34 Years of Data
Rodale’s Farming Systems Trial (FST)
A Case For Transitioning To Organic

By Jeff Moyer
Farm Director
Healthy Soil = Healthy Food = Healthy People
Written on a blackboard in 1942

J.I. Rodale
Founded in 1981, the Farming Systems Trial (FST) is America’s longest running, side-by-side comparison of conventional and organic agriculture.

The project documents the feasibility of transitioning to organic production, as well as its economic, environmental, and energy conservation impacts.

FST has shown the potential of organic agriculture to improve our soil and water, while producing crop yields and net returns that are comparable (and sometimes better) than conventional systems.
Main cropping systems in FST

Organic-manure based

- Tilled manure system
- No-till manure system (added in 2008)

Organic-legume based

- Tilled legume system
- No-till legume system (added in 2008)

Conventional-chemically based

- Tilled conventional system
- No-till conventional system (added in 2008)
**2014-2015 FST Field Map**

**Farming Systems Trial - Field Layout**

- **Sys 1** No-till Manure System
- **Sys 2** Tilled Manure System
- **Sys 2** No-till Legume System
- **Sys 3** Tilled Conventional System
- **Sys 3** No-till Conventional System

**Notes:**
- Plots 221, 223, 222, 231 were shortened to 180 feet
- Plots 632, 613, 612, 611 were shortened to 200 feet

**Abbreviations:**
- B = Winter barley
- C = Corn
- Csil = Corn silage
- clv = clover mix
- HV = Hairy vetch
- O = Oats
- SB = Soybean
- W = Winter wheat
- Hay = Alfalfa / orchard grass mix
- compost is applied before oats and corn silage in the Manure systems

**Legend:**
- o = location of zero tension lysimeters

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**Tree Line**

---60 ft ----

--------------------------------300 ft ---------------------------------------
Areas of research in FST

- Yields & Agronomic Data
- Soil Health Parameters
- Water Quality and Quantity
- Energy Analysis
- Economics
FST long-term grain yields 1981-2010
FST corn yields in years with moderate drought

134
102

Organic

Conventional

Corn yields (bu/a @15.5%)

130 bu/a = Yield goal for Rodale soils

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Soils of the organic systems have a more active soil biological community
→ higher levels of glomalin (a glycoprotein that acts like ‘glue’, binding organic matter to mineral particles),
→ greater populations of mycorrhizae (a fungus that forms a symbiotic relationship with its host plant: the fungus receives carbohydrates from the plant, which in return gains access to water and nutrients).

This leads to improved soil structure and enhanced carbon sequestration.
Long-term soil carbon data
Organic (left) and conventional (right) corn during the 1995 drought – six weeks after planting
Water percolation volumes were 15-20% higher in the organic systems → increased groundwater recharge and reduced runoff under organic management

Nitrate-nitrogen leaching was the same for all systems, and fairly low: 15-18 kg nitrogen/ha/year

Nitrate-nitrogen concentration:
• Conventional plots: 20% of water samples >10 ppm
• Organic plots: 11% of samples > 10 ppm
  (10 ppm = legal limit for nitrate-nitrogen concentration in drinking water)

Herbicides:
• Only detected in water from conventional plots
• When atrazine was applied two years in a row, atrazine levels sometimes exceeded 3 ppb (EPA’s maximum contaminant level for drinking water)
FST Energy Analysis

Energy inputs
45% Higher

<table>
<thead>
<tr>
<th>Energy Inputs</th>
<th>Organic</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Diesel fuel</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Equipment</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Transportation of inputs</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Herbicide</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Seed</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lime</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Compost</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mineral fertilizer</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
## Energy budgets for corn

### 28% Improved Production Efficiency (Energy Unit Per Crop Unit)

<table>
<thead>
<tr>
<th>Energy inputs</th>
<th>Organic Tilled</th>
<th>Organic No-till</th>
<th>Conv Tilled</th>
<th>Conv No-till</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>vetch+ corn</td>
<td>vetch+ corn</td>
<td>corn</td>
<td>vetch+ corn</td>
</tr>
<tr>
<td>Nitrogen fertilizer</td>
<td>0</td>
<td>0</td>
<td>9,875</td>
<td>4,942</td>
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<tr>
<td>Phosphorus fertilizer</td>
<td>0</td>
<td>0</td>
<td>391</td>
<td>391</td>
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<tr>
<td>Potassium fertilizer</td>
<td>102</td>
<td>102</td>
<td>118</td>
<td>118</td>
</tr>
<tr>
<td>Lime</td>
<td>203</td>
<td>203</td>
<td>243</td>
<td>243</td>
</tr>
<tr>
<td>Seed</td>
<td>2,559</td>
<td>2,559</td>
<td>1,182</td>
<td>2,468</td>
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<tr>
<td>Herbicide</td>
<td>0</td>
<td>0</td>
<td>1,055</td>
<td>1,509</td>
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<tr>
<td>Transportation of inputs</td>
<td>247</td>
<td>247</td>
<td>453</td>
<td>486</td>
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<tr>
<td>Equipment</td>
<td>639</td>
<td>615</td>
<td>619</td>
<td>509</td>
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<tr>
<td>Diesel fuel</td>
<td>5,359</td>
<td>3,046</td>
<td>2,725</td>
<td>2,201</td>
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<tr>
<td>Labor</td>
<td>1,041</td>
<td>511</td>
<td>712</td>
<td>563</td>
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<tr>
<td><strong>Total energy (MJ/ha*yr)</strong></td>
<td><strong>10,150</strong></td>
<td><strong>7,283</strong></td>
<td><strong>17,372</strong></td>
<td><strong>13,429</strong></td>
</tr>
</tbody>
</table>

This analysis was performed using the Farm Energy Analysis Tool (FEAT)3
Greenhouse gas emissions

- **Organic**
  - N2O emissions from soil
  - Diesel fuel
  - Equipment
  - Transportation of inputs
  - Herbicide
  - Seed
  - Lime
  - Compost production
  - Mineral fertilizer production

- **Conventional**
  - Emissions from soil processes
  - Emissions from direct inputs

40% Less
FST Economic Analysis

Income, Expenses & Returns in FST organic and conventional systems

Organic & Conventional

Income: 835 vs. 495
Expenses: 277 vs. 306
Returns: 558 vs. 190

$ per acre per year
FST Economic Analysis

Expenses for FST organic and conventional systems

<table>
<thead>
<tr>
<th>Expenses (in percent of total expenses)</th>
<th>Organic</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>fixed expenses</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>interest on op.cap.</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>repair &amp; maintenance</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>repair &amp; maintenance</td>
<td>9</td>
<td>6</td>
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<td>repair &amp; maintenance</td>
<td>16</td>
<td>4</td>
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<tr>
<td>fuel</td>
<td>35</td>
<td>29</td>
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<tr>
<td>labor</td>
<td>3</td>
<td>22</td>
</tr>
<tr>
<td>custom haul</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>seeds</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>herbicides</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>fertilizers</td>
<td>3</td>
<td>1</td>
</tr>
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</table>

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Production budgets for corn

<table>
<thead>
<tr>
<th>Expenses</th>
<th>Organic Tilled vetch+ corn</th>
<th>Organic No-till vetch+ corn</th>
<th>Conv Tilled vetch+ corn</th>
<th>Conv No-till vetch+ corn</th>
</tr>
</thead>
<tbody>
<tr>
<td>fertilizer</td>
<td>0.00</td>
<td>0.00</td>
<td>118.04</td>
<td>90.44</td>
</tr>
<tr>
<td>herbicide</td>
<td>0.00</td>
<td>0.00</td>
<td>108.19</td>
<td>144.56</td>
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<tr>
<td>seeds</td>
<td>139.40</td>
<td>139.40</td>
<td>88.15</td>
<td>148.35</td>
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<tr>
<td>custom haul</td>
<td>30.00</td>
<td>30.00</td>
<td>30.00</td>
<td>30.00</td>
</tr>
<tr>
<td>labor</td>
<td>39.35</td>
<td>18.61</td>
<td>15.78</td>
<td>16.14</td>
</tr>
<tr>
<td>fuel</td>
<td>47.60</td>
<td>23.96</td>
<td>23.76</td>
<td>20.67</td>
</tr>
<tr>
<td>repair &amp; maintenance</td>
<td>17.56</td>
<td>10.35</td>
<td>8.42</td>
<td>8.97</td>
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<tr>
<td>interest on op.capital</td>
<td>6.35</td>
<td>4.54</td>
<td>11.50</td>
<td>13.50</td>
</tr>
<tr>
<td>fixed expenses</td>
<td>52.02</td>
<td>30.98</td>
<td>27.31</td>
<td>27.46</td>
</tr>
<tr>
<td><strong>Total Expenses ($/acre)</strong></td>
<td><strong>332</strong></td>
<td><strong>258</strong></td>
<td><strong>431</strong></td>
<td><strong>500</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Profit ($/acre) *</th>
<th>@ 100 bu/a yield</th>
<th>@ 150 bu/a yield</th>
<th>@ 200 bu/a yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Tilled</td>
<td>504</td>
<td>922</td>
<td>1,340</td>
</tr>
<tr>
<td>Organic No-till</td>
<td>578</td>
<td>996</td>
<td>1,414</td>
</tr>
<tr>
<td>Conv Tilled</td>
<td>-16</td>
<td>191</td>
<td>399</td>
</tr>
<tr>
<td>Conv No-till</td>
<td>-85</td>
<td>122</td>
<td>330</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Break-even price ($/bu)</th>
<th>@ 100 bu/acre</th>
<th>@ 150 bu/acre</th>
<th>@ 200 bu/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Tilled</td>
<td>3.32</td>
<td>2.22</td>
<td>1.66</td>
</tr>
<tr>
<td>Organic No-till</td>
<td>2.58</td>
<td>1.72</td>
<td>1.29</td>
</tr>
<tr>
<td>Conv Tilled</td>
<td>4.31</td>
<td>2.87</td>
<td>2.16</td>
</tr>
<tr>
<td>Conv No-till</td>
<td>5.00</td>
<td>3.33</td>
<td>2.50</td>
</tr>
</tbody>
</table>

These production budgets were calculated using the free on-line Mississippi State Budget Generator (MSBG), developed by the Department of Agricultural Economics at Mississippi State University, (http://www.agecon.msstate.edu/what/farm/generator/). When available, input and price data were taken directly from data collected at the Rodale Institute (2008-2010), otherwise default values from the Budget Generator were used.

* The 3-year average price for organic corn was $8.36/bu, for conventional corn $4.15/bu.
Comparison of FST organic and conventional systems

Yields (lbs/a/yr)

- Organic: 4,079
- Conv: 4,022

Profit ($/a/yr)

- Organic: 558
- Conv: 190

Energy Input (MJ/a/yr)

- Organic: 3,264
- Conv: 4,568

Greenhouse gases (lbs CO2/a/yr)

- Organic: 906
- Conv: 1,400

Yields = grain and forage yields combined
It Really is About The Life In The Soil
Light is the energy source

Human nutrition and health starts in the soil, from which plants draw their nutrients

The soil microbial community provides the nutritional building blocks that plants need to grow and thrive

The soil’s microbial “labor force” incorporates carbon into the soil structure
A Different Way of Farming
Innovation all across the US
**Corn**

**PLOW TILL**
- PLOW
- DISC
- PACK
- PLANT
- ROTARY HOE
- ROTARY HOE
- CULTIVATE
- CULTIVATE
- HARVEST
- (143 Bu/A)

**NO-TILL**
- ROLL/PLANT
- HARVEST
- (160 Bu/A)

A two step organic production system Plant and Harvest!
2013 Corn into Hairy Vetch
Corn Planted Into Hairy Vetch
2013 Soybeans Planted Into Rolled Rye

Yield 59 Bu/A
No-Till Transplanters
The Concept is Scale Neutral
Thank You!

Jeff Moyer

jeff.moyer@rodaleinstitute.org