Soil arthropods differentially respond to cover crops and are indicators of soil health

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Background

Human health depends on soil health[1]

In the cereal-growing region of the Inland Pacific Northwest (IPNW) (Fig. 1), projected climatic variability and the continued use of conventional agricultural management practices may force producers to expand the use of fallow[2].

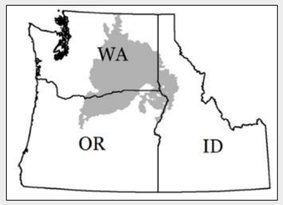


Fig. 1. Cereal growing region of the IPNW

Fallow, the practice of leaving fields unplanted, is not sustainable and reduces soil health. IPNW producers are diversifying agroecosystems with alternatives to fallow[3].

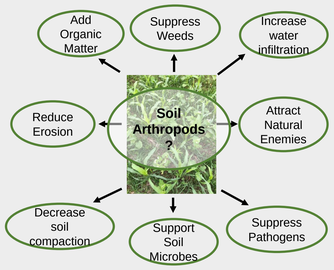


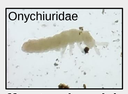
Fig. 2. Cover crop system-wide benefits

Cover cropping is one method of diversification with many benefits for soil health (Fig. 2), but it is unknown how cover cropping affects the biodiversity of soil arthropods.

Arthropods drive ecosystem processes in soils that influence agricultural productivity and soil health, so it is critical to understand their responses to cover cropping.

Predation/ Biocontrol

Decomposition



Affect microbial processes

Herbivory

Soil health is defined as “the ability of a soil to function as a living ecosystem that sustains plants, animals, and humans.” Despite the focus on “life”, typical soil health assessments do not utilize biological indicators[4].

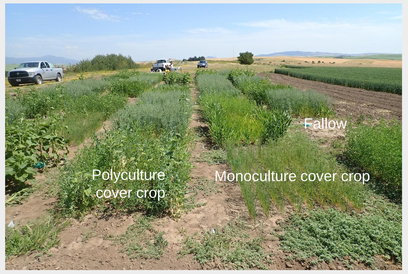
The Soil Biological Quality index (QBS-ar)[5] utilizes soil arthropods as biological indicators to assess soil health (Fig. 3). The QBS-ar is sensitive to short-term land use change, making it an ideal tool to evaluate the impact of different cover cropping practices on soil health.

Objectives

1. Determine if and how soil arthropod communities respond to different cover crop treatments
2. Determine if we can assess soil health/cover crop treatment effects using soil arthropods as biological indicators of soil health

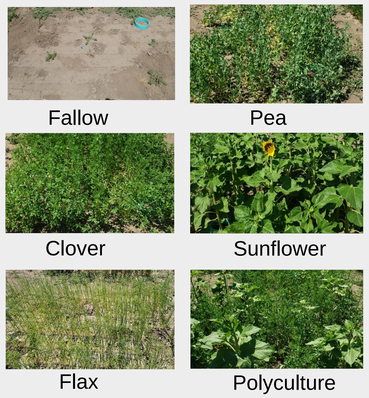
Study design

Small-scale replicated cover crop plots (2x2.5m^2) were established in Pullman, WA in 2019



Soil arthropods were sampled during peak crop growth 2019-2020. 2,000cm^3 soil collected for extraction

Treatments included: each species planted individually, a polyculture of all species, fallow control. 3 reps



Arthropods were extracted from soil samples using Berlese funnels and characterized taxonomically and functionally. QBS-ar was calculated

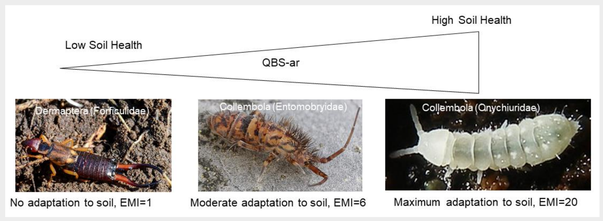


Fig. 3. Determination of QBS-ar score: Soil arthropod taxa are collected from soil samples and assigned an Ecological-Morphological Index (EMI) score based on their adaptation to soil. Soils with high soil health are expected to harbor more soil arthropods that are highly adapted to soil, and vice versa. QBS-ar is the sum of EMI scores for a soil arthropod community.

Results

Polyculture cover crops increase arthropod biodiversity

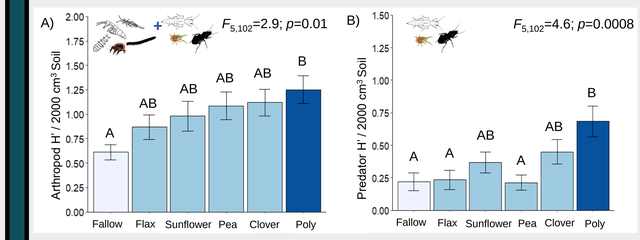


Fig. 4. Effects of cover crop treatment on total soil arthropod diversity (A) and diversity of beneficial natural enemies (B). Mean values of Shannon diversity index (H’). Different letters between treatments indicate significant differences (P<0.05) based on ANOVA. Data pooled across years. Poly=mix of all species

Cover crop richness begets arthropod richness

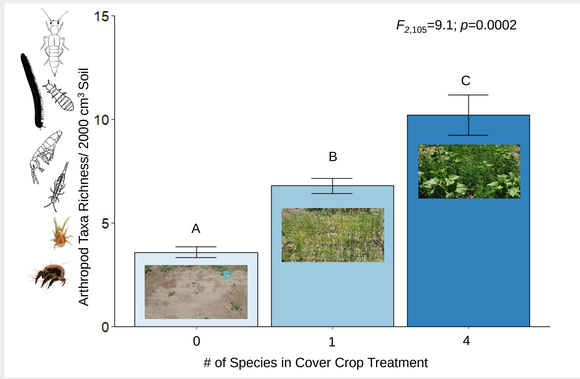


Fig. 5. Effect of # of species in cover crop treatment on soil arthropod taxa richness. Different letters between treatments indicate significant differences (P<0.05) based on ANOVA. Data pooled across years

Cover crops improve soil health

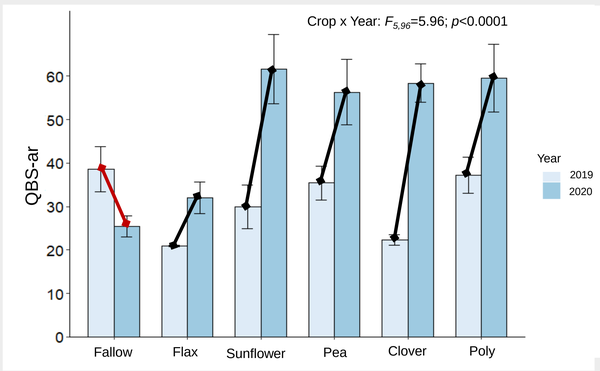


Fig. 6. Effect of cover crop species on soil health (QBS-ar) in year 1 and year 2. Significant differences (P<0.05) based on ANOVA

Discussion

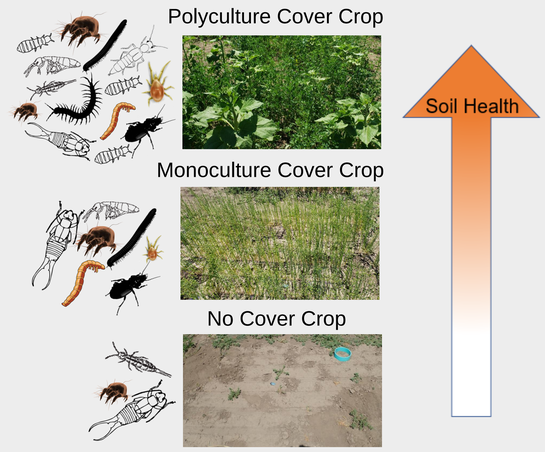
Soil biodiversity is increasingly recognized as providing benefits to human health[1] by improving soil health

Patterns

- A polyculture mix of cover crops significantly increased soil arthropod biodiversity relative to fallow (Fig. 4a).
- Polycultures promoted the diversity of beneficial predatory soil arthropods relative to fallow and two monoculture treatments (Fig. 4b).
- Cover crop richness aboveground begets arthropod taxa richness belowground (Fig. 5). Using any cover crop promotes taxa richness relative to fallow, but polycultures promote soil arthropod richness more than monocultures.
- All cover crops significantly improved soil health relative to fallow from year 1 to year 2. Consecutive fallow significantly decreased soil health (Fig. 6).

Synthesis and applications:

- Fallow is projected to increase with continued use of conventional agricultural practices. Consistent use of fallow decreases soil health, as measured using arthropods as biological indicators. Replacing fallow with any cover crops improves soil health and promotes belowground biodiversity. Biodiversity imparts resilience to soil ecosystems.
- Not all cover crops are “created equal” and functional groups respond differently to different cover crop treatments.
- Ongoing work in our lab is revealing that these organisms are important mediators of crop performance, linking soil ecology to human health.
- ***Understanding how soil biodiversity in agroecosystems can be promoted through improved management practices represents an underutilized resource with the ability to improve sustainable agriculture and human health across the globe.***



Acknowledgements & References

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