

Supplementary Data

The Soil Food Web Model as a Diagnostic Tool for Making Sense Out of Messy Data: A Case of Effects of Tillage, Cover Crop and Nitrogen Amendment on Nematodes and Soil Health

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Abstract: Tillage, cover crops (CC) and nutrient amendments are regenerative agricultural practices (RAPs) that enhance desirable ecosystem services (DEs), including beneficial nematode community structure (BNCS), soil organic matter (SOM), pH and available nitrogen, and the Ferris et al. soil food web (SFW) model relates changes in BNCS to biophysicochemical conditions generating DEs. However, the SFW model's power to identify soil health conditions influencing DEs outcomes has been limited. We tested how tillage, winter rye CC, and 0, 112 or 224 kg N/ha from inorganic- and compost-sources affected the DEs after four years of corn production. SOM and NO₃ in no-till than in tilled, and SOM in the 224 kg-organic-source than in the rest of the N rates were significantly increased. N recovery was not proportional to what was applied. **the variable** effects of the RAPs on the DEs suggest either changing and/or continuing treatments until suitable outcomes are achieved, **all** without knowing source(s) of variability. The SFW model revealed primarily resource-limited and structured (Quadrant C) conditions, suggesting the: a) nutrient-cycling needs biological activities and b) presence of a process-limiting factor may have contributed to the variable results. Impacts of the SFW model as a diagnostic tool are outlined.

Figure S1. Effects of tillage, cover crop and soil amendments on beneficial nematodes

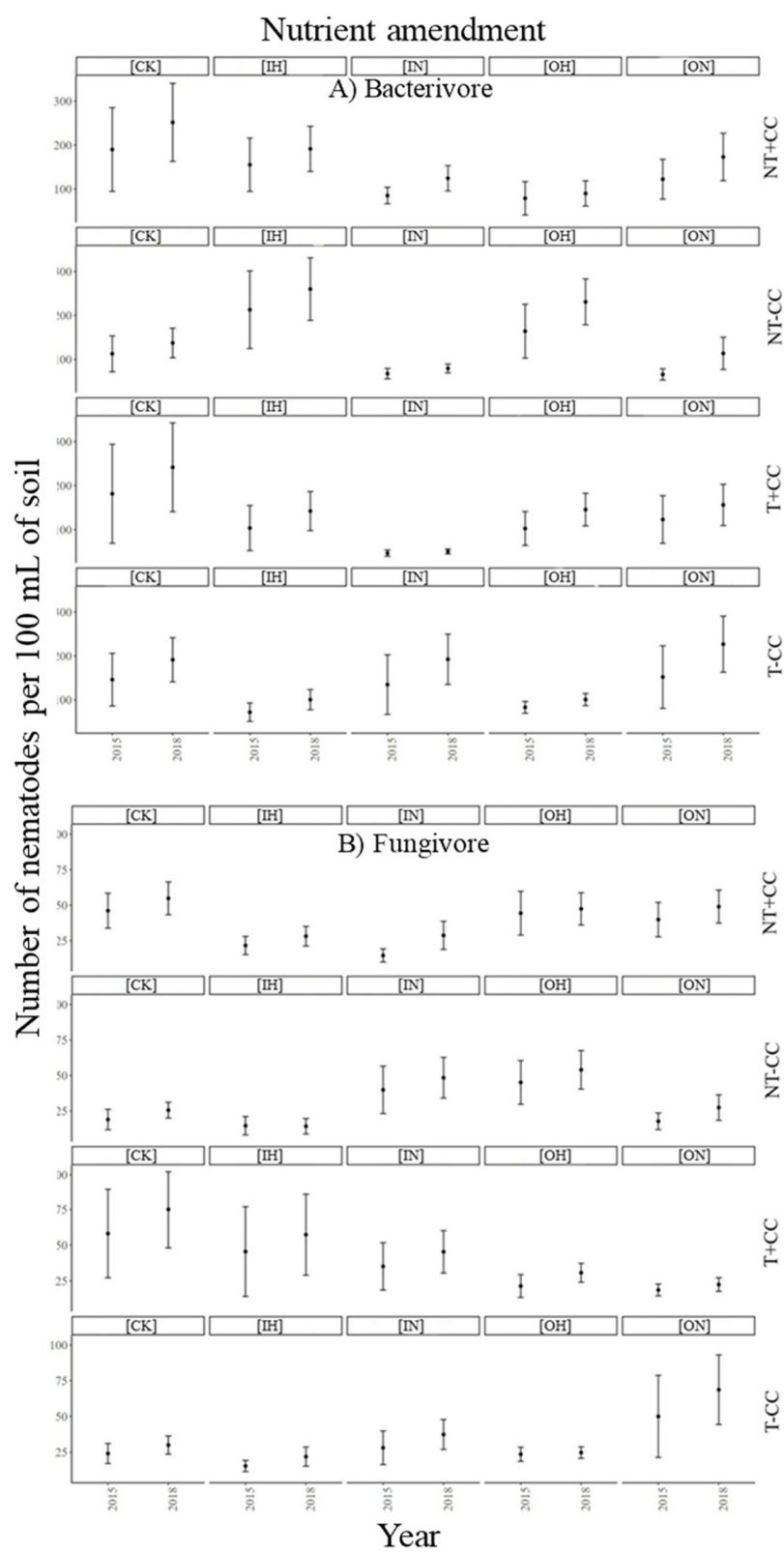
A combination of no-till with cover crop and nutrient amendments resulted in lower number of bacterivore nematodes ($P \leq 0.05$) in the standard rate inorganic and high rate

organic amendments in both years than in the check, standard inorganic and organic rates in 2018 (Fig S1A). In the no-till with nutrient amendments without cover crop, the number of bacterivore nematodes was higher ($P \leq 0.05$) in the inorganic and organic high rates in 2018 than in check and standard inorganic and inorganic rates in both years. The numbers of bacterivore nematodes in the combination of conventional till with cover crop and nutrient amendments in 2015 and 2018 was significantly lower ($P \leq 0.05$) than all, but the check and inorganic high rate amendment in 2015. The combination of conventional till and nutrient amendments without cover crop resulted in lower ($P \leq 0.05$) numbers of bacterivore nematodes in 2015 and 2018 than in the check and standard inorganic and organic rates in 2018 (Fig S1A).

In the combination of no-till with cover crop and nutrient amendments, the fungivore nematode population density was significantly lower ($P \leq 0.05$) in both inorganic amendments in 2015 and 2018 than in the check and both organic amendments in 2018 (Fig S1B). Fungivore nematodes in the high rate in 2015 and in 2018 and the standard rate inorganic amendments in 2015 were also significantly lower ($P \leq 0.05$) than the high rate organic amendment under no-till with cover crop and nutrient amendments. In the combination of no-till and nutrient amendments without cover crop, fungivore nematodes were significantly higher ($P \leq 0.05$) in the standard inorganic and high rate organic amendments in 2018 than in the check and high rate inorganic in both years and standard rate organic amendment in 2015 (Fig S1B). Fungivore nematode population density in the combination of tilled with cover crop and nutrient amendments was lower in the organic amendments in both years than in the check in 2018. There were more fungivore nematodes in the standard organic amendment in 2018 were significantly higher ($P \leq 0.05$) than in all amendments, but the same rate in 2015 (Fig S1B).

Under no-till with cover crop and nutrient amendments, the omnivore nematode population density was lower ($P \leq 0.05$) in the high rate inorganic than in high rate organic in 2015 and 2018 and in standard organic amendment in 2018 (Fig S1C). In the no-till and nutrient amendment without cover crop, the standard inorganic and high rate organic amendments in 2018 had significantly more omnivores in the check and high rate inorganic amendments in 2015 and 2018. The combination of tilled with cover crop and nutrient amendments resulted in lower ($P \leq 0.05$) numbers of omnivores in 2015 and 2018 in the high rate organic amendments than in the check and the standard rate inorganic amendment in 2018 (Fig S1C). Tilled and nutrient treatments without cover crop resulted in lower ($P \leq 0.05$) omnivore nematodes in the check, high inorganic and standard organic amendments in 2015 and 2018 and in 2015 in the standard inorganic amendment (Fig S1C).

The combination of no-till with cover crop and nutrient amendments in 2018 resulted in higher ($P \leq 0.05$) predacious nematodes in both organic amendments than in the high rate inorganic amendment in 2015 (Fig S1D). No-till and nutrient amendments without cover crop resulted in higher predacious nematodes in the high rate organic amendment in 2018 than in the check, high rate inorganic and standard rate organic amendments in 2015 and 2018 (Fig S1D). Under no-till and nutrient amendments without cover crop, the standard inorganic 2018 and high rate organic amendment in 2015 had significantly more ($P \leq 0.05$) predacious nematodes than in check and high inorganic in both years and in standard organic amendment in 2015 (Fig S1D). Under tilled with cover crop and nutrient amendments, the check and the standard inorganic amendments in 2018 had higher predacious nematodes than in high rate inorganic in 2015 and 2018 and high rate organic amendment in 2015 ($P \leq 0.05$). The number of predacious nematodes in tilled and nutrient amendment without cover crop was significantly lower in the high rate inorganic amendments in 2015 and 2018 than in the standard inorganic and both organic amendments in 2018 (Fig S1D).



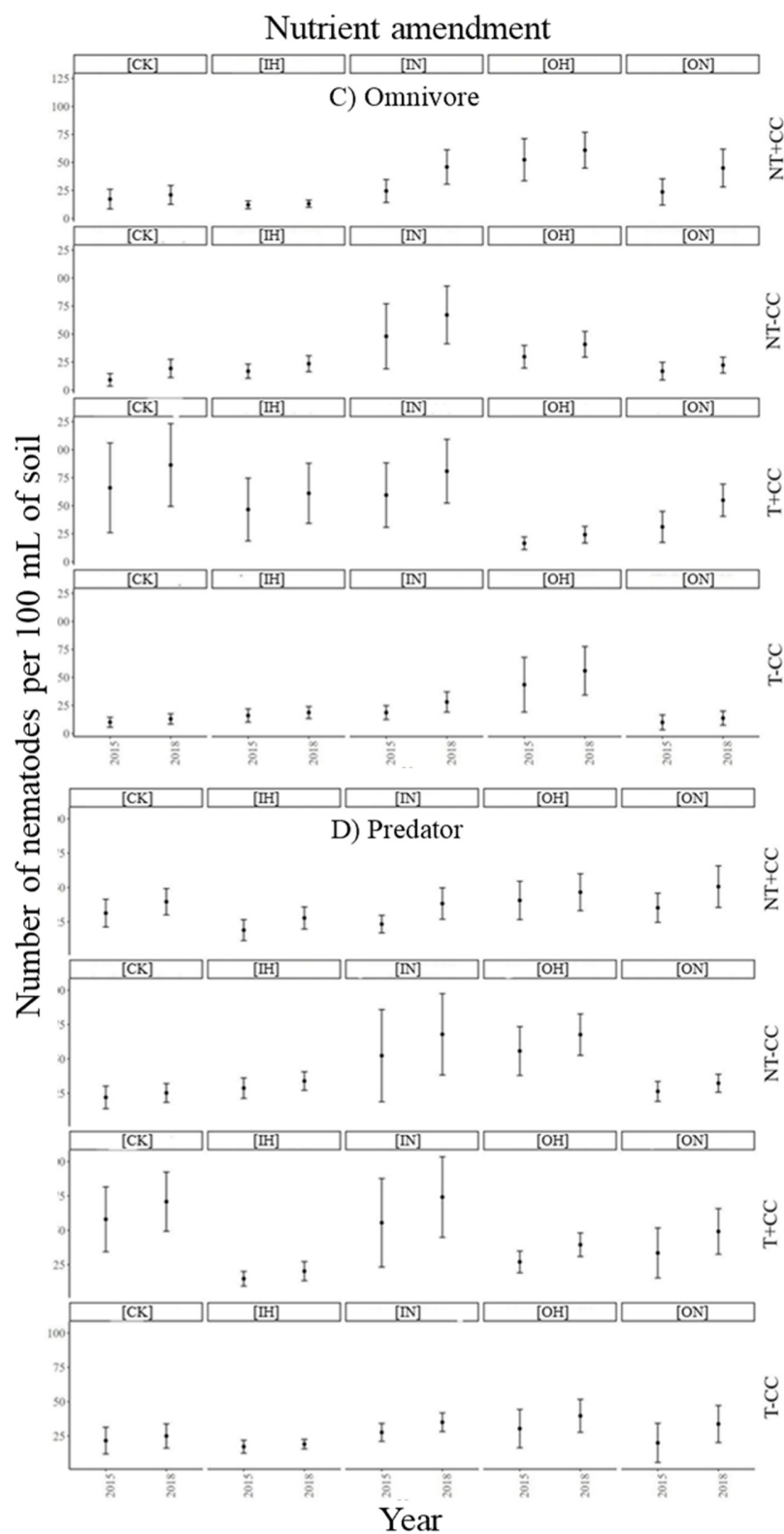


Figure S1. Three-way interaction effects of nutrient amendments delivering either zero or check [CK], inorganic high [IH] or standard [IN], organic high [OH] or standard [ON] amount of nitrogen treatments and no-till with cover crop [NT+CC] or without [NT-CC] winter rye cover crop, or tilled with [T+CC] or without [T-CC] on A) bacterivore, B) fungivore, C) omnivore and D) predator nematodes in 2015 and in 2018. Nonoverlapping error bars within tillage, cover crop and nutrient amendment categories between years and treatments are significantly different ($P \leq 0.05$).

Figure S2. Effects of tillage, cover crop and soil amendments on EI and SI

The interaction effect tillage, cover crop and soil amendment on EI was variable (Fig. S2A). In the no-till plots with cover crop, the high rate inorganic and the standard organic amendments in 2018 had significantly lower ($P \leq 0.05$) enrichment than the high rate organic amendment in both years. In the no-till without cover crop, the high rate inorganic amendment in both years had the lowest enrichment than the rest of the treatments. In the tilled plots with cover crop, the standard inorganic and high rate organic amendments in 2018 had lower ($P \leq 0.05$) enrichment than the standard organic amendment in 2015. In the no-till plots without cover crop, the high rate organic amendment in both years had significantly more enrichment than all treatments but inorganic high rate in 2015 (Fig. S2A).

The interaction of tillage, cover crop and soil amendments affected structure index was variable (Fig. S2B). In the no-till plots with cover crops, structure index in the check, high rate inorganic and standard rate organic amendments was significantly lower ($P \leq 0.05$) in 2018 than in the standard inorganic and high rate organic amendments in both years. In the no-till plots without cover crop, both organic amendments in 2015 had significantly higher ($P \leq 0.05$) structure index than in the check, inorganic high rate and standard organic rate in 2018. In the tilled plots with cover crop, the standard inorganic had significantly higher structure index in both years than all treatments but the check and inorganic high rate amendment in 2015. In the tilled plots without cover crop, the high rate organic amendment in both years had significantly higher structure index than all but the inorganic rates 2015 (Fig S2B).

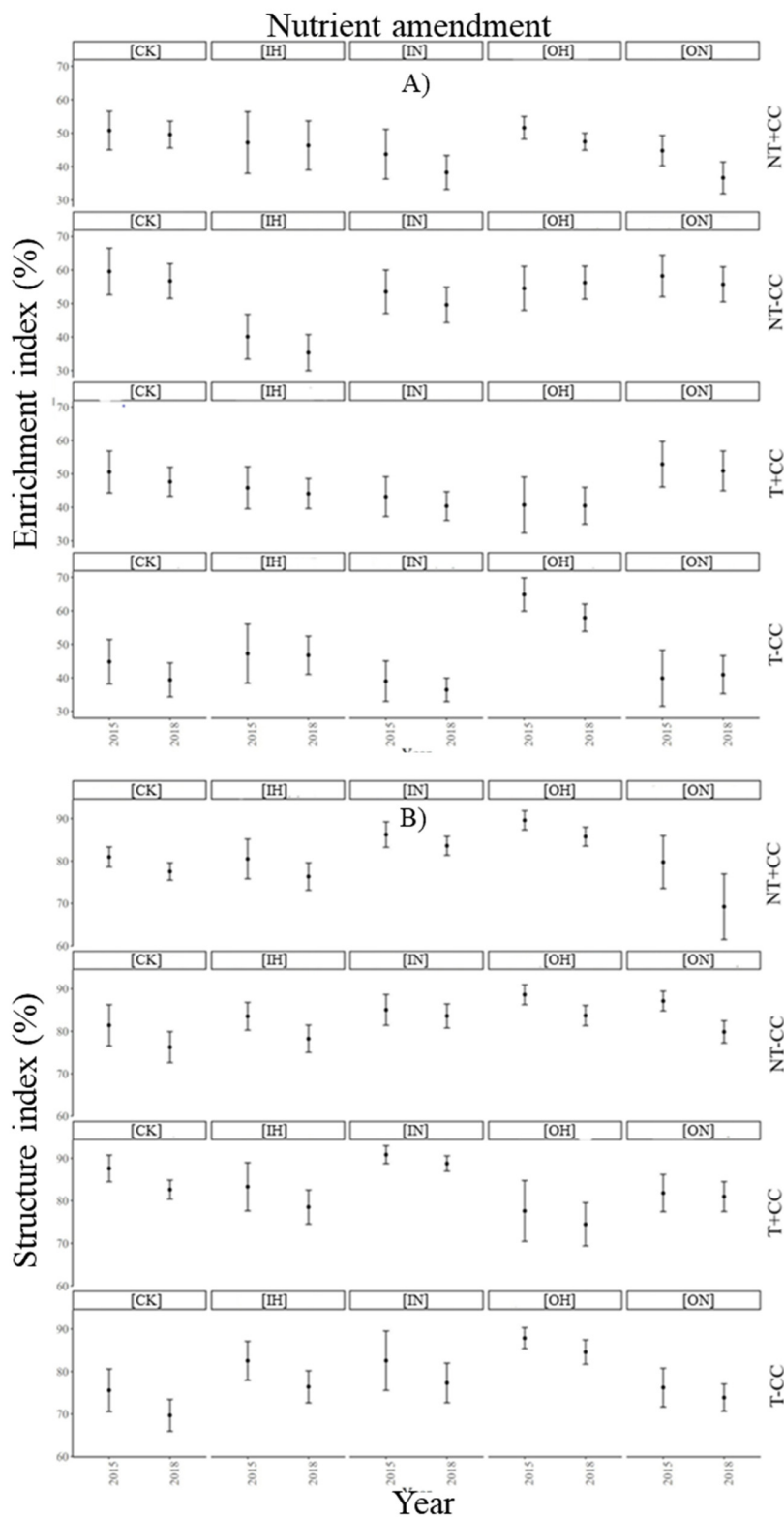


Figure S2. Three-way interaction effects of nutrient amendments delivering either zero or check [CK], inorganic high [IH] or standard [IN], organic high [OH] or standard [ON] amount of nitrogen treatments and no-till with cover crop [NT+CC] or without [NT-CC] winter rye cover crop, or tilled with [T+CC] or without [T-CC] on enrichment (A) and structure (B) indices in 2015 and in 2018. Nonoverlapping error bars within tillage, cover crop and nutrient amendment categories between years and treatments are significantly different ($P \leq 0.05$).