Impacts of N Fertilizer Addition on Soil Structure, C and N Dynamics, and Microbial Populations in Conventional and Organic Farming Systems

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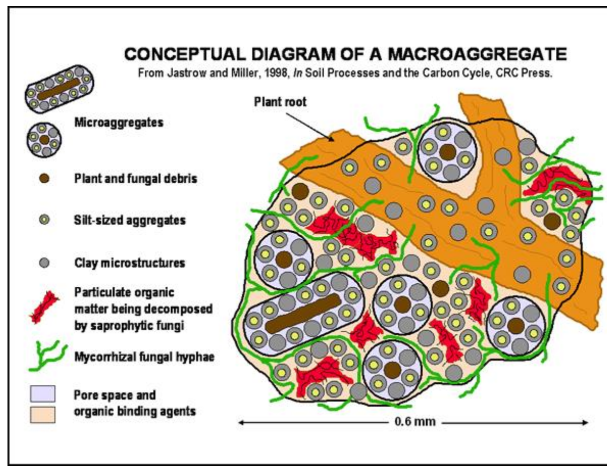
We need to link fundamental soil characteristics (soil chemistry, soil structure) to the presence and activity of microbes (archaea, bacteria, fungi). In view of this overarching goal, in this experiment we studied the microbiological, chemical and physical characteristics of microaggregates in organic and conventional tomato plot soils at Russell Ranch.

- Soil aggregates are the fundamental building blocks of soil and provide characteristics of soil structure. Aggregate stability is an indicator of organic matter content, biological activity, and nutrient cycling in soil . The particles in small aggregates (50-250 µm) are bound by older and more stable forms of soil organic matter (SOM). Microbial decomposition of fresh organic matter releases products (that are less stable) that bind small aggregates into large aggregates (> 2-5 mm). Aggregate stability is critical for infiltration, root growth, and resistance to water and wind erosion. Greater amounts of stable aggregates suggest better soil quality.
  - mineral-organic complexes (<50 µm)
    - surface reactivity
    - chemical stabilization of SOM
  - microaggregates (50-200 µm)
    - water retention
    - physical protection of SOM
    - formed by bacteria and archaea
  - macroaggregates (>200 µm)
    - matrix for microaggregate formation
    - microfaunal habitat
    - soil porosity and aeration
    - formed by fungal hyphae and plant roots



Water stable aggregate distribution with depth

- higher microaggregate numbers in organic treatments

	Organic			Conventional		
Depth (cm)	Silt & Clay <53 µm	Microaggregates 53-250 µm	Macroaggregates >250 µm	Silt & Clay <53 µm	Microaggregates 53-250 µm	Macroaggregates >250 µm
0-15	57% ± 5%	41% ± 5%	1.6% ± 0.5%	65% ± 7%	34% ± 7%	0.9% ± 0.2%
15-30	60% ± 1%	38% ± 1%	1.8% ± 0.8%	70% ± 4%	29% ± 4%	1.0% ± 0.1%
30-60	71% ± 2%	27% ± 1%	1.3% ± 0.5%	73% ± 3%	26% ± 3%	0.7% ± 0.1%

Total microbes in water stable microaggregates

- total microbe, bacteria and archaea in conventional treatments expressed as % of organic treatments
- conventional biomass ≤50% of organic treatment biomass

	Conventional (as % of organic)		
Depth (cm)	Total microbes	Bacteria	Archaea
0-15	50%	51%	32%
15-30	43%	43%	47%
30-60	43%	44%	30%

Denitrifiers: how many can denitrify to N_2?

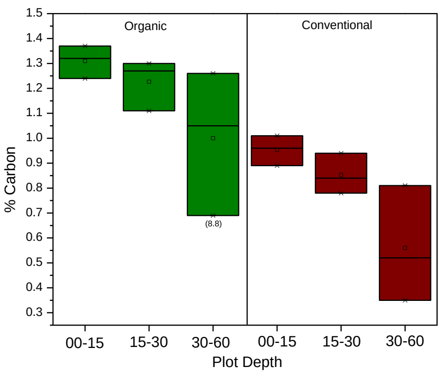
- *nosZ* – critical for last step of denitrification (N_2 production from N_2O)
- higher proportion of denitrifiers in organic system can produce N_2 as final product

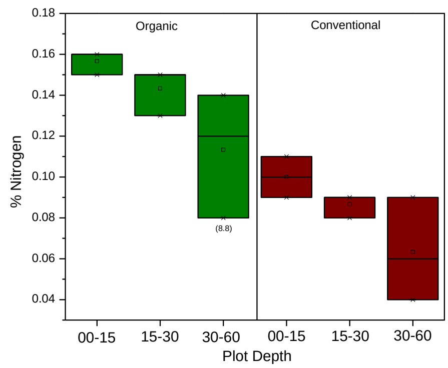
	nosZ as % of total denitrifiers	
Depth (cm)	Organic	Conventional
0-15	56% ± 12%	38% ± 4%
15-30	55% ± 12%	28% ± 8%
30-60	76% ± 36%	20% ± 9%

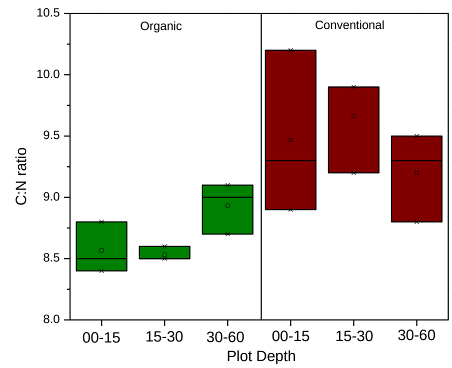
Permanganate Oxidizable Carbon (POxC)= Estimate of labile carbon

- Fraction of the SOM pool (2 to 5 yr residence time)
- Includes the C most readily degradable by microorganisms as well as that bound to soil minerals
- Generally the organic plots had greater labile carbon
- Labile carbon consistently decreased with depth
- POxC trends consistent with measurements of dissolved organic carbon and total microbes

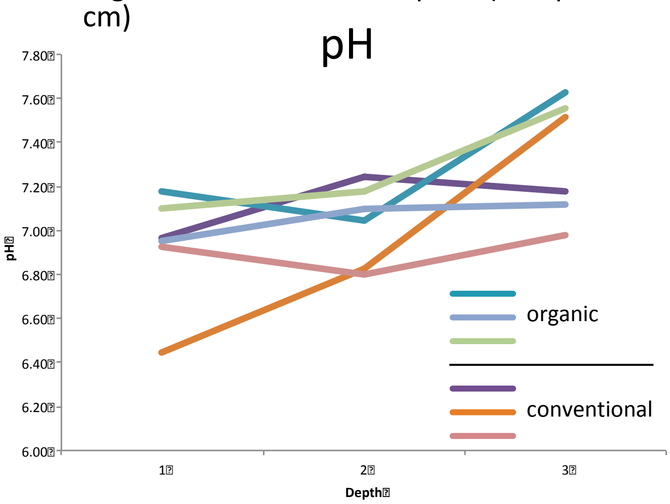
Total Carbon and Nitrogen







- Higher % C in organic plots
- % C decreases with depth
- Higher % total organic C in the organic microaggregates
- Greater variability with depth for both treatments
- Significant differences in C:N ratios between organic and conventional plots (except 30 –60 cm)



- On average pH increased with depth
- Lower pH in conventional plots

- Higher % N in organic plots
- % N decreases with depth
- Higher % total organic N in the organic microaggregates
- Greater variability with depth for both treatments

Ammonia

- Conventional soils have more ammonia, especially in top horizon
  - ammonia fertilizer applications
- Drop in ammonia between horizons is high in conventional and low in organic soils
  - Organic soils less stratified
  - Conventional stratification from continued external additions

Nitrate

- Nitrate content decreases with depth
- Organic soils have more nitrate
  - same behavior in ammonia measurements <u>and</u> nitrate concentrations

Conclusions

Through a history of compost application and other organic farming practices, the organic tomato plots at Russell Ranch have achieved higher water stable microaggregate numbers. In turn, these microaggregates have higher indicators of biological activity, including denser microbial populations and higher carbon and nitrogen concentrations. Indicators of specific activity such as denitrification genes suggest that the microbial populations have diverged, with a much lower proportion of the conventional treatment soil microbes capable of carrying out denitrification to completion.