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

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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 ¹³C/¹⁵N labeled vetch or ¹⁵N 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

Conventional
Low Input
Organic

CT: Conservation Till
ST: Standard Till

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) 200-2500 mm (small macroaggregates)
  3) 50-250 mm (microaggregates)
  4) < 50 mm (silt and clay fraction)

Microaggregates 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 ¹³C from labeled vetch)
• Determination of 5 aggregate-associated carbon pools (Figure 3):
  A. Unprotected macroaggregate C = intact macroaggregate C
  B. Unprotected microaggregate C = intact microaggregate C
  C. Macroaggregate-protected C = < 250 mm crushed macroaggregate C
  D. Microaggregate-protected C = < 53 mm crushed microaggregate C
  E. Microaggregate within macroaggregate-protected C = < 53 mm crushed macroaggregate C

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.