Earthworm Assemblages and Soil Nematode Community Structure in Response to Long-term Tillage Systems in Southern Illinois

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Introduction

- Shifting from conventional tillage to no-till system often improves soil properties over time, including the soil food web. Earthworms and free-living nematodes are two major components of the soil food web.
- Earthworms decompose organic matter and contribute to recycling nutrients and improving soil structure through their casts.
- Free-living nematodes (non-segmented worms) occupy a central position in the soil food web, occur in a high density and diversity across every soil type, react readily to disturbances, and move little in space and time.
- Analysis of nematode and earthworm communities as bioindicators of soil health offers a holistic approach to assess the condition of soils through changes in function and structure of the soil food-web.

Objectives

Our objectives were to (i) evaluate the effect of long-term contrasting tillage systems on earthworm and nematode communities and (ii) assess the relation among soil health indicators including earthworms and nematodes.

Materials & Methods

Field Trial:

- An ongoing field experiment was initiated in 1970 at Belleville Research Center in Belleville, IL.
- The experimental design is a randomized complete block design with four replications.
- Tillage treatments are moldboard plow (CT), alternative tillage of 2-yr no-till followed by 1-yr moldboard plow (AT), chisel plow (RT), and no-till (NT). Figure 1 shows soybean in conventional (RT) vs. no-till (NT) system.

a) b)

Fig. 1: Conventional (a) vs. no-till (b) planted soybean in Belleville, IL in 2019. Soil type is poorly drained Bethalto silt loam.

Sampling for Phospholipid Fatty Acids:

- In spring 2019, phospholipid fatty acids (PLFA) data were sampled (0-15cm) using a sterile knife and immediately packaged and sent to Ward Laboratories (Kearney, Nebraska) for analysis.

Earthworm Sampling:

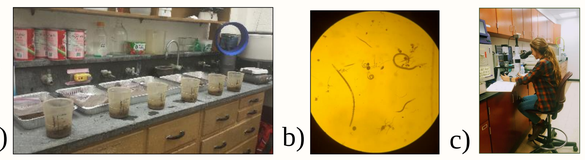
Digging (30×30×5 cm) → Hand sorting → Adding Formalin Capturing earthworms → Identification (Wetzel & Reynolds 2019)

Haney Soil Health Test Sampling:

- Soil samples for Haney soil health test were collected by a soil probe (n=10) at 0-15 cm depth.

Nematode Sampling:

- In fall 2018, eight subsamples were collected from each plot (0-15 cm depth) and nematodes were extracted from a 100-cc subsample (Fig. 2a) using triple elutriation and wet sieving and floated using sucrose and centrifugation (Jenkins 1964).
- Nematodes were identified using Bongers (1987) as a taxonomic key (Fig. b-c).



a) b) c)

Fig. 2: Nematode extraction (a) and identification (b-c).

Statistics:

- Single-variate data were run using the MIXED procedure in SAS 9.4 using Kenward-Rodger's degree of freedom.
- Multivariate data were run using PRIMER-e 7 PERMANOVA option using Bray-Curtis similarity resemblance matrix.
- Canonical Analysis of Principal Coordinates (CAP) in PRIMER-e 7 was used to graph nematode communities using Bray-Curtis similarity resemblance matrix.

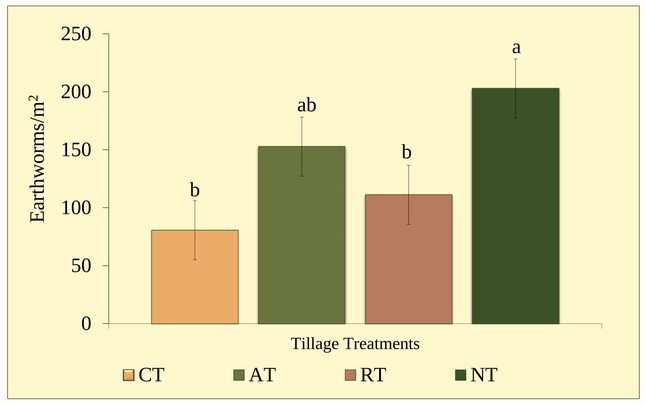
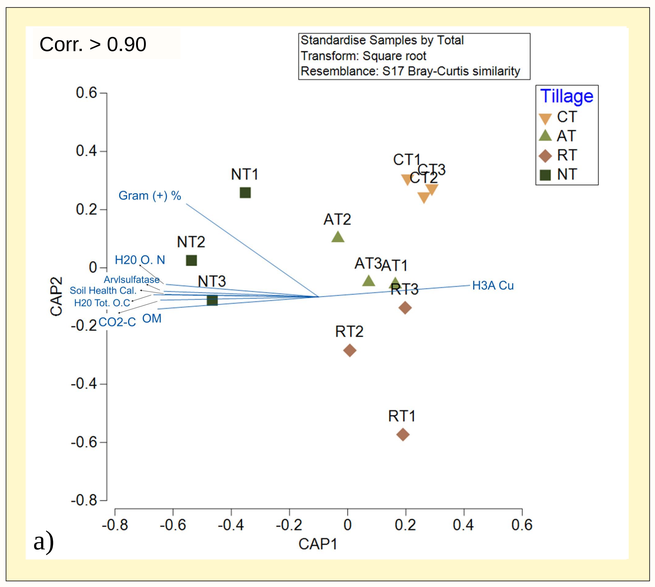


Fig. 3: Earthworm populations/m² affected by tillage.

Table 1: PERMANOVA results for tillage effect on nematode communities.

Source	df	SS	MS	Pseudo-F	P (perm)	Unique perms
Tillage	3	3790.0	1263.3	1.2330	0.232	999
Block	2	2471.6	1235.8	1.2061	0.310	999
Residual	6	6147.6	1024.6			
Total	11	12409.0				



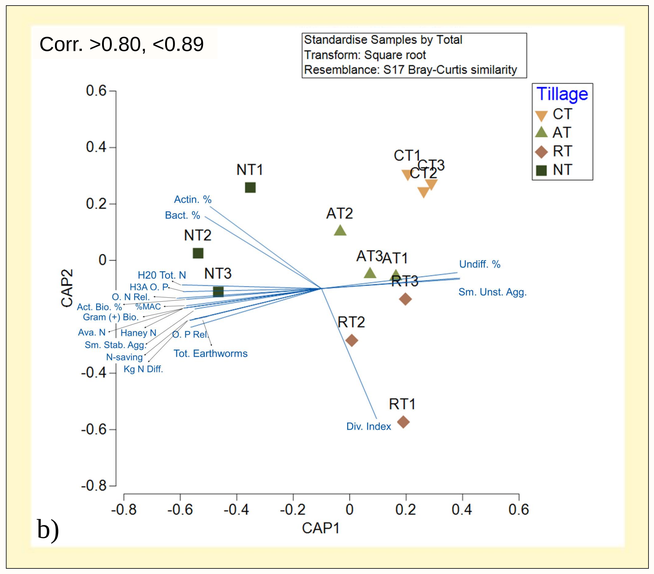


Fig. 4: CAP analysis on nematode communities as influenced by long-term tillage practices.

Environmental factors as vectors were imposed at (a) >0.90 and (b) >0.80, <0.89 correlations.

Vectors include:

(a) Gram (+) %, H_2O Organic N, Arylsulfatase (ppm), Soil Health Calculation (Haney), H_2O Total Organic C, CO_2-C (respiration), and Soil OM.

(b) Actinomycetes %, Bacteria %, H_2O Total N, H_3A Organic P, Organic N Release, Actinomycetes Biomass %, MAC %, Gram (+) Biomass, Available N, Haney N, Small Stable Aggregates %, N-saving, kg N difference, Organic P Release, and Total Earthworms.

Results & Discussion

Earthworms:

- Results showed a significantly higher number of earthworms/m² in NT (203/m²) and AT (153 /m²) treatments compared to RT and CT. This indicates a short-term response of earthworm population to no-till (Fig. 3).

Nematodes:

- PERMANOVA resulted in no significant differences among tillage treatments (Table 1) on nematode communities, but visual grouping in CAP.
- In Fig. 4a, NT supported an increase in soil OM which lead to an increase in soil water extractable C and N, acting as food for soil microbes, resulting in higher respiration, reflected in the Soil Health Calculation (Haney test). Additionally, an increase in complex soil C has been shown to promote gram (+) bacteria which was also highest in the NT treatment.
- Arylsulfatase increases with consistent soil moisture, a common known attribute of NT, accounting for more than 50% of the total activity of soil microbial biomass (Fig 4a), highlighting the importance of soil microflora as an enzyme source (Li & Pariente 2003).
- In Fig. 4b, NT trended towards an increase in bacteria [bacterial (%)] and gram (+) bacteria [Actinomycetes %, Actinomycetes biomass, gram (+) biomass] indicating that although fungus is more desirable than bacteria, the bacterial biomass is driven by gram (+) bacteria, promoted by complex soil C. This is supported by an increase in Microbially Active Carbon (MAC%) which measures how much of the water extractable organic C pool was acted upon by soil microbes, and supports a healthy microbial biomass.
- No-till also trended towards an increase in nutrient cycling and release [H_3A Organic P, Organic P release, H_2O total N, available N, Haney N, N-saving, kg N difference]. There was more available N early in the season in the NT system, despite identical fertility (Fig. 4b).
- There was also a positive trend of earthworm populations with small, stable aggregates and was inversely related to small, unstable aggregates (Fig. 4b).

Conclusions & Future Research

- No-till improves earthworm populations, even in the short-term.
- There is increased soil biologically activity from increased diversity in the NT treatment.
- No-till increases soil enzymatic activity perpetuating soil microbiome diversity and biological activities.
- There were no differences in nematode communities among tillage systems in this sampling, additional samplings will be completed.
- There was more available N early in the season in the NT system, despite identical fertility. Therefore, future studies should focus on time and rate of N fertilization in no-till systems vs. conventional chisel-disk operations.
- Future research should focus on the effectiveness of no-till system in reducing greenhouse gas emissions, and the relation among soil health indicators with crop yield.

Sources

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Acknowledgements & Contact Information

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