A Decade of Cover Crop Research

retrospection on key lessons learned

Dr. Joel Gruver
WIU - School of Agriculture
What does balanced mean to you?

Inputs: Outputs
Costs: Benefits

Work: Play

Ca: Mg
THE MISSOURI PLAN (BALANCED FARMING)

J. W. Burch
University of Missouri

The Missouri Extension Service taught individual farm practices, as did all state colleges, until 15 years ago when the need became apparent for a system of farming that would tie together all of the good practices recommended by the college for a farm in a way to give the greatest net income consistent with continuing improvement of the soil. Throughout the years certain farmers have specialized in beef cattle production and perhaps failed to improve their pastures, and others specializing in crop production failed to receive high net income because of poor feeding practices. The college, with its traditional 12 to 14 departments and Extension specialists for each, undertook to save the farmer by teaching the individual practices, leaving it to the county agent or the farmer to tie these practices together, if any attempt along that line was made.
PFI = balanced!
Cover Crops

Resources

- Cover Crop Directory
- Cover Crop Recommendations
- Cover Crop Decision Tools
- Soybean Herbicides and Grazing Restrictions
- Cover Crops and Livestock
- Grazing Cover Crops Fact Sheet
- Spring Grazing Cover Crops
- Herbicide Use and Cover Crops
- Corn Herbicides and Grazing Restrictions

Adding a Cover Crop to a Corn-Soybean System

PFI field crop specialist Sarah Carlson explains how to add a cover crop to your corn and soybean rotation in this 25-minute video.
Carlson, S. 2013. **Winter rye cover crop effect on grain crop yields:** Year 4. Practical Farmers of Iowa.
IA Soybean Association’s On-Farm Network® Replicated Strip Trial Database

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop</th>
<th>Trial Type and Detail</th>
<th>Location</th>
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<tbody>
<tr>
<td>All Years</td>
<td>All Crops</td>
<td>All Trial Types</td>
<td>All Landform Regions</td>
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<tr>
<td>2014</td>
<td>Corn</td>
<td>Cover Crop</td>
<td>Des Moines Lobe</td>
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<td>2013</td>
<td>Soybeans</td>
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<thead>
<tr>
<th>Trial Type and Detail</th>
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<tr>
<td>Cereal Rye vs Untreated</td>
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<td>Fall Cover Crop Mix vs Untreated</td>
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<td>Rye vs Untreated</td>
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<td>Tillage Radish vs Untreated</td>
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<td>TillageMax DOVER mix vs Untreated</td>
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<td>TillageMax INDY vs Untreated</td>
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</table>

Display Results
Clear Results

Crop Management
Crop Management - Planting Date
Crop Management - Population
Crop Management - Roller
Crop Management - Row Spacing
Crop Management - Tillage

Lower Iowa
Maquoketa
Middle Des Moines
One Hundred and Two
Skunk
South Skunk
Upper Cedar

Adams
Boone
Chickasaw
Dallas
Des Moines
Floyd
Jones
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<th>Watershed</th>
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<td>Jones</td>
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The WIU/Allison Organic Research Farm is located in southern Warren County, ~ 15 miles north-west of Macomb.

cash-rented by WIU since early 90s
Collaboration with neighboring farmers is essential.
Sometimes you just have to use what you have 😊
I am transitioning to organic with my eyes wide open!

He’s visited the farm at least a dozen times!
Teaching undergrads is my #1 mission
Students help me learn about CC innovation

> 300 farmer profiles since 2008
WIU Organic Research farm

Fall 2012

Spring 2012

Student’s home farm the next fall
Allison Organic Research & Demonstration Farm

In 1989, the Agriculture Department at Western Illinois University identified a historically pesticide-free, limited-fertilizer, 80-acre farm located near the WIU campus. From 1989 through 2002, we have completed systematic sampling and characterization of many chemical, physical, and biological properties of these Sable-Muscatine soils, with the cooperation of scientists from several
Organic Research Projects
All the reports below are PDF files. Please contact the School of Agriculture if problems occur when accessing these documents. We will provide site content in a format you can use.

Organic Fertilizers/Soil Amendments

*B* Nature Safe ® 13-0-0 Organic Dry Fertilizer Study
Organic Dry Blended Fertilizer Study
Soybean Yield Response to Hog Manure Application
SumaGrow Study
Humate/Fertility Study
Oat Yield Summary and Allganic® Nitrogen (16-0-0) Trial

Variety/Hybrid Trials

2015 Soybean Variety Trial at Conventional Site
2014 Soybean Variety Trials
2013 Soybean Trials (Yield Summary)
2012 Corn Hybrid Trial
~ 100 presentations available on SlideShare
Radishes – A New Cover Crop for Organic Farming Systems

eOrganic authors: Dr. Joel Gruver, Western Illinois University
Dr. Ray R. Weil, University of Maryland
Charles White, Penn State University
Dr. Yvonne Lawley, University of Manitoba

Over the past decade, radishes have been redefined; once known almost exclusively as a pungent vegetable, radishes have recently gained recognition for their cover cropping potential. After reading this article, you'll be able to make an informed decision about whether cover crop radishes are worth a try on your farm.

Radishes have made rapid inroads as a cover crop for several reasons. First, the radish phenotype is well suited to perform many valuable cover crop functions—provide soil cover, scavenge nutrients, suppress weeds, and alleviate compaction—while creating few of the residue management challenges associated with many other cover crops. Second, recent research including many on-farm trials has documented beneficial effects of radish cover crops on soil properties and subsequent...
soil penetration capabilities
radish > rapeseed > rye
Our data suggest that surface mulch and deep root channels left by winter cover crops can be advantageous for summer crop growth, particularly when soils are highly compacted.

Tap-rooted forage radish and rapeseed cover crops enhanced corn root access to subsurface soil water by providing deep root channels in compacted soils.
Impact of preceding cover crops on cash crop root density

Chen and Weil (2011)
Cover crops as management tools

Click on boxes for related research by Weil et al.

- Soil Cover
- Soil temperature
- Soil Aggregation
- Reduced erosion loss
- Increased infiltration
- Weed suppression
- Food web activity
- Crop growth
- Nematodes
- Nitrogen fertility
- Labile C
- Bio-drilling
- Soil water
- Microbial associations
- P-fertility
- Soil organic matter
- Nutrient capture

http://notillveggies.org/cover-crops-as-management-tools/
There are many windows of opportunity for CCs

- Dormant seeding early or late winter
- Frost seeding
- When planting summer crops
- Prevent plant scenarios

- After weed-free window (early intercropping)
- After small grains
- After early harvested vegetables
- After seed corn or silage corn

- Aerial or high clearance seeding into standing crops in late summer/early fall

- After early corn/bean grain harvest
- After full season corn/bean grain harvest
Frost seeded red clover is a more reliable producer of biomass and fixer of N than legume CCs planted after small grain harvest.
Frost seeded red clover is more weather resilient.
Figure 2. Nitrogen distribution in unharvested red clover biomass.

- Two-thirds above ground: 55-75%, WI Average (160 samples): 96 lb/a
- One-third below ground: 25-45%, Total: 141 lb/a

More than most legumes
Wisconsin data suggest that approximately 70% of whole-plant N will become available in the first year following clover, most released before corn begins its period of rapid uptake.

Figure 3. Relationship between clover nitrogen release and corn nitrogen uptake under conventional tillage. Adapted from Stute and Posner (1995) Agron. J. 1063-1069.
Soybean health experiment – multiple locations across IL

November 2010

Publication in press

Mustard
Rapeseed
Canola
Cereal rye
Cereal rye

Soybeans no-till drilled into cereal rye were the top yielder in 2011
Abstract:

Field trials were conducted from 2010 to 2013 at four locations in Illinois to evaluate the impact of cover crops (cereal rye (Secale cereale), brown mustard (Brassica juncea), winter canola (Brassica napus), and winter rapeseed (B. napus)) on soybean (Glycine max) stands and yield, diseases, pathogen populations, and soil microbial communities. Cover crops were established in the fall each year, and terminated the following spring either by using an herbicide (no-till farms), by incorporation (organic farm), or by an herbicide followed by incorporation (research farm). Although shifts in soilborne pathogen populations, microbial community structure were not detected, cover crops were found to induce general soil suppressiveness in some circumstances. **Cereal rye and rapeseed improved soybean stands in plots inoculated with Rhizoctonia solani and decreased levels of soybean cyst nematode in the soil.** Cereal rye increased soil suppressiveness to *R. solani* and *Fusarium virguliforme*, as measured in greenhouse bioassays. **Cereal rye significantly improved yield when Rhizoctonia root rot was a problem.** Using cover crops repeatedly, in the same field, may achieve more distinct effects on suppressing soybean diseases and build-up beneficial properties in the soil.
Mustard variety trial at the Allison farm in early June 2011

Pacific Gold
- Slower to mature
- More biomass

Ida Gold
- Faster to mature
- Less biomass
Forage brassica comparison

Most winter hardy

Turnip-kale cross

Most winter hardy

Ethiopian cabbage

Winfred

Hunter
Not all ARG varieties were winter hardy

Annual ryegrass variety trial at the Allison farm
November 2010

Bruiser, Bounty and KB Royal had the most top growth
ARG = excellent tolerance of wetness

> 36”
Radish roots at ~ 40” after 45 days
Very dense rooting at the soil surface
Rapid improvement of soil crumb structure
Crimson clover

Chick peas

Green lentils

Fava beans

We have grown demo-plots of lots of other species
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. Weil et al.
### Impact of winter-killed cover crops on *in-row* soil test P and K

<table>
<thead>
<tr>
<th>Mustard</th>
<th>Tillage Radish</th>
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<tbody>
<tr>
<td>Inter-row soil test P - 56</td>
<td>Inter-row soil test P - 62</td>
</tr>
<tr>
<td>In-row soil test P - 60</td>
<td>In-row soil test P - 78</td>
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<tr>
<td>Inter-row soil test K - 482</td>
<td>Inter-row soil test K - 372</td>
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<tr>
<td>In-row soil test K - 1014</td>
<td>In-row soil test K - 948</td>
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<thead>
<tr>
<th>Oat</th>
<th>Phacelia</th>
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<td>Inter-row soil test P - 72</td>
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<td>In-row soil test P - 72</td>
<td>In-row soil test P - 84</td>
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<tr>
<td>Inter-row soil test K - 384</td>
<td>Inter-row soil test K - 454</td>
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<tr>
<td>In-row soil test K - 538</td>
<td>In-row soil test K - 506</td>
</tr>
</tbody>
</table>

All #s are lbs/a Mehlich 3 extractable nutrients as reported by Key Agricultural Services here in Macomb, IL.
Wheat + radish trial at the Allison farm
November 2010

3 lb/a = 2 lb/a = 1 lb/a > 0 lb/c
~ 2.5 bu/a yield boost

It's unclear if this is a nutrient effect
A little extra N can make a big difference

+20 lbs N/a

2x biomass
2012

No radish

Preceded by spring planted radish

Water depletion by the radishes seems likely to have been the primary cause of severe soybean stunting.

Moisture depletion in the spring is normally a good thing on this poorly drained farm.
Impact of added N on radish study

5” of rain shortly after planting => no effect of added Chilean nitrate
Beneficial insect habitat strips along edges of most fields

Mixes of left over CC seed – always include buckwheat
Thinning radish for a population study

AKA making lemonade out of a mistake (reversing the drive and driven) 😐
The full seeding rate (~11 lbs per acre, ~16 seeds per foot) ended up producing the most root and shoot biomass.

4” of warm gentle rain the week after planting! Results would probably have been different if moisture had been limiting.
A 30’ wide strip drilled at >400k!!!

Another mistake that had educational value
Planting into poorly digested red clover residues

25-50% stand loss

Near perfect stands in all other corn plots on the farm
Planting into a furrow =>
good germination during a
very dry June and excellent
in-row weed control

Planting into a furrow
would probably have
prevented the situation
shown on the previous slide.
Annual ryegrass after chisel plowing

Chisel plowing made the next pass with a rotavator easier and more effective
Terminating spring planted oats with a soil finisher
~ 3 weeks before planting corn
Spring planted mustard/pea/oat mix ahead of corn

No negative effects on corn germination

terminated with a Howard rotavator
(Mis) adventures in Organic Strip-till

Some plots had a low rate of NS 13-0-0 delivered into the strip.
Some parts of the field had a good stand of red clover
Other parts of the field had a poor stand of red clover
Inter-row cultivation was delayed by a multi-inch rain
Inter-row cultivation killed most of the inter-row weeds but limited flow of soil into the row failed to bury many in-row weeds.
Too much weed pressure in the row!

Plot yields averaged ~120 bu/a vs > 170 bu/a average for other corn plots in 2014
Much better stand of red clover in fall 2014
Nice strips made by Yetter Mavericks
Planting radish on strips
Filling in where chain broke on planter
Radish established well but red clover was highly competitive
Mowed to reduce competition
In some plots, red clover was suppressed by 1 or 2 cultivations in October and November.
In some plots, red clover and radish were terminated by rotavation in November.
The next spring a beautiful stand of corn received ~ 25” of rain in June and July

A very promising bio-strip till experiment compromised 😞
Small-scale testing of bio-strip till concepts
Precision planted lentils + radishes
Precision planted peas + radishes
Precision planted radishes w/ peas

Precision radishes w/o peas

w/peas => significantly more radish root mass
Far less stimulation of weed germination in-row

Future attempts at organic strip-till will probably use this approach.
Success w/ no-till organic soybeans
Organic No-till research at the Allison Farm

Soybeans drilled after rolling 5’ tall cereal rye

Rye was rolled with a cultimulcher
Early November 2009

Plot yields ranged from 51.6 to 58.6 bu/ac

No significant differences between NT, CT and bio-strip-till systems
November 2010

Significant foxtail pressure but almost no broadleaf weeds

*Plot yields ranged from 42-52 bu/ac*
15’ wide roller built by a local farmer used in 2010 and 2011
Mid-June 2011

Rolled after drilling
Early July 2011
The NT bean plots yielded ~10 bu more than the best tillage system plots.
Planting into 5-6’ tall rye on May 11 2012
Comparison of single drilled vs double drilled with 4” offset
All of July :-<
Our 2012 NT bean yields ranged from
~ 30 to ~ 60 bu/a

Better drained areas of
the field yielded poorly

Wet hole yielded very well
We decided not to plant any NT soybeans in 2013 & 2014 after observing weak/variable stands of rye in the spring.

Rye had been drilled at inadequate rates in mid-late November.
Double drilled NT soybean variety trial in 2015
NT soybeans survived the deluge and are finally growing fast
Later maturing soybean variety (BRH 39C4) is greener
BRH 34A7 plots averaged 62 bu/a vs. 66 bu/a for BRH 39C4
BRH 34A7 vs BRH 39C4
NT soybeans planted on 5/30
Early June
Early July
~ 4 plants per square foot
Both varieties (34A7 & 39C4) averaged just over 70 bu/a
Right after drilling rye for 2017 NT soybeans
15” vs 30” vs 30” w/ high residue cultivation planned for this field
May 2016

rye/oat/pea/mustard mix preceding pumpkins

Rye is volunteer from NT soybeans in 2015

Oats, peas and mustard were planted second week of March
~4 months later
CC roots under a pumpkin!
Adventures in bio-strip till

September 2008
Radish planted on 30” rows using small milo plates in mid-August 2010
Corn following cover crop experiment (2011)

Attempt #4

Corn planted over radish rows w/o GPS guidance
Radishes in fall 2011
May 2012

+20 bu/a corn in plots w/ fall cultivation of radish vs. no fall cultivation???
Radish planted on 30” rows with RTK guidance on August 29 2012
right before Hurricane Isaac rolled in

Attempt #6
4 days later
10 days after planting
Why are the inter-rows so clean?
We had just cultivated some of the radish plots!
Organic bBio-strip till has shown promise but yield effects have been variable

Availability of nutrients to following corn crop seems to be inconsistent

Effort to add radish to established CC may exceed benefit

Extreme weather compromised our most promising attempts at bio-strip till
We are finally taking multispecies CC mixes seriously

Sunn hemp/sunflower/oat/radish/mustard mix planted 8/15/16 following peas
Cereal rye @ ~ 12 lbs/a

CC mix (peas, oats, mustard, phacelia???) will be drilled in early spring 2017

CT vs NT pumpkins planned for summer 2017
It was very easy to adjust rates
# SmartMix Calculator

Use the yellow area to select your seed and your seeding rate per acre. Use the drop down boxes to select the species you want to include.

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<tr>
<th>Species</th>
<th>C:N Ratio (mature growth estimate)</th>
<th>N Fixing Potential (scale of 1-10)</th>
<th>Diversity Rating (scale of 1-10)</th>
<th>Frost Tolerance (scale of 1-10)</th>
<th>* Full Rate</th>
<th>Ibs per acre</th>
<th>Season</th>
<th>% by weight</th>
<th>% by # seed</th>
<th>% by cost</th>
<th>Seeds/lb</th>
<th>Seeds per acre</th>
<th>Cost per pound</th>
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Add your own seed and seed cost in the section below. Totals will be reflected in grand totals at top but not in the Green Cover Seed cost total.

**Green Cover SmartMix total:** $16.95

**Inoculant and mixing:** $0.00
Making the Most of Mixtures: Considerations for Winter Cover Crops in Temperate Climates

Organic Agriculture  May 05, 2016

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Introduction

Cover crops can provide multiple benefits. For example, they can improve soil health, supply nutrients to cash crops, suppress weeds, help manage insect pests, produce forage, support pollinators and beneficial insects, and reduce water and air pollution. However, not all cover crop species provide the same benefits. How can you best reap the multiple benefits of cover cropping with so many species to choose from? To multiply and diversify your cover crop benefits, plant mixtures.
Lots of interesting things happen in mixtures

Cowpea fixed more N when intercropped w/Japanese millet

<table>
<thead>
<tr>
<th>Cover crop species</th>
<th>% N from fixation</th>
<th>Total N fixed (lbs/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowpea</td>
<td>39</td>
<td>37</td>
</tr>
<tr>
<td><strong>Cowpea + Japanese millet</strong></td>
<td><strong>72</strong></td>
<td><strong>59</strong></td>
</tr>
<tr>
<td>Cowpea + SorgumSudan</td>
<td>56</td>
<td>26</td>
</tr>
</tbody>
</table>

FAO