Soil and Crop Yield Response to Harvesting Crop Residues for Biofuel

REAP - Renewable Energy Assessment Project

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The problem

- Renewable motor fuel
  - 30 x ’30
  - 30% motor fuel from renewable sources by 2030

- Field after field of corn residue
  - “Going to waste”
  - Potential source of biomass for energy

- Can crop residues be removed from the land sustainably?
REAP Objectives

- Residue needed to maintain soil function and sustain production
- Trade-off for residue use as bioenergy versus soil carbon feedstock
- Algorithm to guide sustainable harvest of residue for biomass ethanol
- Management strategies for sustainable harvest of residue
REAP (NP 202 - Soil Resource Management)

- Cross Location Research (CLR) project
  - Common objectives for efforts at several locations
  - Regional/National effort

- Funding
  - Existing local projects

- Staff
  - Volunteer
  - Commitment
  - Enthusiasm

EtOH
Long-term Studies on SOC
NRCS Linkage

REAP Team

CQESTR
Simulation of SOC Dynamics

SMAF

REAP
Anticipated products

- Management practices
  - Sustainable harvest of residue
- Algorithm
  - Guide sustainable residue harvest
- Decision support tool and guidelines
  - How much residue must be retained?
  - Trade-off between bio-product and retention for soil carbon
Customers

- Crop producers
- US Department of Energy
- Biomass ethanol producers
- Action agencies (e.g., NRCS, EPA)
Residue needed to maintain SOC

<table>
<thead>
<tr>
<th>Crop rotation</th>
<th>Tillage*</th>
<th>Mg ha(^{-1})</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>mbp</td>
<td>7.5±1.0</td>
<td>6</td>
</tr>
<tr>
<td>Wheat</td>
<td>mbp</td>
<td>5.5±1.1</td>
<td>5</td>
</tr>
<tr>
<td>All</td>
<td>mbp</td>
<td>6.3±1.0</td>
<td>13</td>
</tr>
<tr>
<td>All</td>
<td>Chisel/nt</td>
<td>4.5±0.4</td>
<td>5</td>
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* mbp = moldboard plow
nt = no tillage

**Residue needed to maintain SOC**

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Soil C change

- Cultivation
- Stover harvest
- Management change

Soil carbon vs. Time
Soil C change

Cultivation

Management change

Stover harvest and?
Soil C change

- Cultivation
- Management change
- Stover harvest and change rotation
  - cover crop
  - reduced tillage
  - increase yield
Change allocation of biomass

- Soil carbon
- Food
- Feed
- Fuel
- Fiber
Change allocation of biomass

Left: Soil carbon, Fuel, Fiber, Food, Feed
Right: Soil carbon, Food, Fuel, Fiber, Feed

REAP
Change allocation of biomass vs. increase total biomass production

Increase photosynthetic efficiency 25%, from 4% → 5%

Residue Management Study

Over all years

(Wilhelm et al., 1986)

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<tr>
<th>Y Variable</th>
<th>Coefficient</th>
<th>r^2</th>
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<tr>
<td></td>
<td>Intercept</td>
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<td>Residue</td>
<td>b_0 *</td>
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<td></td>
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<td>0.04</td>
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<td>Grain</td>
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<tr>
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<td>0.02</td>
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</table>

* Mg/ha
** Mg/ha / Mg/ha residue applied
Residue Management Study
Soil organic matter (0-30 cm)

(Maskina et al., 1993)

After 6 yr of treatment application (cont. corn, no tillage)

Soil organic matter (g kg⁻¹)

Amount of previous crop residue returned (%)
Grain yield

![Graphs showing grain yield in 2001 and 2002 with residue removed (%).](image)

- **2001**: Disk (green) and No tillage (brown) grain yield (Mg ha⁻¹) with residue removed (%).
- **2002**: Disk (green) and No tillage (brown) grain yield (Mg ha⁻¹) with residue removed (%).

*REAP*
✓ Multiple biomass
✓ Many technologies
✓ Conservation
✓ Reduced expectations
✓ Asking, and answering, the right question