Using computer microtomography to look at cover crop effects at the soil aggregate scale

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Introduction and Rationale

- Maintaining soil quality is a main objective of sustainable agriculture. Increasing soil organic matter (SOM) is important to soil quality because it affects many soil properties (ex. soil aggregation, water holding capacity).
- Increasing SOM is a well documented benefit of including cover crops in crop rotations. However, how and why cover crops increase SOM is still not fully understood. This prevents the development of optimum strategies for cover crop management..
- SOM protection within soil aggregates is one of the mechanisms of SOM increase. This research uses aggregate images from computer microtomography (µCT) to look at how and why cover crops increase SOM.

Experimental Procedure

- 11 aggregates of 0.2 to 0.25 inch (5-6 mm) size from >20 year corn-soybean-wheat rotation with and without cover crops from the Long Term Ecological Research site, KBS, Hickory Corners, MI.
- Aggregates mounted and scanned at Advanced Photon Source, Argonne National Lab, Argonne, IL

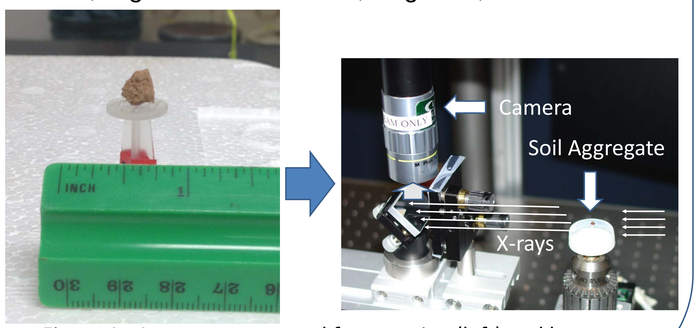

Figure 1: Aggregate mounted for scanning (left) and how an aggregate is scanned (right).

Experimental Procedure Cont.

- Obtain gray scale images at 511 µin (13 µm) resolution
- Select 5 100x100x100 voxel (pixel with volume) cubes
- Run on MSU High Performance Computing Center to obtain 3-D variograms
- Analyze differences in images of aggregates from soil with and without cover crops using variogram characteristics

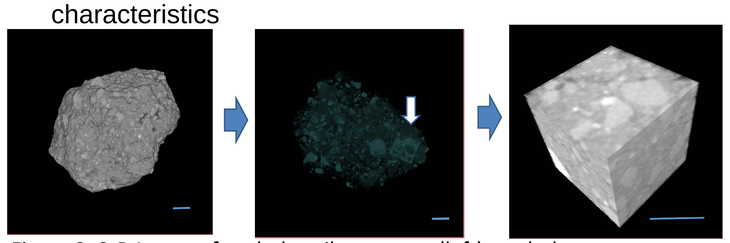

Figure 2: 3-D Image of a whole soil aggregate (left), a whole aggregate with the cube indicated with a white arrow (middle), and 3-D image of a cube used in the analysis. Blue lines indicate 0.05 inch (1.3 mm).

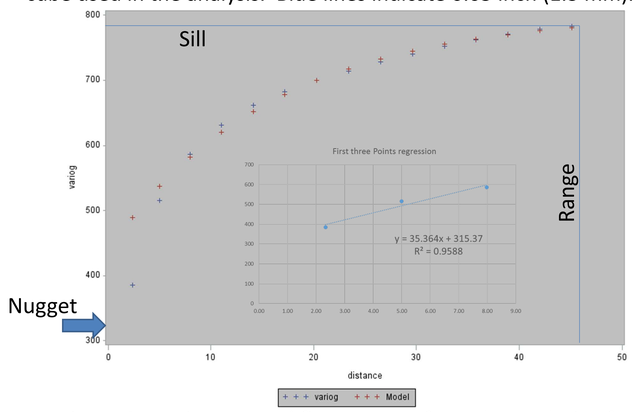

Figure 3: Variogram and fit produced from the analysis of soil aggregate cubes with spatial characteristics shown. Inset is the linear regression of the first three points of the variogram to better estimate the nugget. **Nugget** is the point at which the graph intersects the y-axis. It is an indication of variation at a scale smaller than the voxel. **Sill** is where the graph flat lines. It indicates the amount of spatial variation. **Range** is the distance where the sill is reached. It indicates how far away two points must be to no longer be spatially similar. **Nugget to Sill ratio** indicates how much of the spatial variation takes place at distances less than the image resolution (511 µin/13 µm).

Results and Discussion

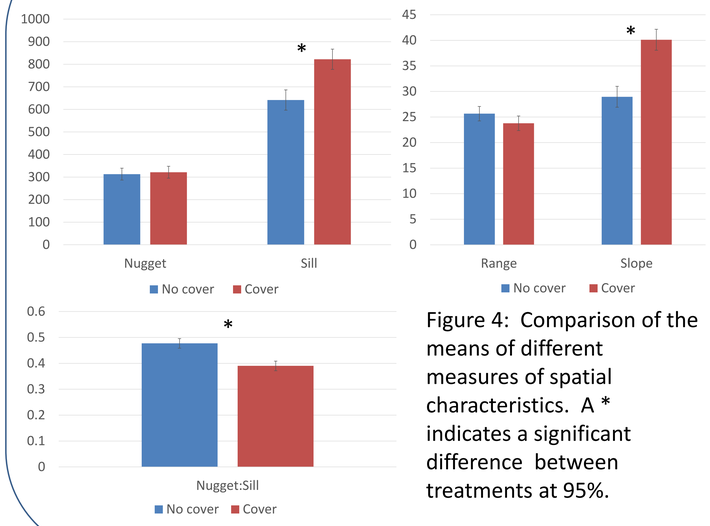

Figure 4: Comparison of the means of different measures of spatial characteristics. A * indicates a significant difference between treatments at 95%.

Conclusions

- Aggregates from soil under >20 years of cover crop based management are different from aggregates from conventional management. Cover crop management shows:
  - Overall spatial variability is higher (larger sill)
  - Spatial variation is higher at shorter distances (larger slope and smaller nugget to sill ratio)
- Greater variability exists in cover crop aggregate soil material than conventional management. We hypothesize this variation is due to:
  - Increased diversity of SOM sources
  - Changes in access to SOM by microorganisms
- Determining the reason(s) for the spatial variability can result in better cover crop recommendations

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