CCRA-9 2014 update

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The question for CCRA 09...

• Do CAPS improve soils?
  • Improve soil fertility?
  • Increase amounts of SOC?
CCRA 09

• We know that CA practices should increase SOC and improve soil fertility

• But…..
The upshot…

• Measuring changes in gross soil C or N is not likely to reflect changes in SOC during <5 years of reduced tillage

• So, we have chosen to focus on
  • Rates of processes that may be sensitive to CAPS
  • Changes in soil C fractions
CCRA Activities

1. Deploy automated chambers to measure soil CO$_2$ fluxes in CAPS experiments in Kenya
   • Installed at SANREM site in Kitale, Kenya, June 2013

2. GIS agroclimatology comparisons to SANREM sites

3. Staple crop and cover crop residue decomposition in the Central Plateau of Haiti: N and C dynamics in surface and buried residues of maize, peanut, Sunn hemp (crotalaria), Sorghum-Sudan
CCRA Activities (cont.)

4. Laboratory incubation studies of four crop residues, plus sesbania and mucuna
   • Measuring i) gross changes in C and N in residue and soils, ii) leachate NH$_4$ and NO$_3$, and iii) CO$_2$ emission/evolution

5. Density fractionation of soil C at shallow soil depths from selected project areas
Static chambers

Automated Soil CO2 Exchange Station
Soil CO$_2$ fluxes - Kitale
Soil CO$_2$ fluxes-Kitale

- Soil NCER is influenced by soil moisture with initial spikes in CO$_2$ flux on wetting, then suppression of CO$_2$ flux.
- No consistent differences between the TA and CA treatments were observed over the initial period of study.
- NCER from both treatments declined over the initial sampling period, likely due to overall drier conditions.
- Diurnally, CO$_2$ flux was greatest during early-to-mid afternoon and least in early morning, following trends in soil temperature.
GIS Agroclimatology Comparison

- An interactive GIS identifying regions of the world with similar agroclimatological parameters to SANREM sites.
- Minimum data:
  - Annual rainfall (total and modality)
  - Temperature regime
  - Elevation
  - Soil type (to suborder, if possible)
  - Slope
  - Photosynthetically active radiation (PAR)
GIS Agroclimatology Comparison

Legend

Agroclimate Layers

Click to toggle the visibility of the agroclimate layers

- SANREM Sites
- Country
- Severe Environmental Constraints
- Protected Lands
- Global Land Cover
- Soil Taxonomy - GWRB
- Soil Taxonomy - USDA
- Soil - Dominant

Virginia Tech
Invent the Future
Density Fractionation of Soil C

- 0-2.5, 2.5-5.0, 5-10 cm depths from replicated plots of CT and ‘best bet’ CA treatment.
- Have or will receive samples from Ecuador, Bolivia, Kenya, Uganda, Cambodia, Haiti.
- Procedure: Soil will be fractionated with sodium polytungstate to separate fractions:
  - light fraction (<1.8 g/mL), intermediate fraction (1.8-2.0 g/mL), and heavy fraction (>2.0 g/mL).
Does density fractionation of SOC represent chemically different carbon pools?

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Abstract
Sometimes, but not often.

Introduction
Many labs employ density fractionation as a proxy for determination of carbon (C) reactivity and lability. However, it is unknown if the resulting fractions correspond to chemically stable, and hence recalcitrant, C. It is generally assumed that phenolic compounds are more recalcitrant than O-alkyl-C and carbonyl-C moieties (Kleber et al., 2011). The objective was to determine if density-based fractionation of SOM represents chemically different C species.

Methods
- Soil samples were taken at 0-5 and 5-10 cm from two sites in Bolivia and two sites in Ecuador (Table 1) in 2010 before implementation of conservation agriculture (CA) treatments.
- The experiments were RCB designs with three replications at each site.
- After sequential density fractionation at <1.8, 1.8-2.0, and >2.0 g cm⁻³, samples were analyzed for total C&N (dry combustion).
- C k-edge near-edge X-ray absorption fine structure spectroscopy (NEXAFS, Fig. 2) was used to determine the relative proportions of functional organic groups.
- SAS Proc GLM was used to determine differences among sites at the 95% confidence level unless otherwise stated.

Results & Discussion
More than 90% of Bolivian whole soil mass was partitioned into the heavy fraction; in Ecuador, the figure was 26.0%.

Table 1. Select characteristics from Bolivia & Ecuador sites

<table>
<thead>
<tr>
<th>Country</th>
<th>Site</th>
<th>Country</th>
<th>Site</th>
<th>Coordinates</th>
<th>Size (g)</th>
<th>Mean annual temp (°C)</th>
<th>Emissivity</th>
<th>Dunam. soil (ppm)</th>
<th>Soil texture</th>
<th>Croping history</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>Suro</td>
<td>Ecuador</td>
<td>Altiplano</td>
<td>W71°18’S</td>
<td>600</td>
<td>8.1-12-1.9</td>
<td>3371</td>
<td>Devonsettisols</td>
<td>Lorn</td>
<td>Maize-bean, full tillage</td>
</tr>
<tr>
<td>Bolivia</td>
<td>Wuyo</td>
<td>Ecuador</td>
<td>Altiplano</td>
<td>W71°17’S</td>
<td>510</td>
<td>8.1-12-1.9</td>
<td>3371</td>
<td>Devonsettisols</td>
<td>Lorn</td>
<td>Maize-bean, full tillage</td>
</tr>
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<td>Devonsettisols</td>
<td>Lorn</td>
<td>Maize-bean, full tillage</td>
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<td>3371</td>
<td>Devonsettisols</td>
<td>Lorn</td>
<td>Maize-bean, full tillage</td>
</tr>
</tbody>
</table>

Figure 1. Total SOC concentration of whole soil and density fractions in Bolivia and Ecuador soils. Error bars represent standard errors of the means.

Figure 2. Schematic of NEXAFS beamline. [Adapted from Lehmann et al., 2009.]

Figure 3. Proportions of C species present in whole soil and density fractions in Bolivia and Ecuador soils. Error bars represent standard errors of the means. Within a site, different letters signify significantly different fractions at p<0.05. All other fraction comparisons within a site are not different.
## Inventory of initial soil samples

Table 57. Samples received and analyses completed as of Sept. 2012

<table>
<thead>
<tr>
<th></th>
<th>Bolivia</th>
<th>Ecuador</th>
<th>Philippines</th>
<th>Cambodia</th>
<th>Kenya</th>
<th>Uganda</th>
<th>Lesotho</th>
<th>Bolivia Gender CCRA</th>
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<td>Samples received</td>
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<td></td>
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<td>Analyses completed:</td>
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<td>Soil testing</td>
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<td>30</td>
<td>76</td>
<td>4</td>
<td>8</td>
<td>16</td>
<td>30</td>
</tr>
<tr>
<td>CN</td>
<td>24</td>
<td>12</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16</td>
<td>30</td>
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<tr>
<td>Density fractionation</td>
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<td>12</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>NEXAFS</td>
<td>22</td>
<td>12</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Bulk density</td>
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<td>no</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>N/A</td>
<td>no</td>
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</table>
Initial samples and status:

<table>
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<th>Country</th>
<th>Location sampled</th>
<th>#Plots</th>
<th>Depths</th>
<th>Total samples</th>
<th>Bulk Density</th>
<th>CN</th>
<th>pH</th>
<th>Soil Test</th>
<th>Fractionated</th>
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<tbody>
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<td>Bolivia</td>
<td>Cebada Jichana</td>
<td>9</td>
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<tr>
<td>Bolivia</td>
<td>15 de Octubre</td>
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<td>0-5, 5-10</td>
<td>18</td>
<td>.</td>
<td>.</td>
<td>yes</td>
<td>yes</td>
<td>yes 12/18</td>
</tr>
<tr>
<td>Bolivia</td>
<td>Waylla Purju</td>
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<td>0-5, 5-10</td>
<td>18</td>
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<td>.</td>
<td>yes</td>
<td>yes</td>
<td>yes 18/18</td>
</tr>
<tr>
<td>Ecuador</td>
<td>Microcuenca del Alumbre</td>
<td>3</td>
<td>0-5, 5-10</td>
<td>6</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Ecuador</td>
<td>Microcuenca del Illangama</td>
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<td>6</td>
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<td>.</td>
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<td>yes</td>
<td>yes</td>
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<tr>
<td>Philippines*</td>
<td>Claveria</td>
<td>16</td>
<td>0-5, 5-10</td>
<td>32</td>
<td>&quot;1.02-1.24&quot; (all)</td>
<td>.</td>
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<td>yes 7/32</td>
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<tr>
<td>Cambodia</td>
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<td>30</td>
<td>0-5, 5-10, (some 10-20, 20-30)</td>
<td>76</td>
<td>yes</td>
<td>.</td>
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<td>yes</td>
<td>no</td>
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<tr>
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<td>4</td>
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<td>.</td>
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<td>no</td>
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<tr>
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<tr>
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<td>Tororo</td>
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<td>0-5</td>
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<td>no</td>
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<tr>
<td>Lesotho</td>
<td>Maphutseng</td>
<td>12 (8)</td>
<td>0-5, 5-10; (4) 0-5, 5-10, 10-15</td>
<td>28</td>
<td>3/28</td>
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<td>yes</td>
<td>yes</td>
<td>no</td>
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<tr>
<td>Haiti*</td>
<td>Central Plateau soil survey</td>
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<td>0-10</td>
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<tr>
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<td>0-5, 5-10</td>
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<td>.</td>
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<td>no</td>
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<tr>
<td>Nepal</td>
<td>Khalagaun</td>
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<td>0-5, 5-10</td>
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<tr>
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<td>yes</td>
<td>.</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

Density fractionation was conducted based on sequential density fraction procedure described by Sollins et al. (2009), using sodium polytungstate (SPT) to create three density fractions: light fraction (<1.8 g/mL), intermediate fraction (1.8-2.0 g/mL), and heavy fraction (>2.0 g/mL). A whole sample of bulk soil (whole soil) was also included in the analysis.