EFFECT OF SUBSURFACE AND SURFACE TILLAGE ON STRUCTURE AND PERMEABILITY OF SOLONETZIC AND CHERNOZEMIC SOILS OVER TWO YEARS

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INTRODUCTION

• Saskatchewan has ~ 44% of Canada’s total cultivated farmland (Statistics Canada, 2012).

• Considering soil physical attributes (permeability, structure & strength) is important: affects root growth, ability to explore for nutrients and water.

• Wheel traffic compaction, dense horizons can negatively affect root zone (Soane et al., 1994).

Tillage is one management strategy to alter water and air permeability, structure and strength, in the root zone.
In Canada, wheel traffic from heavy equipment can lead to compaction, with reduced porosity and permeability & greater resistance to root penetration.
Introduction (cont’d)

- Naturally high Na leads to clay dispersion, formation of dense Solonetzic B horizons that affect productivity.

**Subsoiling (15-30 cm) may improve conditions in compacted, dense subsoils.**
Introduction

• **Surface tillage** (e.g. vertical tillage) is utilized for residue rut management and alters soil conditions mainly at surface.

• **Raking and burning** may also be used for management of difficult crop residues like flax straw.
• Very few recent studies on tillage strategies to address physical limitations in soils of the Northern Great Plains.
STUDY OBJECTIVES

• To assess soil water infiltration, air permeability, structural attributes, as influenced by subsurface and surface tillage treatments in compacted and non-compacted Solonetzic (sodium affected) and Chernozemic soils over two years.
STUDY LOCATION

Near Central Butte, Saskatchewan

Subsoiling Solonetz Site (Echo association)

Subsoiling Chernozem Site 1 (Haverhill association)

Surface Tillage, Rake Burn on Flax Stubble Chernozem Site 2
Subsoiling Tillage Operation

- A John Deere 2100 Minimum-Till subsoiler with five shanks spaced 76.0 cm apart and set to penetrate 30.0 cm into the soil in Fall 2015.

Narrow subsoiler shank creates minimal surface disturbance.
Tandem Disc and Vertical Tillage Operations

• Tandem disc with John Deere Frontier TM5132 to a depth of 8-10 cm in Fall 2015.

• Vertical Tillage with John Deere 2623VT to a depth of 5 cm in Fall 2015.
Raked Burn & No-Burn (Flax stubble)
Measurements

Field Saturated Hydraulic Conductivity

Air Permeability

Aggregate Size
Measurements

Soil Strength
Results
North Central Butte Solonetzic Site 2016-2017 Subsoiling:


<table>
<thead>
<tr>
<th>Treatment</th>
<th>Aggregate Size MWD (mm)</th>
<th>Air Permeability (m s⁻¹)</th>
<th>Hydraulic Conductivity (cm min⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Compacted Subsoiled</td>
<td>12.99</td>
<td>13.66</td>
<td>1.15E-06</td>
</tr>
<tr>
<td>Non-Subsoiled</td>
<td>13.40</td>
<td>13.84</td>
<td>9.78E-07</td>
</tr>
<tr>
<td>(P value)</td>
<td>0.7335</td>
<td>0.5940</td>
<td>0.8309</td>
</tr>
<tr>
<td>Post-Compacted Subsoiled</td>
<td>12.37</td>
<td>14.41</td>
<td>5.20E-07</td>
</tr>
<tr>
<td>Non-Subsoiled</td>
<td>14.05</td>
<td>13.64</td>
<td>4.15E-07</td>
</tr>
<tr>
<td>(P value)</td>
<td>0.4594</td>
<td>0.585</td>
<td>0.6110</td>
</tr>
<tr>
<td>Control</td>
<td>Subsoiled</td>
<td>10.03</td>
<td>11.65</td>
</tr>
<tr>
<td>Non-Subsoiled</td>
<td>11.60</td>
<td>13.05</td>
<td>6.40E-07</td>
</tr>
<tr>
<td>(P value)</td>
<td>0.1609</td>
<td>0.0990</td>
<td>0.3097</td>
</tr>
</tbody>
</table>

Subsoiling tended to increase air permeability, hydraulic conductivity (p<0.10).
Subsoiling of Solonetz reduced soil strength to ~20 cm depth.
South Central Butte **Chernozemic** Site 1 2016-2017 **Subsoiling:**


<table>
<thead>
<tr>
<th>Treatment</th>
<th>Aggregate Size MWD (mm)</th>
<th>Air Permeability (m s⁻¹)</th>
<th>Hydraulic Conductivity (cm min⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-10 cm</td>
<td>0-10 cm</td>
<td>0-10 cm</td>
</tr>
<tr>
<td><strong>Subsoiled</strong></td>
<td></td>
<td>2016</td>
<td>2017</td>
</tr>
<tr>
<td>Compact</td>
<td>14.42</td>
<td>11.99</td>
<td>2.87E-06</td>
</tr>
<tr>
<td>Non-Compact</td>
<td>15.52</td>
<td>12.53</td>
<td>4.15E-06</td>
</tr>
<tr>
<td>(P value)</td>
<td>0.0159</td>
<td>0.8013</td>
<td>0.5685</td>
</tr>
<tr>
<td><strong>Non-Subsoiled</strong></td>
<td></td>
<td>2016</td>
<td>2017</td>
</tr>
<tr>
<td>Compact</td>
<td>15.14</td>
<td>12.62</td>
<td>4.50E-07</td>
</tr>
<tr>
<td>Non-Compact</td>
<td>14.29</td>
<td>14.42</td>
<td>1.38E-06</td>
</tr>
<tr>
<td>(P value)</td>
<td>0.6037</td>
<td>0.1484</td>
<td>0.0650</td>
</tr>
<tr>
<td><strong>Subsoiled vs Non-Subsoiled</strong></td>
<td>0.7413</td>
<td>0.5766</td>
<td>0.0315</td>
</tr>
<tr>
<td>Compaction</td>
<td>0.6558</td>
<td>0.2678</td>
<td>0.0007</td>
</tr>
</tbody>
</table>

Air permeability increased in 1ˢᵗ year by subsoiling of wheel traffic compacted areas
Vertical Tillage **Chernozemic Site 2 2016-2017:**


<table>
<thead>
<tr>
<th>Treatment</th>
<th>Aggregate Size MWD (mm)</th>
<th>Air Permeability (m s⁻¹)</th>
<th>Hydraulic Conductivity (cm min⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-10 cm</td>
<td>0-10 cm</td>
<td>0-10 cm</td>
</tr>
<tr>
<td>Till Tandem Disc</td>
<td>12.67</td>
<td>12.58</td>
<td>1.95E-06</td>
</tr>
<tr>
<td>Vertical</td>
<td>11.61</td>
<td>13.29</td>
<td>6.09E-07</td>
</tr>
<tr>
<td>(P value)</td>
<td>0.2439</td>
<td>0.7034</td>
<td>0.0837</td>
</tr>
<tr>
<td>Till Burn</td>
<td>12.43</td>
<td>13.26</td>
<td>2.61E-06</td>
</tr>
<tr>
<td>No Burn</td>
<td>12.58</td>
<td>12.30</td>
<td>3.99E-06</td>
</tr>
<tr>
<td>(P value)</td>
<td>0.9216</td>
<td>0.6167</td>
<td>0.3446</td>
</tr>
<tr>
<td>(P value) Till vs No Till</td>
<td>0.6672</td>
<td>0.9007</td>
<td>0.0249</td>
</tr>
</tbody>
</table>

Vertical tillage decreased air permeability in first year vs untilled and tandem disc: Action of baskets increases proportion of fine pores
But what about the yield??
Crop Yield 2016

Subsoiling of long-term wheel traffic area in Solonetzic soil increased yield

Subsoiling - Solonetzic Site Canola Grain Yield

Subsoiling – Chernozem Site 1 Wheat Grain Yield

Surface Tillage – Chernozem Site 2 Wheat Grain Yield
Crop Yield 2017

Surface Tillage-Chernozemic Site 2
Peas Grain Yield

Subsoiling - Solonetzic Site
Wheat Grain Yield

Subsoiling Chernozem Site 1
Peas Grain Yield

Grain yield (Kg ha⁻¹)

PRE-Compacted  POST-Compacted  Control  Subsoiled  Non-Subsoiled  Subsoiled  Non-Subsoiled  Compaction  Non-Compaction  Compaction  Non-Compaction  Tandem Disc  Vertical Tillage  Burn  No Burn

Surface Tillage
Summary & Conclusions

- **Subsoiling** results in increased air permeability, hydraulic conductivity, no effect on aggregate size.

- **Subsoiling** reduces soil strength.

- **Subsoiling** of compacted Solonetz increased canola yield in 2016, but no benefit to wheat yield on Chernozem.

- **Vertical tillage** decreased air permeability in first year.

- No effect of **vertical or tandem disc or burning** in fall of 2015 on the 2016 wheat yield or 2017 pea yield.

Most beneficial tillage strategy: subsoiling of long-term wheel traffic compacted sodium-affected (solonetzic) soils.
Acknowledgements

• **Assistance lab and field:**

• **Funding:**
  - Saskatchewan Agriculture Development Fund
  - Saskatchewan Wheat Development Commission
  - Western Grains Research Foundation
  - Sask Pulse Growers

• **Equipment courtesy of:**
  - [Western Sales]
  - [Government of Saskatchewan]
Thank you