Soil Redox Potential and Carbon Fractions in Manured and Cover-Cropped Soils under Reduced Tillage

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Measuring Redox

- Redox potential (Eh) is a measure of the tendency of atoms to gain electrons (be reduced) or lose electrons (oxidize). Redox potential in soil depends on water content and microbial consumption of O_2. Eh has been tracked as a factor in the functioning of hydric soils, but it has received little attention in agricultural settings.
- Redox probes were custom made by MVH consulting (Netherlands) with sensors 4 and 10cm below the soil surface to account for residue decomposition and activity within the surface horizon.
- Continuous measurements were taken for at least one week, occasionally longer to capture the return to consistent values after a rainfall event.

Diurnal Variations

- In a 1992 study of redox potentials in tilled and no-till soils in South Dakota, Clay et al.[1] observed that tillage type influenced diurnal cycles of soil temperature and redox.
- Below are line graphs showing continuous redox measurements of soils in a long-term tillage experiment (40yr+) at Penn State's Agronomy Farm (Rock Springs) over a 5-day period in August 2017. The blue and orange lines show redox values measured by two separate probes inserted in the same field.

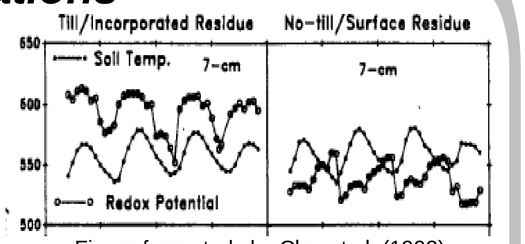
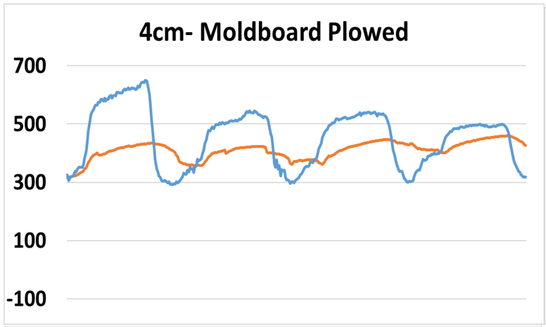
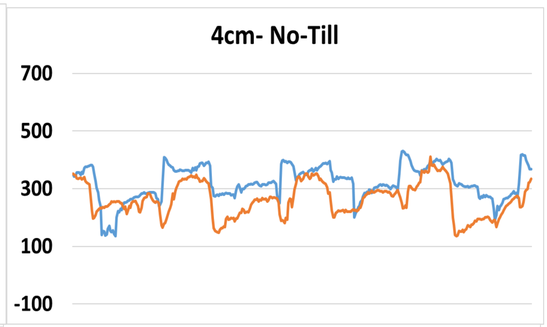
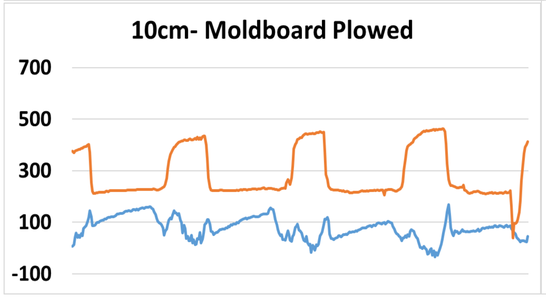
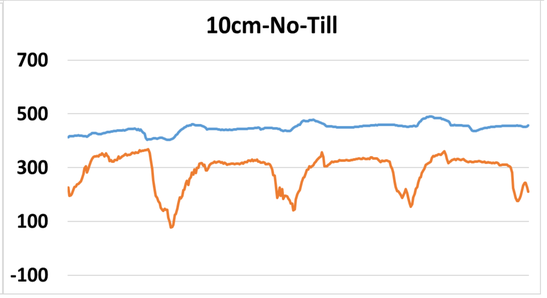


Figure from study by Clay et al. (1992)







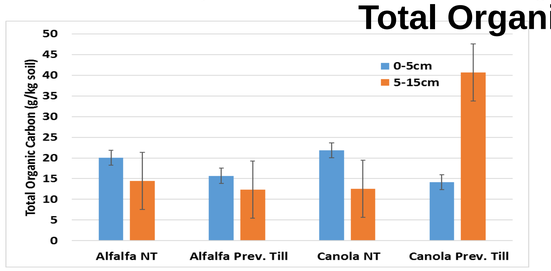


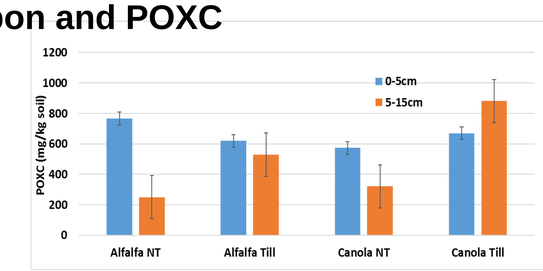
- Redox measurements at the same depth in one field (probes < 2 m apart) showed clear diurnal patterns and varying by as much as 400 mv.
- At 4-cm depth, no-till soils had lower redox values than plowed soils, which could result from greater amounts of crop residues on the surfaces of these plots.
- At 10-cm depth, soil redox values were generally higher in no-till soils than in plowed soils, indicate spatial differences in microbial activity at different depths.

Carbon Content

- The USDA-NESARE Sustainable Dairy Cropping System (SDCS) at Penn State Agronomy Farm combines no-till, dairy manure application and cover cropping to enhance soil carbon content and soil health.
- In one rotation, plots were tilled in 2012, the only tillage event in the experiment's 6-year history.
- In 2017, soil samples were taken after cover-crop termination from replicate plots that either had the 2012 tillage or no tillage for 6 years. Two different cover crops were alfafa/orchard grass mix and canola.
- Carbon was analyzed in these treatments because of concern from grower-advisors that one tillage event could substantially reduce soil carbon with long-lasting effects.

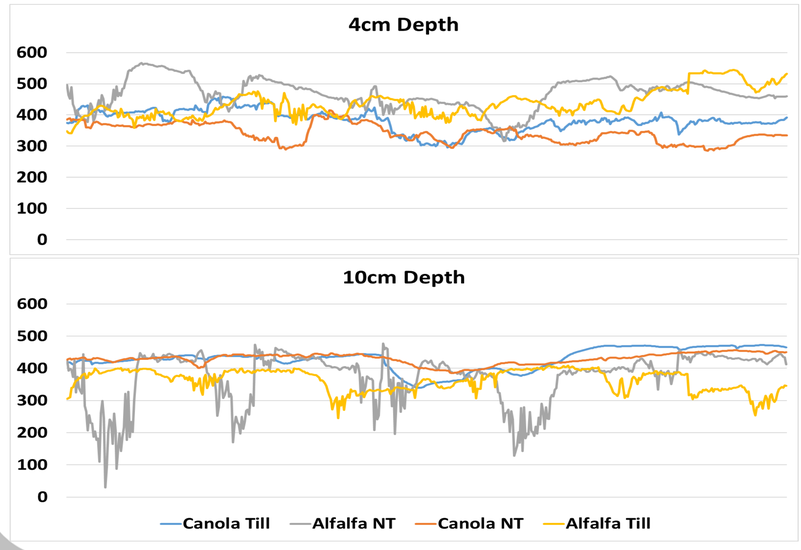
Total Organic Carbon and POXC





- TOC and POXC were determined with a Thermo elemental analyzer and the Weil[3] "Permanganate Oxidizable Carbon" protocols, respectively.
- The soils not receiving tillage all have higher amounts of Total and Labile (POXC) carbon at the 0-5cm depth. This is attributed to carbon stratification not usually present in plots receiving tillage. Plots receiving tillage did not have significantly higher carbon than no-till treatments.

Redox Potentials Over 6 Days After Cover Crop Termination



These graphs depict the average redox potentials measured in 2 plots (2 probes per plot) of each treatment.

The diurnal variation in redox for no-till plots at 10 cm depth following alfalfa/orchardgrass is most notable, ranging from 30 mV to 480 mV. Such strong diurnal change was not observed with terminated canola.

In these same plots, mean redox values were higher at the 4 cm depth than at 10 cm depth.

These preliminary observations suggest that deeper rooting cover crops may respond differently to a single legacy tillage event.

Conclusions and Future Research

- The plots having one legacy tillage did not have significantly different amounts of organic carbon than plots that had not been tilled. This suggests that carbon was not lost with one single tillage event in this cropping rotation, but rather redistributed throughout the profile.
- Redox potential influences microbial activity and nitrogen cycling. By further understanding values of redox potential, management recommendations could be developed to encourage nitrogen retaining pathways.
- Further research will study plots receiving more frequent tillage, as well as soil properties such as nitrate, ammonium, and additional carbon fractions to evaluate the potential influence on redox.

[1] Clay, D. E., Clapp, C. E., Molina, J. A. E., & Linden, D. R. (1990). Soil Tillage Impact on the Diurnal Redox-Potential Cycle. *Soil Sci. Soc. Am. J.*, *54*: 516–521.
[2] Matejovic, I. (1993) Determination of carbon, hydrogen, and nitrogen in soils by automated elemental analysis (dry combustion method). *Communications in Soil Science & Plant Analysis* 24(17-18):2213-2222.
[3] Weil, R. R., Islam, K. R., Stine, M. A., Gruver, J. B., & Liebig, S. E. S. (2003). Estimating Active Carbon for Soil Quality Assessment: A Simplified Method for Lab and Field Use. *American J. of Alternative Agric.*, *18*:2–16.

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