Tillage and Fertility
Opportunities and Challenges

Dick Wolkowski
Department of Soil Science
UW-Madison
rpwolkow@wisc.edu
Today’s potpourri of issues

- Vertical tillage/subsoiling
- Crop residue management alternative
- Fertilizer placement
- Foliar feeding
Vertical tillage

- Defined as deep tillage designed to create vertical zones by cutting a slot, shattering, and lifting the soil
  - Minimal inversion
  - Prepares seedbed
  - Various spacings
  - Fall or spring
- What is the motive for deep tillage
  - Part of a system associated with crop management programs, e.g. Zone-till™, ProfitPro™
    - Compaction not diagnosed
  - Response to poor soil condition (aka subsoiling)
    - Compaction diagnosed
“Vertical tillage” implements
Are all situations responsive to deep tillage?

Soil bulk density profile, Arlington, Wis., 1998

**PLANO SILT LOAM**
EFFECT OF TILLAGE AND K FERTILIZATION ON FIRST-YEAR CORN YIELD AFTER SOYBEAN (2 yr. avg.)

Arlington, Wis.
Soil abuse that causes compaction is all too common.
Deep tillage can be beneficial where compaction is diagnosed.
First: ID depth and strength of compaction
Sunflower tool used in Hancock deep tillage study, 2003
Cone index in a potato hill as affected by compaction and deep tillage, Hancock, Wis.

Cone Index (MPa)

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>0</th>
<th>0.5</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y/N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y/Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deep Till. Yield (cwt/a)
- No: 373
- Yes: 398

Compacted/Subsoiled
- N/N
- N/Y
- Y/N
- Y/Y

Plainfield loamy sand Compacted 15 April, 2x
There are differences between subsoilers

“V-Ripper”
- Leading disks
- Parabolic shanks
- Winged points

“Conservation”
- Cutting coulters
- Straight shanks
- Horizontal points
EFFECT OF SUBSOILER TYPE ON SOYBEAN AND CORN YIELD ON A SILTY CLAY LOAM SOIL

Manitowoc, Wis.
Compacted soils are responsive to K fertilization

**Corn response to 45 lb K₂O/a in row**

3 yr. avg.  
Oshkosh, Wis.

**Alfalfa response to soil test K**

Sum of 3 hay years  
Arlington, Wis.
DETERMINING THE NEED FOR SUBSOILING

- Evaluate depth and severity of compaction
- Check with penetrometer, probe, shovel
- Dig plants to examine roots
- Leave untreated strips for comparison
- Subsoiling is an expensive operation
- Subsoiling is not a cure-all, address compaction
• Burial of crop residue
• Destruction of natural channels
• Sidewall smearing
• May bring stones, clay, infertile soil to the surface
• Does not address compaction cause
Crop Residue Management: Regional trend for more CT

- Eight Midwestern states:
  - 106 million acres of cropland
  - 37 percent of all U.S. cropland
- 46% of no-till acres in U.S. in the Midwest
- 2002 Midwest data
  - 17 million acres of no-till soybeans
  - 7 million acres of no-till corn
  - Forty-five million acres (42.5 %) used conservation tillage

*CTIC Website (2002 data)*
Wisconsin behind regional trend

CTIC Website (2002 data)
Tillage has a measurable effect on the soil condition

Direct or interactive effects

- Physical
  - Residue modifies temperature and moisture
  - Consolidation vs. loosening

- Chemical
  - Nutrient and pH stratification

- Biological
  - C distribution
  - N transformations
Soil temperature affected by tillage and crop residue

Effect on crop residue, Arlington, 1994

Effect on in-row soil temperature, Arlington, 1994
Effects of long-term tillage on the plow layer pore size distribution

Hill et al., 1985
Fertilizer placement affects corn root distribution (0-6 in.)

<table>
<thead>
<tr>
<th>Tillage</th>
<th>Fert. placement</th>
<th>Root length (km/m³)</th>
<th>Untracked Inter-row</th>
<th>Tracked Inter-row</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH</td>
<td>ROW</td>
<td>17.1</td>
<td>3.0</td>
<td>0.8</td>
</tr>
<tr>
<td>CH</td>
<td>INTER-ROW</td>
<td>12.0</td>
<td>4.4</td>
<td>1.4</td>
</tr>
<tr>
<td>NT</td>
<td>ROW</td>
<td>19.8</td>
<td>2.5</td>
<td>0.8</td>
</tr>
<tr>
<td>NT</td>
<td>INTER-ROW</td>
<td>10.8</td>
<td>6.1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Kaspar et al., 1991
Controlled traffic is a key to making reduced tillage work.

- Controlled traffic research, Australia
- Practiced on 2.5 million acres
- 500 GPS guided tractors
- Research shows 10-15% yield increase from controlled traffic
Strip tillage expands crop residue management

Three categories

- **ROW OR RESIDUE CLEARING**
  - REMOVE RESIDUE
  - FINGER COULTERS, BRUSHES, SWEEPS

- **STRIP TILLAGE (SHALLOW: < 6 in.)**
  - MOVE RESIDUE, SEEDBED PREP., ROW FERTILIZER
  - FLUTED COULTERS, DISCS

- **STRIP TILLAGE (DEEP: > 6 in.)**
  - DISRUPT COMPACTION, DEEP-PLACE FERTILIZER
  - KNIVES
  - SOME WITH COULTERS TO MOVE RESIDUE OR CREATE MINI-RIDGES
Tillage and P and K availability

Possible issues
- Nutrient stratification
  - Surface applied nutrients
  - Crop residues
  - Vertical and horizontal
- How to collect a representative sample
- Fertilizer placement considerations
Soil test stratification following five years of tillage management, Arlington, Wis.

Wolkowski, 2003 (Corn/soybean rotation)
Reduced tillage is more responsive to fertilization

- Positional availability
  - Surface vs. sub-surface
  - Wheel track vs. non-wheel track effects on root distribution
- Reduced P and K fixation by the soil
- Reduced K uptake from zones of poor aeration
- Complete starter material recommended
INTERACTIVE EFFECT OF TILLAGE AND ROW FERTILIZER, ARLINGTON, 1994-1996

YIELD (bu/a)

TILLAGE

FZ
FS
FZ
2x2

NONE
FS
FZ
2x2
EFFECT OF ROTATION, TILLAGE, AND FERTILIZER ON TISSUE K CONCENTRATION 45 DAP, ARLINGTON, WIS., 2001

<table>
<thead>
<tr>
<th></th>
<th>CC</th>
<th>SbC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CH</td>
<td>ST</td>
</tr>
<tr>
<td></td>
<td>-------</td>
<td>%</td>
</tr>
<tr>
<td>NONE</td>
<td>2.23</td>
<td>2.37</td>
</tr>
<tr>
<td>BDCT</td>
<td>2.35</td>
<td>2.19</td>
</tr>
<tr>
<td>2 x 2</td>
<td>2.85</td>
<td>3.26</td>
</tr>
</tbody>
</table>

Wolkowski, 2003
RESPONSE OF CORN TO TILLAGE AND FERTILIZER PLACEMENT, ARLINGTON, WIS. 2001-2003

Yield (bu/a)

200 lb 9-23-30/a
Foliar fertilization of crops

- Plants are not made to absorb nutrients through leaves
- Nutrient use by crops is substantial
- Leaf damage likely because of salt injury
- Most research with soybean (podfill)
- Micronutrients (B and Mn) for soybean under certain conditions
### Response of soybean to foliar fertilization at three Minnesota locations

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Waseca</th>
<th>Becker</th>
<th>Rosemount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>54</td>
<td>56</td>
<td>61</td>
</tr>
<tr>
<td>Foliar (NPKS) 4x</td>
<td>57</td>
<td>53</td>
<td>63</td>
</tr>
</tbody>
</table>

Adapted from Rehm, 1997
## Summary of Midwest research for foliar B on soybean

<table>
<thead>
<tr>
<th>Treatment</th>
<th>IL</th>
<th>MO</th>
<th>OH</th>
<th>WI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>42.2</td>
<td>43.0</td>
<td>52.4</td>
<td>51.2</td>
</tr>
<tr>
<td>Foliar</td>
<td>43.2</td>
<td>43.3</td>
<td>53.3</td>
<td>51.5</td>
</tr>
<tr>
<td>Soil</td>
<td>38.3</td>
<td>42.8</td>
<td>52.5</td>
<td>51.9</td>
</tr>
</tbody>
</table>

Avg. of 0.25, 0.5, and 1.0 lb B/a foliar; 3 lb B/a soil
Response of soybean grown on a high pH, high O.M. soil to Mn fertilization

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mn Rate</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>--</td>
<td>50</td>
</tr>
<tr>
<td>Row 10</td>
<td>10</td>
<td>61</td>
</tr>
<tr>
<td>Row 20</td>
<td>20</td>
<td>64</td>
</tr>
<tr>
<td>Row 40</td>
<td>40</td>
<td>63</td>
</tr>
<tr>
<td>Foliar (2x) 0.5</td>
<td>0.5</td>
<td>62</td>
</tr>
<tr>
<td>Foliar (2x) 1.0</td>
<td>1.0</td>
<td>61</td>
</tr>
<tr>
<td>Foliar (2x) 2.0</td>
<td>2.0</td>
<td>59</td>
</tr>
</tbody>
</table>

Randall et al., 1975
2 yr. avg.
Consider your motive and need for deep tillage

Subsoiling more likely to be beneficial where compaction is identified

Avoid compaction
- Stay off wet soils
- Watch load weight
- Control traffic

Tillage has a profound effect on soil properties and affects nutrient availability
- Residue increases water content and lower temperature
- Soil is more consolidated
Summary

- Reduced tillage has numerous benefits
- pH, P, and K stratify
- No-till (strip-till) corn is more responsive to fertilization
- Band placement often beneficial, however broadcast may be acceptable
- Foliar fertilization not recommended for NPKS
- Foliar fertilization can be useful where a micronutrient need is identified