Straw Management and Crop Rotation
Alternatives to Stubble Burning:
Assessing Economic and Environmental Trade-offs

DOE Presentation – Feb. 12, 2013
by Gerard Birkhauser

Co-Principle Investigators
Dave Huggins, Soil Scientist
Tim Paulitz, Plant Pathologist
Kate Painter, Ag. Economist
Field Studies and Lab Analyses

DOE-1 Field Study (12 x 12 ft plots)

• 15 sites with 6 treatments (Fall ‘11 Burn, Spg. ‘12 Burn, Control, Fertilized/Nonfert.)

DOE-2 Field Study (12 x 12 ft plots)

• Rotations after Fall Burn: (1) ww-sb-sw; (2) ww-cp-sw; (3) ww-ww-sw.

DOE-3 Field Study (10 x 50 ft plots)

• 2 rotations (ww and ww-l) and 3 tillage
DOE-1 Test Plots of the 3-Treatments with the 2 Fertilizer Applications.
Transformation of Pre-plant Test Plot to 3-Treatments (x2 Fertilizer Applications)

DOE-1 and DOE-2 Test Plots
(Fall 2011 Burn is shown)
DOE-3 Plots with the various rotations and tillage treatments.
Project Objectives

2011-2012 study documenting:

(1) Wheat stubble burning impacts (SOM; C, N, P losses)

(2) Crop rotations and sequences that benefit from retaining winter wheat residues in DS systems

(3) Effects of wheat straw management and rotation alternatives on root pathogens

(4) An economic analysis
Methodology Used to Accomplish the Objectives

• Measure soil chemical and physical characteristics (soil pH, POM, bulk density, water content, nutrient contents).

• Assess the residue loads (biomass, yields, C and N contents, net collected weights).

• Compute C, N, and P losses (mass balance on soil, plants, and residue).

• Evaluate micronutrient fluxes (PRS probes).
Progress Made Since June Meeting

- Process the collected residue from Spg burn.
- Assessed the Spg 2012 burn residue loads.
- Harvested and threshed crops to determine yields for all three DOE fields.
- Collected post-harvest soil samples (90).
• Prepared residue samples of Spg 2012 burn for nutrient analysis.

• Reviewing and summarizing nutrient flux data from PRS probes.

• Performing physical and chemical testing on soil samples.

• Computing C, N, and P losses (mass balance on soil, plants, and residue) of Spg burn.
Residue Loss from Spg 2012 Burn

- 7,152 lb/ac (preBurn) vs. 1,832 lb/ac (postBurn)
- Residue mass lost to burning ranged 51 – 89%
- Average residue lost to burning for 15 sites was 74% compared to:
  - 78% - **fall 2011** 10,264 (PreB) 2,302 (PostB) lb/ac
  - 55% - **spg 2010** 5,166 (PreB) 2,353 (PostB) lb/ac
  - 62% - **fall 2009** 8,092 (PreB) 3,064 (PostB) lb/ac
- Plotting residue consumed from burning, slope correlation were lower than previous burn data.
Residue Loss from Recent Burns

Percentage Residue Loss to Burning

Residue Loss

Test Plot Number

Spring 2012
Fall 2011
Residue Loss from Prior Burns

Percentage Residue Loss to Burning

Residue Loss

Test Plot Number

Spring 2010
Fall 2009
Comparison of Crop Yields for Various Treatments

In comparing Burning to Control (non-burn):

<table>
<thead>
<tr>
<th></th>
<th>Fertilized Plots</th>
<th>Non-Fertilized</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2011-2012 Harvest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall Burn</td>
<td>18% ↑ yield</td>
<td>25% ↑ yield</td>
</tr>
<tr>
<td>Spring Burn</td>
<td>4% ↑ yield</td>
<td>3% ↓ yield</td>
</tr>
<tr>
<td><strong>2009-2010 Harvest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall Burn</td>
<td>3% ↓ in yield</td>
<td>13% ↑ in yield</td>
</tr>
<tr>
<td>Spring Burn</td>
<td>10% ↓ in yield</td>
<td>4% ↓ in yield</td>
</tr>
</tbody>
</table>
## Crop Yields for DOE-1

<table>
<thead>
<tr>
<th>Spring Wheat</th>
<th>Control</th>
<th>Fall Burn</th>
<th>Spring Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N Applied</td>
<td>No N Applied</td>
<td>N Applied</td>
</tr>
<tr>
<td>Grain Yield (bu/ac)</td>
<td>59a</td>
<td>47b</td>
<td>57a</td>
</tr>
<tr>
<td>Grain Protein (%)</td>
<td>11.0a</td>
<td>9.1b</td>
<td>11.4a</td>
</tr>
<tr>
<td>Grain Yield (bu/ac)</td>
<td>51</td>
<td>36</td>
<td>60</td>
</tr>
<tr>
<td>Grain Protein (%)</td>
<td>8.3</td>
<td>8.2</td>
<td>8.3</td>
</tr>
</tbody>
</table>
## Crop Yields for DOE-2

<table>
<thead>
<tr>
<th>Crop</th>
<th>2010 Harvest Control</th>
<th>2010 Harvest Fall Burn</th>
<th>2012 Harvest Control</th>
<th>2012 Harvest Fall Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter Wheat Yield following Winter Wheat, (bu/ac)</td>
<td>82a</td>
<td>82a</td>
<td>72</td>
<td>82</td>
</tr>
<tr>
<td>Garbanzo Bean Yield following Winter Wheat, (lbs/ac)</td>
<td>1624a</td>
<td>1634a</td>
<td>1934</td>
<td>2008</td>
</tr>
<tr>
<td>Spring Barley Yield following Winter Wheat, (lbs/ac)</td>
<td>4733b</td>
<td>5234a</td>
<td>4059</td>
<td>4415</td>
</tr>
</tbody>
</table>
Outreach Efforts to get the word out about DOE-funded Project

- ASSS Conference
- Stakeholder Presentations
- Field Day Presentations to Local Growers and Scientific Researchers
- “Subcontractor” Technical Presentations
Straw Management and Crop Rotation Alternatives to Stubble Burning

Gerard Birkhauser
WSU

DOE Study results – Aug. 2012
Cook Farm Field Day
Growers & Researchers Presentation
Straw Management and Crop Rotation Alternatives to Stubble Burning

Gerard Birkhauser & Dave Huggins

WSU - USDA

DOE Study results – Oct. 2012

American Society of Soil Science Annual Meeting

Poster Session
Straw Management and Crop Rotation Alternatives to Stubble Burning

Dave Huggins
USDA - WSU

DOE Study results – Jan. 2013
Columbia Conservation District Annual Meeting
Dynamics of Ion Sorption by Synthetic Resin Membranes (PRS Probes)

Eric Bremer and Troy Radtke
Western Ag Innovations

Dave Huggins and Gerard Birkhauser
USDA - WSU

DOE PRS Study results – Feb. 2013

Alberta Soil Science Workshop
Anion probe

- Anion Membrane
- quaternary R-NH₃⁺

Cation probe

- Cation Membrane
- sulfonic acid R-SO₃⁻

Field Deployment & Lab Incubation Studies
Nutrient Flux Measurements using the PRS Probes for Lab Incubation study.

14 Nutrients are collected on probes that simulate what a plant would take-up during the burial period.
Week-3 Plot #8
Fall Burn w/ PRS
Probes deployed between rows Spg. Wht.
Summary of PRS probe data for Field Deployment

Installed in FB & CON plots (unfertilized subplot)
Burial periods: 1-day and 1, 2, 3, 4-week

Spring 2012

• May 10th (started 24-hr period) – June 15th
• Prior Precpt.: 19.2 in (actual) – 16.1 (normal)
• Test time rainfall: 3.3 in (act.) – 3.1 (norm.)

Spring 2010

• April 14th – May 20th
• Prior Precpt.: 9.5 in (actual) – 14.5 (normal)
• Test time rainfall: 4.6 in (act.) – 3.5 (norm.)
NO3-N
Spring 2010

Field
Lab

µg NO3-N 10 cm^-2

1d 1wk 2wk 3wk 4wk 5wk

Burned
Control
K
Spring 2010

Field

Lab

μg K 10 cm⁻²

0 20 40 60 80 100 120 140

1d 1wk 2wk 3wk 4wk 5wk

1d 1wk 2wk 3wk 4wk

Burned
Control
Items to Complete (next 6 mon.)

• Physical analyses of soil (45 samples).
• Nutrient analyses of plants (12 samples).
• Nutrient analyses of residue (12 samples).
• C & N contents of soil and residue for spring 2012 Burn (30 samples each).
• N mineralization incubations 28-day cycle.
• Evaluation of PRS probe data.
Items to Complete (continued)

- Soil erosion and condition index estimates.
- Economic assessment of lost residue.
- Completion of Final Report.
- Continue outreach efforts to communicate the project findings.
- Compile a manuscript of results for the 2-growing seasons (2009 – 2012).
Cook Agronomy Farm
Direct Seed and Precision Farming Systems

Location of Field Studies based on the 3 Objectives

2009-2010 DOE 1 & 2 Field A

2009-2010 DOE 3 Field

2011-2012 DOE 1 & 2 Field B
DOE-1 Burn Plots: Fall 2011 and Spring 2012
### DOE 3 Plot Map SY2011-HY2012, PCFS Field

#### Rotation

<table>
<thead>
<tr>
<th>Rep 1</th>
<th>Rep 2</th>
<th>Rep 3</th>
<th>Rep 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-L-3 SBCS</td>
<td>W-1 CT</td>
<td>W-3 NBCS</td>
<td>W-L-1 CT</td>
</tr>
<tr>
<td>W-L-4 NBCS</td>
<td>W-2 FBCS</td>
<td>W-4 NBH</td>
<td>W-L-3 SBCS</td>
</tr>
<tr>
<td>W-L-2 FBCS</td>
<td>W-3 NBCS</td>
<td>W-1 CT</td>
<td>W-L-5 NBCS</td>
</tr>
<tr>
<td>W-L-1 CT</td>
<td>W-4 NBH</td>
<td>W-L-4 NBCS</td>
<td>W-2 FBCS</td>
</tr>
<tr>
<td>W-L-5 NBH</td>
<td>W-L-2 FBCS</td>
<td>W-L-5 NBH</td>
<td>W-L-1 CT</td>
</tr>
<tr>
<td>W-4 NBH</td>
<td>W-L-5 NBCS</td>
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</tr>
<tr>
<td>W-L-3 NBCS</td>
<td>W-L-5 NBH</td>
<td>W-1 CT</td>
<td>W-2 FBCS</td>
</tr>
</tbody>
</table>

#### Rotation

- **W** - continuous winter wheat
- **W-L** - winter wheat-legume

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<thead>
<tr>
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<th>Rep 1</th>
<th>Rep 2</th>
<th>Rep 3</th>
<th>Rep 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Tillage</td>
<td>W-L-1 CT</td>
<td>W-L-2 FBCS</td>
<td>W-L-3 SBCS</td>
<td>W-L-5 NBH</td>
</tr>
<tr>
<td>Fall Burn, Cross Slot</td>
<td>W-L-3 NBCS</td>
<td>W-2 FBCS</td>
<td>W-L-4 NBCS</td>
<td>W-L-5 NBCS</td>
</tr>
<tr>
<td>No Burn, Cross Slot</td>
<td>W-L-4 NBCS</td>
<td>W-1 CT</td>
<td>W-3 NBCS</td>
<td>No Burn, Cross Slot</td>
</tr>
<tr>
<td>No Burn, Horsh</td>
<td>W-L-5 NBH</td>
<td>W-L-2 FBCS</td>
<td>W-4 NBH</td>
<td>W-L-5 NBH</td>
</tr>
</tbody>
</table>
## Residue Load Impacts from Burn Treatments

<table>
<thead>
<tr>
<th>Winter Wheat Residue</th>
<th>Fall 2009 Burn</th>
<th>Spring 2010 Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-burn</td>
<td>Post-burn</td>
</tr>
<tr>
<td>Residue Load (lbs/ac)</td>
<td>8093a</td>
<td>3059c</td>
</tr>
<tr>
<td>Residue N (%)</td>
<td>0.44d</td>
<td>0.78a</td>
</tr>
<tr>
<td>Residue C (%)</td>
<td>39.9b</td>
<td>39.9b</td>
</tr>
<tr>
<td>Residue C/N</td>
<td>92.0a</td>
<td>54.5b</td>
</tr>
<tr>
<td>Residue N (lbs/ac)</td>
<td>35.9a</td>
<td>24.2c</td>
</tr>
<tr>
<td>Residue C (lbs/ac)</td>
<td>3228a</td>
<td>1218c</td>
</tr>
</tbody>
</table>