EFFECT OF LONG-TERM TILLAGE AND CROP ROTATION ON MINERAL ASSOCIATED ORGANIC MATTER DISTRIBUTION ALONG THE SOIL PROFILE

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ABSTRACT

Soil carbon (C) stability in soil organic matter (SOM) is critical for mitigating climate change as well as for providing food security. SOM associated with mineral Mineral-associated organic matter (MAOM) has a longer residence time than the light, sand-sized particulate organic matter (POM). Therefore, it is important to study the effect of conservation practices like no tillage and crop rotation on MAOM distribution to better understand carbon stability and persistence. The objective of this study is to understand the effect of long-term tillage and crop rotation on MOAM distribution along the profile. The soil samples are collected from the long-term tillage site established in 1975 at Purdue University Agronomy Center for Research and Education (ACRE) at West Lafayette, IN in 2022 after 46 years of treatment establishment. The experiment was Randomized Complete Block design in a split-plot design with all treatments replicated four times. The treatments combination includes 3 types of tillage practices (No-tillage, chisel plow and mold board plow) and 3 types of crop rotation (continuous corn, continuous soybeans, and corn-soybeans). The result of the study showed that the MAOM C concentration across the soil profile followed the similar trend as SOC concentration (g kg^{-1}) only for no-till. However, MAOM C were significantly lower in the tillage treatments across all the depth. The significantly higher MAOM C in no-till until 50-75 cm explains the evidence of translocation of C towards the subsoil layers. The ratio of MAOM C to the total soil carbon content showed the potential carbon saturation of in the surface layer of no-till system whereas translocation of the carbon in the lower profile.

INTRODUCTION

Soil has the largest pool of carbon and is key in the process of carbon sequestration for minimizing climate change and providing food security. No-tillage and crop rotation are adopted conservation practices for C sequestration. In the literature, the positive to neutral effect of no-till on C sequestration has been documented (Sun et al. 2020). Mineral associated organic matter (MAOM), organic matter attached to silt and clay, is hypothesized to have a longer residence time than the light, sand-sized particulate organic matter. The subsoil layer has a greater potential for C sequestration but very few studies have considered the soil sampling depth below 60 cm (Osanai et al. 2020). None of the studies have considered MAOM studies below the surface layer although knowing the importance of MAOM for long term storage of C. Therefore, it is imperative to understand the long-term impact of residue management and crop rotation on MAOM distribution along the profile in addition to the carbon distribution of the profile.

MATERIALS AND METHODS

The experimental site was established in 1975 at Purdue University Agronomy Center for Research and Education (ACRE) at West Lafayette, Indiana in a fine, silty, mixed, mesic Typic Endoaquoll soil. Plots were arranged in a Randomized Complete Block Split-plot design. The soil samples were collected after 47 years of continuous management. The top 15 cm samples were collected using hand push probes. Sub-surface soil was sampled using a hydraulic probe. Total N and total C percentages were analyzed using a dry combustion method (LECO, St. Joseph, MI). The samples with a pH greater than 6.8 and showing positive response to HCL effervescence test were treated with 1 M HCL to remove the inorganic carbon from the samples. Soil organic matter fractionation was carried out by using size and density fractionation with Sodium polytungstate (SPT) of density 1.8 g/cm^3 (Figure 1.).

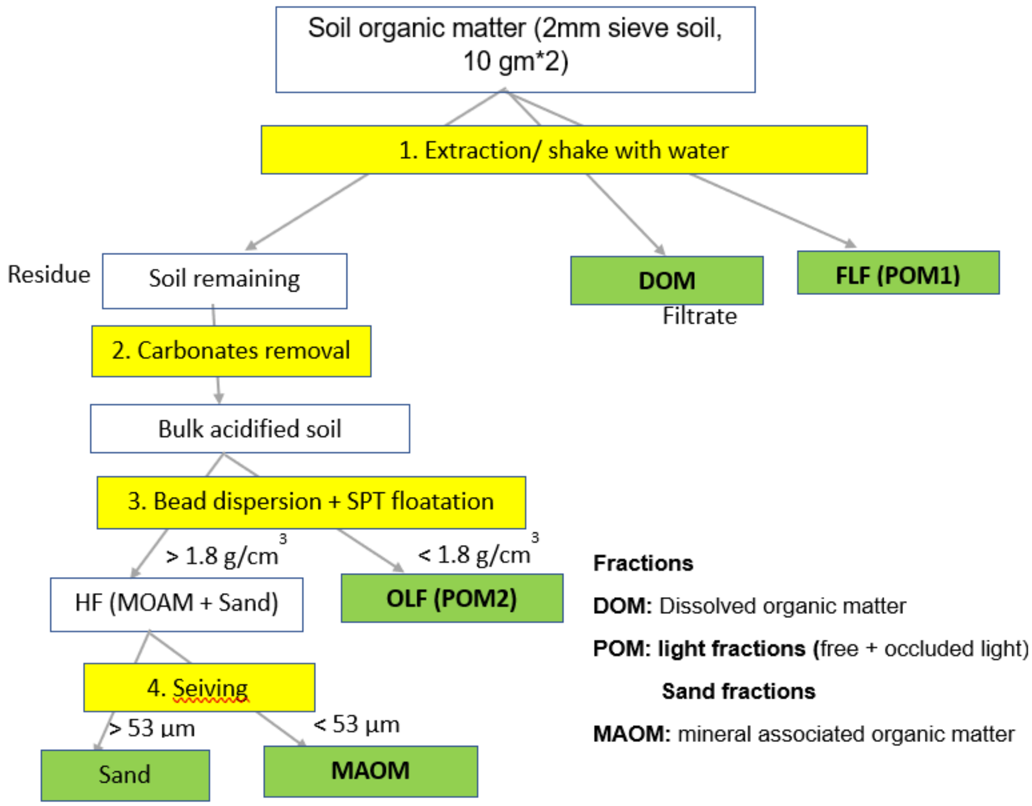

Figure 1: Schematic figure of SOM fractionation

MAOM mass obtained from the SOM fractionation was grounded and analyzed to determine the C and N concentration. MAOM mass is the weight of MAOM (gram) obtained per gram soil used in fractionation, expressed in percentage. Similarly, MAOM C per total SOC is calculated as the ratio of the carbon content in MAOM mass per total SOC expressed in percentage.

RESULTS AND DISCUSSION

The MAOM C is significantly higher in no-till, as compared to chisel plow and MB plow until 75 cm soil depth (Figure 2). Less soil disturbance in no-till increases soil aggregation and soil structure that promotes organo-mineral association. SOC concentration in no-till is equivalent to chisel plow at 5 - 15 cm and MB plow at 15 - 30 cm soil depths (Table 1). This result demonstrates the SOC contribution through residue incorporation within the plow depths. However, MAOM C was greater for no-till relative to the tillage treatments from 5-30 cm, demonstrating that SOC contributions do not always equal MAOM C. The percentage of MAOM C follows a similar trend as MAOM mass (Figure 7 and 8). MAOM C follows a similar trend as SOC concentrations in no-till. However, the trends differ when comparing MAOM C and SOC among tillage treatments, indicating the importance of soil texture for the formation of MAOM C in each depth. There are no significant differences between continuous corn and corn-soybean cropping systems considering SOC and TN concentration, as well as MAOM C and MAOM N concentration.

Table 1: Impact of tillage intensity on soil organic matter (SOC) and total nitrogen (TN) concentration.

Depths (cm)	SOC ($g\ kg^{-1}$)†			TN ($g\ kg^{-1}$)		
	No-Till	Chisel plow	MB plow	No-Till	Chisel plow	MB plow
0 – 5	39.4 a	25.4 b	21.7 c	2.86 a	2.04 b	1.73 b
5 – 15	25.2 a	24.1 a	22.01 b	2.07 a	1.81 b	1.72 b
15 – 30	20.7 a	17.2 b	20.5 a	1.70 a	1.45 b	1.61 a
30 – 50	9.55	9.03	9.08	0.96	0.97	0.85
50 – 75	5.4 a	4.2 b	4.15 b	0.56 a	0.33 b	0.31 b
75 – 100	3.4	3.0	3.14	0.25	0.21	0.23

†Different letters indicate that the values are significantly different across treatments at the given depth

Table 2: Impact of crop rotation on soil organic carbon (SOC) and total nitrogen (TN) concentration.

Depths (cm)	SOC ($g\ kg^{-1}$)†			TN ($g\ kg^{-1}$)		
	C-C	C-B	B-B	C-C	C-B	B-B
0 – 5	30.2 a	29.9 a	26.4 b	2.49 a	2.27 a	1.86 b
5 – 15	24.8 a	24.0 a	22.4 b	2.01 a	1.90 a	1.69 b
15 – 30	20.5	19.3	18.6	1.65 a	1.58 ab	1.53 b
30 – 50	9.90	8.81	8.95	1.02	0.88	0.88
50 – 75	4.57	4.49	4.70	0.39	0.38	0.43
75 – 100	3.04	3.39	3.06	0.22	0.26	0.22

†Different letters indicate that the values are significantly different across treatments at the given depth

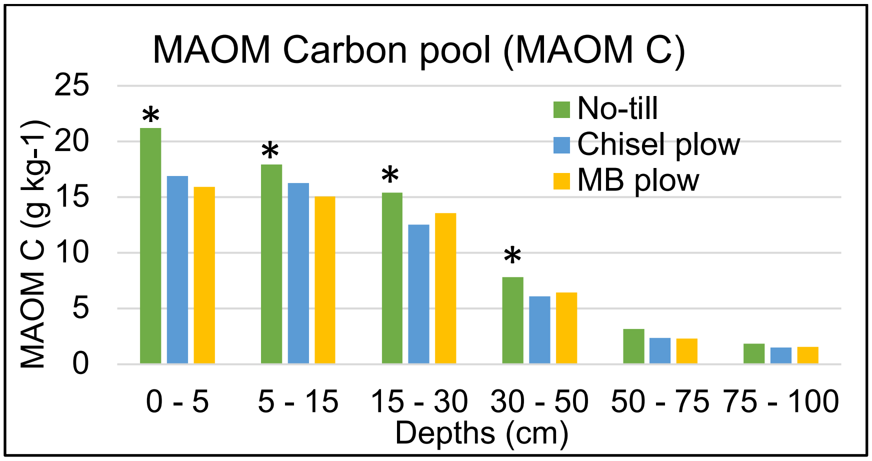

Figure 2: Impact of tillage on carbon concentration of mineral associated organic matter (g kg^{-1})

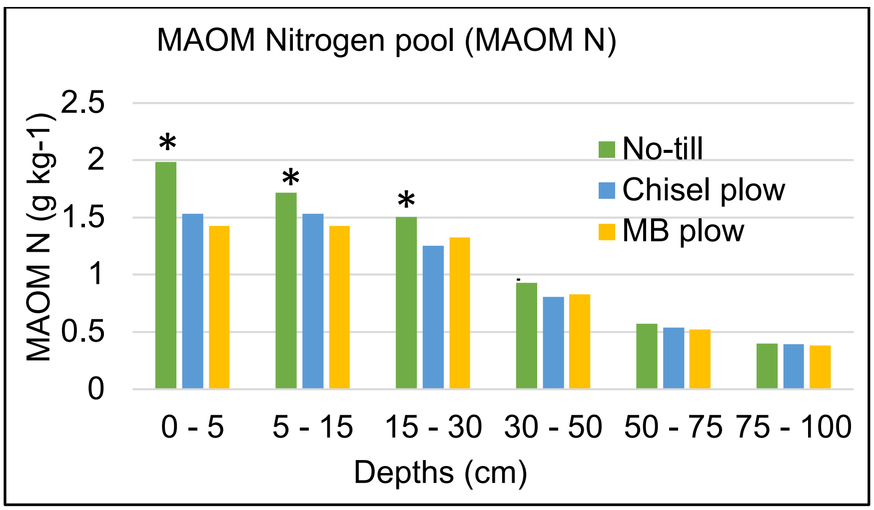

Figure 3: Impact of tillage on nitrogen concentration of mineral associated organic matter (g kg^{-1})

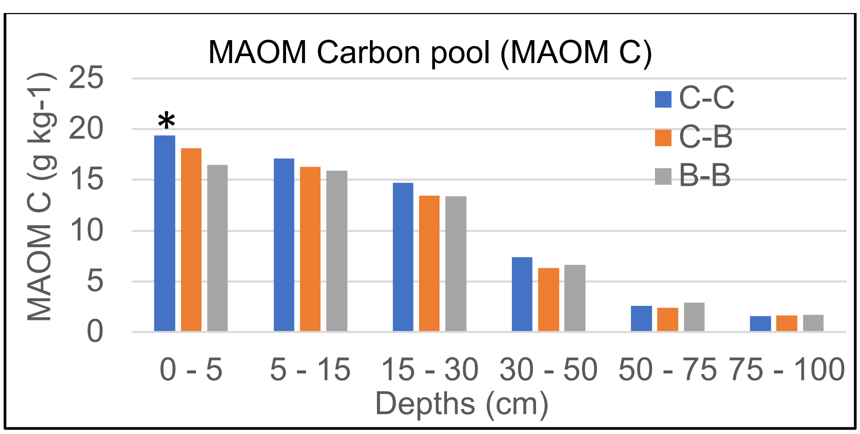

Figure 4: Impact of crop rotation on carbon concentration of mineral associated organic matter (g kg^{-1})

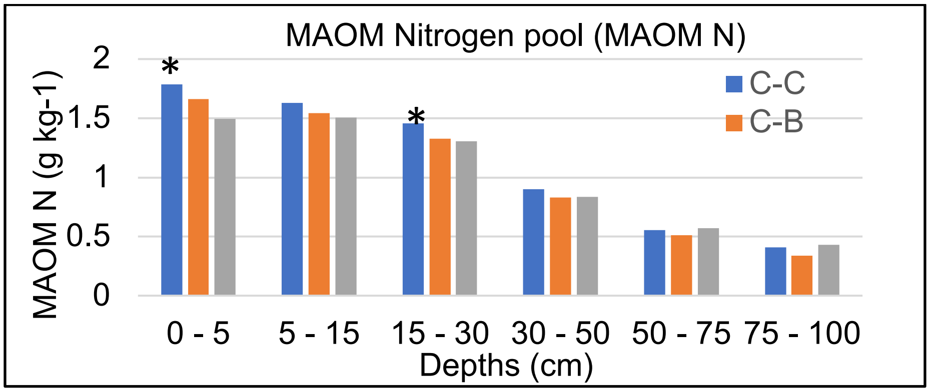

Figure 5: Impact of crop rotation on nitrogen concentration of mineral associated organic matter (g kg^{-1})

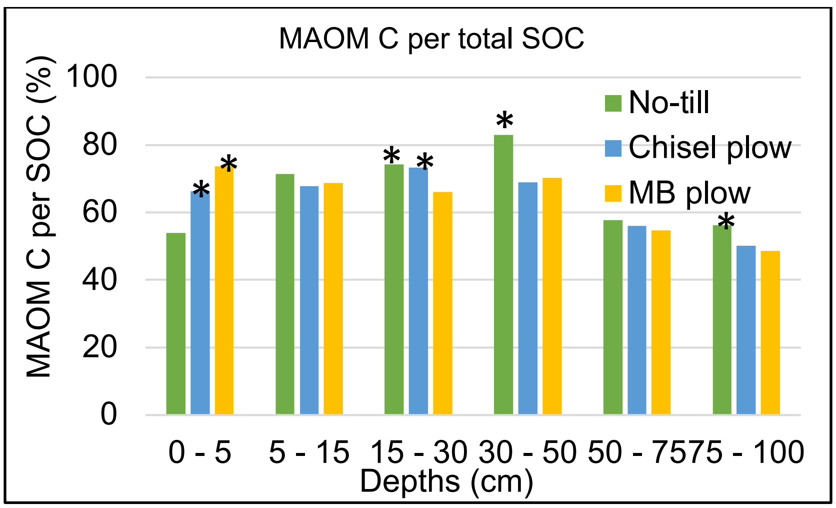

Figure 6: Impact of tillage on MAOM C per total SOC.

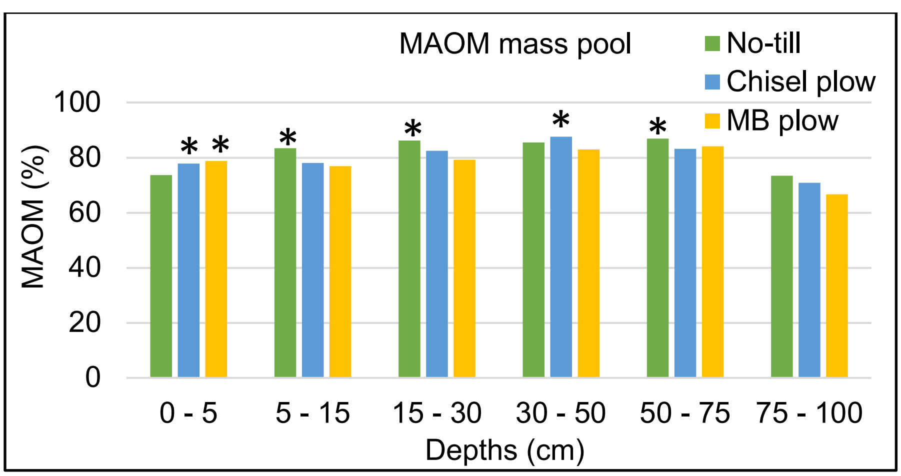

Figure 7: Impact of tillage on MAOM mass.

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