Effect of Tillage Practices On Organic Carbon, pH, Bulk Density and Soil Enzyme Activities

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Abstract

Soil tillage practices affect the physical, chemical and biological processes in soil, which in turn determine soil productivity, sustainability, and overall soil quality. In this study the effects of two tillage practices on soil organic carbon, pH, bulk density and soil enzyme activities was evaluated. The experimental design was a split-plot design with two treatments, conventional till (CT) and no till (NT), replicated four times at two soil depths (0-5 cm and 5-15 cm). Physical and chemical properties of the soil as well as soil enzyme activities were analyzed for CT and NT systems. The results showed that the percent organic carbon was significantly higher ($p<0.01$) in the NT plots compared to the CT plots as well as in the 0-5 cm soil depth compared to the 5-15 cm soil depth. Soil bulk density and pH were significantly ($p<0.01$) higher at 5-15 cm depth compared to 0-5 cm depth for both CT and NT. Enzyme activities were significantly ($p<0.5$) higher in NT compared to CT with acid phosphomonoesterase levels revealing significantly higher ($p<0.5$) levels at 5-15 cm depths in the NT plots compared to similar depth in the CT.

Introduction

Conventional tillage has been associated with high soil erosion, soil compaction, and loss of organic matter resulting in soil degradation. No-tillage system is often presented as a useful alternative to avoid some of these problems. It was first demonstrated to further reduce erosion in North America and was then widely adopted and recommended by the USDA (Logan et al., 1991). In the past 20 years no-till or direct seeding methods have gained interest for their potential to further reduce soil erosion, fuel and labor costs, and equipment wear (Carpenter-Boggs et al., 2003). Conventional tillage has historically being the predominant method of land preparation in the southeastern US. However, these soils are more sensitive to degradation from repeated tillage due to erosion and loss of soil organic matter (Feng et al., 2003). To halt this degradation process it may be desirable to adopt the no-tillage systems. It has been documented that the no-tillage practices increase soil organic matter (SOM) content, which in turn improve soil structure, infiltration rate, water holding capacity and nutrient cycling. SOM also serve as a nutrient reservoir for plant growth and substrate for soil microorganisms (Feng, 2003). Many agricultural management practices have detrimental effects on the SOM quantity and quality (Ding et al., 2002). Ekenler (2002) stated that soil microorganisms and their processes are the major contributors to the maintenance of soil quality and the fertility status of soils depends upon both the size and activity of microorganisms. Nutrient cycling in soils involves a series of biochemical processes that are meditated by microorganisms, plant roots and soil animals. These biochemical reactions are catalyzed by enzymes, which are proteins that increase the rate of chemical reactions without undergoing permanent alterations themselves (Tabatabai, 1982). Soil enzymes have been found to correlate to the biochemical cycling of various elements in soils (C, N, and S) and their measurement has been used as specific indexes of microbial activity (Ekenler, 2002).

Objectives

The main objective of this study is to evaluate the effect of tillage types on physical and chemical properties of soil as well as soil enzyme activities.

The specific objectives are:

1) Evaluate the effect of two tillage systems, CT and NT, on organic carbon, pH, bulk density, and phosphomonoesterase and phosphodiesterase enzyme activities.

2) Examine possible relationships among the soil enzymes and the soil parameters.

Materials and Methods

Study Area: Tennessee Valley Research and Extension Center, Belle Mina, Alabama (Figure 1). The experimental plots consist of long-term continuous cotton-corn systems on Decatur silt loam (fine, kaolinitic, thermic rhodic paleudults).

Experimental Design: Split-plot with two treatments, conventional till (CT) and no till (NT), replicated four times at two soil depths (0-5 cm and 5-15 cm).

Sampling: Composite samples were collected for each depth and stored in cool boxes and later transported to the laboratory for analysis.

Lab Analysis: Enzyme activities (acid phosphomonoesterase, alkaline phosphomonoesterase and phosphodiesterase) were analyzed using the methods described by Tabatabai and Bremner (1969). Soil pH was measured using a Fisher brand pH meters, after adding 10 grams of soil and 20 ml of de-ionized water into a specimen cup, mixing and allowing the mixture to equilibrate. Organic carbon was determined by dry combustion on an Elementar Vario EL C/N analyzer. Bulk density (BD) was determined from the mass of the oven-dry (105° C for 24 hours) and volume of undisturbed soil using the following formula: BD = Mass of Oven-dry Soil (g) / Volume of Soil (cm^3).

Results and Discussions

The results showed that the NT soils had significantly higher ($p<0.01$) enzyme activities at both 0-5 and 5-15 cm depths compared to the CT soils, except for the alkaline phosphomonoesterase (Table 1; Figure 2). This difference was more pronounced for 0-5 cm depth.

The percent carbon at 0-5 cm depth was significantly higher ($p<0.01$) for NT compared to CT, but not significantly different at 5-15 cm depth (Figure 2). Phosphomonoesterase activity revealed significant differences between depths for NT (Figure 3).

The percent carbon was positively correlated to the activities of all three enzymes (Table 2) with alkaline phosphomonoesterase showing the highest correlation ($r=0.958$; $p<0.01$). This suggest that enzyme activities could be used as surrogate data for the percent organic carbon.

The bulk density was significantly higher ($p<0.01$) in the 5-15 cm soil depth compared to the 0-5cm depth (Table1).

The alkaline phosphomonoesterase activity was highly correlated ($r = 0.938$ $p<0.01$) with the activities of both phosphodiesterase (Table 2) suggesting that determination of either of enzyme activities suffices.

Figure 1: Experimental site

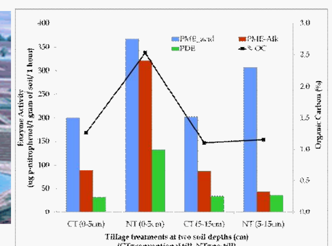

Figure 2: Enzyme Activity and Organic Carbon vs. Tillage for two depths

Table 1. Treatments effects on Enzyme Activity and Soil Parameters

Treatment Combinations	PME_Acid (ug p-nitropenol per 1gram of soil per hour)	PME_Alk (ug p-nitropenol per 1gram of soil per hour)	PDE (ug p-nitropenol per 1gram of soil per hour)	Soil pH	Soil Bulk Density (g/cm3)	% Organic Carbon
No-tillage (0-5cm)	367.385	321.1075	131.87	6.7	1.52	2.53
Conventional-tillage (0-5cm)	200.385	89.0625	31.835	7.0	1.52	1.26
No-tillage (5-15cm)	306.8875	43.65	36.1175	6.3	1.65	1.15
Conventional-tillage (5-15 cm)	202.1925	86.925	33.975	7.8	1.66	1.10
Significance of F test from AOV						
No-tillage vs. Conventional-tillage	**	**	**	NS	NS	**
Soil Depth (0-5cm) vs. (5-15 cm)	**	**	**	NS	**	NS
Tillage X Soil Depth	**	**	**	NS	NS	NS

**= Significance at 0.01 level
PME_Acid = Phosphomonoesterase Acid, PME_ALK = Phosphomonoesterase Alkaline, PDE = Phosphodiesterase

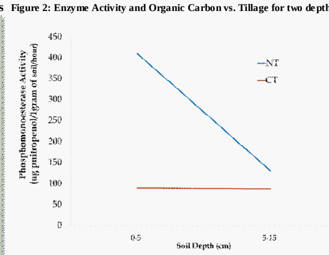

Figure 3 : Phosphomonoesterase Activity vs. Soil Depth

Conclusion

No-till practices have been reported to increase soil organic matter content, which in turn improves the physical and chemical properties of the soil and serve as a nutrient reservoir for plant growth and substrate for soil microorganisms.

In the NT plots, the enzyme activities were significantly higher compared to the CT plots. Likewise the percent organic carbon was significantly higher in NT compared to CT plots (0- 5 cm depth). Furthermore, percent organic carbon was found to be positively correlated with enzyme activities. These results illustrate that enzyme activity could be used as a plausible surrogate for percent soil organic carbon. The percent organic carbon was higher for 0-5 cm depth compared to 5-15 cm depth suggesting organic matter build up closer to the soil surface.

Recommendation

We recommend further research to establish the strength of correlation between enzyme activities and percent organic carbon over a wide range of soils. This could lead to saving of cost and time as enzyme activities are much easier and cheaper to determine that the soil organic carbon.

Table 2: Pearson Correlation Coefficients Between Enzyme Activity, pH, Bulk Density

	PME_ACID	PME_ALK	PDE	PH	Bulk Density	% Carbon
PME_Acid		0.574*	0.652**	-0.503*	-0.314	0.682*
PME_Alk			0.938**	0.064	-0.539*	0.958**
PDE				-0.15	-0.452	0.920**
pH					-0.069	-0.034
Bulk Density						-0.575*
% Carbon						

*=Significance at 0.05 level, **= Significance at 0.01 level
PME_Acid = Phosphomonoesterase Acid, PME_ALK = Phosphomonoesterase Alkaline, PDE = Phosphodiesterase

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