots- vertical plastic walls 25 cm deep, sealed with fine mesh on the bottom (electroshocking to remove the earthworms)
- Treatments amended with $^{13}C/^{15}N$ labeled vetch or ^{15}N labeled fertilizer.

Sampling

- 4 sampling dates
- Microplots extracted at end of the growing season for analysis of earthworm populations.

Figure 1: Treatments and plot layout

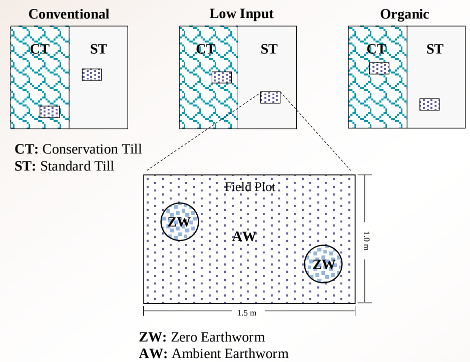
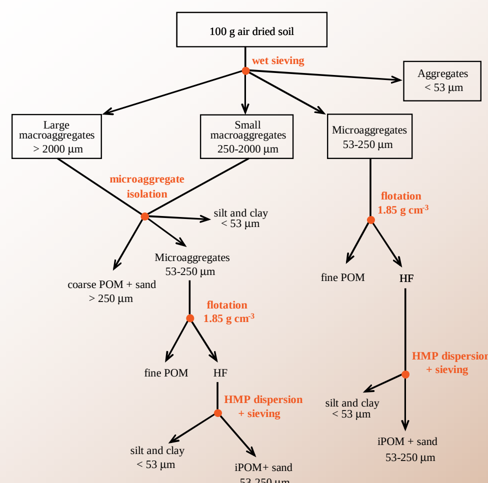


Figure 2: Complete fractionation scheme to isolate the different aggregate size classes and associated particulate organic matter fractions.



Laboratory Methods and Analyses

Aggregate separations

- Field moist soils sieved through an 8 mm sieve and air-dried
- Wet sieving- series of three sieves used to obtain 4 aggregate size fractions:
  1) > 2000 mm (large macroaggregates)
  2) 250-2000 mm (small macroaggregates)
  3) 53-250 mm (microaggregates)
  4) < 53 mm (silt and clay fraction)

Microaggegates within macroaggregates

- Subsamples from macroaggregate fractions will be shaken with glass beads above a 250 µm mesh screen, while a continuous flow of water removes freed microaggregates to prevent further fragmentation

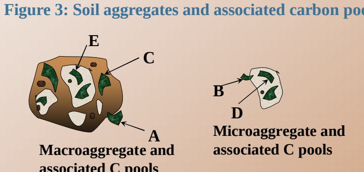
Further separations

- Density flotation to determine free organic fractions of each size class
- Microaggregate dispersion to separate out particulate organic matter from silt and clay fractions and provide a sand free corrections

Carbon protection level by macro- and microaggregates

- Incubations of crushed and intact aggregates to determine biologically labile C (old and newly incorporated ^{13}C from labeled vetch)
- Determination of 5 aggregate-associated carbon pools (Figure 3):
  A. Unprotected macroaggregate C = intact macroaggregate C_{min}
  B. Unprotected microaggregate C = intact microaggregate C_{min}
  C. Macroaggregate-protected C = < 250 mm crushed macroaggregate C_{min} – intact macroaggregate C_{min}
  D. Microaggregate-protected C = < 53 mm crushed microaggregate C_{min} – intact microaggregate C_{min}
  E. Microaggregate within macroaggregate-protected C = < 53 mm crushed macroaggregate C_{min} – < 250 mm crushed macroaggregate C_{min}

Figure 3: Soil aggregates and associated carbon pools



Relevance to Kearney Foundation mission

This research will address the current goals of the Kearney Foundation in several ways:

1) By investigating the role of earthworms in soil aggregate dynamics using isotopes this study will further elucidate mechanisms of soil C storage and better quantify processes that govern soil aggregate formation and C sequestration.
2) Testing multiple management systems and tillage regimes will allow us to better assess anthropogenic influences on C dynamics, while providing information that will help identify appropriate management strategies for the future.