Importance and Management of Soil Organic Matter

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Components of Our Soil

- Biological
- Chemical
- Physical
Biological Components

- Organic matter (OM)
- Microorganisms (MO’s)
- Plant roots
- Large and small flora and fauna
Water Dynamics and OM

• 1% of OM can hold **27,000 gallons** of water per acre

• Decreases evaporation
65% of mo’s live in top 12” of soil

Bacteria

Actinomycetes

Nematodes

Fungi
In One Cup of Soil There Are...

- Over 9 billion mo’s
- 600 million bacteria (over 4,000 species)
- 5T of biomass/acre

E. Ingham (www.soilfoodweb.com)
Functions

- Store and release nutrients
- Improve soil aggregation
- Biological and physical protection of diseases
- And much more
What do Microorganisms Need to Grow and Thrive?

Good Home:
- Food
- Water
- Temperature
- Protection
- Sometimes a host
Microbes and Manure
### Microbe Plate Counts

<table>
<thead>
<tr>
<th>Trt</th>
<th>MO Biomass (ug/g)</th>
<th>Fungi (cfu/g)</th>
<th>Bacteria (x1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manured</td>
<td>371</td>
<td>29.6</td>
<td>2,920</td>
</tr>
<tr>
<td>Non-manured</td>
<td>204</td>
<td>17.8</td>
<td>1,670</td>
</tr>
</tbody>
</table>

Samples taken at the WCROC on July 18\(^{th}\), 2002 on soybean fields.

ARS analyzed soil samples.
Arbuscular Mycorrhizae (AM)

- Form a physical barrier around the root
- Bring in nutrients and water

Photo Carinbondar.com
## Nutrient Uptake (micrograms/plant)

<table>
<thead>
<tr>
<th>Element</th>
<th>No Mycorrhizae</th>
<th>With Mycorrhizae</th>
<th>Increase in Nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td>750</td>
<td>1,340</td>
<td>44%</td>
</tr>
<tr>
<td>Potassium</td>
<td>6,000</td>
<td>9,700</td>
<td>38%</td>
</tr>
<tr>
<td>Calcium</td>
<td>1,200</td>
<td>1,600</td>
<td>25%</td>
</tr>
<tr>
<td>Magnesium</td>
<td>430</td>
<td>630</td>
<td>32%</td>
</tr>
<tr>
<td>Zinc</td>
<td>28</td>
<td>95</td>
<td>71%</td>
</tr>
<tr>
<td>Iron</td>
<td>80</td>
<td>147</td>
<td>46%</td>
</tr>
</tbody>
</table>
Chemical Components

- pH
- Nutrient holding capacity (CEC)
- Nutrient availability
- Salts
Nitrogen Cycle - Inputs

Nitrogen Gas ($N_2$)

N Fertilizer, $NH_3$, $NO_3^-$

Legume $N_2$ Fixation

Plant residue and manure
Nitrogen Cycle

Nitrogen Gas (N$_2$)

N Fertilizer, NH$_3$, NO$_3^-$

Legume N$_2$ Fixation

Plant residue and manure

Mineralization

Immobilization

NH$_4^+$

Nitrification

NO$_3^-$
Nitrification (aerobic)

a. Nitrosomonas

\[ \text{NH}_4^+ + 1.5 \text{O}_2 \rightarrow \text{NO}_2^- + 2\text{H}^+ + \text{H}_2\text{O} \]

Ammonium to Nitrite

b. Nitrobacter

\[ \text{NO}_2^- + 0.5 \text{O}_2 \rightarrow \text{NO}_3^- \]

Nitrite to Nitrate
Temperature *and* Leaching Potential

<table>
<thead>
<tr>
<th>Date Applied</th>
<th>Soil Temp at 6”</th>
<th>Converted to NO$_3$ in 2 weeks (lb/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 7</td>
<td>60</td>
<td>70 (~50%)</td>
</tr>
<tr>
<td>Oct 15</td>
<td>45</td>
<td>20 (~15%)</td>
</tr>
<tr>
<td>Oct 24</td>
<td>37</td>
<td>5</td>
</tr>
</tbody>
</table>

150 lb/a Urea applied

Averaged over no-till, chisel and moldboard
Nitrogen Cycle - Outputs

Nitrogen Gas (N$_2$)

- Legume N$_2$ Fixation
- Plant residue and manure
- Crop removal
- Plant Uptake
- Volatilization: NH$_4^+$ → NH$_3$
- Mineralization
- Immobilization: NH$_4^+$ + NO$_3^-$
- Nitrification: NO$_3^-$ → NH$_4^+$ + NO$_3^-$
- Denitrification: NO$_3^-$ → N$_2$ + N$_2$O
- Leaching

Outputs
- N Fertilizer, NH$_3$, NO$_3^-$
Denitrification (anaerobic)

13 different bacteria:

\[ \text{NO}_3^- \rightarrow \text{NO}_2^-, \text{NO}, \text{N}_2\text{O}, \text{N}_2 \]

Nitrate to gaseous forms of N
(nitrite, nitric oxide, nitrous oxide, N gas)

Can lose up to 2-4 pounds/acre/day
What is the Nutrient Value of Soil Organic Matter??

Assumptions:

2,000,000 lbs. soil in top 6 in.
1% organic matter = 20,000 lbs.
Nutrients

Nitrogen: \(1,000 \text{ lbs} \times .63/\text{lb}\) \(\$630\)

Phosphorus: \(100 \text{ lbs} \times .60/\text{lb}\) \(\$60\)

Potassium: \(100 \text{ lbs} \times .42/\text{lb}\) \(\$42\)

Sulfur: \(100 \text{ lbs} \times .45/\text{lb}\) \(\$45\)

Carbon: \(10,000 \text{ lbs or 5 ton}\) \(\$0\)

Value of 1% SOM Nutrients/Acre \(~\$775\)
Physical Components

- Aggregation
- Porosity
- Bulk density
- Water movement, availability and storage
Many Benefits from Soil Structure
#1 Natural Defense Against Soil Compaction

And Tillage **DESTROYS** Structure!
Air Permeability and CT Images of a Clay Affected by Compaction
Water Stable Aggregates

photo by Ray Weil
Tillage DESTROYS Structure!
Wind Erosion

Wind erosion occurs from wind speeds greater than 13 mph on smooth, wide, bare fields.

Photos: D. Gatchell
The Value of Snirt (snow + dirt)

15% residue

45% residue
## Soil Accumulation in 6 WC - MN Ditches

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>High</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.6 T/ac</td>
<td>32.6 T/ac</td>
<td>9.1 T/ac</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Nutrient</th>
<th>$/lbs</th>
<th>Ave Lbs of Nutrient Lost/Acre</th>
<th>Ave Money Lost/Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>$0.50</td>
<td>55</td>
<td>$27.50</td>
</tr>
<tr>
<td>Potassium</td>
<td>$0.42</td>
<td>37</td>
<td>$15.54</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>$0.60</td>
<td>13</td>
<td>$ 7.80</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$50.84/ac</strong></td>
</tr>
<tr>
<td>Loss not including the B, Fe, Mn, Mg, Cu, Ca, Co</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Shelterbelts needed for high sustained winds
Acceptable soil loss is 5T an acre per year.

40 acres = 16 dump truck loads of soil!
Value of Topsoil

5T/ac x $25/T x 40 ac = $5,000
Cover - the single most important factor influencing soil loss!!
Differences in Equipment
Vertical Till

Classified as mulch till. Shallow (1-3”) and full field tillage.
Benefits of Vertical Tillage:

Can get into wet fields
Chops and Sizes Residue
Leaves Some Residue Intact
Primary and Secondary Tillage
Speed - 7 to 10 mph
Limited Fertilizer Incorporation
Where to Try Vertical Tillage

- Sizing residue and introducing air
- Wet Spring or Fall
- When fall tillage wasn’t completed
Where to Try Vertical Tillage

- Decrease residue build-up
- Leaves residue = good on slopes
- Rotational tillage
Field Cultivator
3-4” Depth
Even mixing of soil
Even fertilizer and weed incorporation
Challenges: Little residue remaining
Smearing in a Wet Soil
Field Cultivator Mgmt

- One pass in spring
- Shallow incorporation of nutrients
- Use least aggressive set-up
Disks
Disks

- More destructive forces
- Shears and presses soil
Great at Sizing Residue and Clods

Too good
Challenges for a Disk

- Loss of soil structure and moisture
- More compaction potential
- Major residue incorporation
- Keep it shallow
Where to Use a Disk

To break up clods and make a roadbed 😊
Chisel and Shanks:

- Lifts and separates the soil
- Less destruction of soil structure
Even CP Can Be a Conservation Tool – It’s all Relative

- Residue burial variable depending on point
- Less fuel and time compared to MBP and DR
- Incorporate manure and fertilizer

Provided by Dick Wolkowski, UW
Chisel Plow Points

Sweeps and spike points bury less residue than do straight points or twisted points. Slower speeds and shallower operating depths usually leave more residues.

(A) 3 inch twisted, (B) 3 inch straight, (C) 2 inch wide Straight, (D) Sweep, (E) 4 1/2 inch wide twisted, (F) 4 1/2 inch straight point.

Provided by Dick Wolkowski, UW
Twisted Shovel vs. Sweep

Provided by Dick Wolkowski, UW
Variable Depth Tillage!!

VT and/or Chisel Plow
Strip Tillage
Maintains surface residue between the rows

Considered “enhanced no-till”
Seed planted directly in cleared strips in Spring

P and K applied 6-8” deep in berm

N can be applied in berm, at planting or side dressed
3 Year Tillage Research

- Fall of 2009
- Carlisle and Clarkfield, MN
- Looking at varying residue levels
<table>
<thead>
<tr>
<th>Tillage Rotation</th>
<th>3 Year Soybean Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residue (% after planting)</td>
</tr>
<tr>
<td>Strip Till</td>
<td>64</td>
</tr>
<tr>
<td>Vertical Till, 2 passes</td>
<td>49</td>
</tr>
<tr>
<td>Vertical Till, 2 passes</td>
<td>50</td>
</tr>
<tr>
<td>(prev. tillage, CP)</td>
<td></td>
</tr>
<tr>
<td>Chisel Plow + FC</td>
<td>50</td>
</tr>
<tr>
<td>(prev. tillage, DR)</td>
<td></td>
</tr>
<tr>
<td>LSD (0.10)</td>
<td>*</td>
</tr>
</tbody>
</table>
## Corn Data - Clarkfield

<table>
<thead>
<tr>
<th>Tillage Rotation</th>
<th>3 Year Corn Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residue (% after planting)</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Strip Till</td>
<td>43</td>
</tr>
<tr>
<td>Vertical Till, 2 passes</td>
<td>26</td>
</tr>
<tr>
<td>Chisel Plow + FC (prev. tillage, VT)</td>
<td>29</td>
</tr>
<tr>
<td>Disk Rip + FC (prev. tillage, CP)</td>
<td>32</td>
</tr>
<tr>
<td>LSD (0.10)</td>
<td>*</td>
</tr>
</tbody>
</table>
No-Till

Vertical Tillage

Chisel Plow

Strip Tillage

crop residue
top soil
subsoil
Natural “Tillage” in Dry years
Think about tillage based on:

- Residue levels
- Slope
- Soil type/texture
- Drainage ability
Tips to Reduce Tillage

- Evenly spread chaff
- Shallow-up tillage depth
- Try to cut out a tillage pass
- Change-out twisted points, use narrow points
- Planter in great working order
Reduced Tillage Saves:

- Time, labor, fuel
- Organic matter
- Structure

Your SOIL!
Questions?