Soil Microbial Changes with No-Till

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Soil Microbial Communities

- Microbial Community Size
- Community Structure
- Microbial Diversity
- Processes

- Fungi
- Protozoa
- Bacteria (G+, G-, actino)
To identify major trends in soil microbial communities associated with no-tillage across several locations and soils using publications from 1980-present.
Soil Microbial and Biochemical Changes Associated with Reduced Tillage (John W. Doran, 1980)
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Table 1—Climatic, soil, and management characteristics of experimental sites with long-term no-till/conventional tillage comparisons.

<table>
<thead>
<tr>
<th>Location (Cooperators)</th>
<th>Mean annual</th>
<th>Soil series (classification)</th>
<th>Conventional tillage method (depth, cm)†</th>
<th>Herbicides used (rate, kg/ha)†</th>
<th>Years (crop) in no-till conventional till, previous cropping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky, Lexington (Bob Blevins, Wilbur Frye)</td>
<td>113.0</td>
<td>Maury Silt Loam (fine, mixed, mesic Typic Paleudalfs)</td>
<td>Spring plow (20) disked twice</td>
<td>Paraquat (0.28)</td>
<td>9 years (corn), 50 to 60 years Bluegrass sod</td>
</tr>
<tr>
<td>Minnesota, Waseca (Gyles Randall)</td>
<td>76.1</td>
<td>Nicollet Clay Loam (fine-loamy, mixed, mesic Aquic Hapludolls)</td>
<td>Fall plow (20-25) Spring cult. with mulch harrow</td>
<td>Simazine (1.68) Atrazine (1.68)</td>
<td>9 years (corn), previously corn</td>
</tr>
<tr>
<td>W. Virginia, Morganton (Orus Bennett, Tom Staley)</td>
<td>102.0</td>
<td>Wharton-Cookport Silt Loam (fine-loamy, mixed, mesic Aquic Hapludalfs)</td>
<td>Spring plow (25) disked twice</td>
<td>Atrazine (2.24)</td>
<td>5 years (corn), previously Bromegrass sod</td>
</tr>
<tr>
<td>Nebraska, Lincoln (Lloyd Mielle, Jim Ellis, Jim Schepers)</td>
<td>74.2</td>
<td>Crete-Butler Silty Clay Loam (fine, montmorillonitic, mesic Pachic Argiustollus-Abruptic Argiaquolls)</td>
<td>Spring plow (20) disked twice</td>
<td>Atrazine (2.24)</td>
<td>3 years (corn), previously soybeans</td>
</tr>
<tr>
<td>Nebraska, Sidney (Charles Fenster, Gary Peterson)</td>
<td>44.6</td>
<td>Duroc Loam (fine-silty, mixed, mesic Pachic Haplustolls)</td>
<td>Spring plow (10-15) Cult. 2 to 3 times Rot. rot 1 to 2 times</td>
<td>Paraquat (1.1) Glyphosate (0.84)</td>
<td>9 years (wheat-fallow), previously native sod</td>
</tr>
<tr>
<td>Nebraska, Sidney (Charles Fenster)</td>
<td>44.6</td>
<td>Alliance Silt Loam (fine-silty, mixed, mesic Aridic Argiustolls)</td>
<td>Same as above</td>
<td>Same as above</td>
<td>10 years (wheat-fallow) previously cult. wheat fallow &amp; crested wheatgrass</td>
</tr>
<tr>
<td>Oregon, Pendleton (Don Rydych, Ray Almaras)</td>
<td>40.6</td>
<td>Walla Walla Silt Loam (coarse-silty, mixed, mesic Typic Haploxerolls)</td>
<td>Spring plow (15) Cult. twice Rot. rot 3 to 4 times</td>
<td>Paraquat (0.84) Glyphosate (0.84) Cyanazine (2.24) + IPC (3.36)-1978</td>
<td>9 years (wheat-fallow), previously cult. wheat fallow</td>
</tr>
</tbody>
</table>

† Spring plow = spring moldboard plow, cult. = cultivation, rot. rot = rotary rodweed management
Ratio = No-till/Conventional till.

This ratio enables better comparison of tillage effects across locations with minimum effects from differences in soil moisture or management at time of sampling.

Ratios > 1 = increase in values with no-tillage.

Ratios < 1 = decrease in value with no-tillage.
Long-term tillage effects

<table>
<thead>
<tr>
<th>Microbial group</th>
<th>0-7.5 cm</th>
<th>7.5-15 cm</th>
<th>0-15 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Aerobes</td>
<td>1.35***</td>
<td>0.71***</td>
<td>1.03</td>
</tr>
<tr>
<td>Fungi</td>
<td>1.57***</td>
<td>0.76**</td>
<td>1.18</td>
</tr>
<tr>
<td>Actinomycetes</td>
<td>1.14</td>
<td>0.98</td>
<td>1.08</td>
</tr>
<tr>
<td>Aerobic bacteria</td>
<td>1.41***</td>
<td>0.68***</td>
<td>1.03</td>
</tr>
<tr>
<td>NH₄⁺ oxidizers</td>
<td>1.25 (1.13)§</td>
<td>0.55** (0.56)</td>
<td>0.89†(0.87)</td>
</tr>
<tr>
<td>NO₃⁻ oxidizers</td>
<td>1.58 (0.92)</td>
<td>0.75** (0.42)</td>
<td>1.14 (0.71)</td>
</tr>
<tr>
<td>Facultative anaerobes</td>
<td>1.57*</td>
<td>1.23</td>
<td>1.32*</td>
</tr>
<tr>
<td>Denitrifiers</td>
<td>7.31*(2.70)</td>
<td>1.77 (1.92)</td>
<td>2.83†(1.99)</td>
</tr>
</tbody>
</table>

Ratio of microbial populations (NT/CT) with depth
Dehydrogenase activity
Microbial activity index

- **0–7.5 cm:**
  - Higher microbial act. under no-till soil

- **7.5- 15 or 15- 30 cm:**
  - Trends **were reversed**
  - Mic. Act: similar or higher in conv. till.
No-tilled Soils

- **Distinct Microbial Communities**
- **Saprophytic fungi and bacteria** concentrate and recycle nutrients
- **Arbuscular Mycorrhizae** concentrate due to the large root biomass
No-tilled Soils

- ↑ Organic matter Cont.
- Better Soil Structure
- ↑ Water Infiltration
- ↑ Aeration
Higher CO₂ efflux immediately after tillage and lasted for 4 d.

Respiration was similar in both soils until the 4th day after tillage, and then declined in the tilled soil.

The authors concluded: these trends suggest that tillage makes available previously protected organic N.
Clay: < 0.02 µm
Silt: 0.02-0.2 mm
Sand: 0.2-2 mm

Bacteria: 0.1 µm - > 2 µm

Fungi:
- Degradation products are cementing agents
- Physically - Bring aggregates together
Soil Microbial Community Change and Recovery after One-Time Tillage of Continuous No-Till
(Wortmann, C.S. et al. 2008)

- Occasional tillage = One-time tillage operation in a system that was otherwise maintained without tillage.

- Objective: Determine changes in microbial community after one-time tillage of NT and their recovery dynamics over one or two cropping seasons following tillage.
<table>
<thead>
<tr>
<th>Site</th>
<th>Continuous NT history</th>
<th>Date of one-time tillage</th>
<th>Crops following tillage</th>
<th>Soil series</th>
<th>Soil classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMF</td>
<td>12</td>
<td>26 Mar. 2003</td>
<td>sorghum†-soybean-sorghum soybean-sorghum soybean-corn</td>
<td>Sharpsburg Si-Cl-loam</td>
<td>Typic Argiudoll</td>
</tr>
<tr>
<td>RMF</td>
<td>13</td>
<td>24 Oct. 2003</td>
<td></td>
<td>Sharpsburg Si-Cl-loam</td>
<td>Typic Argiudoll</td>
</tr>
<tr>
<td>ARDC</td>
<td>7</td>
<td>26 Nov. 2003</td>
<td></td>
<td>Yutan Si Cl-loam</td>
<td>Mollic Hapludalf</td>
</tr>
</tbody>
</table>

† Underlined crop is the first crop after the one-time tillage.
Tillage effects on soil microbes

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Moldboard plow, spring (RMF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>-39.0***</td>
</tr>
<tr>
<td>5-20</td>
<td>+32.6**</td>
</tr>
<tr>
<td>20-30</td>
<td>+20.6+</td>
</tr>
<tr>
<td>0-5</td>
<td>-31.4***</td>
</tr>
<tr>
<td>5-20</td>
<td>+10.7</td>
</tr>
<tr>
<td>20-30</td>
<td>+3.4</td>
</tr>
<tr>
<td>0-5</td>
<td>-63.5***</td>
</tr>
<tr>
<td>5-20</td>
<td>+138.4**</td>
</tr>
<tr>
<td>20-30</td>
<td>+56.1</td>
</tr>
<tr>
<td>0-5</td>
<td>-64.9***</td>
</tr>
<tr>
<td>5-20</td>
<td>-0.8</td>
</tr>
<tr>
<td>20-30</td>
<td>-5.7</td>
</tr>
</tbody>
</table>
Research in the High Plains

USDA-ARS, Lubbock
V. Acosta-Martínez
Ted Zobeck
Robert Lascano
Jill Booker

http://www.texas-on-line.com/graphic/ctytexas.gif
Tillage effects on Microbial Communities in a Sandy Soil

✓ Olton sandy loam (Fine, mixed, superactive, thermic Aridic Paleustolls)
✓ Avg. 16.4% clay and 67.6% sand
✓ 0.65 g kg\(^{-1}\) of OM
“High Biomass Crop” Study

Low Cropping Intensity

Continuous cotton (Cv. Till)
Cotton-sorghum
Cotton-rye-sorghum
Haygrazer-rye

High Cropping Intensity

(Cv. & No-till)
Microbial biomass C

No impacts due to tillage during the study.
How long changes on the microbial component can occur depend...

- Soil
- Cropping systems
- Environment
Conclusions: **Tillage**

- One-time tillage can affect soil microbial communities (i.e., Reduced Fungi ↓↓ and Bacteria↓).  
- Short-term changes in nutrient dynamics:
  - N losses (denitrification and nitrate leaching)
  - C losses (↑ org.matter degr. & CO₂).
- These changes will possibly affect long-term ecosystem function.
Conclusions: **No-Tillage**

- No-till agriculture ↑ or similar crop yields as conventional tillage practices.
- Protects soil against erosion
- Distinct soil microbial communities and ↑ microbial activities (↑ C storage in soil).
Questions?