Soil Microbial Activity with Depth in Claypan Soils of Southeast Kansas

K·STATE Research and Extension

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Introduction

Claypan soils are defined as soils having a dense, compact, slowly permeable layer in the subsoil with a much higher 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. Previous study on claypan soils shown that the response to land management practices including crop rotation, irrigation, and tillage is often different from typical soils *(Buckley, 2008)*.

Extracellular enzymes mediate biogeochemical cycles in soils, but 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 functions of depth in claypan soils and across different treatments. Ratios of enzymatic activities are used as indicators of microbial nutrient demand and soil health status.

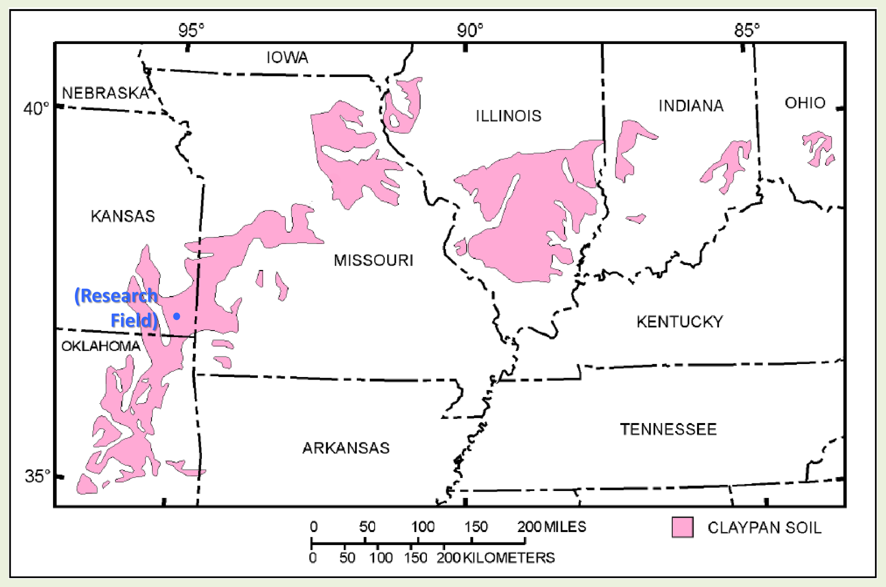

Figure 1. There are approximately 4 million hectares of claypan soils in the Midwestern USA. *Smith et al., 1979.*

Objectives

- To assess changes in the potential activities of hydrolytic and oxidative enzymes involved in microbial C, N and P acquisition with increasing soil depth in claypan soils.
- To determine how clay content and tillage mediate changes in soil enzyme activities with depth.

Table 1. Target enzymes.
Methodological consideration: German et.al., 2011.

Enzyme	Abbr.	Enzyme function	Indicator
Hydrolase			
α-glucosidase	aG	Release α-D-glucose from starch	C-cycling
β-glucosidase	bG	Release β-D-glucose from cellulose	C-cycling
acid phosphatase	AP	Release phosphate groups	P-cycling, C-cycling
N-acetyl-glucosaminidase	NAG	Hydrolysis of glycosidic (N-acetyl-β-glucosaminide) bonds in chitin	Semi-quantitative indicator of soil fungal biomass, both C/N cycling
L-Aminopeptidase	LAP	hydrolysis of leucine and other N-terminus amino acid residues	N-cycling
Oxidase			
phenol oxidase	POX	lignin degradation, C mineralization and sequestration, dissolved organic C export	C-cycling, oxidative stress response, detoxification of phenolic compounds or defense
peroxidase	PER		

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Research Site

- Cherokee County, Southeast Kansas (37.21N, 94.87W)
- Mean annual precipitation: 900-1150 mm (35"-45")
- Soil Type: Parsons silt loam, 0-1% slope
- 5 Depth Intervals: 0-5, 5-15, 15-30, 30-60, 60-73 cm
- 3 management practices: long term conventional-till (CT), no-till (NT), and grassland (Gra).

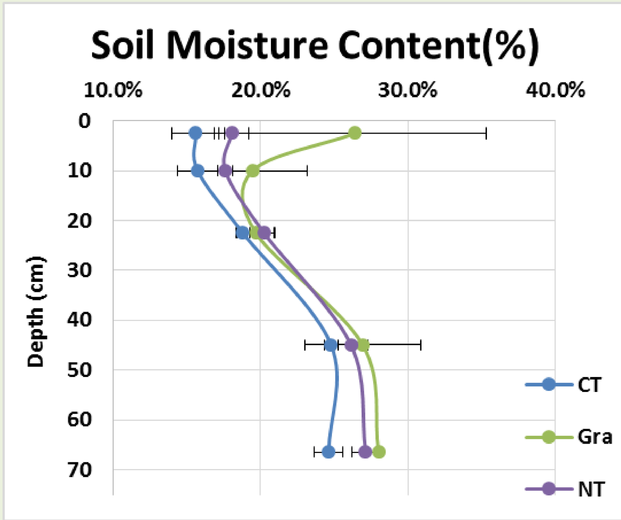

Figure 2. Change in moisture content by depth in soil profile

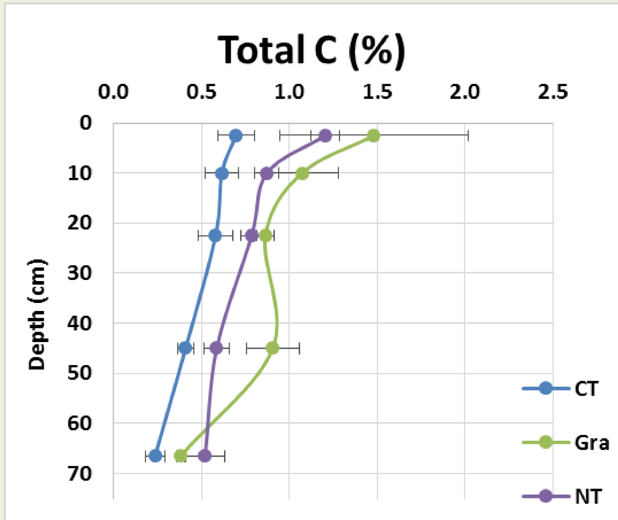

Figure 3. Changes in total carbon content by depth in soil profile

Extracellular Enzyme Activities

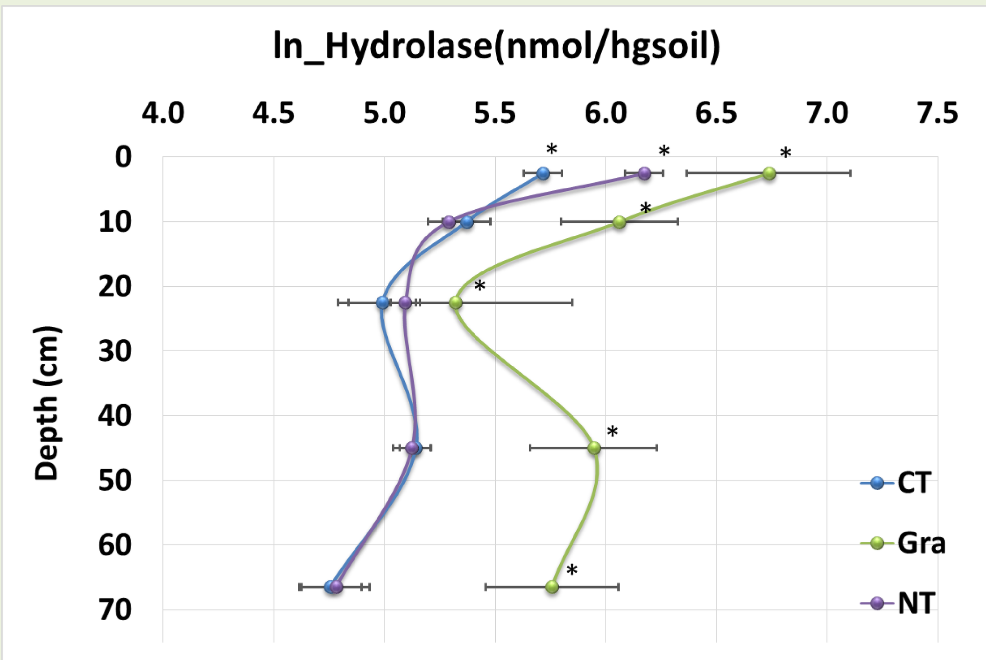

Figure 4. Changes in soil hydrolase activities change with depth by different management practices. Hydrolase = aG+ bG+ AP+ NAG+ LAP. *significant difference under 95% confidence level

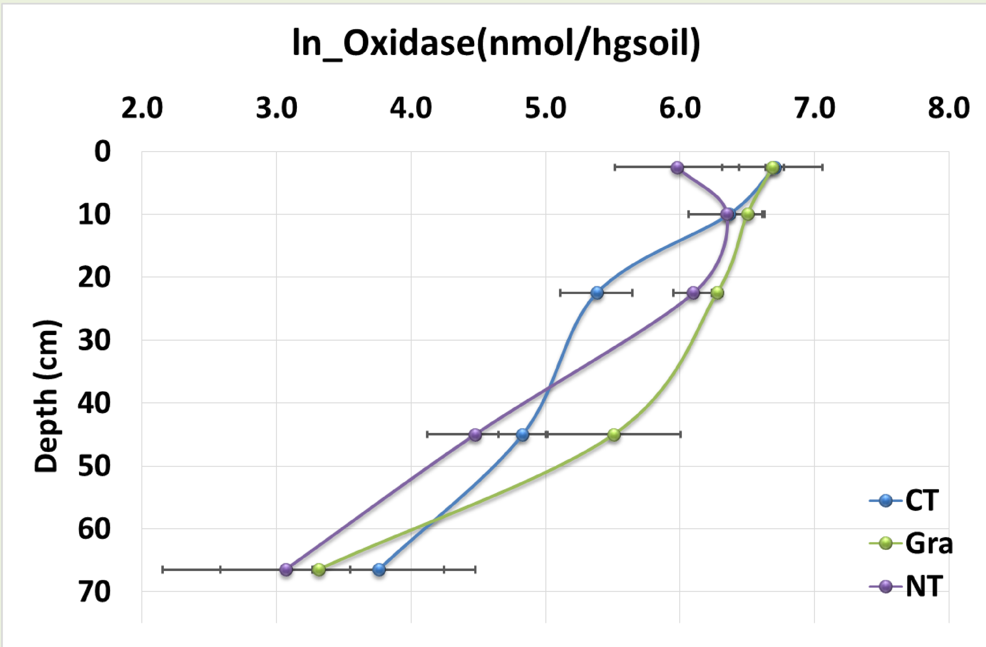

Figure 5. Change in soil oxidase activities change with depth by different management practices. Oxidase = POX+ PER.

Key Findings

- All hydrolases have increased activity at 30-60cm, may be related to changes in increasing clay content.
- Hydrolase activity of grassland is different at every depth with cropland (NT and CT).
- Hydrolase activity for CT and NT was only significantly different at 0-5cm.
- No significant difference were observed in oxidase activity between management practices.

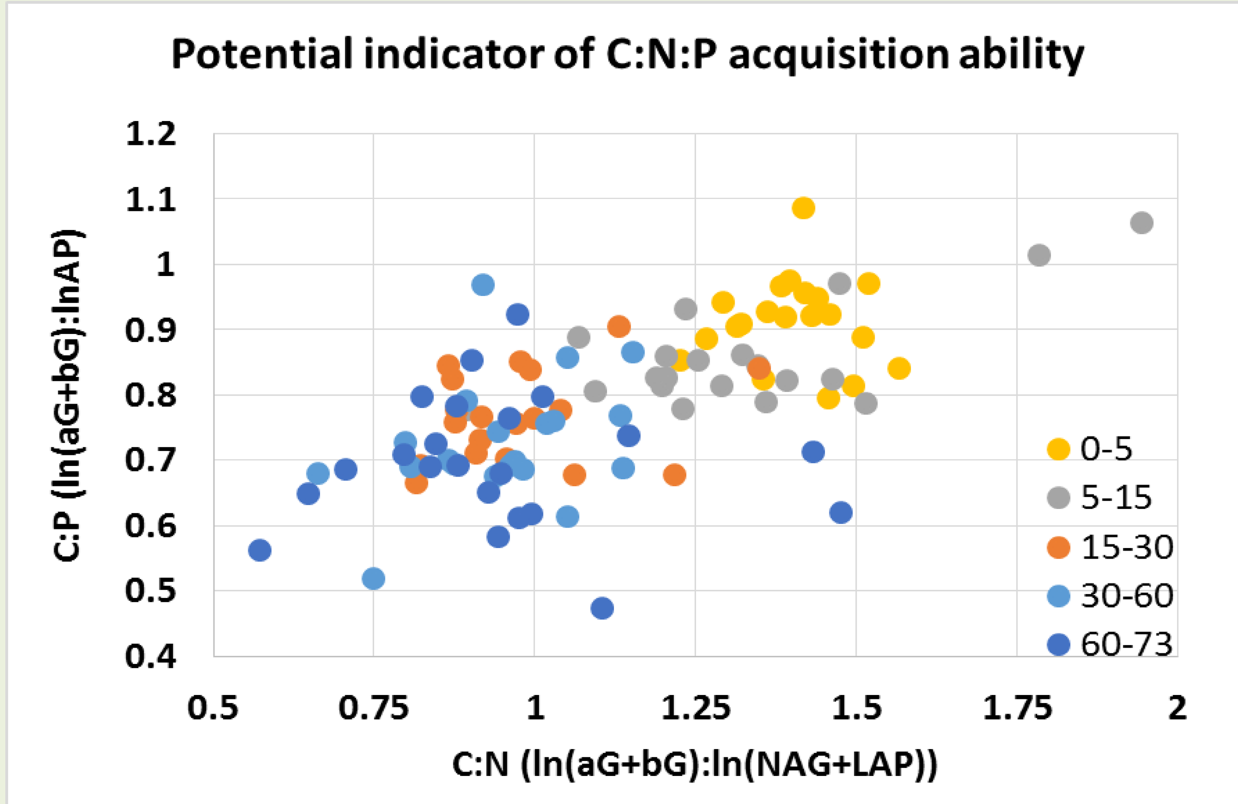

Figure 6. Ratio of ln(aG+bG): ln(NAG+LAP) in relation to ln(aG+bG) : ln(AP). An indicator of potential C:N acquisition ability to potential C:P acquisition ability.

Key Findings

- Soil microbes expend more energy acquiring P relative to C, and more energy acquiring N relative to C, as depth increases.

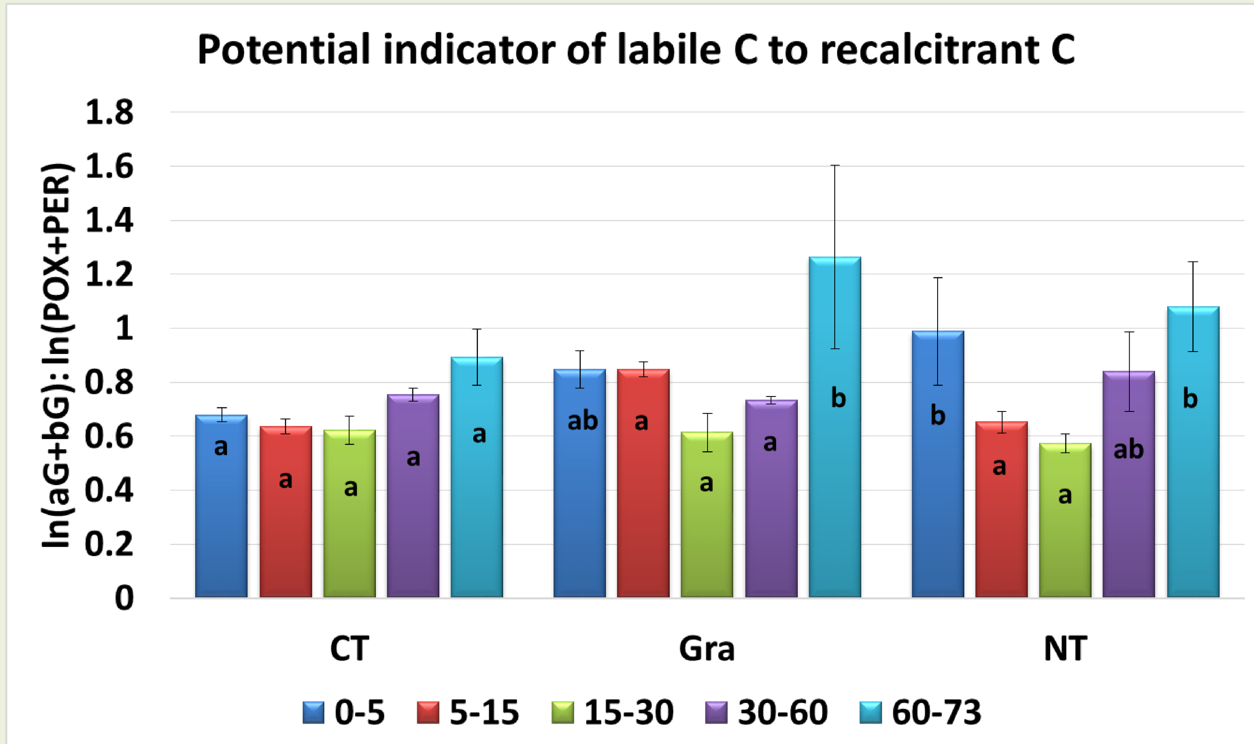

Figure 7. Ratio of labile C (ln(aG+bG)) to recalcitrant C (ln(POX+PER)) changes with depth and treatments. This ratio is correlated to labile C availability. A higher ratio is associated with more labile C.

Key Findings

- The indicator for labile C availability decreased with depth down to 30-60cm, then increased again below 60cm.
- There is no significant difference between different management practices.

Summary

- Our study indicates that different ratios of enzymatic activities may be a good method of monitoring management practices to develop improved soil health.

References

- Buckley M, 2008. Effect of tillage on the hydrology of Claypan soils in Kansas. Dissertation at Kansas State University.
- MSEA, Management Systems Evaluation Area; modified from Smith et al., 1979, p. 3
- German et al., 2011. Optimization of hydrolytic and oxidative enzyme methods for ecosystem studies. Soil Biology & Biochemistry 43, 1387-1397

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