Adoption of Zero Till* in Western Canada and Other Areas

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Sept. 19, 2017

*Zero Till and No Till are assumed to be the same and include applying most fertilizer while seeding.
Summerfallowed field

Note the loss of organic matter in the lighter-colored knoll.
What is wrong with black, bare soil?

1. **Economics**
   - costs time and money to maintain
   - no crop production (for up to 20 months)

2. **Environment**
   - potential wind erosion
   - possible water erosion
   - release of CO$_2$
3. **Soil Quality**
   - low water infiltration
   - reduced organic matter
   - decline in soil-available nitrogen
   - loss of CO$_2$
   - decrease in yields & net returns
Water Infiltration Study (1991)

3.2 inches applied in 1 hour

<table>
<thead>
<tr>
<th>Rotation</th>
<th>SF/wheat</th>
<th>5 yr. ZT</th>
<th>10 yr. ZT</th>
<th>13 yr. ZT</th>
</tr>
</thead>
<tbody>
<tr>
<td>% org. matter</td>
<td>2.7</td>
<td>3.8</td>
<td>4.8</td>
<td>5.1</td>
</tr>
<tr>
<td>Total water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>infiltration (in.)</td>
<td>1.5</td>
<td>2.1</td>
<td>2.5</td>
<td>2.7</td>
</tr>
<tr>
<td>Runoff</td>
<td>1.7</td>
<td>1.1</td>
<td>.7</td>
<td>.5</td>
</tr>
</tbody>
</table>

(Charles Maulé, Agricultural Engineer, Univ. of Saskatchewan)
As a result of his study, Charles Maulé concluded the following.

“Zero tillage has a definite effect upon organic matter content and in turn, water infiltration; the greater the years of zero till, the greater the organic matter content, and the greater the water entry rate. Organic matter helps to stabilize soil aggregates against disruption by raindrop impact and thus can help to maintain higher infiltration rates as the conducting pores do not become clogged by small particles.”

In other words...

Increasing the years of continuous zero tillage increased the soil’s ability to absorb rainfall!
Measurements were done by Dr. Brian McConkey from Agriculture and Agri-Food Canada in 1998.

<table>
<thead>
<tr>
<th></th>
<th>Native Prairie</th>
<th>Conventional Till</th>
<th>20 Years Zero Till</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Organic Matter (Tons/Acre)</td>
<td>65</td>
<td>44</td>
<td>57</td>
</tr>
<tr>
<td>Saturated Hydraulic Conductivity (Inches/Hour)</td>
<td>3.4</td>
<td>1.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Total Nitrogen Available (Pounds/Acre)</td>
<td>6077</td>
<td>4117</td>
<td>5759</td>
</tr>
<tr>
<td>Soil Organic Carbon (Tons/Acre)</td>
<td>38</td>
<td>26</td>
<td>33</td>
</tr>
</tbody>
</table>
Available Nitrogen from Mineralization

Results from soil analysis and plot trials comparing Long-term (LTNT) and Short-term (STNT) zero-till soils

LTNT soil produced 50 – 65 lb. more nitrogen in a season.

This meant higher yields and protein in plots for the same amount of applied nitrogen.
Storage of Carbon Dioxide

Our loam soils had stored an average of

1.0 tonne of CO$_2$/acre on knolls

1.25 tonne of CO$_2$/acre on level areas

per year over 20 years.

All measurements were made by Agriculture and Agri-Food Canada.
Crop Yields and Net Returns
LTNT vs. STNT

Yields over 10 years
- wheat 16% higher
- canola 14% higher

Net returns over 10 years
- LTNT $48/acre more on average

Benefits of LTNT were even greater in years of low or high moisture (i.e., under stress).
## Adoption of Zero Till in Western Canada

Research Study by Dep’t of Bioresource Policy, Business & Economics (University of Saskatchewan, 2016)

<table>
<thead>
<tr>
<th></th>
<th>1991</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>3</td>
<td>65</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>10</td>
<td>70</td>
</tr>
<tr>
<td>Manitoba</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total Prairie average</strong></td>
<td></td>
<td><strong>61.6%</strong></td>
</tr>
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Summerfallow acres 19.5 M. 5.1 M.

As of 2011, 14.4 million more acres were in production each year.
Era of Zero Till Lookers (before adoption)

1984/85 Meetings
- Topics emphasized problems but offered few solutions.

Feb. 1987 Manitoba/North Dakota Zero Till Workshop
- held in Regina, Sask. – 1200 people attended
- start of Saskatchewan Soil Conservation Association

July, 1992, Indian Head Zero Till Field Day
- attendance went from 150 – 400
- became a 2-day event with 200 per day

1992 – Conserva Pak went from sales of 5 - 7/year to 26
1. Researchers at Univ’s of Saskatchewan & Manitoba were seeding winter wheat into stubble.

2. A few farmers were using box drills to try and seed into stubble. Some cultivators had banding knives and rear- mounted packers. We started using a Haybuster disk drill in 1979.
3. Roundup cost $25 – 30/litre. The recommended use was 1.0 L/ac with 10 gals. water. This was costly. - .5 - .6 L/ac and 5 gals. water worked as well for pre-season burnoff.

4. Farmers initiated the Manitoba/North Dakota Zero Till and Alberta Conservation Tillage organizations.
Major Limitations to Zero Till (up to 1985)

1. Nitrogen fertilizer had to be banded in the fall/spring or spread on the surface.
   - This was inefficient.

2. Most combines did a poor job of spreading straw and chaff.
   - This hampered direct seeding.
3. Most seeders could not do a good job of seeding into stubble.
   - Disk drills “hairpinned” on straw.
   - Box hoe drills could not clear stubble/residue.
   - Cultivators with air delivery lacked depth control and packing. Seed and fertilizer delivery was not uniform.

4. Roundup was expensive.
5. Farmers lacked zero till knowledge.

6. 30 – 35% of Western Canada was being summerfallowed each year.

7. Many professional agrologists were negative about zero till.
Equipment Developed for Zero Till

1. Straw and chaff spreading
   - various modifications
   - spinning rotors for chaff-spreading

Initial development was by prairie companies. Then major companies adopted the ideas.
2. Seeder developments
   - Flexicoil 5000 in late 1980’s – air product delivery, shanks to bolt on tips and then rear packers
   - had better straw clearance than box hoe drills
   - Various bolt-on openers tried to separate high fertilizer rates and seed.
3. Other companies developed air hoe drills.
   - Concord – Fargo, N.D.
   - Morris
   - Bourgault
   - John Deere

The early versions had no individual seed row depth control.
4. Conserva Pak

- developed from 1983 – 1988
- had individual seed row depth control and packing
- conducted numerous field trials
- sales began in 1989
- various copies in Western Canada and Australia

Most companies now have individual seed row depth control with knife-type openers.
Conserva Pak Opener

John Deere bought the latest Conserva Pak technology, patents, and trade mark in 2007.
Key Seeder Developments

1. Carbides for fertilizer and seed openers
   - We lengthened the life of openers from 6 – 800 acres to 10,000 acres.
   - With one-pass fertilizing, seeding, and packing, the time and cost for the openers was greatly reduced.
   - Farmers placed fertilizer 3½ - 4” deep in the soil which created benefits of establishing roots deeper and fracturing any tillage hard pan.
In Dec., 1996, original Conserva Pak openers tested in West Australia wore 2 inches off in 6 miles (40 acres on a 50 ft. seeder).
Carbides on openers after 48 miles (300 acres) show minimal wear.

Then we need to protect the rest of the opener and rear-mounted tubes, etc.
2. Increased accuracy of seed and dry fertilizer delivery
   - Early systems had coefficient of variation of >15% for low seed rates (canola @ 5 lbs/acre) and fertilizer rates (> 150 lbs/acre).

3. Optional Fertilizer Choices
   - Research that proved use of anhydrous ammonia at seeding (up to 100 lb N/acre) banded at seeding
   - Liquid fertilizer availability
   - Large-capacity dry product carts
Zero Till Research

1. Limited up until the 1990’s
   - zero till not common on farms
   - lack of adequate equipment such as ZT plot seeders and large plot combines

   - expanded to 6 stations in a few years
3. Cooperative trials at stations in Alberta, Saskatchewan, and Manitoba soon generated results.

4. Limited ZT agronomy research at universities - Soils researchers cooperated with Ag. Canada.
Extension Activities

1. 1975 to present
   - Farmer-directed conservation groups held winter meetings.

   - Federal Government’s “green plans” supported groups’ to access equipment, etc.
3. Ducks Unlimited have promoted zero till since 1990 with emphasis on winter wheat for spring duck/geese nesting.

4. Ag. Canada stations began to promote zero till at their summer field days.

5. Farmer groups acquired zero till seeders for use on 15 – 30 farms/year.
Farmer Adoption of Zero Till: Western Canada

Saskatchewan - slow & steady increase
- earlier adoption in Parkbelt instead of southern areas

Alberta - limited earlier adoption
- had fuel and fertilizer subsidies
- rapid increase after 2000 including numerous Hutterite colonies

Manitoba - most adoption is in SW part of province
- eastern area likes tillage to warm the soil
Farmer Adoption of Zero Till: Australia

Western Australia
- produces 40% of wheat
- low rainfall, poor soils
- ZT farmers association claimed they had 0 – 100% adoption in 10 years

New South Wales & Victoria
- generally, better soils and rainfall
- more livestock
- slow but steady adoption of zero till
- challenge to combine ZT and livestock on same farm

South Australia
- limited ZT until about 1998
- many very stoney areas
- rapid adoption once started
Farmer Adoption of Zero Till: United States

North Dakota / Montana
- has been slow adoption since early 1990’s
- many prefer disk drills and tillage before seeding
- subsidies & government programs restricted adoption

Pacific Northwest (Idaho, Oregon, Washington)
- our first experience on Palouse Hills was 1998
- fairly rapid adoption
- developed side-hill compensating hitch for hills
- farmers with 100 bus/acre wheat crops will use mowers to shorten stubble
- a lot less tillage now
Oklahoma/Kansas
- experience with John Deere in 2007/2008
- Oklahoma State & Kansas State universities were trying to establish winter canola as a rotation crop where winter wheat tends to be grown every year

**Observations:**
- very little zero till
- areas showing both wind and water erosion
- saw “deep plowing” and zero till in adjacent fields
- major challenge was inconsistent winter canola survival across fields

2017 – Farm contacts estimate 25 – 30% use zero till now.
Research:
- 10 farms all with some type of disk drill (John Deere, Great Plains, and Sunflower)
- compared to JD 1870 Conserva Pak
- Mark Boyles from OSU did a very thorough evaluation of emergence, winter survival at 3 dates, and final yields.

The following is from Mark Boyles’ Report.
OKANOLA

JD 1870 Direct Seeding

No-Till Research – Winter Canola

Mark Boyles – Extension Canola

Plant and Soil Sciences Dept.,
Oklahoma Cooperative Extension Service,
Monsanto, John Deere, and Cooperating Farmers.
Canola Yield Comparison
JD 1870 'vs' Other Drills

Planting Rate of 5 lbs /A

Seed used was DKW 13-69 RR. Conventional and No-Till Sites
No-Till Wheat Straw - Yield Comparison
JD 1870 'vs' Other Drills

Planting Rate of 5 lbs /A

Seed used was DKW 13-69 RR.

Four Locations
JD 1870 Summary

- Better moisture placement
- More consistent planting depth
- Excellent residue management
- Excellent at planting fertilizer placement
- More consistent emergence
- Improved initial stands and final stands
- Improved Conventional Tillage stand survival.
- Improved No-Till stand survival
- Improve yields conventional and no-till compared to other drills.
Western Canada Benefits from Adoption of Zero Till (U of S Research Study)

FARM:

<table>
<thead>
<tr>
<th>Short-term Benefits (1985 – 2012)</th>
<th>$ billion</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>- reduced machinery, labor, fuel and inputs cost</td>
<td>3.9</td>
<td>16</td>
</tr>
<tr>
<td>- increased production (reduced fallow)</td>
<td>7.7</td>
<td>32</td>
</tr>
<tr>
<td>- increased water use efficiency</td>
<td>6.0</td>
<td>25</td>
</tr>
<tr>
<td>Total short-term</td>
<td>17.7</td>
<td>72</td>
</tr>
</tbody>
</table>
(FARM):

**Long-term Benefits (1985 – 2012)** $ billion % of total

<table>
<thead>
<tr>
<th>Benefit</th>
<th>$ billion</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>- reduced wind erosion</td>
<td>0.7</td>
<td>3</td>
</tr>
<tr>
<td>- increased soil organic matter</td>
<td>4.8</td>
<td>20</td>
</tr>
<tr>
<td>- reduced salinity</td>
<td>0.2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total long-term</strong></td>
<td>5.7</td>
<td>24</td>
</tr>
</tbody>
</table>

**Total on-site (FARM)** $ 23.4 B 96 %

**Non-FARM (offsite)**

- soil carbon capture                   | 0.92      |
- fuel emission reduction               | 0.06      |
- reduced NO$_2$                        | 0.02      | 4          |

**$ 24.4 B 100**
Costs / Benefits calculated for funds spent on Zero Till Research, Development, and Extension:

**Public funds:**
$1 spent on research → $109 benefit

**Public & Private funds:**
$1 spent on research → $60.80 benefit

*Remember:*
The total benefits are still accruing. This only covered 1985 – 2012.
Managing Water With Zero Till: Australia

- Initially, they were not concerned about storing non-growing-season moisture.

- Now they do everything they can to preserve soil-stored water.

- They have learned that they can seed up and down hill and avoid water erosion with furrows left by the seeder.
New South Wales near FORBES  Aug.14/02

Both were Pasture Paddocks
Rainfall: February - 4", April - 1", May - 24 pts

Sprayed : September
    February
    April
Seeded : May 20th
    on 24pts of rain with a
    CONSERVA PAK

Cultivated : September
    February
    2 x May
Seeded : June with
    a conventional seeder
Managing Water With Zero Till: Western Canada in 2017

- Had very good moisture stored from 2016

- Had very low 2017 growing-season rainfall – many areas had 3 – 5 “ compared to normal 9 – 11”

- 2017 growing season was also very warm

- Overall results have generally produced an average crop (to the surprise of most people!)
Zero Tillage (one pass, low disturbance) is the closest annual cropping system to the original native grass ecology of the prairies; some crop grows every year. Because the new crop is planted directly into the stubble of the previous year’s crop, the old roots plus the new ones anchor the soil and provide aeration and water channels.

This parallels what happened with the original native grasses. In both systems, some crop is harvested each year. The remainder of the plant slowly decays on the surface, recycling nutrients into the soil for use by future crops.
One pass, low disturbance zero tillage can be even better for the land than native grasses were.

**We can:**
- add nutrients and increase biomass produced;
- choose which crop we want to grow, and grow better crops; and
- leave more residue to be recycled.