Cover crops, tillage and soil quality

Dr. Joel Gruver
WIU – Agriculture
j-gruver@wiu.edu
Cover crops are multi-functional

Cover Crops

- Suppress weeds
- Suppress diseases
- Suppress nematodes
- Reduce erosion
- Increase infiltration of water
- Decrease nutrient loss
- Attract beneficial insects
- Alleviate subsoil compaction
- Add organic matter
- Enhance mycorrhiza
- Add N (legume)

Adapted from Magdoff and Weil (2004)
Most ag inputs have 1 target effect

3 oz of product X should do the trick

Adapted from Magdoff and Weil (2004)
Cover crops are not idiot-proof!

Using cover crops to capture multiple benefits often requires more management.

There are few profits in idiot-proof systems.
Long term no-till

Intensive tillage

Plow pan

Network of biopores

Depth (cm)

Ontario Ministry of Ag and Food
Long term no-till

Is this what always happens?

Intensive tillage

Ontario Ministry of Ag and Food
Is this what always happens?

No! Eliminating tillage does not create biopores!

Biology creates biopores!
Long term no-till

Intensity tillage

Is this what always happens?

No! Eliminating tillage does not create biopores

Biology creates biopores!
Effect of tillage on microbial activity

Havlin et al. (1999)
Effect of tillage on microbial activity

Soil respiration in CT system

Havlin et al. (1999)
Effect of tillage on microbial activity

Soil respiration in NT system

Havlin et al. (1999)
Effect of tillage on microbial activity

Which tillage system has more microbial activity?

Soil respiration in NT system

Havlin et al. (1999)
Effect of tillage on microbial activity

Havlin et al. (1999)

The primary factors controlling microbial activity vary with time.

Which tillage system has more microbial activity?

Soil respiration in NT system

Which tillage system has more microbial activity when the crop benefits from the CO₂?

Havlin et al. (1999)
Commentary

Tillage and soil carbon sequestration—What do we really know?

John M. Baker a,b,*, Tyson E. Ochsner a,b, Rodney T. Ventera a,b, Timothy J. Griffis b

a USDA-ARS, 454 Borlaug Hall, 1991 Upper Buford Circle, St. Paul, MN 55108, USA
b Department of Soil, Water & Climate, University of Minnesota, 439 Borlaug Hall, 1991 Upper Buford Circle, St. Paul, MN 55108, USA

Received 1 February 2006; received in revised form 24 April 2006; accepted 3 May 2006
Available online 27 June 2006

Abstract

It is widely believed that soil disturbance by tillage was a primary cause of the historical loss of soil organic carbon (SOC) in North America, and that substantial SOC sequestration can be accomplished by changing from conventional plowing to less intensive methods known as conservation tillage. This is based on experiments where changes in carbon storage have been estimated through soil sampling of tillage trials. However, sampling protocol may have biased the results. In essentially all cases where conservation tillage was found to sequester C, soils were only sampled to a depth of 30 cm or less, even though crop roots often extend much deeper. In the few studies where sampling extended deeper than 30 cm, conservation tillage has shown no consistent accrual of SOC, instead showing a difference in the distribution of SOC, with higher concentrations near the surface in conservation tillage and higher concentrations in deeper layers under conventional tillage. These contrasting results may be due to tillage-induced differences in thermal and physical conditions that affect root growth and distribution. Long-term, continuous gas exchange measurements have also been unable to detect C gain due to reduced tillage. Though there are other good reasons to use conservation tillage, evidence that it promotes C sequestration is not compelling.

© 2006 Elsevier B.V. All rights reserved.

Keywords: Carbon sequestration; Tillage; Organic matter; Sampling depth
It is widely believed that soil disturbance by tillage was a primary cause of the historical loss of soil organic carbon (SOC) in North America, and that substantial SOC sequestration can be accomplished by changing from conventional plowing to less intensive methods known as conservation tillage. This is based on experiments where changes in carbon storage have been estimated through soil sampling of tillage trials. However, sampling protocol may have biased the results. In essentially all cases where conservation tillage was found to sequester C, soils were only sampled to a depth of 30 cm or less...
Very few tillage studies have been sampled deeper than 1’
Many experiments have only been sampled 6” deep!
The Myth of Nitrogen Fertilization for Soil Carbon Sequestration


Intensive use of N fertilizers in modern agriculture is motivated by the economic value of high grain yields and is generally perceived to sequester soil organic C by increasing the input of crop residues. This perception is at odds with a century of soil organic C data reported herein for the Morrow Plots, the world’s oldest experimental site under continuous corn (Zea mays L.). After 40 to 50 yr of synthetic fertilization that exceeded grain N removal by 60 to 190%, a net decline occurred in soil C despite increasingly massive residue C incorporation, the decline being more extensive for a corn–soybean (Glycine max L. Merr.) or corn–oats (Avena sativa L.)–hay rotation than for continuous corn and of greater intensity for the profile (0–46 cm) than the surface soil. These findings implicate fertilizer N in promoting the decomposition of crop residues and soil organic matter and are consistent with data from numerous cropping experiments involving synthetic N fertilization in the USA Corn Belt and elsewhere, although not with the interpretation usually provided. There are important implications for soil C sequestration because the yield-based input of fertilizer N has commonly exceeded grain N removal for corn production on fertile soils since the 1960s. To mitigate the ongoing consequences of soil deterioration, atmospheric CO₂ enrichment, and NOₓ pollution of ground and surface waters, N fertilization should be managed by site-specific assessment of soil N availability. Current fertilizer N management practices, if combined with corn stover removal for bioenergy production, exacerbate soil C loss.

The shift from biological- to chemical-based N management that provided the impetus for modern cereal agriculture originated during the late 1940s as synthetic N fertilizers became more widely available following World War II. By the 1950s, traditional legume-based rotations that had long been practiced in the Midwestern USA were being replaced by more intensive row cropping with corn as the principal source of grain production. The past five decades have seen a remarkable increase in corn yield and in the use of fertilizer N (USDA, 2007).

Despite the use of forage legumes, many Midwestern soils had suffered a serious decline in their content of N and organic matter by the mid-twentieth century, except in cases involving regular manuring. There was good reason for concern that this decline could adversely affect agricultural productivity and sustainability because organic matter plays a key role in maintaining soil aggregation and aeration, hydraulic conductivity, and water availability; cation-exchange and buffer capacity; and the supply of mineralizable nutrients. There were also important implications for atmospheric CO₂ enrichment because soils represent the Earth’s major surface C reservoir (Bolin, 1977).

With the introduction of chemical-based N management, a new strategy became available for increasing not only grain yield, but also the input of crop residues, which was assumed to be of value for maintaining soil organic matter (SOM) (Lyon et al., 1952; Melsted, 1954; Tisdale and Nelson, 1956). Ample fertilizer N was believed to promote humus formation by narrowing the C/N ratio of carbonaceous residues and by providing a major elemental constituent (Lee and Bray, 1949; Millar and Turk, 1951; Melsted, 1954).
Nitrogen fertilizer effects on soil carbon balances in Midwestern U.S. agricultural systems

Ann E. Russell,1,3 Cynthia A. Cambardella,2 David A. Laird,2 Dan B. Jaynes,2 and David W. Meek2

1Department of Natural Resource Ecology and Management, Iowa State University, Ames, Iowa 50011 USA
2USDA-ARS National Soil Tilth Laboratory, Ames, Iowa 50011 USA

Abstract. A single ecosystem dominates the Midwestern United States, occupying 26 million hectares in five states alone: the corn–soybean agroecosystem [Zea mays L.–Glycine max (L.) Merr.]. Nitrogen (N) fertilization could influence the soil carbon (C) balance in this system because the corn phase is fertilized in 97–100% of farms, at an average rate of 135 kg N·ha−1·yr−1. We evaluated the impacts on two major processes that determine the soil C balance, the rates of organic-carbon (OC) inputs and decay, at four levels of N fertilization, 0, 90, 180, and 270 kg/ha, in two long-term experimental sites in Mollisols in Iowa, USA. We compared the corn–soybean system with other experimental cropping systems fertilized with N in the corn phases only: continuous corn for grain; corn–corn-oats (Avena sativa L.)–alfalfa (Medicago sativa L.); corn–oats–alfalfa–alfalfa; and continuous soybean. In all systems, we estimated long-term OC inputs and decay rates over all phases of the rotations, based on long-term yield data, harvest indices (HI), and root : shoot data. For corn, we measured these two ratios in the four N treatments in a single year in each site; for other crops we used published ratios. Total OC inputs were calculated as aboveground plus belowground net primary production (NPP) minus harvested yield. For corn, measured total OC inputs increased with N fertilization (P < 0.05, both sites). Belowground NPP, comprising only 6–22% of total corn NPP, was not significantly influenced by N fertilization. When all phases of the crop rotations were evaluated over the long term, OC decay rates increased concomitantly with OC input rates in several systems. Increases in decay rates with N fertilization apparently offset gains in carbon inputs to the soil in such a way that soil C sequestration was virtually nil in 78% of the systems studied, despite up to 48 years of N additions. The quantity of belowground OC inputs was the best predictor of long-term soil C storage. This indicates that, in these systems, in comparison with increased N-fertilizer additions, selection of crops with high belowground NPP is a more effective management practice for increasing soil C sequestration.

Key words: agroecosystems; carbon mineralization; corn, oats, alfalfa, and soybean crop rotations; Midwestern U.S. corn–soybean ecosystem; Nashua and Kanawha sites, Iowa, USA; net primary production; nitrogen fertilization; root production; soil carbon sequestration.
Increases in decay rates with N fertilization apparently offset gains in carbon inputs to the soil in such a way that soil C sequestration was virtually nil in 78% of the systems studied, despite up to 48 years of N additions.
Nitrogen fertilizer effects on soil carbon balances in Midwestern U.S. agricultural systems

Ann E. Russell, 1,3 Cynthia A. Cambardella, 2 David A. Laird, 2 Dan B. Jaynes, 2 and David W. Meek 2

1Department of Natural Resource Ecology and Management, Iowa State University, Ames, Iowa 50011 USA
2USDA-ARS National Soil Tilth Laboratory, Ames, Iowa 50011 USA

Abstract. A single ecosystem dominates the Midwestern United States, occupying 26 million hectares in five states alone: the corn–soybean agroecosystem [Zea mays L.–Glycine max (L.) Merr.]. Nitrogen (N) fertilization could influence the soil carbon (C) balance in this system because the corn phase is fertilized in 97–100% of farms, at an average rate of 135 kg

The quantity of belowground OC inputs was the best predictor of long-term soil C storage. This indicates that, in these systems, in comparison with increased N-fertilizer additions, selection of crops with high belowground NPP is a more effective management practice for increasing soil C sequestration.

Cover crops are a great way to add more belowground organic inputs to cropping systems.
20 years of similar tillage intensity and C inputs
20 years of similar tillage intensity and C inputs but contrasting types of organic inputs.
What to Look For in A Cover Crop

- Fast germination and emergence
- Competitiveness
- Tolerance to adverse climatic & soil conditions
- Ease of suppression/residue management
- Fertility/soil quality benefits
- Low-cost
Matching objectives with species

http://www.sdnotill.com/Field_Facts_wheat_cover_crop.pdf

Grazing

*turnips, rape, radish, lentils, rye, oat, triticale, sorghum-sudan*

Reducing Compaction

*radish, canola, turnip (and hybrids), sugarbeet, sunflower,*
*sorghum-sudan, sweet clover, alfalfa*

N-fixation

*clovers, vetches, lentils, cowpeas, soybean, field pea, chickling vetch*

Residue Cycling

*canola, rape, radishes, turnips, mustards*

Nutrient Cycling

*sunflower, sugarbeets, *brassicas, small grains*
Other key considerations

How will I seed the cover crop?
What will soil temperature and moisture conditions be like?
What weather extremes and field traffic must it tolerate?
Will it winterkill in my area?
Should it winterkill, to meet my goals?
What kind of regrowth can I expect?
How will I kill it and plant into it?
Will I have the time to make this work?
What’s my contingency plan—and risks—if the cover crop doesn’t establish or doesn’t die on schedule?
Do I have the needed equipment and labor?
How will I seed the cover crop?
What will soil temperature and moisture conditions be like?
What weather extremes and field traffic must it tolerate?
Will it winterkill in my area?
Should it winterkill, to meet my goals?
What kind of regrowth can I expect?
How will I kill it and plant into it?
Will I have the time to make this work?
What's my contingency plan—and risks—if the cover crop doesn't establish or doesn't die on schedule?
Do I have the needed equipment and labor?

**Other key considerations**

Be realistic about potential cover crop challenges
<table>
<thead>
<tr>
<th>Species</th>
<th>Aliases</th>
<th>Type</th>
<th>Hardy through Zone</th>
<th>Tolerances</th>
<th>Habit</th>
<th>pH (Pref.)</th>
<th>Best Established</th>
<th>Min. Germin. Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual ryegrass p. 74</td>
<td>Italian ryegrass</td>
<td>WA</td>
<td>6</td>
<td></td>
<td>U</td>
<td>6.0–7.0</td>
<td>LSp, LSu, EE, F</td>
<td>40F</td>
</tr>
<tr>
<td>Barley p. 77</td>
<td></td>
<td>WA</td>
<td>7</td>
<td></td>
<td>U</td>
<td>6.0–8.5</td>
<td>F, W, Sp</td>
<td>38F</td>
</tr>
<tr>
<td>Oats p. 93</td>
<td>spring oats</td>
<td>CSA</td>
<td>8</td>
<td></td>
<td>U</td>
<td>4.5–7.5</td>
<td>Lsu, ESP, Wi in 8+</td>
<td>38F</td>
</tr>
<tr>
<td>Rye p. 98</td>
<td>winter, cereal, or grain rye</td>
<td>CSA</td>
<td>3</td>
<td></td>
<td>U</td>
<td>5.0–7.0</td>
<td>Lsu, F</td>
<td>34F</td>
</tr>
<tr>
<td>Wheat p. 111</td>
<td></td>
<td>WA</td>
<td>4</td>
<td></td>
<td>U</td>
<td>6.0–7.5</td>
<td>Lsu, F</td>
<td>38F</td>
</tr>
<tr>
<td>Buckwheat p. 90</td>
<td></td>
<td>SA</td>
<td>NFT</td>
<td></td>
<td>U</td>
<td>5.0–7.0</td>
<td>Sp to Lsu</td>
<td>50F</td>
</tr>
<tr>
<td>Sorghum–sudan p. 106</td>
<td>Sudax</td>
<td>SA</td>
<td>NFT</td>
<td></td>
<td>U</td>
<td>6.0–7.0</td>
<td>LSp, ES</td>
<td>65F</td>
</tr>
<tr>
<td>Mustards p. 81</td>
<td>brown, oriental white, yellow</td>
<td>WA, CSA</td>
<td>7</td>
<td></td>
<td>U</td>
<td>5.5–7.5</td>
<td>Sp, Lsu</td>
<td>40F</td>
</tr>
<tr>
<td>Radish p. 81</td>
<td>oilseed, Daikon, forage radish</td>
<td>CSA</td>
<td>6</td>
<td></td>
<td>U</td>
<td>6.0–7.5</td>
<td>Sp, Lsu, EF</td>
<td>45F</td>
</tr>
<tr>
<td>Rapeseed p. 81</td>
<td>rape, canola</td>
<td>WA</td>
<td>7</td>
<td></td>
<td>U</td>
<td>5.5–8</td>
<td>E, Sp</td>
<td>41F</td>
</tr>
<tr>
<td>Berseem clover p. 118</td>
<td>Bigbee, multicut</td>
<td>SA, WA</td>
<td>7</td>
<td></td>
<td>U</td>
<td>6.2–7.0</td>
<td>ESp, EF</td>
<td>42F</td>
</tr>
<tr>
<td>Cowpeas p. 125</td>
<td>crowder peas, southern peas</td>
<td>SA</td>
<td>NFT</td>
<td></td>
<td>SU/C</td>
<td>5.5–6.5</td>
<td>ESu</td>
<td>58F</td>
</tr>
<tr>
<td>Crimson clover p. 130</td>
<td></td>
<td>WA, SA</td>
<td>7</td>
<td></td>
<td>U/SU</td>
<td>5.5–7.0</td>
<td>Lsu/ESu</td>
<td></td>
</tr>
<tr>
<td>Field peas p. 135</td>
<td>winter peas, black peas</td>
<td>WA</td>
<td>7</td>
<td></td>
<td>C</td>
<td>6.0–7.0</td>
<td>E, ESp</td>
<td>41F</td>
</tr>
<tr>
<td>Hairy vetch p. 142</td>
<td>winter vetch</td>
<td>WA, CSA</td>
<td>4</td>
<td></td>
<td>C</td>
<td>5.5–7.5</td>
<td>EE, ESp</td>
<td>60F</td>
</tr>
<tr>
<td>Medics p. 152</td>
<td></td>
<td>SP, SA</td>
<td>4/7</td>
<td></td>
<td>P/Su</td>
<td>6.0–7.0</td>
<td>EE, ESp, ES</td>
<td>45F</td>
</tr>
<tr>
<td>Red clover p. 159</td>
<td></td>
<td>SP, B</td>
<td>4</td>
<td></td>
<td>U</td>
<td>6.2–7.0</td>
<td>Lsu, ESp</td>
<td>41F</td>
</tr>
<tr>
<td>Subterranean cl. p. 164</td>
<td>subclover</td>
<td>CSA</td>
<td>7</td>
<td></td>
<td>P/SP</td>
<td>5.5–7.0</td>
<td>Lsu, EF</td>
<td>38F</td>
</tr>
</tbody>
</table>
**Managing Cover Crops Profitably**

### Chart 3A CULTURAL TRAITS

<table>
<thead>
<tr>
<th>Species</th>
<th>Aliases</th>
<th>Type</th>
<th>Hardy through Zone</th>
<th>Tolerances</th>
<th>Habit</th>
<th>pH (Pref.)</th>
<th>Best Established</th>
<th>Min. Germin. Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual ryegrass p. 74</td>
<td>Italian ryegrass</td>
<td>WA</td>
<td>6</td>
<td></td>
<td>U</td>
<td>6.0–7.0</td>
<td>Esp, LSU, EE, EF</td>
<td>40F</td>
</tr>
<tr>
<td>Barley p. 77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.0–8.5</td>
<td>F, W, Sp</td>
<td>38F</td>
</tr>
<tr>
<td>Oats p. 93</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.5–7.5</td>
<td>LSU, ESP, W in 8+</td>
<td>38F</td>
</tr>
<tr>
<td>Rye p. 98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.0–7.0</td>
<td>LSU, F</td>
<td>34F</td>
</tr>
<tr>
<td>Wheat p. 111</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.0–7.5</td>
<td>LSU, F</td>
<td>38F</td>
</tr>
<tr>
<td>Buckwheat p. 90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.0–7.0</td>
<td>Sp to LSU</td>
<td>50F</td>
</tr>
<tr>
<td>Sorghum–sudan p. 106</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.0–7.0</td>
<td>LSp, ES</td>
<td>65F</td>
</tr>
<tr>
<td>Mustards p. 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.5–7.5</td>
<td>Sp, LSU</td>
<td>40F</td>
</tr>
<tr>
<td>Radish p. 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.0–7.5</td>
<td>Sp, LSU, EF</td>
<td>45F</td>
</tr>
<tr>
<td>Rapeseed p. 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.5–8</td>
<td>F, ESP</td>
<td>41F</td>
</tr>
<tr>
<td>Berseem clover p. 118</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.2–7.0</td>
<td>ESP, EF</td>
<td>42F</td>
</tr>
<tr>
<td>Cowpeas p. 125</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.5–6.5</td>
<td>LSU</td>
<td>58F</td>
</tr>
<tr>
<td>Crimson clover p. 130</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.5–7.0</td>
<td>LSU/ESU</td>
<td></td>
</tr>
<tr>
<td>Field peas p. 135</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.0–7.0</td>
<td>F, ESP</td>
<td>41F</td>
</tr>
<tr>
<td>Hairy vetch p. 142</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.5–7.5</td>
<td>EE, ESP</td>
<td>60F</td>
</tr>
<tr>
<td>Medics p. 152</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.0–7.0</td>
<td>EE, ESP, ES</td>
<td>45F</td>
</tr>
<tr>
<td>Red clover p. 159</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.2–7.0</td>
<td>LSU, ESP</td>
<td>41F</td>
</tr>
<tr>
<td>Subterranean cl. p. 164</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.5–7.0</td>
<td>LSU, ES</td>
<td>38F</td>
</tr>
</tbody>
</table>
WELCOME TO THE MIDWEST COVER CROPS COUNCIL WEBSITE

The goal of the Midwest Cover Crops Council (MCCC) is to facilitate widespread adoption of cover crops throughout the Midwest, to improve ecological, economic, and social sustainability.

WHO WE ARE?

The MCCC is a diverse group from academia, production agriculture, non-governmental organizations, commodity interests, private sector, and representatives from federal and state agencies collaborating to address soil, water, air, and agricultural quality concerns in the Great Lakes and Mississippi river basins (including Indiana, Michigan, Ohio, Manitoba, Ontario, Illinois, Wisconsin, Minnesota, Iowa, and North Dakota).

WHY COVER CROPS?

NEWS

Three new fact sheets are available from OSU Extension
- Using Cover Crops to Convert to No-Till
- Sustainable Crop Rotations with Cover Crops
- The Biology of Soil Compaction

2010 MCCC Meeting/Workshop
March 3-4
Ames, IA
Click here for the brochure
Midwest Cover Crop Innovators 2008
All Sites
INNOVATOR PROFILES

Terry Taylor
Geff, IL

Summary of operation
300 acres of continuous no-till corn with cover crops
1500 acres of continuous no-till corn/corn/soybeans with cover crops whenever possible
600 acres of bottom ground no-till on ridges
320 acres of CRP and filter strips

Background information
Terry Taylor is from Geff, IL and has operated his several thousand acre farm as a single unit since his father's retirement. He attended the University of Illinois and is currently 55 years old. He has spoken at many conferences such as the Tri State Conservation Tillage Conference and has been interviewed for various magazines such as Prairie Grains. He became interested in cover crops by growing up on a livestock farm with legumes, small grains, and hay as a vital components.

Cover crop management
Mr. Taylor uses hairy vetch on his continuous corn acres as much as possible. Any other acres harvested before September 20th get annual ryegrass seeded into them. Cereal rye gets seeded on any other acres that get a cover crop after that date. Mr. Taylor plants hairy vetch before Sept
Terry Taylor’s continuous NT corn w/ hairy vetch system
Red clover frost seeded into winter wheat.

Seed is broadcast onto frozen and cracked soil in mid-March after snow melt. Seedlings remain relatively small until wheat harvest, at which time they have full sunlight and three months to grow and fix atmospheric nitrogen. Total nitrogen accumulation typically exceeds 100 lbs./a by the end of the growing season.
How much N can frost seeded red clover fix??

<table>
<thead>
<tr>
<th>Year</th>
<th>Legume</th>
<th>Lbs. DM/a</th>
<th>Total lbs. N/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>Red clover</td>
<td>4456</td>
<td>128</td>
</tr>
<tr>
<td>1992</td>
<td>Red clover</td>
<td>3918</td>
<td>110</td>
</tr>
<tr>
<td>1993</td>
<td>Red clover</td>
<td>4125</td>
<td>119</td>
</tr>
<tr>
<td>1994</td>
<td>Hairy vetch</td>
<td>4459</td>
<td>146</td>
</tr>
<tr>
<td>1995</td>
<td>Red clover</td>
<td>3407</td>
<td>100</td>
</tr>
<tr>
<td>1996</td>
<td>Red clover</td>
<td>5049</td>
<td>147</td>
</tr>
<tr>
<td>1997</td>
<td>Hairy vetch</td>
<td>2110</td>
<td>84</td>
</tr>
<tr>
<td>1998</td>
<td>Red clover</td>
<td>4458</td>
<td>109</td>
</tr>
<tr>
<td>1999</td>
<td>Red clover</td>
<td>7607*</td>
<td>265</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>4399</td>
<td>134</td>
</tr>
</tbody>
</table>
Hairy vetch can be successfully planted after wheat harvest. On the two occasions (out of 18 site-years of the WICST trial) when the red clover failed to establish well, the vetch produced an average of 115 lbs./a of nitrogen, providing an excellent “back-up plan” that reduces one of the potential risks of relying on a companion-seeded cover crop for nitrogen. Late July vetch plantings can be riskier than frost seeding clover.
Cover crops can provide most of the nitrogen required by corn.

WI trials to determine whether supplemental nitrogen was worthwhile found that additional nitrogen (either starter or sidedressed) produced a significant yield increase only about one-fourth of the time. The exceptions always occurred during years with cool springs, when there is a slow release of legume nitrogen.
Many vegetable crop residues are comparable to a legume cover crop.

Residues with a low C:N ratio that decompose quickly can release N even though they are not legumes.
Pat Sheridan (Fairgrove, Michigan)

We've done some PSNT tests with and w/o fall seeded radish. Kind of a moving target (year to year) in N credits, but I will say that we've always had a bigger credit following radish than what we had without. That could be for a lot reasons. Weather, soil types, temp, etc. I've had an increase of almost 80#s of N using radish vs none, and I've had an increase of 20# vs none.

N credit is a very nice benefit of using a cover like radish, but I also like the other benefits from radish we've observed. Trouble with cover crops is putting a $ benefit on many of them. I can hardly ever say that if I spend 10 bucks on a particular cover, it'll for sure give me 20 back next year. In the big picture, I feel that if looked at over say a 5 or 10 year period, we've put more money in the bank by using covers than we've spent. I don't know how to quantify things $ wise like the value of increased OM, for example.
Forage brassicas have good cover crop potential
Forage brassicas have good cover crop potential
Compacted layers can severely limit root growth
Sub-soil water and nutrients
Which solution would you use?
Visual evidence of biodrilling

Canola root
Please plant me no-till next spring!!
The experiment was planted to corn Blue River 66P32 30,000 seeds/acre on May 29 2008

No N was added

Weed pressure appeared lower in the radish rows but there were no clear differences between the treatments with respect to crop appearance
Some very interesting yield results !!

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rep</th>
<th>Yield monitor (bu/acre)</th>
<th>Trt Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>clover/oats</td>
<td>1</td>
<td>160.3</td>
<td></td>
</tr>
<tr>
<td>clover/oats</td>
<td>2</td>
<td>164.3</td>
<td>160.8</td>
</tr>
<tr>
<td>clover/oats</td>
<td>3</td>
<td>157.9</td>
<td></td>
</tr>
<tr>
<td>clover/radish</td>
<td>1</td>
<td>170.6</td>
<td></td>
</tr>
<tr>
<td>clover/radish</td>
<td>2</td>
<td>178.4</td>
<td>174.6</td>
</tr>
<tr>
<td>clover/radish</td>
<td>3</td>
<td>174.7</td>
<td></td>
</tr>
<tr>
<td>clover/radish/oats</td>
<td>1</td>
<td>179.0</td>
<td></td>
</tr>
<tr>
<td>clover/radish/oats</td>
<td>2</td>
<td>191.4</td>
<td>170.2</td>
</tr>
<tr>
<td>clover/radish/oats</td>
<td>3</td>
<td>140.4</td>
<td></td>
</tr>
<tr>
<td>radish</td>
<td>1</td>
<td>187.0</td>
<td></td>
</tr>
<tr>
<td>radish</td>
<td>2</td>
<td>178.7</td>
<td>183.5</td>
</tr>
<tr>
<td>radish</td>
<td>3</td>
<td>184.8</td>
<td></td>
</tr>
</tbody>
</table>
Some yield results !!

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rep</th>
<th>Weigh wagon (bu/acre)</th>
<th>Trt Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>clover/oats</td>
<td>1</td>
<td>132.1</td>
<td></td>
</tr>
<tr>
<td>clover/oats</td>
<td>2</td>
<td>133.9</td>
<td>131.9</td>
</tr>
<tr>
<td>clover/oats</td>
<td>3</td>
<td>129.6</td>
<td></td>
</tr>
<tr>
<td>clover/radish</td>
<td>1</td>
<td>137.2</td>
<td></td>
</tr>
<tr>
<td>clover/radish</td>
<td>2</td>
<td>144.7</td>
<td>142.2</td>
</tr>
<tr>
<td>clover/radish</td>
<td>3</td>
<td>144.7</td>
<td></td>
</tr>
<tr>
<td>clover/radish/oats</td>
<td>1</td>
<td>145.4</td>
<td></td>
</tr>
<tr>
<td>clover/radish/oats</td>
<td>2</td>
<td>156.5</td>
<td>139.5</td>
</tr>
<tr>
<td>clover/radish/oats</td>
<td>3</td>
<td>116.5</td>
<td></td>
</tr>
<tr>
<td>radish</td>
<td>1</td>
<td>150.4</td>
<td></td>
</tr>
<tr>
<td>radish</td>
<td>2</td>
<td>147.5</td>
<td>149.0</td>
</tr>
<tr>
<td>radish</td>
<td>3</td>
<td>149.0</td>
<td></td>
</tr>
</tbody>
</table>
What is this??
What is this??

- Annual Rye 1.5 – 2.0 bu / acre
- Turnips 3.0 lb / acre
- Millet 1.5 lb / acre
- Wheat 1.0 – 2.0 bu / acre
- Soybeans 2 bu / acre
Aerial Seeding Turnips, Oats and Rye
8-20-2001
**Cliff Schuette**

*Turnips and Cereal Rye*

Airseed 8/25/2000

Barkant Turnips-3 lbs
Rye 2 Bu
Airplane $8/Acre
Corn 183 Bu/acre
Atrazine 1 lb
Partner April 28
November 1, 2000

Turnips - Spring Oats
Corn Stalks
Seeded August 15
Turnips- 4 lbs
Oats 1 Bu.
40 LBS N

November 1, 2000

Spring Oats -Cereal Rye
Corn Stalks
Seeded August 15
Oats- 1 Bu.
Rye-1 1/2 Bu.
40 LBS N
November 1, 2000
Turnips - Spring Oats - Corn Stalks
Seeded August 15
Turnips - 4 lbs
Oats 1 Bu.
40 LBS N

November 1, 2000
Spring Oats - Cereal Rye - Corn Stalks
Seeded August 15
Oats - 1 Bu.
Rye - 1 1/2 Bu.
40 LBS N
Paul Smith

Annual
Rye grass
aerial seeded
into standing corn

Fall, 2001
John Hebert
Inspecting Ryegrass
No-till into corn stubble
Fall, 2001
Charles Martin and his sons from Perry County, PA built this High-boy cover crop air seeder. The platform extends to 9’6 “ high to run through standing corn and it drops cover crop seed through tubes from the air seeder down in between each row of corn. It covers 18 rows of corn with a pass.

It’s hydraulic driven and has an individual hydraulic drive on each wheel, you can turn both the front and rear set of wheels. There is a variable speed drive that synchronizes the ground speed with the seed box flutes turning so the seed drop flow is coordinated with the ground speed. And you can disengage that when at the end of the field and for turning. The headlands will be a challenge on some fields, running down some plants in the headlands to get through.
It's hydraulic driven and has an individual hydraulic drive on each wheel, you can turn both the front and rear set of wheels. There is a variable speed drive that synchronizes the ground speed with the seed box flutes turning so the seed drop flow is coordinated with the ground speed. And you can disengage that when at the end of the field and for turning. The headlands will be a challenge on some fields, running down some plants in the headlands to get through.

Charles Martin and his sons from Perry County, PA built this High-boy cover crop air seeder. The platform extends to 9'6" high to run through standing corn and it drops cover crop seed through tubes from the air seeder down in between each row of corn. It covers 18 rows of corn with a pass.
Support British Design & British Manufacturers

For the low cost & accurate establishment of OSR, Mustard, Stubble Turnips and other small seeds and pellets...

*Please be patient while pictures load*
Tillage System experiment

Conventional till
Minimum till
No-till

Established in fall 08
Early June 2009
Early June 2009
Early June 2009
~1 week after planting
~2 weeks after planting
Early August 2009
Late August 2009
Plot yields ranged from 51.6 to 58.6 bu/ac

No significant differences between systems
Tillage radish drilled in early September (~ 10 lbs/ac)
Tillage radish on 30” rows with oats on 7.5” rows
Biomass Production
Annual Cropping Systems

Cover crops for resource assimilation and dry matter production

Dry matter production or resource loss (mass/time)

Spring  Summer  Autumn  Winter

Annual grain crop

Winter cover crop

Additional opportunities for resource losses

after A.H. Heggenstaller
Biomass Production
Annual Cropping Systems

Cover crops for resource assimilation and dry matter production

Dry matter production or resource loss (mass/time)

Annual grain crop

Winter cover crop

Spring Summer Autumn Winter

opportunities for resource losses

less

after A.H. Heggenstaller
# U of I on-farm covercrop research

(grain yields = bu/acre)

<table>
<thead>
<tr>
<th>Location</th>
<th>Cover Crop</th>
<th>Grain Crop</th>
<th>0 lb N/ac</th>
<th>60 lb N/ac</th>
<th>180 lb N/ac</th>
<th>240 lb N/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hortin</td>
<td>Hairy Vetch</td>
<td>Corn</td>
<td>169</td>
<td><strong>184</strong></td>
<td>180</td>
<td>184</td>
</tr>
<tr>
<td>Hortin</td>
<td>No CC</td>
<td>Corn</td>
<td>105</td>
<td>142</td>
<td>162</td>
<td>164</td>
</tr>
<tr>
<td>Hortin</td>
<td>Rye</td>
<td>Corn</td>
<td>65</td>
<td>102</td>
<td>119</td>
<td>120</td>
</tr>
<tr>
<td>Hortin</td>
<td>Hairy Vetch</td>
<td>Sorghum</td>
<td>90</td>
<td><strong>97</strong></td>
<td>99</td>
<td>100</td>
</tr>
<tr>
<td>Hortin</td>
<td>No CC</td>
<td>Sorghum</td>
<td>74</td>
<td>87</td>
<td>94</td>
<td>92</td>
</tr>
<tr>
<td>Hortin</td>
<td>Rye</td>
<td>Sorghum</td>
<td>54</td>
<td>72</td>
<td>77</td>
<td>74</td>
</tr>
</tbody>
</table>

# U of I on-farm covercrop research
(grain yields = bu/acre)

<table>
<thead>
<tr>
<th>Location</th>
<th>Cover Crop</th>
<th>Grain Crop</th>
<th>0 lb N/ac</th>
<th>60 lb N/ac</th>
<th>180 lb N/ac</th>
<th>240 lb N/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hortin</td>
<td>Hairy Vetch</td>
<td>Corn</td>
<td>169</td>
<td>184</td>
<td>180</td>
<td>184</td>
</tr>
<tr>
<td>Hortin</td>
<td>No CC</td>
<td>Corn</td>
<td>105</td>
<td>142</td>
<td>162</td>
<td>164</td>
</tr>
<tr>
<td>Hortin</td>
<td>Rye</td>
<td>Corn</td>
<td>65</td>
<td>102</td>
<td>119</td>
<td>120</td>
</tr>
<tr>
<td>Hortin</td>
<td>Hairy Vetch</td>
<td>Sorghum</td>
<td>90</td>
<td>97</td>
<td>99</td>
<td>100</td>
</tr>
<tr>
<td>Hortin</td>
<td>No CC</td>
<td>Sorghum</td>
<td>74</td>
<td>87</td>
<td>94</td>
<td>92</td>
</tr>
<tr>
<td>Hortin</td>
<td>Rye</td>
<td>Sorghum</td>
<td>54</td>
<td>72</td>
<td>77</td>
<td>74</td>
</tr>
</tbody>
</table>


Cereal rye often suppresses corn and sorghum yields
Impact of hairy vetch and rye cover crops on corn yield in IL
Impact of cover crops on soybean cyst nematodes

<table>
<thead>
<tr>
<th>Site</th>
<th>Bare</th>
<th>Cereal Rye</th>
<th>Ryegrass</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7533</td>
<td>717*</td>
<td>117**</td>
</tr>
<tr>
<td>2</td>
<td>3650</td>
<td>320*</td>
<td>0**</td>
</tr>
<tr>
<td>3</td>
<td>1559</td>
<td>722*</td>
<td>386*</td>
</tr>
<tr>
<td>4</td>
<td>1202</td>
<td>390*</td>
<td>279*</td>
</tr>
</tbody>
</table>

* Significant .05    ** Significant .01

2 years /3 replications

M Plumer
<table>
<thead>
<tr>
<th>Depth (in)</th>
<th>Density (g/cm³)</th>
<th>Ryegrass cover crop</th>
<th>No cover crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.49*</td>
<td></td>
<td>1.66</td>
</tr>
<tr>
<td>16</td>
<td>1.58</td>
<td></td>
<td>1.54</td>
</tr>
<tr>
<td>24</td>
<td>1.48*</td>
<td></td>
<td>1.65</td>
</tr>
</tbody>
</table>

* sig. .05

M Plumer
Average annual flow-weighted nitrate-N concentration of drainage water for 2002-2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Control</th>
<th>Rye Cover Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>19.1</td>
<td>5.8</td>
</tr>
<tr>
<td>2003</td>
<td>24.7</td>
<td>11.8</td>
</tr>
<tr>
<td>2004</td>
<td>19.8</td>
<td>9.3</td>
</tr>
<tr>
<td>2005</td>
<td>21.6</td>
<td>8.0</td>
</tr>
<tr>
<td>Avg.</td>
<td>21.3</td>
<td>8.7</td>
</tr>
</tbody>
</table>
~ 14% of wells in IL are contaminated with excessive nitrate.
Potential relative reductions in nitrate leaching in Corn Belt for specific corn/soybean mgt. changes

<table>
<thead>
<tr>
<th>PRACTICE</th>
<th>CHANGE</th>
<th>REDUCTION POTENTIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>N rate on corn</td>
<td>150 reduced to 125 lb/ac</td>
<td></td>
</tr>
<tr>
<td>timing</td>
<td>no fall N-fertilizer</td>
<td></td>
</tr>
<tr>
<td>cropping</td>
<td>switch to perennials</td>
<td>combine summer crops with winter cover crops</td>
</tr>
<tr>
<td>buffer strips</td>
<td>1-5% of area</td>
<td></td>
</tr>
<tr>
<td>tillage</td>
<td>plow to long-term,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>continuous no-till</td>
<td></td>
</tr>
<tr>
<td>wetlands</td>
<td>1-5% of area</td>
<td></td>
</tr>
</tbody>
</table>
Innovative Cover Cropping
Are you a cover crop innovator?
If not, are you ready to become a cover crop innovator?
Closing Thoughts

“The best way to farm hasn’t been invented. I reserve the right to change my mind tomorrow.”

Dick Thompson