Cover crops—Potential impacts on soil fertility and water quality

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Sources of information

Purposes of cover crops
- Reduce erosion from water and wind
- Increase soil organic matter
- Capture and recycle or redistribute nutrients
- Provide biological nitrogen fixation
- Improve soil physical conditions (aggregation, compaction, moisture mgmt.)
- Weed suppression, biodiversity, soil biological activity, extra forage

Cover crop as part of a system
- Choose cover crops to best fit desired purpose(s) and niche (window) in system.
- “Green manure” crop—cover crop or forage grown to incorporate into soil while green or flowering, to improve soil
- “Catch” crop or “trap” crop—cover crops planted to reduce nutrient leaching following a main crop
- “Living mulch”—cover crop interplanted with cash crop
- Forage crop—can serve as green manure crop after grazing or haying is finished.

Cover crops and nutrient cycling
- Trap nutrients that would otherwise “leak out” during fallow periods
- leaching through soil
- losses as eroded soil or runoff
- Release nutrients later—ideally at the time needed by the next crop
- Fix N from atmosphere (legumes)
- Translocate nutrients from deeper in subsoil, to near surface after cover crop death
- Increase soil biological activity in topsoil, potentially releasing nutrients from soil minerals
- Cover crops do not “create” nutrients in soil, but can recycle and release; except legumes can add N

Cover crops and N cycling
- Legumes—biological N fixation
  How much N fixed? and released? and when?
- Non-legumes—How much N trapped? and released? and when?
Key points:

- Non-legumes do not contribute N through bacterial fixation
- Over time cover crops and forages (as green manure crops) add to the organic matter content of the soil and build nutrient content
- Less nutrient and organic matter increase if cover crops and forages are harvested

Legume Green Manure Crops

- Produce 40-200 lbs.N/acre, depending on species, biomass produced, %N in plant
- Approx. 40-60% of N available to subsequent crop
- Incorporation of green manure into soil results in increased N for 4-6 weeks; after this supplemental N may be required

Table 1. Average biomass yields and nitrogen yields of several legumes (4).

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Biomass Tons/acre</th>
<th>Nitrogen lbs./acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet clover</td>
<td>1.75</td>
<td>120</td>
</tr>
<tr>
<td>Berseem clover</td>
<td>1.1</td>
<td>70</td>
</tr>
<tr>
<td>Crimson clover</td>
<td>1.4</td>
<td>100</td>
</tr>
<tr>
<td>Hairy vetch</td>
<td>1.75</td>
<td>110</td>
</tr>
</tbody>
</table>

Example N yields from legume cover crops in upper Midwest

<table>
<thead>
<tr>
<th>Where</th>
<th>Cover</th>
<th>lbs N/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>Red clover</td>
<td>~80 lbs</td>
</tr>
<tr>
<td>Mich.</td>
<td>Crimson clover</td>
<td>38-68 lbs</td>
</tr>
<tr>
<td>Mich.</td>
<td>Hairy vetch</td>
<td>48-100</td>
</tr>
<tr>
<td>Ontario</td>
<td>Red Clover</td>
<td>~50</td>
</tr>
</tbody>
</table>

(after wheat crop, for next corn crop)

Table 2. Distribution of plant nitrogen in legume tops and roots (6).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Tops %N</th>
<th>Roots %N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybeans</td>
<td>93</td>
<td>7</td>
</tr>
<tr>
<td>Vetch</td>
<td>89</td>
<td>11</td>
</tr>
<tr>
<td>Cowpeas</td>
<td>84</td>
<td>16</td>
</tr>
<tr>
<td>Red clover</td>
<td>68</td>
<td>32</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>58</td>
<td>42</td>
</tr>
</tbody>
</table>

Challenges

- Long enough growth period to produce enough biomass to fix sufficient N, in cooler climates (for full season corn in field crop system)
- Good results in south (longer winter growth)
- Earlier work at Purdue showed limited N fixation in central Indiana for corn crop
- Usually need manure, composts, or other organic materials in addition to legume covers, to provide sufficient N to main crop
Red Clover seeded into corn just prior to canopy closing in mid-June. It provides a cover crop protecting soil and capturing nutrients over the winter.

Red Clover flowering the following June after the corn has been harvested in the fall. It will now be plowed down as a green manure crop to provide some nitrogen for the next crop.

Field Rotation-Hardwick Farm - England
Stockfree
(Iain Tolhurst- 20 yrs of organic farming on 17 acres)

- Year 1 + 2: Red clover. Cut and mulched.
- Year 3: Potato O/w green manure, clover/vetch if sown by mid Sept, Cereal rye for later sowing.
- Year 6: Carrot after leek. Parsnip after onion. Possible B. Beans sow Oct-March
- Year 7: Sweet corn. Squash. Both u/s red clover/Lucerne.

Nutrient Key: Legume / Catch Crop

Trap crops

- Amount of biomass produced is key to nutrient uptake—good stand, rapid growth
- Age/stage of plant when killed, determines N%, C:N, plant composition, and therefore decomposition rate (along with weather!)
  
**Huge challenge!**

- Cereal rye, annual ryegrass, wheat, oats, barley

### 2002 cover crop demonstrations—Indiana

<table>
<thead>
<tr>
<th>Location</th>
<th>Crop</th>
<th>Sampled</th>
<th>% N</th>
<th>lbs biomass/A</th>
<th>biomass lb N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Putnam Co.</td>
<td>an. ryegrass w manure</td>
<td>April 3</td>
<td>3.54</td>
<td>900</td>
<td>31.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May 3</td>
<td>2.24</td>
<td>3635</td>
<td>81.4</td>
</tr>
<tr>
<td>Fountain Co.</td>
<td>an. ryegrass</td>
<td>May 1</td>
<td>1.94</td>
<td>660</td>
<td>12.8</td>
</tr>
<tr>
<td>Jennings Co.</td>
<td>an. ryegrass</td>
<td>May 22</td>
<td>0.90</td>
<td>2865</td>
<td>25.7</td>
</tr>
<tr>
<td></td>
<td>wheat</td>
<td>May 22</td>
<td>0.95</td>
<td>1109</td>
<td>10.5</td>
</tr>
</tbody>
</table>

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Wide Carbon to N Ratio > 25/1

### Residue Addition and N Availability

- High carbon residues added: Immobilization (tie-up) 
- Low carbon residues added: No Immobilization (tie-up) 
- Mineralization (release of N)
Table 1. Average yield and related parameters by selected crop [g/ha]

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield</th>
<th>Biomass</th>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar</td>
<td>3000</td>
<td>100</td>
<td>200</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>2000</td>
<td>50</td>
<td>150</td>
<td>75</td>
<td>150</td>
</tr>
<tr>
<td>Barley</td>
<td>1500</td>
<td>25</td>
<td>100</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

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Water quality impacts

- In Indiana, Ohio, and Illinois, much of the N leaching losses occur in fallow period (fall, winter, early spring), because most of the tile drainage flows occur during this time.
- Winter cover crops can reduce N losses significantly, by trapping N that would otherwise leach to tile drains, and possibly by reducing total water flow to tiles.
- Effectiveness depends on good stand and rapid biomass production.
- Trap crops cannot absorb indefinitely—excessive nutrient applications for ex. with excessive manure, will still result in high nitrate concentrations and losses.

Summary

- Legume cover crops can “fix” N from atmos.
  - Amount depends on amount of growth, species, soil, etc.
  - Often need additional N sources such as compost or manure
- Non-legume cover crops effective to “trap” N that would leach through soil
  - Amount depends on amount of growth
  - Release depends on C:N ratio, weather, etc.
- Cover crops as part of a system for nutrients.