Effect of management on soil organic matter distribution near intra-aggregate pores as determined by µCT images

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Introduction

Soil organic matter (SOM) is vital for sustainable agriculture. In addition to positively benefiting several soil characteristics that improve crop yield (soil aggregation, cation exchange capacity, soil water holding capacity, and soil drainage), SOM, as a major terrestrial sink of CO_2, can help to mitigate climate change.

We investigated three contrasting land use and management systems that are known to influence SOM:

- Conventional tillage (T1) utilizing tillage and no cover when not actively growing a cash crop.
- Organic (T4) still uses tillage, but keeps cover all year.
- Primary succession (T7) has cover year round and does not use tillage.

SOM storage capacity increases from T1 to T4 to T7.

SOM storage is believed to occur within soil aggregates, but detailed mechanisms are still lacking. It is assumed that intra-aggregate pore structure is important to SOM storage as the pores regulate access to carbon sources for microorganism, as well as their mobility.

The objectives of this research is to determine the effect management has on grayscale values (GVs) at different distances from image identified pores in soil aggregates. We assume that GVs correlates to SOM, but low GVs can also result from micropores, mineralogy, etc.

Methods

- 10-11 aggregates of 5-6 mm size from >20 year corn-soybean-wheat rotation from T1, T4, and T7 treatments at the Long Term Ecological Research site, KBS, Hickory Corners, MI.
- Aggregates were mounted and scanned at 13 µm resolution at Advanced Photon Source, Argonne National Lab, Argonne, IL
- From the gray scale images, 3 200x200x200 voxel cubes were taken from each aggregate (n=96).
- Using 3DMA and indicator kriging, pores within the aggregates were identified.
- Using ImageJ, layers at 5, 10, and 15 voxels were obtained. The first voxel past the identified pores were also labeled as "pores" to avoid partial volume effects. To account for high density bias, GV 255 was also removed.
- Histograms of each layer and the bulk cube (minus pores) were obtained and analyzed in SAS using ANOVA statistics.

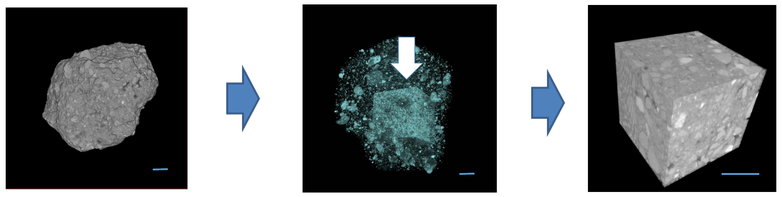

Figure 1: 3-D Image of a whole soil aggregate (left), a whole aggregate with the cube indicated with a white arrow (middle), and 3-D image of a cube used in the analysis. Blue lines indicate 1.3 mm.

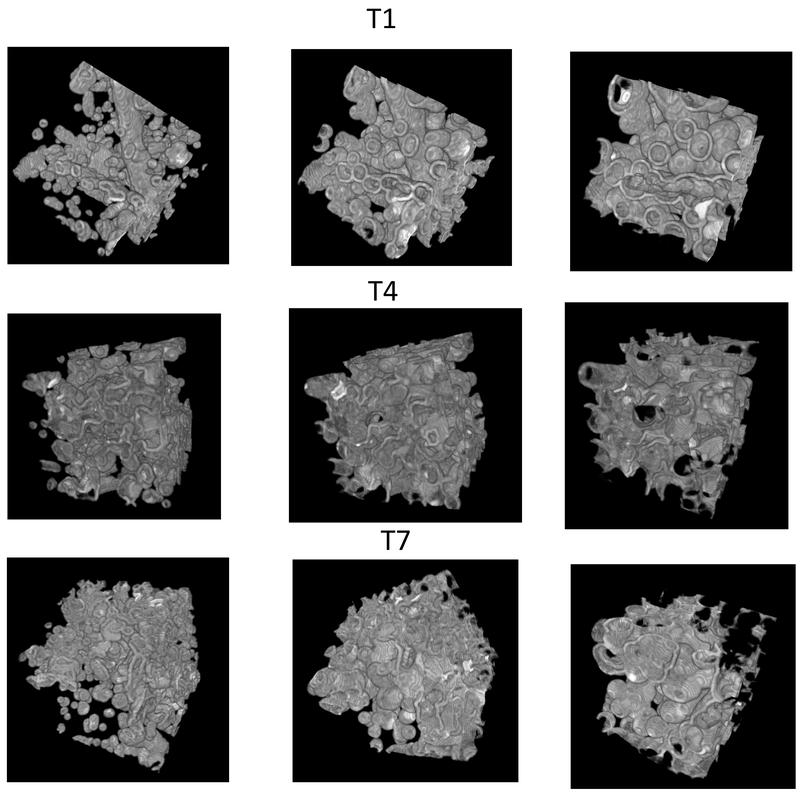

Figure 2: 3-D images of T1 (top), T4 (middle), and T7 (bottom) at distances 5 voxels (left), 10 voxels (middle), and 15 voxels (right).

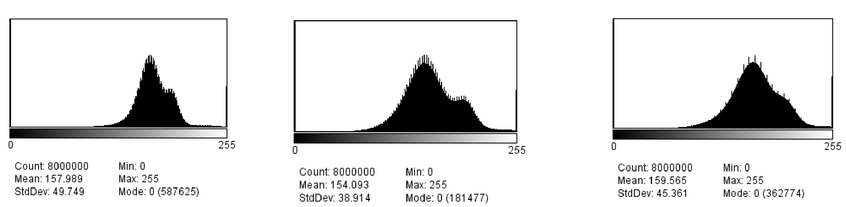

Figure 3: Histograms of total cubes for T1 (left), T4 (middle), and T7 (right) used as a base comparison.

Results and Discussion

Treatment	Distance 5	Variance 5	Distance 10*	Variance 10	Distance 15	Variance 15
T1	-8.03a	689a	-0.34a°	554a	1.43a	530a
T4	-7.76a	849b	0.65b	725b	3.09b	697b
T7	-8.65a	798b	0.019ab°	669b	2.61b	649b

Different letters in columns indicate significant differences at α=0.05. *T1 and T4 is significantly different at α=0.1. °Indicates no difference from bulk.

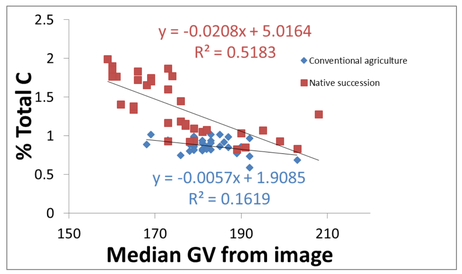

Figure 4: Graph from M.S. thesis of K. Ananyeva (MSU, 2012) showing correlation between GVs and SOM.

Consistent with previous findings (unpublished), T4 and T7 have more variability in GVs than T1. At 5 voxels, the equally lower GVs are independent of treatment and may indicate concentration of SOM near pores, as GVs have been shown to correlate to SOM (Figure 4). The lighter GVs at 15 voxels, may indicate a lack of SOM or perhaps micropores further from image identified pores.

Conclusion

- All three treatments have lower GVs concentrated near image identified pores. This may possibly indicate SOM concentration around pores.
- There is more variation in GVs in T4 and T7 than in conventional tillage.
- T4 and T7 are lighter than the bulk at 15 voxels, possibly indicating less organic matter migration into the aggregates of T4 and T7 than T1. Another possibility is a lack of micropores at this distance.
- Further research is necessary to determine the exact cause of the lighter than bulk GVs at 15 voxel

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