Influence of organic, reduced-tillage crop rotations on earthworms and other indicators of soil quality

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Introduction

Organic, reduced-till (ORT), dryland cropping systems have the potential to meet soil erosion prevention needs and improve soil quality in the highly erodible, arable fields of the Palouse region of eastern Washington and northern Idaho. Despite its potential to positively impact biological indicators of soil health, ORT grain production is extremely limited in this area, most likely due to the need for tillage to control weeds. The overall objectives of this study were to 1) compare the impact of one conventional reduced-till and two ORT cropping systems on earthworms and other indicators of soil health, and 2) document yields of each crop phase to assess longer-term sustainability of these systems. Cropping systems were tested in a replicated, randomized complete block study near Pullman, WA. The plots (9.1 x 15.2 m) were established in 2003 and the current crop rotations have been in place since 2008. Rotations included a 5-year organic alfalfa-wheat system (Org-Alf-Syr), a 3-year organic pea-wheat system (Org-PPW) and a 3-year conventional pea-wheat system (Con-PPW). All cropping systems were direct seeded.

Results and Discussion

The dominant species found at the research site is Aporrectodea trapezoides (photo above, left). A. trapezoides has been classified as both polytrophic endogeic (living within the top 15 cm of soil and feeding on soil organic matter), and epi-endogeic (primarily feeding on plant litter and microbial biomass). The ability of A. trapezoides to withstand a wide range of environmental conditions, to thrive through drought periods, and reproduce rapidly likely contribute to its success in the dryland agroecosystems of the Palouse. This species tends to backfill burrows with casts (photo above, right) instead of casting at the surface, which may moderate its impact on soil physical properties.

Earthworm density (a) and biomass (b) were measured in the winter wheat phases of Org-PPW and Con-PPW and annually in Org-Alf-Syr (c and d). Density was greater in Org-PPW (p<0.05) compared to Con-PPW and increased over time in Org-Alf-Syr, despite greater disturbance and correspondingly higher soil tillage intensity rating (STR) values (Con-PPW=25 < Org-Alf-Syr=36 < Org-PPW=44). In Org-Alf-5yr, earthworms may be responding to high manure inputs in 2008-09 (7173 kg ha⁻¹ yr⁻¹), followed by 3 years of no-tillage. In Org-PPW earthworm response may be due to frequent manure inputs (wheat phases), lack of synthetic chemicals, and/or a rise in pH (5.8 in Org-PPW versus 5.5 in Con-PPW within the near surface soil, data not shown).

Significant Spearman rank correlations (P<0.05) for soil properties aggregated across cropping system were found between earthworms and microorganisms and earthworms and chemical properties, suggesting earthworms may have a significant influence on a wide range of soil health indicators.

Summary and Conclusions

• Biological indicators of soil health (including earthworms) were more sensitive to differences in cropping system management than were physical indicators, which did not differ among the cropping systems.
• Lack of change in soil physical properties despite greater earthworms in organic systems may be due to the burrowing habits of A. trapezoides. A longer time period (>10 years) may be required for influence of A. trapezoides on soil physical properties to be realized in Palouse agricultural soils.
• High organic matter inputs from manure, and potentially plant residues, in the organic cropping systems may have offset SOC loss that can result from greater tillage.
• Correlation of earthworms to FEC, FEN, SOC and TN supports other research on the impact of earthworms on the overall health of a soil.
• Similar yields between Org-PPW and Con-PPW were attained. With improvements to soil health and competitive yields, further research of ORT cropping systems at the commercial field scale are merited.

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