Integrating Cover Crops in Soybean Rotations

Challenges and Recommendations for the North Central Region

NCSRP NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

Midwest Cover Crops Council

Integrating Cover Crops in Soybean Rotations

Challenges and Recommendations for the North Central Region

Acknowledgements

Project Team

This publication was created by the Midwest Cover Crops Council (www.mccc.msu.edu). Contributors represent specialists from land-grant universities and organizations in the North Central Region (NCR). Our findings are based on surveys of farmers and certified crop advisers/agronomists, interviews with farmers, academic research, a review of current literature, and our knowledge and expertise of cover crop use.

Team members for this publication include:

Dean Baas, Michigan State University Extension
Shaun Casteel, Purdue University
David Clay, Drought Center, South Dakota State University
Sharon Clay, South Dakota State University
Paul Gross, Michigan State University Extension
James Hoorman, Ohio State University Extension
Richard Hoormann, University of Missouri Extension
Tom Kaspar, USDA-ARS National Laboratory for Agriculture and the Environment
Eileen Kladivko, Purdue University
Matt Ruark, University of Wisconsin-Madison & University of Wisconsin-Extension
Neville Millar, Michigan State University
Helene Murray, Minnesota Institute for Sustainable Agriculture, University of Minnesota
Sarah Noggle, Ohio State University Extension
Donald Wyse, University of Minnesota

Farmers Interviewed

We would like to thank the farmers who graciously provided their time and insights for this publication:

Ron Alverson, Chester, South Dakota
Jim Bethmann, St. Peters, Missouri
Scott Carlson, Lake Preston, South Dakota
Carl Ehrlich, Laddonia, Missouri
Carmen Fernholz, Madison, Minnesota
Jim Hebbe, Green Lake, Wisconsin
Mike Jorgenson, Clinton, Minnesota
Leon Klopfenstein, Haviland, Ohio
George Krom, Rochester, Indiana
Mark McDonald, Mount Pleasant, Michigan
Ryan Noggle, Haviland, Ohio
Mike Shuter, Frankton, Indiana
Tim Smith, Eagle Grove, Iowa
Lee Thelen, St. Johns, Michigan
Nick Viney, Evansville, Wisconsin
Joel Zwiefel, Fenton, Iowa

Funding

The authors thank the North Central Soybean Research Program (www.ncsrp.com) for funding this project.

Graphic Design and Editing

Purdue University Agricultural Communication.

Photograph Credits

All photos in this publication are courtesy of the contributors.

Contents

Introduction....3
Approach....4
Cover Crop Benefits....5
General Cover Crop Principles....5
Reducing Soil Erosion....6
Reducing Soil Compaction....6
Increasing Yield....7
Controlling Weeds....7
Managing Nitrogen....8
Cover Crop Challenges....10
Establishment/Timing Challenges....10
General Planting Principles....10
Deciding When to Plant....11
Deciding How to Seed....14
Tillage Considerations....16
Economic Challenges....17
General Economic Principles....17
Direct Costs....18
Indirect Costs....19
Opportunity Costs....20
Potential Cost Savings....20
Increased Revenue Potential....21
Decreased Revenue Potential....21
Other Challenges....21
Other General Principles....21
Selecting the Right Cover Crop Species....22
Balancing Crop Moisture Use....22
Terminating Cover Crops....23
Navigating Crop Insurance Rules....23
Using Cover Crops on Rented Land....24
Summary....24
Selected Cover Crop Resources....24
References....25
Survey Summaries....26

Introduction

If you are a soybean farmer who plants (or is thinking about planting) cover crops, or a CCA/agronomist who is expanding cover crop services to soybean farmers, this publication has been written for you. Our goal is to answer the question: "What do we know about using cover crops in soybean production?"

Interest in cover crops has increased greatly, as increasing numbers of meetings, workshops, and field days about the topic can attest. In 2012, the National Agricultural Statistics Service included cover crops in its census and reported that U.S. farmers planted 10.3 million acres of cover crops in 2012 — in the same year, farmers in the North Central Region (NCR) planted 4.5 million acres of cover crops. Cover crops represent 3.6 percent of total NCR cropland, so they have a long way to go before becoming common and accepted before or after soybeans (or in general).

While there is no one-size-fits-all cover crops solution for NCR soybean farmers, there are many options that may provide benefits and improve profits. This publication will help soybean producers explore the many cover crop choices available to them and minimize the challenges they face.

We were interested in learning the views about cover crops from farmers (both those who do and do not use cover crops) and from certified crop advisers (CCAs) and agronomists. We used the insights from our surveys and interviews to determine what benefits people are seeking and what challenges they face when they consider using cover crops in soybeans. To supplement the discussion and recommendations, we searched for literature and publications about cover crops from researchers and agricultural educators.

The result of our efforts is this publication, which you can think of as an à la carte menu: help yourself to what interests or makes sense to you from any section. It is our sincere desire that this information will increase your knowledge of cover crops and lead you to adopt them in your operation.

Throughout the publication, you'll find interviews with real soybean farmers from the NCR who shared their perspectives on the use and nonuse of cover crops. The interviews will give you an on-the-farm sense of the different approaches to and challenges of using cover crops. The interviews begin with Mike Shuter who makes cover crops work (see A Farmer's Perspective: Making them Work, right) and Ryan Noggle who is not ready for cover crops yet (see A Farmer's Perspective: Justifying the Expense, page 4.

As you read, keep in mind the specifics of your operation, climate, and location. We list resources and contacts at the end of this publication. We also encourage you to talk to farmers in your area who are using cover crops and to attend workshops and field days. All of these resources will help you take the next step in planning your cover crop use.

A Farmer's Perspective

Making them Work

Mike Shuter

Frankton, Indiana

Mike Shuter has made cover crops work for him for a number of years — both before and after soybeans. Shuter is one of an increasing number of farmers adopting cover crops. He has been planting cover crops for several years and says he has seen the cover crops improve his soil health and organic matter, help manage weeds, and improve water infiltration. Shuter believes cover crops should be an integral part of a soil management system.

But it took some innovation to effectively fit covers into his system. For example, he developed equipment that successfully broadcasts cover crop seed into standing corn and soybeans. The most opportune time to seed cover crops, he says, is in standing crops prior to harvest. At that time, the workload is less.

"We like to seed when soybean leaves are yellow," he says. "We get the seed on the ground when the leaves fall off. We get rain; we get good establishment."

Shuter and his sons farm 3,000 acres with a crop rotation of two years in corn and one year in soybeans. They receive some manure from their hog finishing houses and beef cattle herd. The farm grows about 1,000 acres of soybeans each year and cover crops contribute to their average yields of 58.8 bushels per acre. For covers, Shuter has used oilseed radish, annual ryegrass, crimson clover, cereal rye, and oats.

"Using cereal rye ahead of soybeans is the reason we don't have a problem with marestail," he says.

Shuter says he likes mixing two or three cover species, and he believes that getting the right cover mix should be a top research priority.

Approach

Before we wrote this publication, we surveyed farmers and CCAs/agronomists to understand the benefits of, the challenges to, and the practices being used for cover crops before and after soybean production. Of the farmers we surveyed, 164 said that they use cover crops and 194 said they don't. Of the CCAs/agronomists we surveyed, 275 responded about the cover crop usage of the farmers they advise.

In addition to the survey, we also interviewed 16 farmers to gather additional insight into farmer perspectives about using or not using cover crops with soybeans. Insights from these interviews are presented throughout the publication as A Farmer's Perspective.

The farmers we surveyed farmed more than 558,000 acres in 2013 — about 223,000 in soybeans. Farmers using cover crops farmed just fewer than 320,000 total acres — more than 132,000 in soybeans. Of those who use cover crops, about 25,000 acres (or about 19 percent) were before soybeans and more than 18,000 acres (or about 14 percent) were after soybeans. CCAs/agronomists reported approximately 350,000 acres of cover crops used before and the same amount after soybeans for the farmers they advise.

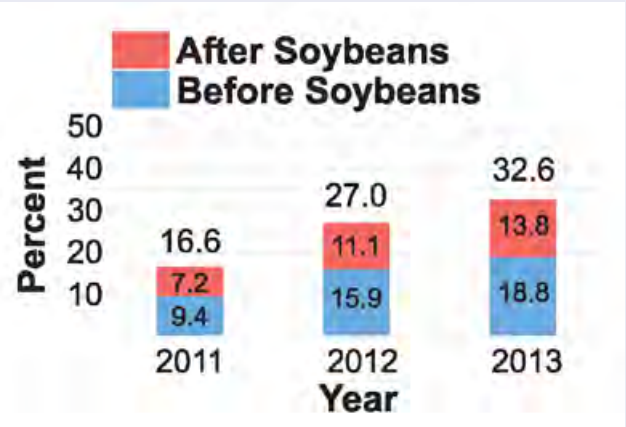
The survey also supported anecdotal and other survey evidence that cover crop use is increasing (see Survey Results: Cover Crop Use Increasing, below).

Survey Results

Cover Crop Use Increasing

Multi-year data about cover crop use in the NCR is not readily available. Various sources (such as cover crop seed sales, workshop/field day attendance, and other surveys) indicate that cover crop use is increasing.

The farmers who said they use cover crops in our survey reported nearly doubling their cover crop acres between 2011 and 2013. Cover crop use before soybeans is increasing at a greater rate than after soybeans.



This chart shows the total percentage of acres with cover crops of the farmers we surveyed. Sample sizes: before soybeans=121 respondents; after soybeans=100 respondents.

A Farmer's Perspective

Justifying the Expense

Ryan Noggle

Haviland, Ohio

Ryan Noggle is a grower who takes a more cautious approach to covers. He hears about their benefits, but isn't convinced he'll see a return on investment.

"We don't use any covers right now," Noggle says. "We are looking at them because they are pretty big, but we are not ready for them yet."

He is worried about timely planting for a good cover crop stand and doesn't want to spend money unless he's sure he'll get the results he wants.

"Some of our neighbors are doing it with good results, but I feel there are too many dollars at risk to make a mistake," he says.

Noggle isn't alone. He says there is tremendous competition for land in his part of northwest Ohio. Landowners and farm managers expect perfect crops and don't understand the benefits of cover crops.

"When I take them a bill for fertilizer, seed, lime, etc., they understand the benefit," Noggle says. "If I handed them a bill for cover crop seed, I would just get this funny look."

He stresses that it can be difficult to show land managers the value of planting covers.

Noggle and his father farm 2,450 acres. They grow corn, some wheat, and about 1,150 acres of soybeans each year. Each fall, they use vertical tillage on all their corn and soybean acres. He says he would like cover crops to fit and likes what he sees with oilseed radish, so he is considering them for his operation.

The survey and interview information guided our presentation and discussion of the most sought-after benefits from, and most significant challenges to, cover crop use in soybeans. And the discussions that follow include the survey results. To review summaries of the survey data, see Survey Summaries, page 26.

Cover Crop Benefits

Cover crops have a number of benefits. Survey Summaries (Table 1, page 27) lists many of the common cover crop benefits. In our interviews, both farmers who use cover crops (A Farmer's Perspective: Innovator Sees Benefits, right) and farmers who do not (A Farmer's Perspective: Keep the Soil, Feed the Herd, page 6; A Farmer's Perspective: Respecting the Land, page 7) discuss the benefits. And our survey of farmers and CCAs/agronomists indicates that soybean farmers are looking for similar benefits as farmers in general (see Survey Results: Why Are Soybean Farmers Using Cover Crops?, below).

Farmers and advisers throughout the NCR recognize that cover crops have many potential benefits. They identified that using cover crops with soybeans can be most helpful for:

- Reducing soil erosion
- Reducing soil compaction
- Increasing yield
- Controlling weeds
- Managing nitrogen

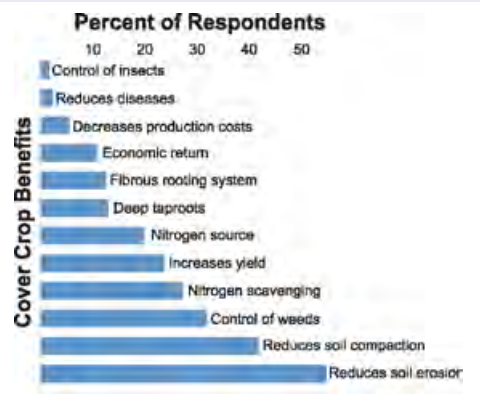
The sections below briefly introduce and describe these benefits, and then summarize research that has investigated them. Most of the research was carried out in the NCR, but studies from other states have also been included. In all of the studies, researchers compared plots where cover crops were grown to plots that were left fallow.

Survey Results

Why Are Soybean Farmers Using Cover Crops?

Our survey indicates that soybean farmers and CCAs/agronomists, continue to say that reducing soil erosion is the top benefit of using cover crops. This is consistent with previous surveys.

After reducing soil erosion, our survey indicates that reducing soil compaction and controlling weeds were the next most important cover crop benefits for soybean farmers. The 2013-2014 Cover Crop Survey Report by the Sustainable Agriculture Research and Education Program and Conservation Technology Information Center about general cover crop benefits also ranked reducing soil compaction and controlling weeds after reducing soil erosion. Soybean farmers chose nitrogen scavenging next, while farmers in general chose nitrogen sourcing. It is not surprising that providing nitrogen is not ranked very high for soybean production.



This chart shows what benefits the farmers and CCAs/agronomists we surveyed hope to gain from cover crops. Sample size: 538 respondents.

A Farmer's Perspective

Innovator Sees Benefits

Leon Klopfenstein

Haviland, Ohio

Leon Klopfenstein is a small, yet innovative, farmer. In his machine shed you will see numerous tools he has adapted for a number of cover crop uses, including some that interseed covers into growing crops. The most interesting is the corn detassler he adapted to plant cereal rye and oilseed radish into standing corn.

For Klopfenstein, the benefits of cover crops are obvious. They are so important that he's built these tools to plant them.

Klopfenstein farms 150 acres near Haviland, Ohio. He plants 50 acres of soybeans and includes covers before and after them. His rotation includes corn, soybeans, and wheat.

Klopfenstein has planted cover crops since the 1980s and has considerable knowledge about their establishment and benefits. His goals with cover crops are to have live roots in the soil all year and to find the species that can best build soil health. He also feels the cover crops help conserve water but is quick to point out the limitations. Weather is the biggest challenge before soybeans, Klopfenstein says.

Klopfenstein has been experimenting with different mixes and species. Before soybeans and after wheat he uses six-way mixes that include combinations of cereal rye, red clover, crimson clover, oats, sorghum-sudangrass, peas, sunflowers, and sunn hemp. His seeding methods include drilling after wheat, interseeding, and broadcasting into standing crops near maturity.

"Cover crops are a tool and not the total answer," he says.

General Cover Crop Principles

For cover crops to provide all of their potential benefits they must grow enough and be adapted to the location and

cropping system. In other words, a cover crop that doesn't grow much is not going to provide much benefit.

The goal should be to provide continuous living cover. Having living plants on the soil all year long more closely mimics natural ecosystems than does a corn-soybean rotation that has living plants for only five months of the year.

Reducing Soil Erosion

Soil erosion is a serious problem in the North Central Region (NCR). Researchers from Michigan State University and the U.S. Army Corps of Engineers have estimated that the total amount of sediment being lost from agricultural croplands in the Great Lakes Basin (including Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin) is more than 25 million tons per year (Ouyang et al., 2005).

Soils without living crops or crop residue cover are much more likely to lose soil through erosion. Planting cover crops can help reduce soil erosion by:

- Reducing the impact of rainfall on the soil
- Decreasing the force of water and wind on the soil
- Increasing the ability of the soil to absorb and hold water
- Stabilizing soil aggregates
- Holding other residues in place

Research in the NCR has shown that soil erosion and runoff losses are larger during soybean years than during corn years (Alberts et al., 1985). Researchers believe this is because soybean roots loosen the soil more and leave less residue on the soil surface than corn (Buyanovsky and Wagner, 1986).

Two studies carried out in the NCR investigated how cover crops planted into a rotation with soybeans affect soil lost by erosion:

- In Iowa, researchers found that over-seeding oat and cereal rye cover crops into soybeans in late summer reduced inter-rill and rill erosion in April caused by rain splash and flowing water (Kaspar et al., 2001). Cover crop root and shoot residues reduced erosion by slowing water flow, anchoring soybean residues, and binding soil with roots.
- In Missouri, researchers found that planting any one of several cover crops (Canada bluegrass, downy brome, and common chickweed) into a soybean crop before harvest and allowing them to reseed in later years virtually eliminated all soil loss from erosion (Zhu et al., 1989). Most likely, the cover crops increased soil cover from late spring to early summer when soil erosion typically takes place. However, soybean yields were substantially decreased — see page 7.

Reducing Soil Compaction

Soils can be compacted by heavy machinery, animals, tillage, and natural consolidation due to weathering and water movement. In compacted soils there is less space for air and water, which can restrict root growth and reduce water and nutrient uptake, leading to poor plant growth and reduced crop yields.

A Farmer's Perspective

Keep the Soil, Feed the Herd

Mike Jorgenson

Clinton, Minnesota

Wind and water erosion are an issue on Mike Jorgenson's farm and throughout his area in west-central Minnesota. He says most farmers in his area want to leave their soil black in the fall. However, that fall tillage makes them susceptible to erosion.

Jorgenson is well versed in the agricultural practices of the region. In addition to operating the family farm, he serves as the supervisor of the Soil and Water Conservation District for Big Stone County, Minnesota. He is not currently using cover crops, but wants to fit them in his rotation, because they have the potential to reduce soil erosion and provide other benefits on his 320 acres.

Jorgenson's farm is a cash crop and beef cow-calf operation. He plants about 150 acres of soybeans annually and considers livestock part of his rotation. He is interested in how cover crops could reduce soil erosion while providing forage for his herd, improving soil health and structure, and increasing soil biological activity.

Jorgensen is investigating whether to add cover crops, in particular, their use in corn.

"With harvest in October, there is not enough time to get the cover established before winter," he says.

Jorgensen plans to blend at least four cover crop species that include cool-season grasses, warm-season grasses, cool-season legumes, and warm-season legumes. That may not be enough, but the blends help reduce the risk that cold weather could kill the covers before they establish. He's also concerned that cover crops could take too much moisture.

"I want to keep every drop of rain on my farm," he says. "In October we are at the mercy of the weather."

Plant roots can help break up compacted soil layers, which can reduce the need for more intensive and disruptive mechanical tillage. Plants with wider roots can penetrate through denser soil layers better than those with smaller roots. Farmers can use cover crops with deep taproots as "biodrills." The larger soil pores these cover crops create allow more water to infiltrate the soil and form less of a barrier to future crop roots (Cresswell and Kirkegaard, 1995).

Three studies (one inside and two outside the NCR) investigated how cover crops in rotation with soybeans affected soil compaction:

- In Illinois, researchers found that cereal rye and vetch cover crops introduced into a corn-soybean rotation helped reduce the risk of soil compaction by increasing soil porosity and reducing bulk density (Villamil et al., 2006). The cover crops provided more frequent and greater residue addition to the soil surface. Their gradual incorporation into the soil through decomposition helped increase soil porosity and reduce bulk density.
- In Maryland, researchers found that the thick taproots of forage radish and rapeseed cover crops were able to penetrate further into compacted soils than rye cover crops that have thinner, more fibrous roots (Chen and Weil, 2010).
- Also in Maryland, researchers found that soybean roots were able to grow into compacted soil by accessing the root channels left behind by decomposing forage radish roots grown the previous winter (Williams and Weil, 2004).

Increasing Yield

Cover crops and their management can affect the yield of the following cash crop either positively or negatively. Many of the soil benefits cover crops provide, and which can increase soybean yield, will take many years to realize. It is difficult to understand and predict how cover crops will interact to affect soybean yield. No doubt, this uncertainty discourages many growers from adopting cover crops.

Five short-term studies have been carried out in the NCR that have reported the effect of winter cover crops in rotation with soybeans on soybean yield:

- In Iowa, ongoing research during the last five years shows that when cereal rye was planted before soybeans, soybean yield increased in four fields, decreased in one, and did not affect 13 (www.practicalfarmers.org).
- In Michigan, researchers found that planting winter wheat and cereal rye cover crops before soybeans did not reduce the yield of the following soybean crop (Thelen and Leep, 2002). The cover crops increased the net economic return to land.
- In Missouri, researchers found that planting Canada bluegrass, downy brome, and common chickweed, which was not terminated and was allowed to reseed, lowered yields in the following soybean crop between about 25 and 75 percent. Yield losses were attributed to soil moisture competition due to drought (Zhu et al., 1989)..
- In Iowa, researchers found that planting a cereal rye cover crop before soybeans did not significantly reduce the yield of the following soybean crop (Kaspar et al., 2007; 2012).
- In Minnesota, researchers found that planting a cereal rye cover crop before soybeans had a minimal effect on the yield of the following soybean crop when they applied herbicide twice to manage the rye and weeds (De Bruin et al., 2005).

A Farmer's Perspective

Respecting the Land

Joel Zwiefel

Fenton, Iowa

Joel Zwiefel and his family respect the land and the importance of good soil management.

"We always want to leave the ground better than we found it," he says. "You can really see the farms where they don't care — the soil blows. Good, healthy soils do not blow."

Zwiefel has no-tilled soybeans into corn for 30 years. He doesn't use cover crops, but sees their potential value and has experimented with them in the past.

"When we planted some plow-down alfalfa, we could still tell it in the soil tilth for three years," he says. But for Zwiefel, anecdotes and potential can't replace solid research that would identify the cover crops he ought to use.

Zwiefel farms 850 acres — he owns 170 acres and rents 680. The farm is about 20 miles from an ethanol plant. High demand for corn encourages farmers in the area to plant corn after corn. Zwiefel says he does not really like this rotation, but concedes the money is in it. He rotates corn and soybeans and plants more than half his acres to soybeans.

"We have a huge biological engine out there in the fields, so harvesting corn stover off for ethanol is counter to the process," Zwiefel says.

The ethanol plant agronomists have introduced local farmers to a number of cover crop species and showed them how to manage them. Farmers now have more information about covers and are more likely to plant them.

Controlling Weeds

Cover crops can help reduce weed problems by:

- Smothering and outcompeting weeds for water and nutrients
- Altering the environment during the weed seed's germination
- Acting as a weed herbicide by releasing chemical compounds from their roots

Living cover crops are better at suppressing weeds than cover crop residues, and cover crop residues are better at reducing early season weed emergence than they are at lowering late-season weed density.

Four studies carried out in the NCR investigated the effects of winter cover crops in rotation with soybeans on weed control:

- In Illinois, researchers found that cereal rye residue provided nearly complete control of all of the common weeds (giant foxtail, velvetleaf, smooth pigweed, and common lambsquarters) in the following soybean crop, regardless of additional herbicide treatment (Liebl et al., 1992). When the cereal rye was killed at soybean planting, weed control was typically more effective than when the cereal rye was killed two weeks before soybean planting.
- In Wisconsin, researchers found that living cereal rye mulch reduced the mass of weeds by more than 75 percent compared to no mulch (Ateh et al., 1996). When the rye was planted at a higher density, it provided more soil cover and better weed control than when it was planted at a lower density. In most cases, soybean yield was negatively affected unless supplemental herbicide was also used.
- In Minnesota, researchers found that organically managed cereal rye mulch lowered the populations of common annual weeds both before and after soybean planting (Forcella, 2014).
- In Minnesota, researchers found that where weed pressure was high, cereal rye did not adequately reduce weed populations and substantially reduced soybean yield without additional herbicide. However, with low weed pressure, including cereal rye did not negatively affect soybean yield and economic return (De Bruin et al., 2005).

A Farmer's Perspective

Timing Is Everything

George Krom
Rochester, Indiana

"We have tried covers both before and after soybeans with mixed results," says George Krom.

Krom farms 3,000 acres in north-central Indiana. He doesn't hire any labor, so making time is a challenge for him. Krom usually has about 1,200 acres of soybeans, but only about 150 acres of cover crops.

"I just don't have time in the fall," he says, noting his difficulty in planting covers after soybeans.

Krom thinks aerial seeding cover crops four weeks before soybean harvest gives the cover a chance to establish, but establishing a good stand has been a challenge. He says cereal rye has worked best after soybeans when he has planted covers after harvest.

Before soybeans, Krom says the jury is still out. He has not been able to get a good cover crop stand to establish when planted after corn because of the short growing season. Aerial seeding into corn is an option, but results have been mixed when he's tried it.

Managing Nitrogen

Nitrogen (N) is probably the most difficult-to-manage nutrient in agriculture. Many of its forms in soil are mobile and hard to contain. Even with good management, large quantities of N can be lost to the air or water. Growers are concerned about N losses through leaching of nitrate (NO_3-), volatilization of ammonia (NH_3), and denitrification of NO_3- to nitrous oxide (N_2O) and dinitrogen gases (N_2).

Cover crops can help growers conserve N in their cropping systems. Growers can reduce N losses when they can manage cover crops so that they provide a good supply of inorganic N when the cash crops need it. Good management can also ensure that the covers lock up N in the soil or plant material when cash crops do not need it or are absent.

N is lost most frequently and in the largest amounts when there are no crop plants to take it up. This is the case in the period between cash crop maturity in one year and planting the cash crop in the next year. During this period, NO_3- from residual fertilizer and mineralization of soil organic matter and crop residues are being leached.

The ability of cover crops to reduce NO_3- leaching varies considerably (see summaries below). As with N from fertilizer or manure, any cover crop N not taken up by the cash crop can be lost as described above, unless another cover crop is planted to continue recycling it.

Three studies carried out in the NCR investigated the effects of winter cover crops in rotation with soybeans on NO_3- uptake and NO_3- in water:

- In Iowa, researchers found that a cereal rye cover crop reduced NO_3- concentrations and NO_3- amounts in subsurface drainage water by more than half when averaged over four years (Kaspar et al., 2007). In a later study at the same site, NO_3- concentrations in the drainage water from the cereal rye plots continued to be reduced by about half over five years (Kaspar et al., 2012).
- Also in Iowa, researchers found that an oat cover crop that was broadcast seeded before soybeans also reduced NO_3- concentrations in the drainage water by about 25 percent over five years (Kaspar et al., 2012). N uptake by the cover crops probably reduced the NO_3- concentrations, and oats were less effective than cereal rye at taking up NO_3-, probably because they didn't grow as much as rye, and they winter killed and did not grow in the spring.

- In Minnesota, researchers found that, averaged over three years, a cereal rye cover crop planted before soybeans reduced the amount of NO_3- lost through tile drainage by about 13 percent and the total amount of water lost by about 10 percent (Strock et al., 2004).

Further studies carried out in the NCR investigated the effects of winter cover crops in rotation with soybeans on soil N and cover crop N concentrations:

- In Illinois, researchers found that a cereal rye cover crop took up most of the residual soil N (RSN) that was left in the soil following a cash crop harvest (Ruffo et al., 2004).
- In Nebraska, researchers found that a cereal rye cover crop planted after soybeans reduced the total amount of spring RSN by 20 to 30 percent in most of the years studied (Kessavalou and Walters, 1999). The cereal rye contained about 40 pounds of N per acre, similar to the reduction of spring RSN when compared to plots without the cover crop.
- In Michigan, researchers found that cereal rye and winter wheat cover crops lowered the levels of NO_3- in the soil profile by up to 60 percent following corn or soybean crops (Jewett and Thelen, 2007).
- In Iowa, researchers found that unfertilized winter triticale planted after soybeans captured 50 to 80 pounds of N per acre (Nance et al., 2007). This was increased to more than 130 pounds per acre when they fertilized the triticale with about 60 pounds of N per acre. Growing winter triticale lowered the amount of RSN in the soil even when the N fertilization rates were much more than the triticale needed for maximum grain production.

Nitrous oxide (N_2O) is a greenhouse gas (GHG) that soils naturally emit when soil microbes use or process mineral N in the soil. N_2O emissions can increase substantially when farmers add large amounts of N to a cropping system. This N can be from fertilizer, manure, or crop residues. Through their ability to reduce NO_3- leaching from cropland, cover crops may also indirectly lower N_2O emissions from wetlands, streams, and lakes.

Three studies carried out in the NCR investigated the effects of winter cover crops in rotation with soybeans on N_2O emissions:

- In Iowa, researchers found that adding a cereal rye cover crop (either after soybeans and before corn or after corn and before soybeans) did not affect N_2O emissions (Parkin and Kaspar, 2006).
- In Michigan, researchers found that winter wheat planted after soybeans and cereal rye planted after corn did not affect N_2O emissions (McSwiney et al., 2010).
- In Indiana, researchers found that annual ryegrass planted after corn and before soybeans increased N_2O emissions (Smith et al., 2011). Annual ryegrass planted after soybeans and before corn did not affect N_2O emissions.

A Farmer's Perspective

No Time Left

Mark McDonald

Mount Pleasant, Michigan

The demands on time, labor, and equipment are challenges for establishing more cover crops on Mark McDonald's mid-Michigan farm. McDonald farms about 7,000 acres in Isabella and Gratiot counties, which includes 2,500 acres of soybeans and the rest in corn, wheat, and sugar beets. With so many acres to harvest, fall is a particularly demanding season.

He says it is easy to establish cover crops after winter wheat harvest during a slower part of the season. On those acres, he plants oilseed radishes after harvest with good results. For acres that are going from soybeans to winter wheat, McDonald plants an early group bean. The early beans are harvested first and the wheat is no-tilled into the soybean stubble

For soybean acres not going to wheat, harvest constraints limit his ability to plant cover crops after harvest. He says aerial application also may be a viable means for establishing covers into growing crops, but he says more research is needed that shows the benefits and economic returns of cover crops.

McDonald says he carefully examines each practice and must see some economic return before implementing it. The fact that there is not much information about the measureable economic returns of using cover crops keeps him from adding more acres of covers too quickly.

"I am trying to figure out how to use more of them," he says.

Cover Crop Challenges

When it comes to integrating cover crops into their rotations, farmers face a number of challenges. Survey Summaries (Table 2, page 26) lists common challenges to cover crop use that farmers identified in our survey. In our interviews, farmers and CCAs/agronomists discussed many of the challenges to cover crop use (see A Farmer's Perspective: Timing is Everything, page 8).

Results from our survey indicated three major categories of cover crop challenges:

1. Establishment/timing challenges
2. Economic challenges
3. Other challenges (selection, soil moisture management, termination, uncertainty of crop insurance rules)

We will discuss each of these challenges and offer ways to overcome them.

Establishment/Timing Challenges

Many of our survey respondents indicated challenges with getting cover crops established and with having sufficient time in the fall to seed them (see A Farmer's Perspective: No Time Left, page 9; A Farmer's Perspective: It's Hard to Do, right). The next several sections provide some general principles for planting cover crops, a description of the main planting time windows, a description of each of the main seeding methods, and then some other considerations regarding tillage systems and cover crops.

General Planting Principles

If you are new to cover crops, here are nine recommendations that can help you overcome the challenges of establishing and managing cover crops before and after soybeans:

1. **Start small.** This allows you to experiment with different methods and cover crop species before expanding to plant them on a larger scale. Cover crop management has a significant learning curve.
2. **Start with a single species rather than a mixture.** It is easier for a beginner to manage and evaluate one species than it is for multiple species (for example, see A Farmer's Perspective: Starting Slow, page 11).
3. **Learn from others who are already using cover crops.** Other farmers using cover crops can help you avoid problems, especially if that farmer is from your area.
4. **Consider your location, cropping system, climate, and farm operation when evaluating cover crop information on the Internet or in farm media.** A cover crop species or practice that works well at one location or with one rotation may not be appropriate for your farm or location.
5. **Consider planting some acres of cash crop varieties with earlier maturities than you normally use.** This allows more time to plant and grow the cover crop.

A Farmer's Perspective

It's Hard to Do

Jim Bethmann

St. Peters, Missouri

"I don't know how a guy would do cover crops from a time and labor standpoint," says Jim Bethmann.

Bethmann does not currently use cover crops. He has about 50 landlords and 130 parcels and farms 3,000 acres just outside of St Louis. He plants 1,000 to 1,400 acres of soybeans each year — he plants the rest to corn and some wheat. His farm is near the Missouri River, so many of his fields flood in the spring, which adds challenges to his operation. Most of his soils have no cover after harvest except some of the sand ridges where he plants small grains to prevent erosion.

He says there is a very tight window to plant covers, so the practice has never really caught on. Bethmann has planted sunflowers for hunting and noticed the soil after the sunflowers is very mellow. This has piqued his interest, and he says he would like to explore how he might use sunflowers as a cover to improve his heavy soils.

Bethmann also says he'd be interested in cover crops, because they could improve his soils and help manage problem weeds such as henbit and marestail. Soybean yields on the farm have remained flat for the past several years and cover crops might be a way to increase yields and improve other management issues.

But before this can happen, Bethmann says, "We need simplicity in getting them established."

6. **Plant easy-to-manage cover crops.** If you're planting before soybeans, use winter cereals. If you're planting after soybeans and before corn, use spring small grains or other cover crop species that will die over the winter (winter kill). Winter-killed cover crops before corn allow for earlier corn planting. Because soybeans are normally planted later than corn, you have more time to let a cover crop that overwinters grow in the spring before terminating it before soybean planting. Plan ahead. Line up seed and logistics for planting cover crops well before your projected planting date. Also, consider arranging for help to seed cover crops while harvest operations are in progress or consider aerial seeding cover crops before harvest.

7. **Pay attention to the weather and change your seeding method or rate when conditions warrant.** For example, if you have a wet fall that delays harvest, you may want to change to broadcast/aerial seeding with aircraft. If you have a dry fall, you may want to wait to plant until after harvest.
8. **Pay attention to new developments.** Cover crop seeding technology and equipment are changing rapidly.
9. **Take advantage of decision tools and local expertise.** Use the Midwest Cover Crops Council selector tools (www.mccc.msu.edu) and consult with your local extension service to determine the appropriate seeding dates and cover crop species for your area and cropping system.

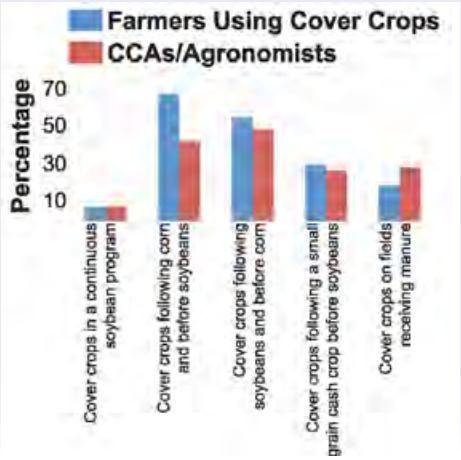
Survey Results

Where Do Cover Crops Fit in Soybean Rotations?

Results from our survey indicate that more farmers are using cover crops following corn and before soybeans.

This was surprising since soybeans are harvested before corn in much of the region, which would provide greater opportunity for growth in the fall. Additionally, aerial seeding into soybeans just before leaf drop can work very well. In contrast to the farmers, the CCAs/agronomists recommend cover crops slightly more following soybeans and before corn.

A very low percentage of farmers who plant cover crops use them in a continuous soybean rotation. The lower percentage using cover crops following a small grain most likely results from the prevalence of the corn-soybean rotation and the smaller number of farmers in the survey who are using a corn-soybean-small grain rotation. The reasons for these differences in placement in the rotation warrant further investigation to better understand the challenges to cover crop use.



This chart shows where and when the farmers and CCAs/agronomists we surveyed are planting cover crops. Sample sizes: farmers using cover crops=118 respondents; CCAs/agronomists=223 respondents.

A Farmer's Perspective

Starting Slow

Tim Smith

Eagle Grove, Iowa

Tim Smith encourages farmers to start slow when adopting covers. He often recommends cereal rye both before and after soybeans (aerial-seeded or broadcast with shallow incorporation), which he considers the "beginner's cover crop," because it is relatively easy to establish.

"I had some cereal rye that was spilled on the concrete; it sprouted," he says. "I knew then that is what I was going to try."

Smith plants cover crops on his 800 acres that include 400 acres of soybeans and 400 acres of corn. The farm has been in the family since 1881. He will plant 400 acres of cover crops this fall with the goal of reducing nitrates in the water as part of the Iowa Nutrient Reduction Strategy. Smith establishes covers in corn ahead of soybeans and following soybeans before corn. He plans to increase the number of cover crop species he plants after he gets more comfortable managing them.

Smith notes that cover crops that winter kill decrease risk, but for him, it's a priority to have live roots in the soil during the winter and spring.

Deciding When to Plant

In Upper Midwest corn and soybean cropping systems, the first challenge of cover crops is to successfully seed and establish them in fall. Farmers in our survey reported they are using cover crops more after corn and before soybeans (see Survey Results: Where Do Cover Crops Fit in Soybean Rotations?, left). In general, planting cover crops in fall conflicts with fall harvest operations and unpredictable fall weather makes fall planting even more difficult.

Cover crops that are winter hardy (like cereal rye) ideally need to emerge and grow to a minimum size to be hardy enough to survive the winter and grow in the spring. In general, cover crops that are not winter hardy need to grow at least four to six weeks in the fall before a killing freeze in order to achieve reasonable benefit from them.

If you harvest your cash crop early enough, the most reliable establishment method is to seed cover crops after the cash crop harvest by drilling or broadcasting with shallow incorporation (see Deciding How to Seed, page 14). But harvest can be hard to predict for any given location, cash crop, and growing

conditions. In some years, planting cover crops after harvest may be too late for enough fall growth for cover crops that are not winter hardy.

In most of the North Central Region (NCR), farmers can normally drill winter cereal cover crops until late October. From our survey, farmers reported they are using winter cereal cover crops more than other species (see Survey Results: What Covers Are Popular in Soybean Rotations?, below). However, Minnesota, Wisconsin, South Dakota, North Dakota, and northern Iowa can experience hard frosts and surface soil freezing in late October and early November. Such conditions limit the establishment, fall growth, and winter survival of even winter rye, which is the most hardy winter cereal.

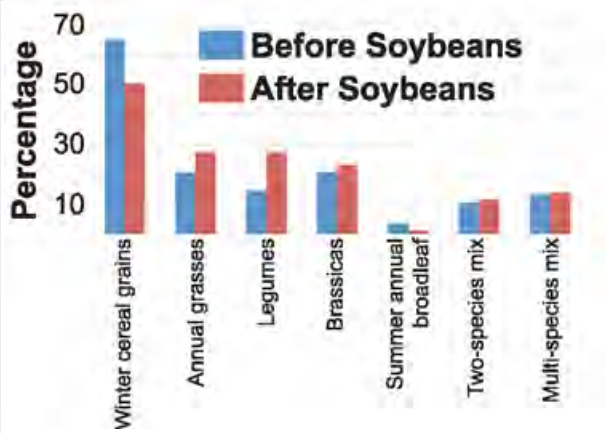
In these areas, planting cover crops after a late corn or soybean grain harvest may not allow sufficient time for the cover crop to establish enough to survive the winter. Even in a normal year, planting cover crop species that do not overwinter after corn or soybean harvest in the northern portion of the region would not result in very much growth.

Survey Results

What Covers Are Popular in Soybean Rotations?

We surveyed farmers across the North Central Region about what cover crops they planted before and after soybeans. Farmers preferred winter cereal grains more than twice as much as all other options because of their higher probability of success in Midwest planting windows.

Annual grasses do not establish well when planted late and may present termination problems. Legumes, Brassicas, and summer annual broadleaves do not typically have sufficient growing time after corn or soybean harvest. In general, interest in mixes is increasing, but a low percentage of the farmers we surveyed appear to be using them. This may be an example of starting slow as farmers learn how to manage mixes in their production systems.



This chart shows the most common cover crop species that the farmers we surveyed are planting. Sample sizes: farmers using cover crops=118 respondents; CCAs/agronomists=214 respondents.

A Farmer's Perspective

Young and Restless

Scott Carlson

Lake Preston, South Dakota

Scott Carlson farms 1,500 acres in a corn-soybean rotation in east-central South Dakota. He is a young farmer who does not currently use cover crops for reasons you might expect.

"Our biggest challenge is our short season," he says.

Carlson says he has not used covers for many reasons including the challenges of establishment, moisture, competition, and yield reduction in the following crop. He also is concerned about terminating cover crops in the spring.

Despite not using cover crops, Carlson believes in good farming practices and that his practices contribute to the value of his land. He works very hard to increase organic matter and feels that increasing it 0.1 percent annually can increase the land value by $75 per acre.

If he could use cover crops, the benefits Carlson would look for are improving water infiltration and soil health. He also wonders if better rotations can provide the same value as planting cover crops.

As a young farmer, Carlson says he tries to manage his resources very carefully. He is restless with his current practices and always looking for ways to better manage his acres.

"I am willing to invest in cover crops for improving organic matter," he says. "I don't need to see an instant return, but I need to see a value over time."

There are three times to plant fall cover crops, and each has advantages and disadvantages. Broadly speaking, the seeding times are: pre-harvest, post-harvest, and early-season interseeding (for more information about actual seeding methods, see Deciding How to Seed, page 14).

Pre-harvest Planting

Pre-harvest planting occurs a few weeks before maturity all the way to just before harvest. The advantages of pre-harvest seeding are that it:

- Does not interfere with harvest timing or labor.
- Provides more time for establishment, growth, and rainfall. For cover crop species that do not overwinter, this may increase the probability that reasonable growth will occur before a killing freeze.

- Can provide much more cover crop growth and better winter survival

The disadvantages of pre-harvest seeding are that it:

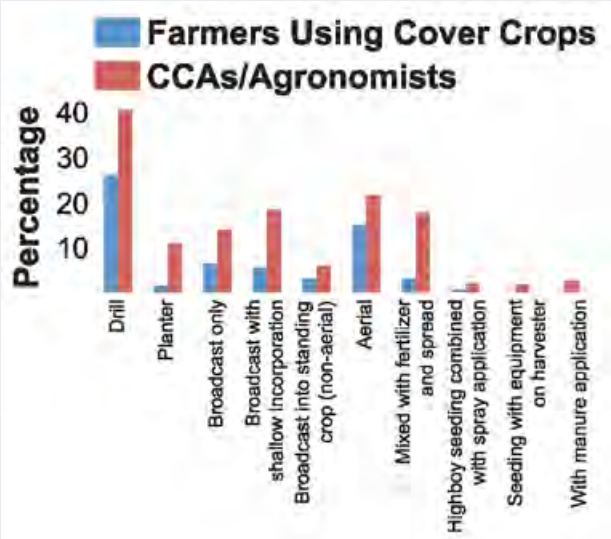
- Requires custom application by aircraft or specialized high-clearance, ground-based equipment.
- Typically requires substantial rainfall after seeding to establish, because seed is often broadcast on the soil surface. This may be very risky in drier areas or in years with dry surface soil layers at time of seeding.
- Is subject to seed loss from bird, insect, slug, or mammal feeding.
- Is subject to some seed loss because the seed can get lost in the canopy of main crop, especially in corn.
- Requires higher seeding rates and carries a greater risk of poor or uneven stands.
- Usually works best with dense, small-seeded cover crops.
- Can result in cover crop damage at harvest when wheel traffic runs over them or residue from the main crop covers them.

Survey Results

What Cover Crop Seeding Methods Are Popular in Soybean Rotations?

The farmers and CCAs/agronomists that we surveyed reported that using a drill is the most popular method for planting cover crops.

Aerial seeding was the second most popular method, reinforcing anecdotal reports that aerial seeding of cover crops is expanding. Aerial seeding can overcome timing challenges to establishment and growing season. CCAs/agronomists are using a broader range and higher percentage of all seeding methods, indicating the range of cover crop services available through them.



This chart shows the most common cover crop planting methods used by the farmers and CCAs/agronomists we surveyed. Sample sizes: farmers using cover crops=87 respondents; CCAs/agronmists=182 respondents.

A Farmer's Perspective

Keep It Simple

Nick Viney

Evansville, Wisconsin

"You can't take a step backward planting cover crops," says Nick Viney.

Viney aerial seeds his cover crops into corn and soybeans — for him, this is the only way to go. He has had pretty good success, but feels cover crop establishment after soybeans is still inconsistent. He has tried several practices and cover crop species. He likes cereal rye and is experimenting with spring barley.

Viney uses cover crops on his 1,400 acres in south-central Wisconsin; roughly half his acres are in soybeans each year. The farm has been in his family since 1849. They aerial seed cover crops into soybeans about mid-September when 50 percent of the soybeans are yellow, or about 10 days prior to harvest. He strip-tills in the fall with deep fertilizer placement. Viney has averaged yields of 200 bushels of corn per acre and 64 bushels of soybeans per acre the past five years.

He likes legumes and has no problem killing them. The "holy grail" would be a legume in soybeans that will benefit the following corn crop. He has some concern about a big cover crop ahead of corn that might immobilize nitrogen.

Viney is a progressive, tech-savvy farmer and uses covers on all his acres. He likes to keep things simple and wants to fit covers in when they don't interfere with crops.

"I don't think it has to be complicated to be successful," he says.

- Can slow cover crop growth because the main crop shades the cover crop or uses more water. If planted into the main crop too early, the main crop can kill or damage the cover crop.

Post-harvest Planting

Post-harvest planting occurs after harvest. The advantages of post-harvest seeding are that it:

- Allows for multiple planting equipment options: drill, planter, shallow incorporation, or with manure application.
- Normally results in better emergence, populations, and distribution than surface broadcasting before harvest.

- Requires less seed because of better emergence success and less predation.

The disadvantages of post-harvest seeding are that it:

- Conflicts with or may be delayed by harvest. That is, waiting until harvest is complete on all fields is often too late to plant, especially in the northern parts of the NCR.
- May not give certain species enough time to grow to provide benefits. In much of the NCR, cover crop species that don't overwinter often do not grow enough if they are planted after harvest. This is especially true for cover crops planted after corn and before soybeans in areas where soybeans are harvested first.

Early-season Interseeding

Early-season interseeding usually occurs before canopy closure. The advantages of early-season interseeding are that it:

- Does not interfere with harvest.
- Can be combined with other field operations.

The disadvantages of early-season interseeding are that it:

- Is highly experimental, so it carries a risk of reducing main crop yields, mostly when interseeding into corn before soybeans. Crop insurance policies may not allow this practice, so check your policy before proceeding.
- Needs to be done after the corn or soybean weed-free period. For in-season cover crops, this means the cover crop must be shade tolerant. Also, this method limits the use of residual herbicides before cover crop planting and most weed control methods after planting.
- Is difficult in high-yielding soybeans because the canopy is usually too dense. This leads to low light, limited water, and disease problems for the cover crop, which may cause the cover to fail. Similar problems can exist for interseeding into a high-population corn crop, but shading by a corn canopy is usually not as complete as a soybean crop.

Deciding How to Seed

While considering the advantages and disadvantages of the different planting windows and the likely timing in your operation, you should also consider the specific seeding methods available.

As with selecting the right cover crop species, choose the method best suited to your operation, cash crop, and desired planting window. Although you may decide on one primary seeding method, maintaining some flexibility to seed with alternate techniques (depending on the weather or delays in harvest) can be an advantage in some years. From our survey, farmers and CCAs/agronomists reported that drilling is the most popular cover crop seeding method followed by aerial seeding (see Survey Results: What Cover Crop Seeding Methods Are Popular in Soybean Rotations?, page 13).

If you plant a mixture of cover crops, you may require more specialized equipment, particularly if you plant seeds that differ widely by volume, shape, and density. Drills with multiple boxes and double-tube systems usually work well for planting different species in a single pass.

If you plant a seed mixture with planting equipment that has only one seed box or tank, mix the seed well, fill the box or tank in the field (not in the shop), and refill the hopper more often so seed mixtures have less time to separate before planting. Adjust the seed opener to accommodate the largest seed size in the mix.

Always check the tags or inspection paperwork for each seed lot. Important information includes the pure live seed (PLS) percentage, weed seed, and inert material. Adjust your seeding rates for PLS. Do not use seed lots with weeds, particularly troublesome or noxious weeds. As with any seed, it is better to use cleaned, inspected, and tested seed.

Consult the *Midwest Cover Crops Field Guid*e (available from the Purdue Extension Education Store, www.edustore.purdue.edu) or the Midwest Cover Crop Council cover crop selector tools www.mccc.msu.edu) for recommended seeding rates for different species.

The six main methods for seeding cover crops are discussed below.

No-till drilling into wheat stubble.

Drilled Seeding

As the name implies, drilled seeding uses a seed drill to plant the cover crop after the cash crop is harvested.

When using this method:

- Consider planting earlier maturing corn hybrids or soybean varieties if the normal cash crop harvest date is usually too late to establish a cover crop. This will give cover crops more time to be planted and grow after harvest.
- Drilling cover crop seed improves seed-to-soil contact. However, hard soils, soil compaction, soil crusting, or inadequate soil moisture and rain may still reduce seed germination and establishment.

- Set up the drill for good seed depth placement and spacing. For cover crop seeding rate settings, consult your seed drill owner's manual or dealer. It is always a good idea to calibrate your drill and it is worth the extra time to calibrate for mixes. If possible, check the rate by turning gears manually in the shop or on a hard surface, and then collecting and weighing the seed output. Penn State University Extension (extension.psu.edu) has a useful article about drill calibration called, "Calibration of Grain/ Seed Drills."

Broadcast seeding combined with a fertilizer application.

Broadcast Seeding With Shallow Incorporation

This method involves broadcast seeding the cover crop onto the soil surface after the cash crop has been harvested, and then using shallow or light tillage to incorporate the seed.

When using this method:

- Consider mixing cover crop seed with fall fertilizer. This is an efficient method.
- Ensure adequate soil moisture and that the seed is not buried too deep.
- Be aware that rainfall after seeding helps, but is not as critical as with aerial seeding or broadcasting on the surface.
- Check distribution and spreading when broadcasting cover crops because differences in seed size and density can lead to uneven stands, especially with mixtures.
- Increase the seeding rate so that it is 10 to 20 percent more than drilled rates to achieve adequate stands.

Loading seed for aerial seeding.

Aerial/Surface Seeding

Aerial (or surface) seeding involves broadcast seeding the cover crop above or below the cash crop canopy at, or slightly before, crop maturity by using aircraft or ground-based, high-clearance vehicles.

This is an area of rapid innovation by farmers and agricultural suppliers, particularly with high-clearance vehicles. Innovations include drop tubes that deliver seed through the canopy to the soil surface, and some ability to lightly incorporate the dropped seed into the soil.

When using this method:

- Begin seeding in corn (ideally) four to six weeks before harvest — just before corn reaches black layer, its lower leaves are beginning to yellow, and at around 50 percent sunlight penetration. If rainfall and soil moisture are good, it is acceptable to seed earlier.
- Begin seeding in soybeans (ideally) when 25 percent of the leaves are yellow. Again, if rainfall and soil moisture are good, it is acceptable to seed earlier.
- Ensure good soil moisture at seeding. Soil moisture and 0.5 to 1 inch of rainfall after seeding will improve germination and establishment. Compacted, crusted, or residue-free soils may reduce establishment.
- Consult state or regional agricultural aviation associations to obtain a list of good aerial seeding pilots. You can find a list on the National Agricultural Aviation Association website: www.agaviation.org. Wind, equipment, calibration, height above ground, and speed affect the uniformity of seed distribution.
- Be aware that small-seeded cover crops (grasses, oilseed radishes) germinate better from aerial seeding than large-seeded cover crops (cowpeas, winter peas) due to their ability to absorb moisture from the soil surface.

In the end, the timing of broadcast seeding into a standing crop before harvest should consider a combination of the calendar date in terms of time needed by the cover crop to grow, the rainfall pattern and soil moisture, and how cash crop growth can negatively affect cover crop growth.

Planting with a row crop planter.

Row Crop Planter Seeding

This method involves using a row crop planter after the cash crop has been harvested. Row crop planters generally result in the best cover crop establishment due to good seed-to-soil contact, good depth control, and consistent seed spacing. Row crop planters require 10 to 50 percent less seed than drilling. However, it may be difficult to plant the cover crops at optimum seeding rates or row spacings with a row crop planter without significant modifications.

When using this method:

- Consider planting earlier maturing corn hybrids or soybean varieties if the cash crop harvest is usually too late to establish a cover crop. This will allow more time for cover crops to be planted and grow.
- Consult your planter's owner's manual or dealer for cover crop seeding rate settings. Planters may require special seed plates, cup holders, brushes, or planter modifications to adequately plant cover crop seed (depending on the type and size of seed). As with drills, it is essential to calibrate planters and adjust for the correct seed depth.

Manure slurry seeding cover crops.

Slurry Manure Seeding

This method involves mixing cover crop seed with slurry manure, and then applying it immediately behind soil that has been fractured by tines or coulters. Alternately, manure slurry and cover crop seeds could be surface-applied and then incorporated with shallow tillage. The nutrients in the manure promote rapid cover crop growth and the cover crop takes up manure nutrients, especially N, which prevents losses.

With this method:

- Be aware that there are generally fewer plants per acre. However, there is more growth per plant, so there is equal or greater growth per acre. This is all accomplished in one efficient pass.
- This method has been used successfully with most grass, legume, and Brassica cover crops except crimson clover according to Michigan State University research. Non-legumes are usually more efficient than legumes at scavenging N from the applied manure.

Frost seeding cover crops.

Frost Seeding

This method involves broadcasting cover crop seed onto ground that has been broken up by late winter freeze-thaw cycles. Frost seeding usually occurs just before spring.

With this method:

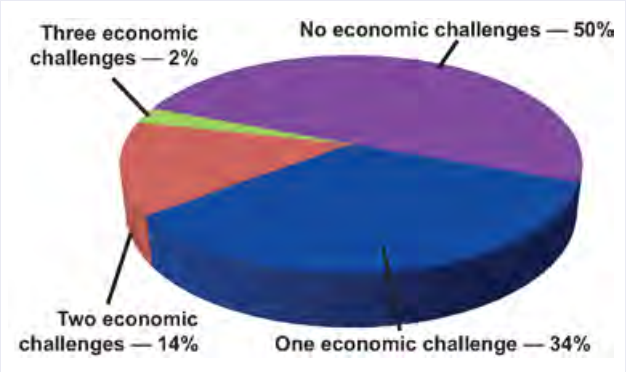
- Seed legume crops (like red clover and sweetclover) into wheat in late February and early March when the soil is frozen.
- Seed cereals (such as spring wheat and spring oats) in late winter or early spring (February to early April) to establish an early spring cover crop.

Tillage Considerations

Although the harvest or maturity date of the previous crop determines when you can establish cover crops, the tillage system also is important. Any tillage reduces the time available for cover crop growth. In general, cover crops are easier to integrate into no-till and strip-till systems (or other partial-width tillage systems) than into full-width tilled systems. That's

Survey Results

How Important Are Economic Challenges?



In our survey, we asked farmers and CCAs/agonomists to list their top three challenges to planting cover crops. This chart shows how many of those three challenges are economic. Sample sizes: farmers =358 respondents; CCAs/agronomists=274 respondents.

because no-till and strip-till allow earlier planting in the fall and more time for cover crop growth in the spring before termination with herbicides.

Cover crops also provide synergistic benefits to no-till or strip-till systems. For example, cover crop roots can help alleviate the compaction sometimes associated with these systems by adding organic matter and penetrating compacted soil with their roots (Kaspar and Singer, 2011). In South Dakota, cover crop mixtures that include Brassicas have been reported to increase bacteria populations and speed up the decomposition of surface residues (Hoffbeck et al., 2008; Reese et al., 2014).

In full-width tillage systems, spring tillage makes better use of cover crops than fall tillage. Many types of spring tillage can be compatible with cover crops, especially when you can delay spring tillage until just before planting the cash crop. However, for some soil types or cash crops, delaying tillage until just before planting is undesirable — especially if you till to dry out and warm the soils or if the freshly tilled soils need time for larger soil clods to break down. Alternately, full-width tillage after harvest in the fall would delay the planting of the cover crop. It could also terminate a cover crop that was aerial seeded into the cash crop at maturity or planted after a short-season cash crop.

If additional labor is available, farmers can till and plant cover crops into fields that are already harvested while harvest operations continue on other fields. In any case, although it is possible to incorporate cover crops into systems with fall tillage (especially in the southern part of the NCR), it is much more difficult and leaves less time for cover crop growth.

Economic Challenges

The most common economic challenges for cover crops are managing input costs (the costs of seed, and planting and managing) and demonstrating a measurable economic return. In our survey, farmers and CCAs/agronomists gave us insight into how important economics are to cover crop use (see Survey Results: How Important Are Economic Challenges?, left).

In our survey, approximately half of the farmers and CCAs/agronomists listed at least one or more economic factors in their top three cover crop challenges both before and after soybeans.

It is important to note that concerns about the economics of using cover crops were significant enough to include at least one economic challenge when asked to select only three challenges. This indicates the need not only to better quantify the current economics of cover crop use, but also to investigate ways to improve the economics.

General Economic Principles

Input costs — the costs of cover crop seed, and the fuel, equipment, and labor costs of planting and terminating covers — are no small consideration. There is little we can offer scientifically that will reduce these costs, because they are subject to regional markets.

But we can offer this guidance: since input costs are difficult to reduce, start small when adopting cover crops to minimize the overall cost to your farm. Learning through trial and error or other experimentation is part of the cover crop adoption process, so minimize your risks. Then, after you feel you've mastered the techniques, scale-up.

It also is important to remember that while the costs are set each year, the benefits are variable year-to-year, so select the correct seed and manage the cover crop in the ways described in Cover Crop Challenges, page 10. While it is clear that some farmers see immediate, short-term benefits from cover crops (such as increased yields), we lack quantitative data to show how often these short-term results can be expected.

Because we can't consistently predict immediate benefits for all cover crops, the economic focus should consider the long term. It is clear that including cover crops annually in the crop rotation will improve soil health for crop production over time (by adding C and N, stimulating soil microbes, and diversifying the rotation). Research shows that increased soil organic matter can increase the water available to plants and provide resilience against extreme climatic conditions (Clay et al., 2014).

Evaluations are ongoing, and researchers will need to measure results over a long period (10 years or longer) to truly quantify both the soil health and the economic value of cover crops. In addition, the long-term benefits require frequent cover crop use with good growth in the cropping system, which means farmers will need to overcome the other management challenges (establishment and termination) posed during each phase of the crop rotation.

These recommendations can help you manage the economic challenges of using cover crops before and after soybeans:

- Be patient, and remember the long-term economic value of cover crops. You will not always immediately see the benefits, and the time to obtain the benefits will vary from field to field. For example, cover crops can drastically reduce erosion. Erosion unquestionably reduces crop yields and increases yield variability. Yet the impacts of erosion develop slowly and are more noticeable only in parts of fields.
- Limit your exposure by starting small as you learn. This allows you to minimize costs while you experiment with different methods and cover crop species.
- Stick to known and well studied cover crops at first. If these crops succeed, then you might explore alternative cover crops later.
- Plant a cover crop as often as possible (preferably every year). This will maximize the long-term benefits to the soil.
- Plant cover crops in rotation with biomass-removal crops like corn silage. The cover crop will help to at least maintain the productivity of the soil by reducing erosion and maintaining soil organic matter.
- Don't discount the unquantified economic benefits to the environment through improvements to soil, air, and water quality.
- Consider purchasing seed early. This may reduce your overall costs.
- Piggyback field operations for cash crops and cover crops when possible. This will help reduce your overall costs. For example, terminating a cover crop with herbicides can probably replace a pre-plant burndown application in no-till systems.
- If you have livestock operations, consider using cover crops that could also provide grazing, forage, and calving/pasture opportunities. This can provide short-term economic returns.

Cover crop practices have external and internal costs, as well as the potential for cost savings and increased or decreased revenue.

This publication will not discuss external costs in much detail. Suffice it to say that external costs are associated with society and the environment.

We can divide internal costs into three categories:

1. Direct costs
2. Indirect costs
3. Opportunity costs

Direct costs are associated with establishing, managing, and terminating cover crops — for example, seed, labor, equipment, and material costs.

Indirect costs are associated with the potential negative effects cover crops can have on a cropping system — for example, delayed soil warming, nitrogen immobilization, and cover crops becoming weeds.

Opportunity costs are associated with income losses if you change how you manage your main crop in order to include cover crops in the rotation — for example, if you include less profitable crops in the rotation (like a small grain that allows early planted cover crops) or if you grow cover crops instead of another cash crop (double cropping).

Let's examine each of these costs in more detail.

Direct Costs

Direct costs are the easiest to quantify, and farmers tend to weigh them the most when making cover crop decisions. The main direct costs are:

- Material costs (seed and herbicides)
- Establishment costs (labor and equipment for field preparation and planting)
- Termination costs (labor and equipment for herbicide application and/or tillage)

The farmers and CCAs/agronomists we surveyed told us what they were willing to pay in direct costs for cover crops (see Survey Results: What Are Farmers Willing to Pay?, page 19).

Material Costs

The most obvious material cost is seed.

Seed costs can vary considerably depending on species, supply, and location. Generally, variety not stated (VNS) seed is the cheapest seed that suppliers offer. Bin-run wheat and oats can also be a lower cost alternative to certified seed. However, these seed options have risks: they could have poor germination, lack genetic purity, contain weed seeds, or cause other problems.

Retailers generally offer discounts when you order early and when you order large quantities. Early ordering lowers shipping costs —as you get closer to planting time, more urgent shipping from more distant suppliers will be more expensive.

Certified seed costs more than VNS or bin-run, but the quality may deliver greater performance. If you plant higher quality seed, you may offset the higher seed costs with lower seeding rates and by using precision planting (such as planting covers with a planter on 30-inch or 15-inch rows).

Some farmers reduce their seed costs by growing their own cover crop seed. This requires dedicating some land, because cover crops do not mature to seed within most cover crop growing windows; cover crop seed production will require a fall or spring planting. Harvested seed also requires special care in handling, drying, and storing. It is usually recommended that you clean the seed before planting.

Establishment Costs

Cover crop seeding costs vary widely by planting method. Drills and planters generally deliver the best cover crop stands, because they provide more uniform planting depth and seed-to-soil contact. Broadcast seeding costs less, but has similar success to a drill when you also lightly incorporate.

The best strategy for reducing establishment costs is to piggyback cover crop field operations with cash crop operations whenever possible. If you broadcast cover crop seed blended with fertilizers or lime, the only additional cost is blending. Slurry seeding with manure only requires mixing seed in the manure tank. Some harvesters have equipment that allows you to broadcast seed a cover crop during harvest, however, this may slow harvest operations due to cover crop seed handling.

Termination Costs

Terminating cover crops does not need to be an additional expense. If you plant cover crops that are not winter hardy, then winter kill can eliminate the need for chemical or mechanical termination.

In no-till and minimum till systems, pre-plant burndown herbicide applications are already typical. The same herbicides may control any cover crops that are present.

Indirect Costs

Indirect costs come from the challenges cover crops can add to a cropping system. They often vary from year to year. For example, it may be difficult to terminate a cover crop in a timely way during a wet spring. This could reduce plant-available N concentrations at planting (more N taken up by a growing cover crop) and lead to immobilization of N early in the growing season (more mature cover crop residue with a higher C:N ratio).

Another example is when cover crops become weeds because of their hard seed — that is, seeds that do not germinate for some time after the original seeding — or because inadequate termination allowed the cover to produce seed and re-establish. These cover crop plants may then grow and compete with cash crops during the summer growing season.

Cover crops also may interfere with planter performance. Planting in a higher residue environment will require planter adjustments. To minimize cover crop residue effects on cash crop establishment, you may need to add residue management, down-pressure, and furrow closing attachments to your planting equipment.

Selected Cover Crop Resources (page 24) lists sources that can help you understand the potential negative effects different cover crops may have in your system. If you are uncertain, remember to start small — try your cover crop choice on a test site and see how it will work in your system. Following the guidelines under General Planting Principles (page 10) also will help minimize indirect costs.

Survey Results

What Are Farmers Willing to Pay?

Our survey asked farmers and CCAs/agronomists how much they would be willing to pay (in dollars per acre) to:

1. Buy cover crop seed
2. Establish cover crops
3. Buy herbicides to terminate cover crops

The results are in the table below.

Those using cover crops are willing to pay 50-55 percent more in direct costs than those who are not using them. Farmers using cover crops and CCAs/agronomists are fairly well aligned on the acceptable costs for cover crop use.

	Seed Cost ($/acre)		Establishment Cost (labor, equipment, or contractors) $/acre		Herbicide Cost Above Normal Burndown $/acre		Total Cover Crop Cost $/acre	
	Average	(Range)	Average	(Range)	Average	(Range)	Average	(Range)
Farmers not using cover crops	12.81	(0-50)	8.48	(0-25)	6.12	(0-20)	27.41	(0-95)
Farmers using cover crops	20.33	(10-50)	12.95	(0-50)	7.45	(0-20)	40.73	(10-120)
CCAs/ agronomists	20.90	(0-70)	13.40	(0-50)	8.42	(0-40)	42.73	(0-160)

A Farmer's Perspective

Don't Trade Dollars

Lee Thelen

St. Johns, Michigan

Getting a measurable economic return is important to Lee Thelen, a St. Johns, Michigan farmer.

"I would like to get a three-to-one return on a practice before I will do it," Thelen says. "I just don't want to trade dollars."

He is always willing to try new products and practices and will tell you just how they worked and what he thinks of them. Thelen uses covers both before and after soybeans, depending on the situation. He wants to increase his cover crop acres as the situations allow.

Thelen practices no-till and strip-till with highly variable soils on 1,900 acres in central Michigan. He plants about 950 acres of soybeans each year. The primary crop rotation is corn, soybeans, and wheat. He is flexible in how he manages each field depending on soil type and season. On what he calls his "poor ground," he will rotate soybeans and wheat; and on his "good ground" he will rotate corn and soybeans.

He plants multispecies mixes that include oats, rye, and oilseed radish. He chooses what he thinks will be the best available seeding method — typically drilling, broadcast, or aerial. When seeding after soybeans, he plants some of the acres to winter wheat to harvest for grain the following year, or he will broadcast cereal rye for a cover only.

Opportunity Costs

Opportunity costs are associated with the potential income you lose if you plant a cover crop instead of a double crop. Shorter season cash crops can allow you to harvest them earlier and give you more time to seed and establish covers. That said, earlier maturing varieties of your cash crop could have lower yields than later maturing varieties.

However, there are early corn and soybean varieties with high yield potential. Remember too, that even later maturing varieties may not yield more than earlier maturing varieties because of weather conditions that growing season. Planting early maturing cash crop varieties in some fields allow you to start harvest earlier and spread out grain drying and handling.

Another opportunity cost is committing labor and equipment to planting cover crops while cash crops remain to be harvested. It may be better to commit on-farm resources to harvesting the cash crops. Increasingly, farmers who plant large-scale cover crop acreage after harvest are hiring dedicated labor for planting covers or hiring custom operators.

Potential Cost Savings

Cover crops have the potential to reduce cropping system costs by reducing your use of herbicides, nitrogen fertilizer, subsoiling, and irrigation.

Some cover crops are noted for their ability to suppress weeds through competition, shading, and allelopathy (when a plant produces organic compounds that have negative effects on other plants). These covers can reduce herbicide use (see A Farmer's Perspective: All In, right).

The symbiotic relationship between legumes and N-fixing bacteria allow N uptake from the atmosphere. Legume plant biomass decomposes more quickly and has a higher N concentration than grasses, with net N mineralization more likely during the subsequent growing season. Legume cover crops are called green manures and are considered an N source — although it is difficult to estimate the exact amount of N to credit from green manures, because it will vary from year to year. We recommend testing the soil to determine the appropriate N credit.

Farmers annually spend $30 to $35 per acre to till their soils. Deep tillage to reduce subsoil compaction is even more expensive. Tillage destroys soil structure, makes soil more susceptible to compaction with wheel traffic, and burns up soil organic matter. With cover crops, farmers can spend $30-$35 per acre on cover crop seed and planting to improve soil structure, decrease soil compaction, and add or increase soil organic matter.

Cover crops may be a slow fix for problems like soil compaction and it may require several years to see improvement, however, the results are usually longer lasting and more permanent if cover crops are used yearly. Biotillage by using cover crops can save money and provide additional benefits. Increasing soil organic matter increases the soil's water storage capacity, which could reduce the need for irrigation or timely rainfall.

One of the greatest opportunities for offsetting cover crop costs is to use them as forage for livestock through harvest or grazing.

Another source of funds to offset costs of cover crops is subsidy programs. There are federal (Conservation Stewardship Program (CSP), Environmental Quality Incentive Program (EQIP)) and state programs. Check with your local USDA-Natural Resources Conservation Service office or state agriculture department for requirements and cost-share information.

A Farmer's Perspective

All In

Ronnie Moore

Carl Ehrlich

Ronnie Moore, Farm Manager

Laddonia, Missouri

Carl Ehrlich is an active cover crop user and he and Ronnie Moore, his farm manager, have incorporated nearly a dozen different cover crop species as well as mixes into his east-central Missouri operation. Ehrlich notes that cover crops reduce his herbicide costs by about a third.

Ehrlich is "all in" with cover crops before and after soybeans. He uses each cover crop species for a specific purpose and matches each one to each field's needs. Species he uses include cereal rye, annual ryegrass, clovers, buckwheat, oilseed radish, sunflower, turnips, sunn hemp, and hairy vetch.

Ehrlich farms 1,500 acres in a corn-soybean-wheat rotation. He typically grows about 400 acres of soybeans annually, but only had 150 acres in 2013. He uses minimum tillage on most of his acres. Before soybeans he plants covers with a drill or planter into wheat stubble and into fields receiving manure.

"We want a good stand," Ehrlich says. "But even if it is light, we still see benefit."

After soybean harvest, he sticks with cereal rye and annual ryegrass. Those cover crops, he says, work every time — timing is key. He also likes covers with good fibrous root systems and deep taproots.

When selecting species, Ehrlich looks for a cover crop that can control weeds, reduce soil compaction, and decrease the cost of production in the following crop.

Increased Revenue Potential

There is some evidence that cover crops can improve soil quality, may increase yield, and/or may reduce annual yield variability. However, additional long-term field trials in the NCR are required to confirm these yield improvements over time, for varied climates and different geographic regions.

The yield response should be most evident on poor or degraded soils. Increasing revenue by improving cash crop yields is a long-term endeavor that may require using cover crops in the rotation whenever possible.

Decreased Revenue Potential

The most widely reported revenue loss from cover crops comes from corn grain yield suppression when corn is planted too soon after terminating grass cover crops. It's not clear what causes this yield reduction. Speculation about the causes includes lower soil moisture, reduced nutrient availability, allelopathic effects, or increased pests or pathogens.

As a general rule, terminate cereal rye and other grass cover crops 10 days to two weeks before planting corn to avoid yield reductions. Grass cover crops do not lower soybean yields when terminated about a week before planting soybeans. Later termination before soybeans is not usually a problem if water is not a limiting factor.

Other Challenges

There are many challenges to using cover crops. Our survey of farmers and CCAs/agronomists noted other challenges that are not exactly related to economics or establishment. These challenges include:

- Selecting the right cover crop species
- Balancing crop moisture use
- Terminating cover crops
- Navigating crop insurance rules
- Using cover crops on rented land — our survey did not address this topic, but it came up in several interviews

Other General Principles

If you are new to cover crops, these recommendations can help you overcome some of the other challenges of using cover crops before and after soybeans:

- Research the options appropriate for your location before selecting the appropriate cover crop for your operation. Resources include:
  - Books, publications, fact sheets, bulletins and Web-based resources from reputable sources (such as university extension services and the USDA; see Selected Cover Crop Resources, page 24). In particular, the Midwest Cover Crop Councils website (www.mccc.msu.edu) includes cover crop selector tools.
  - Cover crop workshops, meetings, demonstrations, and field days in your area.
  - Farmers who are using cover crops.
  - Cover crop experts from extension, agribusiness, USDA-NRCS, conservation districts, and state departments of agriculture.
- Start small. Build your knowledge and experience with new cover crop selections, and consider planting test plots to evaluate your selection before planting large acreages.
- Plant a low-biomass cover crop or one that does not overwinter, or terminate the cover crop early if you want to preserve moisture or plant very early in spring. But remember: cover crop benefits depend on the amount of growth.

A Farmer's Perspective

It's Worth the Hassle

Carmen Fernholz

Madison, Minnesota

Carmen Fernholz says the challenges of growing cover crops before soybeans include selecting species, getting them established, getting enough economic return, and investing his time and labor. He believes he can overcome all of these. Cover crops are worth it because he sees the value they put in his rotation.

"Many growers don't like the hassle factor of planting cover crops," he says.

Fernholz farms about 400 acres near Madison in southern Minnesota and is an avid cover crop user. He plants 60-100 acres of soybeans annually and tills his fields only once every two or five years depending on where he is in the rotation of corn, soybeans, small grains and forages. He knifes in liquid hog manure and plants multispecies cover crop mixes.

Fernholz does not till the soybean stubble and uses conservation tillage on the balance of his farm. He no-till plants covers with small grain crops ahead of soybeans. He does not plant any cover crops after fall soybean harvest; he no-till plants those fields to a small grain in the spring.

Fernholz looks for certain characteristics from his cover crops, including ones that winter kill, that have both fibrous roots and deep taproot systems, that grow quickly, and that have abundant biomass. Those who know Fernholz know that he promotes cover crops and readily shares his views.

"We can't guarantee there will be no production risk," Fernholz says. "But if we can make the connection between soil health and profitability, cover crops will take off."

- Wait to terminate cover crops chemically until weather and temperature conditions are good. Do not use chemicals if conditions are poor. Always follow herbicide label guidelines.
- Be prepared to make a second herbicide application paired with a residual application if initial termination is not completely successful.
- If not using herbicides and field conditions prevent mechanical termination, till as soon as possible and use multiple passes to ensure termination and to incorporate excess biomass.
- Always consult your crop insurance agent, Farm Services Agency, and USDA-NRCS guidelines for local crop insurance requirements. The requirements for the timing of termination have been relaxed some.
- Inform landlords, and work with them to include cover crops on rented land, in lease agreements, and in crop sharing agreements.

Selecting the Right Cover Crop Species

Before you select a cover crop, it's important to consider your cropping system, location, soil types, seed costs, and the window of opportunity (or time period) when you can grow the cover crop. A cover crop species that thrives under all these conditions is said to be in its proper window. In continuous soybean rotations and corn-soybean rotations, planting windows will limit your cover crop choices, especially post-harvest.

However, most farm operations have a number of possible planting windows. A good rule of thumb is that a cover crop needs to grow at least four to six weeks to justify the expense.

Some growing windows depend on your objectives. For example, planting a cover crop late can provide erosion protection even though growth is limited.

Like many things, the key to selecting the right species is to plan ahead and find out what cover crops other farmers in your area are using. Decide where the cover crops will fit in your cropping system, and then be ready to plant when the time comes. For many producers, this means keeping the spreader or drill full of the cover crop seed ready to go while they're still harvesting the cash crop.

See Selected Cover Crop Resources (page 24) for more information and tools to help you select the right cover crop for your operation.

Balancing Crop Moisture Use

Cover crops may reduce available moisture for cash crops, but they have also been shown to increase water infiltration and snow catch and to preserve soil water after termination through surface mulching. Therefore, cover crops can increase and reduce the moisture available to cash crops (see A Farmer's Perspective: The Right Thing, But Moisture, right).

Consider cover crop water use if you are growing them in areas with low precipitation, high evaporation, or unpredictable rainfall. In such areas, two things should guide your decision-making.

First, carefully consider how much biomass the cover crops produce. Low-biomass cover crops require less water; high-biomass cover crops require more. That said, more biomass could help reduce soil temperature and evaporation later during hot, dry periods when the cash crop is growing. Also, additional cover can help trap more snow, which is an important precipitation source in some regions. The low-biomass strategy is the more conservative approach in rainfall-

A Farmer's Perspective

The Right Thing, But Moisture

Ron Alverson

Chester, South Dakota

"We could have a disaster if we couldn't manage the cover and it took all the moisture," says Ron Alverson.

He farms in eastern South Dakota, which receives about 24 inches of rainfall annually, so he always considers water conservation in his management.

"We know [using cover crops] is the right thing to do for our soils, but we just need to figure out how to get them in," he says.

Alverson and his son farm 2,600 acres — about 2,000 acres are planted to corn each year and 600 acres to soybeans. They irrigate about 30 percent of their acres. Most of their acres are corn-on-corn, which is driven by economics. They farm on ridges. Their five-year average yields are 170 bushels per acre for corn and 52 bushels per acre for soybeans. They have tried covers and still look for opportunities to get them established.

His son Keith would like to include covers "to get the rotational effect in our corn-on-corn rotations."

They would love to get a small grain into their rotation but it would not be successful economically. The benefits they are looking for include nitrogen scavenging, soil carbon, rotational effect, and soil health. In the past, they have aerially seeded annual ryegrass in standing corn on about 400 acres under irrigation ahead of soybeans. The annual ryegrass had good growth, but when they harvested, the crop residue covered up the ryegrass and smothered it. Their dryland covers never germinate because of lack of rain. A cover crop using too much moisture is a big concern because of low annual rainfall in the area.

limited regions and still allows for some of the beneficial effects of a cover crop, including erosion control and feeding soil biology.

Second, consider the cover crop's termination date before planting the cash crop. It may be desirable to use cover crops that winter kill or to terminate the cover crop several weeks before planting the cash crop to allow rainfall to recharge soil moisture.

Terminating Cover Crops

Completely terminating cover crops can be a challenge. Terminating covers in the spring with herbicides may be difficult because of scheduling pressures and the need to complete pre-plant field operations.

Spring weather presents the greatest challenge to terminating cover crops. Wet conditions and cool temperatures can affect the timing and the effectiveness of termination.

Recognize and minimize the potential difficulties of terminating cover crops by planning ahead and timing termination for the best possible conditions. If spring termination is a concern, consider planting cover crops that will winter-kill, even though they will offer fewer benefits because of limited fall growth and the potential of an early freeze.

The USDA-NRCS publication *Cover Crop Termination Guidelines* provides some helpful information about termination. It is available at www.nrcs.usda.gov.

Broadly speaking, there are two cover crop termination methods: chemical and mechanical.

Chemical Termination

Farmers can terminate cover crops chemically as part of pre-plant herbicide application programs. Variable spring weather can lead to herbicide applications under less than ideal conditions.

To effectively kill some cover crops (such as annual ryegrass), the cover crop must be actively growing to translocate the herbicide. When it is cool, translocation may be limited. As a result, the herbicide may damage but not completely kill the cover crop, which can lead to regrowth or very slow termination.

Strictly follow herbicide guidelines for application timing and conditions to increase the odds of successful chemical cover crop termination. Some cover crop species may require a second application, which may be paired with residual herbicides to improve weed control in the subsequent crop.

Mechanical Termination

You can terminate cover crops mechanically with spring tillage, however, this can present challenges under wet conditions. Wet fields can keep you out of the field, which can result in increased biomass production and maturity. In turn, the additional biomass may require additional tillage passes to complete termination. In addition, increased maturity can immobilize N. If it rains after you till to terminate cover crops, it can allow some cover crop plants to survive. In such cases, your field may require additional tillage passes.

A Farmer's Perspective

Tell It to the Landowner

Jim Hebbe

Green Lake, Wisconsin

Like other Midwest cover crop users Jim Hebbe faces an additional challenge of dealing with landowners.

"Farmers are not farming rented land like the ground that they own," says Hebbe.

Renters are afraid to make long-term investments knowing they might lose the ground next year. It's a battle between the long and short term.

Hebbe farms 1,200 acres with a corn-soybean-wheat-alfalfa rotation in central Wisconsin. He has no-tilled since the 1980s. He plants a corn-corn-soybean-wheat rotation, adding alfalfa on fields with slopes. Each year he has about 350 acres of soybeans. He tries to plant cover crops after soybeans.

Hebbe describes his bottom line for cover crop use: "They can work for you, but they can hurt you if the timing is not right."

He looks for covers that reduce erosion, provide an economic return, and cycle nutrients. He sometimes worries we are going backward on erosion — sheet erosion is on the rise.

When it comes to cover crops on rented land he notes, "I have to go to our landowners and explain no-till and covers. . . . On rented ground, all the work I do over the years building organic matter can go out the window when the next farmer takes it and tills it."

That's why he thinks landowners need to be educated about cover crops.

Navigating Crop Insurance Rules

Crop insurance rules for cover crops can be confusing. When using cover crops, the guidelines for insuring the following cash crop vary around the North Central Region.
In general, these factors affect whether you can insure the cash crop:

- Whether or not you harvest the cover crop.
- When you terminate the cover. Insurance programs may require a minimum number of days after terminating the cover crop before you can plant (and insure) the cash crop.

- In very dry locations, no insurance program will insure the cash crop if you plant cover crops.

Before you plant cover crops, consult with your crop insurance agent and Farm Services Agency office to determine the local requirements to maintain the insurability of your cash crop.

Using Cover Crops on Rented Land

Many farmers admit that one of their challenges is justifying cover crops on rented land to landlords (see A Farmer's Perspective: Tell It to the Landowner, page 23).

The economic benefits of cover crops will not be realized under short-term leases. When farming on shares, landlords readily understand sharing the cost of seed and fertilizer, but question the costs of cover crops. Some landlords may even have a kind of nostalgia for the way things have always been done, including full-width tillage and bare black soil in the spring.

In any case, it may be worthwhile to share information and articles about the benefits of cover crops with landlords. Consider inviting landlords to attend a cover crop workshop or field day in your area. Farmers have reported that landlord attitudes toward cover crops can change after attending such events.

Understanding cover crops as a sustainable practice that demonstrates good stewardship and that can protect and improve their land may lead landlords to not only support their use, but eventually to demand their use. Including cover crops in the lease agreement can secure longer leases that benefit both the farmer and the landlord.

Summary

If you don't use cover crops, we hope this publication will help you consider using them in soybean production; if you do use cover crops, we hope it helps you expand and improve their use. If you set goals; plan properly; account for available resources; and pay attention to your location, climate, and soil type, cover crops can be an important part of your soybean production system.

There are benefits and challenges to using cover crops, and we need more research to better address the challenges soybean farmers have with using them. What we have learned from this project will help guide that research.

At the same time, researchers and farmers are discovering more about cover crops and their use every day. There are strategies that farmers are using to meet the challenges, and we encourage you to learn from others and do your homework about using cover crops by consulting articles, publications, and workshops, and attending field days and conferences.

Selected Cover Crop Resources

Your Local Extension Service

Check your land-grant extension service for local cover crop and soybean production information.

Midwest Cover Crops Council

www.mccc.msu.edu

The Midwest Cover Crops Council aims to improve ecological, economic, and social sustainability through the widespread adoption of cover crops. Their website includes tools to help you select cover crops best suited to your region, cropping system, and goals.

Midwest Cover Crops Field Guide

Available from the Purdue Extension Education Store, www.edustore.purdue.edu.

This pocket-size, in-field reference will help readers effectively select, grow and use cover crops in their farming systems. It was written by members of the Midwest Cover Crops Council. Topics include choosing cover crops, fitting cover crops into your system, and positive and negative effects of cover crops.

Managing Cover Crops Profitably

Available from the Sustainable Agriculture Network and the Sustainable Agriculture Research and Education Program of USDA-CSREES, www.sare.org/Learning-Center.

This comprehensive guide to cover crops has further information and ranks cover crops on a national rather than regional scale.

National No-Tillage Conference

Information available from *No-Till Farmer*, www.no-tillfarmer.com/nntc.

The National No-Tillage Conference shares the best no-till management practices and ideas to improve no-tillers' bottom lines. Speakers include no-tillers, agronomists, consultants, and university experts from South and North America. Topics range from soil biology to precision ag, to fertility management, to cover cropping.

No-till on the Plains

www.notill.org

No-till on the Plains (based in Salina, Kansas) is a nonprofit educational organization whose mission is to provide education and networking on agricultural production systems that model nature. Their conference helps producers understand basic concepts and principles of moving to a no-till system and helps long-term no-tillers who are seeking to optimize their management.

Conservation Tillage and Technology Conference

Information available from Ohio State University Extension, fabe.osu.edu/CTCon.

The Conservation Tillage and Technology Conference is an annual two-day educational program with about 60 speakers. Session titles typically include: Corn University, Soybean School, Cover Crops, Nutrient Management, Soil & Water Quality, Precision Agriculture, Planters, Advanced, Scouting Techniques, and No-till Systems.

USDA-NRCS National Soil Health and Sustainability Team

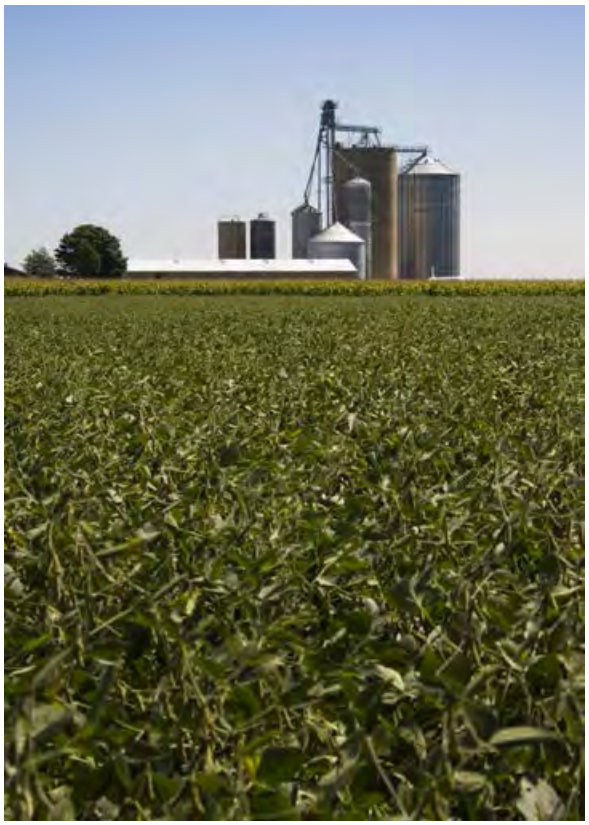
www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/?cid=stelprdb1237522

The USDA-NRCS National Soil Health and Sustainability Team specializes in technology transfer and training to improve soil health, productivity, and air and water quality. The interdisciplinary staff conducts soil health training for NRCS employees, conservation partners, farm groups, and producers; develops educational materials and demonstrations to highlight conservation practices that improve soil health; and works with state soil quality/soil health specialists to incorporate soil health concepts into conservation planning and programs.

Buz Kloot: Explore the Science of Soil Health videos

Available from the USDA-NRCS at www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/health/?cid=stelprdb1245890

These are a series of short videos from Robin "Buz" Kloot that focus on the science of soil health.



References

Alberts, E.E., R.C. Wendt, and R.E. Burwell, 1985. Corn and Soybean Cropping Effects on Soil Losses and C Factors. Soil Sci. Soc. Am. J., 49(3): 721-728.

Ateh, C.M. and J.D. Doll, 1996. Spring-Planted Winter Rye (Secale Cereale) as a Living Mulch to Control Weeds in Soybean (Glycine Max). Weed Technology, 10(2): 347-353.

Buyanovsky, G.A. and G.H. Wagner, 1986. Post-Harvest Residue Input to Cropland. Plant and Soil, 93(1): 57-65.

Chen, G.H. and R.R. Weil, 2010. Penetration of Cover Crop Roots through Compacted Soils. Plant and Soil, 331(1-2): 31-43.

Clay, D., S. Clay, K. Reitsma, B. Dunn, A. Smart, G. Carlson, D. Horvath, and J. Stone. 2014. Does the conversion of grasslands to row crop production in semi-arid areas threaten global food security? Global Food Security.

Cresswell, H. and J. Kirkegaard, 1995. Subsoil Amelioration by Plant-Roots — The Process and the Evidence. Soil Research, 33(2): 221-239.

De Bruin, J.L., P.M. Porter, and N.R. Jordan, 2005. Use of a Rye Cover Crop Following Corn in Rotation with Soybean in the Upper Midwest. Agronomy Journal, 97(2): 587-598.

Forcella, F., 2014. Short- and Full- Season Soybean in Stale Seedbeds Versus Rolled-Crimped Winter Rye Mulch. Renewable Agriculture and Food Systems, 29(1): 92-99.

Hoffbeck, C., J. Ruland, and J. Miller. 2008. Benefits of cover crops in no-tillage wheat stubble. Field Fact 8(13), Pioneer Hi-bred Int. Johnston, IA.

Jewett, M.R. and K.D. Thelen, 2007. Winter Cereal Cover Crop Removal Strategy Affects Spring Soil Nitrate Levels. Journal of sustainable agriculture, 29(3): 55-67.

Kaspar, T.C., D.B. Jaynes, T.B. Parkin, and T.B. Moorman, 2007. Rye Cover Crop and Gamagrass Strip Effects on No3 Concentration and Load in Tile Drainage. Journal of Environmental Quality, 36(5): 1503-1511.

Kaspar, T.C., D.B. Jaynes, T.B. Parkin, T.B. Moorman, and J.W. Singer, 2012. Effectiveness of Oat and Rye Cover Crops in Reducing Nitrate Losses in Drainage Water. Agricultural Water Management, 110(0): 25-33.

Kaspar, T.C., J.K. Radke, and J.M. Laflen, 2001. Small Grain Cover Crops and Wheel Traffic Effects on Infiltration, Runoff, and Erosion. Journal of Soil and Water Conservation, 56(2): 160-164.

Kaspar, T.C., J.W. Singer. 2011. The use of cover crops to manage soil. In: J.L. Hatfield, T.J. Sauer, editors. Soil Management: Building a stable base for agriculture. Madison, WI: American Society of Agronomy and Soil Science Society of America. p. 321-337.

Kessavalou, A. and D.T. Walters, 1999. Winter Rye Cover Crop Following Soybean under Conservation Tillage: Residual Soil Nitrate. Agronomy Journal, 91(4): 643-649.

Liebl, R., F.W. Simmons, L.M. Wax, and E.W. Stoller, 1992. Effect of Rye (Secale-Cereale) Mulch on Weed-Control and Soil-Moisture in Soybean (Glycine Max). Weed Technology, 6(4): 838-846.

McSwiney, C.P., S.S. Snapp, and L.E. Gentry, 2010. Use of N Immobilization to Tighten the N Cycle in Conventional Agroecosystems. Ecological Applications, 20(3): 648-662.

Nance, C.D. and L.R. Gibson, 2007. Soil Profile Nitrate Response to Nitrogen Fertilization of Winter Triticale. Soil Science Society of America Journal, 71(4): 1343-1351.

Ouyang, D., J. Bartholic, and J. Selegean, 2005. Assessing Sediment Loading from Agricultural Croplands in the Great Lakes Basin. The Journal of American Science, 1(2): 14-21.

Parkin, T.B. and T.C. Kaspar, 2006. Nitrous Oxide Emissions from Corn-Soybean Systems in the Midwest. J. Environ. Qual., 35(4): 1496-1506.

Reese, C., D.E. Clay, S.A. Clay, A. Bich, A. Kennedy, S. Hansen, and J. Miller. 2014. intercover crops impact on corn production in semi-arid regions. Agron. J. 106:1479-1488.

Ruffo, M.L., D.G. Bullock, and G.A. Bollero, 2004. Soybean Yield as Affected by Biomass and Nitrogen Uptake of Cereal Rye in Winter Cover Crop Rotations. Agronomy Journal, 96(3): 800-805.

Smith, D.R., G. Hernandez-Ramirez, S.D. Armstrong, D.L. Bucholtz, and D.E. Stott, 2011. Fertilizer and Tillage Management Impacts on Non-Carbon-Dioxide Greenhouse Gas Emissions. Soil Sci. Soc. Am. J., 75(3): 1070-1082.

Strock, J.S., P.M. Porter, and M.P. Russelle, 2004. Cover Cropping to Reduce Nitrate Loss through Subsurface Drainage in the Northern US Corn Belt. Journal of Environmental Quality, 33(3): 1010-1016.

Thelen, K.D. and R.H. Leep, 2002. Integrating a Double-Cropped Winter Annual Forage into a Corn-Soybean Rotation. Crop Management, 1(1).

Villamil, M.B., G.A. Bollero, R.G. Darmody, F.W. Simmons, and D.G. Bullock, 2006. No-Till Corn/Soybean Systems Including Winter Cover Crops: Effects on Soil Properties. Soil Science Society of America Journal, 70(6): 1936-1944.

Williams, S.M. and R.R. Weil, 2004. Crop Cover Root Channels May Alleviate Soil Compaction Effects on Soybean Crop. Soil Science Society of America Journal, 68(4): 1403-1409.

Zhu, J.C., C.J. Gantzer, S.H. Anderson, E.E. Alberts, and P.R. Beuselinck, 1989. Runoff, Soil, and Dissolved Nutrient Losses from No-Till Soybean with Winter Cover Crops. Soil Science Society of America Journal, 53(4): 1210-1214.

Survey Summaries

Some of the results of the survey we conducted with farmers, CCAs, and agronomists are summarized throughout this publication:

- Cover crop use — Survey Results: Cover Crop Use Increasing, page 4
- Cover crop benefits — Survey Results: Why Are Soybean Farmers Using Cover Crops?, page 5
- Where cover crops are used — Survey Results: Where Do Cover Crops Fit in Soybean Rotations? page 11
- Cover crop species used — Survey Results: What Covers Are Popular in Soybean Rotations?, page 12
- Cover crop seeding methods — Survey Results: What Cover Crop Seeding Methods Are Popular in Soybean Rotations?, page 13
- Economic challenges to cover crop use — Survey Results: How Important Are Economic Challenges?, page 17
- Cover crop costs — Survey Results: What Are Farmers Willing to Pay?, page 19

Table 1 (page 27) summarizes additional survey information about the respondents' selections for their top three desired cover crop benefits.

Table 2 (page 27) provides more survey information about their selections for the top three cover crop challenges.

Table 1. Benefits of cover crops. This table shows the percentage of survey respondents who indicated the benefits they hope to gain from using cover crops. Sample sizes: farmers using cover crops=164 respondents; CCAs/agronomists=274 respondents.

Group	Benefit														
	Control of insects	Control of weeds	Nitrogen source	Nitrogen scavenging	Reduces diseases	Reduces soil compaction	Reduces soil erosion	Winter kills easily	Winter hardiness/survival	Economic return	Decreases production costs	Increases yield	Fibrous rooting system	Deep tap roots	Ease of termination
	Percentage of Respondents														
Farmers not using cover crops	2	20	24	18	1	47	45	14	2	11	9	28	10	20	8
Farmers using cover crops	2	40	23	32	5	48	55	4	5	10	7	29	19	10	11
CCAs/agronomists	1	36	15	31	2	35	61	11	4	12	2	18	11	10	12
Total	2	32	20	27	2	42	55	10	4	11	6	24	13	13	11

Table 2. Challenges to cover crop use before and after soybeans. This table shows the percentage of survey respondents who indicated the various challenges to using cover crops both before and after planting soybeans. Sample sizes: farmers using cover crops=164 respondents; CCAs/agronomists=274 respondents.

Group	Challenge																																	
	Selecting the right cover crop species for my operation		Establishing cover crops		Increases overall crop production risk		Cover crop becomes a weed the following year		Nitrogen immobilization (N not available for the crop)		Cover crop sometimes uses too much soil moisture		Increased disease potential		Increased insect potential		Time / labor required for planting and increased management		Cost of planting and managing cover crops		No measurable economic return		Yield reduction of the following crop		Cover crop seed cost		Cover crop seed availability		Residual herbicide carryover		Difficulty terminating cover crops		Uncertainty of crop insurance rules	
	Before[1]	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Farmers not using cover crops	19	15	29	37	4	3	15	10	1	2	12	9	4	2	5	3	46	47	33	34	17	19	7	6	22	19	5	3	5	4	14	12	8	5
Farmers using cover crops	18	20	52	45	2	4	7	7	2	6	13	6	1	1	5	4	38	37	30	24	13	13	3	9	23	24	6	4	6	5	12	11	11	9
CCAs/ Agronomists	15	15	38	41	9	7	18	13	3	7	17	15	3	2	8	8	37	34	27	27	24	21	8	11	23	19	4	5	11	7	20	15	6	5
Total	17	16	39	41	6	5	14	11	2	5	15	11	2	2	6	6	40	39	29	28	19	18	6	9	22	20	5	4	8	6	16	13	8	6

[1]Percentage of survey respondents who indicated this is a challenge before or after planting soybeans.

Here are some of the farm families who generously gave us their time to participate in this project.

Thank you.

May 2015

Non-Discrimination Statement

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.