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Soil Health Profile in Claypan Soils

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Cover Page Footnote

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Summary

Soil health is critical for crop growth and agricultural sustainability. Soil microbial properties are a primary component of soils and a potential indicator of the soil health status. Little is known about the soil microbial properties in claypan soils. Our research confirmed that changes in soil management practices, including tillage and production system, affected the activity of soil microorganisms in surface soils and the degree of increase in enzyme activity in subsoils. A greater concentration of microbial biomass and fungi in the hay meadow systems indicated an increased soil health in this production system. Our research also indicated the vertical stratification of soil properties in claypan soil. Management practices determined the microbial properties in surface soils, while parent materials determined the microbial properties in soils in the claypan layer.

Introduction

Healthy soil is the foundation of a sustainable agronomic production system. Microorganisms include bacteria (such as actinomycetes), fungi, and protozoa. Soil microorganisms, or microbes, exist in large numbers in soils and are critical for decomposition of organic residues and nutrient recycling. Soils with ample and diverse microbial populations can provide more essential nutrients for crop growth and development. Soil microbial properties are considered one of the major indicators of soil health.

Soil microbial properties can be measured by the activity and the composition of microorganism populations. Phospholipid fatty acids (PLFA) are the primary components of cell membranes. They can be used to estimate the total amount, or biomass, of bacterial and fungal microbes in the soil. The assay measures the amount of phospholipid fatty acids per weight of soil (nmol PLFA/g soil) and is expressed as the PLFA microbial biomass. Microorganisms within the soil release enzymes that degrade organic material to release nutrients needed to support the microbial community. These nutrients are also used to support plant growth. One of the major groups of soil enzymes, hydrolases, decomposes soil material to release carbon, nitrogen, and phosphorus. By measuring the enzymatic activity of these hydrolases within the soil profile, calculated as the amount of substrate decomposed over time for a given weight of soil (nmol/hr/g soil), we can determine the activity of the microbial community.

Claypan soils have a dense, impermeable subsoil that impedes root system development. The soils can be productive, but the productive capacity is often limited by shallow topsoil depth. The poorly drained clayey layer saturates the surface soils, impairs root

growth, and exacerbates soil erosion compared to well-drained soils. Crop production on claypan soils requires careful management to maintain productive capacity. It is important to understanding the role of soil microbial properties integrated with soil physical and chemical properties to provide optimal management practices in claypan soils. Little is known about soil microbial properties in claypan soils or how the textural changes in claypan soils impact microbial activity and communities.

In this report, we present how management practices influenced soil microbial properties and describe how soil texture mediates changes in soil microbial properties with depth in claypan soil.

Experimental Procedures

Soil samples were collected from a field at the Southeast Research and Extension Center research station in Columbus, KS. The soil type is a Parsons silt loam. Three management practices were selected: conventional tillage row crop production (CT), no-till row crop production (NT), and hay meadow (HM). Soil samples were collected and partitioned into 7 different depth intervals (0-2, 2-6, 6-10, 10-14, 14-18, 18-22, and 22-30 in.). The samples were processed for soil texture analysis, nutrient content, soil microbial community composition by phospholipid fatty acid (PLFA) analysis, and soil microbial activity by extracellular enzyme activities analysis (Hsiao et al., 2018).

Results and Discussion

The results demonstrate a noteworthy impact of management practices on soil microbial properties at both the surface soil and within the claypan layer. In the surface soil (0-6 in.), microbial biomass was nearly 10-fold greater in the HM than in the cropped soils in the top 2 in. of soil (Figure 1). The microbial biomass decreased rapidly at greater depth within the soil profile for all production systems. While the microbial biomass in the CT and NT systems were the same below 6 in., the biomass in the HM system was greater than the cropped systems throughout the soil profile, until the very deepest sampling interval (22-30 in.).

As with the microbial biomass observed in Figure 1, the HM system had much greater microbial community activity, as determined by the hydrolase activity (Figure 2). While the hydrolase activity initially decreased with depth within the soil profile (0 – 10 in.), the activity then increased in the lower soil profile within the clay layer. Within the claypan layer (below ~15 in.), the increase in enzyme activity in HM soils was the greatest. No difference in hydrolase activity was observed in the surface soils or in the subsurface soils for the cropped systems. This increase in microbial activity in HM soils within the clay layer may have important implications for optimal management of clay soils. In contrast to annual cropping systems, a long-term perennial grass system (such as the HM) has plants that occupy the land continuously, indicating the potential of grass systems to utilize more of the soil profile by establishing roots within the clay layer.

The claypan region of Kansas is part of the tallgrass prairie ecoregion. These soils perform well as prairie, potentially due to the ability of grasses to grow within the clay layer. By adapting production practices to include more grasses in the crop rotation, or

using grasses as cover crops, we may be able to use more of the soil profile. Grasses are able to create rooting networks that extract more of the soil nutrients from lower soil layers, due in part to their denser rooting systems. Clark et al. (1998) demonstrated that gamagrass grew successfully within the clay layer, creating root channels that could then be utilized by other plants to grow to greater depths within a clay soil. Our results indicate the importance of management system to improve soil health. Reducing tillage and incorporating more grasses within our production systems can support the microbial communities, increasing the water and nutrient cycling within the soil and improving the productive capacity of soil.

Acknowledgment

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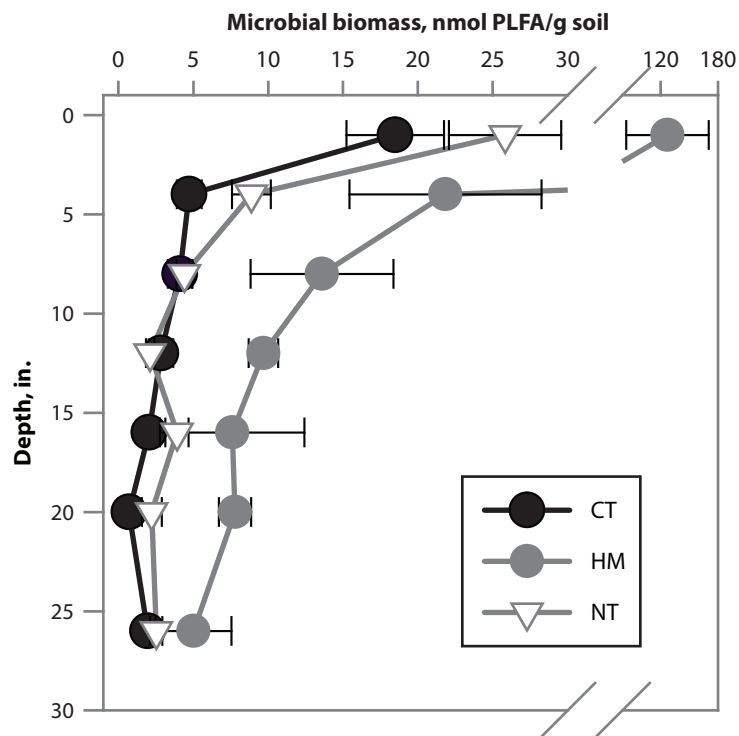


Figure 1. Change in microbial biomass with depth for three production systems, NT, no-till; CT, conventional till; and HM, hay meadow. Note the break in the axis between 30-120 nmol PLFA/g soil. The results are the average of all replications with standard error.

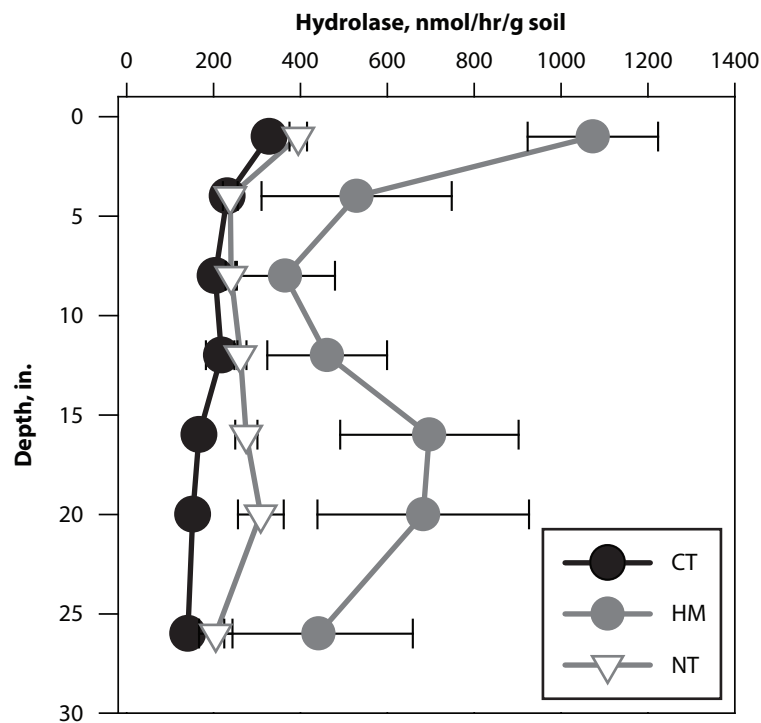


Figure 2. Change in soil enzyme activity with depth for three production systems, NT, no-till; CT, conventional till; and HM, hay meadow. The results are the average of all replications with standard error.