4th Year of Testing with the USDA – NRCS Re-active Carbon Test Kit in the New Mexico Soil Health workshops and training sessions.

Integrated Cropping Systems and Water Management Handbook (AGRO-76)

USDA – NRCS New Mexico

Clarence L. Chavez
SDQS (Soil Health / TSS)

Rudy Garcia
State Agronomist
What is Reactive Carbon?

The Reactive carbon component in soil consists of: Plant and Animal (soil biota)

1. Microbial biomass carbon
2. Particulate organic matter
3. Soil carbohydrates / Sugars
4. Amino acids / Protein
5. Etc…

Just to name a few, there are many more.
The Soil Food Web is sustained by: Crop Residues, Root Exudates, Soil Biota (e.g., predator-prey interactions), Manure, Compost, Plant Symbiosis & Soil Humus. (Photos: Soil Biology Primer)

Healthy Soils grow Healthy Plants, which produce Nutritious & Healthy Crops. Therefore, manage soil as an ecosystem.

Soil Health is either improving, sustaining or degrading (i.e., management & cultural practices have a major effect on soil health).

Agronomy Tech Note 76 (http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)
The Reactive C Field Kit

Many soil properties impact soil quality, but soil organic matter deserves special attention.

It affects several critical soil functions and can be manipulated by conservation practices.

(Only through Crop rotations, cover crops, application of manure or compost and moving towards minimum or no till).
The NRCS Reactive C Field Kit is about $650 per Kit
Does 10 samples at a time (5 gr / sample).
Critical solutions made up for analysis (permanganate solution)
Pocket colorimeter and cuvettes
Taking the color density reading
10 SAMPLES AT A TIME WITH DUPLICATES
How does organic matter work?
Which soil properties will change?
Section 1 of 22 (1b - Soil Organic Matter & Organic Carbon Gains and Losses Guide)

Plant Organic Compounds: sugars, starches, simple proteins, crude proteins, hemicellulose, cellulose, fats, waxes, lignins, etc.

**NOTE:** The Crop Residues Carbon:Nitrogen (C:N) ratio strongly influences the rate of decomposition.

**Humification:** The process involved in the decomposition of organic matter and leading to the formation of humus

(http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html)
How does organic matter work?

- Once you begin working towards enhancing soil organic matter, a series of soil changes and environmental benefits follow.

- The rate or degree of these changes and the best practices being used are still dependent on soil, climate, and previous management history.
Surface Structure becomes water stable and less prone to crusting and erosion (Glomalin/Soil Biota/10 - 20% AWHC).

Soil Infiltration and water holding capacity increase.
Beneficial soil organisms become more numerous and active with diverse crop rotations and higher organic matter levels.
Crop health and vigor increase when soil biological activity and diversity increase.

The primary use of Compost or Manure is to supplement nutrients and add beneficial soil biota with a measure of Organic Matter.

Beneficial Soil Microbes improves when residue management improve.

Transitioning from conventional to organic Conventional Fertilizers (derived from Fossil Fuels in the form of fertilizers)

The best approach is to feed the soil biota, which will in turn feed the plant.
Notice the difference in time

Now lets take a deeper look inside the soil aggregate.

Loamy Sand / Sandy Loam Soil – That is Highly Structured

Glomalin the Super-Glue of soils

Water-Stable Soil Aggregates: The Foundation of a Healthy Soil

- **Clay particles**
- **Soil Humus**
- **Sand particles**
- **Micro-pores** (i.e., where water enters the aggregate & where gases are exchanged)

**Other soil organisms**, such as protozoa and nematodes, live in the water held between aggregates. Arthropods live in the top soil and surface residues and in decayed root channels, earthworm burrows, etc.

**Soil moisture inside the aggregate** (contains dissolved solids and gases and soluble OM)

**Fine Roots**

**Root Exudates**

**Bacterial Colonies** (produces polysaccharides)

**Slake Test**

**Water-Stable Soil Aggregates**

(Ref. Soil Ecology: P. Lavelle, A. Spain)

Biodiversity with minimal soil disturbance drives soil health
Glomalin in its natural state is brown. A laboratory procedure reveals glomalin on soil aggregates as the green material shown here.

Fungal Hyphae & Spore

Glomalin is very stable, glycoprotein, that stores carbon in the soil as a glue and protects the soil biota. It makes up a large amount of soil organic matter and a portion is reactive carbon.
Mycorrhizal fungi and other members of the fungi family are -- soil structure builders.

In this photo, sand grains are bound to a root by hyphae from endophytes (fungi similar to mycorrhizae), and by polysaccharides secreted by the plant and the fungi.
USDA-NRCS is using this photo under the exclusive right to use for technology transfer and teaching.

USDA-NRCS does not support, promote or endorse soil secrets.
New Mexico Reactive Carbon

FY 2011 C. Chavez

Special Study Area

0 to 6 inches Depth
6 to 12 inch Depth

mg/Kg
0 to 6” Depth

6 to 12” Depth

New Mexico Reactive Carbon Testing Is Showing: Clovis, NM.
New Mexico Reactive Carbon Testing

Is Showing: Las Cruces, NM

0 to 6” Depth
Reactive Carbon is higher

6 to 12” Depth
Reactive Carbon is lower
Reactive Carbon Field Test

In New Mexico Soils - Reactive Carbon range from 2.5% to 15.3% of the Total Carbon in the Soil.

It takes a small amount of Reactive Carbon to change soil health for large benefits.

Higher Reactive Carbon
- Poor Aggregate Stability
- 400 mg-Kg
- Soil Organisms
- Glomalin
- Root Exudates
- Organic Matter etc.

Increasing Reactive Carbon

Low Reactive Carbon
- Good Aggregate Stability

Benefits of Soil “Reactive Carbon”
- Soil Reactive Carbon (SRC)
- Total Carbon
- Aggregation & Infiltration
- Water & Nutrient Holding
- Productivity
- Air & Water Quality, Soil Biota Habitat


Clarence Chavez 2012
**Reactive Carbon and Soil Health Categories**

**By lbs/ac/ft\(^{-6}\)**

<table>
<thead>
<tr>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;350</td>
<td>550</td>
<td>750</td>
<td>1500 mg/kg</td>
</tr>
<tr>
<td>x1.7</td>
<td>x1.7</td>
<td>x1.7</td>
<td>x1.7</td>
</tr>
<tr>
<td><strong>595 lbs/ac/ft(^{-6})</strong></td>
<td><strong>935 lbs/ac/ft(^{-6})</strong></td>
<td><strong>1,275 lbs/ac/ft(^{-6})</strong></td>
<td><strong>2,550 lbs/ac/ft(^{-6})</strong></td>
</tr>
</tbody>
</table>

Conversion Factor of 1.7 is based on Bulk density of the Texture and conversion of ppm to lbs/Ac/Ft at a 6 inch depth.
Benefits of Soil “Reactive Carbon”

Soil Reactive Carbon (SRC)

- Total Carbon
- Aggregation & Infiltration
- Water & Nutrient Holding
- Productivity
- Air & Water Quality; Soil Biota Habitat

Initially, managing for greater soil organic matter may require higher pesticide, herbicide, or nutrient applications.
What does it mean?

- Soil Biota increase. (Microbes)
- Aggregate Stability (Soil Structure).
- Bulk Density of a soil will increases (Not Compaction)
- Improves Traffic-ability (Becomes more resilient)
- Increased infiltration. (Microbes/OM)
- Reduced soil crusting. (Glomalin/Soil Glues)
- Higher water holding capacity. (Range: 10 to 20%)
- Improved nutrient cycling.
Organic Matter makes the soil darker and richer looking.

Taking the soil from this ...

To this in 3 to 5 years with an Integrated Cropping System
Reactive Carbon Readings
Sample 25 - 37 mg/kg
Sample 26 - 127 mg/kg

7 year old Grapevine with new cover crop
Reactive Carbon Readings

Sample 27 - 48 mg/kg
Sample 28 - 86 mg/kg

3 Yr. Grapevine with out cover crop
Managing for soil quality - Farming

- Add organic matter - Cover crops, manure, green manure, compost. (Integrated Cropping System)
- Avoid excess tillage – it causes soil compaction & destroys Structure.
- Carefully manage fertilizer and pesticide use. Chemicals will harm microorganisms.
- Increase ground cover – reduces both wind and water erosion. (Cover Crops/mulching)
- Diversity across the landscape.
- Integrated Pest Management
Managing for soil quality - Rangeland

- Manage grazing, fire, and vehicle use.
- Increase/maintain plant species production.
- Improve plant cover and minimize bare spots.
- Promote species diversity and root diversity.
- Protect soil from water and wind erosion by plant cover.
- Use designated trails or roads; to reduce the number of trips.
"Human kind has not woven the web of life. We are but one thread within it. Whatever we do to the web, we do to ourselves. All things are bound together. All things connect."

Chief Seattle, 1854
**PHOTOSYNTHESIS**

\[ 6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 \text{(sugar)} + 6\text{O}_2 \text{(oxygen)} \]

Carbon Dioxide (CO₂) is a byproduct of respiration

Oxygen is needed by roots & soil biota for respiration

Uptake of Soil Nutrients & Water by Roots & Soil Biota

- N
- P
- K
- S
- Ca
- Mg
- B
- Fe
- Mn
- Zn
- Cu
- Mo

Deep Percolation

The Soil Food Web is sustained by: Crop Residues, Root Exudates, Soil Biota (i.e., Predator-Prey Interactions), Manure, Compost, Plant Symbiosis & Soil Humus.

Soil Food Web
- Bacteria
- Fungi
- Protozoa
- Nematodes
- Arthropods
- Earthworms
- Other (Algae, etc.) (i.e., important in nutrient cycling, building soil structure & healthy soils)

Root Exudates (i.e., sugars) & Sloughed-off roots

Evaporation

Transpiration

Rain

Snow

Irrigation

runoff

Agronomy Tech Note 76 (http://www.nm.ncrc.usda.gov/technical/handbooks/iwm/nmiwm.html)
Biodiversity with minimal soil disturbance drives soil health. Therefore, growing diverse crops will develop a diversity of organisms in the soil. This will result in restoring soil health and crop productivity.

**Nutrient Management**

**Irrigation System & Laser Leveling**

**COMPOST MANURE MGT.**

**IPM, Weed Mgt., other.**

**Crop Rotations**

**Residue MGT.**

**Cover Crops**

**No-Till & Min-Till**

**Introduction to Section 1 (i): Dynamic Cropping System Practices needed to complete the Agro Ecological Puzzle**

**Nutrient Analysis**

- Irrigation Water Analysis
- Soil Analysis
- Nutrient Inputs

**Soil Health**

**Grass Grazing**

**The Xerces Society**

**Parasitoid wasp**

**Soldier beetle**

**Lahillard beetle**

Many of the same flowering plants that support pollinators also support beneficial predatory and parasitic insects.
The NRCS Reactive C Field Kit

- Provides a fairly accurate assessment of a critical soil quality factor (Lab proxy)

- Test samples should be sent to: NRCS - State Office - soil section for analysis.
“The nation that destroys its soil, destroys itself.”

- Franklin D. Roosevelt
Where can we go from here:
Farmer Soil Health Workshops

In 4 years we have given 58 workshops
For more information Please Contact Your Local Office of the Natural Resource Conservation Service or Soil and Water Conservation District.
REFERENCES:


Cynthia A. Stiles*
USDA-NRCS
National Soil Survey Center (Active Carbon Test Kit)
100 Centennial Mall N.
Lincoln, NE 68508-3866
currently at
NRCS, Pacific Islands Area
300 Ala Moana Blvd., Rm. 4-118
Honolulu, HI 96850-0050


R. David Hammer
Mark G. Johnson
USEPA National Health and Environmental
Effects Research Lab., 200 S.W. 35th St. Corvallis, OR 97333

Richard Ferguson – Active Carbon
USDA-NRCS National Soil Survey Center
100 Centennial Mall N., Lincoln, NE 68508-3866

Dr. Christine Jones - Amazing Carbon
Founder, Australian Soil Carbon Accreditation Scheme
13 Laurence Avenue, ARMIDALE NSW 2350 , AUSTRALIA, Ph: +612 6772 5605
Christinejones22@aol.com

Dr. Kris Nichols
Soil Microbiologist
Kristine.Nichols@madan.ars.usda.gov
USDA-ARS-Northern Great Plains Research Laboratory
1701 10th., Ave SW, Mandan, ND 58554
Phone: 701-667-3008
Sustainability is our future!

Clarence Chavez
Soil Scientist
NM - NRCS

Any QUESTIONS?
For more information Please Contact Your Local Office of the:

Natural Resources Conservation Service

or

Soil and Water Conservation District

[USDA NRCS logo]
Non-Discrimination Statement

- "The U.S. Department of Agriculture (USDA) prohibits discrimination in all of its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex (including gender identity and expression), marital status, familial status, parental status, religion, sexual orientation, political beliefs, genetic information, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD)."