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

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Kate Painter, Ag. Economist
Gerard Birkhauser, PhD Grad. Student
Farmer incentives for burning stubble include:

- Facilitating the establishment of the next crop
- Decreasing incidence of soil-borne disease
- Decreasing nutrient (e.g. N) tie-up by decomposing cereal residues
- Positive response of crop growth, yield and economic return
Grower disincentives to burning stubble can be difficult to quantify.

- Negative impacts on overall soil organic matter levels
- Loss of nutrients (e.g. N, P and S)
- Increased hazard of soil erosion if burning is combined with too much tillage
Assessing trade-offs has not adequately addressed:

- Quantities of residues and associated nutrients (e.g. N, P, S) lost via burning
- Field burning impacts on labile soil organic matter that effect crop nutrient availability (e.g. N, P, S)
- Soil-borne disease or straw toxicity effects
- Field-scale variation and site-specific effects (Precision Ag. Applications)
Project Objectives (1)

(1) Document and economically assess wheat stubble burning effects on:

- Soil organic matter
- Site-specific soil erosion estimates
- Soil condition index (SCI)
- Residue C and nutrient (N, P, S) losses
Develop principles and strategies that reduce risk, increase profits and improve environmental quality
Pattern Analysis

Non-aligned grid sampling scheme

Geo-referenced sample locations

water course
Methods (Objective 1)

Evaluate the loss of C and nutrients (N, P, S) from residue burning:

- (1) fall burning of winter wheat residues
- (2) spring burning of winter wheat residues
- (3) no burning of winter wheat residues

15 locations
<table>
<thead>
<tr>
<th>Winter Wheat Residue</th>
<th>Fall Burn</th>
<th></th>
<th>Spring Burn</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-burn</td>
<td>Post-burn</td>
<td>Pre-burn</td>
<td>Post-burn</td>
</tr>
<tr>
<td>Residue lbs/ac</td>
<td>8093a</td>
<td>3059c</td>
<td>5168b</td>
<td>2354c</td>
</tr>
<tr>
<td>Residue N (%)</td>
<td>0.44d</td>
<td>0.78a</td>
<td>0.52c</td>
<td>0.69b</td>
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<tr>
<td>Residue C (%)</td>
<td>39.9b</td>
<td>39.9b</td>
<td>43.0a</td>
<td>40.5b</td>
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<tr>
<td>Residue C/N</td>
<td>92.0a</td>
<td>54.5b</td>
<td>84.6a</td>
<td>59.5b</td>
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<tr>
<td>Residue N lbs/ac</td>
<td>35.9a</td>
<td>24.2c</td>
<td>27.3b</td>
<td>16.3d</td>
</tr>
<tr>
<td>Residue C lbs/ac</td>
<td>3228a</td>
<td>1218c</td>
<td>2226b</td>
<td>955c</td>
</tr>
<tr>
<td>Soil Property</td>
<td>Control</td>
<td>Fall Burn</td>
<td>Spring Burn</td>
<td></td>
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<tr>
<td>------------------------</td>
<td>---------</td>
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<td></td>
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<tr>
<td>Soil N (%)</td>
<td>0.15a</td>
<td>0.16a</td>
<td>0.16a</td>
<td></td>
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<tr>
<td>Soil C (%)</td>
<td>1.84a</td>
<td>1.88a</td>
<td>1.80a</td>
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<tr>
<td>Soil C/N Ratio</td>
<td>11.84a</td>
<td>11.92a</td>
<td>11.48a</td>
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<tr>
<td>Bulk Density (g/cm³)</td>
<td>1.33a</td>
<td>1.34a</td>
<td>1.34a</td>
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<tr>
<td>Soil pH</td>
<td>6.04a</td>
<td>6.18a</td>
<td>6.03a</td>
<td></td>
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<tr>
<td>PON (%)</td>
<td>2.27b</td>
<td>2.58a</td>
<td>2.27b</td>
<td></td>
</tr>
<tr>
<td>POC (%)</td>
<td>32.2b</td>
<td>36.9a</td>
<td>32.0b</td>
<td></td>
</tr>
<tr>
<td>POM C/N Ratio</td>
<td>14.3a</td>
<td>14.3a</td>
<td>14.2a</td>
<td></td>
</tr>
<tr>
<td>Spring Wheat</td>
<td>Control</td>
<td></td>
<td>Fall Burn</td>
<td></td>
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<td>-----------------------</td>
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</tr>
<tr>
<td></td>
<td>N Applied</td>
<td>No N Applied</td>
<td>N Applied</td>
<td>No N Applied</td>
</tr>
<tr>
<td>Grain Yield (bu/ac)</td>
<td>59a</td>
<td>47b</td>
<td>57a</td>
<td>53a</td>
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<tr>
<td>Grain Protein (%)</td>
<td>11.0a</td>
<td>9.1b</td>
<td>11.4a</td>
<td>8.9b</td>
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<tr>
<td>Crop Residue N (lbs/ac)</td>
<td>22.9a</td>
<td>8.3b</td>
<td>25.3a</td>
<td>10.6b</td>
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<tr>
<td>Crop Residue C (%)</td>
<td>44.6a</td>
<td>44.5a</td>
<td>44.5a</td>
<td>44.6a</td>
</tr>
<tr>
<td>Crop Residue C (lbs/ac)</td>
<td>2282a</td>
<td>1240c</td>
<td>2246a</td>
<td>1578b</td>
</tr>
</tbody>
</table>
Plant Root Simulator (PRS) Probes
<table>
<thead>
<tr>
<th>Spring Wheat and Soil Properties</th>
<th>Control</th>
<th>Fall Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Stem Leaves (no)</td>
<td>3.94b</td>
<td>4.53a</td>
</tr>
<tr>
<td>Tillers (no)</td>
<td>1.26a</td>
<td>1.61a</td>
</tr>
<tr>
<td>Plant N (%)</td>
<td>3.3b</td>
<td>3.9a</td>
</tr>
<tr>
<td>Plant Dry Weight (lbs/ac)</td>
<td>96b</td>
<td>176a</td>
</tr>
<tr>
<td>Plant N (lbs/ac)</td>
<td>3.3a</td>
<td>7.0b</td>
</tr>
<tr>
<td>Extracted Soil NO₃-N, Day 1, (ppm)</td>
<td>21.5a</td>
<td>24.1a</td>
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<tr>
<td>PRS probe Nitrate-N, Day 1, Field, (µg 10 cm⁻² 24hr⁻¹)</td>
<td>10.7a</td>
<td>21.8a</td>
</tr>
<tr>
<td>PRS probe Nitrate-N, 7 Days, Field, (µg 10 cm⁻² 7days⁻¹)</td>
<td>62.5b</td>
<td>87.8a</td>
</tr>
<tr>
<td>PRS Probe P, Day 1, Field, (µg 10 cm⁻² 24hr⁻¹)</td>
<td>0.80a</td>
<td>0.56a</td>
</tr>
<tr>
<td>PRS Probe S, Day 1, Field, (µg 10 cm⁻² 24hr⁻¹)</td>
<td>19.6a</td>
<td>19.6a</td>
</tr>
</tbody>
</table>
Key Findings

- Fall burning reduced surface winter wheat residue mass by 62% whereas spring burning reduced residue mass by 55%.

- Overall, 2,010 lbs C/ac were lost from fall burning while 1,271 lbs C/ac were lost during the spring burn.

- The average amount of N lost by burning was similar with 12 lbs N/ac lost during the fall burn and 11 lbs N/ac lost during the spring burn.
Key Findings

Winter wheat residue N lost during the spring burn was 40% and for fall burn 33% of total; N losses from burning were appreciably lower than the previously reported losses of nearly 100% (laboratory studies).

Residue burning had little impact on: soil N%, soil C%, soil C/N ratio, bulk density, soil pH and particulate organic matter (POM) C/N ratio, for this one year study.
Key Findings

- Fall burning of winter wheat residue increased early season (wheat tillering stage) soil N availability, spring wheat growth and development and spring wheat N uptake.

- Aboveground spring wheat N uptake (tillering) was 112% greater in fall burned as compared to control plots.

- Field deployed PRS probes had 40% more μg N 10 cm⁻² 7 days⁻¹ in fall burned as compared to control plots.
Next Steps

- Analyses of crop residues: S and P
- Economic analyses: (1) the loss of N, P and S; (2) treatment differences in net N mineralization and the dollar value associated with an equivalent amount of N fertilizer.
- The potential for soil erosion and evaluation of the Soil Conditioning Index for the 92 acre field.
**Nutrient Removal in Baled WW Straw**

Yield: 90 bu/acre
Baled Average: 3778 lbs/acre

**Field average**
- N: 14 lb/acre
- P$_2$O$_5$: 6 lb/acre
- K$_2$O: 33 lb/acre
- S: 3 lb/acre
SCI, No-till, Baled Straw

WW-SP-SW Rotation

-0.02 - 0.06
0.07 - 0.13
0.14 - 0.21
0.22 - 0.28
0.29 - 0.35

Meters

0 125 250 500 750 1,000
(2) Identify and economically assess crop rotations and sequences that benefit from retaining winter wheat residues in direct-seed systems.
<table>
<thead>
<tr>
<th>Crop</th>
<th>Control</th>
<th>Fall Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter Wheat Yield following Winter Wheat, (bu/ac)</td>
<td>82a</td>
<td>82a</td>
</tr>
<tr>
<td>Garbanzo Bean Yield following Winter Wheat, (lbs/ac)</td>
<td>1624a</td>
<td>1634a</td>
</tr>
<tr>
<td>Spring Barley Yield following Winter Wheat, (lbs/ac)</td>
<td>4733b</td>
<td>5234a</td>
</tr>
</tbody>
</table>
DOE 3 Field Study Parameters

• 2 different rotations:
  – continuous ww
  – ww-legume

• 3 types of planting:
  – conventional
  – cross slot
  – Horsh

• 4 replicates
(3) Document effects of wheat straw management and rotation alternatives on root pathogens
Effect of burn and N treatments on Fusarium Crown Rot (Severity 0-4 rating)

Burn Treatments

- Control
- Fall Burn
- Spring Burn
- N Applied
- No N applied

Severity (0-4 rating)

- A
- B

- Control: 0.4
- Fall Burn: 0.6
- Spring Burn: 0.6

Legend:
- No N applied
- N Applied

- A
- B
Key Finding: Objective 3

- In spring wheat, less Fusarium Crown Rot occurred in treatments with burning, and higher disease occurred with N fertilizer.
(4) Convey project findings through electronic and print media, field days, conferences and research site tours
Outreach

Large-scale field studies
‘Seeing is believing’

People: creative force behind global solutions

Field Days

Outdoor Classroom
Budget

- Budget (September 1, 2011 through June 30, 2013)
- Salaries (0.75 FTE Assoc. in Res. 2 yrs.) $28,534
- Benefits @ 28.4% 8,105
- Total salaries, wages, and benefits $36,639
- Supplies and Services for lab anal. 2,250
- Total Direct Costs $38,889
- Total F and A @ 8.00% 9,042
- Total Costs $47,931