CHAPTER 13

Winter Cover Crops

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Winter cover crops are planted into or after harvest of a cash grain, oilseed, or vegetable crop before the next crop is planted the following spring. In this context, winter cover crops are not grown for harvest. Cover crops can also fit into other niches like a summer fallow, but this chapter will focus on winter cover crops such as winter rye and hairy vetch, used in grain cropping systems. See the section on green manures in Chapter 4 on fertility and Chapter 12 on forages for other cover crop-related information.

LYNN BETTS, NRCS

Figure 13-1. *Cover crop on a field in Black Hawk County, Iowa.*

Table 13-1. Potential benefits and risks of winter cover crops

BENEFITS	RISKS
Nutrient enhancement	Additional management and labor
Soil nutrient capture	Additional expense for seed cost
Soil moisture retention	Interference with primary crop establishment
Erosion protection	Soil moisture depletion (if cover crop actively growing in spring)
Weed control	Cooler soil temperatures in spring because of plants on surface
Improved soil structure	Competition with primary crop
Disease control	Nutrient depletion by non-legumes
Nematode control	Nutrient availability not timely for subsequent crop
Increased soil organic matter	Allelopathic effects on primary crop

Winter cover crops can provide several benefits but have several risks (Table 13-1). Winter cover crops are best adapted to areas with a long enough time to establish in the fall and without soil moisture deficits in the spring.

Selecting cover crops

This chapter will focus on the species most commonly used in the upper Midwest. The first step in selecting a cover crop species is to determine the main goal of the cover crop (Table 13-2). Many organic producers select cover crops to add nitrogen, control weeds, protect soil, and/or to increase soil organic matter. There are two main categories to consider—cover crops that overwinter and regrow in the spring, and those that do not.

Table 13-2. Important functions of winter cover crops in cropping systems. *These cover crops are recommended for the Upper Midwest.*

FUNCTION	WINTER COVER CROPS
Nitrogen source	Hairy vetch, red clover
Nitrogen scavenging	Winter rye
Provide soil organic matter	Winter rye
Erosion control	Winter rye, oats, annual ryegrass
Improved soil structure	Brassicas
Control weeds	Winter rye, hairy vetch, oats, annual ryegrass, brassicas
Control diseases	Brassicas

WINTER HARDINESS

In northern climates, many cover crop species will not survive the winter. Winter rye and hairy vetch are cover crops that have the best potential to overwinter in the upper Midwest. Oat planted in the fall is an example of a cover crop that will winter kill. Of course, there is potential for any winter cover crop to have low survival rates, even if it is hardy (Figure 13-2). Producers will need to choose if overwintering is a desirable winter cover crop characteristic. There will be different risks associated with either strategy.

Reducing risk: winter hardiness. If an overwintering cover crop is selected, ensure that it is winter hardy for the location. Using local seed can reduce your risk of cover crop failure, but poor winter conditions will always be a hazard to survival.

NITROGEN SOURCE

Leguminous cover crops will provide nitrogen to subsequent crops. This nitrogen can increase yield in corn (Figure 13-3). Red clover (see Forages chapter) and hairy vetch are the best choices.

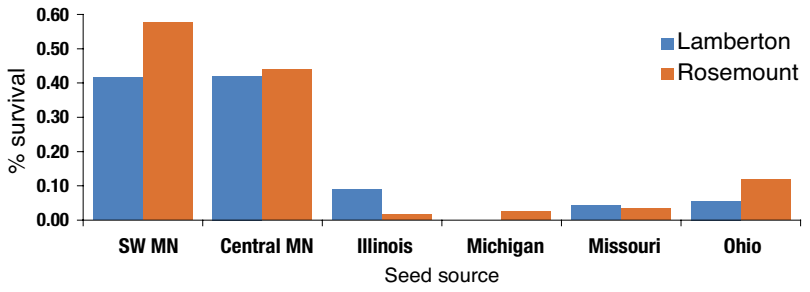

Figure 13-2. Hairy vetch winter hardiness. *The origin of hairy vetch seed is important to winter survival. Research conducted at Lamberton and Rosemount, MN, found that Minnesota seed has better survival than seed from other locations.*

When grown in the upper Midwest as a winter cover crop, hairy vetch will produce 40 to 80 pounds nitrogen per acre depending on the amount of biomass. The nitrogen that is fixed by legumes is not entirely available to the next crop until the residue decomposes. A large amount of the nitrogen is released within a week of killing a cover crop. Incorporated biomass will decompose more quickly than biomass left as mulch. Scavenged nutrients in grass cover crops like winter rye are usually not as available to subsequent crops as legume nutrients because the residue takes longer to decompose.

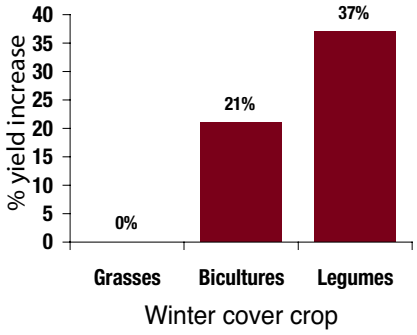

Figure 13-3. Winter cover crop effects on corn yield. *In an analysis of winter cover crop studies, legumes and legume-grass bicultures had a positive effect on yield in corn. Grass cover crops did not increase or reduce yield. Adapted from Miguez and Bollero, 2005.*

Reducing risk: nitrogen. Choose a legume versus a grass or brassica for nitrogen. Non-legume cover crops have the potential to deplete soil nitrogen. The timing of nitrogen release may not coincide with subsequent crop needs so supplementary soil amendments may be necessary.

SOIL ORGANIC MATTER

Cover crop species that produce high biomass will be the best contributors to soil organic matter. Winter rye will be the best choice. Hairy vetch can also produces high biomass, but legume biomass tends to degrade quickly without making great contributions to soil organic matter. Oat, annual ryegrass, and the brassicas also do not contribute greatly to soil organic matter when compared to winter rye.

Reducing risk: organic matter. Choose a cover crop species that will produce high-quality biomass under your conditions.

SOIL PROTECTION

Any cover crop that leaves residue over the winter will provide some soil protection and can reduce nutrient leaching. Winter rye grown following corn can scavenge excess nutrients, thereby reducing loss through leaching (Figure 13-4). Overwintering cover crops like winter rye will provide the ultimate in erosion control. Cover crops such as spring oats that do not overwinter but are allowed to produce adequate growth before frost can aid in soil protection.

Reducing risk: soil protection. Choose a cover crop that will produce high biomass in the fall to offer soil protection over the winter.

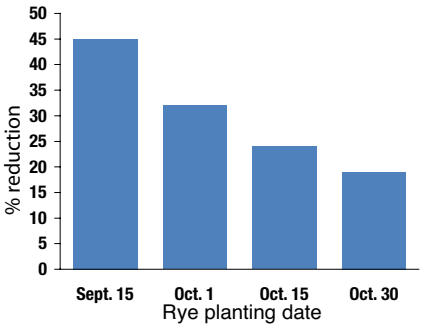

Figure 13-4. Rye and nitrate leaching. *Including winter rye in a corn-soybean rotation can reduce nitrate leaching up to 45% compared to without rye. The amount of reduction is dependent on rye planting date. Adapted from Feyereisen et al., 2006.*

IMPROVED SOIL STRUCTURE

Compacted soil can be improved by cover crops with deep taproot. The best example would be brassica cover crops. The roots can go down several feet (Figure 13-5). In the spring, those roots decompose, leaving channels in the soil that aid in aeration and water filtration.

Reducing risk: soil structure. Plant brassicas by September 1st in southern Minnesota to produce extensive root systems and herbage for ground cover.

WEED CONTROL

Cover crops help control weeds in spring and fall by out-competing them for resources, by not allowing a niche for them to germinate and through allelopathic compounds. Be aware that all weeds and all weed species will not be controlled, even under ideal cover crop growth. Season-long weed control cannot be expected; early season control of weeds is more likely. Small seeded annual weeds are controlled more than other weeds by cover crops. Cover crop residue can have allelopathic effects that inhibit the germination of some weed species (Table 13-3). However, this effect will be more efficient with high amounts of residue.

CARMEN FERNHOLZ

Figure 13-5. ***Roots of oilseed radish at different growth stages.***

Reducing risk: weed control. Expect to use mechanical weed control operations in addition to cover crops. Ensure that cover crops can produce adequate growth.

OTHER PEST CONTROL

Some cover crops, especially the brassicas, can have negative effects on pests other than weeds. They can suppress nematodes and some pathogenic fungi. Fresh residue must be worked into the soil for this effect, which then limits the soil protection that would be available if the residue overwintered. Generally, consider these benefits to be minimal under the climate of states such as Minnesota.

Table 13-3. Cover crops and the weeds on which they have shown allelopathic effects. ***Compiled from various sources.***

COVER CROP	WEEDS INHIBITED
Brassicas	Pigweeds
	Shepardspurse
	Green foxtail
	Kochia
	Hairy nightshade
	Barnyardgrass
Winter rye	Wild oat
	Dandelion
	Crabgrass
	Barnyardgrass
	Common ragweed
	Lambsquarters
Hairy vetch	Common chickweed
	Redroot pigweed
	Wild carrot
	Knotweed

Reducing risk: pest control. Do not rely on cover crops solely to meet pest control needs. They should be part of a diverse rotation.

SOIL MOISTURE

Cover crops can also preserve soil moisture by shading the soil and reducing evporation. However, cover crops that are actively growing in the early spring can use soil water that may be needed by the cash crop (Table 13-4). Soil water depletion due to cover crops is a concern in areas that receive less than 30 inches of precipitation. Mean annual precipitation is 35 inches in extreme southeast Minnesota, an amount that gradually decreases to 19 inches in the extreme northwest

portion of the State. Timing of killing the cover crop becomes more critical as the probability of rainfall decreases.

At times when there is excess spring soil moisture, a cover crop may increase the time it takes for soil to be dry enough for field operations. This can delay planting.

Reducing risk: moisture. To prevent soil water deficits or surplus in spring, plant a non-overwintering cover crop or terminate overwintering cover crops in early spring.

One organic producer in Redwood County has tried using winter rye, but in two years out of three, the moisture has limited establishment in the fall. He believes fall moisture will always be a risk for this crop in his area.

PRODUCER PROFILE

An organic producer from Faribault County uses cover crops in his cropping system. He utilizes winter rye, hairy vetch with oats, and red clover underseeded in oats. For rye, he uses an airplane to broadcast seed into corn in the fall. The rye re-grows in spring and it is terminated by disking at four to eight inches tall because he finds that a high rye biomass can lead to seed maggot. Soybeans are planted 7 to 10 days after rye is disked. This step is essential; otherwise there will be negative yield effects on his soybeans. He does not use a cover crop after soybeans. Moisture can be an issue for cover crop success in his area.

When he grows hairy vetch and spring oats as a winter cover crop, the winter-killed oats provide some protection for the overwintering vetch. The vetch is controlled in the spring by disking twice.

Another combination he uses is oats underseeded with red clover. He really likes red clover for his farm. After the oats are taken off, the clover is clipped if it is growing well. In the fall, compost is spread and the clover is disked. Any red clover that comes back in the spring is killed by disking before corn planting.

Table 13-4. Winter rye competition for spring moisture.
In research conducted in Morris, Lamberton, and Waseca, MN, winter rye used as a winter cover crop reduced yields in a subsequent soybean crop when moisture levels were too low. Adapted from Warnes et al, 1991.

SOIL CONDITIONS	AVAILABLE WATER IN INCHES	EFFECT ON SOYBEAN
Dry	10	yield reduction
Average	15	no yield reduction
Excess moisture	20	no yield reduction

Establishing cover crops

When and how cover crop planting occurs is determined by the cover crop growth rate, the length of the growing season, and the previous crop. There are different options for establishing winter cover crops, either while the row crop remains or after summer crop harvest. Establishing can be done either by broadcast seeding or drilling, dependent upon whether the cash crop is still standing.

PLANTING DATE

To maximize fall biomass production, most cover crops require 40 to 60 days of growth before a killing frost (Table 13-5). For southern Minnesota, this requires planting by September 1. Timely planting will lead to increased soil cover and biomass (Figure 13-6). However, there may be constraints to planting at the ideal time. Row crops like corn and soybean will still be in the field during the best times to plant. Planting too early in the season will mean competition with the row crop or interference with harvest, while planting too late is risky for cover crop establishment before winter.

The period after small grain harvest allows more time to establish a cover crop. This option is lower risk relative to planting a cover crop during or after a row crop.

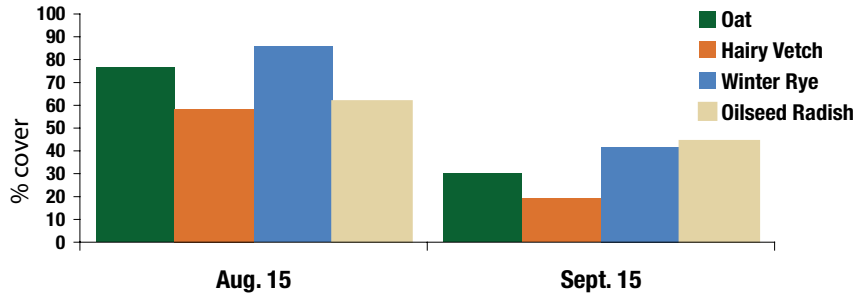

Figure 13-6. Cover crop planting dates. *In research conducted in Lamberton, MN, cover crops were planted into standing soybean on two dates. Earlier planting led to increased cover for all the species.*

Reducing risk: planting date. Match the correct cover crop species to the correct time to plant in your rotation in order to provide time for adequate growth in the fall. Plant cover crops after small grains, instead of row crops which are harvested later, to ensure establishment success.

Table 13-5. Risk to successful establishment of winter cover crops by planting date.
Other factors that will affect planting date risk are limiting soil moisture, method of planting, and winter hardiness.

Risk level
High
Moderate
Low

SPECIES	July	Aug 1-15	Aug 16-31	Sept 1-15	Sept 16-30	Oct 1-7	Oct 8-14
Winter rye	High	Moderate	Low	Low	Low	Moderate	High
Hairy vetch	High	Moderate	Low	Low	Moderate	High	High
Oat	High	Moderate	Low	Low	Low	Moderate	High
Annual Ryegrass	High	Moderate	Low	Low	Moderate	High	High
Brassicas	High	Moderate	Low	Low	Low	Moderate	High

PLANTING METHOD

Cover crops can be either planted into the summer crop by broadcast seeding or planted after harvest by drilling or broadcasting.

Broadcast seeding into row crop. Cover crop seed can be broadcast into standing corn or soybean (Figure 13-7). Broadcast seeding is less efficient than drilling in establishing a cover crop. More seed is needed, up to twice as much, when compared to drilling. Other things to consider are whether a cover crop will tolerate shade from a standing crop or if dry conditions in late summer will hinder establishment.

Reducing risk: broadcast seeding. Use the proper seeding rate when using the broadcast method (see cover crop profiles in this chapter). Dry weather after seeding will be a great risk to establishment. Plant in a timely manner that will not cause interference with cash crop harvest.

Planting post grain crop. Planting post harvest can be accomplished either by drilling or broadcast seeding. Generally, this will lead to better initial establishment compared to planting into a standing row crop. However, it may not be feasible timewise; it depends on when the primary crop is harvested and which winter cover crop is used.

Post harvest planting using no-till methods may fit into a cropping system better after small grains than after row crops. In the case of planting after small grain harvest, seed can be broadcast and lightly harrowed or disked to incorporate the seed. Another option is to drill cover crop seed into the grain stubble. Waiting until after corn or soybean harvest is generally not recommended because most cover crops will not have enough time to establish and form adequate cover. However, corn harvested for silage or sweet corn will be the exception.

Figure 13-7. *Oilseed radish cover crop that was broadcast into soybean.*

Reducing risk: planting after crop. Dry weather after seeding will be a great risk to establishment. Planting post harvest after a small grain will reduce risk compared to planting after row crop harvest.

ADVANCED TECHNIQUE: Early varieties to accommodate cover crops

Producers may choose to plant earlier-maturing row crops in order to accommodate cover crop integration into their rotations. Early-maturing corn and soybean may leave more time to establish a winter cover crop (Table 13-6). This may result in reduced grain yield; varieties that mature early yield less. However, the benefits to soil health through using cover crops may outweigh small yield reductions. This will be an option that organic producers will need to evaluate for their individual operations.

Table 13-6. *Cover crop performance in early and late maturity soybeans in Lamberton, MN (2007). The early soybean variety allowed for greater cover crop growth and dry weight compared to the later variety. In this case, there was no loss in yield.*

VARIETY	COVER (%)	COVER CROP DRY WEIGHT (g/ft²)	SOYBEAN YIELD (BU/ACRE)
Early Soybean	46.7	5.5	43.2
Late Soybean	30.3	2.3	41.2

Terminating cover crops

A fall-planted, winter-hardy cover crop will need to be killed or controlled in the spring before the next crop can be planted. For the organic producer, cover crops can be terminated in the spring by mowing, chopping, rolling, undercutting, or plowing to incorporate (Table 13-7). Combinations of the above techniques like mowing followed by chisel plowing can also be used. Effective termination is one of the riskiest aspects in organic cover crop management.

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Figure 13-8. *An organic producer flail-mows a rye and vetch cover crop.*

TERMINATION WITH TILLAGE

Tillage is more effective for killing cover crops when compared to no-till methods, but tillage is more detrimental to soil health. The weed control benefits of a cover crop may be lessened when tillage incorporates mulch leaving the soil uncovered. Tilled-under cover crops break down rapidly once they are incorporated into the soil and this quicker decomposition may lead to nutrient losses through leaching.

Cover crops can be incorporated using a chisel or moldboard plow (Figure 13-9). A cover crop can be terminated whenever the soil can be worked. The benefit to using tillage is that there will be more flexibility when a cover crop is terminated compared to other methods. The only mechanical control method effective at vegetative stages will be incorporation.

The type of tillage needed to incorporate a cover crop will be dependent on soil type and cover crop. A cover crop such as winter rye, which produces a large amount of spring biomass, may reduce soil temperature and reduce the growth of the next crop. Therefore, more aggressive tillage may be preferred to prevent these effects.

Table 13-7. Summary of termination options *for overwintering cover crops and their associated risks of regrowth. Risk will be dependent on timing of termination.*

TERMINATION OPTIONS		RISK
With incorporation	Moldboard plow	Low
	Chisel plow	Moderate
No incorporation	Disking	Moderate
	Flail chop	Moderate
	Rotary mow	High
	Roll and crimp	High

Figure 13-9. *Moldboard plow.*

Reducing risk: termination with tillage. Use a tillage approach that will allow the same weed control operations as when there is not a cover crop. Ensure that soil conditions permit tillage in spring. Tillage will require more labor and energy than non-tillage termination methods.

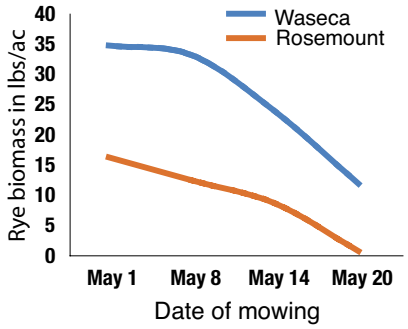

Figure 13-10. Rye regrowth after mowing different dates.
Rye regrowth was substantial when mowed in early May. When mowing occurred near anthesis at the end of May, there was little regrowth. Adapted from DeBruin et al, 2005.

TERMINATION WITHOUT TILLAGE

When tillage is not used to terminate a cover crop, the timing of termination is very important. Hairy vetch will need to be controlled mechanically at flowering, which occurs in mid-June. Rye is best controlled at or before flowering (Figure 13-10). This occurs in late May. These times may be late for starting a subsequent corn or soybean crop.

Non-tillage cover crop termination methods are mowing/chopping and roller-crimping (see "No-till cover crop system" section). Mowing can be accomplished with a flail mower, rotary mower, or sickle-bar mower. Flail mowing will cut closer and be more effective than a rotary mower. A sickle-bar mower may not work with hairy vetch, which has viny growth. Mowed foliage will decompose more rapidly than roller-crimping because of the smaller plant segments produced. Rye may be harder to kill with mowing. Rye must be cut below the developing inflorescence.

Cover crop mulch will be left on the surface, which provides good weed control and slower decomposition. A winter cover crop used for the purpose of weed control has to produce adequate residue. Mulch does not need to be incorporated fully to get nitrogen benefits. Roller-crimping is better for weed control than flail chopping due to heavier mulch.

Many organic producers state that the greatest risk for cover crops that overwinter is controlling them, especially when there is significant herbage growth.

Reducing risk: termination without tillage. Attempting to control cover crops at immature stages will result in cover crop re-growth. However, waiting until flowering increases the risk of seed set and cover crop volunteers in the subsequent crop.

Incomplete termination of a rye cover crop may not be all bad. A producer from Polk County says volunteer rye at low densities does not compete greatly with soybean and provides seed as a bonus. Rye and soybean seeds are easily separated at harvest.

Planting the next crop

Cover crops that are winter-killed will generally not interfere with planting in the spring. For over-wintering cover crops, when using tillage to terminate a cover crop, wait one week after incorporation before planting next crop to reduce allelopathic effects. Wait longer, a minimum of 10 days, when cover crops are left as surface mulch. However, methods such as the roller-crimper plant the primary crop at the same time as terminating the cover crop. Some crops like soybean may be more tolerant of being planted into fresh mulch. Be aware that soil temperatures will stay cooler under mulch.

Reducing risk: planting next crop. Delay planting after cover crop termination if possible. Plant an earlier maturing variety of the primary crop if conditions necessitate.

No-till cover crop system: roller-crimper

No-till cover crop systems are used extensively in conventional systems through the use of herbicide to kill the cover crop before no-till drilling of grains into the mulch. An organic variation on the no-till scheme is to use the roller-crimper (Figure 13-11) developed at the Rodale Institute (http://www.rodaleinstitute.org/no-till_revolution). The University of Minnesota began experiments using the new system in 2008.

Figure 13-11. *Roller-crimper attached to the front of a tractor.*

The roller-crimper is used to terminate cover crops while planting cash crops like soybean (Figure 13-12). Mounted on the front or rear of a tractor, a large roller with blades crimps and flattens cover crop vegetation, killing the cover crop and leaving a thick layer of mulch (Figure 13-13). At the same time, a crop like soybean can be planted into the mulch using a high-residue planter or drill.The crop grows within the mulch (Figure 13-14) and does not require plowing or cultivating, which can save producers time and money. Other benefits: the mulch of the cover crop can suppress weeds, build soil organic matter, prevent erosion, and conserve moisture.

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Figure 13-12. *A roller-crimper rolling down a biculture of winter rye and hairy vetch while planting soybeans.*

Figure 13-13. *Winter rye after rolling-crimping.*

Figure 13-14. *Soybean growing into killed cover crop mulch.*

As with many new techniques, the learning curve is steep and lack of success can lead to crop failure. The cover crop may not be fully controlled by the roller-crimper operation. This can lead to delayed planting or poor establishment of the cash crop. Perennial weeds may not be controlled, and insects like cutworms may become issues. In Minnesota, the soil may take much longer to get warm, delaying development of warm season crops. In areas with low soil moisture, the cover crop may use up moisture that the primary crop needs. Residue can also leave the soils too wet, especially when the soil is poorly drained.

Table 13-8. Soybean yields in a no-till roller-crimper rye cover crop system and mowed rye cover crop system *in 2008 at Lamberton, MN. Yields were significantly lower when compared to the no cover crop control.*

COVER CROP TREATMENT	SOYBEAN YIELD (BU/ACRE)
Rolled rye	7
Mowed rye	3
No cover crop	22

Preliminary research conducted at Lamberton and Rosemount, MN, has demonstrated the following risks:

Delayed planting – the rye needs to be rolled following anthesis, which typically does not occur until late May to early June.

Moisture depletion – due to growth of the rye in the spring.

Inconsistent planting depth led to poor establishment – the no-till drill was not properly adjusted.

Significant regrowth of the rye – the rye was not killed well with the roller-crimper.

The subsequent soybean yields were negatively affected by the rolled-crimped rye cover crop (Table 13-8). Results from 2009 were somewhat more encouraging. Soybean yields were 26.5 bushels per acre, although the planting rate (300,000 seeds/acre) was twice that as compared to 2008. This system has potential, but because it can be high risk, it will need refinement before it can be recommended for widespread use in Minnesota.

ADVANCED TECHNIQUE:
Rye as a cover crop prior to no-till organic soybeans in Minnesota

Dr. Paul Porter at the University of Minnesota conducts research using winter rye as a cover crop with no-till soybeans. A rye cover crop is planted in the fall after small grains or corn harvest. Soybeans are no-till drilled into rye the next spring. Rye is controlled with mowing and shredding. He has the following recommendations for organic producers who want to try this technique:

STEPHEN AUSMUS, ARS

Figure 13-15. *Rye cover crop*

Rye planting. Ideally, plant rye in late August to early September at 1.0 to 1.5 bushels per acre. If planting later, use a rate of 1.5 to 2.5 bushels per acre. Drilling is best, but broadcasting and light harrowing also work if a slightly higher seeding rate is used.

Soybean planting. Plant soybean into rye about the time you would normally plant soybean, or slightly later. Increase seeding rate above normal—180,000 to 400,000 seeds/acre. The higher seeding rates can give good results if soybeans are planted late. No-till drill the soybeans at < 7.5" row width using a good drill. Cross-seeding (planting in two-directions) can be used to give a good spatial distribution of soybean plants and can adequately control/shred the rye by laying down the rye on the first pass and cutting it up on the second pass. It is desirable to have adequate seed-furrow closure.

Rye mowing/shredding. Wait until the rye has headed; it is best when pollen shed is or has occurred. Typically this will be in June, and the soybeans will be at the first or second visible trifoliolate growth stage. Shred rye as low to the ground as possible, but above the height of the soybeans. You can use a flail mower, a sickle mower, or a rotary mower, but avoid creating windrows with the residue. This step is unnecessary if cross-seeding is done.

Harvesting the soybean. There will be rye seed in the soybean seed harvested, but this can be cleaned out and sold for feed.

Reducing risks: no-till soybeans. Have the proper equipment for seeding the soybeans and mowing/shredding the rye. If rye stand is poor in spring, consider turning under the rye, but do this before rye stem elongation. Wet or dry conditions may delay soybean planting, but this is okay if a short-season soybean variety is used. Timing field operations is very important—controlling rye too early will lead to re-growth. Use good quality rye and soybean seed.

Cover crops species profiles

WINTER RYE

Use: Over-wintering cover crop

Planting date: Early September is ideal. Rye needs four to six inches of growth before a killing frost in the fall.

Planting rate: Drilled – 60-120 pounds/acre, broadcast – 90-160 pounds/acre

Planting depth: One to two inches

Preferred conditions: Prefers sandy or loamy soils, but is tolerant of clay; pH of 5.8 or higher; tolerant of drought. Minimum temperature for germination is 34° F.

Termination: Mow at anthesis to soft dough stage; chop and disk; plow or disk at 20 inch height; roller-crimper at anthesis to soft dough stage. Do not plant next crop for at least 10 days after terminating rye.

Subsequent crop: Soybean

Overview: A rye winter cover crop can control weeds, scavenge nutrients, protect soil from erosion, and improve the soil. Rye is the most winter hardy and tolerant of the late-planted winter cover crops suitable for Minnesota. It is adaptable to a variety of soils and is easy to establish by overseeding. However, tied-up nitrogen inthe rye forage will not be immediately available to the next crop, and rye can deplete soil moisture. Winter rye is susceptible to ergot.

Reducing risk: Winter rye. **Rye may not be the best choice on low fertility fields. Don't plant rye under low moisture conditions. Plant soybeans after rye, rather than corn. Rye can produce a large amount of biomass which can lead to difficulties in residue management. There is a risk of reduced yield in subsequent crops.**

HAIRY VETCH

Use: Over-wintering cover crop

Planting date: 30 – 45 days before killing frost, Aug 15 to Sept 15.

Planting rate: Drilled – 15-20 pounds/acre, broadcast – 25-30 pounds/acre

Planting depth: 1/4 to 1/2 inch

Preferred conditions: Prefers sandy or loamy soils; needs good levels of P, K, and S; snow cover benefits winter survival; tolerant of acidic soils. Minimum temperature for germination is 60° F.

DAVID L. HANSEN

Figure 13-16. ***Hairy vetch.***

Termination: Best time to control is at 75-100 percent bloom. Kill with rotary mowing, flailing, cutting, undercutting, or roller/crimper to produce mulch for weed and moisture control or incorporate with tillage for higher N contribution to next crop in the short term.

Subsequent crop: Corn

Overview: Hairy vetch is an excellent source of nitrogen; it suppresses weeds and improves and protects soil (Figure 13-16). It provides much of the nitrogen needed for a subsequent corn crop. The nitrogen credit is 40 to 80 pounds per acre. It will improve soil tilth, but does not add much to soil organic matter in the long term. Drought is usually not an issue in Minnesota for growing hairy vetch. Winter annual and perennial weeds can be an issue. Hairy vetch may be an alternate host of soybean cyst nematode (SCN).

Reducing risk: Hairy vetch. Vines can interfere with machinery. Don't grow in fields with high levels of SCN. Not reliably winter hardy for northern Minnesota. Verify seed is from a local source. Hairy vetch has 10-20% hard seed and can become a weed, especially in small grains (Figure 13-17). Winters without snow cover can lead to winter kill, especially on poorly drained soil. It can be planted in grain stubble, which may provide some protection over winter by retaining snow cover. Sowing seed on dry ground can lead to ineffective inoculation by the rhizobium strain. It can be difficult to kill unless incorporated.

Figure 13-17. *Hairy vetch weed in wheat.*

SPRING OATS

Use: Winter-killed cover crop

Planting date: Aug 15 – Sept 15, will need 6-10 weeks of growth

Planting rate: Drilled – 64-96 pounds/acre, Broadcast – 96-128 pounds/acre

Planting depth: 1/2 -1 inch

Preferred conditions: Needs adequate moisture, pH range 5.5-7.0 is best but will tolerate a wider range, moderate fertility. Minimum temperature for germination is 38° F.

Termination: NA, will winter-kill

Subsequent crop: Corn, Alfalfa, Soybean

Overview: Oats can suppress weeds, protect soil, and scavenge nutrients. Soil water infiltration in the spring may be enhanced. Oats planted as a winter cover crop in the fall will not produce grain because of winter kill. They are tolerant of wet conditions. Oats are inexpensive. It can be beneficial for the soil to plant oats into soybean because of how soybean produces little residue (Figure 13-18). Oats will need to be seeded before soybean harvest. The best time to establish oat is when the soybean is still standing (leaf-yellowing stage) by broadcast seeding between August 15 and September 1, depending on soybean variety, planting date and weather. If conditions permit, disk lightly for seed incorporation. Seeding at harvest is risky. Light disking in spring will prepare the seed bed for the next crop.

Reducing risk: Oats. Oats will be one of the lowest risk options for a winter cover crop in Minnesota. They produce enough biomass with timely planting to provide soil protection, but do not require termination operations in the spring. They are inexpensive and establish quickly and easily. Fall-planted oats have not been found to impact yield in soybean or a subsequent corn crop.

Figure 13-18. *Oats planted into soybean in the fall.*

ANNUAL RYEGRASS

Use: Winter-killed cover crop

Planting date: 40-60 days before killing frost, Aug. 15 – Sept. 1

Planting rate: Drilled – 10-20 pounds/acre, broadcast – 20-30 pounds/acre

Planting depth: 1/4 inch

Preferred conditions: Optimum soil pH is 6 to 7, but will tolerate pH of 5 to 8; needs moisture; prefers loamy soil but will tolerate sandy and clay soils. Minimum temperature for germination is 40° F.

Termination: NA, will winter kill

Subsequent crop: Soybean

Overview: Annual ryegrass can be confused with winter rye, but annual ryegrass (*Secale multiflorum*) is a different species that does not over-winter in Minnesota. Annual ryegrass establishes very quickly under cool conditions. It provides good erosion control over winter and increased water filtration in the spring. It can be broadcast seeded into corn at final cultivation or after harvest, or overseeded into soybean at leaf-yellowing stage or later. Rust can be a problem. Annual ryegrass has the potential to produce greater biomass than oats.

Reducing risk: Annual ryegrass. Dry soil conditions will be a risk to establishment. To produce adequate soil cover, it will need to be planted 40-60 days before a killing frost. Drilling will establish ryegrass better than broadcasting. It is more expensive than oats.

BRASSICAS

Use: Winter-killed cover crop

Planting date: Aug. 15 – Sept. 30. Plant at least four weeks before 28° F freeze.

Planting rate: Refer to Table 13-8

Planting depth: Refer to Table 13-8

Preferred conditions: pH range of 5.5 – 8.5; do not do well with poor drainage; require high level of sulfur, and sufficient nitrogen. Refer to Table 13-8 for more information.

Termination: NA, will winter-kill

Subsequent crop: Soybean or corn

Overview: Brassicas are a group of related plants that can be used as cover crops. They can be divided into four types including mustards, turnips, rapeseed/canola, and radish (Figure 13-19). Brassicas are tap-rooted and

Table 13-9. Planting information for brassicas.

SPECIES	PLANTING DEPTH	DRILLING RATE	BROADCAST RATE	PREFERRED CONDITIONS
Mustards	1/4-1/2 inch	5-12 lbs/ac	10-15 lb/ac	Minimum temperature for germination is 40° F Best in neutral soils Not tolerant of drought or of excess moisture
Rapeseed	1/2-3/4 inch	5-10 lbs/ac	8-14 lbs/ac	Minimum temperature for germination is 41° F Best in neutral soils Not tolerant of drought or of excess moisture
Radishes	1/4-1/2 inch	8-12 lbs/ac	12-20 lbs/ac	Somewhat drought tolerant Minimum temperature for germination is 45° F
Turnips	1/2 inch	4-7 lb/ac	10-12 lb/ac	Minimum temperature for germination is 42° F

some can penetrate the soil a few feet. Thus, one of the strongest benefits to using these species will be in improving soil tilth. One unique quality of the brassicas is the potential to biofumigate soil, meaning that certain disease pathogens and nematodes may be suppressed. Brassicas can also be used to prevent erosion, scavenge nutrients, and control pests. These traits will not fulfill their potential completely in northern areas because of winter kill; residues decompose quickly so erosion may be higher, weed control may be lower, and nutrient release may not be concurrent with crop needs. Cost of seed is moderate to high. Planting date is very important (Table 13-10). After mid-September, it will be too late. Drilling will lead to better establishment. Broadcast seeding into corn and soybean can work, but incorporating the seed by harrowing will improve this method. Rapeseed will winter kill at 10° F, while mustards, radishes, and turnips winter kill at 25° F.

ADRIA FERNANDEZ ADRIA FERNANDEZ

Figure 13-19. *Oilseed radish (left) and mustard (right) are common brassica cover crops.*

Reducing risk: Brassicas. **Suppression of pests is not consistent among species or varieties. Plant before September 15. Be aware that weed control may be limited in spring because of how quickly the residue decomposes. If planted too early, plants can set seed leading to volunteers in subsequent crop. Don't plant brassicas more than two years in a row in same field. Seed may not be easy to find—buy seed early.**

Table 13-10. *Fall above ground biomass produced by different brassica species planted on September 1 in Lamberton, MN. (unpublished data from Adria Fernandez)*

BRASSICA COVER CROP	BIOMASS (TON/ACRE)
Florida broadleaf mustard	0.61
Tendergreen mustard	0.68
Dorsing mizuna mustard	0.82
Oilseed radish	0.69
Purple globe white top turnip	0.82
Dwarf Siberian kale	0.76

Figure 13-20. *Winter rye and hairy vetch mix.*

BICULTURES

Another cover cropping option is two complementary crops grown together as a biculture. The most feasible option for bicultures that overwinter in Minnesota is a combination of winter rye and hairy vetch (Figure 13-20). One possible benefit of a biculture is there is a higher chance that at least one of the species survives the winter. Drawbacks include that the species may differ in time of maturity and thus may be more difficult to control than a monoculture. In the case of a winter rye and hairy vetch biculture, the rye benefits from the legume's nitrogen, and the rye contributes more than vetch alone to the soil organic matter. The biculture can produce higher biomass than monocultures. Rye mixed with hairy vetch can slow down decomposition and nitrogen release which may cause nutrient availability to synchronize with the next crop better.

OTHER SPECIES

Red clover, alfalfa, and perennial grasses are forages that can provide many of the same functions as winter cover crops in cropping systems. They overwinter, protect the soil and the legumes provide N benefits to the next crop. For more information on these crops, see the Forages chapter. Non-wintering legumes like berseem or crimson clovers can be planted as a winter cover crop, but they will need to be planted earlier than mid-August to have time to make substantial growth. These species may be best used after a small grain crop.

Conclusion

Using cover crops can involve different risks. Take the following quizzes to assess your risk in growing cover crops.

Cover Crops Risk Management Quiz #1

If you are planting a non-overwintering cover crop, take this quiz.
If you are using hairy vetch, take Quiz #2 on the next page.
If you are using winter rye, take Quiz #3 on the following next page.

NON-OVERWINTERING COVER CROPS

	Points	Score
1. Which cover crop will you use?		
Oats	5	
Annual ryegrass	3	
Brassica	3	
2. What is your primary goal?		
Provide nitrogen	0	
Provide soil organic matter	1	
Improve soil structure	5	
Prevent erosion	5	
Control weeds	1	
3. When will you plant the cover crop?		
August 15	5	
September 1	4	
September 15	3	
October 1	1	
4. How will you plant the cover crop?		
Broadcast	1	
Drill	3	
TOTAL		

QUIZ # 1:	
If your score is:	Your risk is:
5 - 7	High
8 - 11	Moderate
12 - 18	Low

Cover Crops Risk Management Quiz #2

If you are planting a non-overwintering cover crop, take Quiz #1 on the previous page.
If you are using hairy vetch, take this quiz.
If you are using winter rye, take Quiz #3 on the next page.

HAIRY VETCH

	Points	Score
1. What is your primary goal?		
Provide nitrogen	5	
Provide soil organic matter	2	
Improve soil structure	3	
Prevent erosion	3	
Control weeds	2	
2. When will hairy vetch be planted?		
August 15	5	
September 1	3	
September 15	3	
October 1	1	
3. How will you plant hairy vetch?		
Broadcast	1	
Drill	3	
4. How and when will you terminate the hairy vetch?		
Vegetative stage with tillage	3	
Flowering stage with tillage	5	
Vegetative stage without tillage	0	
Flowering stage without tillage	1	
5. What equipment will be used to terminate the hairy vetch?		
Mower/chopper	1	
Roller-crimper	1	
Other/combination of techniques	3	
Chisel plow	5	
Moldboard plow	5	
6. What will be the subsequent crop?		
Corn	5	
Soybean	1	
Other	3	
7. When will the subsequent crop be planted?		
At vetch termination	1	
Less than 1 week after termination	3	
1 to 2 weeks after termination	5	
TOTAL		

QUIZ # 2:	
If your score is:	**Your risk is:**
7 -15	High
16 - 25	Moderate
26 - 33	Low

Cover Crops Risk Management Quiz # 3

If you are planting a non-overwintering cover crop, take Quiz #1 on the previous page.
If you are using hairy vetch, take Quiz #2 on the previous page.
If you are using winter rye, take this quiz.

WINTER RYE

	Points	Score
1. What is your primary goal?		
Provide nitrogen	0	
Provide soil organic matter	5	
Improve soil structure	3	
Prevent erosion	5	
Control weeds	3	
2. When will winter rye be planted?		
August 15	3	
September 1	5	
September 15	3	
October 1	1	
3. How will you plant winter rye?		
Broadcast	1	
Drill	3	
4. How and when will you terminate the winter rye?		
Vegetative stage with tillage	3	
Flowering stage with tillage	5	
Vegetative stage without tillage	0	
Flowering stage without tillage	1	
5. What equipment will be used to terminate the winter rye?		
Mower/chopper	1	
Roller-crimper	1	
Other/combination of techniques	3	
Chisel plow	5	
Moldboard plow	5	
6. What will be the subsequent crop?		
Corn	0	
Soybean	5	
Other	3	
7. When will the subsequent crop be planted?		
At rye termination	1	
Less than 1 week after termination	3	
1 to 2 weeks after termination	5	
	TOTAL	

QUIZ # 3: If your score is:	Your risk is:
4 -15	High
16 - 25	Moderate
26 - 33	Low

FOR MORE INFORMATION

An Introduction to Cover Crop Species for Organic Farming Systems.http://www.extension.org/article/18542

Managing Cover Crops Profitably, Sustainable Agriculture Network. http://www.sare.org/publications/covercrops/covercrops.pdf

Legume Cover Crops in Wisconsin: A Guide for Farmers. http://www.cias.wisc.edu/wicst/pubs/legume_seeding.htm

Small Grain Cover Crops for Corn and Soybean, Iowa State University Extension. http://extension.agron.iastate.edu/soybean/documents/PM1999._covercrops.pdf

UC SAREP Online Cover Crop Database, University of California Sustainable Agriculture Research and Education Program. http://www.sarep.ucdavis.edu/ccrop/

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The Midwest Cover Crops Council (MCCC) is a diverse group from academia, production agriculture, non-governmental organizations, commodity interests, private sector, and representatives from federal and state agencies collaborating to facilitate adoption of cover crops.

Regional and state information is available about cover crop species, current research, and upcoming cover crop events. Soon to be available are a cover crop selector tool, cover crop seed suppliers, and an "ask the expert" feature. Visit their website— http://www.mccc.msu.edu/ —for more information.

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