Pesticide seed treatments containing neonicotinoids have limited effect on soil microbial community structure under different tillage regimes.

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Abstract

Pesticide seed treatments (PST) which contain fungicides and insecticides are commonly used in agriculture; however, little is known about their effect on soil microbial communities and soil health. Neonicotinoids – controversial insecticides which are common in PST – have received criticism due to potential non-target effects. While fungal pathogens need to be moderated, PST have the potential to disturb broader fungal communities which could lead to reduced nutrient cycling and poor soil health. Given the broad use of PST, their effect on soil fungi needs to be studied within the context of other agricultural management practices. For example, tillage regimes can result in distinct fungal communities which may respond differently to PST. An experimental site was established in 2013 with a corn-soy rotation under three tillage treatments: Full-till, Strip-till, and No-till. Since 2016, seeds with or without PST (fungicides and insecticides) were planted under each tillage regime in a fully factorial design. In 2018, bulk soil was collected from within rows while soy was growing. A range of soil physicochemical variables were measured, and soil function was determined with substrate-induced respiration and enzyme assays. DNA was extracted from soil and the ITS region was sequenced to determine fungal community structure and diversity. While tillage significantly affected fungal community structure ($p < 0.01$), there was no effect of PST on either community structure ($p = 0.59$) or diversity ($p = 0.52$). This indicates that PST does not affect bulk soil fungal communities; however, they may have an impact at different temporal or spatial scales than those studied here. Across all treatments, fungal community structure correlated with soil water holding capacity ($rs = 0.23$, $p = 0.04$) and electrical conductivity ($rs = 0.26$, $p = 0.01$). Despite not finding an effect of PST on fungal communities, we did find that PST increased potentially mineralizable nitrogen under no-till and shifted community level physiological profiles determined by substrate-induced respiration. These results suggest that while PST can affect certain aspects of soil health, there are no clear effects on the soil fungal community.

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Objectives

Investigate how pesticide seed treatment (PST) affects soil microbial communities and soil health under different tillage treatments.

Figure 1. Corn seeds with and without PST.

Figure 2. One plot from each tillage treatment. Photo taken after tilling was conducted in 2018.

Methodology

- Field trial with corn-soy rotation.
- Fully factorial design with 4 replicates of each treatment.
- Tillage treatments since 2013:
  - 1. No Till 2. Strip Till 3. Full Till.
- Pesticide seed treatments since 2016:
  - 1. No PST 2. PST.
- PST is combination of fungicides and insecticides (including neonicotinoid).
- Soil collected from top 5 cm, within rows, 26 days after soy was sown in 2018.

perMANOVAs

	Till	PST	Till x PST
Physico-chemical qualities	**0.001**	0.824	0.263
Substrate-induced respiration	0.081	**0.030**	0.708
Enzyme activity	0.442	0.913	0.704
Fungal community	**0.001**	0.497	0.464
Prokaryotic community	**0.001**	0.645	0.278

Table 1. p-values from perMANOVAs with a) 13 soil physical and chemical properties b) substrate induced respiration from 15 substrates c) enzyme activities for 5 enzymes d) fungal community (ITS SVs) and c) prokaryotic community (16S SVs).

Microbial diversity

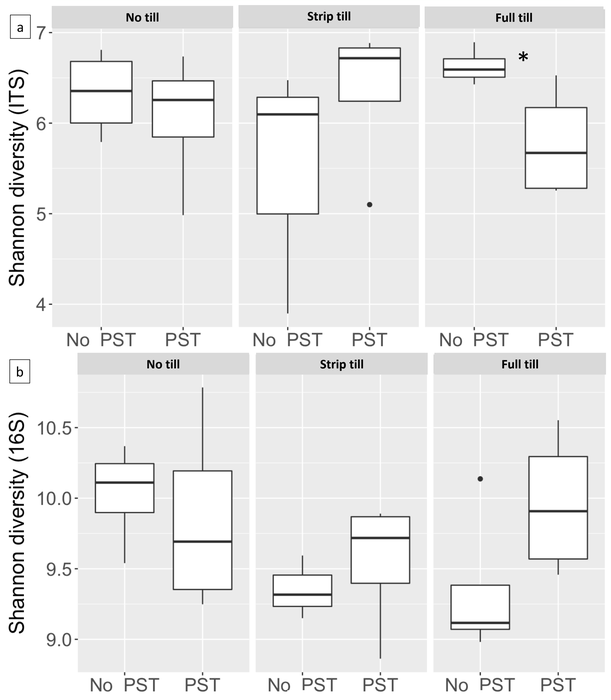

Figure 3. Tillage and PST did not affect diversity (ANOVAs; all p values > 0.05). However, under full till PST reduced fungal diversity (T-test, p=0.04).

Active microbial biomass

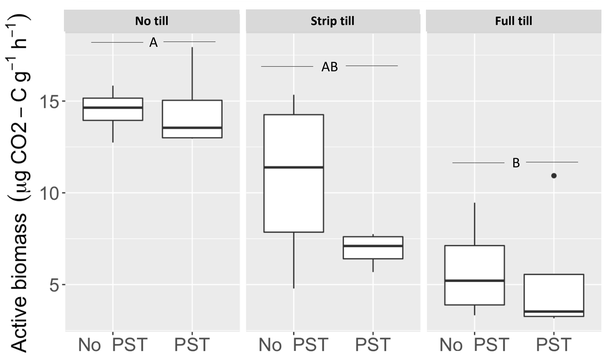

Figure 4. Tillage reduced microbial biomass. PST had no effect on microbial biomass.

Unique/shared taxa

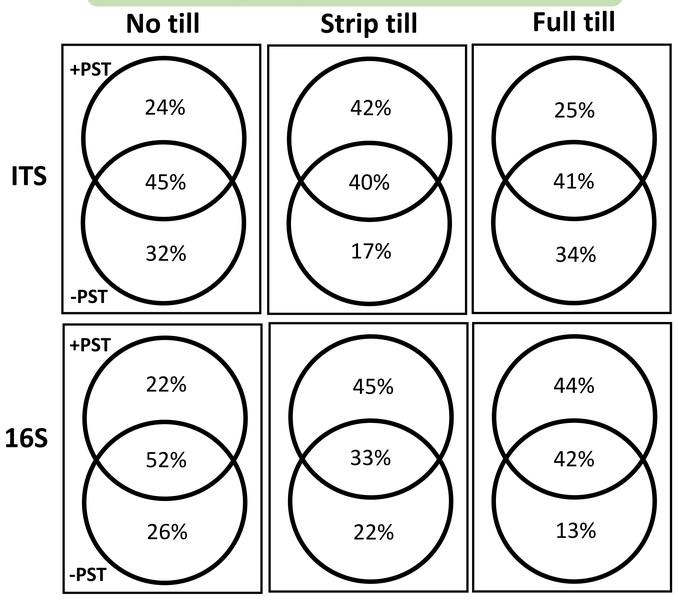

Figure 5. Plots with PST shared 33-52% of their sequence variants (SVs) with plots without PST. The greatest effect of PST on taxa composition was under strip till.

Substrate-induced respiration

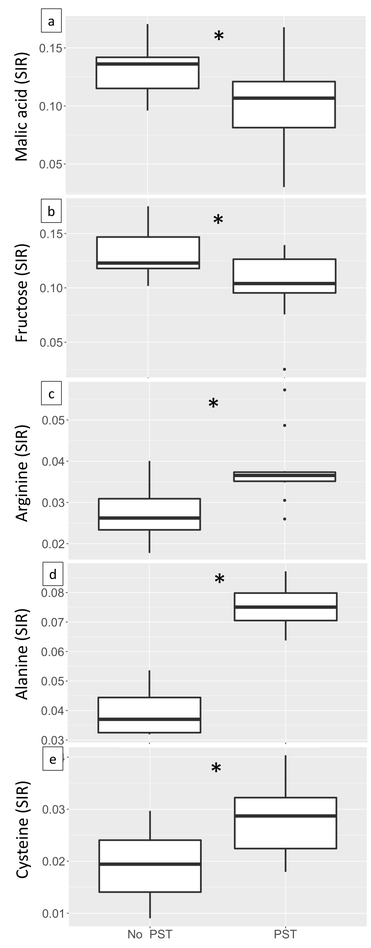

Figure 6. In a MicroResp assay, induced respiration for 5 of the 15 substrates was significantly affected by PST. Graphs show main effect of PST, except for c) which shows the effect of PST under full till. SIR for each substrate is standardized to total SIR.

Potentially mineralizable nitrogen (PMN)

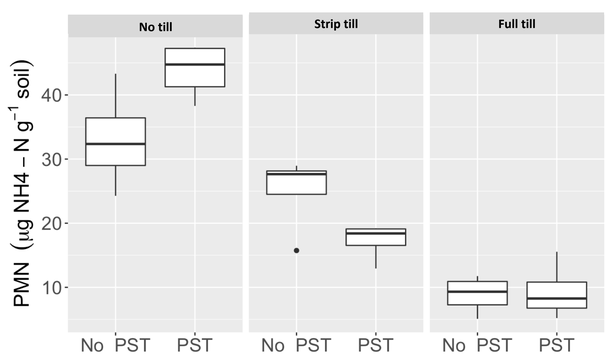

Figure 7. There was a significant interaction between the effect of tillage and PST on potentially mineralizable nitrogen (p-values: Till < 0.05; PST = 0.20; Till x PST = 0.007).

Summary

- Tillage altered soil physico-chemical properties and microbial community structure but had no effect on microbial diversity.
- Under full till, PST reduced fungal diversity.
- Tillage reduced microbial biomass.
- PST altered microbial community structure most under strip till.
- PST altered microbial function, either increasing or decreasing SIR depending on substrate.
- PST increased PMN under no till, but decreased PMN under strip till.

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