Using soil nematode community structure to make soil health associations in semi-arid dryland barley systems

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Introduction

Changes in soil nematode community structure and composition can inform crop managers about soil quality and function (Bongers, 1990; Ferris et al., 2001; Ferris, 2010; Freckman and Ettema, 1993). Nematodes are directly observable and quantifiable using simple laboratory techniques and useful generalizations can be made based on their community composition. These changes in the nematode community provide vital insight into short- and long-term fluxes in the soil ecosystem. However, few studies have assessed soil nematode community structure under agricultural systems in semi-arid regions such as the Northern Great Plains. Results from this study will provide new information on nematode community structure for Montana dryland cereal systems and how they are interrelated with crop management and soil nutrients.

Objective

- Determine if barley-pea cropping sequences have any benefit to soil biology by using nematodes as bioindicators.

Methods

- Three year randomized complete block design with 4 replicates of 7 crop sequences: barley following fallow, continuous barley, barley following dry pea (for grain), barley following dry pea (brown manure), fallow following barley, dry pea (for grain) following barley, and dry pea (brown manure) following barley.
- Trial was located at the Arthur H. Post Farm, Bozeman, MT, conventionally tilled, and planted with a double disc drill.
- Soils were sampled prior to planting and post-harvest for soil nutrients, nematodes, and soil moisture.
- Nematodes were identified and counted by microscopy and ecological measures, Enrichment Index (EI, abundance of early colonizer, nutrient enrichment indicating fungivorous and microbivorous nematodes), and Structure Index (SI, abundance of persisting, structure indicating nematodes of all feeding habits) calculated.
- ANOVA for RCBD was performed using lme4 at $\alpha<0.05$ and post hoc tests performed using emmeans and predictmeans packages in R.

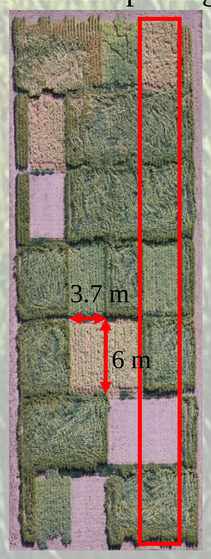

Figure 1: Plot map for 2016. In 2017, reciprocal crop phases were present, and again in 2018.

Results

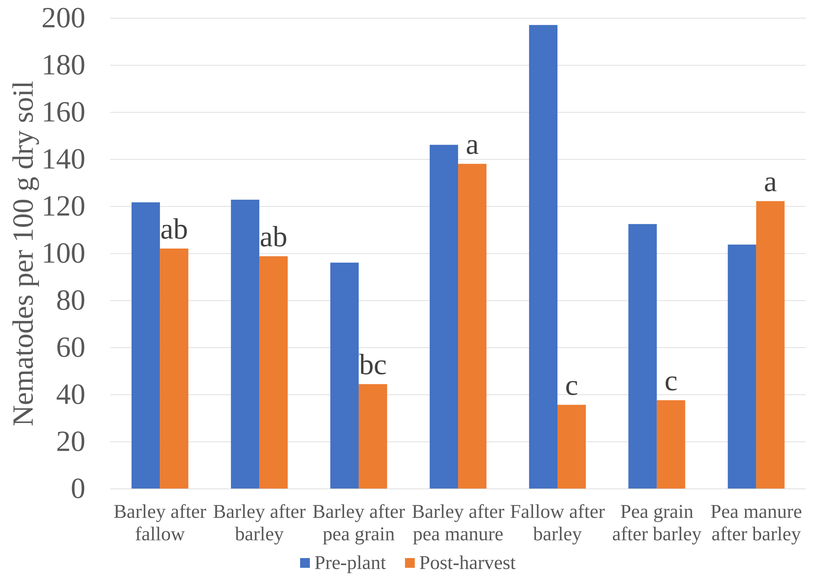

Figure 2: Total herbivores by phase and sample timing averaged over all 3 years. Within the same sample timing, different letters indicate significant differences among crop phases. No differences were observed prior to planting.

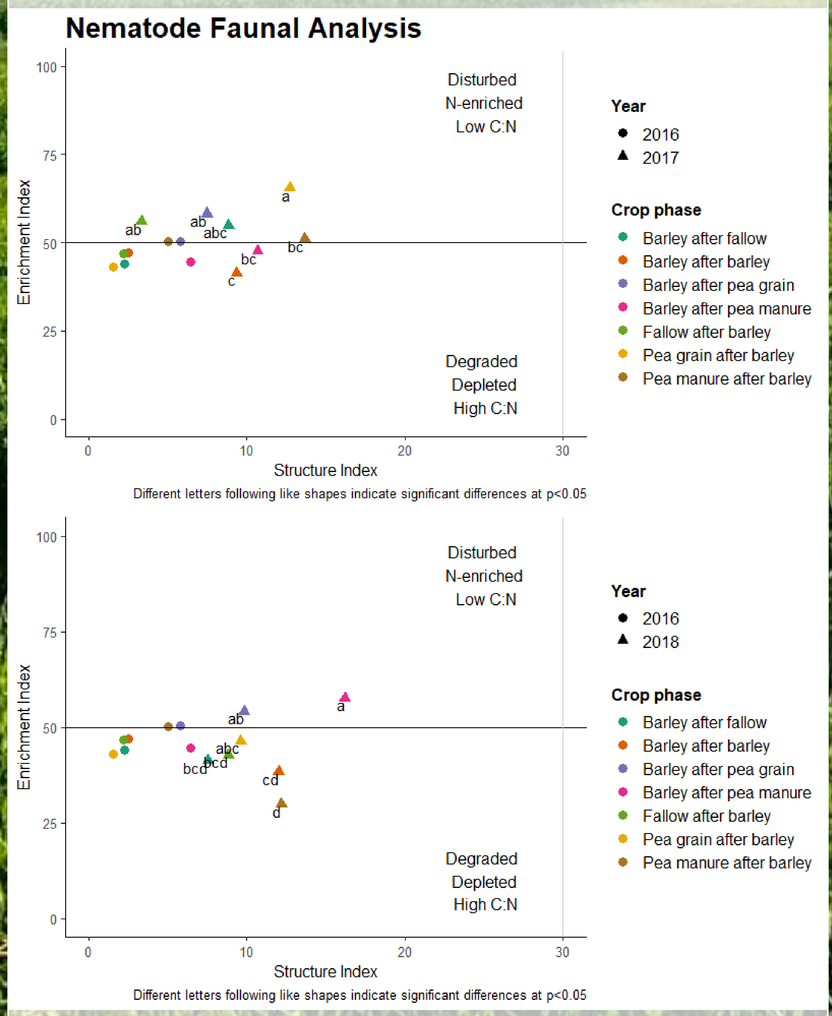

Figure 3: Structure and Enrichment Index nematode faunal analysis. No differences were observed in 2016, which is included in both panels to provide reference. Within the same year, different letters indicate significant differences for the EI among crop phases.

Discussion

- Herbivores were significantly higher post-harvest under the barley-pea manure system than the barley-pea grain system and fallow after barley sequence.

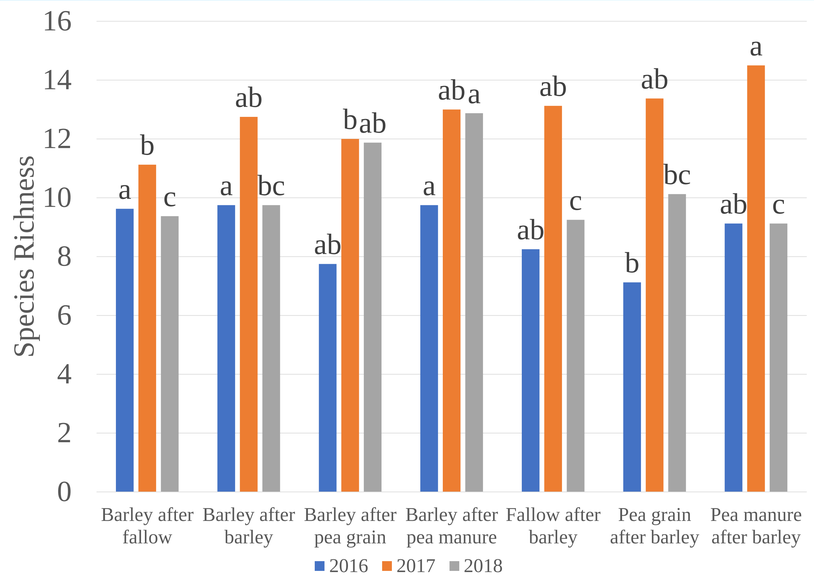

Figure 4: Species richness among crop phases for each year of the study. Within the same year, different letters indicate significant differences among crop phases.

Discussion

- EI was higher in 2017 under the barley-pea grain system compared to the barley-pea manure and continuous barley systems. In 2018, barley following a pea manure had a higher EI than pea manure following barley and the barley-fallow and continuous barley systems.
- Species richness in 2017 was highest under pea manure following barley and lowest under barley after fallow and barley after a pea grain. In 2018, species richness was highest under barley following pea manure compared to either pea crop following barley or the barley-fallow system.
- Year to year differences were heavily influenced by weather.

Conclusions

Barley systems incorporating peas have, on average, higher capacity within the soil to sustain more enrichment indicating nematodes. However, when peas are grown as a brown manure, this comes at the cost of higher herbivore pressure later in the season. This calls into question the potential use of peas as a cover crop following barley due to higher than average pressure from nematode herbivory.

Literature Cited

- Bongers, T. 1990. The maturity index: an ecological measure of environmental disturbance based on nematode species composition. Oecologia, 83:14-19.
- Ferris, H., Bongers, T., and de Goede, R.G.M. 2001. A framework for soil food web diagnostics: extension of the nematode faunal analysis concept. Appl. Soil Ecol., 18:13-29.
- Ferris, H. 2010. Contribution of nematodes to the structure and function of the soil food web. J. Nematol. 42(1):63-67.
- Freckman, D., and Ettema, C.H. 1993. Assessing nematode communities in agroecosystems of varying human intervention. Agric., Ecosystems, and Environ., 45(3):239-261.

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