Effect of long-term winter rye (*Secale cereale* L.) cover crop on soil quality and yields in rainfed Michigan corn

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Introduction

The inclusion of winter cover crops (WCC) in a cropping rotation is often encouraged in the U.S. Corn Belt to mitigate the problems associated with reduced soil quality from intensive management of corn production. However, because of the short window of opportunity to plant in SW Michigan, farmers are often limited in choices of WCC that can establish successfully after corn harvest. One option is winter rye (*Secale cereale* L.), known to be one of the hardiest and cold-tolerant cereals, allowing it to be seeded later in the fall than other cover crops. In addition, winter rye produces more aboveground biomass compared to other cover crops, and develops extensive, deep roots that improve soil structure and nutrient cycling.

However, inconsistency in the scientific literature on the impacts of winter cover crops on soil quality indicators have made farmers hesitant to adopt WCC into their rotation. Farmers may experience some yield penalties from asynchrony in N mineralization or allelopathic effects when WCC is mismanaged. Additionally, changes in soil quality indicators are gradual and may take many years of management practices to detect. Increasing soil quality indicators will ultimately lead to yield benefits. Our research aimed to bridge some of the missing evidence to support WCC effects on soil quality and corn production.

Objectives

The main objective of this study was to quantify the effect of winter rye cover crop use on physical, chemical, and biological soil quality indicators after 9-yr cumulative use in a corn-corn-soy rotation under conventional tillage practices in a sandy-loam soil. Additionally, we wanted to assess the impact of cover crops on corn yields.

Methods

This experiment was conducted between 2006 and 2013 at Michigan State University's Kellogg Biological Station located in SW Michigan (42°24` N, 85°24` W). The main plot consisted of two winter management systems: winter cover crop (WCC) or no cover crop (fallow). Main plots were divided into seven subplots, which were randomly assigned nitrogen (N) fertilizer rates of 0, 34, 67, 101, 134, 168, or 202 kg N ha^{-1}. In the final year of the study, identified and evaluated the integrative effect of a winter rye cover crop on the physical, chemical and biological indicators of soil quality useful to agroecological farm management. The following soil quality indicators were measured:

- Physical: soil texture, bulk density, total porosity, water-stable soil aggregates, soil water retention
- Chemical: soil pH, CEC, Bray-1 P, K^+, Mg^{2+} and Ca^{2+} availability
- Biological: litter bag decomposition, soil extracellular enzyme activity, particulate organic matter, permanganate oxidizable C

Corn yields were also measured each year corn was grown in rotation.

Results

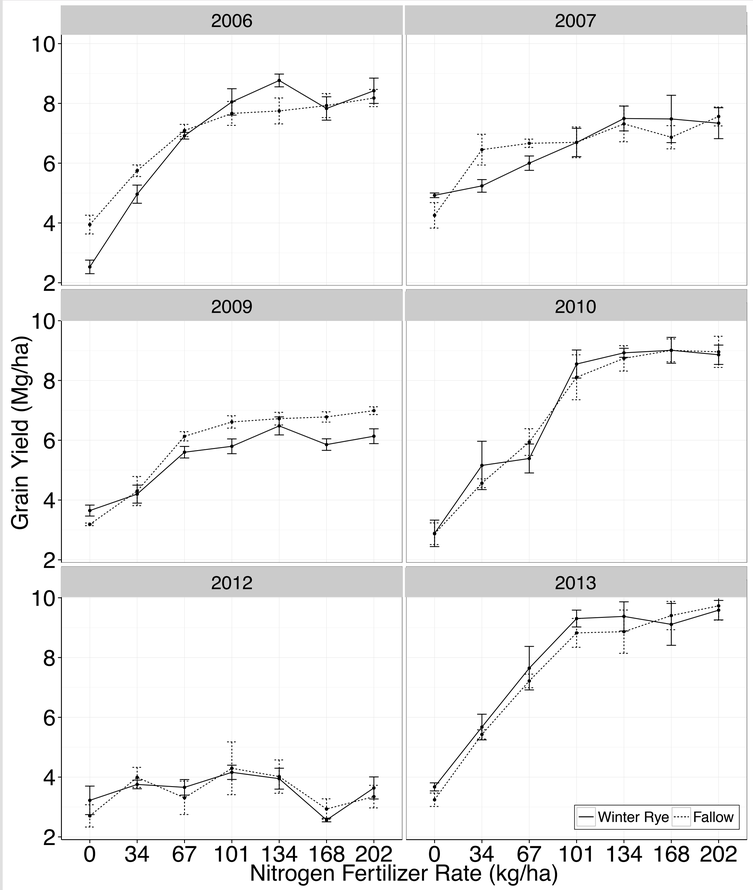

Figure 1.

Corn grain yields (Mg/ha) under winter rye cover crop and no cover crop (fallow) under seven different rates of N fertilizer (kg/ha) from 2006 – 2013 under rainfed conditions.

Cover crop biomass accumulation:

- Biomass accumulations of winter rye and weedy fallows that were measured in 2007, 2010 and 2013. There was an overall significant effect of treatment (WCC vs. fallow) on the cumulative biomass incorporated in 2007, 2010 and 2013 ($p = 0.01$). Over the course of the study, biomass accumulation ranged from 0.43 – 1.46 Mg/ha.

Soil quality indicators:

- The use of rye WCC did not affect the physical soil quality indicators tested, which included bulk density, total porosity, water-stable soil aggregates, soil water retention ($p>0.05$). Winter rye as a cover crop use did not affect any of the chemical soil quality indicators tested, which were soil pH, CEC, Bray-1 P, K^+, Mg^{2+} and Ca^{2+} availability ($p>0.05$). Additionally, the were no of rye WCC on litter bag decomposition, soil extracellular enzyme activity, particulate organic matter, permanganate oxidizable C ($p>0.05$).

Corn grain yield analysis:

- There was no effect of WCC on corn yields in any of the years between 2006 and 2013. However, there were significant effects of N fertilizer rate ($p=0.01$), year ($p=0.01$) and the interaction between N fertilizer rate × year ($p=0.01$) on corn grain yields. Year to year variability of corn yields are highly influenced by weather patterns in a given year.

Conclusions/Implications

- The overall average cereal rye biomass produced in WCC plots was greater than the weedy fallow plots from the combined period of this study.
- There were no effects of 9 yrs of consecutive use of WCC use in a corn-corn-soy rotation in any of the physical, chemical and biological soil quality indicators tested.
- We observed no negative effects on yields in any of the 6 yrs that corn was grown in rotation throughout the experiment, indicating that there is low-risk associated with adopting WCC into corn rotations.

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