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Soil Microbial Activity with Depth in Claypan Soils of Southeast Kansas

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Abstract

Enzyme activities in soil indicate the relative activities of microbes, which include bacteria, fungi, algae, and other organisms. Changes in soil management alter the composition and activity of soil microbes. Plants rely on soil microbes to break down soil nutrients, and make those nutrients available for plant growth. Symbiotic relationships between soil microbes and plants enhance plant growth and productivity. Alternatively, antagonistic relationships between the soil microbial community and plants limit plant production. Soil dwellers such as nematodes or disease-causing fungi such as *Macrophomina phaseolina* (the fungus responsible for charcoal rot) can be particularly deleterious to crop growth and yield. Changes in the soil microbial community impact crop performance through the synergistic or antagonistic relationships between crop plants and soil biological activity. Our research is designed to explore soil microbial activity, assess changes in the potential activities of hydrolytic and oxidative enzymes involved in nutrient acquisition in the soil, and determine their potential impact on the productive capacity of soil.

Keywords

soil

Authors

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Summary
Enzyme activities in soil indicate the relative activities of microbes, which include bacteria, fungi, algae, and other organisms. Changes in soil management alter the composition and activity of soil microbes. Plants rely on soil microbes to break down soil nutrients, and make those nutrients available for plant growth. Symbiotic relationships between soil microbes and plants enhance plant growth and productivity. Alternatively, antagonistic relationships between the soil microbial community and plants limit plant production. Soil dwellers such as nematodes or disease-causing fungi such as *Macrophomina phaseolina* (the fungus responsible for charcoal rot) can be particularly deleterious to crop growth and yield. Changes in the soil microbial community impact crop performance through the synergistic or antagonistic relationships between crop plants and soil biological activity. Our research is designed to explore soil microbial activity, assess changes in the potential activities of hydrolytic and oxidative enzymes involved in nutrient acquisition in the soil, and determine their potential impact on the productive capacity of soil.

Introduction
Soils in southeast Kansas are predominantly silt loam in texture, overlying a dense claypan. Claypan soils are defined as soils having a dense, compact, slowly permeable layer in the subsoil composed of high clay content. The clayey subsoil can impede downward root growth, and may have reduced drainage, increased surface runoff and lateral movement of water above the claypan. A previous study on claypan soils showed that the response to land management practices including crop rotation, irrigation, and tillage is often different from other soil types (Buckley, 2008).

Extracellular enzymes mediate soil nutrient cycles, breaking down nutrients in the soil, making them available for uptake by plants. Two enzyme groups of particular interest in nutrient management include hydrolases and oxidases. Hydrolytic enzymes (hydrolase) decompose complex organic compounds in the soil, and oxidative enzymes (oxidase) destabilize phenolic compounds from organic matter in the soil. The activity of these two groups of enzymes breaks down soil matter and makes nutrients more available for plants. Hydrolases include alpha- and beta-glucosidases, acid phosphatase, N-acetyl-glucosaminidase (NAG), and L-aminopeptidase. Alpha- and beta-glucosidases release glucose from starch and cellulose in carbon cycling. Acid phosphatase releases phosphate groups in phosphorus and carbon cycling. NAG regulates the hydrolysis of glycosidic bonds in chitin (commonly found in insect exoskeleton and fungal cell walls). The activity of NAG is a semi-quantitative indicator of soil fungal biomass, and is involved in both carbon and nitrogen cycling. L-aminopeptidase hydrolyzes leucine and other n-terminus amino acid residues involved in nitrogen cycling. Oxidases include phenol oxidase and peroxidase, which are involved in lignin degradation, carbon mineralization and sequestration, and export dissolved organic carbon. Ratios of enzymatic activities can be used as indicators of microbial nutrient demand and soil health (Sinsabaugh and Shah, 2012).

While these enzymes are important in soil nutrition, most studies of extracellular enzyme activity have only focused on the nutrient-rich surface soil layers. The importance of the subsoil for the nutrient acquisition by plants and microorganisms is poorly characterized. Moreover, changes in biological properties of claypan soils are still unknown. This study examined changes in extracellular enzyme activity as a function of depth in a claypan soil and across different soil and crop management systems.

Experimental Procedures

Soils were sampled from research plots on a Parsons silt loam soil at the Southeast Research and Extension Center research station near Columbus, KS. Soil samples were divided into 5 depth increments (0-2"; 2-6"; 6-12"; 12-24"; and 24-30") and processed for determination of enzymatic function using standard procedures (German et al., 2011). Test plots from three management practices were sampled: conventional tillage row crop production (CT), no-till row crop production (NT), and long-term grass field (GRA).

Target enzymes included hydrolase and oxidase. The resulting activity data are correlated with microbial activity and decomposition and nutrient release.

Results and Discussion

Hydrolase activity of NT was significantly greater than CT at the soil surface (0-2"). This may indicate that the additional plant residues in the NT system increased microbial activity. Higher hydrolase activity indicates a greater release of readily available organic compounds, nitrogen and phosphorus, thus enhancing soil health. Hydrolase activity was highest at the soil surface, and decreased with depth down to 10" (Figure 1). After this depth, the hydrolase activity increased at 12-24" depth in the soil. This may be related to changes in increasing clay content. Hydrolase activity of the grassland soil was significantly greater at all depths compared to cropland soils (NT and CT). No significant differences were observed in oxidase activity between management practices (Figure 2). Further work will examine other properties in relation to enzyme activity to better understand the changes in soil enzyme activity, their impact on crop performance, and their potential as an indicator of soil health.

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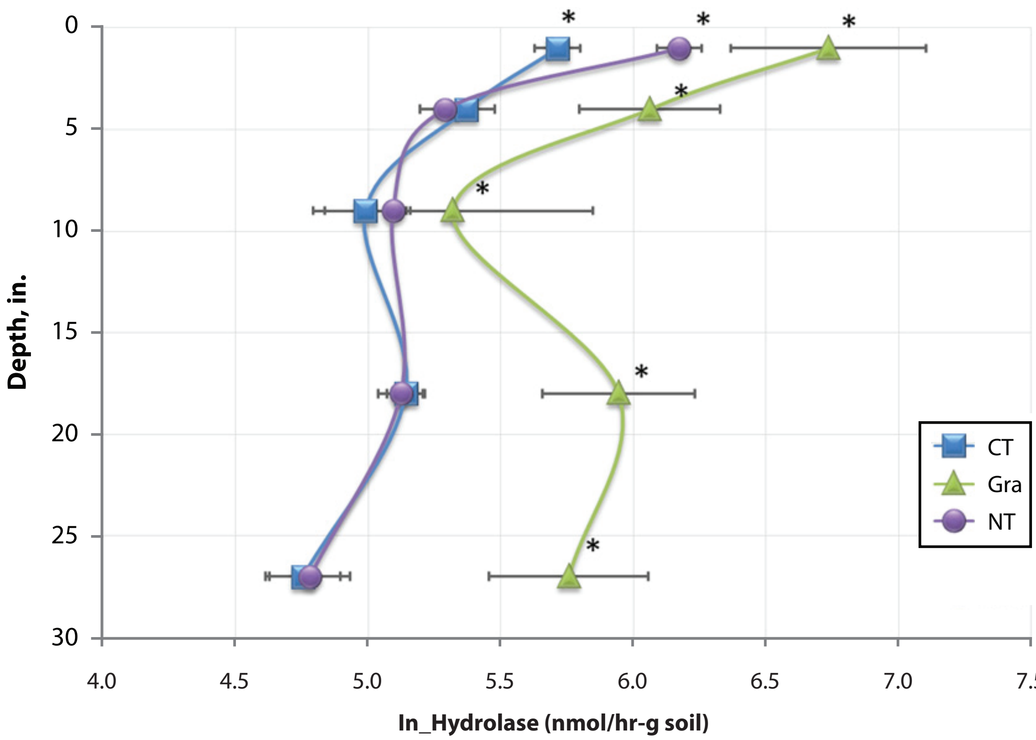

Figure 1. Change in soil hydrolase activity with depth measured as the amount of hydrolase activity (nmol) per hour for a standard weight of soil for three different management systems, Conventional Till crop production (CT), No-Till crop production (NT) and Grassland (Gra). *Significant difference at 95% confidence level.

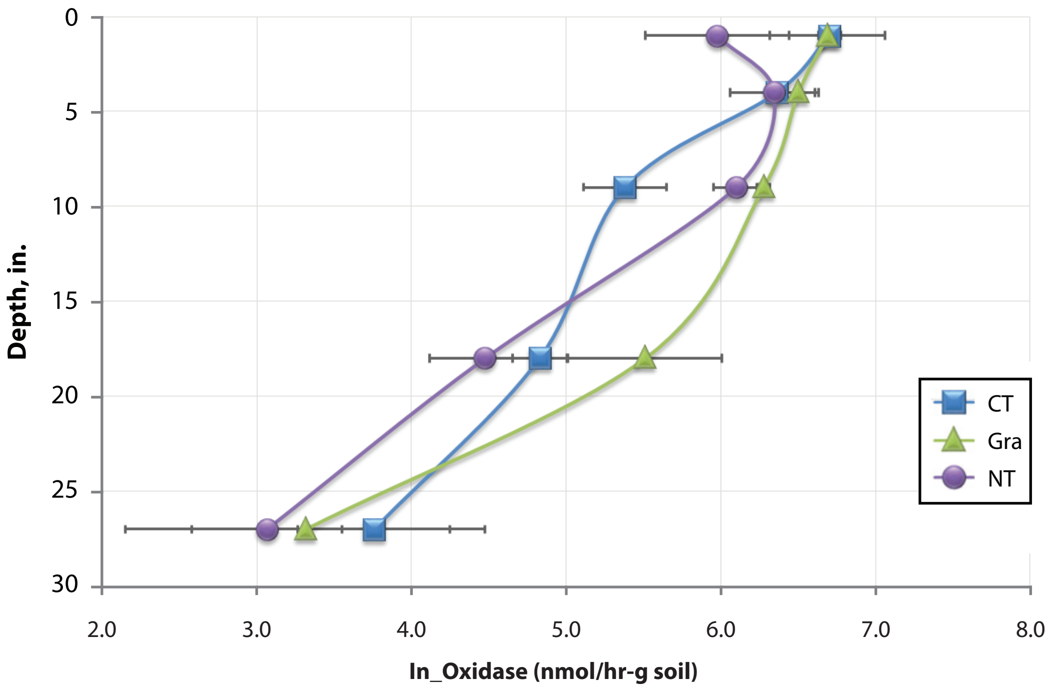

Figure 2. Change in oxidase activity with depth in the soil profile measured as the amount of oxidase activity (nmol) per hour for a standard weight of soil for three different management systems, Conventional Till crop production (CT), No-Till crop production (NT) and Grassland (Gra).