Relationships between Carbon Input, Aggregation, and Soil Organic Carbon Stabilization in Sustainable Cropping Systems

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Introduction
Approximately 10% of the earth’s soil C is stored within agricultural ecosystems. Because farming systems hold promise for sequestering C, their sustainability, environmental impact, and potential role in mitigating rising atmospheric CO₂ concentrations must be addressed. Our current challenges are to quantify the mechanisms, capacity, and longevity of agricultural lands as C sinks. Agronomic practices that influence yield and, therefore, affect the proportion of crop residues returned to the soil (e.g. cover cropping, irrigation, fertilizer addition, and compost application) are likely to influence soil organic carbon (SOC).

Objectives
Determine the influence of C input on C sequestration in SOC fractions and evaluate how aggregation (MWD) relates to SOC and cumulative C input across 10 different cropping systems at LTRAS/SAFS.

Hypotheses
Hypothesis: Total soil organic carbon (SOC) increases with increased carbon input.
Hypothesis: Increased C input results in greater aggregate stability.
Hypothesis: Soil Carbon is preferentially stabilized in microaggregates within macroaggregates.

Methods
- Sampled soils (0-15 cm depth) from all ten cropping systems at the LTRAS/SAFS in April 2003.
- Soils were analyzed for organic C content and aggregation stability by the slaking methodology.
- Archived soils from years of establishment (1993) of experiment were analyzed for organic C content.

Cropping Systems at LTRAS

<table>
<thead>
<tr>
<th>Cropping System</th>
<th>Even Years</th>
<th>Odd Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfed wheat control (RWC)</td>
<td>rainfed wheat</td>
<td>rainfed wheat</td>
</tr>
<tr>
<td>Rainfed wheat/legumes (RWL)</td>
<td>rainfed wheat</td>
<td>rainfed wheat</td>
</tr>
<tr>
<td>Irrigated wheat control (IWC)</td>
<td>irrigated wheat</td>
<td>irrigated wheat</td>
</tr>
<tr>
<td>Irrigated wheat/legumes (IWZ)</td>
<td>irrigated wheat</td>
<td>irrigated wheat</td>
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<tr>
<td>Irrigated wheat/legumes (IWY)</td>
<td>irrigated wheat</td>
<td>irrigated wheat</td>
</tr>
<tr>
<td>Conventional wheat/legumes (CWL)</td>
<td>soil treated</td>
<td>soil treated</td>
</tr>
<tr>
<td>Conventional wheat/legumes (CCL)</td>
<td>soil treated</td>
<td>soil treated</td>
</tr>
<tr>
<td>Organic/legumes (OCL)</td>
<td>soil treated</td>
<td>soil treated</td>
</tr>
</tbody>
</table>

Carbon Input Calculations
- Corn residue (kg DW/ha) = 1.0577 x grain DW + 503.37 (R² = 78)
- Corn roots (kg DW/ha) = 0.23 x aboveground biomass DW
- Tomato residue (kg DW/ha) = 0.001 x (tomato yield DW) + 0.049 x tomato yield DW + 0.33 (R² = 0.97)
- Tomato roots (kg DW/ha) = 0.22 x aboveground biomass DW
- Winter wheat residue (kg DW/ha) = 1.06 x grain DW + 388.97 (R² = 68)
- Wheat roots (kg DW/ha) = 0.22 x aboveground biomass DW

Results
SOC sequestration was linearly related to C input levels across cropping systems in this typical Californian soil characterized by low soil carbon levels. The low input systems rather lost SOC than sequestered SOC over the 9 years of the experiment. The organic cropping system accumulated the greatest amount of SOC, but had also a disproportional higher level of C inputs.

Hypothesis 2
SOC and Aggregate Stability Relationships of 10 Cropping Treatments at LTRAS

The linear increase in mean weight diameter (MWD) with increasing SOC level indicates the close relationship between aggregate stability and the accumulation of SOC.

Methods (continued)

Soil Fractionation

<table>
<thead>
<tr>
<th>Microaggregate</th>
<th>Macroaggregate</th>
<th>Soil fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-5 mm</td>
<td>2-0.25 mm</td>
<td>100 g air dried soil</td>
</tr>
<tr>
<td>0.25-0.05 mm</td>
<td>0.05-0.005 mm</td>
<td>100 g air dried soil</td>
</tr>
</tbody>
</table>

Carbon Input Calculations

The majority of the increase in SOC associated with the macroaggregates was within the microaggregates occluded within the macroaggregates.

Conclusion
All 3 of our hypotheses are corroborated by the results and indicate that the potential of C sequestration across cropping systems is strongly controlled by C inputs and governed by the stabilization of SOC in microaggregates occluded within stable macroaggregates.