Proceedings of the Midwest Cover Crops Council (MCCC) Annual Meeting

February 28-29, and March 1, 2012, held in West Lafayette, Indiana

Contents

State/Province Reports

Invited Speakers

NRCS, SWCD, and other reports and publications

Tuesday February 28- MCCC Day 1—Rm. 143

8:00 - 9:00 am Registration and view posters

9:00	Welcome, and "State of the Union" of MCCC—Eileen Kladivko
9:15	Group discussion on future directions for MCCC—some input to be used for further planning meeting on Thursday morning. (Also research ideas can be added to flip charts)
9:45	Small working groups (3) to brainstorm next steps with some of our Extension/outreach activities (get coffee while in these sessions) 1) Website—reorganization, other features 2) Selector tool— next steps, additional features, as we expand/improve the next version 3) Multi-state Extension activities and products—which things do we want to do as multistate activities, and outline them, and which things are individual state/province. Specific items include: webinar series; pocket guide; trainings and other products.
10:30	Small groups report back to larger group on their ideas, and plans for how to proceed
10:45	Brief reports from partners and other organizations Ryan Stockwell, National Wildlife Federation Richard Warner, Green Lands Blue Waters Angie Williams, CTIC (Conservation Technology Information Center) Barry Fisher, Indiana NRCS—new Soil Health Initiative Kendall Lamkey, Iowa State University—Administrative Advisor to NCCC-211
12:15-1:30	Lunch and Poster Session
1:30 - 2:30	State and Province Reports/Updates (3) -- 20 min each, highlight one or two research projects so others get information on the types of research going on. ▪ IN ▪ MI ▪ IA
2:30 - 3:00	Break and Posters
3:00 - 5:00	Continue State/Province Reports/Updates (7) ▪ ONT ▪ OH ▪ MN ▪ MO ▪ WI ▪ ND ▪ IL

Wednesday February 29—MCCC Day 2—Multi-purpose Room (Rm 143)

7:30 - 8:15 am Registration, view posters

8:15	Welcome to annual meeting. General introduction to MCCC and its activities and cover crop educational tools and activities—Dr. Eileen Kladivko, Purdue
8:30	Practical ways to use cover crops as biofumigants—Dr. Mathieu Ngouajio, Mich. State
9:00	Cover crops and their impacts on nematodes—Dr. George Bird, Michigan State
9:45	Break
10:00	Dr. Ray Weil, Univ. of Maryland—Forage radish cover crops to improve soil health
11:00	Farmer panel—three Indiana farmers share ideas and experiences with cover crops. Dan DeSutter, Rodney Rulon, Cameron Mills. Moderator: Dan Towery, CCSI
12 noon	Lunch, view posters
1:00 pm	Hal Weiser, N. Dakota NRCS, Cover crop mixes and building soil health
2:00 - 2:30	Breakout discussions session 1—choose 1 of the 5 topics offered
2:35 - 3:05	Breakout discussion session 2—choose 1of the 5 topics
	See separate (blue) sheet with a description of the breakout discussions and topics
3:05	Break
3:15	Soil nitrogen cycling with cover crops—When do we get the N back again? Dr. Jim Camberato, Purdue Agronomy
3:45	Radishes, manure, and N cycling: Case study in Michigan--Dr. Tim Harrigan, Mich. State
4:15	Cover crop costs compared with possible additional revenue from stover removal—Dr. Wally Tyner and Ms. Michelle Pratt, Purdue Agricultural Economics
4:45	15 Tips in 30 Minutes—Best ideas from a panel of farmers and advisors. Moderator: Dr. Hans Kok, CCSI
5:15	Adjourn

Thursday March 1-- MCCC strategic planning meeting – Room 117 (concurrent w/ RC&D workshop)
8:00 am – 12 noon - Follow up on Tuesday’s working sessions, for Extension, research, and policy/communication plans for future.

Minutes of NCCC-211 meeting, held in conjunction with Midwest Cover Crops Council (MCCC), Feb 28, 29, March 1, 2012

The first business meeting of the NCCC-211 working group began at 8am Tuesday February 28, with Chair Tom Kaspar presiding and Secretary Eileen Kladivko taking notes. Dale Mutch was nominated and elected as secretary-elect for the group, with his duties beginning in 2013, while Eileen Kladivko will rotate into the Chair position. Kendall Lamkey (Agronomy Department Head at Iowa State University) serves as Administrative Advisor to the group. Mary Ann Rozum from NIFA (and our NIFA representative on the committee) called in at 8:15 and spoke with the group through 8:45am. She discussed federal budgets and programs that might pertain to cover crops. She also encouraged the group to submit comments to the AFRI program for suggestions for the 2013 call for proposals. The business meeting adjourned at 8:50am so that the group could go to the main general session which opened at 9am in an adjacent room.

<u>Day 1 (Tue Feb 28) General session, 9am-12noon (notes taken by Edwin Suarez)</u>

State of the Union (Eileen Kladivko):

- History of the MCCC:
    - Success of the website and need of logo
    - Advances of each year meeting
    - Selector tool
    - Pocket Guide Release TODAY
    - Missouri included in 2012
- Celebrate Successes
    - Website, list serve
    - Pocket guide
    - Crop insurance
    - Annual meetings
    - Becoming the “go to” place for cover crops
    - Multistate extension & research
    - Cover crop adoption
- Less success in funding for research (need to get money)

Open Table – suggestions and ideas (Everyone):

- Where to start with extension bulletins? Demonstration of planting methods, weather patterns & other factors affecting (would MCCC approach this??) Include videos on the website of planting methods, webinar topics.

- Cover crops & herbicides information approach (costs, interaction, carryover, unite efforts & ideas)
- Use the list serve as an ideas resource
- Click on map>state>farm (like Google maps but with the selector tool)
- Vegetable growers: do some research about cover crops before vegetables
- Pursuit of conservation grants?? Not as a group but as states.
- Nematodes should be a researchable topic (reduction of nematodes)
- Value of legumes and economical value, nitrogen capture and economical benefits.

Web Update (Erin Taylor):

- General information and contents for anyone unfamiliar
- 299 members in 2012 (31 more)
- Selector tool: demography of visitors/states, visitor number, time of the year, countries
- Flow of visitors? Is it constant or has spikes during the year?
- Characteristics of visitors and must visited links (facebook, Google and other tools interaction)
- Future organization: what is needed for the website and events announcement

Small Working Groups:

Multi State Extension Activities and Products (notes taken by Edwin Suarez)

- What do we want to achieve in extension?
- Improve networking
- include seed companies in extension efforts
- Train the trainer
- Role of extension vs. private industry > How to include private sector without losing independence and objectivity?
- Seed company perspective > also attends extension but some don't commit to extension
- What type of materials are needed? Written copies, webinars, email, phone (time as an issue)
- Publications:
    - Centering the information (time) website should be that tool
    - Small posters for ag retailers (Ontario) info & MCCC website
    - Challenges > Funding and volunteering
    - SARE funding might be an option, involving adult education
    - Information out in the field (how crop advisors have been educated), training for them
    - Demo plots and data
    - Need of better ways to get info out and also collect data > train the trainers
- Webinars:
    - Pros and Cons
    - ASA could take care of the logistics for the webinar.

- Define the Audience, time, date
    - How short or long?
    - Define specific topics and define needs
    - Topic answers, quick topic > YouTube and mini webinars to address needs.
    - Two kinds of audiences, those who want to get answers and those who want to learn.
    - Small videos could be used by others
    - SWCD's can be the perfect platform
    - For farmers, YouTube videos can be a good dialogued tool but printed material is more trustable. (youtube + paper = good option)
- Training:
    - How training programs should look in the future?
    - Cover crop study groups, train the conservation partnership
    - How to increase the use of cover crops?
    - Working in co-op on cover crop training (CCA's, retailers)
    - Work with fertilizer companies and with chemical companies.
    - How to market the MCCC?
    - Get some funding from fertilizer committees. > Data to show the value of cc
    - Sell service related to cover crops > economics on cc

Small groups report back:

<u>Website</u>

- More about cover crops, less about MCCC
- Change the Homepage (include a picture)
- Grower committee to get the input for website
- Grower page
- FAQ page or Forum > Ask the expert
- Check on cc species (sheets)

<u>Selector Tool</u>

- Trouble with charts and browsers
- Mixes should be included
- Hardiness zone map / seeding dates review
- Incorporate manure to the tool (performs well or not with manure) application styles, types of manure, manure application date.
- Details about layout and clean up tool

REPORTS FROM PARTNERS AND ORGANIZATIONS

Ryan Stockwell NWF:

- Talked about cover crop and insurance regulations issues.
- Informed about meeting with risk management agents and the need to show data that proves that cover crops do not decrease yield.
- Cover crops are water management tools (risk reduction)
- Policy changed thanks to combined efforts
- Report NWF future friendly farmers (chapter on cover crops benefits and how it changes farming for future generations)
- New project focused on cover crop, developing a cover crop road map, get input from stakeholders from all aspects of cover crops to understand use and knowledge of cover crops
- Developing solutions for barriers to implement cover crops.

Richard Warner – Green Lands Blue Waters:

- Brief overview of Green Lands Blue Water, status, organization and current projects.
- Cover crops are one of their five strategies.
- Discussed potential for their five strategies
- Promotion of the MCCC
- Sponsor combined events on working groups
- Implementation site development

Angie Williams - CTIC:

- Great Lakes cover crop initiative GLCCI initiative explanation
- Educators working in field days and continuous education
- Workshops and trainings
- Focus is direct implementation of cover crops (get acres planted)
- Look for an extension of the CTIC

Barry Fisher – Indiana NRCS:

- Soil Health as an initiative to increase use of cover crops.
- Cover crops as an insurance (risk reduction)
- System vs no system comparison (health, N leaching, yields etc)
- Soil Health is a priority in Indiana (NRCS) in 2012
- No till + cc + nutrient management +best management + crop rotation + buffers = soil health as a reality
- Soil health specialists > teams for local training
- Soil health items > 50% of training to soil health

<u>Kendall Lamkey – Iowa State Univ Agronomy Dept Head, and Administrative Advisor to NCCC-211:</u>

- Regional projects, good coordination with stakeholders.
- 300 bushels corn without soil health is impossible
- 7-12 inches of water are needed to get extra 100 bushels/acre
- Also nitrogen is needed

Tuesday afternoon was devoted to individual state reports from all participating states and provinces (IN, MI, IA, ONT, OH, MN, MO, WI, ND, IL). See state/province reports at end of minutes. The meeting adjourned around 5pm.

<u>Wednesday Feb. 29</u> had invited speakers, farmer panels, and breakout discussion sessions—see detailed agenda at beginning of minutes.

<u>Thursday morning March 1</u>, the second business meeting of NCCC-211 and the MCCC working group was held from 8:00- 10:30am.

<u>MCCC Planning Visioning Meeting March 1, 2012 (notes taken by Tom Kaspar)</u>

Present: Tom Kaspar, Eileen Kladivko, Dale Mutch, Dean Baas, Alan Sundermeier, Jim Hoorman, Ryan Stockwell, Anne Verhallen, Laura Van Eerd, Rich Hoormann, Richard Warner, Bill Kuenstler, Jerry Lemunyon, Barb Stewart, Erin Taylor, Marisol Berti, Tim Harrigan, Florian Chirra, Victoria Ackroyd, Charles Ellis, Elizabeth Wissel, Edwin Suarez, Dave Robison

Comments from Partners about future collaboration with and work of MCCC:

Ryan Stockwell –National Wildlife Federation

1. Continuing work with RMA in relation to cover crops and conservations
    a. First step of many
    b. Data came in the form of farmers that were showing good yields with cover crops
    c. Other RMA regions to work on – maybe St. Paul MN, Topeka, KS, and Billings, MT regional offices, which include Iowa, Minnesota, Wisconsin, Missouri, Nebraska, Kansas, South Dakota, and North Dakota.
2. How NWF looks at the Farm Bill in terms of cover crops
    a. How cover crops relate or could be included in existing programs
    b. Getting information about cover crops to the state NRCS technical committees so they are included in the list of practices for a program
    c. For congressional aides prepare (1 pg – 2 sides) fact sheets, which highlights how cover crops impact every farm - e.g. improve water availability

    d. Invite congressional staffers to field days - state commodities groups or organic groups can help to pull in congressional staffers.
3. National Wildlife Federation also cooperates with other groups on Farm Bill Issues
    a. Izaak Walton League
    b. Land Stewardship Project
    c. Etc
4. Stakeholder meeting in June this summer on "Roadmap For Increasing Cover Crop Adoption"
    a. Wants participation of MCCC members
    b. Want MCCC support and endorsement of meeting
    c. Wants SWCS support and endorsement of the meeting
    d. Discussion of what are the issues/barriers to cover crop adoption

Richard Warner – Green Lands Blue Waters

1. Keep soil covered – Perennialization of Landscape - Green Lands Blue Waters has 5 working groups to integrate these practices across landscapes
    a. Cover crops – MCCC has been affiliated with GLBW since shortly after our start
    b. Agroforestry
    c. Biofuel
    d. Livestock
    e. Perennial Grains
2. Economics is an important component for all these practices
    a. Costs
    b. Short-term and Long-term benefits to farmers
    c. Secondary economic benefits – local coops
    d. Value of environmental benefits
    e. An example is Matt Liebman and Craig Chase's economic analysis of rotations in Iowa
3. Is planning a forum late in the year on how to deliver cover crops (not sure if just cover crops or all 5 practices) on the ground
    a. Farm planning
    b. How do cover crops fit in
    c. Economics
    d. Whole package

NRCS – Bill Kuenstler, Jerry Lemunyon, and Barb Stewart

1. Soil Health is a new initiative
    a. Indiana is taking the lead in this
    b. Not sure how far this is going
2. NRCS wants information on how to "sell" cover crops to farmers
    a. What is the $ value of cover crops to farmers?
    b. What is the return?
    c. What is the yield benefit long-term?

d. What is the cost of erosion? What is the value of the nutrients in eroded soil?
e. How do cover crops reduce their risk?
f. How do cover crops affect yield stability?
g. How do we get cover crops to "appeal" to landowners – 60% of farmed land is rented?
h. Farmer values for cover crops and case studies are good.\

Group we should get more involved with is National Agricultural Aviators Association

1. Do we need a certification program?
2. Dave Robison mentions that the aerial applicators generally have a fly-in day in each state.
3. Field days?
4. Dean Baas and Dave Robison were leading this discussion

MCCC Working Committees/Groups

One-pager/White paper

Tom Kaspar, Jim Hoorman, Alan Sundermeier, Ryan Stockwell, and Eileen Kladivko

Purpose: Information to give to congressional staffers/legislators/government officials. We had one in the beginning that Paul Porter in Minnesota worked on. "Best way to reach 300 bu corn is to improve the soil because there is only so much water and nutrients.

MCCC Web Site Working Group

Erin Taylor, Anne Verhallen, Rich Hoorman, web person from GLBW, Tim Harrigan

Suggestions/Discussion

1. Put case studies – yield results on site - farmer derived values of cover crops
2. Keep visuals and audio separate when making videos. Keep then short 2 -3 min.
3. We need a general definition of cover crops
4. We need cover crop picture on home page – maybe rotating pictures
5. Templates for videos – standard beginning and end
6. Erin can't do editing or quality control for videos
7. Suggestions for cover crop mixture seeding rate calculators
8. Suggestions for cover crop cost and values calculators

Education/Extension Needs

Suggestions/Discussion

1. Question heard over-and-over from farmers last two days was "How do I get started?"
    a. For the complete novice – Cover Crops For Dummies – especially for corn/soybean rotation
    b. Cook book – recipe for cover crops in corn-soybean rotation
    c. Cover Crops 101: maybe we need a curriculum or series of webinars
    d. Maybe a series of one pagers for simple cover crops for a state and rotation
    e. Maybe we need something like a Master Gardner coarse
    f. We have to get into the farmers mindset
        i. Incorporate cover crops into their system/machinery
        ii. Tailor to their rotation
        iii. Maybe train industry/coops/NRCS to provide assistance designing a system for them
        iv. Start small and simple and cheap – e.g. oats in fall
2. Some discussions of cover crop posters for coops or offices
3. Short Term and Long Term Values of cover crops
    a. Reasonable expectation of results – doesn't happen overnight
    b. There will be problems
    c. Don't oversell cover crops
    d. What is the farmer's tolerance for risk
    e. In long-term cover crops should stabilize risk and reduce variability

<u>Research Ideas</u>

1. Value of Cover Crops
    a. Need Ag Economists
    b. Farmer derived values
    c. Consider economic models
        i. Whole farm cost calculators like FINPAC
        ii. Environmental Services models
        iii. Risk management models
    d. Quantify values of erosion prevention
    e. Quantify value of soil organic matter
    f. Quantify value of nutrient recycling
    g. Quantify value of water holding capacity and rooting depth
    h. Quantify yield stability or yield in "bad" years
    i. Quantify yield increase over long-term – soil productivity increase
    j. Quantify value of cover crops to general public – water and air quality, wildlife
2. Increase in yields or stability of yields over time
    a. Long-term plots
    b. Rooting depth
    c. Water holding capacity

    d. Potential mineralization
    e. Soil organic matter
3. Modeling
    a. Ag Systems models – process oriented models
    b. Need better cover crop growth models or components
        i. Current models focused on mature plant biomass and yield and don't predict vegetative growth well
        ii. Overwintering plants are difficult to model
        iii. Rooting depth and N uptake
    c. Models for predicting/analyzing soil health and soil processes with cover crops
4. Cover crop genetics
    a. Breeding
    b. Selection from existing genotypes
    c. Cover crops more susceptible to contact herbicides
    d. Cover crops with different maturities/development/flowering
    e. Cover crops with faster fall growth
    f. Cover crops with better winter hardiness
    g. Fast growing cool season legumes
    h. Mention of NRCS Elsberry Plant Center
        i. Measuring plant characteristics like canopy cover and growth for RUSLE2
5. Phosphorus
    a. Radish and phosphorus
    b. Response of different species
    c. How do cover crops affect runoff and infiltration
    d. How do cover crops affect soluble phosphorus
    e. Cover crops and manure

6. Nitrogen
    a. Cover crops and N release
    b. N release over multiple years
    c. Potential N mineralization
    d. Relationship to C storage
    e. Leaching losses with cover crops
        i. Timing of establishment and kill
        ii. Manure
        iii. Rooting depth
        iv. Biomass
        v. N content of biomass
7. Water Quality
    a. Nitrogen
    b. Phosphorus
    c. Sediment

8. Soil Health/Quality/Productivity
    a. Soil organic matter/C – hard to measure changes
    b. Earthworms
    c. Microorganisms
    d. Nematodes etc
    e. Potential mineralization
    f. Compaction
    g. Rooting depth
    h. Infiltration/water holding capacity
9. How do we seed cover crops more reliably before harvest?
    a. Seed treatments
    b. Machinery/aerial
    c. Selection of species
    d. Timing – near maturity or near layby or cultivation
    e. Decision aide
10. How do we get cover crops successfully incorporated into corn/soybean rotations?
    a. Seeding before or after harvest
    b. Machinery to overseed
    c. Machinery to get it in ground before harvest
    d. Herbicides before cover crops
    e. Killing cover crops early with herbicides
    f. Other means of killing cover crops
    g. Seed treatments
    h. Shade and traffic tolerant cover crops – tetraploid Italian ryegrass
    i. Reduced risk to yield of corn and soybean
    j. Using shorter season corn and soybean genotypes
11. IPM and Cover crops
    a. Help or hurt
    b. Insects/diseases/weeds/nematodes/rodents
12. Measure change in cover crop adoption
    a. Question(s) in Ag Census – Ryan Stockwell says there will be one
    b. Yearly cover crop data from NASS state surveys
    c. Use satellite pictures/data to quantify cover crop use
    d. Surveys/questionnaires

Input for NIFA/AFRI programs—Research, Extension, and Education

Cover Crops

The Midwest Cover Crops Council (www.mccc.msu.edu) held its annual meeting Feb. 28- March 1, 2012 in West Lafayette, Indiana. Over 200 people attended all or part of the 3-day meeting. A wide variety of stakeholders participated including producers, seed industry, Extension, NRCS, National Wildlife Fed'n, state agencies, and researchers. Input was gathered on research and outreach needs of the stakeholders through listening and discussion sessions and through forms asking for their ideas. The large amount of input is briefly summarized below. **A more complete version of the meeting responses will be in the meeting "Proceedings" to be available in late April on the website listed above.**

Research grant size

The multi-state research/Extension group encourages grants in the $2-5million range. The large $20million CAPs are too large for much of the needed work, are more difficult to operate, and too narrowly focus the limited resources available (ie cut out too many good researchers and ideas). But the $500,000 foundational grants are too small to do the true multi-state work that is needed for things like cover crops. The group strongly encourages grants in the $2-5million range, for integrated (research/Extension or research/education) and multi-state projects.

Research needs—Regionally appropriate!

(Note—although cover crops are widely used in the south and southeast, there are challenges to using them on a large scale in the Midwest. Research is needed specifically to address cover crops across the vast acreages of corn and soybeans in this region, with its soils, climate, and cropping systems.)

1. **Quantify effects of cover crops on soil health, crop productivity and yield stability, resilience of system to climate variation, and water quality over the longer term (3-5+ yrs). Benefits are not expected in one or two years in many cases.**
2. **Quantify the economic value of cover crops, explicitly including the longer-term benefits of soil health (water holding capacity, organic matter, nutrient cycling, rooting depth), resilience to climate stresses, and potential reduction in yield risk over the long term. This requires some of the physical data that needs to be obtained in item #1. Include private benefits to the producer and public benefits of improved water and air quality, wildlife benefits, etc.**
3. Improve crop and soil models to include specific cover crops and their effects on soil properties over the long term. This again presupposes work done in #1.
4. Develop cover crop selection and breeding programs to produce cover crops that meet more specific needs, including faster fall growth, better winter hardiness, different rooting structures, different maturities, and greater or lesser susceptibility to herbicides.
5. Quantify nutrient cycling (uptake, fixation, release) by different cover crops, particularly in systems with longer-term use of cover crops.
6. Determine the impacts of different cover crops within IPM context, for their potential positive or negative effects on insects, diseases, weeds, nematodes, and rodents.
7. Develop and evaluate novel methods to integrate cover crops into corn-soybean systems, including new seeding methods and timing, selection of species, seed treatments, machinery, shade or traffic tolerant species.

Extension/outreach needs

A range of programs, products, and media were suggested, including videos, webinars, field days and demonstrations, on-farm demonstrations, Extension meetings, train-the-trainer sessions, fact sheets, posters, articles in newsletters and the farm press, and continued development of the MCCC website.

Topics to be included in the various programs or materials listed above, included many of the same things discussed under research needs (ie many of the questions from stakeholders are not currently able to be answered), but also included things that are known and need to be made more accessible. Topics included:

1. How to get started in cover crops (Cover Crops 101)—selection, seeding, terminating.
2. Economics of cover crops, sample spreadsheets
3. Videos of seeding methods with discussion
4. Simple "recipes" for cover crops in specific cropping systems, for the novice
5. Further refinement of the cover crop selector tool, to include mixes
6. Education of landlords and land managers, about the importance of cover crops
7. Information and fact sheets to help convince producers to use cover crops
8. Long term soil health improvement and yield stability or increase
9. Managing cover crops for nutrient cycling
10. Managing cover crops for IPM

Comments submitted by Eileen Kladivko (Purdue University) and Tom Kaspar (ARS, Ames, IA) on behalf of the Midwest Cover Crops Council, April 16, 2012.

Cover crops could potentially fit in a number of different AFRI programs, although none are particularly obvious. In other words, the main priorities of these programs would not in the past have provided any real opportunity for cover crop research.

- Foundational Program—Agriculture systems and technology
- Challenge Area—Climate variability and change
- Foundational Program—Renewable energy, natural resources, and environment
- Foundational Program—Plant health and production and plant products.

Midwest Cover Crops Council
State/Province Report for February 28--29, 2012 Meeting in West Lafayette, Indiana

State/Province Name: **Indiana**

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Research
A number of new research projects have been started in the last two years. New studies by Dr. Eileen Kladivko and graduate students include:

1. Nitrogen cycling with oilseed radish cover crop in corn-soybean rotations in Indiana. (graduate student Kaylissa Horton). The objectives of this study are to evaluate the effect of oilseed radish alone vs. oilseed radish mixed with oats or cereal rye, on nitrogen uptake in the fall and subsequent release the following spring/summer in a field growing corn. The impact of the treatments on soil penetration resistance will also be measured. (See poster at meeting).
2. Using bicultures to improve the management of sediment and phosphorus loss in oilseed radish cover crops (graduate student Jason Cavadini). The objectives of this study are to evaluate the effect of oilseed radish alone vs. oilseed radish mixed with oats or cereal rye, on phosphorus uptake in the fall and subsequent release the following spring/summer in a field growing corn. The impact of the treatments on erosion and P loss in runoff and sediment will be measured with rainfall simulation in spring. (See poster at meeting).
3. Slurry seeding of cover crops (graduate student Edwin Suarez). This project is part of a Conservation Innovation Grant led by Tim Harrigan at Michigan State. Purdue has conducted field trials with annual ryegrass and swine manure on three farmers' fields and with oilseed radish and swine manure on one farmer's field. Mini-plots at a research farm evaluated the effect on germination of time lag between slurry seeding and the first rainfall. Growth chamber studies evaluated seed germination as affected by time of exposure and manure strength and salinity levels. (See poster at meeting).
4. Cover crops for organic tomato production (graduate student Jessica Garvert). This is a new project on organic agriculture led by Dr. Kevin Gibson, a weed scientist in the Dept. of Botany and Plant Pathology. It includes eight faculty and six students across five departments. Our part is to evaluate cover crops for improving soil quality and to provide nitrogen to the crop. Red clover is the main legume used in the project so far, for N contributions. The new cover crop trial portion of the project began in fall 2011 and includes legumes of winter pea and hairy vetch, and non-legumes of mustard and rye. (See poster at meeting).
5. Corn Systems Coordinate Agricultural Project (CSCAP)—We are part of a large regional project on corn systems and climate, led by Dr. Lois Wright Morton at Iowa State. The project includes 10 states and over 40 principal investigators. Cover crops are one of the practices being studied by about six of those states. The objectives are to determine the effect of rye cover vs. no cover, in both corn and soybeans, on the resilience of the

system to climate stresses. This includes measurements of soil moisture content, soil quality measures, soil nitrate in fall and spring, and crop growth and yield. Rye was chosen as the cover crop because it was the most widely adaptable across the whole region in the project. Some states (like us) are also doing smaller studies with other cover crops, such as radishes (see #1 and 2 described above). Some evaluation of disease and insect pressure will be done starting in 2012 (for diseases it will be Dr. Kiersten Wise, Dept. of Botany and Plant Pathology, kawise@purdue.edu)

6. Cover crop growth and N uptake. We sampled various cover crops for biomass and N content on several farmer fields or demonstration plots, as initial information (not replicated) around the state.
7. Oilseed radish growth as affected by soil and plant density. A greenhouse experiment was conducted with 3 radish varieties at two plant densities and two soil bulk densities, to measure overall growth, tuber size, root and shoot biomass, and N content. (graduate student Mohammad Amini, thesis finished May 2011)

New work by Dr. Keith Johnson, Dept. of Agronomy (johnsonk@purdue.edu)

8. Utilizing cover crops and summer annuals as double cropped forages following wheat (graduate student John McMillan). The objective of this study is to determine the suitability and forage quality of ten crop species at varying nitrogen application rates. The crops that are being investigated are; grain amaranth, BMR sorghum sudangrass, pearl millet, teff, foxtail millet, oat, chickling vetch, forage turnip, and oilseed radish.

New work by Dr. Lori Hoagland, Dept. of Horticulture (lhoaglan@purdue.edu)

9. Developing best management strategies for organic hop production – We are evaluating different cover crop species and cover crop management practices in organic hopyards in WA and MI to determine their potential to improve soil health and provide supplemental nitrogen. Other collaborators on the project are evaluating whether these can suppress weeds and provide habitat for beneficial impacts.
10. Evaluating fall planted cover crops in organic tomato systems – Project led by G. Kibson. Our role in this project is to evaluate impacts of cover crop species and tillage on soil microbial communities, and the interaction of these practices with select tomato varieties on early blight disease suppression. One of my new students (Brett) is specifically interested in evaluating impacts on mycorrhizal assemblages in bulk soil and in the rhizosphere. Matt will be evaluating impacts of a few of the treatments on nitrogen cycling communities and estimating greenhouse gas contributions.

Some long-term or always ongoing work continues:

11. Winter wheat cover crop used in tile drainage research project, where nitrate is measured in tile drainflow. Long-term (25+yrs) but no simultaneous comparison without cover crop. Could make more measurements related to N cycling, if regional collaboration.
12. Biomass crops, new and old work (Miscanthus, switchgrass)
13. Ongoing work on pest suppression (disease, nematode, weeds) and in vegetable production (Dept. of Botany and Plant Pathology; Dept. of Horticulture)
14. Always ongoing work on forages for hay or grazing (Dr. Keith Johnson, Dept. of Agronomy, johnsonk@purdue.edu)

Extension/Education/Outreach/On-farm trials

There has been greatly increased interest in cover crops in Indiana over the past three years. All of the partners in the Indiana Conservation Partnership have seen the need for increased training and services related to cover crops. The Indiana Conservation Partnership includes NRCS, Soil and Water Conservation Districts (SWCD), Conservation Cropping Systems Initiative (CCSI), Indiana State Department of Agriculture (ISDA), State Soil Board, and Purdue Extension. Highlights of major activities are given here:

1. Purdue Extension worked with colleagues in the MCCC on two major Extension products—the Cover Crop Selector Tool (led by Dean Baas and Michigan State and on-line for about one year now) and the Cover Crop Pocket Guide (led by Purdue, in-press). The Indiana team for the Selector Tool included Fisher, Towery, Johnson, Robison, Swaim, and Kladivko. The Pocket Guide includes all interested MCCC states/provinces and is scheduled to be available by February 28, 2012 at the MCCC meeting.
2. Conservation Cropping Systems Initiative (CCSI)—this two year old initiative of the Conservation Partnership put two experienced people on the ground, for working with farmers interested in no-till, cover crops, and other conservation practices. (Hans Kok and Dan Towery). They work with SWCDs and NRCS to promote and educate. See website http://www.in.gov/isda/ccsi/ (also see brochure in Proceedings)
3. Jasper County SWCD Cover Crop Demonstration Program--2011. This was an excellent example of on-farm cover crop demonstrations, with 10 different farmers with over 2200 acres of cover crops. This demonstration program was led by Dan Perkins, Watershed and Conservation Program Specialist (www.jaspercountyswcd.org). (See program report in Proceedings). Other demonstration plots or on-farm trials occurred at various locations around the state. The on-farm trials are usually initiated by farmer interest but may be facilitated by NRCS, SWCD, Extension, or agronomic consultant. The small demonstration plots are usually initiated by the local SWCD.
4. Cover crop training (or "train the trainer") programs—An "Advanced Cover Crop Training" was held for NRCS and county Extension on Sept 6, 2011 at the Throckmorton Purdue Agricultural Center, attended by about 70 people. More trainings are planned for 2012, to help educate field staff of all the Partnership, about details related to cover crops, selection, management, and soil health.
5. New NRCS Soil Health Initiative—Indiana NRCS is the leader of a new focus of NRCS on soil health, officially announced in December 2011. Barry Fisher, State Agronomist (barry.fisher@in.usda.gov), is now the new State Soil Health Specialist. Many trainings of the new state Soil Health Team are planned for 2012, to include cover crops, no-till, and other conservation practices. The new initiative will also include participation by Extension and the rest of the Partnership along with NRCS. http://www.in.nrcs.usda.gov/news/
6. Field days and winter meetings. These are sometimes held at the field demonstration sites. Others are part of broader field days or extension meetings. Speakers are usually NRCS, Extension, or agronomic consultant, along with the farmer cooperator.
7. Participant in Great Lakes Restoration project that is targeting cover crops in Michigan, Ohio, and Indiana, by providing one-on-one technical assistance.
8. Discussion of cover crops as a way to reduce nitrate leaching to tile drains, is included as a standard part of Extension talks on tile drainage and water quality.

Communication/Policy

As part of the MCCC Executive Committee, we participated in discussions trying to resolve some serious issues with crop insurance related to cover corps. Partners with National Wildlife Federation, NRCS state and national leadership, and land grant universities worked with Risk Management Agency (RMA) to change their policy on cover crops, especially as it related to the very wet spring of 2011. The good news is that finally in December 2011 they changed the policy!

New Extension publications in 2011 (also see in Proceedings)

- Kladivko, E.J. 2011. Cover crops for modern cropping systems. http://www.ag.purdue.edu/agry/extension/Documents/CoverCropsOverview.pdf

- Kladivko, E.J. 2011. Cover crops for nitrogen management. http://www.ag.purdue.edu/agry/extension/Documents/CoverCropsNitrogen.pdf

- Kladivko, E.J., and B. Fisher. 2011. Cover crops for prevented planting acres. http://www.ag.purdue.edu/agry/extension/Documents/PreventedPlantingCovers.pdf

Impacts

- Increased knowledge about cover crops and their benefits to soil and water quality, among farmers, county Extension, field NRCS staff, county SWCD, and others
- Increased knowledge about how to select cover crops appropriate for specific situations and how to establish and manage them as part of a cropping system
- Increased numbers of farmers trying cover crops, as witnessed by requests for help and advice
- Increased numbers of acres of cover crops in Indiana (hard to document—need to discuss as a group, some possible approaches)
- CCSI has participated in or organized over 155 educational events (field days, winter meetings, etc.) and reached over 10,000 Indiana farmers since their inception in September 2009. In addition, they have consulted one-on-one with over 150 farmers.

State/Province Report: Ontario, Canada

During 2011 there was sharp growth in interest in cover crops. Much of the interest revolved around "Tillage Radish" and other daikon style oilseed radish. There was also significant interest in the use of biofumigant cover crops to reduce soil borne pests and disease in vegetable crops. Traditional chemical fumigants are under regulation and environmental pressure. Growers are looking for alternatives.
Request for cover crop talks by growers and ag industry personnel has also increased. More than 30 extension, scientific and policy presentations on cover crops have been made by members of the Soil Team and associated researchers.

In 2011- 2012 cover crops were profiled at a number of venues including:

- Plots tours: Assessing biofumigant cover crops: practicality, effectiveness, impact on soil health (attendance 30)
- Vegetable Open House, University of Guelph, Ridgetown Campus (attendance – 80)
- Cover Crop Open House/plot tour – University of Guelph, Ridgetown Campus (attendance 75)
- Southwest Agricultural Conference - University of Guelph, Ridgetown (attendance 1600)
- Sound Advice – Radio report/podcast, part of CFCO Farm show (listeners – 13,000)

Project	Lead
1. Impact of Cover Crops on Processing Tomato: Yield, Quality, Pest Pressure, Soil Health, and Economics. 2. Underseeding cover crops to maximize biomass and ground cover in seed corn. 3. Filling in the knowledge gaps of N dynamics in horticultural-cover crop systems: Utilizing lysimeters. Cucumber rotation 4. Bringing cover crop decision-making tools and knowledge to Ontario growers and agribusiness personnel. Includes: - innovative grower profiles - website development - survey of students and agribusiness - cover crop meeting 5. IWM Vegetable Working Group – Adapting the MCCC Cover Crop Decision Tool for Vegetable Production Systems across Eastern Canada (under development and review)	Dr. Laura Van Eerd, University of Guelph, Ridgetown Campus lvaneerd@ridgetownc.uoguelph.ca
Cover Crop Herbicide Study: Replicated multiple year project to determine the following specific outcomes: 1) determine how soil water holding capacity, nutrient uptake	Dr. Darren Robinson, University of Guelph, Ridgetown Campus

and organic matter production of non-leguminous species (i.e. annual rye, wheat, oat, ryegrass, sorghum-sudangrass, buckwheat, oilseed radish) are affected by residual herbicides (ie. Broadstrike RC, Callisto, Classic, Command, Converge, Kixor, Integrity, Primextra II Magnum, Prism, Pursuit, and Valtera) applied the previous year, and 2) determine the effect of application of the above residual herbicides on the establishment, biomass and organic matter production of the above non-leguminous cover crops.	drobinson@ridgetownc.uoguelph.ca
http://www.plant.uoguelph.ca/research/agronomy/research/ Identifying and Correcting Causes of Uneven Red Clover Stands Underseeded to Winter Wheat Use of cover crops to alleviate negative effects of biomass removal for bioenergy: Cover crop establishment in soybean intensive rotations	Dr. Bill Deen, University of Guelph bdeen@uoguelph.ca
Evaluation of zone tillage and cover crops as weed management practices in field vegetables. – literature review Factsheet: http://www4.agr.gc.ca/resources/prod/doc/pmc/pdf/1304452312132_eng.pdf	National Reduced Risk IWM Vegetable Working Group – Kristen Callow, OMAFRA kristen.callow@ontario.ca
Assessing biofumigant cover crops: practicality, effectiveness, impact on soil health (final year)	Anne Verhallen, OMAFRA anne.verhallen@ontario.ca
Cover Crops and Reduced Tillage – proposed to GFO 2012	Greg Stewart, OMAFRA greg.stewart1@ontario.ca

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Ontario

UNIVERSITY of GUELPH
RIDGETOWN CAMPUS

2011 State Report on Cover Crop Activities and Research in Iowa
Primary Contact: Tom Kaspar, USDA-ARS-NLAE, (tom.kaspar@ars.usda.gov)

Effectiveness of Oat and Rye Cover Crops in Reducing Nitrate Losses in Drainage Water

T.C. Kaspar (tom.kaspar@ars.usda.gov), D.B. Jaynes, T.B. Parkin, T.B. Moorman, and J.W. Singer

Much of the NO_3 in the riverine waters of the upper Mississippi River basin in the United States originates from agricultural land used for corn (*Zea mays* L.) and soybean (*Glycine max* [L.] Merr.) production. Cover crops grown between maturity and planting of these crops are one approach for reducing losses of NO_3. In this experiment, we evaluated the effectiveness of oat (*Avena sativa* L.) and rye (*Secale cereale* L.) cover crops in reducing NO_3 concentrations and loads in subsurface drainage water. The oat fall cover crop was broadcast seeded into living corn and soybean crops before harvest in late Aug. or early Sept. and was killed by cold temperatures in late Nov. or early Dec. The rye winter cover crop, which had already been used annually for four years, was planted with a grain drill after corn and soybean harvest, overwintered, grew again in the spring, and was killed with herbicides before main crop planting. These treatments were evaluated in subsurface-drained field plots with an automated system for measuring drainage flow and collecting proportional samples for analysis of NO_3 concentrations from each plot. The rye winter cover crop significantly reduced drainage water NO_3 concentrations by 48% over five years, but this was less than the 58% reduction observed in its first four years of use. The oat fall cover crop reduced NO_3 concentrations by 26% or about half of the reduction of the rye cover crop. Neither cover crop significantly reduced cumulative drainage or nitrate loads because of variability in cumulative annual drainage among plots. Both oat and rye cover crops are viable management options for significantly reducing NO_3 losses to surface waters from agricultural drainage systems used for corn and soybean production.

Rye Cover Crop Effects on Soil Properties in No-Till Corn Silage / Soybean Agroecosystems

E. B. Moore, T.C. Kaspar (tom.kaspar@ars.usda.gov), and M. Wiedenhoeft

Farmers in the U.S. Corn Belt are showing increasing interest in winter cover crops. Cover crops are known to reduce nitrate leaching, soil erosion, and weed germination, but evidence of improvements in soil productivity would provide further impetus to use cover crops. On the high organic matter soils that are typical of central Iowa it is often difficult to show an increase in soil carbon with cover crops. Therefore, the objective of this experiment was to determine the effects of a rye (*Secale cereale* L.) winter cover crop on particulate organic matter, potential nitrogen mineralization, and total organic carbon in a no-till corn silage/soybean rotation in central Iowa. One reason for using a rotation with corn silage is that without the large input of corn residues it may be easier to measure the effect of the cover crop. Soil properties were measured on four treatments and at two depths, 0-5cm and 5-10cm. Treatments included no rye (control), rye following soybean [*Glycine max* (L.) Merr.], rye following corn silage (*Zea mays* L.), and rye following both soybean and corn silage. Plots were established in 2001 and results from 2010 are presented. A rye cover crop increased total soil organic matter and particulate organic matter, particularly in the top 5cm of soil. There was not a significant difference among treatments for nitrogen mineralization potential following a soybean crop, however there was a significant difference when a rye cover crop followed corn silage. This may be due to the fact that rye has an earlier establishment window in fields that are harvested for silage, giving the rye more time to grow and add more organic matter to the soil. On average, a rye cover crop following corn silage produced 2.78 Mg/ha of shoot dry weight compared with 0.51 Mg/ha for rye planted following soybean harvest.

Iowa Farm Poll and Rural Life Poll Questions about Cover Crops Report Summary

Jay Arbuckle, arbuckle@iastate.edu

Arbuckle, J. Gordon Jr. and John Ferrell. (in revision). "Attitudes Toward Cover Crops in Iowa: Benefits and Barriers." Extension Report PMR----. Ames, IA: Iowa State University Extension.

This report presents analysis of data on attitudes toward and use of cover crops collected through the 2010 Iowa Farm and Rural Life Poll. Areas of inquiry included perceptions regarding potential agroecological benefits, barriers to use, and interest in learning more about cover crops. Results show that most Iowa farmers believe that cover crops can lead to improved productivity and reductions in soil erosion and nutrient loss. Assessment of potential barriers to cover crop use indicated that climatic factors, in particular lack of time between harvest and winter, are viewed as major impediments. In addition, most farmers cite lack of knowledge and necessary equipment as barriers. Comparisons between different groups of farmers showed that larger-scale farmers and farmers who plant corn and/or soybeans tend to have less favorable attitudes toward cover crops, while those with greater knowledge and previous experience with cover crops have more favorable attitudes. Results suggest that more awareness and knowledge-building efforts are necessary, both with farmers and the agricultural networks that support them (i.e., crop advisers, input suppliers). In addition, continued innovation in cover crops management, especially as related to climate-related barriers, will be important if cover crops are to achieve widespread use.

Nitrogen Fertilization of Corn Grown with a Cover Crop

John Sawyer, professor, jsawyer@iastate.edu
Jose Pantoja, graduate assistant
Daniel Barker, assistant scientist
Department of Agronomy Iowa State University

Introduction

Objectives of this project are to study corn nitrogen (N) fertilization requirement and corn-soybean yield response when grown in a rye cover cropping system. Multiple rates of N fertilizer are applied, with measurement of corn yield response to applied N and soybean yield with and without a fall planted winter rye cover crop. The study is being conducted at multiple research farms, with the intent for comparison of with and without a cover crop system across varying soil and climatic conditions in Iowa.

Materials and Methods

The first year was in 2009, with 2011 the third year. Locations are the Ag Engineering/ Agronomy Research Farm, Ames (Webster silty clay loam); Armstrong Research Farm, Lewis (Marshall silty clay loam); Southeast Research Farm, Crawfordsville (Mahaska silty clay loam); and the Northeast Research Farm, Nashua (Floyd loam). In 2011 an additional site was added at the Northwest Research Farm, Sutherland (Primghar silty clay loam). Each location is in a corn-soybean rotation. The winter rye cover crop ("Wheeler" variety) was no-till drill planted at 1 bu/acre in the fall of 2010 as soon as possible after soybean and corn harvest (Sept. 30-Oct. 7 after soybean and Sept. 17-Oct. 7 after corn). The rye cover crop growth was controlled with Roundup in the spring (Apr. 20-May 2 before corn and May 5-18 before soybean), with the targeted control at least seven days prior to corn planting and at or within one week of soybean planting. The corn and soybean crops were no-till planted in 30-inch rows (May 3-12 for corn and May 6-18 for soybean). Rye control and corn-soybean planting occurred as conditions allowed. Nitrogen fertilizer rates were applied early sidedress as urea-ammonium nitrate (UAN) solution (0, 40, 80, 120, 160, and 200 lb N/acre). The UAN was coulter-injected on 60- inch spacing. The corn hybrid and soybean variety were early season adapted for the location. Pest management practices were those typical for the region and rotations. Corn and soybean were harvested with a plot combine and yields corrected to standard moisture.

Results and Discussion

Rye growth and aboveground biomass production varied between years and sites due to differences in previous crop and spring conditions. In 2011, the rye biomass production was generally low and greater before the soybean planting (Table 1). At each location there was no difference in soybean yield with or without the cover crop (Table 2); average yield 59.0 bu/acre with and 59.5 bu/acre without the rye. This has been consistent across years. Across locations in 2011, corn yield at the maximum N response rate averaged 5 bu/acre lower when planted in conjunction with the rye cover crop (Table 3). The largest differences in yields were at Crawfordsville and Nashua. In 2010 the average corn yield was 20 bu/acre lower with the cover crop and in 2009 was 7 bu/acre lower. The rye cover crop has not resulted in a corn yield increase at any site and year. Across all sites and years, the response to N rate was similar with or without the rye cover crop (Figure 1). The average yield at the economic optimum N rate was 12 bu/acre lower with the rye cover crop (183 bu/acre with and 195 bu/acre without), but the difference in economic optimum N rate was only 6 lb N/acre higher with the cover crop (164 vs. 158 lb N/acre). With these three years of study, there was no effect of the rye cover crop on soybean yield, no effect on economic optimum N rate for corn, but a corn yield reduction of 6%.

Acknowledgments

Appreciation is extended to the farm superintendents and their staff for assistance with this project. This project is supported in part by the Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation, through funds appropriated by the Iowa General Assembly. This research is part of a regional collaborative project supported by the USDA-NIFA, Award No. 2011-68002-30190, "Cropping Systems Coordinated Agricultural Project (CAP): Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems." Project Web site: sustainablecorn.org.

Figure 1. Corn yield response to N rate across locations with and without rye cover crop, 2009-2011.

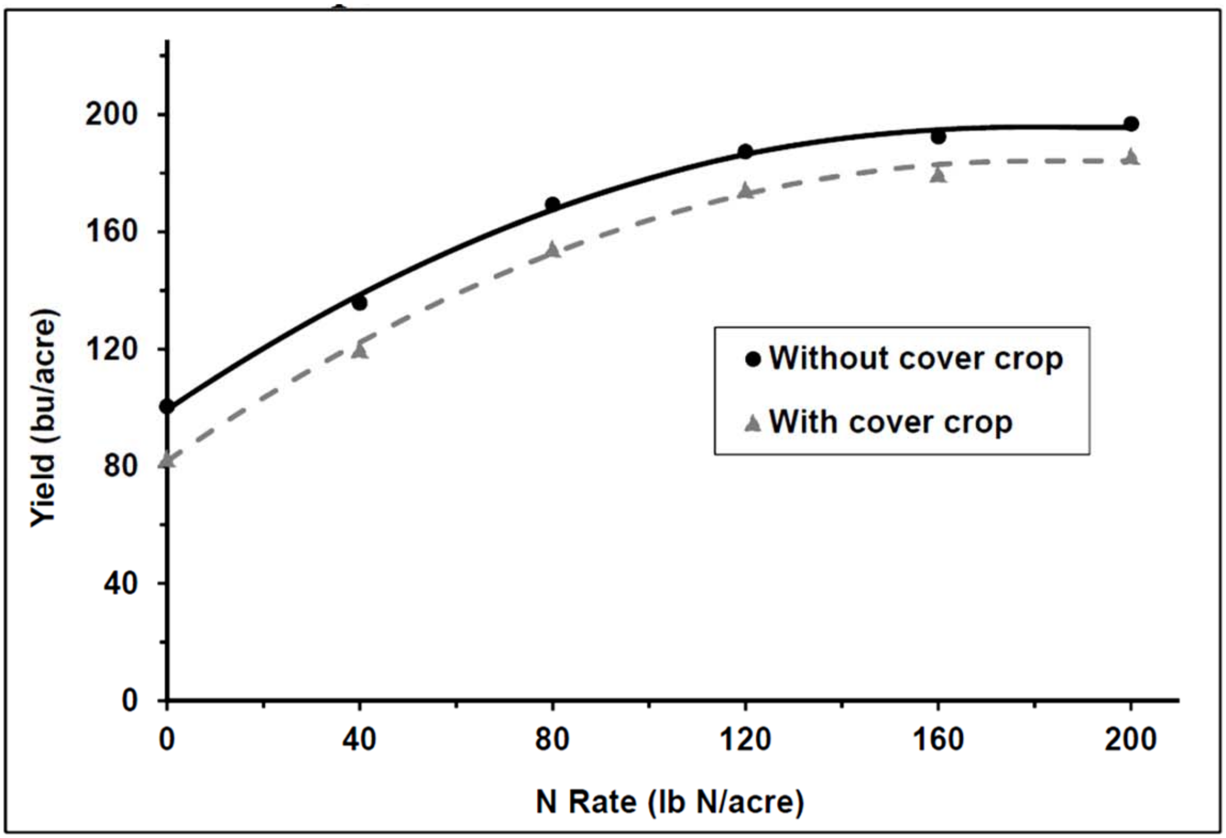

Table 1. Winter rye biomass dry matter before controlling growth with herbicide, spring 2011.

Cover Crop	Ames	Crawfordsville	Lewis	Nashua	Sutherland
	---------- lb/acre ----------				
Before corn	550	1,200	380	245	210
Before soybean	640	1,510	555	320	210

Table 2. Soybean grain yield with and without rye cover crop, 2011.

Cover Crop	Ames	Crawfordsville	Lewis	Nashua	Sutherland
	---------- bu/acre ----------				
With cover crop	56.5a	49.4a	66.9a	61.5a	60.6a
Without cover crop	55.7a	53.8a	66.0a	62.0a	60.1a

Yields at a location followed by the same letter are not significantly different. $p \leq 0.05$.

Table 3. Corn grain yield at the maximum N rate response with and without rye cover crop, 2011.

Cover Crop	Ames	Crawfordsville	Lewis	Nashua	Sutherland
	---------- bu/acre ----------				
With cover crop	191	179	172	196	208
Without cover crop	193	190	169	207	209

Yields at the point of maximum N response for each location determined from regression equations.

Iowa Learning Farms and Practical Farmers of Iowa – Cover Crop Field Days and Workshops

John Lundvall, jlundval@iastate.edu and Sarah Carlson sarah@practicalfarmers.org

Iowa Learning Farms and Practical Farmers of Iowa held 10 cover crop workshops and field days across Iowa in 2011, which were attended by 414 people. These field days are supported by the Leopold Center and the Iowa Department of Agriculture and Land Stewardship. Presenters at these workshops and field days normally included farmers, NRCS personnel, Iowa State agronomists, and scientist s from USDA-ARS. Iowa Learning Farms also developed an extension publication on Cover Crops and a "how-to" video on DVD titled "Adding a Cover Crop to a Corn-Soybean System".

Practical Farmers of Iowa 2011 Cover Crop Activities

Sarah Carlson sarah@practicalfarmers.org

PFI did most of this work in partnership with ILF and Rural Advantage (MN) with funding from IDALS, Leopold Center, Walton Family Foundation, and SARE.

On-Farm Research and Demonstration

Spring Biomass sampling on 25 farms. We have collected 2010 fall planting date data, spring 2011 kill method, sampling date, planting rate, planting method, species planted and dry biomass-lbs/A from 25 different farms around Iowa. All samples were ground during the summer and have been sent to the National Laboratory for Agriculture and the Environment Lab for total carbon and total nitrogen measurements. We will be combining this season's data with previous data collected over the past three years to run analysis using the growing degree days available for each area of the state where samples were collected and determine which planting method, rate, species and date provide us with the most spring biomass.

Late Spring Soil Nitrate Test on 3 farms following winter rye cover crop. We collected soil samples on three farms that had a winter rye cover crop and sent those samples for Late Spring Soil Nitrate testing at Iowa State University. On two farms we also sampled nearby strips with no cover crops. A winter rye cover crop can reduce the amount of nitrogen in the soil horizon.

- Across Bill Buman's farm, significantly high levels of nitrogen were present in the soil. The cover crop was able to reduce the abundance by 48lbs/N.
- On George Schaefer's farm, 88lbs-N/A of additional N was recommended where corn followed cover crops compared to 32lbs-N/A additional on the no cover strips.
- Paul Ackley's test recommended an additional 96lbs-N/A where corn followed cover crops. Paul split his corn field into either plots: 4 with an additional 60lbs-N/A applied as side-dress versus 4 plots with no additional nitrogen. He will take corn yield data this fall.

Mow-killing cover crops to control weeds in soybeans. Aaron Lehman near Des Moines in the spring of 2011 tilled under a winter rye cover crop and planted soybeans. In addition, he waited two weeks and then mowed, killing a cover crop at "boot" stage and planting soybeans into the mulch. A month later Aaron noticed considerably fewer weeds in the mow-killed soybean area of his field as compared to the tilled area.

Alternative cover crop varieties. Fred Abels and Earl Hafner both tried over-seeding an annual ryegrass cover crop using a plane. Both Earl and Fred say that the annual ryegrass they flew on is already up. We will monitor these sites to see how well the annual ryegrass will over-winter in Iowa. Steve Cassabaum and Gary Guthrie over-seeded or seeded following cash crop harvest two annual ryegrass varieties to increase the number of locations we are able to test the over-wintering and biomass potential of this cover crop species. A winter coverage rating of the annual ryegrass has been taken.

Cover crop silage and corn silage for livestock. Gary Lien harvested corn silage yields on three plots: One with no cover crop, one with a winter rye cover crop and one with a winter triticale cover crop to determine cover crop effect on corn silage yield, relative feed value of the cover crop silage and dry biomass production of the cover crop.

Aerial seeding versus drilled cover crop. Steve McGrew finished a cover crop project that compared seeding method of a cover crop mix of hairy vetch, rapeseed and cover crop radish. An attached article featuring Steve was published in the PFI Newsletter and also re-published in Wallace's Farmer August issue.

Cover Crop Variety Testing

In the fall of 2010, we planted 19 different cover crops to determine their ability to over-winter in Iowa when planted following soybean harvest in central Iowa. Over-wintering data was analyzed and reported in the PFI Newsletter article below. This report was also published in the July issue of Wallace's Farmer. Of the cover crops that over-wintered after taking a spring biomass sample prior to a typical corn planting date on half of our plots, we then let the plants go to grain harvest. On July 14, 2011, we harvested grain from Hard red winter wheat (Red fife, Arapahoe, Expedition and Overland); Soft red winter wheat (Wesley, Excel 44 and Kaskaskia); Winter rye (Elbon, Maton, Wheeler and VNS); Winter triticale (Fridge); and Winter barley (P954, P919, Tambar 501 and Pennbar 66). The cover crop radish and the winter lentil did overwinter. Those samples were sent to the ISU Seed Science Center Experiment Station, where these samples have been used for students to learn how to use cleaning equipment. Alan Gaul, the director of the lab, was excited to partner with us because his lab has a difficult time working with alternative crops to corn and soybeans. Our seeds were used as demonstrations during several summer workshops that seed industry, end-users and custom grain cleaning businesses attended. Our next steps are to finish cleaning the seed that was harvested, and to analyze the yield data and run the samples through an NIR machine to determine the protein, oil and starch content of the grains. Finally we will conduct kitchen tests in time for one of our two big winter meetings: the Annual Conference or the Cooperators Meeting.

On September 19, 20 and 22, 2011 we over-seeded into standing corn and soybeans 54 different legumes, brassicas and small grains to build on our over-wintering cover crop study from fall 2010 to spring 2011. Some of the seeds we planted were from seed we harvested in July to see how well farmers can save seed from a cover crop seeding and re-plan that seed. In addition we planted 21 new varieties, including annual ryegrass, hairy vetch, crimson clover, cowpeas, medics, mustards, radishes, experimental legumes, winter peas and berseem clovers. We also planted spring wheat and oats. We will again measure the fall stands of these cover crops prior to snowfall around December 1, 2011, and take the same data next spring as the previous study. We hope to see better over-wintering capabilities of other cover crops by planting about one month earlier than last year's seeding.

Next Generation Experiment with Cover Crops

PFI worked with the Wright and Hamilton County MRBI watershed coordinator to secure two FFA's to establish cover crops on their school's farmground. Clarion-Goldfield HS FFA coordinated the flying on of a winter rye cover crop into standing cash crops on August 25, 2011, during the Clarion Coop's annual FFA field day at the FFA farm. About 50 parents and students attended the field day. Webster City FFA will be drilling their winter cover crop following grain harvest this fall. Also a PFI member from Carroll County helped us contact the Carroll HS FFA and PFI staffer Sarah Carlson presented at their fall field day. 45 parents and students attended the field day to learn about cover crops and the plans the students have for trying out cover crops on the farmground. Carroll, IA is very close to Templeton, IA the locally famous distillery of Templeton Rye. The students came up with the idea to let some of the rye go to be harvested for grain that would be tested at the Templeton Rye distillery.

In addition we are helping the Iowa Learning Farms work with four other FFA chapters who are interested in establishing cover crops this fall.

Developing Better "Cover Crop" Markets (farm to bakery development)

The headquarters of Great Harvest Bread Company in Dillon, Montana, test baked two samples of hard red spring wheat from Iowa farmers and gave us feedback. One of the samples scored 75 out of 100 points on their test bake procedure. The protein on this wheat was 13.7% and the test weight was 56.7lbs. Their bake test consists of a score on volume, texture, taste, absorption, and also some other minor things. They commented, "Usually the main characteristic that wheat will fall short in is volume. When milling the whole wheat berry, the bran in the flour tends to reduce the size of the loaf if the wheat gluten is not strong enough to support it. Sometimes if a loaf gets too big, the texture of the loaf will become open and lacey and will fall apart." The other sample scored 88 out of 100 points on the same test. This one scored better, but was still less than 90 points, which is the minimum score they accept. They did not take specs for protein and test weights on this second sample because of the way it baked. While the volume of wheat was better for this sample, the texture was too open. Here is their comment: "Open texture is when the cell structure has too many holes to support the weight of the bread. Basically it will sink in the middle and jam/honey will run through the holes. Sourdough has an open cell structure. We need a nice even cell structure that is not too open as well as not dense. If you have a dense cell structure, usually you will have small loaves of bread. Open texture can depend on variety or crop year conditions. Wheat lots that have good volume are more likely to have an open cell structure because of good oven spring. So it is a balance between very active wheat that has good volume but has a nice even cell structure. The only way we can test this is by actually baking the wheat itself. That is why it so important for our wheat lots to stay identity preserved."

Great Harvest told us that no wheat from outside of Montana has passed their bake test in the past. However, they've been finding it interesting to see the quality of Iowa grown wheat that we've sent and have agreed to continue test baking our samples as they get cleaned.

While we continue to send 25 lbs of each sample to Great Harvest, we will also conduct a small batch bake test in a home kitchen. We will display the different types of small grains and samples of bread using different small grains to conduct an informal tasting at one of our winter meetings to increase awareness on Iowa grown small grains among both our famer and non-farmer members.

Finally, we have put together the resource guide for growing and marketing small grains, which include the list of cleaners and millers in Iowa, seed houses to buy small grains seeds, as well as publications which discuss marketing locally grown small grains. The guide will soon be finalized, posted on our website, and the distributed at our events.

Cover Crop Hotline & Business Directory
PFI staff had steady phone calls and emails following spring planting from farmers, NRCS agency personal, ISU Extension Agronomists and field staff. On average PFI staffer Sarah Carlson receives 5-8 emails or phone calls a week from various non-PFI members asking about cover crop concerns.

PFI staffers updated our Cover Crop Business Directory and made it available online. We have given more than 300 farmers and resource personal our business directory during events since April 2011. We have begun to be contacted by aerial applicators and seed companies wanting to be listed on the directory.

In addition we have provided a CD of Adding Cover Crops to a Corn and Soybean System, Cover Crop Business Directory and the SARE publication Managing Cover Crop Profitably to 303 farmers who requested the materials at field days this summer.

Conservation Districts of Iowa (CDI)
PFI Staffer Sarah Carlson, who is also an elected county commissioner in Story County, brought a resolution to the recent CDI conference to add cover crops to the State's cost share list that counties can use to encourage farmers to put in voluntary conservation and water-quality improving practices. The resolution passed with 70% of the vote of the more than 300 CDI commissioners present at the meeting.

Farmer-to-Farmer Networking (also mentioned in ILF report)
COVER CROPS total
06/01/2011 Rob Stout, Washington Co = 33 participants
06/17/2011 Jeff Joyce, Palo Alto Co = 56
07/20/2011 Dave and Gary Nelson, Webster Co = 52
08/25/2011 Clarion-Goldfield FFA=50
8/27/2011 Paul Mugge=15
8/30/2011 Kelly Tobin=50
09/20/2011 Carroll FFA=45

09/30/2011 Floyd Jansma=10
10/27/2011 Jeremy and Steve Gustafson=60

Articles:
Which small grains over-winter the best? (The Practical Farmer, Summer 2011) and Wallace's Farmer, July 2011.

Cover Crop Investigation (The Practical Farmer, Summer 2011) and Wallace's Farmer, August 2011.

Public News Service Stories:
More farmers deciding not to farm naked. May 13, 2011
http://www.publicnewsservice.org/index.php?/content/article/20072-2

Blogs
Cover Crop Business Directory announced http://practicalfarmers.org/blog/2011/cover-crop-business-directory

Tips for killing cover crops in spring http://wallacesfarmer.com/story.aspx/tips-for-killing-cover-crops-in-spring-9-48662 Also was posted on the PFI list serve.

June 1 West Chester Field Day http://practicalfarmers.org/blog/2011/june-1-west-chester-cover-crop-field-day

Cover Crop Field Day Spencer, IA http://practicalfarmers.org/blog/2011/cover-crop-field-day-spencer-ia

Special Funding for Cover Crops http://practicalfarmers.org/blog/2011/special-funding-available-for-winter-hardy-cover-crops

Storm Damage is Opportunity for Cover Crops http://wallacesfarmer.com/story.aspx/storm-damage-is-opportunity-for-cover-crops-9-51424 and on PFI's Blog

Flying on cover crops this fall? http://wallacesfarmer.com/story.aspx/flying-on-cover-crops-this-fall-9-53152 This article also went out to all NRCS field offices and was posted on PFI's list serve.

Cereal Rye Cover Crop Effect on Soybean Yield

Alan Sundermeier, Agriculture & Natural Resources Extension Educator
Jim Hoorman, Agriculture & Natural Resources Extension Educator

Objective

To evaluate effect of cereal rye cover crop on soybean yield.

Background

Cooperator:	O.A.R.D.C. NW Branch	Soil test:	
County:	Wood	Fertilizer:	none
Nearest Town:	Hoytville	Planting Date:	6-7-11
Drainage:	Tile, well-drained	Planting Rate:	180,000
Soil type:	Hoytville, clay	Row Width:	7.5 in.
Tillage:	notill	Herbicides:	Envive, 2,4-D, Honcho, Roundup weathermax
Previous Crop:	Corn		
Variety:	Pioneer 92M91	Harvest Date:	10-17-11

Methods

The entries were replicated ten times in a randomized complete block design. Plot size- 10 x 90 feet each entry. Harvest data was collected from the center rows.
On September 18, 2010 cereal rye cover crop was overseeded into corn at a rate of 1.5 bu/acre.
On May 9, 2011 these cover crop plots were killed with Envive, 2,4-D ester, Honcho spray.
Plots were planted with a drill no-till.

Results

Treatment	Yield bu/acre	Significance
Cereal Rye	68.4	A
No cover crop	65.6	B

LSD (.05) = 2.1

Summary

Using a cereal rye cover crop had a significant soybean yield increase when compared to no cover crop.

Per acre economics
Value of soybean yield increase:
    2.8 bu x $11.50 / bu (soybean price) = $ 32.20
Cost of cereal rye cover crop:
    1.5 bu x $ 10.00 / bu (seed cost) = $ 15.00
    Net return from cover crop = $ 17.20

Acknowledgement

The author expresses appreciation to the staff at the Ohio Ag Research & Development Center, Northwest Agricultural Research Station for assistance with this research, Matt Davis manager.

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Cover Crop x Nitrogen Rate Comparison

Alan Sundermeier, Agriculture & Natural Resources Extension Educator

Objective

To evaluate the effect of cover crop and nitrogen rate on corn yield.

Background

Cooperator:	O.A.R.D.C. NW Branch	Soil test:	
County:	Wood	Fertilizer:	see N rate below, no P or K
Nearest Town:	Hoytville	Planting Date:	6-7-11
Drainage:	Tile, well-drained	Planting Rate:	30,000
Soil type:	Hoytville, clay	Row Width:	30 in.
Tillage:	notill	Herbicides:	Lumax, Laddok, Honcho, AMS
Previous Crop:	wheat	Harvest Date:	11-4-11
Variety:	Beck 5354HXR		

Methods

The entries were replicated four times in a randomized complete block design. Plot size- 10 x 70 feet each entry. Harvest data was collected from the center 2 rows. All treatments received the same herbicide. All treatments were no-till planted. After 2010 wheat harvest, all plots had glyphosate applied to control volunteer wheat and weeds. On August 2, 2010 cover crops were planted. Cowpea was inoculated and drilled at 40 lbs/acre. Soybeans were drilled at 50 lb/acre. Soybean variety Pioneer PI93M42. A White splitter planter was used to plant inoculated winter pea at 30 lb/acre and oilseed radish at 4 lb/acre. Radish was placed in the rows where corn was planted the following spring, with the winter pea 15 inches over from the radish rows. All cover crops had good growth that covered soil canopy(at least 12 inch topgrowth). Cover crops were naturally killed by winter cold temperatures. Corn was no-till planted in all treatments. Nitrogen was sidedress applied at V6 stage on June 27, 2011 with liquid 28% injected.

Results

Treatment	Cover Crop	N-Rate	Corn Yield bu/acre
1	none	0	77.2 A
2	none	140	175.8 C
3	none	220	191.9 D
4	Radish/Winter Pea	0	91.7 B
5	Radish/Winter Pea	140	174.4 C
6	Cow Pea	0	82.0 AB
7	Cow Pea	140	173.4 C
8	Soybeans	0	78.0 A
9	Soybeans	140	175.7 C

LSD (.05) 12.9

Summary

With the 0 nitrogen rate, the Radish/Winter Pea (treatment 4) was significantly different from the no cover crop and the soybean cover crop with 0 nitrogen. One can conclude that the Radish/Winter Pea did add significant amounts of nitrogen to increase corn yields. The CowPea cover crop at 0 nitrogen had similar corn yield compared to Radish/Winter Pea with 0 nitrogen.

With 140 lb/acre nitrogen there was no significant difference between no cover crop versus any of the cover crops.

The 220 lb/acre nitrogen rate was significantly different from all other treatments with an average corn yield of 191.9 bu/acre. This shows that the 140 lb/acre nitrogen rate was not sufficient for maximum yield.

Soil quality improvements from using cover crops were not analyzed.

Acknowledgement

The author expresses appreciation to the staff at the Ohio Ag Research & Development Center, Northwest Agricultural Research Station for assistance with this research, Matt Davis manager.

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Winter Pea Cover Crop x Nitrogen Rate Comparison

Alan Sundermeier, Agriculture & Natural Resources Extension Educator
Jim Hoorman, Agriculture & Natural Resources Extension Educator

Objective

To evaluate the effect of cover crop and nitrogen rate on corn yield.

Background

Cooperator:	O.A.R.D.C. NW Branch	Soil test:	
County:	Wood	Fertilizer: see N rate below, no P or K	
Nearest Town:	Hoytville	Planting Date:	6-4-11
Drainage:	Tile, well-drained	Planting Rate:	30,000
Soil type:	Hoytville, clay	Row Width:	30 in.
Tillage:	disk chisel,harrow	Herbicides:	Cinch, Prequel, Honcho, 2,4-D ester, AMS
Previous Crop:	wheat		
Variety:	Beck 5354HXR	Harvest Date:	11-18-11

Methods

The entries were replicated four times in a randomized complete block design. Plot size- 10 x 70 feet each entry. Harvest data was collected from the center 2 rows. All treatments received the same herbicide. After 2010 wheat harvest, all plots were tilled to a fine seedbed. On August 18, 2010 a White splitter planter was used to plant inoculated Austrian winter pea at 30 lb/acre and oilseed radish at 4 lb/acre. Radish was placed in the rows where corn was planted the following spring, with the winter pea 15 inches over from the radish rows. On September 14, 2010 a second cover crop planting of Austrian winter pea and radish was planted at the same rates as the August planting. A third cover crop planting on September 14, 2010 included Windham variety of winter pea and oilseed radish at the same rates as previous planting. Cover crops were naturally killed by winter cold temperatures. Corn was no-till planted in all treatments. Nitrogen was sidedress applied at V6 stage on June 27, 2011 with liquid 28% injected.

Results

Treatment	Cover Crop/ planting date	N-Rate	Corn Yield bu/acre
1	none	0	108.2 A
2	none	140	189.6 CD
3	none	220	205.7 E
4	Austrian Winter Pea, August	0	137.2 B
5	Austrian Winter Pea, August	140	183.1 C
6	Austrian Winter Pea, September	0	130.4 B
7	Austrian Winter Pea, September	140	194.8 D
8	Windham Winter Pea, September	0	134.4 B
9	Windham Winter Pea, September	140	191.1 CD

LSD (.05) 8.9

Summary

With the 0 nitrogen rate, the no cover crop (treatment 1) was significantly less corn yield compared to all other cover crop plantings with 0 nitrogen. One can conclude that the Radish/Winter Pea did add significant amounts of nitrogen to increase corn yields. The planting date or type of winter pea cover crop at 0 nitrogen had similar corn yield.

With 140 lb/acre nitrogen there was significant difference between Austrian winter pea planted in August (treatment 5) compared to Austrian winter pea planted in September (treatment 7). The later planting resulted in higher corn yield. This was the only significant difference comparison with 140 lb/acre nitrogen.

The 220 lb/acre nitrogen rate was significantly different from all other treatments with an average corn yield of 205.7 bu/acre. This shows that the 140 lb/acre nitrogen rate was not sufficient for maximum yield.

Soil quality improvements from using cover crops were not analyzed.

Acknowledgement

The author expresses appreciation to the staff at the Ohio Ag Research & Development Center, Northwest Agricultural Research Station for assistance with this research, Matt Davis manager.

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Michigan State MCCC Report

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Mark Whalon – whalon@cns.msu.edu

We still have plots in several growers' orchards utilizing cover crops to benefit beneficial insects and to reduce pest species. The effort involves 6 cherry orchards and a number of apple growers. The orchards extend up the W coast of MI from north of the Ridge to Northport, MI. All of the study sites involve large 2-5A replicates of three treatments: 1- orchard grass, 2- legume/grass mix and 3- herbicide clean strip under the trees. All of the drive rows are a mixture of orchard grass, fescue and some short stem varieties. All the orchard's inputs including weed sprays and ground directed insecticides are recorded. We are utilizing an Functional Ecology assessment system that measures the 'calling-area' of standard yellow sticky traps that estimate the abundance of beneficial insects including native and domesticated bees, predators and parasites. To date, the legumeXgrass replicated plots have scored the highest natural enemy and beneficial arthropods in them while the grass understory was second and the herbicide sprayed understory recorded the lowest abundance, diversity and evenness measures. Researchers: Mark Whalon, Pete Nelson and Duncan Selby, Dept of Entomology, MSU.

Jim Isleib – isleibj@anr.msu.edu

I am in the second year of a 2-year Regional Project GREEEN-funded on-farm cover crop trial in Alger County. It involves replicated small plots with the following cover crop treatments: Marathon red clover, sorghum-sudan, fallow, and "N Builder" cover crop seed mixure from Hubbard Feeds Inc., Bismarck ND. The N Builder includes: soybeans, lentils, forage peas, sweet clover, putple-top turnips, oil seed radish, pearl millet, forage oats and sunflower. The cover crop plots were established last year, this year, we till them in and plant oats across all plots. We will look for differences in oat performance.

PROJECT TITLE: Comparing multi-species and mono-culture cover crop systems to improve soil fertility and crop performance in Michigan's Upper Peninsula.

Objectives: 1) Compare differences in crop performance following 3 season-long cover crop treatments including a multi-species cover crop seed mixture as currently used by North Dakota no-till grain farmers, a typical legume and grass mono-culture cover crop seeding, and fallow. 2) Model economic potential of using a multi-species, season-long cover crop to enhance soil fertility.

Hypotheses: Crop performance following a full-season, multi-species cover crop will be better than crop performance following a typical mono-culture cover crop or fallow treatment. Soil tests will indicate a trend of enhanced soil fertility, including organic matter content, following the multi-species cover crop treatment. Utilization of multi-crop cover crop will compare favorably economically to utilization of mono-crop or fallow treatment.

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Perennial Wheat

Research is being conducted with funding from USDA OREI (4 year grant) and CERES Trust at Michigan State University led by Dr. Sieglinde Snapp and team members from MSU, WSU and TLI to investigate the opportunities availed by Perennial Wheat. The perennial characteristic of this plant offers potential value as an excellent cover crop for an extended period supplemented by several grain harvests. The grain is of culinary quality but work continues to identify Pwheat lines that are durable in climates such as Michigan, Washington State and Kansas. Three institutes are partnering on these grants to further develop the potential of this as a crop, MSU, Washington State University and The Land Institute. More information at http://www.carrs.msu.edu/public/pwheat/.

Mathieu Ngouajio – Ngouajio@msu.edu

1. Seeking cover crops that offer biofumigation value

Michigan State University, led by Dr. Mathieu Ngouajio Michigan State University, led by Dr. Mathieu Ngouajio (Vicki Morrone and Hoa Jianjum team members), is conducting research on station and on- farm in Michigan to assess biofumigation attributes of Brassica cover crops' impact on crop production for organic vegetable systems, with funding from the CERES Trust. Five varieties of mustards are being tested; Tilney, Ida Gold, Defender, Forge, and Pacific Gold on sandy to sandy-loam soil. Findings are not conclusive (1st year) but we do see the need for adequate moisture for good stand establishment and biofumigation impact following cover crop incorporation Also, careful crop planning is needed to avoid crop succession with a Brassica cash crop as flea beetles are a shared pest. Due to lack of moisture there was not difference detected among the mustard varieties, which were evaluated by fruit weight and fruit quantity of the test crop (melon-Athena) that was planted 0-15 days following cover crop incorporation. Research will continue in the 2012 field season on farm and on station.

2. Brassica cover crops for perennial vegetable cropping systems

Mathieu Ngouajio is leading a study investigating the potential to integrate brassica cover crops in perennial vegetable cropping systems to limit losses due to the replant suppression problem. Asparagus replant suppression is the failure of asparagus to establish well in a field that was previously used to grow asparagus. This is a major threat to asparagus production in Michigan and worldwide. Preliminary results suggest that brassica cover crops can be planted successfully in established asparagus fields between late July and mid August when the crop is going dormant. Cover crop establishment is excellent during the first years (1-3 years) when the fern is young but may be less effective as the fern become dense. Also the herbicide program may affect cover crop establishment. Preliminary yield data (first two years) show improved yield in the brassica cover crop plots. This is an ongoing study funded by NIFA-PMAP program.

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Research Farm Trials

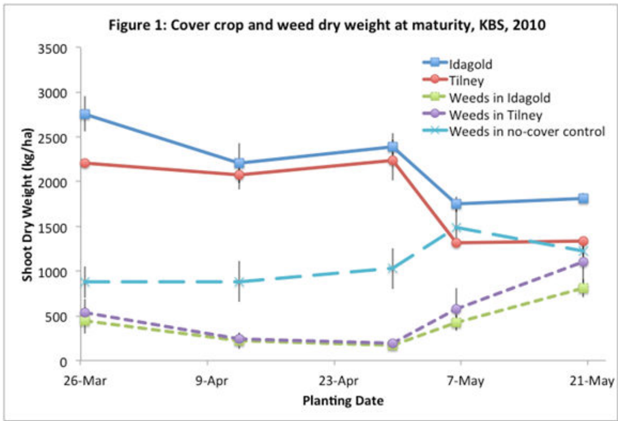
Trial 2: Mustard timing (spring), KBS

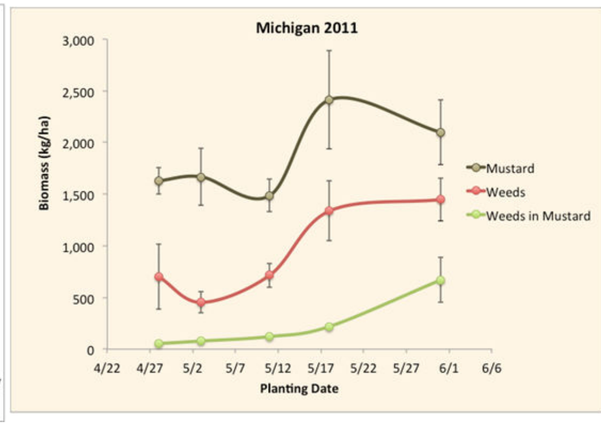
Objective: To evaluate the effects of timing of mustard planting (5 timings beginning in March) and cover crop variety (Tilney or Idagold) on 1) mustard biomass accumulation, and 2) weed suppression.

Treatments: 5 planting dates at approximately 2 week intervals x 2 varieties

Methods: See Appendix for protocol details. Identical trial is being conducted in NY and IL.

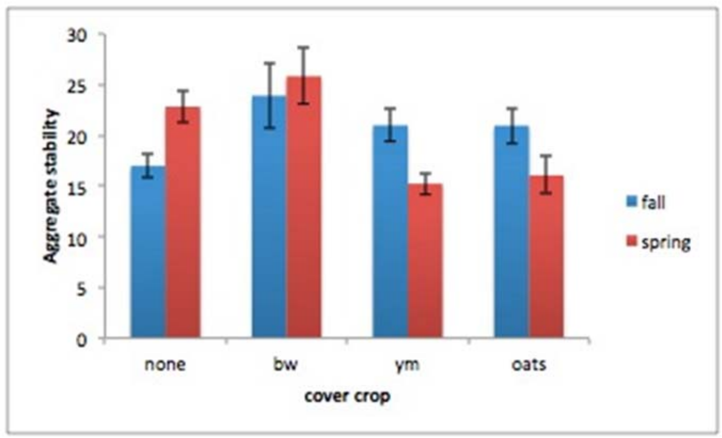
Results. Mustard planted before the first week of May suppressed weeds adequately. Mustard planted after mid May resulted in abundant weed biomass. In 2010, mustard biomass was greatest before early May. However, in 2011 mustard biomass was equivalent or greater when planted after May 17, perhaps due in part to excessively moist conditions early in the spring in 2011.





Trial 5/6: Cover crop and tillage timing effects on snap beans

Objectives: To evaluate the effects of cover crops (Buckwheat, yellow mustard, oats or none sown late the previous summer) and timing of tillage (fall versus spring) on 1) soil health 2) weeds and 3) snap bean quality and yield.



Preliminary Results from 2010-11. Cover crops established well and suppressed weeds adequately in the fall. Soil health indicators have not been extensively evaluated, but preliminary analysis shows improvements in aggregate stability with buckwheat relative to bare soil, and improvements with mustard and oats when fall incorporated (see figure below). However, when mustard and oats were incorporated in the spring, aggregate stability was lower than bare soil. The reasons for these interactions are still unclear.

Beans established poorly in all treatments due in part to poor seed quality (discovered later) and to seed corn maggot attack. Interestingly, seed corn maggot damage appeared to be greater where cover crops were present, regardless of the time of tillage. As a result of poor stand from the first planting, the entire experiment was replanted.

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Brassica Variety Trials – NRCS Rose Lake Plant Material Center

Little growth and development data are currently available for brassicaceous cover crops. Data from this study will be included in the database for conservation planning tools such as Revised Universal Soil Loss Equation, Version 2 (RUSLE2) and Wind Erosion Simulation Models (WEPS). Both require plant growth measurements to accurately predict the conservation effects of plants.

This brassicaceous cover crop evaluation is a collaborative effort. Other partners include Michigan State University Kellogg Biological Station Cover Crops Program, the University of Minnesota, and USDA-NRCS Central National Technology Support Center and the modelers and conservation planning tool developers which they represent. At least 10 individuals have been involved in field operations.

Brassicacous cover crops were planted in late summer 2010 and 2011 following small grain harvest. Design was a randomized complete block with four replicates. Individual plots were 10 ft X 30 ft. Fertilization was according to soil test laboratory recommendations and irrigation was applied to maintain optimum growing conditions. Growth parameters such as plant population; groundcover; flower presence; root, shoot, and total plant length; and root and stem diameter were measured and recorded in the field at 15-day intervals. Plants were collected and partitioned into below ground, stem and root (if heaved), and leafy components on each sample date for dry matter determination. Laboratory analyses to determine N content were or will be performed for one sample date near the end of each growing season. Air temperature data were recorded for growing degree day determination.

Oilseed radish produced the fastest and most complete groundcover. Ninety percent groundcover was achieved at 38 and 39 days in 2010 and 2011, respectively. Total biomass did not vary within species groupings within years, e.g., 13 oilseed radishes were not different in 2010 and 9 oilseed radishes were not different in 2011. Later established cover crops (2011) achieved less total biomass than those that were established earlier (2010).

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Strip-till and Dual Cover Crops – MSU Farms and Kellogg Biological Station

There is an opportunity to increase the profitability of corn production by reducing herbicide and fertilizer costs using strip tillage and in-row brassica and between-row legume cover crops for corn production following wheat. Enhancing strip tillage with brassica and legume cover crops will suppress weeds and supply nitrogen while improving soil tilth, organic matter and infiltration. We propose that a system that combines the benefits of strip tillage, in-row brassica and between-row legumes can reduce corn production costs while maintaining or increasing corn yield.

The objectives of this study are:

1. Evaluate the benefits of individual and combined strip-till, in-row brassica cover crop and between-row legume cover crop systems compared to conventional no-till for a corn-soybean-wheat rotation.
2. Compare and quantify the effects on weed suppression, nitrogen availability, corn yield and soil characteristics between conventional no till, strip-till, strip-till plus one in-row brassica cover crop, strip-till plus three different between row-legumes and strip-till plus one in-row oilseed radish plus three different between-row legumes.
3. Compare and quantify the economic impact on net production cost and net production income between no-till and strip-till, in-row brassica, between-row legumes and combination systems.

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Effect of Cover Crops On Nitrous Oxide Emissions, Nitrogen Availability and Carbon Accumulation in Organic Versus Conventionally Managed Systems

Michigan State University was recently awarded this NIFA Organic Transition Grant. We propose a study to investigate the effects of various cover crops, specifically their residue quality and termination time, on nitrous oxide (N2O) emissions, nitrogen (N) availability patterns and carbon (C) accumulation in major Midwest field crop systems under organic and conventional management.

Our goals are 1) to determine the potential of cover crops as management options for improving N synchrony with cash crops, 2) evaluate the impact of cover crops on N2O emissions, and 3) improve farmer knowledge of cover crop utilization in relation to N utilization efficiency (NUE) and economic potential through decision tools and communications.
Over three field seasons we will conduct in situ measurements of N2O fluxes, soil N availability and C concentrations, and relate these to field operations and crop quality parameters at certified organic and conventionally managed plots at the same site.

We will use these data to 1) improve extension tools by providing information on the greenhouse gas (GHG) impacts and NUE of using cover crops, 2) evaluate economic costs associated with transitioning between conventional and organic systems, 3) identify opportunities for including cover crop management in offset methodologies for environmental markets, and 4) expose data for use by others to test and refine process-based, field-scale GHG simulation models.

This research will address USDA ORG 2011 program priorities for 1) Documenting and understanding the effects of organic practices on GHG emissions and 2) Improved technologies and metrics to document and optimize the environmental services and climate change mitigation ability of organic farming systems.

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Great Lakes Cover Crop Initiative

The Great Lakes Cover Crop Initiative is a collaborative effort by Conservation Technology Information Center, Michigan State University, Ohio State University and Purdue University to promote cover crops and conservation tillage throughout the Great Lakes Watersheds in Indiana, Ohio and Michigan.

This program provides technical and educational support through

- Experts in each watershed
- One-on-one consultation with farmers
- Workshops
- Field Days
- Networking Opportunities
- Web site resources
- Providing speakers and expertise for groups working with agriculture

The project will implement 15,000 acres of cover crops with conservation tillage by April of 2013. Agricultural producers will be provided with technical, educational and social support which will work together to create strong cover crop and conservation tillage systems that can be sustained after the project ends.

We will work with partners to host 18 workshops in the three watersheds (Lake Michigan Watershed, Lake Erie Watershed and Lake Huron Watershed) promoting Cover Crops and conservation tillage systems. Three workshops will be held in each watershed each year for the first two years of the projects.

Following the workshops Watershed Coordinators (WC) will act as crop consultants and work closely with agricultural producers willing to use cover crops and conservation tillage. The WC will each work in one of the three watersheds. Each WC will be an experienced extension educator and will have the expertise to provide enough information to ensure the best possible results for these producers as they use the cover crop and conservation tillage system.

Farmers will receive regular communications via an email list serve and a comprehensive project web site which will provide useful information from project partners and other farmers. Producers will also be encouraged to participate in additional activities such as the National No till Conference and local conservation agriculture events.

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Cover Crops in Organic Dry Beans

Michigan is the number one producer of organic dry beans in the nation. With the limited inputs allowed in organic systems, it is essential to maximize the potential benefit of cover crops for increasing weed control, nutrient availability, and ultimately crop yields. The aim of this research, funded by the USDA Organic Research and Extension Initiative, is to determine the effect of cover crops on weed suppression, nitrogen availability, and dry bean populations and yields in an organic system. To meet this goal, an experiment was conducted at the Michigan State University Student Organic Farm (East

Lansing, MI) and at the Kellogg Biological Station (Hickory Corners, MI) during the 2010-2011 growing season. The cover crops studied included: medium red clover, oilseed radish, and cereal rye; a no cover treatment was also included. Within each cover crop treatment there were four bean varieties: 'Zorro' and 'Black velvet' black beans and 'Vista' and 'R-99' (non-nodulating mutant) navy beans. Weed management was uniform across the experiment following dry bean planting. Cover crop biomass was recorded at peak production and included both above and belowground growth. Weed biomass and populations by species were recorded at two times, 1) V2 bean stage- after early season weed management was complete (i.e. tined weeding and rotary hoeing) 2) R5 bean stage- following final cultivation. Throughout the course of the experiment several methods were used to monitor nitrogen availability, including: the use of a chlorophyll meter at numerous stages of bean development (V2, R1, and R5), soil sampling (fall, planting, V2, R1, R5, and harvest), and ion exchange resin strips were also set out and changed every 2 weeks throughout the growing season. Dry bean populations were recorded at the V2 stage and at harvest prior to taking yields.

Peak biomass production was seen in the clover cover crop and no cover crop treatments (i.e. biomass from weeds) at the Kellogg Biological Station (both at 3,200 lbs/ha), followed by oilseed radish (2,000 lbs/A) and rye (1,500 lbs/A). However, at the Student Organic Farm, rye was unable to be controlled in a timely manner due to rain and reached a biomass of over 6,200 lbs/A. As a result of this difference, the locations were analyzed separately. There was only a significant difference among covers for weed suppression at the V2 bean stage at the Kellogg Biological Station location. Rye (2 lbs weeds/A) and radish (3 lbs weeds/A) provided greater weed biomass suppression than clover (21 lbs weeds/A); no cover (14 lbs weeds/A) fell in between. At both the V2 and R1 stages, bean chlorophyll florescence was highest in the beans following a clover cover crop, though the difference was not always significant. Information regarding plant available nitrogen as assessed from soil sample and ion exchange resin strips is currently being analyzed and will be discussed at the reporting session. Beans following an oilseed radish cover crop had significantly higher populations than the no cover treatment at both the V2 stage (both locations) and at harvest (KBS only), with 14-35% more plants. At the Student Organic Farm, bean yields following oilseed radish were higher (2,400 lbs/A), clover (2,100 lbs/A), and no cover (2,000 lbs/A) were higher than beans following rye (1,300 lbs/A). These reduced yields could be the result of the rye reducing soil moisture early in the season and immobilizing nutrients. No differences in yield based on cover crop treatment were observed at the Kellogg Biological Station. Two more field seasons of this research are planned to clarify the impacts of cover crops on organic dry beans.

Michigan State University
(additional project listing)

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Strip tillage and cover cropping effects on weed emergence and growth and cabbage growth and yield.

This research was conducted at the Farming Systems Center and assessed the impacts of strip tillage (ST) and conventional tillage (CT), cover cropping, and crop competition on (1) in-row (IR) and between-row (BR) weed emergence after tillage and after cabbage planting, (2) weed growth and fecundity, and (3) cabbage growth and yield. Cover crop impacts on these variables, as well as edaphic conditions, often interacted with tillage—the effect of the cover crop depended on whether residue was left on the surface of undisturbed soil or incorporated with tillage. For example, both IR and BR soil moisture was often higher in the ST plots with surface cover crop residue compared to plots with incorporated residue or plots without residue. Weed emergence (objective 1) was also affected by this interaction; immediately after tillage, BR weed emergence was lowest in strip tilled plots with a cover crop (without soil disturbance and with a mulch layer of cover crop residue). However, these plots had the highest emergence of weeds when seeds were sown after planting. Mechanistic trials suggest that fungal pathogens and water play a role in initially suppressing weed emergence in undisturbed areas with cover crop residue mulch. After tillage, emergence of fungicide-coated weed seeds was higher than uncoated seeds when cover crop residues were present (either on the surface or incorporated), suggesting that fungal pathogens may be limiting weed emergence in cover cropped areas. This effect, however, was temporary as emergence of treated weed seeds was similar to untreated seeds when sown after planting. Additional water increased seedling emergence in plots without cover crop residue but did not affect emergence in plots with residue, suggesting that cover crop residues helped to retain soil moisture sufficient for seed germination and seedling emergence. This effect was not observed in seeds sown after planting; higher soil moisture at this time, compared to the earlier trial, may have negated any moisture-conserving effects of the residues. For objective 2, final IR weed biomass was affected by the interaction between tillage with cover crop and tillage with crop. Regardless of whether cabbage was present, final IR weed biomass was similar in ST and CT without a cover crop but lower in ST compared to CT when a cover crop was present. Averaged over cover crop and no cover crop, IR weed biomass was similar across tillage treatments when cabbage was not present, but was higher in ST compared to CT with cabbage. Final BR weed biomass and cabbage yield (objective 3) did not differ between treatments.

NCCC211: Cover crops to improve environmental quality in crop and biofuel production systems in the Great Lakes and Upper Mississippi basins.

2012 Report submitted by Clark J. Gantzer – University of Missouri GantzerC@missouri.edu

Clark J. Gantzer was a member of the Planning Committee for the Soil and Water Conservation Society (SWCS) Conference in Decatur, Illinois entitled *Effective Cover Cropping in the Midwest* held December 7 and 8, 2011. A total of 285 individuals attended. The conference was geared to Midwest growers and cover crops service providers—seed dealers, consultants, and equipment suppliers. Video's of most of the presentations made at the conference can be found at: http://vimeopro.com/swcs/swcs-cover-crops-2011/ .

Gantzer is preparing a proposal South Central Region Sun Grant (SC-SGI Regional RFA 2012 (USDA) (2012-2014)), entitled *Sustainable Production of Sweet Sorghum and Sunflower for Biomass and Oil Feedstock Using Cover Crop Polyculture.* Study of cover crop polyculture for use with bioenergy production Work will occur at the University of Missouri Bradford Research Center and the Kansas State University South Experimental Field. Sweet sorghum and sunflower will be used. A cover-crop polyculture of cereal rye, hairy vetch, crimson clover, Austrian winter pea, and tillage radish will be planted in late Sep. at two seeding rates; 1/5 and 2/5 of the monoculture seeding rates to study fall and winter plant growth.

He will make a presentation at the 2012 SWCS Annual Meeting in Fort Worth Texas, based on the work related to a funded USDA Missouri Conservation Initiative Grant (CIG), entitled *Sustainable Cropping Systems Using Cover Crops, Native Species Field Borders, and Riparian Buffers for Environmental Quality.* This presentation will focus on the application of sustainable management practices for no-till cultivation using cover crops, native species field borders, and fast growing woody species integrated in vegetative strips and riparian buffers. This work done with Tim Reinbott (Superintendent Bradford Research & Extension Center) ReinbottT@missouri.edu has established cover crop plots at Bradford this fall. We will present information on annual cover crops usage for row-crop rotations that emphasize the contribution of biologically fixed nitrogen, weed growth suppression, carbon sequestration, and soil health.

William J. Wiebold Extension Professor of Crop Science University of Missouri WieboldW@missouri.edu is completing two M.S Graduate Students working on a cover crop study "Use of Cover Crops to Replace Corn Biomass Removal." The objective of this project is to determine how changes in the standard midwestern corn/soybean cropping system because of biomass use for ethanol affect both rotation crops. Specific objectives are to: 1) determine the effects of corn biomass removal on corn and soybean growth, development, yield, and grain composition, and 2) determine the effects of cover crops (used to replace corn biomass) on corn and soybean emergence, development, yield, and grain composition. Kellar Nelson's thesis title is *Soybean Growth and Development Following Corn Stover Removal for Biofuel.* It was found that while a rye cover crop reduced soybean stand-density, there was no effect of use of the cover crop on soybean yield. Deanna Boardman-Smith's thesis title is *Corn Residue Removal for Biofuels: Effects on Soybean and Corn Plants.* Removal of corn residue increased soybean stand density, but had little effect on corn stand density. The rye cover crop did not affect soybean or corn yields in 2010 a year with 28.2 inches growing season precipitation, but significantly reduced corn yield by 24% in 2009 a year with 24.4 inches growing season precipitation.

Ranjith P. Udawatta UdawattaR@missouri.edu has submitted a National USDA Conservation Initiative Grant (CIG), *Implementation of multispecies cover crop-buffer systems for a sustainable agricultural system to improve soil health, environmental quality, and farm productivity.* This is a multi-institutional, multi-disciplinary project designed to stimulate adoption of cover crop, no-till management, crop rotation, and vegetative buffer conservation technologies to develop a sustainable and resilient agricultural management system to corn-soybean farmers and landowners in the Midwest to increase farm productivity and ecosystem services.

Robert J. Kremer (ARS Columbia, MO Soil Scientist), KremerR@missouri.edu has a Funded USDA-National Institute of Food and Agriculture (NIFA) grant: " Factors Affecting Carbon Sequestration and Nitrous Oxide Emission in Three Organic Cropping Systems" University of Missouri & USDA-ARS-Cropping Systems and Water Quality Research Unit in Columbia, Missouri (CSWQRU). Some of objectives are to: 1) Compare tillage and cover crop practices to optimize C sequestration and reduce carbon dioxide emission in claypan soils, and 2) Determine combinations of organic amendments plus cover crops for maximizing grain yields in organic systems. The experimental approach (in progress and to be initiated) is:

Rotation: Wheat – soybean – corn
Main Plots: Cover crop X tillage
Cover crops prior to each of following " main crop"
Corn cover crop: cereal rye + hairy vetch (currently established)
Soybean cover crop: cereal rye (currently established)
Wheat cover crop: buckwheat (to be established following wheat harvest)

Dr. Kremer also has an on-farm project since 2002 assessing the perennial kura clover as a cover crop, or permanent alley crop, in pecan on the loess soils of the Missouri River uplands in Chariton County.

Wisconsin NCCC211 Report
Cover Crops to Improve Environmental Quality in Crop and Biofuel Production Systems in the Great Lakes and Upper Mississippi Basins
West Lafayette, Indiana
February 28-29, 2012

RESEARCH

Soil Erosion and Nutrient Runoff in Corn Silage Production with Kura Clover Living Mulch and Winter Rye. Arthur Schwab, Ken Albrecht and Bill Jokela.

Corn (*Zea mays* L.) is a productive and popular forage crop that can exacerbate soil loss, surface water runoff, and nonpoint source nutrient pollution from agricultural fields. The objective of this research was to compare the effects of using kura clover (*Trifolium ambiguum* M. Bieb.) living mulch and winter rye (*Secale cereale* L.) in corn silage production on runoff, soil physical properties and organic matter, and forage yields. On loess soils with 8 to 15% slope, during simulated, short, heavy rainstorms, kura clover living mulch reduced water runoff by 50%, soil loss by 77%, and P and N losses by 80% relative to monocrop corn. Rye reduced water runoff by 67%, soil loss by 81%, P loss by 94%, and N loss by 83% when planted after corn silage harvest. When rye was planted following corn silage in kura clover living mulch, water runoff was reduced by 68%, soil loss by 77%, P loss by 94%, and N loss by 84% relative to monocrop corn. Dissolved reactive P, NH_4-N, and NO_3-N were often, but not always, higher in monocrop corn. Treatment differences in nutrient losses were primarily due to differences in runoff amount rather than concentrations. Greater ground cover, soil aggregate stability, and soil organic matter, as well as soil disturbance from rye planting, were associated with improved infiltration and reduced soil and nutrient losses in the cover cropped treatments. When grown in kura clover living mulch, both corn and rye had lower yields but this was offset by lower fertilizer requirements and improved farmland and environmental function and quality.

Spring-seeded legume cover crops for organic sweet corn production. Jaimie West, Matt Ruark, A.J. Bussan, Jed Colquhoun, and Erin Silva.

A range of nitrogen (N) sources are available for organic production systems. However, little information exists related to optimal use of composted manure and green manure in organic agriculture on sandy soil. Research plots were established in 2011 at the Hancock Agricultural Research Station. Three early season inputs were compared (composted chicken manure, field pea, or none). The field pea was planted on April 15th and plowed under on June 3rd. Chicken manure was spread at this time as well and all plots were moldboard plowed. Sweet corn was planted on June 15th. Two additional factors were evaluated: intensity of weed management and N fertilizer rate. Two levels of weed management were imposed: moderate and intense. Intense weed management involved weekly hoeing or weeding of plots to limit the amount of weed growth. Moderate plots received only occasional weeding, allowing some weed pressure to occur, but not severely limit sweet corn growth. Within each early season input and weed management treatment plots, four levels of N fertilizer were applied: 0, 112, 168, and 224 kg ha^{-1} of N. The N source was 11-0-0 (feather meal) OMRI approved fertilizer. Cover crop samples were collected prior to plow under to estimate N contribution. Weed samples were collected prior to harvest to determine N uptake by weeds. Sweet corn was hand harvested and whole plant samples were collected to determine N recovery. Preliminary results indicate that early season N inputs of green manure or composted chicken manure did not affect optimum N rates, as yields were maximized with 224 kg ha^{-1} of N as 11-0-0 across all early season and weed management treatments.

No-till organic agriculture. Erin Silva.

Dr. Erin Silva is conducting research regarding no-till organic systems. The long-term goals of the project are to maintain and enhance soil quality in organic systems by maximizing cover, minimizing erosion, and improving soil ecology and biological processes to reduce environmental and economic costs and optimize yield stability. The hypothesis driving this national, long-term project is that organic systems based on cover crops and reduced tillage will result in improved soil health, including increased carbon sequestration and greater biological diversity, and greater economic returns by reducing costs of production and lowering energy costs. This hypothesis will be tested using a comprehensive approach including the collaboration of multiple researchers and growers over a range of environmental conditions. By taking this regional collaborative approach, meaningful research results will be expedited and knowledge-sharing between both farmers and researchers facilitated.

Continuation of Wisconsin Integrated Cropping Systems Trials. Josh Posner and Janet Hedtcke

The Wisconsin Integrated Cropping Systems Trial (WICST) was established in 1989 to evaluate long-term effects of soil quality and agronomic production of commonly used cropping systems in Wisconsin. Green manure crops have been used in the organic grain cropping systems since 1991. Inter-seeded red clover drilled into winter wheat (in early spring) was the primary green manure crop until 2004; in 2005, we shifted to a sequential seeding of berseem clover and oats after wheat harvest. Without any summer tillage after wheat harvest, we were finding increasing foxtail and quackgrass pressure in the following corn crop. We anticipated that we would fix less N with the later seeded cover crop and have a period when the field would be "open" with the potential for increased erosion. However, late Jul y is usually a hot and dry part of the season and an ideal time to break the weed growth cycle —especially to desiccate quackgrass rhizomes. The inter-seeded red clover at plowdown averaged across the 20 site-yrs was 2.4 tons DM/a (1.6 tons/a aboveground +0.8 tons/a belowground) with 127 lbs/a N (16 of the 20 site-yrs had an N credit over 100 lbs/a). The shorter season oat/berseem cover crop (planted in mid-August) resulted in an average of 2.2 tons total DM/a and about 80 lbs N/a (80% from oats, 20% from clover). However, in this shorter data set with berseem clover/oats, 2 of 6 site-yrs had total biomass yields less than 1.1 ton DM/a due to a dry period following planting (with less than 1" of rain in the 3 weeks following planting). We did find however that ground cover was quickly re-established due to inclusion of oats in the cover crop mix. Biomass yield and N levels from sequentially seeded oat/berseem following wheat (6 site-years) were 80% less than inter-seeded red clover (20 site-years). The average yield for organic corn from 2002 to 2005 was 106 bu/ac and the average organic corn yield from 2006 to 2009 was 163 bu/ac, which may be an effect of reduced weed pressure.

Publications

Bernstein, E.R., J.L. Posner, D.E. Stoltenberg, and J.L. Hedtcke. 2011. Organically managed no-till rye-soybean systems: Agronomic, economic, and environmental assessment

Jokela, W., J. Posner, J. Hedtcke, T. Balser, H. Read. 2011. Midwest cropping system effects on soil properties and on a soil quality index. Agron. J. 103:1553-1562.

Extension

Establishment of a cover crop Extension team

Matt Ruark, Kevin Shelley, Jim Stute, A.J. Bussan, Ken Schroeder, Nick Schneider, Richard Proost, Mike Ballweg, Heidi Johnson, Keith Vandervelde, Tim Wood, and Rhonda Gildersleeve. This newly formed Cover Crop Extension Team was established to conduct on-farm research and develop Extension materials regarding optimum cover crop use for growers in Wisconsin.

On-farm research/demonstration trials

* These on-farm trials were established in the fall of 2011, preliminary data has been collected but not analyzed. To-date, radish, clover, or rye samples at each site were collected prior to winter kill (tops and roots collected separately for radish) and 20 cm soil samples collected were radish or other cover crop was harvested. Plant material will be analyzed for total C and total N and soil samples will be analyzed for nitrate.

1) Radish as cover and forage (Wood, Gildersleeve). Strip trial in Grant County, WI comparing establishment of radish varieties and winter rye after soybean. Cows were allowed to graze the plots in the late fall after establishment.
2) Planting radish with solid dairy manure (Schneider). Split-field trial in Winnebago County, WI comparing application of solid dairy manure with no application onto a recently planted radish cover crop.
3) Perennial cover crops in processing crop production (Schroeder, Bussan). Strip Trial in Portage County, WI comparing the seeding of red clover in-row during a snap bean growing season. Sweet corn will be planted next year and a potential N credit will be evaluated.
4) Benefits of radish for no-till corn (Ballweg, Proost, Ruark). Strip trial in Washington County, WI comparing effect of radish with no cover crop on soil properties and corn yield. Radish was planted after winter wheat harvest in 2011. Corn yields will be evaluated in 2012. Small plots will be established in 2012 to determine response to N and to evaluate if there is a potential for an N credit from radish.
5) Radish and radish mixtures (Johnson, Stute). Strip trial in Jefferson County, WI comparing radish grown alone or with field pea. Cover crops were planted after no-till winter wheat and will determine the effect on corn yield in 2012.

6) Optimal radish management (Stute). Systems trial in Rock County comparing fall cover crops of wheat or radish with 0 or 72 kg ha^{-1} of N applied at planting. In 2012, corn will be planted and six N rates will be applied to evaluate the potential N carryover from the radish.

Cover crop webpage

In 2011, we established a new webpage on our UW Soil Science Extension Webpage (www.soils.wisc.edu/extension/covercrop.php) devoted to materials related to cover crop materials.

Cover crop videos

1) Cover crops following winter wheat or corn silage harvest. Matt Ruark UW Dept. of Soil Science. UWEX-Cooperative Extension YouTube Channel (url: go.wisc.edu/1j7725)
2) Benefits of cover crops. Matt Ruark, UW Dept. of Soil Science
3) Where do Cover Crops Fit into your System? Matt Ruark, UW Dept. of Soil Science.

Extension programs

1) Cover Crop In-Service Training, March 2, 2011 in Sparta, WI and April 14, 2011 in Hancock, WI. Attendance was approximately 20 for the Sparta event. Evaluations from the event indicate that 100% of responders would be able to use the information from the workshop in their work (15 responses). Attendees were mostly NRCS, Extension, and Land Conservation Department employees with a few crop consultants.
    - Why cover crops? Jim Stute
    - Proven cover crop applications in Wisconsin. Jim Stute & Kevin Shelley
    - Research update on cover crops. Matt Ruark
    - Discussion and update on cover crop use in WI. Diane Mayerfield
    - Herbicide issues with cover crops. Nick Schneider
    - Cover crops and crop insurance. Kevin Shelley
    - NRCS programs related to cover crops. Terry Kelly (NRCS State Agronomist)
2) Cover Crop Workshop, March 14, 2011 in Jefferson, WI. County Agent Heidi Johnson hosted a county-level workshop focused on cover crops. There were 15 growers and crop consultants in attendance. Part of the workshop included a roundtable discussion about types of on-farm cover crop research that growers would like to see and potentially participate in.
3) Cover Crop In-Service Training, April 13 in Hancock, WI. The attendance was 39 and a similar demographic compared to the Sparta event. 100% of the survey responders (29) indicated that they will be able to use the information presented in the workshop in their own work.

Articles and Reports

Ruark, M.D., K. Shelley, J. Stute. 2011. Radish as a cover crop. New Horizons of Soil Science. Issue 11-1.

Anderson, C. and D. Mayerfield. 2011. Cover crops case studies: JenEhr Family Farm, Vegetables, fruit and pastured poultry. Center for Integrated Agriculture, UW-Extension. CIAS001 I-11-2011

North Dakota - NCCC-21 Report
Cover crops as a source of nitrogen for bioenergy crops, forage for hay and fall grazing, salinity management, and prevented planting.
April, 2011 to March, 2012

NOT FOR PUBLICATION OR CITATION

Marisol Berti[1], H. Kandel[1], P. Carr[2], and S. Zwinger[3]
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COMPLETED RESEARCH

1. <u>Annual cover crops for hay at Carrington and Fargo, North Dakota</u>

Authors: Steve Zwinger, Carrington REC, Marisol Berti, North Dakota State University

Cool-season annual forages

Several cultivars of forage barley (*Hordeum vulgare* L.), oat (*Avena sativa* L.), triticale (*x Triticosecale* Witt.), and mixtures with pea (*Pisum sativum* L.), hairy vetch (*Vicia villosa* L.), and black lentil (*Lens culinaris* Medik. cv. Indian head) were planted at Fargo and Prosper, ND, in 2011. The experiment at Prosper was lost due to excess rainfall and waterlogging. Dry matter yield fluctuated between 2.4 and 7.9 Mg/ha. The highest dry matter yield at Fargo was for all cultivars of oat alone or in mixture with forage peas or lentil. Forage barley was severely damaged by waterlogging at Fargo. At Carrington forage yield fluctuated between 3.0 and 4.9 Mg/ha, highest forage yield was also for oat alone or in mixture with peas (Table 1). Carrington had much less rainfall that the Fargo location which explains the differences in yield.

Warm-season annual forages
Warm-season annuals are used as energy hay forage, since they grow fast and produce high amounts of dry matter with high digestibility. Several annual warm-season crops were planted at Fargo and Prosper, ND, including Japanese millet (*Echinochloa frumentacea*), pearl millet (*Pennisetum glaucum* L.R.Br.), red proso millet (*Panicum mileaceum*), foxtail millet (*Setaria italica* L. cvs. Siberian and German), teff (*Eragrostis tef*), sorghum (*Sorghum bicolor* L.), and sudangrass (*Sorghum bicolor* var. *sudanense).* The experiment at Prosper was lost due to waterlogging. Total dry matter yield fluctuated between 4.1and 16.9 Mg/ha. Highest biomass yield was for the forage sorghum x sudangrass hybrids (Table 2). At Carrington, forage yield fluctuated between 3.7 and 5.7 Mg/ha

Table 1. Cool-season annual cover crops forage yield at Fargo and Carrington, ND, in 2011.

		Fargo	Carrington
Cover crop	Cultivar	Forage yield	
		Mg/ha	
Forage barley	Hayes	2.4	3.2
Forage barley	Haybet	3.1	2.8
Forage barley	Stockford	3.1	2.8
Forage barley	Lavina	3.6	3.3
Forage triticale	Trical Merlin	4.2	2.5
Forage triticale	Trical 141	4.7	3.0
Forage oat	Everleaf	6.2	3.2
Forage oat	Kona	7.1	4.7
Oat	HiFi	7.1	4.6
Oat	Morton	6.7	4.4
Naked oat	Paul	6.9	4.2
Barley	Rawson	3.7	3.6
Forage pea	Arvika	5.3	3.9
Oat/pea	Morton/Arvika	7.7	4.9
Barley/pea	Haybet/Arvika	6.2	4.2
Oat/pea	Everleaf/Arvika	7.4	4.6
Forage triticale	Trical 141 +	6.5	3.4
Forage pea	Arvika		
Oat +	Morton +	7.9	4.2
Black lentil	Indianhead		
Black oat	Soil saver	6.0	3.2
LSD (0.05)		2.1	0.9
CV, %		23.0	18.0

Table 2. Warm-season annual cover crops forage yield at Fargo and Carrington, ND, in 2011.

Cover crop	Cultivar	Fargo	Carrington
		Forage yield	
		Mg/ha	
Japanese millet	Common	4.9	5.5
Pearl millet	PP102M	7.6	4.8
Siberian millet	Manta	4.2	4.5
German millet	Golden German	5.6	3.8
Sudangrass	Piper	15.5	5.7
Red proso	Common	4.1	4.7
Teff	Dessie	6.2	3.7
Teff	Tiffany	7.9	3.7
Sorghum-sudan	Sweething	16.9	5.3
Sorghum-sudan	BMR Sweething	11.5	5.1
Sorghum-sudan	Special Effort	15.1	4.7
Sorghum-sudan	22053BMR	11.9	4.4
Sorghum-sudan	Black Hawk BMR	14.4	4.9
Sudangrass	Pro-Max BMR Sudangrass	13.4	5.4
Teff	velvet	6.8	-
LSD (0.05)		2.8	0.7
CV, %		17	11.1

2. Impact of cover crop termination method and species mixtures at Dickinson, ND.

Author: Patrick Carr and Steve Zwinger, Dickinson and Carrington, REC

The use of legume cover crops on organic production fields is essential. Several studies have been conducted at Dickinson, ND, to evaluate of zero tillage and method of cover crop termination on organic production of corn (*Zea mays* L.) and dry bean (*Phaseolus vulgaris* L.) and weed suppression. Cover crops used were hairy vetch and winter rye. Cover crops were terminated by blade rolling. Biomass yield, weeds dry matter and soil moisture were measured. Preliminary results indicate that winter survival was good for both cover crops especially in no-till plots. Blade rolling terminating success was >95% for winter rye but < 80% for hairy vetch. Delaying termination of winter rye until soft sough stage produced 5568 kg/ha of dry matter. Hairy vetch biomass yield at the same time as winter rye produces greater than 4753 kg/ha. Total above-ground weed biomass averaged 336 kg/ha.

3. Cover crops and cover crops mixtures evaluations in North Dakota

Authors: *Hans Kandel, Patrick Carr, and Marisol Berti*

In North Dakota spring wheat (*Triticum aestivum* L. emend. Thell.) is typically seeded in the early spring and wheat is harvested at the end of July or early August. The average first killing frost in the fall is around the 20th of September in Central ND. This period from wheat harvest to first killing frost would be available for additional forage or biomass production. If a mixture of more cold tolerant species would be included in the plant mixture, the growing window may be extended well into October.

A demonstration cover crop experiment was planted in Fargo, ND, 13 June 2011. The experiment included 13 cover crops, among them 7 legumes annual crops. Highest above-ground biomass yield was for forage turnip Pasja with 10.8 Mg/ha and significantly different than all others. The highest forage legume biomass yield was hairy vetch with 6.8 Mg/ha (Table 3).

Table 3. Cover crops forage yield at Fargo, ND in 2011.

Species	Cultivar	Harvest date	Forage yield
			Mg ha^{-1}
Forage barley	Hayes	9/2/2011	6.5
Naked oat	Paul	9/2/2011	7.1
Forage pea	Arvika	9/2/2011	5.2
Black lentil	Indianhead	9/2/2011	3.8
Forage oat	Rockford	9/2/2011	8.1
Radish	Daikon	10/6/2011	8.6
Forage turnip	Pasja	10/6/2011	10.8
Turnip	Purple Top	10/6/2011	5.4
Hairy vetch		10/6/2011	6.8
Winter pea	Austrian Winter Pea	9/2/2011	5.2
Faba beans	Windsor	9/2/2011	1.6
Sweetclover	Sweetclover	10/6/2011	5.7
Cowpea	Agassiz	9/16/2011	5.5
LSD (0.05)			2.8
CV, %			20.5

Seeding date 13 June 2011

In a different experiment three crop mixtures were seeded into spring wheat and winter wheat stubble after harvest at Fargo, ND, in 2010 (Table 4). Evaluations included above-ground biomass and samples were taken on 8 October. Samples were also taken from plots with only volunteer wheat. Both the winter wheat and spring wheat produced volunteer plants. The wheat was competing with the seeded cover crop as can be seen in photo 1.

Winter wheat volunteers remained relatively prostrate as winter wheat needs vernalization to change to the reproductive phase. The results indicated in Table 4 for the three mixtures are the combination of the seeded cover crop mixture and the volunteer grain.

Table 5 indicates that from wheat harvest to October, mixture 2 produced the most biomass in winter wheat stubble. The dominant species were kale, turnip, and daikon radish (photo 2). There was no difference in biomass yield between volunteer spring wheat and any of the cover crop mixtures. In this case the volunteer spring wheat would have been a better financial choice as no cover crop seed was needed.

The biomass can either be worked into the soil or used for animal feed. The percent crude protein is indicated in Table 5.

Table 4. Common name, latin name, seeds per lb, recommended full seeding rate, companion rate, percent in mix and lbs in mixture of three cover crop mixes used in trials during 2010 and 2011.

Common name	Latin name	Seeds/lb	Full seeding rate	Companion rate	Percent in mixture	Weight in mixture
Mix 1		seeds/lb	----------lbs/A---------		%	lbs
Alfalfa, non-dormant	*Medicago sativa*	200	10	5	25	1.25
Clover, Persian	*Trifolium resupinatum*	1500	3	1.5	25	0.38
Vetch, Common	*Vicia sativa*	5	60	30	25	7.50
Clover, Red	*Trifolium pratense*	275	9	4.5	25	1.13
					Total	10.25
Mix 2						
Lentil, Red or Green	*Lens culinaris*	15	40	20	20	4.00
Kale	*Brassica oleracea*	165	5	2.5	20	0.50
Turnip	*Brassica rapa*	150	4	2	20	0.40
Radish, Daikon	*Raphanus sativus*	48	6	3	20	0.75
Clover, Berseem	*Trifolium alexandrinum*	210	10	5	20	1.00
					Total	6.65
Mix3 Proportional of 1 and 2						
Alfalfa, non-dormant	*Medicago sativa*	200	10	5	11	0.55
Clover, Persian	*Trifolium resupinatum*	1500	3	1.5	11	0.17
Vetch, Common	*Vicia sativa*	5	60	30	11	3.30
Clover, Red	*Trifolium pratense*	275	9	4.5	11	0.50
Lentil, Red or Green	*Lens culinaris*	15	40	20	11	2.20
Kale	*Brassica oleracea*	165	5	2.5	11	0.28
Turnip	*Brassica rapa*	150	4	2	11	0.22
Radish, Daikon	*Raphanus sativus*	48	6	3	11	0.33
Clover, Berseem	*Trifolium alexandrinum*	210	10	5	11	0.55
					Total	8.09

Table 5. Cover crop seeded into winter and spring wheat stubble directly following wheat harvest in 2010.

Cover crop[1]	Biomass yield	Plant height at harvest	Crude protein
	------lbs/acre----	------inches------	-------%--------
	Cover planted into winter wheat stubble		
Mix 1	3850bc[2]	8.6a	18.2ab
Mix 2	5312a	9.1a	15.3b
Mix 3	4400b	8.2a	15.6b
Winter wheat volunteers	3239c	7.8a	18.6a
	Cover planted into spring wheat stubble		
Mix 1	3230a	-	16.1a
Mix 2	3418a	-	15.7a
Mix 3	3104a	-	15.9a
Spring wheat volunteers	3575a	-	15.1a

[1]Cover crop mixture 1. Non-dormant alfalfa, Persian clover, common vetch, and red clover.
Crop mixture 2. Common lentil, kale, turnip, daikon radish and berseem clover.
Crop mixture 3 a mix of the above two mixtures.
[2]Only means in winter or spring wheat section should be compared. If letter behind means is similar, there is no significant difference at $P \leq 0.10$.

Photo 1. 2010 Cover crops growing together with volunteer spring wheat.

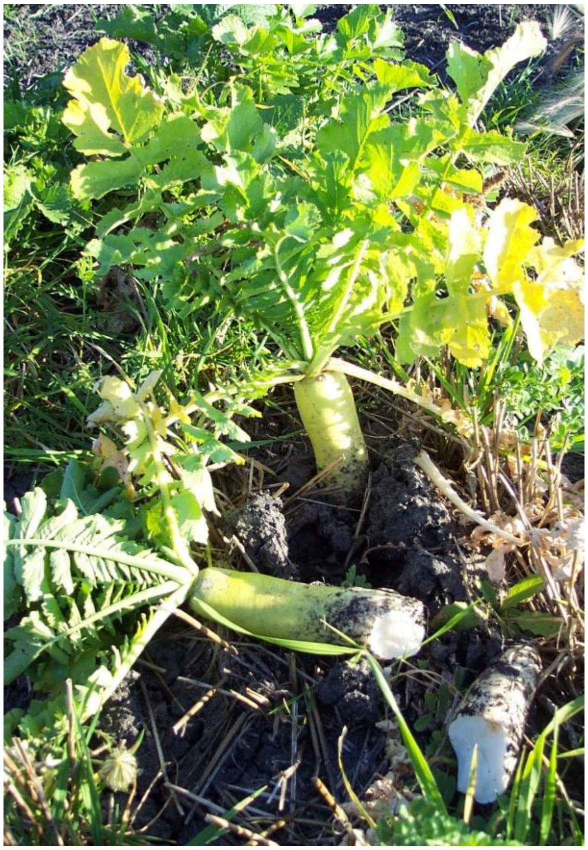
Photo 2. 2010 Daikon radish included in mixture 2 on October 8, 2010 in winter wheat stubble.

In 2011, the same cover crop mixtures were planted after spring wheat harvest, but this time in fallow ground in order to eliminate the completion with spring wheat. Planting took place at the Dickinson Research Extension Center in western North Dakota.

Table 6. Cover crop seeded into fallow directly following wheat harvest in adjacent plots in 2011 at Dickinson, North Dakota.

Cover crop[1]	Number of plants	Biomass yield
	----------no./ft^2--------	---------lbs/acre-------
Mix 1	8.2	162
Mix 2	9.5	1080
Mix 3	6	570
Mean	7.9	604
CV %	66	79
LSD (0.05)	NS	598

[1]Cover crop mixture 1. Non-dormant alfalfa, Persian clover, common vetch, and red clover.
Crop mixture 2. Common lentil, kale, turnip, daikon radish and berseem clover.
Crop mixture 3 a mix of the above two mixtures.

There was a lot of variability in biomass which largely reflected the established plant stand across plots within a treatment. The experience in Dickinson under drier summer conditions with in-season seeding of cover crops suggests that it is a risky practice.

Conclusions

Based on the data from the two experiments the legume mix would not be recommended.
The kale, turnip, radish components in the mix were the best cover crops in the established mixtures.
When seeding into a spring wheat field, the volunteer grain may become the dominant species in the mix.
Under dry conditions the establishment of cover crops can be a challenge.

RESEARCH IN PROGRESS

1. Cover crops as a source of nutrients for bioenergy crops and forage for fall grazing.
   Authors: Marisol Berti, Robert Nudell, Dulan Samarappuli, and Kevin Sedivec

Cover crops in cropping systems

The increasing cost of energy and limited oil and gas reserves has increased the need to develop alternative fuels from renewable sources. Ethanol is one such renewable fuel that has gained interest although current ethanol production from sugar and starch is under intense debate since it may contribute to the increase in global food prices. Alternatively, lignocellulosic biomass has been identified as the future choice of feedstock for ethanol production. Although currently there is a growing interest on forage crops as a potential source of biomass, more focus should be on cropping systems including annual cover crops as potential lignocellulosic feedstock.
A study was conducted to identify the agronomic and forage potential of seven cover crop treatments (3 legume, 3 brassica, and 1 non-cover-crop check) on three different annual biomass crops used as a source of lignocellulosic feedstock for bioenergy production. The experiment was conducted at Fargo and Prosper located in eastern North Dakota. Six cover crop species were planted on 8 to 9 August in 2010 and 2011 following oat Four biomass/forage crops were planted after the cover crops in the spring of each successive year and compared with a check without cover crop. All forage crops were fertilized with 50 kg N/ha at about V8 stage.

Results across locations and years indicated the cover crop forage pea (*Pisum sativum* L. cv. Arvika) produced the highest biomass dry matter yield (3.48 Mg/ha) in the fall before the killing frost (Table 7). The legume cover crops had the highest crude protein content and ranged between 23 and 25.2 % while radishes and turnips ranged between 14.1 and 15.6 %. Forage pea N uptake was 127 kg N/ha and significantly higher than all other cover crops. Nitrogen uptake from turnip and radishes fluctuated between 69 and 76 kg N/ha which we assumed was part of the residual N left in the soil after the cereal crop. If we subtract the N uptake radish and turnip crops to the total N uptake from forage peas we can estimate the biological dinitrogen fixation of peas. Forage pea biological dinitrogen fixation was about 60 kg of N/ha in only 40 days growth in the fall.

Table 7. Biomass yield, crude protein (CP), and nitrogen uptake of cover crops, means across locations and years, Fargo and Prosper, ND, in 2010 and 2011.

Cover crop	Biomass yield	CP	Nitrogen uptake
	------Mg/ha------	---% dry matter--	----kg/ha---
Forage pea	3.48	23.0	127
Austrian winter pea	2.98	24.0	87
Hairy vetch	2.44	25.2	88
Forage turnip (Pasja)	3.16	14.1	69
Purple top turnip	3.15	15.6	68
Forage radish (Daikon)	3.78	14.1	76
LSD (0.05)	0.8	3.6	36
CV, %	29.6	13.8	37

The annual dedicated energy crops corn sweet sorghum, and forage sorghum biomass yield were 2 to 7 Mg/ha higher than the check when following a legume cover crop. Corn, sweet sorghum, and forage sorghum biomass yield increased 0.8, 6.6, and 4.5 Mg/ha, respectively, following forage peas compared with the check treatment with no cover crop. Sweet and forage sorghum produced higher biomass yield than corn (Table 8). Forage oat and forage barley biomass yield increased 2 Mg/ha and 1.7 Mg/ha when following forage peas compared to the check treatment with no cover crop and 50 kg N/ha from fertilizer.

Biomass yield of oat, corn, and sweet and forage sorghum increased significantly following the forage radish, cv. Daikon. It is presumed that the remobilization of nutrients from deep in the soil and increased water infiltration might account for this effect. The shallow rooted leaf turnip x radish hybrid (Pasja) and Purple top turnips did not increase forage crops biomass yield significantly except for forage sorghum biomass yield which increased 4.9 Mg/ha when planted after Purple top turnip.

Table 8. Biomass yield of five forage crops planted following six cover crops across two locations at Fargo and Prosper, ND, in 2011.

Cover crop	Forage oat	Forage barley	Corn	Sweet sorghum	Forage sorghum	Mean cover crop
	-------------------------------------Mg/ha------------------------------------					
Forage pea	7.1	5.9	18.5	26.1	26.2	17.9
Austrian winter pea	6.3	5.3	18.8	27.9	29.6	18.9
Hairy vetch	5.5	4.2	19.8	23.9	25.3	17.0
Forage turnips (Pasja)	5.4	4.8	18.4	20.3	23.6	15.6
Purple top turnip	5.7	4.4	18.1	24.4	22.5	16.2
Forage radish (Daikon)	6.2	4.8	16.2	21.6	25.4	16.1
Check	5.1	4.3	17.7	19.5	21.7	13.9
Mean forage crop	5.9	4.8	17.9	24.0	25.1	
LSD(0.05) cover crop						2.5
LSD (0.05) forage crop						12.6
CV, %	27.5					

Crude protein content was higher than the check when following forage peas only in forage oat and corn. The CP increase was about 1 percentage point for both crops (Table 9). The lower CP content of corn, sweet and forage sorghum was due to the harvest was conducted at the end of the season as lignocellulosic feedstock not forage, hence the very low forage quality.

Table 9. Crude protein content of five forage crops planted following six cover crops across two locations at Fargo and Prosper, ND, in 2011.

Cover crop	Forage oat	Forage barley	Corn	Sweet sorghum	Forage sorghum	Mean cover crop
	---------------------------------% dry matter---------------------------------					
Forage pea	11.1	9.1	5.8	4.4	4.7	6.8
Austrian winter pea	9.7	11.0	4.6	3.6	4.5	6.2
Hairy vetch	9.5	11.0	5.2	4.5	4.2	6.4
Forage turnip (Pasja)	9.2	10.3	5.3	3.9	4.0	6.1
Purple top turnip	9.7	10.8	5.2	3.9	4.1	6.3
Forage radish (Daikon)	9.1	10.6	4.6	3.4	3.8	5.9
Check	10.1	10.5	4.7	4.5	5.0	6.6
Mean forage crop	9.7	10.7	5.0	4.3	4.0	
LSD(0.05) cover crop						0.6
LSD (0.05) forage crop						1.1
CV, %	14.6					

Nitrogen uptake was significantly higher in all forage crops when following legume cover crops compared with the check with only 50 kg N/ha from fertilizer (Table 10). Crops following forage peas had the greatest N uptake.
It can be concluded then that the higher biomass yield of crops following forage peas is was probably due to the additional N provided by the legume.

Table 10. Nitrogen uptake of five forage crops planted following six cover crops across two locations at Fargo and Prosper, ND, in 2011.

Cover crop	Forage oat	Forage barley	Corn	Sweet sorghum	Forage sorghum	Mean cover crop
	----------------------------------kg N/ha----------------------------------					
Forage pea	127	86	174	182	198.8	158
Austrian winter pea	98	93	137	161	215.0	146
Hairy vetch	83	74	164	171	171.0	133
Forage turnips (Pasja)	79	78	157	125	150.6	121
Purple top turnip	89	76	151	153	149.0	125
Forage radish (Daikon)	90	82	120	116	153.8	116
Check	82	73	133	139	173.6	113
Mean forage crop	92	82	143	148	165.4	
LSD(0.05) cover crop						21
LSD (0.05) forage crop						36
CV, %	31					

2. <u>Forage brassicas in the Northern Plains: An eco-friendly supplemental forage and cover crops</u>

Authors: Marisol Berti, Kevin Sedivec, Joel Caton, Guojie Wang, and Osvaldo Teuber

The objectives of this research include: i) identify forage brassicas with high forage yield and quality and determine optimum management strategies when grown as either full-season or cover crops; ii) evaluate forage brassicas as alternatively grazed forage for beef cattle in terms of nutrient supply, intake, and digestion, and iii) develop educational programs and materials for farmers and ranchers on best use practices of forage brassicas. Anticipated short-term outcomes will include improving Northern Plains grower's knowledge of forage brassica management and the advantages of grazing brassicas on animal performance. Intermediate-term outcomes will include increased use of forage brassicas in farm cropping systems that have a livestock operation. More importantly, the knowledge of brassica forage effects on soil health will not only give the producers insights about the sustainability of their cropping management, but also fill the gap in the scientific realm. A unique outcome of this project is novel information on how forage brassicas contribute to grazing livestock operations in terms of intake, nutrient supply, and extended grazing season for beef cattle. This new information will better equip producers to make management decisions regarding the use of forage brassica in holistic approaches to improving sustainable agroecosystems. Replicated experiments designed to answer the above-indicated objectives will be conducted at Prosper, Carrington, and Streeter, ND starting fall of 2012 until 2014. The experiments will include the evaluation of seven forage brassicas in different seeding dates ranging from early spring to mid-August. Beef cattle will be used to compare selected forage brassicas, against a native range control in forage nutrient quality, intake, digestion, and nutrient supply during late fall and winter grazing settings.

3. <u>Double- and relay- cropping systems for oil and biomass feedstock production in North Central region</u>

Authors: Marisol Berti, Burton Johnson, Russ Gesch, Yun Ji, Wayne Seames, Alfredo Aponte

The ability to integrate bioenergy feedstocks into existing agriculture production systems without straining existing food, feed, and fiber supplies requires advanced crop management coupled with flexible, comprehensive biomass conversion processes. This project focuses on two strategies to advance towards this objective, 1) the development of cropping systems and management practices that allow for the integration of large scale production of oilseed crops into agriculture systems with minimal impact on existing production systems and 2) the use of forage biomass in more complicated, emerging conversion systems that can convert lignocellulosic feedstock into renewable transportation fuels plus chemicals and animal feed co-products. Five task topics associated with meeting the objective strategies include evaluating: i.) field experiments utilizing winter camelina and forage sorghum in advanced cropping systems that include relay- and double-cropping systems, ii.) biomass preparation, pretreatment and hydrolysis to sugars, iii.) sugar bioconversion to triacyl glyceride oil, iv.) triacyl glyceride oil conversion to diesel fuel, and v.) cost and economic analysis of the entire production chain to assess process feasibility. The project will be accomplished by four partner entities with capabilities in different disciplines; ranging from crop production to product conversion and refining. The proposal includes a land-grant University (North Dakota State University), a federal agency (ARS-USDA laboratory Morris, MN), a non-land grant University (University of North Dakota), and a commercial partner (Menon & Associates).

The first task of the project, advanced double-cropping systems evaluation, was started on 1 September. Winter camelina, cultivar Joelle, was planted at Prosper and Carrington, ND, and Morris, MN, on 29 August, 1 September, and 14 September, respectively. The experiments were designed as randomized complete blocks with a split-plot arrangement, where the main plot was winter camelina or fallow and the sub-plot the spring crops, yet to be planted, forage sorghum either double or relay, soybean, and corn. Germination and emergence was successful at all sites. Spring crops will be planted in May and June according to the plan. The graduate student in charge of collecting the data and carry out the field experiments joined NDSU the first week of January of 2012.

Forage sorghum cultivars brown-mid-rib (BMR) and non-BMR from variety trials were ground to 2-mm and sent to the University of North Dakota team for pretreatment experiments. Once they succeed on the pretreatment optimization they will send the pretreated material to Menon & Assoc. for microbial digestion and conversion to triacylglycerides.

GENERAL CONCLUSIONS

In summary, all studies indicate that using of cover crop legumes provide additional nitrogen to the following crop increasing its biomass yield and N uptake and providing soil cover during the fall and winter months, however these results are only applicable to eastern North Dakota where rainfall is greater than 20 inches/season.

Although results indicated in this report support the use of cover crops in North Dakota it is very important to emphasize that most of the results here presented are from locations East of the Missouri river and mainly in the Red River Valley. The use of cover crops is a riskier practice as one moves West in North Dakota because of the failure of the cover crops to establish and grow due to the lack of moisture following the cereal crop. Certainly the minimal data collected at Dickinson, ND, indicate this, but even those data were 'better' than data collected at some other locations, where virtually no above-ground biomass was produced in any year. Therefore, data generated in the Red River Valley or east of the Missouri River may not be transferrable, even following significant modification, to western North Dakota.

PUBLICATIONS (list within each category)

Abstracts

Berti, M.T., B.L. Johnson, R. Gesch, W. Seames, Y. Jin, and S. Orchard. 2012. Double- and relay- cropping systems for oil and biomass feedstock production in North Central region. North Central Region Sun Grant Center annual meeting. 10-11 January, 2012, Indianapolis, IN.

Anfinrud, R., and M.T. Berti. 2011. Nitrogen uptake and biomass and ethanol yield of forage crops as feedstock for biofuel. ASA National Meeting, 16-20 October 2011, San Antonio, TX.

Samarappuli, D., and M.T. Berti. 2011. Use of cover crops as supplemental fall forage and as a nutrient source for following biomass crops. ASA National Meeting, 16-20 October 2011, San Antonio, TX.

Berti, M.T., and R. Anfinrud. 2011. Nitrogen uptake and biomass and ethanol yield of forage crops as feedstock for biofuel. p. 32. *In* Johnson, B.L. and M.T. Berti, (eds.), 23nd Annual AAIC Meeting-2011 Challenges and Opportunities for Industrial Crops: 11-14 September 2011, Fargo, ND.

Samarappuli, D.P., and M.T. Berti. 2011. Biomass crops productivity affected by cover crops. p. 33. *In* Johnson, B.L. and M.T. Berti, (eds.), 23nd Annual AAIC Meeting-2011 Challenges and Opportunities for Industrial Crops: 11-14 September 2011, Fargo, ND.

Non-refereed reports

Carr, P., and T. Winch. 2011. Evaluation of Organic Zero-Till (OZ) for Corn and Dry Bean Production–North Dakota, 2011. IOP progress report. Dickinson Research Extension Center.

Journal articles

Carr, P.M., R. L. Anderson, Y. E. Lawley, Perry, R. Miller, and S.F. Zwinger. 2011. Organic zero-till in the northern US Great Plains Region: Opportunities and obstacles. Renewable Agriculture and Food Systems available at doi:10.1017/s174217421705110004 1X.

Extension publications

Berti, M.T., and S. Zwinger. 2011. Cool-Season Annual Forages for Hay in North Dakota. Forage Focus. May 2011. Midwest Forage Association, St. Paul, MN.

Berti, M.T. and H. Kandel. 2011. Prevented planting options. Forage Clippings. 14 July 2011. Available at http://www.midwestforage.org/newsletter/110714clippings.htm Midwest Forage Association, Saint Paul MN.

Berti, M.T. and H. Kandel. 2011. Prevented planting options. p. 4-6. Bull. 11. Crop & Pest Report. 14 July 2011. North Dakota State University Extension Service, Fargo, ND.

Grants

USDA/NIFA-SUNGRANT Initiative (2011-2013)
PI: Marisol Berti
Project name: Double- and relay- cropping systems for oil and biomass feedstocks production in North Dakota.

IMPACT STATEMENT (no more than 4 sentences)
Cover crops will impact North Dakota's economy by improving soil health, nutrient cycling, productivity of grain and energy crops, reducing expensive nitrogen inputs, and as a source of supplemental summer and fall forage.

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Alleviating Soil Compaction and Improving Weed Suppression with Multi-Functional Cover Crops in Organic Grain Production Systems

Alfonso Suarez-Tapia
Maria B. Villamil
John Masiunas
Daniel Anderson

On Spring 2011, three organic farmers were identified for this project: Allen Williams (Cerro Gordo,IL), Jack Erisman (Pana,IL), Aaron Bulter (Malta,IL). All of them have more than five years of experience with organic corn and soybeans. During June and July 2011, research plots were laid out on compacted and non-compacted areas were identified by the farmers. Fields are designated as Williams, Butler, Erisman A and Erisman B. In each location, two compacted areas were paired with two non-compacted areas. Each compaction level was split in four, with plot size being 20 ft x 50 ft, and one of the four cover cropping treatments was assigned randomly. Recordings of a cone penetrometer SC900 (Spectrum Technologies Plainfield, IL) were performed to confirm compaction levels, confirming statistical difference between compacted and non-compacted fields. The experimental design is a spit plot design, where the whole plots are the two compacted areas. There was a significance difference between compacted and non-compacted areas in each farm ($p<0.001$) verified by the penetrometer at 2.5 cm increments. Samples were taken after 2 or 3 days after a rainfall event. Each compaction level was split in four and one of the cover crop treatments was allocated randomly. The subplot treatments were forage radish; for this project we used the tillage radish (TR) brand, hairy vetch (HV), rye, and buckwheat (BW). Each fall a soil sampling will be conducted before planting the cover crops and again in the spring of each year before planting the grain crops.
Soil samples will be collected on Spring and at the end of the main crop season of every year. Preliminary soil samples were collected on late August from three randomly located sites on every plot. The samples were undisturbed soil cores obtained at four different depths (0-10 cm, 10-20cm, 20-30 cm and 30-40cm) using a split core sampler (Eijkelkamp Agrisearch. Giesbeek, Netherlands) for a total of 768 samples. These undisturbed cores are currently being analyzed for fertility (0-10 cm), bulk density, moisture, total C and N, inorganic N, and water aggregate stability (WAS).
Soybeans will be planted on May 2012 and May 2014. Yield components will be evaluated and correlated with the soil physical and chemical properties previously determined.

Winter Cover Crops and Soil Compaction Alleviation Effects

Juan C.M. Acuña, Shin-yi Lee Marzano, and María B. Villamil

A field experiment was conducted at the Crop Sciences Department Research and Education Center in Urbana, IL on poorly drained soils representative of the soils in the state. Four levels of compaction and six levels of cover crops will be combined in a factorial arrangement to provide a total of twenty four replicated treatments. The different levels of soil compaction will be established using a John Deere 7210 Tractor (axle load 4.45 Mg with pneumatic tires) for the low compaction, a John Deere 8225 Tractor (axle load 9.5 Mg with solid rubber tires) for the medium compaction, and a Top Kick Fuel injection GMC Truck (axle load 9 Mg) for the high compaction treatments. No tractor traffic will occur for the no compaction treatments. The cover crops treatments include: No cover crop; Tillage radish; Tillage radish + rye; Tillage radish + triticale; and Tillage radish + buckwheat.

Measurements: In each plot, we measured soil compaction and soil quality changes and physiological characteristics and yield of the following soybean crop. Soil compaction alleviation was measured through changes in soil physical parameters (bulk density and penetration resistance). Soil quality will integrate determinations of soil physical properties (bulk density, penetration resistance, water aggregate stability, infiltration, temperature, and water content); soil chemical properties (pH and nutrient cycling and availability [nitrogen and phosphorus]); and soil biological properties (soil organic matter [SOM], microbial biomass, activity and diversity). Soil determinations were carried out following the procedures in the Soil Survey Laboratory Methods manual (USDA/NRCS, 2004). During the crop growing season we measured emergence, leaf area index, and crop yield and yield components under the different treatment combinations following standard procedures.
First year findings: Interaction of compaction level, cover crop and depth were statistically significant for soil penetration resistance ($p<0.001$). Bulk density values showed a significant interaction of the compaction levels with depth ($p<0.001$) yet no effect of the cover crops were evident. Similarly, water aggregate stability was not affected by cover crops but showed a significant interaction effect for compaction levels with depth ($p<0.001$).
No significant differences in soil organic matter were observed after the first cover crop season. Soybean yields showed no significant differences among compaction levels ($p<0.001$). Similarly there were no differences in soybean yield between cover crop treatments except for the rye cover crop treatment that yielded significantly less ($p<0.001$). Results reported are preliminary.

MARYLAND COOPERATIVE EXTENSION
UNIVERSITY OF MARYLAND
COLLEGE PARK•EASTERN SHORE

Fact Sheet

Fact Sheet 824

Forage Radish:
New Multi-Purpose Cover Crop for the Mid-Atlantic

Forage radish (*Raphanus sativus* var. *longipinnatus*) is a unique fall/winter cover crop that is relatively new to the mid-Atlantic region. It is a member of the Brassica family, which also includes rapeseed, canola, mustard, and cabbage. Forage radish is also known as 'Daikon' (sometimes spelled 'Dichon') radish or 'Japanese' radish and is used as a vegetable in many types of Asian cuisine. When planted by early September in the Mid-Atlantic region, forage radish exhibits a number of unique and desirable characteristics that distinguish it from other types of cover crops more commonly grown in the region.


Oilseed radish (left) and forage radish (right).

Oilseed radish (*Raphanus sativus* var. *oleiformis*) cultivars such as 'Adagio' or 'Colonel', are similar to the forage radish, but have a stubbier, more branched taproot and tend to be somewhat more winter hardy than the forage radish ('Daikon'). The precise classification of these and other types of radishes is not well established because they can readily cross-pollinate and therefore distinctions among subspecies are often blurred. Most of the traits and management recommendations described here for forage radish should also apply to oilseed radish.

Forage Radish Traits

- Extremely rapid germination and growth
- Large, deeply penetrating taproot
- Winter-kills
- Quick to decompose residues
- High nutrient (N, P, S, Ca, B) content
- Bioactive plant chemicals (glucosinolates)

Multiple Benefits from One Cover Crop

Because of its unique plant characteristics, a forage radish cover crop can provide measurable benefits to the farmer, the soil, and the environment while avoiding many of the problems traditionally associated with cover crops. As a result, farmers are finding that a forage radish cover crop pays for itself with tangible benefits.

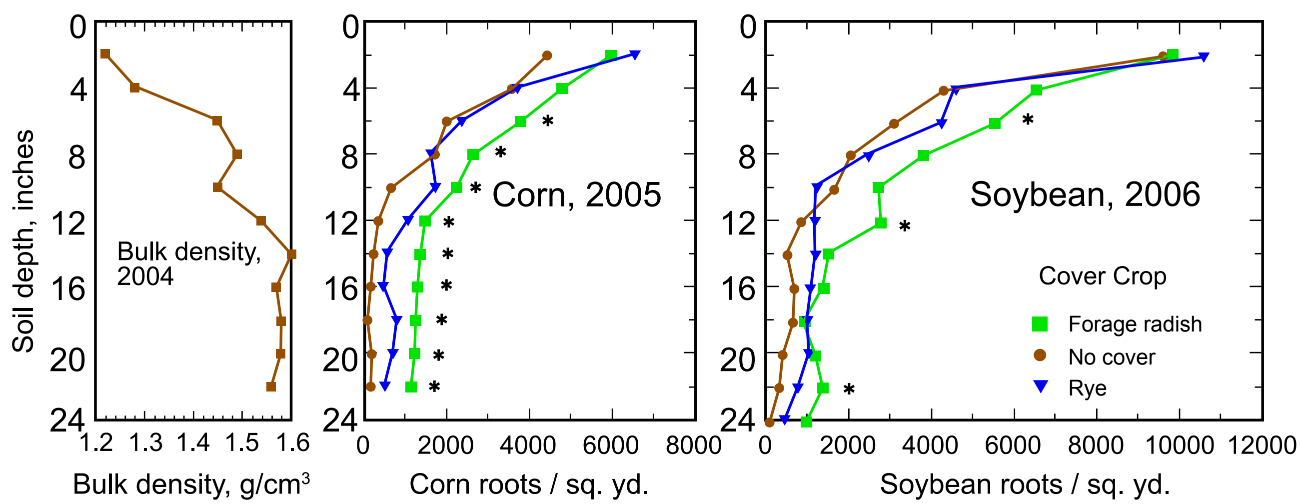
Alleviation of Soil Compaction

Forage radish cover crops are used by many farmers as a biological tool to reduce the effects of soil compaction, leading some farmers to refer to this cover crop as "tillage radish" or "radish ripper." The roots of cool season cover crops can penetrate compacted soils in fall to some extent because they are growing when soils are likely to be relatively moist and easily penetrated. Forage radish roots can penetrate plow pans or other layers of compacted soil better than the other cover crops (such as cereal rye and rapeseed) tested in our research. The thin lower part of the taproot can grow to a depth of six feet or more during the fall. The thick, fleshy upper part of the taproot grows 12 to 20 inches long (including 2 to 6 inches protruding above ground) creating vertical holes and zones of weakness that tend to break up surface soil compaction and improve soil tilth. After the cover crop dies in the winter and the roots decompose, the open root channels can

Multiple Benefits

Forage radish has been shown to:

- Alleviate soil compaction—save on deep tillage
- Suppress weeds—save on herbicides/cultivation
- Enhance seedbed—save time and plant earlier in spring
- Build organic matter—improve soil quality
- Release N early and increase topsoil fertility—save on N and other fertilizers
- Reduce nitrate leaching—save the Bay
- Control erosion—save your soil
- Reduce runoff—conserve rainwater



Summer crop roots in soil profile as affected by previous cover crop. Bulk density of the soil (left, measured before cover crop treatments) shows the typical higher density found in subsoils. Chen and Weil (2006).

be used by roots of following crops to grow through compacted soil layers.

This process, termed "bio-drilling," improves root access to water in the subsoil and makes following crops more resilient under drought conditions. In research plots, four times as many corn roots penetrated a compact subsoil after a forage radish cover crop as after winter fallow and twice as many as after a rye cover crop.

Data suggests that biodrilling with cover crops like forage radish can substitute for expensive and energy intensive deep ripping and other mechanical methods to alleviate the effects of soil compaction. Some farmers plant forage radish in 24- or 30-inch wide rows (with another cover crop species planted between rows—see cover crop mixtures, below) as a form of biological strip tillage. They then plant the following summer crop in these same rows to alleviate restriction of root growth into the subsoil.

Suppression of Weeds

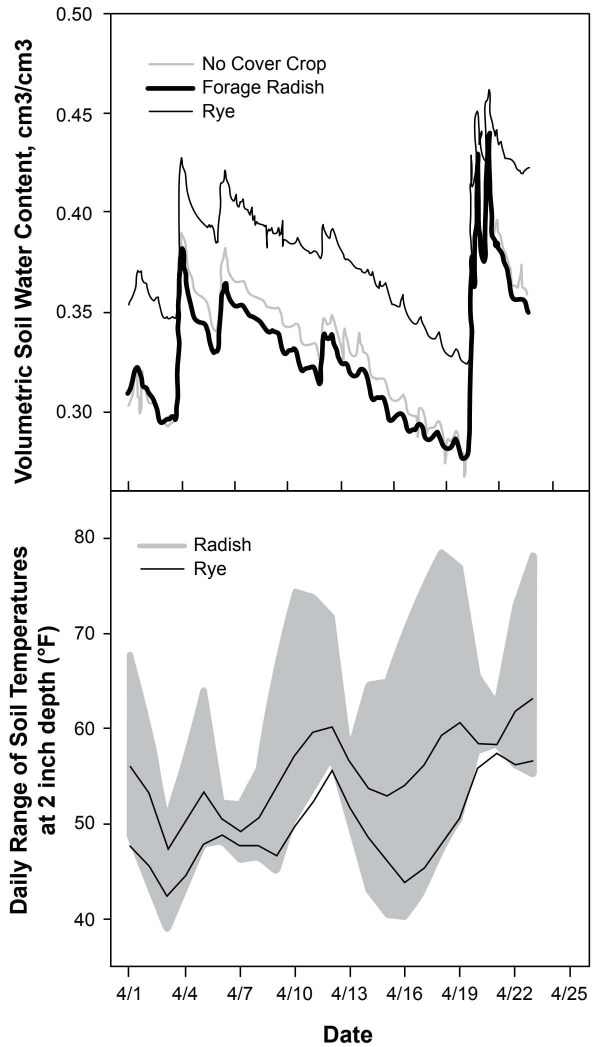
A good stand of early-planted forage radish produces a dense canopy that all but eliminates weed emergence in the fall and winter. This action produces a virtually weed-free seedbed in early spring. To obtain this near-complete weed suppression forage radish should be planted by September 15 (in Maryland) with a stand of 5 to 8 plants per square foot.

Early April appearance of plots planted in fall to cereal rye (left) and forage radish (right).

The near-complete weed suppression can be expected to last until early April, but does not extend into the summer cropping season. The low amount and fragility of residue and weed-free seedbed conditions in early spring following a forage radish cover crop make it possible to plant the summer crop without any seedbed preparation tillage or application of a burn-down (pre-plant) herbicide. In Maryland research where in-season (post emergence) weed control was applied, yields of corn planted after a forage radish cover crop were not affected by skipping the burn-down herbicide before planting.

This system may be of particular interest to organic farmers because it allows no-till planting without herbicides, although cultivation or other weed control will be needed later in the season. Forage radish cover crops have also been observed to suppress or delay the emergence of horseweed or marestail (*Conyza canadensis*) and may provide a useful new tool for controlling herbicide-resistant biotypes of this weed.

Early corn growth was more vigorous after a forage radish cover crop (right, back) than after a rye cover crop (left, front), due partly to better N availability.



Warmer and drier seedbed in April with forage radish compared to rye as cover crop. (Weil and White, unpublished)

Enhancement of Seedbed

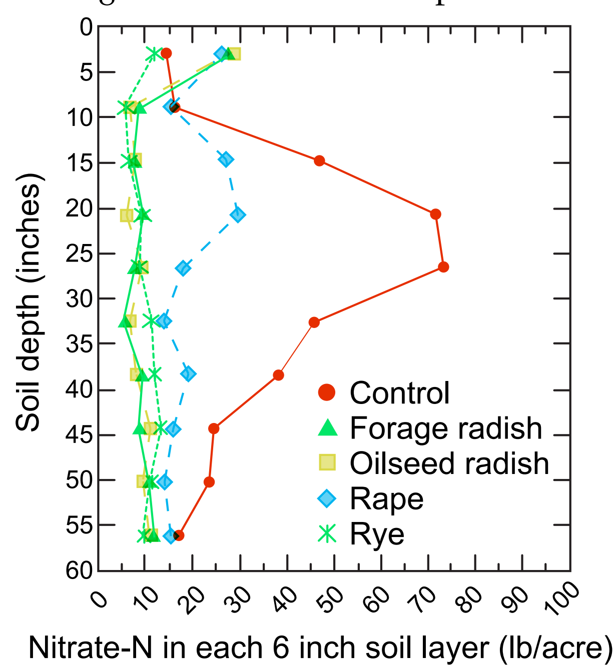
Unlike most other cover crops commonly used in the Mid-Atlantic, forage radish won't complicate or delay spring field operations. Because it winter-kills, it does not need to be killed or incorporated to prepare a spring seedbed. When conditions are favorable, the field will be ready for direct planting. Because forage radish leaves the soil surface weed free, punctured by large root holes, and covered by very thin and sparse residue, the seedbed soil warms up and dries out considerably faster in early spring than do soils covered by either winter weeds or a growing cover crop.

The warmer, drier soil and the elimination of the need for tillage can allow earlier spring planting. The earlier planting made possible by the forage radish cover crop may be important for effective utilization of the N released from the forage radish residue in early spring.

Early Release of N and Increase in Topsoil Fertility

Unlike cereal rye and other cereal cover crops whose residues decompose slowly and immobilize N in the spring, forage radish residue decomposes rapidly and releases its N early. In fact, on sandy soils it is important to plant as early as possible following forage radish cover crops to take advantage of this flush of N before it leaches out of the rooting zone. Forage radish recycles large amounts of N taken up from the soil profile in fall and can reduce the need for N fertilizer in spring.

Because forage radish cover crops do not immobilize N, they are unlikely to slow down growth of the next crop as small



Forage radish and other cover crops clean up nitrate from a sandy soil profile by mid-November. Control soil had no cover crop, only winter weeds. (Data from Dean and Weil, 2009)

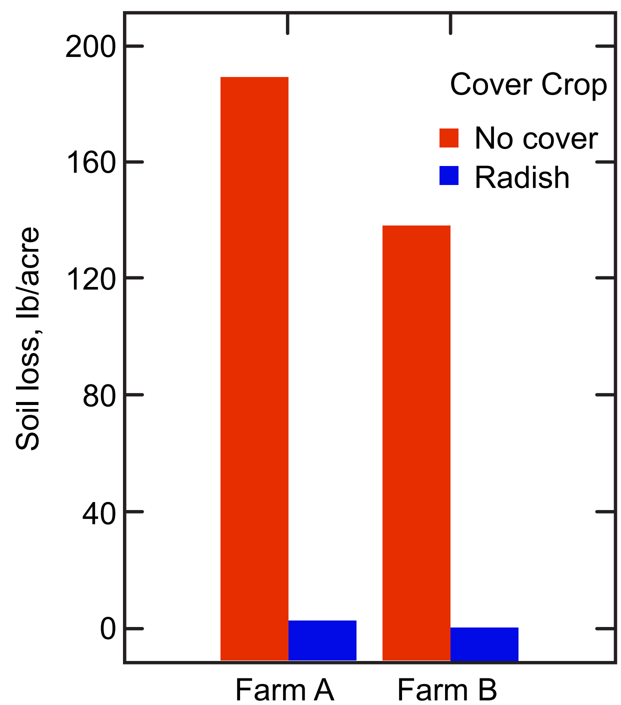
grain cover crops sometimes do. In fact, spring planted crops often show an early boost in growth and N uptake similar to that caused by a planting time N application.

Reduction of Nitrate Leaching

Because of their exceptionally deep root system, rapid growth and heavy N feeding, forage radish cover crops can clean up most of the soluble N left in the soil profile after summer crops have ceased their uptake. This prevents excess N from leaching into groundwater during the fall/winter/spring period, during which there would be little or no plant evapotranspiration or N uptake if fields were left fallow. The forage radish takes up N from both the topsoil and from deep soil layers, storing the N in tissues near the soil surface for use by the next crop. If planted while soils are still warm, forage radish cover crops typically take up 100 to 150 lb/acre of N. Greater amounts of N may be taken up by forage radish when a drought-stricken summer crop has failed to utilize most of the fertilizer applied or on soils that mineralize large amounts of N in the fall due to previous manure applications.

Control of Soil Erosion and Runoff

Forage radish grows rapidly if planted in late summer or early fall and a good stand can provide full canopy closure in three to four weeks. This canopy intercepts raindrops, preventing soil erosion. Even after forage radish is killed by a hard frost, a layer of decomposing residue remains on the soil surface through the winter and into the early spring providing protection from soil erosion. After surface residues have fully decomposed in spring, runoff and erosion are reduced because of the many



Erosion from three February–March storms was negligible for forage radish despite rapid decomposition of the surface residues. (Weil, 2009)

holes left behind from the large taproots. Rainwater rapidly infiltrates into these holes, eliminating runoff and trapping sediment before it leaves the field.

Building of Soil Organic Matter

With typical dry matter production of 5,000 lb/acre shoots plus 2,000 lb/acre of root dry matter, a good forage radish cover crop adds significant quantities of easily decomposed organic material to the soil. Microbially active soil organic matter and aggregation have been observed to increase after using forage radish for several years.

Effects on Crop Yields

In about half of our trials that included a good stand of forage radish, yields of corn (with normal N fertilizer rates) and soybean following the forage radish cover crop were significantly higher than those after fallow or cereal rye. These yield increases may be due to improved N fertility, alleviation of soil compaction, or other effects.

How to Grow Forage Radish as a Cover Crop

Seeding

Establish a good stand of forage radish by seeding at 8 to 10 lb/acre using either a conventional or no-till drill (using either the box for small seed or large seed) or by broadcasting at 12 to 14 lb/acre. When using a drill, seeds are best planted ¼-inch deep when moisture conditions are good, but can be planted as deep as 1 inch during dry conditions if this is necessary to place seed in contact with soil moisture. When broadcasting, germination will be best if seeder is followed by a corrugated roller or very light disking to improve soil-seed contact.

Aerial seeding has been successful using 14 to 16 lb/acre broadcast into standing corn or soybean canopies that have begun senescence (yellowing of lower leaves). Forage radish usually germinates within just 2 to 3 days if the soil is warm and not too dry. Even unincorporated broadcast seed will achieve rapid germination if seeding is followed by a timely rain or irrigation.

Most forage radish seed is produced in Idaho or imported from Asia and Europe. Seeds similar to those used in this research are currently available from Leon Bird Seeds (3282 East State Route 18, Tiffin, OH 44883, 800-743-2473) and Steve Groff Seeds (679 Hilldale Road, Holtwood, PA 17532, 717-575-6778).

Forage radish has a very flexible and aggressive growth habit and will spread out in a rosette to fill the space it is given. Radish plants—especially their fleshy root—will become much larger when grown at lower plant densities.

Planting Date

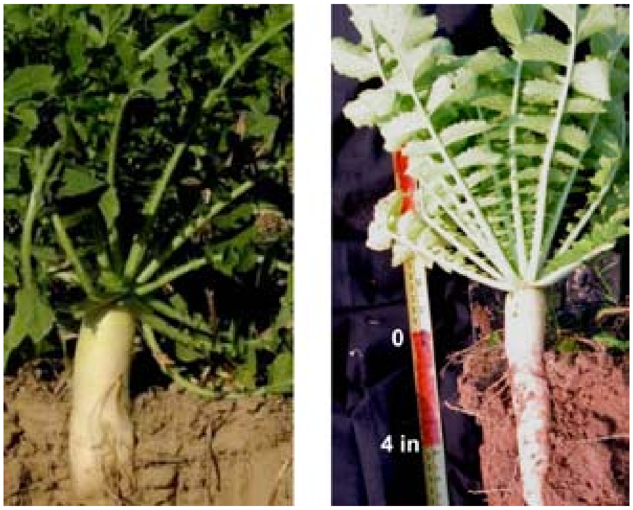
In the Mid-Atlantic forage radish grows best when planted from late July to early September but significant amounts of N can be captured by this cover crop when planted as late as October 1. Forage radish planted in late September may be less susceptible to frost and more likely to overwinter. When planted in late March as a spring cover crop, forage radish did not emerge quickly or grow as well as when planted in fall.

Frost

Forage radish is tolerant of frost until temperatures dip below 25°F. It takes several nights of temperatures in the low 20s to kill forage radish. If mild temperatures resume and the growing point is intact, green leaves may grow back. Usually in Maryland forage radish is damaged by frost by early December but does not die completely until the longer cold spells of January. Under the freeze–thaw winter conditions of the Mid-Atlantic, forage radish tissues decompose rapidly once killed by frost and leave only a thin film of residue by March.

Crop Rotations

Forage radish winter cover crops fit well into corn silage and vegetable crop rotations that have openings for cover crop planting by the end of August. Forage radish has successfully been aerially seeded in early September into standing corn and soybeans on commercial farms. Because forage radish seeding rates are low, the seed may be mixed with other cover crop seed of similar size to bulk it up for more even



Fully grown forage radish plants showing variation in size and root formation with differing populations.

aerial seeding. If forage radish is planted as late as a September 30 grain corn harvest, it is unlikely to provide effective biodrilling and weed suppression, but may still capture nearly as much N as earlier plantings.

Cover Crop Mixtures

Many farmers are experimenting with cover crop mixtures that combine forage radish with other cover crops that fix N or provide N immobilizing residues in the spring. Because forage radish can out-compete most other plants in early fall, seed forage radish in rows one to two feet part to allow enough space for a companion cover crop to grow in between. Taping-off alternating openers in the small and large seed boxes of a no-till drill is one way to create alternating rows of forage radish and a companion crop. Alternatively, reducing the forage radish seeding rate by half also allows other cover crop species to compete and stay in the cover crop mix.

Spring oats and sorghum–Sudan grass compete well with forage radish, winter kill in the Mid-Atlantic, and provide longer lasting residues to immobilize some of the N released from forage radish

Forage radish planted alone (left) and in alternating rows with Sudex (right). The Sudex was already frost killed in this late October photo.

residues in the spring. These additional residues may also help maintain soil moisture, reduce weed growth, and reduce erosion during the next growing season. When rye is mixed with forage radish, the rye overwinters and grows into the spring when it can take up the N released by the decomposing forage radish. Hairy vetch is an N fixing cover crop that overwinters and performed well when mixed with forage radish. Sun hemp fixes N but will winter kill with the forage radish in the Mid-Atlantic.

Problems to Avoid

Forage radish does not tolerate very wet soils, so avoid planting it in low spots that collect standing water. Nitrogen deficiency will limit forage radish growth and may limit its ability to compete with weeds or grow through compacted soil. Nitrogen deficiencies have been observed when planting after silage or grain corn on sandy soils or soils that do not have a history of manure application. In such situations, an application of 15 lbs N/acre is sufficient to stimulate rapid initial growth so that the forage radish may be able to capture 100+ lbs of N from deeper in the soil profile. Nitrogen deficient forage radish plants have been observed to be less susceptible to frost and are more likely to overwinter. If they survive the winter, forage radishes may be attacked by harlequin bugs and flea beetles. Also, be warned that during warm spells in winter, decomposing forage radish residues may produce a rotten egg-like odor.

Summary

Forage radish is a unique cover crop that can provide multiple benefits when suitably integrated into your crop rotation. Provision of most of the benefits mentioned depends on timely planting in early fall.

There is still much to learn about this new cover crop, so experiment! Our work with forage radish has been inspired by the creativity of farmers developing solutions to problems on their own farms. We hope that this fact sheet will provide you with information that helps you innovate on your own farm.

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Forage Radish:
New Multi-Purpose Cover Crop for the Mid-Atlantic

by

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PRACTICAL WAYS TO USE COVER CROPS AS BIOFUMIGANTS: SPECIAL REFERENCE TO VEGETABLE CROPPING SYSTEMS IN REGIONS WITH A TEMPERATE CLIMATE

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Brassica cover crops have been used successfully in cropping systems as biofumigants. Brassica cover crops, including oilseed radish, brown mustard, oriental mustard, yellow mustard, turnip, rape, etc. have been shown to provide multiple benefits in cropping systems. Brassica species produce glucosinolates (sulphur containing substrates), which are secondary metabolites, used by plants to defend themselves against biotic and abiotic stresses. Glucosinolates are hydrolyzed by thioglucosidase (myrosinase) enzymes.

Within the plant, glucosinolates and myrosinase enzymes are physically separated. Glucosinolates are stored in the central vacuole while myrosinases are stored in the cytosol. Upon mechanical damage of plant tissue, insect or pathogen attack, these enzymes are released (get in contact with the glucosinolates) and trigger the breakdown reaction sometime referred to as the "mustard bomb." Upon hydrolysis of glucosinolates by myrosinase enzymes, a number of chemicals are released, in which isothiocyanates, thiocyanates, and nitriles are known to be active and to suppress pests, including phytophagous insects, nematodes, weeds, and fungi. Because of the ability of Brassica species to produce those volatile toxic compounds Brassica cover crops are also called biofumigants. The process of breaking down Brassica tissues and incorporating them in the soil is called "biofumigation". When managed adequately, biofumigants have helped reduce the populations of nematodes, weeds, and diseases in cropping systems. The following are practical ways to use brassica cover crop biofumigants in cropping systems and tips to help maximize their benefits.

A. Practical ways to use cover crops as biofumigants

The cropping system, cash crop growing cycle, and cash crop planting method and seed size all affect the way biofumigants are used.

1. **Perennial cropping systems.**

In a perennial cropping system, the cash crop is established for many years of production. Example asparagus (15-20 years of production). There are two main options for fitting biofumigants in tperennial cropping systems.

a. ***Option 1: Cover crops planted prior to cash crop establishment.*** For management of replant suppression problems many asparagus growers have started to use biofumigants between plantings (before establishment of a new crop). While this practice is relatively new benefits can be maximized by using more than on cycle of biofumigation.
b. ***Option 2: Cover crops planted in the fall when the cash crop is going dormant.*** Brassica cover crops are cool season species and can sustain acceptable growth in the

fall if the seedling is well established. Preliminary studies in Michigan indicate that the cover crops can be integrated into established asparagus production fields with significant yield improvement. In the trials the cover crops were seeded between the end of July and Mid August and allow winterkilling by frost. The major constrain for this practice is to develop an adequate planter for drilling the cover crops into an established field. Also the biofumigation potential is limited by the fact that the cover crops are not incorporated into the soil.

2. Annual cropping systems

Annual cropping systems offer more flexibility compared to perennial cropping systems. However, the cash crop dictates how the biofumigants are used. Brassica cover crops are not recommended in rotation systems with brassica cash crops (cabbage, broccoli, ..). The length of the cash crop growing cycle, the type of seedbed and seeding method influence brassica cover crop management practices.

a. Crops with long growing cycle. When the cash crop has a long growing cycle that spans the entire season, the cover crop should be scheduled in the overall rotation system. Typical examples are onions and carrots. These crops are usually planted early in the spring and may not be harvested before late fall. That does not leave a window to grow brassica cover crops within the same season. In that case growers have planted the cover crops the fall prior to cash crop season. That practice has resulted in about 15% increase in onion yield in muck soils under Michigan conditions. That has also helped reduced onion seeding rate by up to 20% with no yield penalty.

b. Crops with medium to short growing cycle. Crops like cucumber, transplanted celery, allow adequate window early or late in the season to grow brassica cover crops. *Option 1. Early spring cover crop.* When planted early in the spring, the cover crops are incorporated into the soil in late May follow by the cash crop 2 to 3 weeks later. *Option 2. Late summer cover crop.* The cover crops are planted after harvest on an early crop like cucumber, snap bean etc. In this case the cover crops in used in preparation for a cash crop the following year (example a crop with long growing season).

c. Direct seeded vs. transplanted crops. A crop established with transplants offers more flexibility for use of brassica cover crops. The plant back period can be shorter since transplants are in more advanced stage of growth and are less affected by cover crop residue than germinating seeds. Direct seeded crops with small seeds like onion, and carrot require a well-prepared seedbed with low residue for adequate operation of the seeder and uniform seedling emergence and establishment. For these crops, the best results have been obtained when the cover crops were planted the previous fall.

B. Tips to help maximize benefits of cover crops used as biofumigants

Table 1. Some of the recommended practices for efficient biofumigation

Factor	Comment
Species and cultivar selection	Use a species or cultivar with high glucosinolates content. Mustard cover crops vary in their glucosinolate content. Species and cultivar selection is therefore critical.
Biomass Production	Maximize biomass production by using appropriate seeding rate, method, and time. Keep in mind that high seeding rates may actually result in low biomass production due to intra-specific competition. It may be necessary to apply some fertilizer to boost growth. Allow the cover crops to grow to full bloom.
Tissue breakdown	Break down plant tissue to trigger the glucosinolate-myrosinase reaction (a flail mower will do an excellent job).
Soil moisture	Adequate soil moisture is critical during cover crop incorporation. Efficacy of biofumigation is reduced significantly when the cover crops are incorporated into dry soil. If necessary use overhead irrigation about 12 hours before cover crop incorporation.
Residue incorporation	Incorporate the residue immediately because most of the break down products are volatile. Depending on soil conditions a roto-tiller or multiple passes of a disk can be used for residue incorporation.
Soil surface sealing	Seal the soil surface (with irrigation or a packer if possible). In plasticulture systems, lay the plastic immediately after cover crop incorporation. The combined effects of biofumigation and anaerobic soil disinfestation may be achieved with the use of plastic mulch.
Plant back period	Brassica cover crop residue is toxic. Avoid planting susceptible crops shortly after Brassica cover crop incorporation. This is especially important for small seeded crop that are direct seeded. However, severe injury has been reported on transplants. Observe a cash crop plant back period of at least 2-3 weeks (depending on the crop).

Table 2. Some practices to avoid during biofumigation

Factor	Comment
Avoid rotation with other Brassica species	Brassica species do not form mycchorizae. Therefore, monoculture practices could reduce mycchorizae in the soil. Rotate brassica cover crops with non-brassica cover crops. Increase in cabbage maggot populations have been observed in some growing conditions after Brassica cover crops and could negatively affect brassica cash crops. Flea beetles are attracted by Brassica cover crops and may increase the risk of crop injury if Brassica cash crops are a component of the cropping system. It is noted that yellow mustards with hear-like structures, 'Ida Gold' being one, are less attractive to flea beetles than Oriental mustards or oilseed radish.
Avoid volunteer cover crops	Viable seed formation by the cover crops could result in serious weed problems with volunteers. Drilling the cover crops (as opposed to broadcast and incorporation) will also reduce the risk of volunteers.

Synergies Between Cover Crops and Corn Stover Removal

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Abstract

As energy consumption continues to rise, alternative energy sources are continually being sought. In 2007, the Energy Independence and Security Act set requirements on the amount of biofuels to be produced in the United States for future years. More specifically, a mandate has been set to increase production of cellulosic biofuels to 16 billion gallons annually by 2022 (Energy Independence and Security Act, 2007). Cellulosic biofuels are derived from several sources. One such source is corn stover, the natural residue of corn. Of the 16 billion gallons mandated by 2022, 7.8 billion could come from corn stover (United States Environmental Protection Agency, 2010).

Corn stover is a crop residue which is identified as the "above ground material left in fields after corn grain harvest" (Karlen *et al.*, 2011). Crop residues, such as corn stover, which typically remain on the field, are responsible in numerous ways for preserving the soil including: reducing wind and water erosion, runoff and nonpoint chemical pollution, and fertilizer dependence, as well as increasing available plant water, drought resistance, and soil nutrient reserves and maintaining or increasing soil organic matter (SOM) and crop performance (Huggins *et al.*, 2011). Corn stover also acts to supply carbon to the soil (Karlen *et al.*, 2011).

Corn is already grown in large quantities for food and feed. The availability of stover makes its use for biofuels attractive. While corn stover is a promising source of biofuels, several concerns have risen about its removal from the fields. Because residues benefit the soil in many ways, among these concerns are the potential nutrient loss, and more specifically, the loss of soil carbon. Furthermore, corn stover is important in maintaining the productivity of the soil. Therefore, increased removal can have adverse effects. Current acceptable removal rates of corn stover vary, but there is evidence to suggest that rates of removal might be limited to around 1/3rd due to the potential negative effects on soil quality and productivity. However, in order to meet biofuel mandates, more stover will need to be collected, increasing removal rates, but precautions will have to be taken in order to ensure the viability of the soil. Research shows that cover crops have many benefits that could mitigate the potential adverse impacts of stover removal. Furthermore, the use of cover crops may allow corn stover to be removed at higher rates, which could potentially increase farm revenues.

At present, cover crops are not widely adopted in the Midwest. A farm study conducted in 2007 reveals that despite the benefits attributed to cover crop use, almost 90% of farmers in the US corn belt had not integrated them into their farming systems in the past five years (Singer *et al.*). This article cites several reasons for this. The five stated reasons are: too much time involved, too costly, no current runoff problem, currently using no-till practices, and finally, not knowing enough about them (Singer *et al.*, 2007). Furthermore, in a different study by the Maryland Department of Agriculture, it was concluded that farmers were concerned about the risks involved, and while they understood the benefits, they might be more likely to integrate cover crops if they had more information (Singer *et al.*, 2007).

In an attempt to bridge the gap between perceived and actual costs and benefits, we have estimated the establishment and termination costs for several cover crops varieties: annual ryegrass, oats, crimson clover, and hairy vetch. Cost estimates range from just over $38/acre for annual ryegrass to about $63/acre for hairy vetch. The wide range in these cost estimates stems mainly from variability in seeds costs. We then analyze two independent and unique approaches to rye. To gain an understanding of a comprehensive cost estimate for establishing and terminating a cover crop, we use published data from the USDA – ARS office in Auburn, AL, which estimates the cost per acre of cereal rye. The second case is from estimates provided from Ault Family Farms (Personal communication with Aaron Ault, 2012).

Next, we attempt to establish a system to quantify the agronomic benefits of cover crops. We have broken these “additional” benefits into five categories: erosion control, soil organic matter, nutrients, soil quality, and increased yields. Descriptive benefits are pervasive in the literature, but a range of dollar benefits is essential to determine the extent to which cover crops can be economically integrated into farm plans. James Hoorman of Ohio State University has assigned some dollar values to the agronomic benefits of cover crops. For better drainage, he estimates about $32/acre in value, $30 – 35/acre for the deep rooted cover crops if deep ripping the soil can be avoided and $30 – 60/year in soil organic matter and stored nutrients (2010). Overall, this estimates savings of about $62 – 67/acre and another $30 – 60/year by using a cover crop.

At present, generally acceptable rates of removal of corn stover are about 1.5 tons per acre, or 33%. By planting cover crops, it is possible to go 50% removal or higher. If the value of stover is at least $40/ton, given initial estimates of cover crop cost estimates, farmers will break even before even considering the additional benefits. Therefore, while cover crops alone appear to offer many benefits, in combination with corn stover removal, we expect a significant increase in benefits to farmers.

While we have estimates for cover crop costs and some preliminary estimates to quantify the range of values for additional cover crop benefits, the next step is to further explore the literature to get the best possible quantitative estimates of the additional benefits provided by cover crops. Also, in addition to analyzing the synergies between cover crops and corn stover removal as a feedstock for biofuels, we will explore another option for cover crop and stover production systems: stover as animal feed.

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Jasper County SWCD Cover Crop Report 2011

Do cover crops work in Jasper County?

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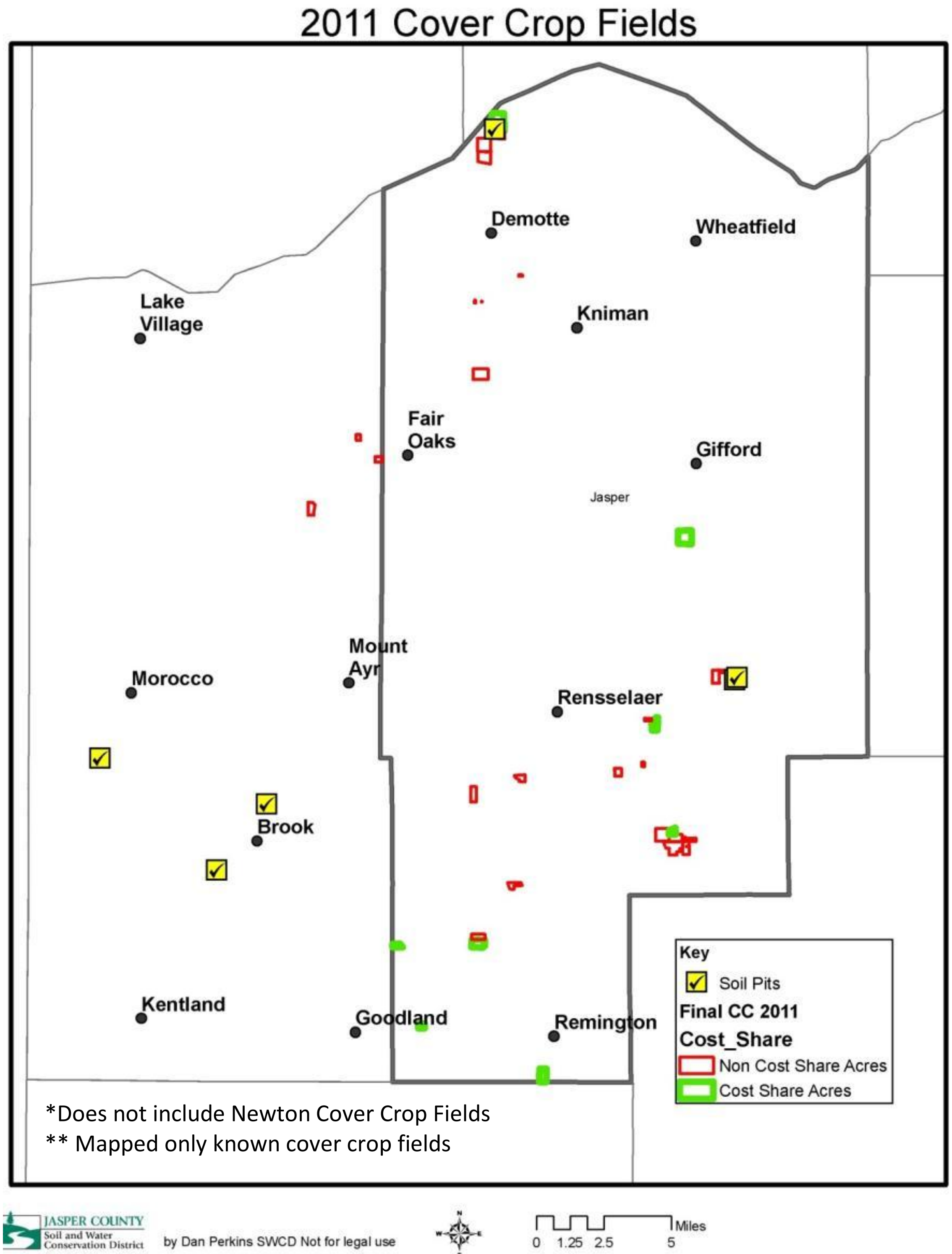

Jasper SWCD Cover Crop Report Fall 2011

In general, cover crops for Jasper and Newton Counties were planted in September and even into mid-October in 2011. I have observed and advised on over 2,200 acres of cover crops in this area, with 10 different farmers. A lot of different cover crop stories are happening and we can say with confidence that cover crops do work in Jasper County! All the information in this report is from cover crops grown in Jasper and Newton Counties.

I have advised on cover crops for use ahead of corn and beans, prevented planting acres, seed corn, after wheat, corn silage, manure situations, irrigated fields, and sub-irrigated fields. We dug 5 soil pits this fall in a variety of crop rotations, soil types, and cover crop mixes. Each field and farm is different and therefore the "right" cover crop can vary a lot.

We had ideal rains for cover crop establishment in 2011. Rainfall total average was 7.5 inches from Aug 15 to Sept 30 (CoCoRaHS network data), compared to just 2.75 inches of rain in 2010 during the same time period. This is the critical establishment window for getting good stands and early growth. Although, many growers seeded well past Sept 30 and are having good stands.

Many growers I talk to mention that their cover crops are not very advanced in their growth and it is mid-November. Does this mean that they are useless or worthless? On Nov 15 and 16 we dug 5 soil pits on a variety soil types and cover crops and this is what we found:

- 21" deep roots on four inch tall Annual Ryegrass
- 15″ deep radish roots that had 2″ tall tops and a "pencil" sized tuber
- 12″ deep crimson clover roots under a 2″ tall top (with many nodules)
- 35″ deep roots on oats that had 20-25″ tall top growth (prevented planting situation planted in early September)
- 30″ deep roots on radishes that had 20-25″ tall top growth and 2-3″ diameter tubers (prevented planting situation planted in early September)
- 20″ deep cereal rye roots with 6″ tall top growth (planted in late August after wheat)

While it would be nice to have more top growth, what's below the soil surface is impressive. As Dr. Eileen Kladivko from Purdue University says…it's what is below the surface that really counts for most farmers.

Earthworms were abundant in the cover crop soils, but not so much in the non-cover cropped fields. Another factor that was impressive was the amount of roots…or the density of the root mass in the soil, even on the short cover crops, this is feeding the soil all winter, building soil health and holding the ground.

So why does this matter? If we are to have better soil structure we need living roots year round, not just during the cropping season. If we are to have better erosion control we need living roots year round. If we are to scavenge nutrients, we need scavenging roots when nutrients are most vulnerable to leaching and loss that is in fall, winter, and early spring. In fact, the roots are what give us the vast majority of the positive benefits most producers find with their cover crops.

A soil pit in your cover crops will really enable you to see the benefits of cover crops. Call you local SWCD and we have professional staff that can point out key features in the pit.

It's hard to believe it, but this short crimson clover had roots over 12" deep. The roots had many nodules on them as well. It will be interesting to see how deep the roots next spring!

Very little top growth does not mean very little root growth. This aerial seeded radish into soybeans had well over 12" of root depth.

These cover crops were flown into a seed corn field in northern Jasper on September2. Both the radish and annual ryegrass had roots over 20" deep.

Top 12 Observations from 2010-2011

1) Aerial applicators seem to be doing a much better job in 2011 than in years past.

2) Correct timing of aerial application into cash crops is vital (that the crops are mature enough for cover crop success). This is going to change year to year based on maturity dates and weather, but in general it seems the first week in Sept is good for seeding into soybeans. Corn is too variable to predict at this point.

3) Corn and soybean variety maturity differences can change "success" rates. If you can plan to use a shorter season corn or bean without sacrificing yield it may be well worth the effort for making the most of a cover crop.

4) It appears that row spacing in soybeans makes a big difference, especially in establishing crimson clover.

5) Rainfall amounts clearly effect stand establishment and early growth with aerial seeding.

6) Plan early for using cover crops and be willing to change the plan as conditions require.

7) Place seed order early (by May), just to get the mixes and varieties needed (varieties do matter!). You can always change or cancel the order.

8) Start small, 20-40 acre field. Oats and radish is a good mix for a first time use of cover crops. They winter kill and establish well in a variety of conditions.

9) Read, talk with other farmers, call your local SWCD office, as they have a list of cover crop users in your area, and plan for success.

10) If you have prevented planting acres, practice good stewardship and try a cover crop!

11) A variety of cost share programs are available! But, the technical advising is probably the most valuable.

12) Please make sure to visit a soil pit in a cover crop field in spring 2012. Mark your calendars for April 3 and 4th for Jasper and Newton Counties.

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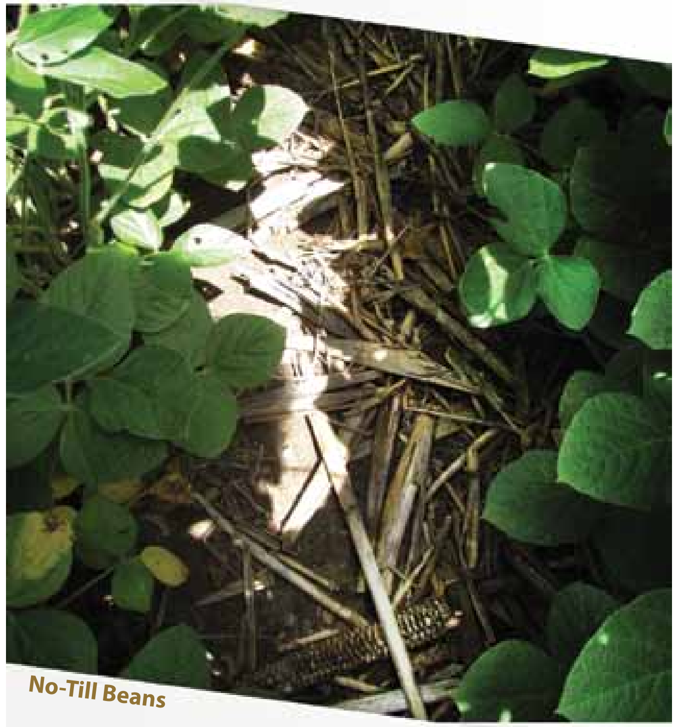

No-Till Beans

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www.iaswcd.org
USDA NRCS in Indiana: **www.in.nrcs.usda.gov**
ISDA: **www.in.gov/isda/index.htm**
Purdue Extension: **http://www3.ag.purdue.edu/extension/**

No-Till Corn

Conservation
Cropping
Systems
INitiative

What is the Conservation Cropping Systems Initiative?

Soil Cover

The Conservation Cropping Systems Initiative (CCSI) promotes a systematic approach to production agriculture. CCSI specialists encourage the adoption of **long-term continuous no-till** practices along with:

- Cover crops,
- Nutrient and pest management,
- Precision-farming technology, and the
- Use of conservation buffers.

The desired result for Indiana cropland is improved soil health and water quality, and profitability for Hoosier farmers.

Through field days, seminars and one-on-one consulting, CCSI experts will show you how to make adjustments in your management practices that can bring environmental and economic success to your operation.

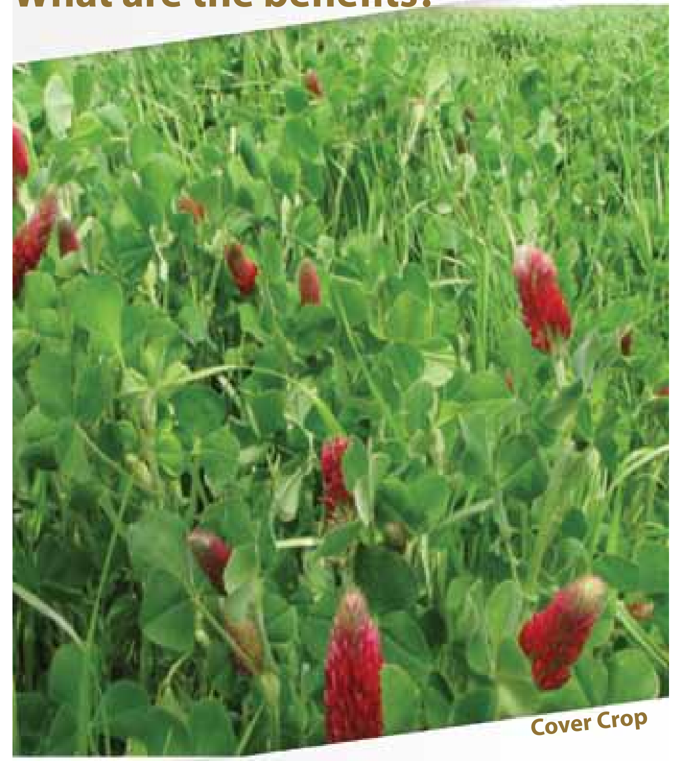
Sustainable cropping is a management strategy

Strip-Till

A sustainable cropping system is a management strategy that protects our natural resources and actually improves our soils. It allows a farmer to efficiently produce food, feed and fiber in an environmentally sound manner. Using this philosophy, a farmer disturbs the soil as little as possible allowing plants, microbes, insects and mother nature to do the work. The result is healthier, more productive soil.

Healthy soil has a balanced biological community and high organic matter with the capacity to retain and cycle nitrogen through a "living" and functioning ecosystem. This is particularly important in much of our Midwestern, system drained, cropland. In healthy soil systems, nutrient management is integrated with conservation crop rotations along with no-till/strip-till, cover crops, precision farming and conservation buffers. These practices are planned and prescribed to complement each other.

What are the benefits?



Cover Crop

The benefits are simple. Less is **more** with a systematic approach to farming:

- Using no-till or strip-till.
- Planting cover crops.
- Applying fewer inputs.
- Using less fuel.
- Improved soil health.

It adds up to less soil compaction, more nutrients in the soil, more moisture when you need it, better drainage, etc.

Just ask the farmers who utilized no-till/strip till and continuous cover crops, what their yields were in the fall of 2011 compared to traditional tillage fields that fell victim to the wet spring and then to the drought of the summer. Sustainable cropping systems protect resources and optimize input utilization.

As an Indiana farmer, you can maximize soil health and profitability. Indiana's CCSI and its partners provide a wealth of information and assistance to help you!