Effects of Soil Functional Zonal Management and Cover Crops on Soil Faunal Communities in Annual Row-Cropping Systems

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Background

Soil biodiversity can be negatively impacted by the intense disturbances (e.g., tillage and agrochemicals) and low crop plant resource diversity (e.g. monocultures and minimal crop residues) that are characteristic of conventional annual row crop systems. Losses in functional biodiversity in the soil can reduce provisioning services, while also impacting a range of other soil services, including nutrient turnover, soil carbon storage, and pathogen suppression. Management strategies that expand resource diversity in space and time (e.g. increased heterogeneity of microhabitats and diversified plant inputs) can support the coexistence of a more diverse soil community with increased functional biodiversity[1,2].

Soil functional zonal management (SFZM) is a field crop agroecosystem management strategy that aims to create distinct, yet functionally complementary zones through non-uniform management of tillage and crop residues[3]. The limited and targeted disturbances in both space and time under SFZM, coupled with strategic management of cover crop residues, is a potential strategy for creating in-field refugia for soil organisms.

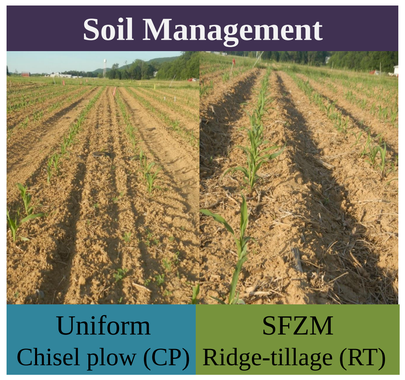
Our research examined if SFZM with cover crops, by minimizing soil disturbance and concentrating plant resources, can enhance soil mesofaunal biodiversity relative to uniformly managed soils without strategic management of disturbance and crop residues.

Hypotheses

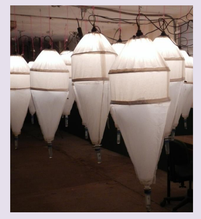
1. **Row and inter-row soil mesofaunal community composition will be more dissimilar under SFZM with cover crops compared to uniformly tilled systems because SFZM creates spatial heterogeneity in disturbance and plant-based resource inputs to the soil.**

2. **Crop rows in SFZM with winter cover crops will have higher soil mesofaunal abundance, richness, and diversity compared to crop rows in uniform tillage without cover crops, because SFZM reduces soil disturbance and concentrates plant residues in the crop row.**

Methods



- Experiment established as a corn-soybean rotation in 2011 at Penn State's Russell E. Larson Agricultural Center near Rock Springs, PA, USA
- Experimental Design was a randomized complete block (n = 4) with two treatments:
  Tillage – Uniform: Chisel-plow, SFZM: Ridge-tillage
  Cover Crop – Winter Fallow, Winter Rye
- Soil mesofaunal sampling & extraction
  - Sampled soil mesofaunal community in rows and inter-rows in each CP and RT plot
  - Samples were collected during corn phase of rotation in 2013 and 2014
  - Soil cores: 5 cm diameter x 17 cm depth
  - Soil mesofauna were extracted from soil cores with Berlese funnels
- Data were analyzed with perMANOVA, NMDS ordination, indicator species analysis, and linear mixed effects models



Diplura Campodeidae

(top) Ridging in RT system - row positions are maintained each year; (right) Berlese funnels and soil mesofauna

Collembola
Hypogastruridae

Enchytraeidae

Results

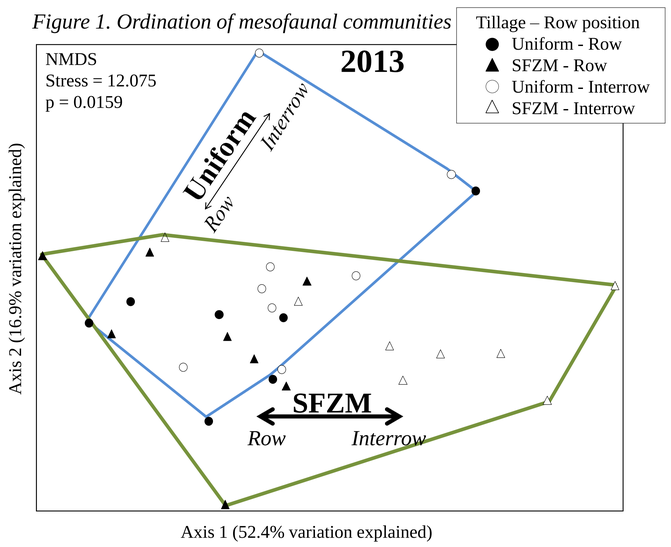
1. Soil mesofaunal community composition was more dissimilar between row and inter-row locations in SFZM compared to uniform tillage (Figure 1).

Multivariate group comparisons with perMANOVA

2013
Cover Crops $F_{1, 20} = 1.9679$, p = 0.050 *
Tillage*Row Position $F_{1, 20} = 2.3055$, p = 0.020 *

2014*
Tillage*Row Position $F_{1, 19} = 2.3066$, p = 0.081·
*Data not shown

Figure 1. Ordination of mesofaunal communities



2. Specific mesofauna taxa were associated with each soil management treatment in 2013 and 2014 (Table 1).

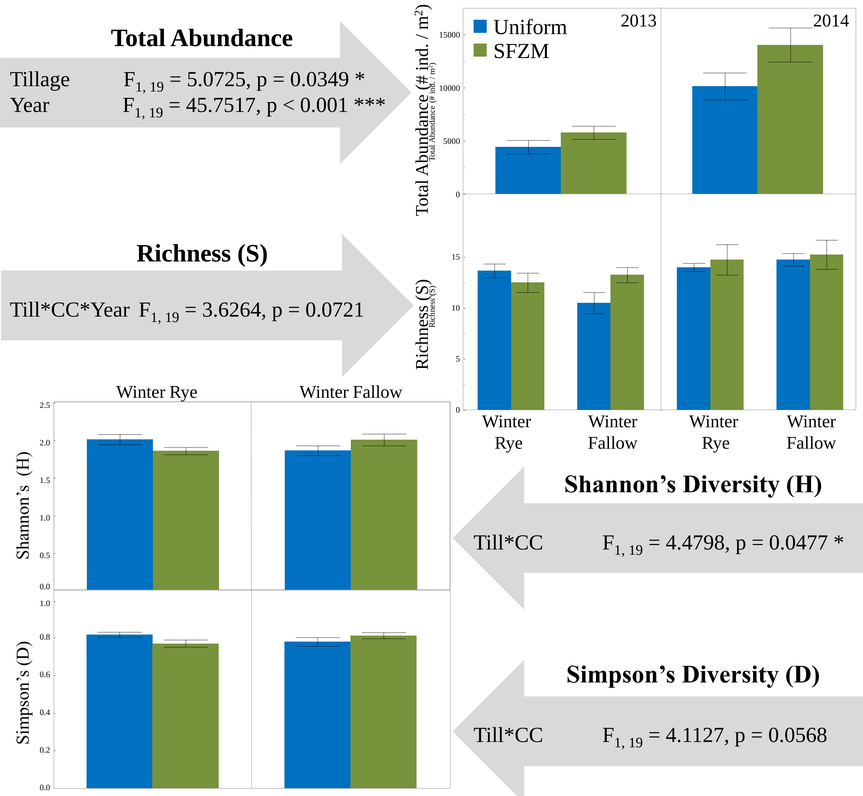
Table 1. Results from indicator species analysis

Year	Treatment	Taxa	Trophic Level	Body Size (mm)	Cuticle	Indicator Value	p
2013	**SFZM**	Diplura Campodeidae	Omnivore	3-5	Soft-membrane	38.7	0.1096
		Diplopoda	Detritivore	5-6	Sclerotized/Calcareous	67.9	0.0438
	Uniform	Diptera larvae.		1-2	Soft-membrane	25.8	0.0864
2014	**SFZM**	Diplura Campodeidae	Omnivore	3-5	Soft-membrane	68.1	0.0006
		Collembola Hypogastruridae	Fungivore	1-2	Soft-membrane	48.6	0.0022
		Acari Oribatida	Detritivore	<1	Highly sclerotized	63.1	0.0698
		Diplopoda	Detritivore	5-6	Sclerotized/Calcareous	53.5	0.0292
	Uniform	Coleoptera larvae		2-5	Sclerotized head Soft posterior	44.5	0.1034
		Enchytraeidae	Detritivore	10-20	Soft-membrane	42.5	0.0150
		Delia platura (Meigen) (Seed corn maggot)	Herbivore	5-6	Soft-membrane	51.7	0.0758

3. Total mesofaunal abundance was higher in SFZM compared to uniform soil management; however, the effect of soil management on species richness and diversity was dependent on cover crops.

Total Abundance
Tillage $F_{1, 19} = 5.0725$, p = 0.0349 *
Year $F_{1, 19} = 45.7517$, p < 0.001 ***

Richness (S)
Till*CC*Year $F_{1, 19} = 3.6264$, p = 0.0721



Shannon's Diversity (H)
Till*CC $F_{1, 19} = 4.4798$, p = 0.0477 *

Simpson's Diversity (D)
Till*CC $F_{1, 19} = 4.1127$, p = 0.0568

Conclusions

Our hypothesis that SFZM results in greater differentiation of soil mesofaunal communities between crop rows and inter-rows was supported by the data. These results may have important implications for soil functions in these zones.

SFZM appears to foster populations of a range of omnivore, detritivore, and fungivore species; while, uniform tillage was associated with fewer potentially beneficial species and an important agronomic pest (seed corn maggot).

Our hypothesis that SFZM results in higher mesofaunal abundance and diversity in the crop row was partially supported by our data. Total mesofaunal abundance was higher in SFZM; however, cover crops appeared to suppress diversity in SFZM relative to when no winter cover crop was grown.

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