Cover crops for the 21st century

Dr. Joel Gruver
WIU – Agriculture
j-gruver@wiu.edu
(309) 298-1215
Soil conservation policy in the United States stems from the devastating erosion events of the 1920s and ’30s.

Out of concern for preserving agricultural productivity came the concept of tolerable soil loss and the creation of the T factor - the maximum annual soil loss that can occur on a particular soil while sustaining long-term agricultural productivity.
Conservationists have focused on reducing soil loss to $T$ by applying practices, such as terraces, contour strips, grassed waterways, residue management and cover crops. Research clearly shows that cover crops are an effective conservation practice. So why have cover crops been so underemphasized by conservationists and underutilized by farmers?
Has your career resulted in more program payments or more stewardship?
Hi Joel,

We ended up with 14.8" of rain over a 4 day period. These pictures show how my friendly neighbors plowed fields look. The gully my son is standing in was up to 4' 4" deep and averaged about 3' deep in a 400' section- that is not a typo! The staked tomato picture is on my side of the property line looking from that ditch-100 feet away. I did have a little bit of erosion but could find nothing over 1" deep…

Steve
From: Steve Groff sgroff@hughes.net

Sent: Thursday, June 29, 2006 5:49 AM

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Steve

Tomatoes
planted no-till into rolled
cover crops

No rills deeper than 1 inch!
Soil Changes After Sixty Years of Land Use in Iowa
Jessica Veenstra, Iowa State University, 1126 Agronomy Hall, Iowa State University, Ames, IA 50010

Soils form slowly, thus on human time scales, soil is essentially a non-renewable resource. Therefore in order to maintain and manage our limited soil resources sustainably, we must try to document, monitor and understand human induced changes in soil properties. By comparing current soil properties to an archived database of soil properties, this study assesses some of the changes that have occurred over the last 60 years, and attempts to link those changes to natural and human induced processes. This study was conducted across Iowa where the primary land use has been row crop agriculture and pasture. We looked at changes in A horizon depth, color, texture, structure, organic carbon content and pH.

Hill top and backslope landscape positions have been significantly degraded.

Catchment areas have deeper topsoil.
Have you noticed changes on your farm?
Mineral fertility parameters (pH, Ca, Mg, Ca:Mg ratio, P and K) were not significantly related to farmer SQ ratings. The strong relationships observed between soil C parameters, soil structural parameters and farmer SQ ratings suggest that efforts to improve SQ in the study region should focus on monitoring and enhancement of soil C and soil structure.
Morrow Plots
- started in 1876 at the U of I
- oldest agronomic experiment in the US

http://agronomyday.cropsci.uiuc.edu/2001/morrow-plots/
Which system produces the most crop residues?

Why doesn’t this system have the most SOM?
A white bread diet might make you fat but makes our soils skinny :-}
"But with the removal of water through furrows, ditches, and tiles, and the aeration of the soil by cultivation, what the pioneers did in effect was to fan the former simmering fires of acidification and preservation into a blaze of bacterial oxidation and more complete combustion. The combustion of the accumulated organic matter began to take place at a rate far greater than its annual accumulation. Along with the increased rate of destruction of the supply accumulated from the past, the removal of crops lessened the chance for annual additions. The age-old process was reversed and the supply of organic matter in the soil began to decrease instead of accumulating."

William Albrecht – 1938 Yearbook of Agriculture
What is happening on your farm?
Most likely corn yields and residue return have increased dramatically.
Unfortunately many farms in IL are just holding steady or even losing SOM despite very high levels of residue return!!

Most likely corn yields and residue return have increased dramatically

erosion and accelerated decomposition
How many times have you heard that SOM increases under no-till?
We know that more SOM accumulates at the surface under no-till.
Long term no-till

...but what about deeper in the profile?
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 have only been sampled 6” deep!
Effect of tillage on microbial activity

Soil respiration in spring tillage 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?

Differences in timing tend to be bigger than total differences

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

Which tillage system has more microbial activity when crops benefit most from the CO$_2$ and nutrients released by microbial activity?
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 130%, a net decline occurred in soil C despite increasing 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 strongly suggest that a reduction in the decomposition of C-rich residues is profound, and the results 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 NO₃ 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 depletion in the magnitude of organic C 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).

A controversial article
Nitrogen fertilizer effects on soil carbon balances in Midwestern U.S. agricultural systems

Ann E. Russell, Cynthia A. Cambardella, David A. Laird, Dan B. Jaynes, and David W. Meeke

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 determined the soil C balance, the rates of N fertilization, 0, 90, 180, and 270 compared the corn pha (Medicago sativa L.; corn–oats–alfalfa–soybean) 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 Kanawa sites, Iowa, USA; net primary production; nitrogen fertilization; root production; soil carbon sequestration.
Increases in decay rates with N fertilization 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.

Cover crops are a great way to add more belowground organic inputs to cropping systems!!
20 years of similar tillage intensity and C inputs but contrasting types of organic inputs.
Cover crops are multi-functional

Adapted from Magdoff and Weil (2004)
In contrast, 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 multi-functional

Adapted from Magdoff and Weil (2004)

3 oz of product X should do the trick

Using cover crops to capture multiple benefits normally requires more management

There are few profits in idiot-proof systems
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*
Matching objectives with species

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

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http://www.sdnotill.com/Field_Facts_wheat_cover_crop.pdf
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?
Is it compatible with my herbicide program?
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?
Do I have the needed equipment and labor?
What’s my contingency plan—and what is at risk — if the cover crop doesn’t establish or doesn’t die on schedule?
Other key considerations

Be realistic about potential cover crop challenges
Forage radish was aerial seeded into soybeans and conditions were favorable for germination but the radishes are growing very poorly.
Residual herbicide effects?

Yes - records indicate probably ‘Callisto’
<table>
<thead>
<tr>
<th>Herbicide</th>
<th># of Months between application and seeding a Brassica</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ally</td>
<td>34</td>
</tr>
<tr>
<td>Ally Extra</td>
<td>22</td>
</tr>
<tr>
<td>Amber</td>
<td>Bioassay</td>
</tr>
<tr>
<td>Beyond</td>
<td>18</td>
</tr>
<tr>
<td>ClearMax</td>
<td>18</td>
</tr>
<tr>
<td>Curtail M</td>
<td>5</td>
</tr>
<tr>
<td>Everest</td>
<td>9</td>
</tr>
<tr>
<td>Glean</td>
<td>9</td>
</tr>
<tr>
<td>GoldSky</td>
<td>9</td>
</tr>
<tr>
<td>Huskie</td>
<td>9</td>
</tr>
<tr>
<td>Maverick</td>
<td>Bioassay</td>
</tr>
<tr>
<td>Olympus</td>
<td>22 Bioassay</td>
</tr>
<tr>
<td>PowerFlex</td>
<td>9</td>
</tr>
<tr>
<td>Rimfire</td>
<td>10</td>
</tr>
<tr>
<td>Silverado</td>
<td>10</td>
</tr>
<tr>
<td>Starane</td>
<td>4</td>
</tr>
<tr>
<td>WideMatch</td>
<td>4</td>
</tr>
<tr>
<td>Wolverine</td>
<td>9</td>
</tr>
</tbody>
</table>
Residual Herbicide Carryover - Legumes

Herbicides Used on Wheat and/or Barley

Ally - (34)
Ally Extra - (22)
Amber - (4)
Beyond - (9)
ClearMax - (9)
Curtail M - (10.5 to 18)
Everest - (9 to NCS)
Glean - Bioassay
GoldSky - (9)
Huskie - (9)
Maverick - Bioassay
Olympus - (12)

# of Months between application and seeding a Legume = (#)

PowerFlex - (9)
Rimfire - (10)
Silverado - (10)
Starane - (4)
WideMatch - (10.5)
Wolverine - (9)
Low Residual Herbicides for Wheat

2,4-D  30 to 90 DAA
Affinity  60 DAA for Brassicas & 45 DAA all other crops
Buctril (Bromoxynil)
Discover  30 DAA
Express  60 DAA for Brassicas & 45 DAA all other crops
Harmony  45 DAA
MCPA
Paraquat
Roundup (Glyphosate)
Vida  30 DAA
Single best source of information

**Chart 3A CULTURAL TRAITS**

<table>
<thead>
<tr>
<th>Species</th>
<th>Aliases</th>
<th>Type¹</th>
<th>Hardy through Zone¹</th>
<th>Tolerances</th>
<th>Habit¹</th>
<th>pH (Prof.)</th>
<th>Best Established²</th>
<th>Min. Germin. Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual ryegrass p. 7-4</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, F</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>E, W, Sp</td>
<td>38F</td>
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<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>
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<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>
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<tr>
<td>Wheat p. 111</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.0-7.0</td>
<td>LSu, F</td>
<td>38F</td>
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<tr>
<td>Buckwheat p. 90</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>5.0-7.0</td>
<td>Sp to LSu</td>
<td>50F</td>
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<tr>
<td>Sorghum-sudan p. 106</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>6.0-7.0</td>
<td>LSp, ES</td>
<td>65F</td>
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<tr>
<td>Mustards p. 81</td>
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<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>
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<tr>
<td>Rapeseed p. 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.5-8</td>
<td>E, Sp</td>
<td>41F</td>
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<tr>
<td>Berseem clover p. 118</td>
<td></td>
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<td></td>
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<td></td>
<td>ESp, EF</td>
<td>42F</td>
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<tr>
<td>Cowpeas p. 125</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>5.5-6.5</td>
<td>ESu</td>
<td>58F</td>
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<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>
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<td></td>
<td></td>
<td>6.0-7.0</td>
<td>E, FSp</td>
<td>41F</td>
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<tr>
<td>Hairy vetch p. 142</td>
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<td></td>
<td></td>
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<td>5.5-7.5</td>
<td>EE, ESp</td>
<td>60F</td>
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<td>Medics p. 152</td>
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<td></td>
<td></td>
<td></td>
<td>5.0-7.0</td>
<td>EE, ESp, ES</td>
<td>45F</td>
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<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>
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<tr>
<td>Subterranean cl. p. 164</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>5.5-7.0</td>
<td>LSu, EF</td>
<td>38F</td>
</tr>
</tbody>
</table>

¹ Types: WA (Warm Air), HP (Hot Prairie)
² Best Established: D (Dormant), E (Early), L (Late)
³ Min. Germin. Temp: F (Freeze)
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
INNOVATOR PROFILES

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.

Probably the most tried and true system of cover crop establishment and benefit to the next crop
## 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.</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>
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<td>1997</td>
<td>Hairy vetch</td>
<td>2110</td>
<td>84</td>
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<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 much 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.
# REALITY CHECK

## PLANTED ACREAGE - PRINCIPAL CROPS

<table>
<thead>
<tr>
<th>Crop</th>
<th>Illinois</th>
<th>United States</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>2009</td>
<td>Indicated 2010</td>
<td>2009</td>
<td>Indicated 2010</td>
</tr>
<tr>
<td>Corn - All purposes</td>
<td>12,000</td>
<td>12,600</td>
<td>86,482</td>
<td>88,798</td>
</tr>
<tr>
<td>Soybeans</td>
<td>9,400</td>
<td>9,500</td>
<td>77,451</td>
<td>78,098</td>
</tr>
<tr>
<td>Winter Wheat 1/</td>
<td>850</td>
<td><strong>350</strong></td>
<td>43,311</td>
<td>37,698</td>
</tr>
<tr>
<td>Sorghum - All purposes</td>
<td>40</td>
<td>40</td>
<td>6,633</td>
<td>6,360</td>
</tr>
<tr>
<td>Oats</td>
<td>40</td>
<td>40</td>
<td>3,404</td>
<td>3,364</td>
</tr>
<tr>
<td>All Hay 2/</td>
<td>610</td>
<td>610</td>
<td>59,755</td>
<td>60,460</td>
</tr>
</tbody>
</table>

1/ Includes acreage sown preceding fall.
2/ Hay acres for harvest.
Broadcasting red clover seed into soybeans just before leaf fall (when soybean leaves start to turn yellow) has been proven a successful method. The leaves that fall after the red clover seed has been broadcast help increase humidity around the seeds.

**Benefits**

Red clover is a short-lived perennial that is winter hardy throughout Pennsylvania. Red clover can be used as a cover crop that provides many benefits such as fixing nitrogen (N) to meet needs of the following crop, protecting soil from erosion, improving soil tilth, competing with weeds, as well as supplying forage.

Red clover is adaptable and is winter hardy in Wisconsin. Red clover grows well in a wide range of soils that are well drained to excessively drained soil. It prefers a pH of 6.0 but can grow in a pH range of 5.0 to 7.0. There are two types of red clover. Medium red clover is darker and more compact than manna red clover. Red clover in Pennsylvania is mostly manna red clover.

**Nitrogen Fixation**

In a study in Wisconsin, red clover fixed enough nitrogen to supply the equivalent of 160 pounds per acre of nitrogen fertilizer. A lower nitrogen contribution is more common, however. In a study in Pennsylvania, showed that a one-year-old red clover stand (without harvest) contributed 70 pounds of nitrogen per acre to the first corn crop following it, while there was a benefit of 50 pounds of nitrogen per acre for the second corn crop following the establishment of the red clover stand.
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.
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
Fall growth and N uptake by brassicas is often faster than small grains
Ability of radishes to capture soil N in fall

Soil Depth, cm

Nitrate-N, mg/kg

Control
Forage radish
Oliseed Radish

Hayden Fall '03

2002 nitrogen?

2003 nitrogen

ns

*
Brassicas appear to be particularly adept at solubilizing P.

Biological pumping + organic acid root exudates.

Third year of cover crop treatments in a corn-soybean rotation.

Soil Test P
Silt loam at Wye, Fall 2003
Means for top 18 inches

Rape Rye control
forage rad oilseed rad

Cover crop treatment

0 30 60 90 120 150
Soil test P, mg/kg

Means for 0-45 cm

Wye, Fall 2003

Brassicas
appear to be particularly adept at solubilizing P.
Compaction can severely limit root growth
Sub-soil water and nutrients
Did this happen on your farm last fall?
Which solution would you use?
Visual evidence of biodrilling

Canola root
January
Early May

Please plant me no-till!
What is this??
Aerial seeding cover crops into standing crops

- Cereal 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
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
Cow eating whole turnip
Protein 16.59
RFV 114

Protein 12.79
RFV 92
Paul Smith

Annual ryegrass aerial seeded into standing corn

Fall, 2001
John Hebert
Inspecting ryegrass no-till drilled into corn stubble
Fall, 2001
• Tyler Johnson
• King’s Grant Farm, Chestertown
• Forage Radish
• Seeded by airplane into standing corn
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.
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 at the WIU Organic research farm

Conventional till
Bio-strip-till
No-till

Established in fall 08
Options for rolling cover crops

Rodale design

Cultimulcher
Early June

1 week later
~2 weeks after planting
Early November

Plot yields ranged from 51.6 to 58.6 bu/ac

No significant differences between systems
Early September 2009
Tillage radish on 30” rows with oats on 7.5” rows

Early November 2009
Tillage radish solid seeded on 7.5” rows (~ 10 lbs/ac)
## 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 applications</td>
<td></td>
</tr>
<tr>
<td>cropping</td>
<td>switch to perennials</td>
<td>How equivalent is combining 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, continuous no-till</td>
<td></td>
</tr>
<tr>
<td>wetlands</td>
<td>1-5% of area</td>
<td></td>
</tr>
</tbody>
</table>
Biomass Production
Annual Cropping Systems

Missed opportunities 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

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

Kaspar et al. J. Environ. Qual. 36:1503-1511
This is not just a problem in the Gulf of Mexico!

~ 14 % of wells in IL are contaminated with excessive nitrate
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>

Note: * Significant .05  ** Significant .01

M Plumer

2 years /3 replications
Bulk density (g/cm$^3$)
all no-tilled 9+ years

Rye grass cover crop   No cover crop
for 6 years

10”  1.49*   1.66

16”  1.58   1.54

24”  1.48*   1.65

M Plumer

* sig. .05
Impact of hairy vetch and rye cover crops on corn yield in IL

Higher corn yield potential following vetch regardless of N rate!
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