Landscape Position and Depth Affect Microbial Abundance and Community Composition at Three Positions in an Agricultural Landscape

H.J. Konschuh[1,2], A.J. VandenBygaart[3], A. Bedard-Haughn[2], and B.L. Helgason[1]

[1]Agriculture and Agri-Food Canada, Research Centre, Saskatoon, Saskatchewan, Canada; [2]Department of Soil Science, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; [3]Agriculture and Agri-Food Canada, Central Experimental Farm, Ottawa, Ontario, Canada

Abstract

Stabilization/destabilization mechanisms of deep soil carbon are not well understood. A number of different controlling mechanisms are suggested; here we explore differences in microbial abundance and community structure as a controlling mechanism. Microbial abundance and community composition with depth was assessed at three different positions within an agricultural landscape. Microbial abundance was significantly affected by sampling depth, while differences in community structure could be attributed to depth, landscape position, and conditions found within the depositional position. Interestingly, substantial biomass existed at a depth of 81cm in a buried A horizon found in the depositional position.

Introduction

Subsurface soil layers contribute significantly to global soil organic carbon (SOC) stocks (Rumpel & Kogel-Knaber, 2011), however, the controlling mechanisms of subsurface SOC dynamics are not well understood. Recent developments suggest that surface and subsurface soil layers may exhibit differences in terms of SOC stabilization/destabilization mechanisms. One hypothesis proposes differences in microbial abundance and community structure with depth as a controlling mechanism. Our broader study goal is to link community structure and function with carbon cycling across an agricultural landscape.

Materials and Methods

The study site is located north of St. Denis, SK, approximately 40 km east of Saskatoon, within the St. Denis National Wildlife Area (SDNWA). In fall 2010, A horizon samples were collected in 5 cm increments at 3 positions in the landscape (Fig.1.).

Figure 1. Study site located at St. Denis, Saskatchewan. Pits are numbered from 1 to 3 from left to right.

In the buried backslope position (pit 3), radiocarbon dating showed the original A horizon to be overlain with 30-40cm of depositional material in the last 50-60 years (Fig.2; Table 1).

Figure 2. Buried backslope position (pit 3) showing evidence of 30-40 cm of depositional material overlaying the original A horizon

Table 1. A Horizon Characteristics

Pit number	Position	Horizon Designation	Depth	Colour	Texture
			cm		
1	Eroded shoulder	Ap	0-15	10YR3/2	CL
		AB	15-29	10YR4/2	L
2	Eroded backslope	Apk	0-17	10YR3.5/2	L
		Apk	17-27	10YR2/2	
		Ahbk	27-37	10YR2/2	
		ABk	37-59	10YR3/3	
3	Buried backslope	Apk	0-26	10YR3/1	L
		Apkb	26-36	10YR2/2	
		Ahkb	36-81	10YR2/1	

For each 5 cm sampling increment, carbon and nitrogen content, ^{137}Cs deposition analysis, and phospholipid fatty acid analysis (PLFA) was completed. PLFA's were extracted from 4g of soil and identified using GC-FID and MIDI software (Helgason, et al. 2010). A linear mixed model was used to perform analysis of variance (ANOVA) (SPSS v.19.0) and non-metric multidimensional scaling (MDS) was performed using PC-Ord v.5.10

Results and Discussion

Microbial Abundance

Total PLFA was significantly affected by sampling depth, but was not different between landscape positions ($p>0.05$). Total PLFA and SOC were highly correlated with depth at all 3 landscape positions ($r=0.40$; $p<.001$)(Fig. 3).

Total PLFA within the buried A horizon in pit 3 was substantial, indicating the presence of viable biomass. Though conditions for growth are sub-optimal, SOC deep in the profile seems to be supporting substantial microbial *biomass*, as indicated by the fact that total PLFA in the buried horizon was not significantly different than the top 10 cm ($p>0.05$)(Pit 3, Fig. 3.)

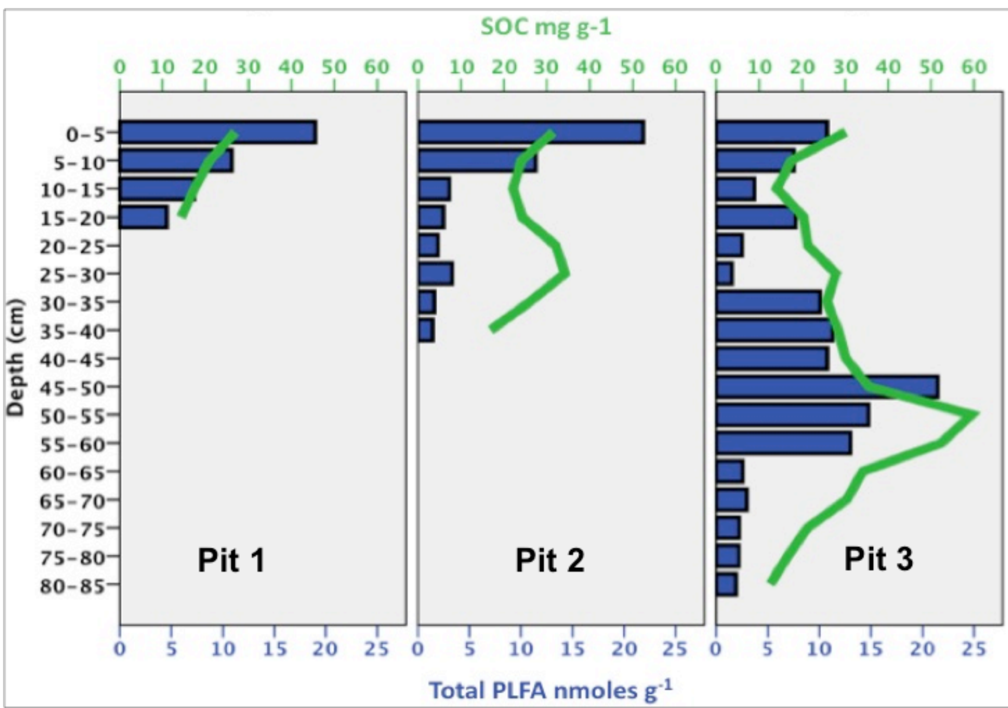

Figure 3. Total PLFA and SOC at Pit 1, Pit 2, and Pit 3

Microbial Community Structure

Differences in community structure could be attributed to depth, landscape position, and conditions within pit 3. Community profiles at pits 1, 2, and 3 differed significantly with depth, which accounted for 22% of variability. This can likely be attributed to resource gradients that typically occur with depth. Total N (r=0.45), protozoa (r=0.45), and SOC (r=0.42) were all positively correlated with community structure in surface depths, while stress 2(r=0.39) was positively correlated with communities found at 15-20cm depths (B, Fig.4).

Microbial community structure within pit 3 was highly varied with depth (0-20cm) and was the dominant source of variability (A+B, Fig.4). This can be seen along axis 1, which accounts for 62% of variability in this analysis. This is most likely regulated by complex factors that are not related to a depth gradient. The least variability in community structure (12.5%) was due to landscape position (A, Fig.4).

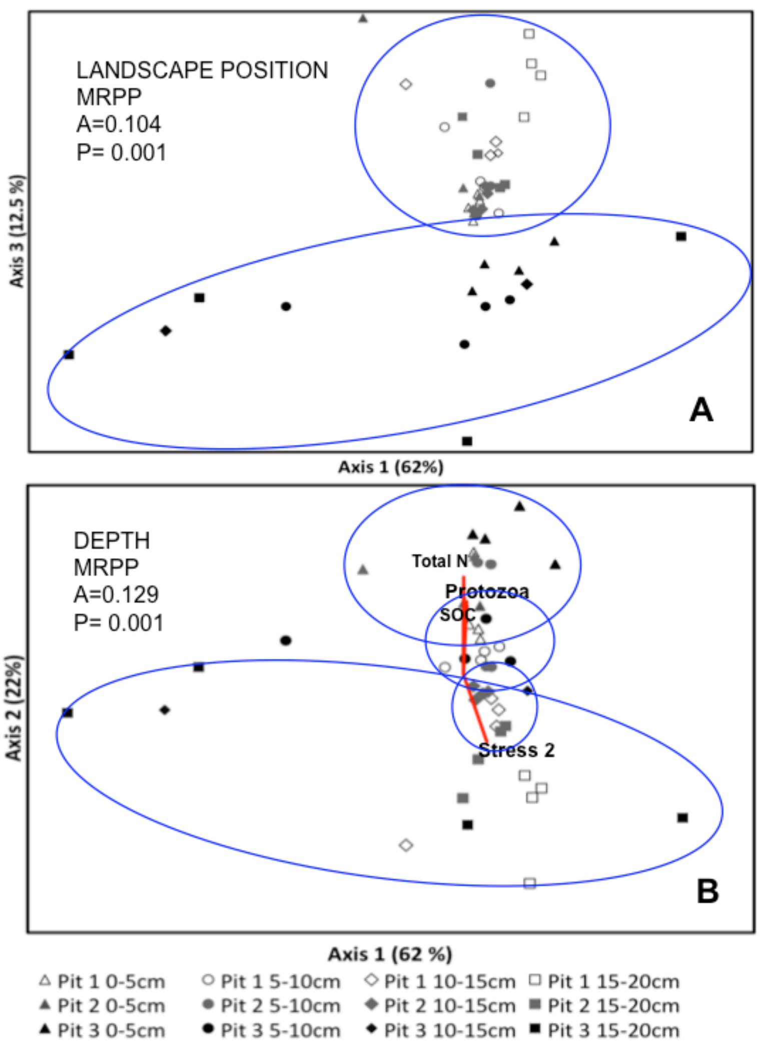

Figure 4. Nonmetric multidimensional scaling (NMDS) analysis of communities found in Pits 1, 2, and 3; A) Axis 1 vs. Axis 3, and B) Axis 1 vs. Axis 2.

Additional Research

Results are pending from a carbon mineralization experiment conducted to compare the availability and susceptibility to loss of both buried and surface SOC using samples taken from the buried backslope position.

References

Helgason, B.L., Walley, F.L., and J.J. Germida. 2010. Soil Biol. And Biochem. 42:2192-2202.

Rumpel, C., and I. Kögel-Knabner. 2011. Plant Soil 338:143-158.