How Tillage, No-till, & Surface Residue Influence Soil Water Storage

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Introduction

• More rain = better yield

• Actually, more *available soil water during plant growth* = better yield

• How does water get into the soil and avoid evaporation?

• We can use soil and residue management to maximize our long-term average yields.

• Water simply moves through cracks and root holes – right?
Introduction

Try to answer these practical questions:

1) If you could use zero tillage but all the surface residue was removed, or do full-width tillage with all the residue remaining on the soil surface, which would be better for water storage?

2) What if you’ve no-tilled for 10 years and now never have runoff, will tilling once set you back to year 1?

3) Is it OK if notill causes an increase in compaction?
Introduction

• ¼ of an inch of extra water = 2 bushels on a long-term average.

• Capture a little more of every precipitation event = less chance of plant stress, better yield components, more deep water for grain fill.

• Good news – The techniques that store more water are great for halting wind and water erosion! Yield and soil quality at the same time.

• My research is focused on winter wheat--summer fallow, but the principles for improving water infiltration and reducing evaporation are the same for irrigated systems.
Topics

• The Mechanics of Water Infiltration
• Soil Organic Matter
• Surface Residue
• Tillage
• Water Use by Weeds
• Available Water and Yield
• Notill
About Me

• Soil scientist, PhD 1991, University of California, Davis.

• In graduate school I worked with irrigated wheat.

• After that I worked on the STEEP On-Farm Testing project, stationed in Pullman. Lots of field work from Davenport to Dayton.

• Private research with McGregor and Craig Walters for a few years.

• 1997 started with the USDA-ARS in Pendleton.
The Data

These principles are not based on theory.
They come from:
Field measurements at research stations (Pendleton, Moro, Lind).
Lab work.
Cooperative studies with farmers and researchers.
Research reports from US and worldwide.
Most gratifying: when a farmers says “Yes, that makes sense. We have seen the same result”
The Mechanics of Water Infiltration

Three possible fates of precipitation:

1. Infiltrate
2. Runoff
3. Evaporate
Tillage--Fertility Experiment, Pendleton

disk, fertilize, cultivate, rod

plow, fertilize, cultivate, rod
The Mechanics of Water Infiltration

Fact #1: Under the soil surface, water is under tension.

Consequence #1: Water rarely flows through open spaces in the soil, it crawls from surface to surface.

(Soil cracks and root holes are not important to water infiltration! )
The Mechanics of Water Infiltration

Fact #1: Under the soil surface, water is under tension.

Consequence #1: Water rarely flows through open spaces in the soil, it crawls from surface to surface.

Fact #2: Free water on the soil surface moves downhill.

Consequence #2: If soil particles are free to move with the water, they will plug any openings where the water is penetrating the surface.

(Mobile soil creates a dense layer on the surface, which stops infiltration.)
Soil Organic Matter
Surface Residue

• Like soil organic matter, surface residue reduces soil particle separation and movement in water.

• Surface residue also reduces immediate evaporation.

• Deeper, faster penetration, faster surface drainage = more storage.
Greater surface residue consistently improves water storage in both tilled and no-till soil.
Tillage
Wasco and Moro, 7 September 2010

Cranston

McCoy

conventional tillage

no-till

sweep once

Peters

Smith

Gravimetric water content (%)

Depth (inches)
Wasco and Moro, 29 September 2010

Conventional tillage

Sweep once

No-till
Weed-free, no-till fallow soil water, Moro, OR, 2014

Gravimetric water content vs. Depth, feet for various dates:
- April 8
- May 6
- May 21
- June 11
- June 26
- July 17
- September 14
Water Use by Weeds
Data from Wayne Thompson

**COVER CROP**
Evapotranspiration (ET)

**FALLOW**
Evaporation (E)
Wheat/Fallow versus Wheat/Camelina/Fallow

Data from Bill Schillinger, WSU, Lind WA

Average of six years
Available Water and Yield
<table>
<thead>
<tr>
<th>inches of water</th>
<th>bushels per inch</th>
<th>Example</th>
<th>bushels per 1/4 inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil available water at planting</td>
<td>6.6</td>
<td>2</td>
<td>13.2</td>
</tr>
<tr>
<td>Over winter gain</td>
<td>7.9</td>
<td>2</td>
<td>15.8</td>
</tr>
<tr>
<td>April rain</td>
<td>4.4</td>
<td>1</td>
<td>4.4</td>
</tr>
<tr>
<td>May rain</td>
<td>7.6</td>
<td>1</td>
<td>7.6</td>
</tr>
<tr>
<td>June rain</td>
<td>12.2</td>
<td>1</td>
<td>12.2</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>53.2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of the plant (2.4 inch)</td>
<td>-16.4 bu</td>
<td></td>
<td>-16.4</td>
</tr>
<tr>
<td>Predicted grain yield</td>
<td></td>
<td></td>
<td>36.8</td>
</tr>
</tbody>
</table>

Information based on Schillinger et al., 2008. Winter wheat after summer fallow.
Notill
Wheat/Pea long-term plots, Pendleton

- Minimum Tillage
- Notill
- Fall Plow
- Spring Plow

Bushels per acre vs. Year (2010-2016)
• A world wide analysis of research results showed a 7.3% increase in yield with no-till versus conventional tillage in semi-arid dryland farming if stubble was retained. (Pittelkow et al., Nature, 2014)
Ten-year side-by-side yield comparisons

Winter Wheat Yield (bushels/acre)

- Chem Fallow
- Tilled Fallow

17 inch average rainfall (Expt. Station)
10.5 inch average rainfall (Echo)
Maximizing Soil Water Storage - summary

• Maximize soil organic matter at the surface (eliminate soil inversion)
• Maintain surface residue – more is better
• Minimize tillage – less is better
• Minimize weed water use
• Delay summer fallow tillage until rain is over

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