VirginiaTech
Invent the Future

CCRA-9 2014 update

Tom Thompson and Wade Thomason
Department of Crop and Soil Environmental Sciences

23 May 2014

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

VirginiaTech
Invent the Future

CCRA Activities (cont.)

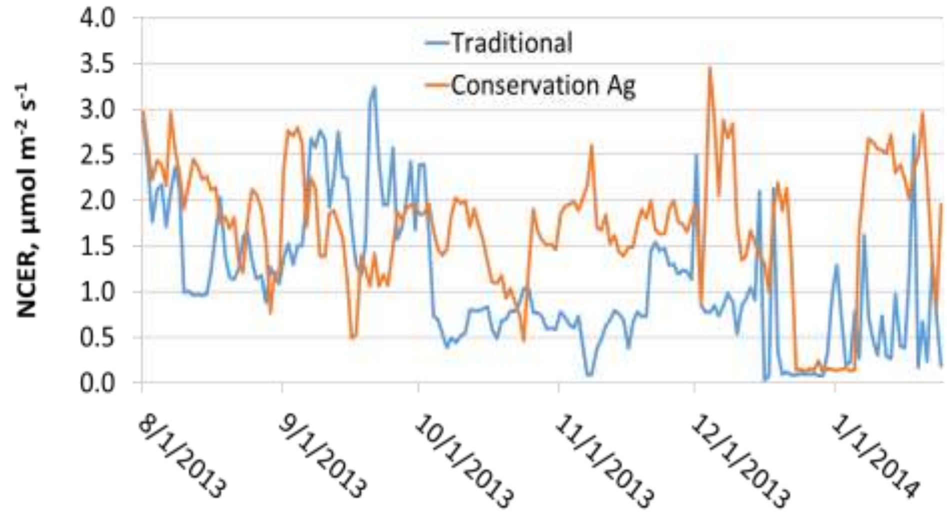
4. Laboratory incubation studies of four crop residues, plus sesbania and mucuna
   - Measuring i) gross changes in C and N in residue and soils, ii) leachate NH_4 and NO_3, and iii) CO_2 emission/evolution
5. Density fractionation of soil C at shallow soil depths from selected project areas

Static chambers

ACE

Automated Soil CO2 Exchange Station

Soil CO_2 fluxes-Kitale



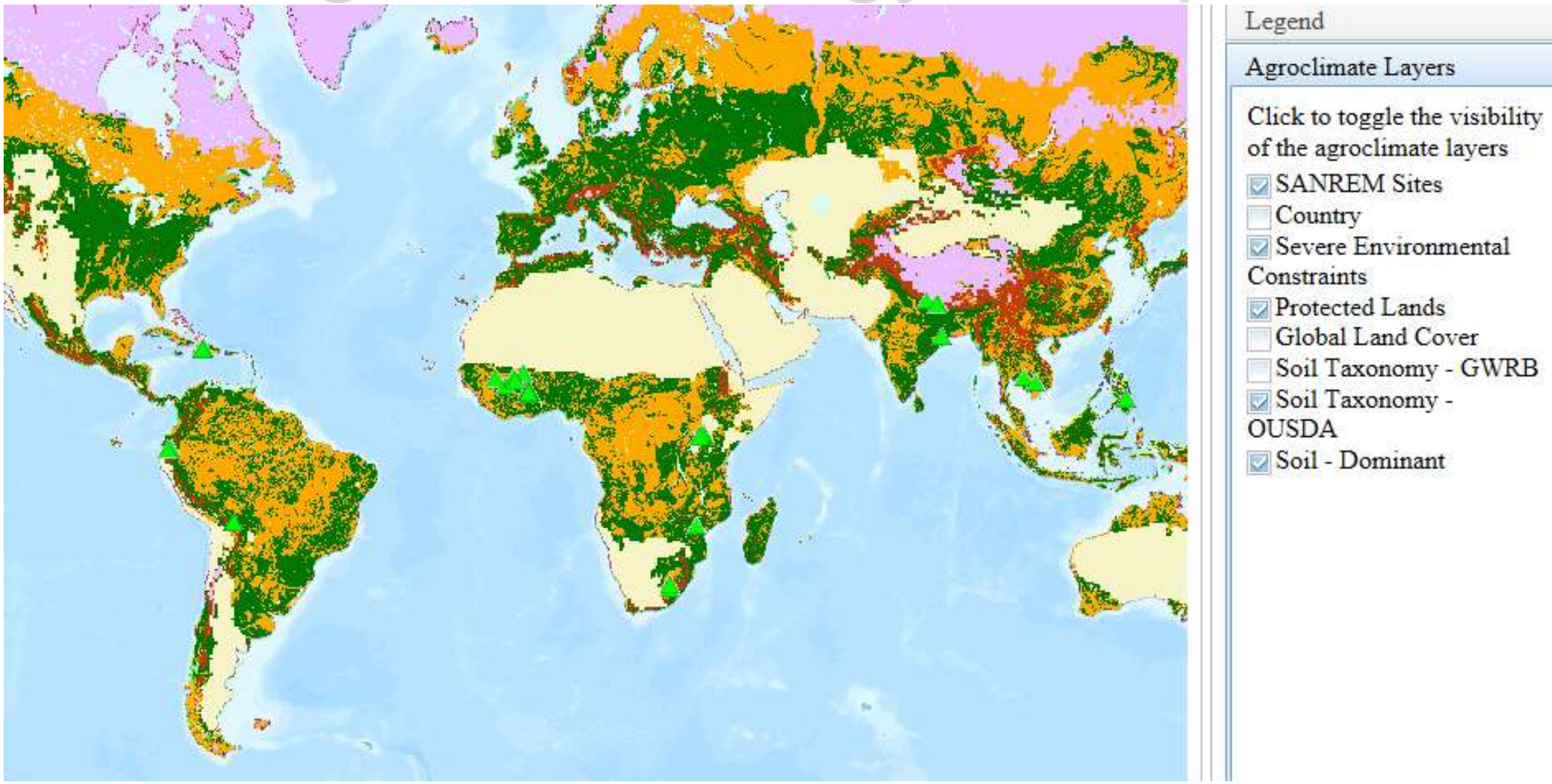
Soil CO_2 fluxes-Kitale

- 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



VirginiaTech
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?

Michael J. Mulvaney[1]*, M. Graham[1], K. Xia[2], R. Botello[4], V. Barrera[3], A.K. Saavedra[4], & P. Mamani[4]

[1]Virginia Tech, Office of Int'l Research, Education, & Development, Blacksburg, VA, USA
[2]Virginia Tech, Dept. of Crop & Soil Environmental Sciences, Blacksburg, VA, USA
[3]Instituto Nacional de Investigaciones Agropecuarias, Ecuador, Quito, Ecuador
[4]Fundación PROINPA, Cochabamba, Bolivia
*Corresponding author: M.Mulvaney@cgiar.org

Abstract

Sometimes, but not often.

Introduction

Many labs employ density fractionation as a proxy for determination of carbon (C) recalcitrance 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 carboxyl-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 organic functional groups.
- SAS Proc GLIMMIX was used to determine differences among fixed effects at the 95% confidence level unless otherwise stated.

Hermon 33 beamline at the SRC

NEXAFS sample preparation

Table 1. Select characteristics from Bolivia & Ecuador sites

Country	Site	Coordinates	Mean annual ppn (mm)	Mean annual temp (°C)	Elev.(m)	Dom. soil type(s)	Soil texture	Cropping history
Ecuador	Alumbre	S01°55'19.4" W79°01'16.4"	570	11.2-22.1	2600	Andic Haplustolls & Entic Dystrandepts	Loam	Maize-bean, full tillage
Ecuador	Illangama	S01°61' W78°98'	690	8.1-20.0	3371-3865	Troporthents, Cryandepts & Dystrandepts	Loam	Potato-pasture, full tillage
Bolivia	15 de Octubre	S17°26'01.9" W65°43'22.9"	510	10.7	3276	Typic Ustropepts	Loam to clay loam	Potato-bean-cereal-fallow, full tillage
Bolivia	Waylla Purju	S17°27'36.1" W65°39'57.1"	510	9.9	3648	Udic Ustochrepts	Loam	Potato-bean-cereal-fallow, full tillage

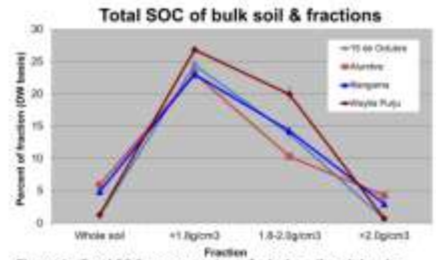


Figure 1. Total SOC concentration of whole soil and density fractions in Bolivia and Ecuador soils. Error bars represent standard errors of the means.

Results & Discussion

More than 90% of Bolivian whole soil mass was partitioned into the heavy fraction; in Ecuador, the figure was ≥60%. As particle density increased, C concentration decreased (Fig. 1), a result corroborated elsewhere (Sollins *et al*., 2009). Generally, SOC species did not differ by depth, nor was a depth x fraction interaction significant. Only in Alumbre was there a significant difference by depth for carboxylic-C and aromatic-C. At all sites, total C&N were significantly different by fraction, as were C:N ratios.

More often than not, fractions did not represent different proportions of C species (Fig. 3).

The data are preliminary evidence that density fractionation sometimes, but not often, represents chemically different SOC species. If density fractionation is a measure of C recalcitrance, this may imply that chemical recalcitrance is less important for C sequestration than physical protection. Future work should include determination of C mean residence times and microbial or plant derivation.

References

Kleber *et al*. 2011. Old and stable soil organic matter is not necessarily chemically recalcitrant: implications for modeling concepts and temperature sensitivity. Global Change Biology 17:1097-1107.

Lehmann *et al*. 2009. Biophysico-Chemical Processes Involving Natural Nonliving Organic Matter in Environmental Systems, John Wiley & Sons, Inc. p. 729-781.

Sollins *et al*. 2009. Sequential density fractionation across soils of contrasting mineralogy: evidence for both microbial- and mineral-controlled soil organic matter stabilization. Biogeochemistry 96:209-231.

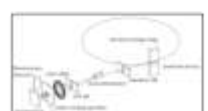


Figure 2. Schematic of NEXAFS beamline. (Adapted from Lehmann *et al*., 2009.)

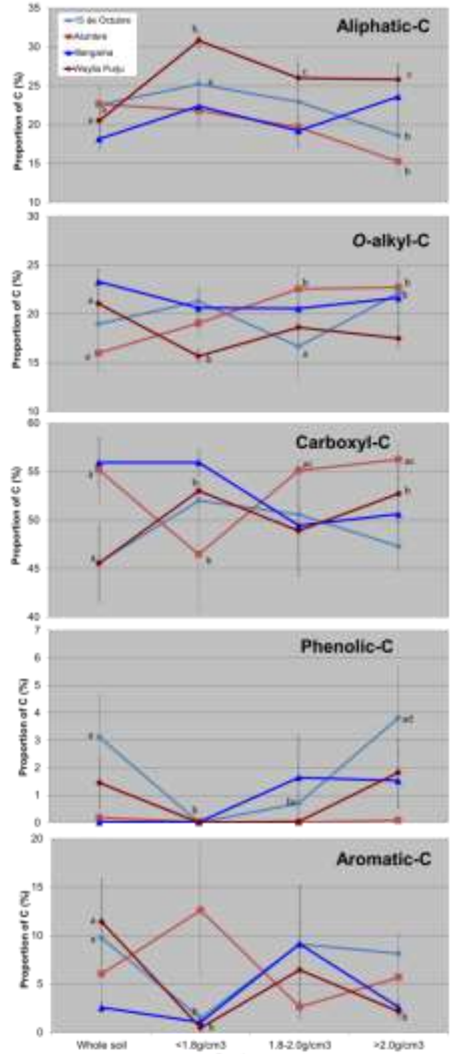


Figure 3. Proportions of C species present in whole soil and density fractions in Bolivia and Ecuador soils. Error bars represent standard errors of the means. Within a site, different letters signify significantly different fractions at $p<0.10$. All other fraction comparisons within a site are not different.

Inventory of initial soil samples

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

	Bolivia	Ecuador	Philippines	Cambodia	Kenya	Uganda	Lesotho	Bolivia Gender CCRA
Samples received	54	12	30	76	4	8	16	30
Analyses completed:								
Soil testing	54	12	30	76	4	8	16	30
CN	24	12	8	0	0	0	16	30
Density fractionation	24	12	7	0	0	0	0	N/A
NEXAFS	22	12	3	0	0	0	0	N/A
Bulk density	no	yes	no	yes	no	no	N/A	no

VirginiaTech
Invent the Future

Initial samples and status:

Country	Location sampled	#Plots	Depths	Total samples	Bulk Density	CN	pH	Soil Test	Fractionated
Bolivia	Cebada Jichana	9	0-5, 5-10	18	.	.	yes	yes	no
Bolivia	15 de Octubre	9	0-5, 5-10	18	yes	yes	yes	yes	12/18
Bolivia	Waylla Purju	9	0-5, 5-10	18	.	yes	yes	yes	18/18
Ecuador	Microcuenca del Alumbre	3	0-5, 5-10	6	yes	yes	yes	yes	yes
Ecuador	Microcuenca del Illangama	3	0-5, 5-10	6					
Philippines*	Claveria	16	0-5, 5-10	32	"1.02-1.24" (all)	.	yes	yes	7/32
Cambodia	Battambang	30	0-5, 5-10, (some 10-20, 20-30)	76	yes	.	yes	yes	no
Kenya	Bungoma	4	0-5	4	.	.	yes	yes	no
Uganda	Kapchorwa	4	0-5	4	.	.	yes	yes	no
Uganda	Tororo	4	0-5	4	.	.	yes	yes	no
Lesotho	Maphutseng	12	(8) 0-5, 5-10; (4) 0-5, 5-10, 10-15	28	3/28	yes	yes	yes	no
Haiti*	Central Plateau soil survey	13	0-10	13	.	.	yes	.	.
Nepal	Hykrang	9	0-5, 5-10	18	yes	.	yes	yes	no
Nepal	Khalagaun	9	0-5, 5-10	18	yes	.	yes	yes	no
Nepal	Thumka	9	0-5, 5-10	18	yes	.	yes	yes	no

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.

VirginiaTech
Invent the Future