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Key Components of Healthy Soils and Their Role in Crop Production

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Key Components of Healthy Soils and Their Role in Crop Production

Abstract

Soil health is a confusing term that means different things to different people. To a crop producer, healthy soils are critical for good crop growth and yield. Some soil properties include soil texture, such as the relative percentage of sand, silt and clay; the water content; nutrient levels; organic carbon content; the microbial community; and microbial activity. These properties are determinants of soil health. Our research confirmed that changes in soil management affect the composition and activity of soil microorganisms in surface soils. Greater concentrations of microbial biomass and arbuscular mycorrhizal fungus (AMF) in the no-till agricultural system indicated healthier soils in this system. Our research also indicated microbial properties in subsurface soils were determined by parent materials and weathering.

Keywords

crop production, soil health, soil microbiology, phospholipid fatty acid analysis, soil enzyme activity analysis

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Summary

Soil health is a confusing term that means different things to different people. To a crop producer, healthy soils are critical for good crop growth and yield. Some soil properties include soil texture, such as the relative percentage of sand, silt and clay; the water content; nutrient levels; organic carbon content; the microbial community; and microbial activity. These properties are determinants of soil health. Our research confirmed that changes in soil management affect the composition and activity of soil microorganisms in surface soils. Greater concentrations of microbial biomass and arbuscular mycorrhizal fungus (AMF) in the no-till agricultural system indicated healthier soils in this system. Our research also indicated microbial properties in subsurface soils were determined by parent materials and weathering.

Introduction

Good soil functionality improves the resiliency of the agronomic production system. Soils work in concert with weather, management practices, and genetics to determine the overall yield from a crop. Nowadays, people realize soil is a living organism, and the Natural Resources Conservation Service (NRCS) (2012) has defined soil health as: "The continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans."

As described by the NRCS, some of the functions of healthy soils include providing habitat for plants, animals, and soil microorganisms; providing stability and support; providing nutrient cycling; filtering and buffering; and water relations.

Some soil characteristics are commonly measured, such as the physical makeup (clay/silt/sand content; bulk density, water content, and drainage ability) and the chemical characteristics (pH and nutrient levels, including carbon (C), nitrogen (N), phosphorus (P), potassium (K) and micronutrients). These are important determinants of soil health. The final component that is critical to the overall capacity of soil to provide a "vital living ecosystem" is the biological component. We are learning much more about the factors involved in the biology of soils and their role in soil health.

The biological components of the soil include the plant roots, bacteria, fungi, protozoa, nematodes, arthropods, earthworms, and animals. Some of these are beneficial, for example the Rhizobia bacteria that work with plants to fix nitrogen in certain nitrogen-fixing plant species such as soybeans. Arbuscular mycorrhizal fungi (AMF) are a group of beneficial fungi that form close bonds with plants, actually growing into the root cells of vascular plants and helping the plants take up nutrients. Other microorganisms are detrimental, such as the fungi *Macrophomina phaseolina* that causes charcoal rot.

We know a good bit about how to manage the physical and chemical characteristics of soils to improve their productive capacity. We are learning the importance of biological components, and their contribution to agronomic productivity. Biological soil characteristics are important for their role in integrating physical and chemical characteristics of the soil for optimal productivity.

This report presents the factors that are important for healthy soils. It also describes new research in progress on soil health.

Experimental Procedures

Soil samples were collected from a research field in Columbus, KS, under three management systems: conventional tillage row-crop production (CT); no-till row crop production (NT); and a long-term hay meadow (HM). The soil is a Parsons silt loam, nearly level. Soil samples were collected at different stages during the production cycle (preplant, after planting, at bloom, and at harvest) and separated into 7 different depth intervals (0-2, 2-6, 6-10, 10-14, 14-18, 18-22, and 22-30 inches). The soil samples were processed for microbial community composition by phospholipid fatty acid (PLFA) analysis and for microbial activity by soil enzyme activities analysis.

Results and Discussion

The soil in the field is a Parsons silt loam soil, described by the NRCS Web Soil Survey (2016) as prime farmland, with loess soil over clayey alluvium or clayey residuum weathered from clayey shale. The typical soil profile has productive silt loam soil to a depth of 14 inches, with a somewhat poorly drained silty clay layer, commonly referred to as the claypan, below about 14 inches.

In the surface soils, microbial biomass was greatest in the hay meadow, followed by no-till, and then conventional-till production systems (Figure 1). Subsoils from the HM had the greatest microbial concentration at every depth interval. Soil enzyme activities also followed a similar pattern. Microbial activity was greatest in the surface soils of the HM, followed by NT and CT agricultural systems.

Land management practices impacted microbial community composition (Figure 2). The fungal fraction was greatest in the soils from the HM, as indicated by the greater ratio of fungi to bacteria. No significant differences in total fungi content were measured between NT and CT soils. However, in contrast to the total fungal populations, the AMF fraction showed a greater concentration in the NT system than in the CT system.

The results also demonstrate a stratified response of soil microbial properties with depth in the soil profile. The land management practices influenced soil biological activity in the upper 6 in. of the soil profile (Table 1). The soil microbial properties in the lower soil profile (below approximately 14 in.) were dependent on the parent material and weathering. The intermediate depths in the soil profile could be influenced by both parent materials and management practices.

These results demonstrate the impact of management practices on soil microbial activity. Because AMF are important in nutrient cycling and nutrient uptake by plants, their increased populations in NT systems improves the productive capacity of the soil. Changes in management practices can have profound impacts on the health of the soil, and hence on its productive capacity.

References

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Table 1. Significant factors controlling biological activity in claypan soils

Soil depth	Tillage	Clay %	Carbon %	Nitrogen %	Phosphorus (ppm)	Potassium (ppm)
0-6 in.	X	-	X	X	-	X
6-14 in.	-	X	-	-	-	X
14-30 in.	-	X	X	X	-	X

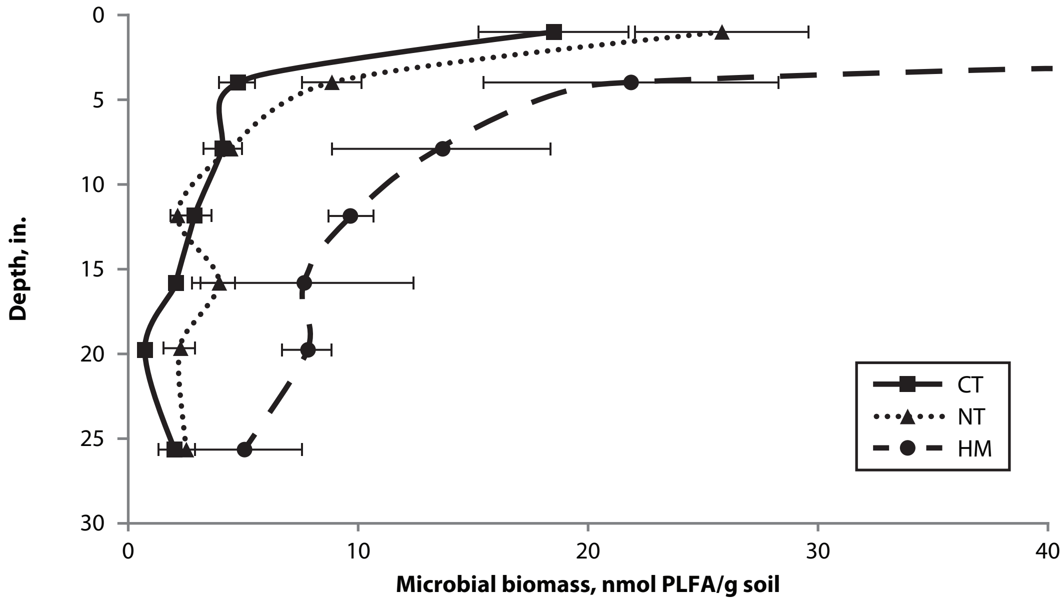

Figure 1. Change in microbial biomass with depth for three production systems, NT, no-till; CT, conventional till; and HM, hay meadow. The results are the average of all replications with standard error.

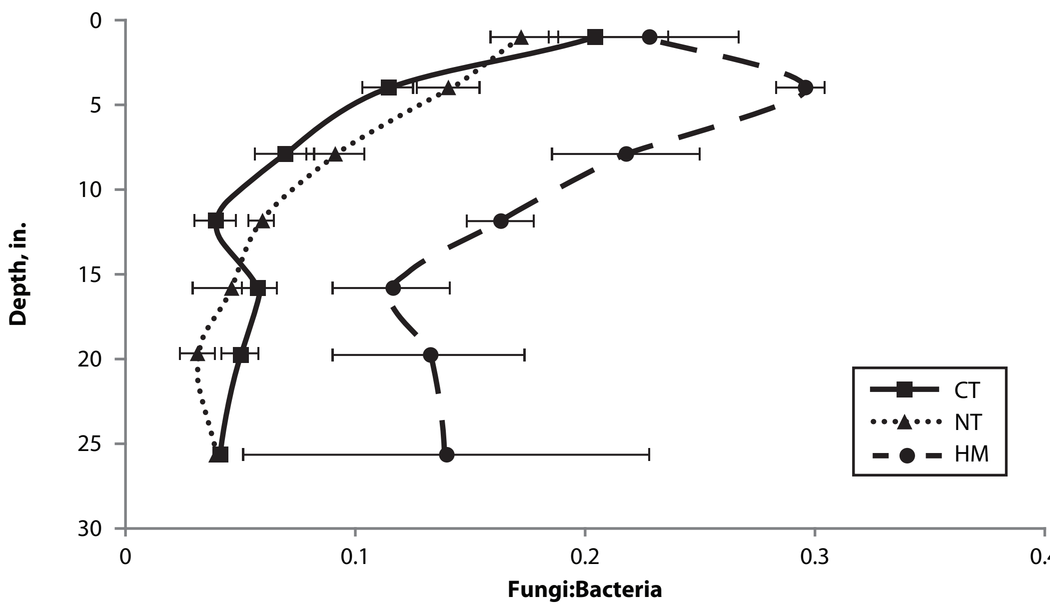

Figure 2. Change in the ratio of Fungi to Bacteria with depth in the soil profile for three production systems, NT, no-till; CT, conventional till; and HM, hay meadow. The results are the average of all replications with standard error.