Soil Management Strategies for Improving Air Quality & Enhancing Energy Efficiency

Clarence Chavez 4/2010
Quality Feed takes less Energy to Produce
Produce a high quality feed and the animal intake will be less!
Soils are not machines:
It’s an ecosystem that needs to be Fed and Covered with Plants and residue at all times.

We must realize that a destroyed soil takes more energy to manage and creates both Air and Water Quality Problems.
Soil’s holds the sustenance of our lives!

A soil that filters, breathes and grows the food, but not without the interaction with water and air.

We as an agency have started to teach our field employees about soil quality and soil health as they relate to Water Quality, Plant Health, Air Quality, Energy Efficiency, etc...!
What is your Base Line?

Soil Health & How’s it Functions.

If you do not know your soils and where they are.

You probably do not know how to improve air quality or enhancing energy efficiency.
What do we assess and where?

The Soil Survey is a good start
Use it with wisdom...

Farmed soils have been Plowed, Land Leveled, Disked, Chiseling, Irrigated, Fertilized, Animal Hoof Action, Grazing, etc.
Testing for your Soil Baseline

Tissue, Water and Soil Lab Tests - $110

Active Carbon Tests

Soil Quality Test Kits in each office

Since the soils have been manipulated we must depend on field assessments.
Soil Health / Soil Function

To reduce energy and improve air and water quality

Taking care of the soil is where it is at!
Soil Respiration

Soil Biota

CO²

O²

Soil Infiltration
Infiltration: Tilled vs Non-Tilled

Tilled soils use more energy than non-tilled soils – horse power, fuel, and create air quality and erosion problems.
## Respiration / Infiltration

### Soil Respiration

<table>
<thead>
<tr>
<th>lbs CO₂-C/a/d</th>
<th>Class</th>
<th>Soil Condition (Table 1, pg. 53)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No soil activity</td>
<td>Soil has no biological activity</td>
</tr>
<tr>
<td>&lt; 9.5</td>
<td>Very low soil activity</td>
<td>Soil is very depleted of available OM and has little biological activity.</td>
</tr>
<tr>
<td>9.5 - 16</td>
<td>Mod. low soil activity</td>
<td>Soil is somewhat depleted of available OM, and biological activity is low.</td>
</tr>
<tr>
<td>16 - 32</td>
<td>Medium soil activity</td>
<td>Soil is approaching or declining from an ideal state of biological activity.</td>
</tr>
<tr>
<td>32 – 64</td>
<td>Ideal soil activity</td>
<td>Soil is in an ideal state of biological Activity has adequate OM and active populations of microorganisms</td>
</tr>
<tr>
<td>&gt; 64</td>
<td>Unusually high soil activity</td>
<td>Soil has a vary high level of microbial activity and has high levels of available OM, possibly from the additions of large quantities of fresh OM or manure.</td>
</tr>
</tbody>
</table>

### Infiltration Rate (inches/hr)

- > 20: Very rapid
- 6 – 20: Rapid
- 2 – 6: Mod. rapid
- 0.6 – 2: Moderate
- 0.2 – 0.6: Mod. slow
- 0.06 – 0.2: Slow
- 0.0015 – .06: Very slow
- < 0.0015: Impermeable

### Infiltration Class

Table 3. pg. 56

Very rapid
Rapid
Mod. rapid
Moderate
Mod. slow
Slow
Very slow
Impermeable
Soil Respiration

Use of cover crops not only helps the soil biota and control erosion as well as improve:

- Soil tilth
- Increase organic matter levels
- Enhances water infiltration
- Lessens pests (weeds and bugs)
- Soil organic matter levels (up or down)
- Recycle Nutrients
Soil Infiltration is sensitive to near surface conditions.

Indicator of compaction or soil pore clogging (degradation)

Which leads to decreased yields and increased erosion rates.

Soil Biota help create good infiltration
Bulk Density

<table>
<thead>
<tr>
<th>Bulk Density (Soil Type Table 4. pg. 57)</th>
<th>Ideal Bulk Densities (g/cm³)</th>
<th>Bulk Densities that restrict root growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>sands, loamy sands</td>
<td>&lt; 1.6</td>
<td>&gt; 1.80</td>
</tr>
<tr>
<td>sandy loams, loams</td>
<td>&lt; 1.4</td>
<td>&gt; 1.80</td>
</tr>
<tr>
<td>S. C. loams, loams, clay loams</td>
<td>&lt; 1.4</td>
<td>&gt; 1.75</td>
</tr>
<tr>
<td>silts, silt loams</td>
<td>&lt; 1.3</td>
<td>&gt; 1.75</td>
</tr>
<tr>
<td>silt loams, silty clay loams</td>
<td>&lt; 1.4</td>
<td>&gt; 1.65</td>
</tr>
<tr>
<td>S. clays, silty clays, some clay loams</td>
<td>&lt; 1.10</td>
<td>&gt; 1.58</td>
</tr>
<tr>
<td>clays (&gt; 45% clay)</td>
<td>&lt; 1.10</td>
<td>&gt; 1.47</td>
</tr>
</tbody>
</table>
Bulk Density / Compaction

Ground Truth
Minimize the number and weight of field operations.

- We all know that working soil too wet is detrimental. It should be avoided at all costs.

- However, soil with good structure and an extensive network of roots will be resilient to compaction.
Indicates the amount of salts present in the soil. ($K^+$, $Ca^+$, $Mg^+$, $Na^+$, $SO_4^{-2}$, $Cl^-$, $HCO_3^-$, $CO_3^{-2}$)

Excess salts will hinder plant growth i.e. salt affected irrigation water. Salt   Crop Tolerance Table

<table>
<thead>
<tr>
<th>Salts in the soil</th>
<th>EC range for 1:1 soil:water suspension for which yield reductions occur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating</td>
<td></td>
</tr>
<tr>
<td>(Table 6. pg. 61)</td>
<td></td>
</tr>
<tr>
<td>S = Sensitive</td>
<td>$&gt; 0.90$ dS/m</td>
</tr>
<tr>
<td>MS = Mod. Sensitive</td>
<td>$&gt; 1.40$ dS/m</td>
</tr>
<tr>
<td>MT = Mod. Tolerant</td>
<td>$&gt; 2.50$ dS/m</td>
</tr>
<tr>
<td>T = Tolerant</td>
<td>$&gt; 4.0$ dS/m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Irrigation Salinity (pg. 80)</th>
<th>EC</th>
<th>TDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification - Table 11</td>
<td>(dS/m)</td>
<td>(mg/l)</td>
</tr>
<tr>
<td>No effects usually noticed</td>
<td>0.75</td>
<td>500</td>
</tr>
<tr>
<td>Can have detrimental</td>
<td>0.75 – 1.50</td>
<td>500 – 1,000</td>
</tr>
<tr>
<td>effects on sensitive crops</td>
<td>1.50 – 3.00</td>
<td>1,000 – 2,000</td>
</tr>
<tr>
<td>Can have adverse</td>
<td>3.00 – 7.50</td>
<td>2,000 – 5,000</td>
</tr>
<tr>
<td>effects on many crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can be used for tolerant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>plants (on permeable soils)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Electrical Conductivity

Use a soil test and water test to be accurate then use the Crop Salt Tolerance Tables.
Soil and Water EC

The bottom line

- Timing and amount of watering will help in the management of salts in any soil.

- Soil Health is very important – Infiltration, Leaching, Structure, Tilth, Plant Vigor.
pH -- is the measure of the acidity or alkalinity of a soil or Water, which affects the availability of plant nutrients, activity of microorganisms, and the solubility of soil minerals.
Soil and Water pH

The bottom line

- Soil pH also affects the activity of beneficial microorganisms, which affects nutrient availability, uptake and stability.

- A healthy soil, high in Organic Matter will regulate its own pH, appropriate to the plant root.

- pH values between 6 and 7.5 are optimum for general crop growth, NM soils range from 7.5 to 8.2
Nitrogen requirements from fertilizers, irrigation water and the decompositions of crop residue by microbes must be checked for excess.
Nitrate \( (\text{NO}_3) \) / Nitrite \( (\text{NO}_2) \)

Proper fertilizer use.

- Fertilizers (in crop residue, manure, etc...) that enhance the soil. The best approach is to feed the soil biota, which will in turn feed the plant.

- A good soil will grow healthy crops. Don’t over do it with fertilizer amendments (follow a nutrient management plan) as that is a waste and can be a pollutant.
Water Stable Aggregate:
See the difference: what Tillage would do to a healthy soil.

New Mexico: Clay Soil
Georgia: Silty Clay Soil

Tilled Soil Non-Tilled Soil Non-Tilled Soil Tilled Soil
Aggregate Stability / Soil Slaking - Classes

- Class 0 to 3 are relatively unstable.
- Class 4 indicates some stability, but very little strength.
- Classes 5 and 6 represent relatively stable soil fragments or aggregates.

*strength relates to the ability of the soil to resist loss of its structure*
### Aggregate Stability

**Table 8:**

<table>
<thead>
<tr>
<th>Organic Matter (%)</th>
<th>Water Stable Aggregates (%)</th>
<th>Clay (%)</th>
<th>Water Stable Aggregates (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4</td>
<td>53</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>0.8</td>
<td>66</td>
<td>10</td>
<td>65</td>
</tr>
<tr>
<td>1.2</td>
<td>70</td>
<td>20</td>
<td>70</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
<td>30</td>
<td>74</td>
</tr>
<tr>
<td>4</td>
<td>77</td>
<td>40</td>
<td>78</td>
</tr>
<tr>
<td>8</td>
<td>81</td>
<td>60</td>
<td>82</td>
</tr>
<tr>
<td>12</td>
<td>85</td>
<td>80</td>
<td>86</td>
</tr>
</tbody>
</table>

For example: for a soil with 2% organic matter and 10% clay, the suitable aggregate stability range (taken from Table 8) would be 65 to 75% water stable aggregates.
Aggregate Stability

- Protects organic matter from rapid breakdown from soil biota.
- Minimize tillage practices such as: “Plow – Disk – Floating etc...”

Note: Tillage systems that maximize surface residues are preferred.
Use tillage sparingly to solve specific soil problems.

Major practices – cover crop or cocktail mixture cover crops (2 to 12 seeds),
no till or minimum till

crop rotation, mulching, composting,
IWM, IPM, nutrient management, etc.
Fungal Hyphae – produce humic compounds and organic “glues” (extra-cellular polysaccharides, proteins, lipids, etc…)

Glues bind soil particles into aggregates which improves soil porosity, nutrient cycling, respiration, reduce erosion.

Symbiosis of the Mycorrhizal fungi and other members of the fungi family are -- soil structure builders
Increasing Nutrients Availability: “Available plant nutrients (N, P, & K) tend to be higher in fresh earthworm casts than in the bulk soil.”
[Edwards et al., 1995]

10 Earthworms per cubic food is a good indicator of soil health
Soil Moisture is used for cooling the plant

Soil Moisture is used for growing the plant

ENVIRONMENT FOR SOIL BIOTA AND CROP ROOTS (I.E., INCREASED NUTRIENT CYCLING AND WATER USE EFFICIENCY)
Soil Temperatures

- 140 degrees, soil bacteria die.

- 101-130 degrees, 100% moisture lost through evaporation and transpiration. Some species of bacteria, arthropods, start dying

- 95-100 degrees, 15% moisture used for growth, 85% moisture lost through evaporation and transpiration.

- 65 - 95 degrees, 100% moisture used for growth. Soil Biota is active and doing their job.
Soil physical observations and estimations of: depth, roots, structure, texture, and aggregate stability

• Measuring the depth of topsoil

• Observe plant roots

• Examine soil structure, texture, color, fragments, pore space, depth etc...

Hidden Message: Root Diversity and Keep Roots Growing
Active Carbon
What is Active Carbon?

The active carbon component in soil consists of:

1. Microbial biomass carbon
2. Particulate organic matter
3. Soil carbohydrates
4. Amino acids
5. Fine and very fine roots
Active C

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

• It affects several critical soil functions, can be manipulated by land management practices, and is important in most agricultural settings across the country.
The Active C in the Field

1) Organic matter enhances nutrient and water holding capacity
2) Improves soil tilth
3) Improves soil structure (Glomalin, Soil Biota)
4) Enhances crop productivity and quality
5) Environmental quality (Air and Water)
6) Reduce the severity and costs of natural atmospheric CO2, levels that contribute to climate change.
7) Reduces soil /wind erosion.
The NRCS Active C Field Kit
Does 10 samples at a time (5 gr each)
Critical solutions made up for analysis (permanganate solution)
Taking the color density reading
What does Active C – do in soil?

- Small amounts of Active Carbon makes a huge difference in aggregate stability (Soil Structure).

- Bulk Density of a soil will decrease with higher amounts of organic carbon (no matter how small the increase).

- Increased infiltration. (Microbes/OM)

- Reduced soil crusting. (Glomalin/Soil Glues)

- Higher water holding capacity.

- Improved nutrient cycling.
Lab Testing

Is a means of estimating the nutrient supplying power of the Soil, Water, Tissue
Tissue
Water
Soil
**PW-2 Irrigation Water, Soil and Plant Tissue Analysis Interpretation GUIDE** (Example)

**1.** Producer: Nambe, NM  
**Crop:** Peas  
**Yield:** 2,379 lb/ac  
**Irrigation Water:** 13 ac-in (No. of irrigations = )

**2.** Tillage Operations: minimum tillage with incorporated cover crops (rye)

**3.** Soil Texture: Clay  
**Soil Structure:** Granular  
**Aggregate Stability:** Good (high Organic Matter)

**4.** Nutrients | Irrigation Water Analysis (ppm x 0.23 x 13” - lb/ac) | Soil Analysis 0-6” depth (ppm x 1.7 - lb/ac) | Nutrient Inputs | Plant Tissue Analysis Note: N is kjeldahl nitrogen & Sulfur is total Sulfur | Should I Apply Nutrients? | Conservation Practices to consider for achieving sustainability
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ON = Organic Nitrogen mineralized</td>
<td>ppm or mg/l</td>
<td>Pounds per Acre</td>
<td>ppm or mg/Kg</td>
<td>Pounds per Acre (VL, L, M, H, &amp; VH)</td>
<td>Pounds per Acre</td>
</tr>
<tr>
<td>5. Organic Matter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. N mineralized</td>
<td>Not</td>
<td>Analyzed</td>
<td>32.0</td>
<td>1.51%</td>
<td>25.670</td>
</tr>
<tr>
<td>7. Nitrate-Nitrogen Phosphorus</td>
<td>5.0</td>
<td>Not</td>
<td>44.0</td>
<td>7.5</td>
<td>12.8</td>
</tr>
<tr>
<td>8. Potassium</td>
<td>26.7</td>
<td>15.0</td>
<td>78</td>
<td>0.62</td>
<td>1.1</td>
</tr>
<tr>
<td>9. Sulfate-Sulfur Calcium</td>
<td>2.7</td>
<td>8.1</td>
<td>78</td>
<td>Not</td>
<td>340</td>
</tr>
<tr>
<td>10. Magnesium</td>
<td>8.5</td>
<td>25.4</td>
<td>67.9</td>
<td>Not</td>
<td>112</td>
</tr>
<tr>
<td>11. Zinc</td>
<td>8.5</td>
<td>25.4</td>
<td>67.9</td>
<td>Not</td>
<td>112</td>
</tr>
<tr>
<td>12. Iron</td>
<td>8.5</td>
<td>25.4</td>
<td>67.9</td>
<td>Not</td>
<td>112</td>
</tr>
<tr>
<td>13. Manganese</td>
<td>26.7</td>
<td>15.0</td>
<td>78</td>
<td>Not</td>
<td>340</td>
</tr>
<tr>
<td>14. Copper</td>
<td>26.7</td>
<td>15.0</td>
<td>78</td>
<td>Not</td>
<td>340</td>
</tr>
<tr>
<td>15. Boron</td>
<td>26.7</td>
<td>15.0</td>
<td>78</td>
<td>Not</td>
<td>340</td>
</tr>
<tr>
<td>16. Molybdenum</td>
<td>26.7</td>
<td>15.0</td>
<td>78</td>
<td>Not</td>
<td>340</td>
</tr>
<tr>
<td>17. Chloride</td>
<td>26.7</td>
<td>15.0</td>
<td>78</td>
<td>Not</td>
<td>340</td>
</tr>
<tr>
<td>18. Bicarbonate</td>
<td>26.7</td>
<td>15.0</td>
<td>78</td>
<td>Not</td>
<td>340</td>
</tr>
<tr>
<td>19. Carbonate</td>
<td>26.7</td>
<td>15.0</td>
<td>78</td>
<td>Not</td>
<td>340</td>
</tr>
</tbody>
</table>

**5. Additional Assessments to Consider in evaluating your Cropping System (soil pH, free lime & CEC):**
- Electrical Conductivity of Irrigation Water (ECiW) = 0.182 mmhos/cm
- Sodium Adsorption Ratio (SAR) from soil test = 0.24 & pH = 7.3
- Refer to Irrigation Water Quality Guidelines (WQ-8) for infiltration assessment. Total Dissolved Solids = 119 mg/l (soluble salts applied = 425 lb/ac/yr.)
- ECe (EC of Soil Saturation extract) = 1.41 mmhos/cm & pH = 7.8
- Sodium Adsorption Ratio (SAR) from soil test = 0.89
- Refer to Crop Salt Tolerance Table (WQ-6) to evaluate for potential yield reduction and salinity management considerations/options


* Rudy Garcia 2009*
Soil Management Strategies

The best approach is to feed the soil biota, which will in turn feed the plant.
Soil Management Strategies

- Cover Crops
- IWM
- IPM
- Crop Rotations,
- Soil Temperature
- Plant/Root Diversity
- No-Till or Minimum Till
Soil Management Strategies

Green Manure
Roller Chopping
Crop Residue
Manure Mgt.
Soil Management Strategies

Pasture Management and Grazing

Mob Grazing only take 50% of forage
Soil Management Strategies

- Green Manure or Cover Crops
- Composting or Minimum Till
- Minimum Till Seeding
- No Till - Seeding
Soil Management Strategies

Water Inefficiency
Soil Management Strategies
Soil Management Strategies

Soil Moisture Monitoring and Irrigation Record keeping

I W M

2.5 – 3% Organic Mater in New Mexico
Air Quality

Only comes after building Soil Quality and Good Soil Health
Sustainability is our future!!!!!!

Clarence Chavez
Soil Scientist
NM - NRCS

Any QUESTIONS?