CEREAL RYE COVER CROP MANAGEMENT IN WISCONSIN

Cover crops can provide multiple benefits for grain and forage cropping systems. Cereal rye (*Secale cereale*), also called winter rye, has been widely used as a cover crop as it is relatively easy to establish, survives winter conditions of the upper Midwest, has readily available and cost-effective seed sources, and can produce large amounts of biomass. While a fall-established cereal rye cover crop can be a great tool for summer annual cropping systems in Wisconsin, correct management is essential. Improper cereal rye management can result in issues such as nitrogen deficiency in subsequent crops, depletion of soil moisture, and/or new pest issues whereas good management can result in benefits such as reduced erosion, lower nitrogen and phosphorus losses, improved soil health, and weed suppression. Optimal management of a cereal rye cover crop can vary year-to-year and differ between farms depending on the cropping system and equipment available on the farm. Planning for a successful rye cover crop requires knowledge about establishment methods, interactions between management and achieving specific benefits/goals, potential risks on the following cash crop, and impacts of termination timing/methods on subsequent cash crop growth.

ESTABLISHMENT

Growing a cereal rye cover crop that has the greatest potential benefits is dependent on maximizing fall growth. Fall growth helps sequester nutrients following cash crop harvest and manure application, while the established roots and above-ground biomass in the spring help reduce erosion and allow early suppression of weeds. Seeding methods vary depending on the desired time for cereal rye establishment and crop rotation.

In-season interseeding for corn or soybean

Interseeding cereal rye during the vegetative growth stages for corn (V3–V5) has also been researched in Wisconsin (Smith et al., 2019). Cereal winter rye does not always readily establish via interseeding in corn. To improve the chances of success, the corn crop should be weed free at the time of interseeding, adequate moisture should be available for corn growth, and precipitation should be forecasted following interseeding. Corn growth structure, seeding rate and rye planting method may have a significant impact on success along with the environmental conditions. For soybean, interseeding cereal rye during the vegetative growth stages is not recommended based on Wisconsin research exploring interseeding cereal rye into 30 inch row soybean at the Lancaster Agricultural Research Station during the 2016/17 field season (data not published).

Seeding before corn or soybean harvest

Prior to corn or soybean harvest in the fall, rye can be overseeded into the standing crop by broadcasting either using a plane or high-clearance field equipment. Rye establishment with broadcast seeding varies depending on seed-to-soil contact and adequate soil moisture for germination. Research conducted in southern Wisconsin has demonstrated
that broadcast seeding cereal rye after soybean leaf senescence is a good option for rye establishment (Malone et al., 2022). In southeast Minnesota, the most important factor identified for the successful establishment of aerially seeded cereal rye in corn and soybean was rainfall within the week following seeding (Wilson et al., 2013). Moreover, higher germination was found in finer textured soils with higher moisture content at the soil surface (Wilson et al., 2013). Aerial seeding should occur after crop leaf senescence has begun and when sunlight can reach the soil surface. Higher seeding rates are recommended for broadcast seeding methods used prior to corn or soybean harvest.

Cereal rye cover crop recommended seeding rates
Adapted from: A4176 Cover Crops 101

<table>
<thead>
<tr>
<th>Seeding method</th>
<th>Seeding rate</th>
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<tbody>
<tr>
<td>Broadcast</td>
<td>60–90 lb/acre</td>
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<tr>
<td>Incorporated broadcast</td>
<td>44–66 lb/acre</td>
</tr>
<tr>
<td>Conventional drilled</td>
<td>40–60 lb/acre</td>
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<tr>
<td>Organic drilled</td>
<td>3 million pure live seeds/acre (~180 lb PLS/acre)</td>
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Seeding after corn or soybean harvest

After crop harvest, several options are available for seeding rye including no-till drills or vertical tillage implements paired with an air seeder. A challenge with broadcasting rye after corn grain harvest is a large amount of crop residue on the soil surface can reduce germination by preventing rye seed contact with the soil. Seeding rye with a no-till drill is the preferred method for many Wisconsin farmers because they can achieve better seed-to-soil contact and control of planting depth, therefore maximizing the potential for a dense and consistent stand of rye; a seeding depth of 0.75–1.5 inch is recommended. Higher seeding rates and earlier seeding dates are recommended in organic systems that rely on rye for weed suppression prior to crop planting and during the growing season (see table Cereal rye cover crop recommended seeding rates). Rye seeding prior to late September in southern Wisconsin and early September in northern Wisconsin is highly recommended in organic systems to maximize early-season weed suppression. The use of vertical tillage implements with air seeders has become popular in Wisconsin for improving the germination of cereal rye compared to broadcasting, as the rye seed is shallowly incorporated. Rye seed can also be broadcast following corn or soybean harvest and then shallowly incorporated with a vertical tillage implement; however, this practice does require an additional pass in the field, and planting depth control is critical when using a vertical tillage tool to incorporate the seed. A risk associated with the use of a vertical tillage implement in the fall includes an increased likelihood of erosion between fall and spring depending on rye growth. An ideal time to seed rye occurs immediately following corn silage harvest, as a longer window for rye growth is available. Rye growth can be further maximized if planted after crops that are harvested in late summer/early fall, such as small grains, allowing for the even earlier establishment of a cereal rye cover crop or a diverse cover crop mix.

Precision cover crop planting

Some farmers have started using a precision planting method of cover crop establishment where rye is only seeded in the inter-row spaces of fields that will be planted to corn or soybean with 30 inch row spacing using a no-till drill. This method is used with the intention of reducing competition between the rye and newly planted cash crop. Research conducted in Illinois determined that using precision cover crop planting methods results in lower costs of establishing rye with a reduction of $3.40/acre due to lower seeding rates, while benefits such as nutrient sequestration and carbon accumulation were similar to traditional seeding (Sadeghpour et al., 2021). This approach is facilitated through the use of GPS tractor guidance systems to assist with the precision planting of the cereal rye and the following crop.
First time use considerations

First-time cover croppers will have the best success when using recommended practices and guidance from local resources (e.g., experienced farmers, agency employees [Natural Resource Conservation Service, Land Conservation Districts], or university and Extension personnel) with experience growing cereal rye as a cover crop. It is always a good idea to try new practices on a smaller field or area to acquire more familiarity with using cereal rye or any new cover crop operation.

Herbicide carryover concerns

Research from several universities including the University of Wisconsin-Madison has shown that cereal rye is readily established following many residual herbicides used in corn and soybean cropping systems (Smith et al. 2017, Cornelius and Bradley 2017). These systems were researched using rye after corn (silage and grain) and soybean. If the cereal rye is being established for forage or grain value, herbicide label rotational restrictions must be followed. See the NPM publication Herbicide Rotational Restrictions (https://ipcm.wisc.edu/download/pubsPM/2019_RotationalRestrictions_final.pdf) for more information.

Fall growth concerns

Conditions such as cold fall weather and delayed/prolonged harvest can create difficulties in establishing a rye cover crop that will achieve substantial fall growth. While an effective cover crop can still be grown by seeding later in the fall, if soil conditions allow for drill seeding, growth will not be observed until the following spring, thus substantially decreasing potential benefits, especially if planning to terminate the cover crop early. If seeding late, delayed termination in the spring can allow for more biomass production to gain value from the rye cover crop. Therefore, late seeding is not recommended unless planning for a later termination timing (e.g. “planting green”).

Rye cover crop planting incentives

There are opportunities to receive incentives for seeding cover crops from several organizations, including the Natural Resource Conservation Service (NRCS) through the Environmental Quality Incentives Program and Wisconsin County Land and Water programs. Funding and requirements for these incentives vary, so it is necessary to determine if qualifications are met prior to planting cover crops.
MANAGING FOR SPECIFIC BENEFITS

Improving soil water infiltration, moisture management and storage

The first-year use of a cereal rye cover crop with no-till soil management in Wisconsin corn silage systems has been shown to increase infiltration in the spring resulting in reduced runoff, lower sediment losses and lower phosphorus losses (Adams, 2017). This is especially important for reducing nutrients losses from manure applied in the fallow season. A cereal rye stand with both more above-ground and below-ground growth will better achieve this benefit in the fall and spring.

Wet soil from recent rain events and/or poor drainage can negatively impact cash crop establishment. Tillage has been historically used to manage water by increasing evaporation but at the cost of breaking soil structure and increasing soil compaction. An actively growing rye cover crop can improve moisture management by increasing infiltration and/or serving as a “biological water pump” to actively uptake excess soil water and release it into the atmosphere with transpiration. “Planting green” into cereal rye is an effective way to manage rye intended to mitigate saturated soil conditions during cash crop planting. See the Reduced plant available water in dry conditions section for recommendations on managing cereal rye when water might be limiting cash crop production.

The continued use of cereal rye over multiple cropping years has been shown to improve the water storage capacity of soils during the growing season as a result of increased amounts of soil carbon and rye root growth, which improves soil aggregate formation (Basche et al., 2016). Therefore, managing cover crops so that they have time to accumulate more root biomass will enhance improvements in soil structure for greater infiltration and soil water storage capacity.

Reduced nitrate leaching

A well-established rye cover crop can reduce the loss of nitrogen to the environment by incorporating excess nitrogen in cover crop growth, reducing runoff and preventing soil erosion. It has also been shown to be effective for managing nitrate leaching, especially in sandy soils; early and good establishment is required to produce the necessary biomass (Thapa et al., 2018).

Weed suppression

A cereal rye cover crop has been shown to suppress the density and growth of many broadleaf weeds (e.g., lambsquarters, waterhemp, common ragweed) in Wisconsin. These benefits are strongly correlated to the amount of aboveground biomass accumulated by the cover crop and the persistence of the residue that covers the soil surface. Low amounts of biomass (less than 1,300 lb/acre) have been shown to reduce the biomass and density of emerging weed species when “planting green” in Wisconsin field research (Grint et al., 2022b). High amounts of rye residue that persist on the soil surface well into the growing season are needed to achieve reliable in-season weed suppression of late-emerging weeds (e.g., waterhemp). For large-seeded broadleaf weeds (e.g., giant ragweed), research has also indicated that weed suppression by a cereal rye cover crop is less effective (Ficks et al., 2022). Farmers with known populations of glyphosate-resistant weeds (e.g., horseweed, giant ragweed) that emerge at the time of cover crop termination should plan on using additional control methods, such as an effective synthetic auxin herbicide (e.g., 2,4-D, dicamba) when these weeds are present.
MANAGING FOR SPECIFIC RISKS

Potential corn or soybean yield reduction

Termination timing and the amount of biomass produced by a cereal rye cover crop is one of the most important management decisions impacting the rye cover crop’s effects on corn or soybean yield. Research conducted in Wisconsin has shown that under normal weather conditions, the use of a rye cover crop does not reduce corn yield compared to no-till when cereal rye (500 lb biomass/acre) is terminated at the time of crop planting or sooner (Grint et al., 2022a). However, termination of cereal rye (3,600 lb biomass/acre) two weeks after corn planting did reduce corn yields.

Under normal weather conditions, no difference in soybean yields was observed between soil management with tillage, no-till, cereal rye terminated prior to soybean planting, cereal rye terminated at the time of soybean planting, and cereal rye (2,300 lb biomass/acre) terminated two weeks after soybean planting (Grint et al., 2022a). In general, yield losses may occur with higher rye biomass amounts at termination, but soybean have been observed to have greater resilience to these higher amounts than corn.

Allelopathy concerns

Allelopathy is the suppression of a sensitive organism by a chemical produced from another organism; this can be advantageous for the chemical-producing organism by suppressing sensitive pest organisms. Some of the chemicals produced by rye have been observed to have phototoxic effects on other plant species, which has caused concern regarding injury to corn, soybean and other cash crops.

Research on benzoxazinoids, one of the main allelopathic chemicals produced by cereal rye, has found that it has a very short persistence in the soil (Rice et al., 2012); this indicates that it’s effect on corn and soybean may be negligible in most cases. There are other suspected allelochemicals but limited research exists on their suppressive effects.

The main contributing factors for the suppression of weeds from cereal rye are from physical suppression and other competitive effects such as nutrient starvation, shading and less available water (Teasdale and Mohler, 1993; Krueger et al., 2011; Williams et al., 2018).

Nitrogen tie-up in corn

The symptom of reduced/stunted vegetative growth observed in corn planted into a rye cover crop when “planting green” or if the rye was terminated close to the time of crop planting is often misdiagnosed as an effect of allelopathy; however, this effect is likely a result of less available nitrogen present early in the growing season.

A growing rye cover crop sequesters many nutrients from the soil, especially nitrogen. The return of this nitrogen to the soil in a plant-available form is dependent on the quality of plant material (e.g., Carbon:Nitrogen ratio) and the activity of soil microbes. Wisconsin research has found that for cereal rye with less than 1,000 lb/acre of dry rye biomass, there is no need for adjustments to nitrogen management (Ruark et al., 2019). Greater biomass amounts may warrant adjustment of expected available nitrogen, with estimated nitrogen uptake of 25–45 lb of nitrogen for rye with 1,000–2,000 lb/acre dry biomass and greater than 50 lb of nitrogen uptake for rye with greater than 2,000 lb/acre of dry biomass. Research on nitrogen release from cereal rye residue in the Midwest indicates that much of the nitrogen from cereal rye residue decomposition following termination will not be available for a corn crop during the same growing season, and the decomposition process of cereal rye residue isn’t occurring in a manner that makes sequestered nitrogen
available again by the peak time for corn nitrogen demand (Nevins et al., 2020; Roth et al., 2022). Strategies hypothesized to mitigate the potential risks of nitrogen tie-up by a cereal rye cover crop is the application of nitrogen near the time of corn planting by using starter fertilizer with higher nitrogen content (30–40 lb nitrogen/acre) and applying nitrogen in-season with a sidedress application.

Reduced plant available water in dry conditions
An actively growing cereal rye cover crop lowers soil moisture through evapotranspiration (Qi and Helmers, 2010). This process can be beneficial for cash crop planting in high precipitation situations by removing excess soil moisture in saturated soils but has negative effects if soils become too dry for the optimal establishment. This can be especially important in shallow and/or sandy soils.

In the weeks prior to planting a cash crop, evaluate the field’s soil moisture and monitor the forecast to determine if dry conditions might affect seedling establishment. If dryer than normal conditions are expected to persist, be prepared to terminate the rye earlier if necessary.

Green bridge for pests
Actively growing rye plants near the time of crop planting can serve as hosts for insects or disease pathogens, potentially creating a “green bridge” for these pests. Several insect pests have been documented as using a living rye cover crop as a green bridge to corn seedlings, with armyworms being one of the main pests of concern. This issue has not historically been a major concern in Wisconsin, however, the potential for this to occur does exist and requires good pest monitoring, record keeping and reporting.

Research conducted in Iowa detected the transfer of corn seedling pathogens from cereal rye to corn seedlings with subsequent stand reduction and yield loss from infection from multiple Pythium species when rye was terminated close to the time of crop planting or “planting green” was practiced (Acharya et al., 2017, 2022). If concerned about disease pathogens, it is recommended to terminate the rye at least 10–14 days prior to planting the cash crop.

TERMINATION
Selecting the proper termination timing and method are key to obtaining the desired benefits from a rye cover crop while minimizing the risk of negative effects on subsequent cash crops. If using crop insurance, always check that cover crop termination method and timing meet requirements.

Termination before cash crop planting
Terminating a rye cover crop prior to planting poses the lowest risk to the cash crop with respect to competition with the rye or exacerbation of pest issues. Termination 1–2 weeks before planting has been historically recommended to avoid these negative impacts.

In Wisconsin, early chemical termination can be challenging because cool temperatures (< 55°F) limit cereal rye biomass accumulation and consequently, that benefit from the cover crop. The most effective method for early termination is to use a quick-acting systemic herbicide such as glyphosate.


Planting green

“Planting green”, an increasingly popular practice in Wisconsin, refers to chemical termination of the cover crop that occurs near the time of planting, resulting in planting of cash crops into green cover crop biomass. This practice allows the rye to accumulate more biomass and increases the benefits received from growing a cover crop while establishing the crop in a timely fashion, optimizing its yield potential. Farmers using this practice experience benefits at planting that are facilitated by the presence of the actively growing cereal rye, including quicker field drying and improved planting conditions in a wet spring, reducing the effects of wheel traffic due to the drier soils and surface residue provided by the cover crop. Reduced weed density and biomass in corn or soybean production have also been identified as benefits of delaying termination and planting green. If terminating rye at the time of crop planting and using a preemergence herbicide, applicators may have the option of combining the preemergence herbicide with the herbicide being used for cover crop termination in a single application. Because of the risk of corn yield loss, it is recommended that farmers that are new to planting green experiment with soybean first.

The same principles that are relevant when planting corn or soybean in no-till and or tilled soil apply when planting green. Good seed-to-soil contact, maintaining proper seeding depth, and closing the seed furrow are all critical to successful cash crop establishment. General recommendations about planting into high residue situations include setting front no-till coulters 1 inch shallower than desired seeding depth and applying more down pressure on row units and/or closing wheels as residue amounts increase and in fine-textured soils. When changing fields, monitoring proper seeding depth and seed furrow closure by running test passes at the desired planting speed is strongly advised, especially when planting into high amounts of residue. Be aware that row cleaners and some aftermarket closing wheels have been observed to become entangled in tall cereal rye cover crop residue.

Using rye as a forage

Harvesting cereal rye as a spring forage crop in mid-late May is also being practiced on Wisconsin farms and has been discussed as providing several benefits, including providing a good heifer or cow feed source as a double-crop, along with social and environmental benefits. For a thorough summary of the opportunities and challenges as told by Wisconsin dairy farmers and crop consultants, see the NPM publication Planting Cover Crops After Corn Silage for Spring Forage Harvest (https://ipcm.wisc.edu/download/pubsNM/CoverCropsSummary_FINAL.pdf). Harvest needs to occur at the boot to early heading stages of rye growth (optimally, Feekes 9–10.3) to achieve the maximum amount of quality forage. Research on corn silage forage systems in Wisconsin has observed a 6–7% increase in total annual forage production when spring harvested rye forage is preceded by corn silage compared to systems where rye forage isn’t used (West et al., 2020).

Roller-crimping

Roller-crimping cereal rye has historically been practiced in organic production systems as a chemical-free method of termination while maintaining soil coverage with cover crop residue. This practice can be beneficial in both organic and conventional systems. Termination with crimping works by crushing the cereal rye stem in several places resulting in the death of the plant and redirecting the stems of plants to be oriented horizontally. Crimping must occur when cereal rye plants are at full anthesis for effective termination in the absence of chemicals (Mirsky et al., 2009). Multiple passes of crimping may be required if rye is observed to bounce back up. If termination is ineffective or delayed too long, cereal rye plants will reproduce and can inadvertently distribute cereal rye seed. Challenges that can reduce the efficacy of crimping include uneven maturity of cereal rye across the field and terminating too early. However, the use of herbicides, such as glyphosate, in conventional systems in addition to crimping can help farmers obtain the benefits of crimping while speeding up the death of cereal rye and reducing the likelihood of failed termination.
CITATIONS


