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Entire manual is available at **IWMguide**.

Chapter 12: Cover Crops for Weed Suppression

Jess Bunchek, Steven Mirsky, Victoria Ackroyd, and William Curran

Summary

Cover crops play a significant role in a multi-tactic approach to weed management. As herbicide-resistant weeds have become more prominent, interest in the use of cover crops for weed suppression has increased. In the Northeast, growing interest in organic products also has increased interest in cover crops for their role in weed suppression. Cover crops suppress weeds most effectively when actively growing, outcompeting weeds for essential resources (light, nutrients, water, and space). Cover crops affect weed germination and emergence by reducing the amount of light that reaches the soil surface, lowering soil temperatures, and providing a physical mulch or barrier after plants have been terminated. Cereal cover crops can also tie-up (immobilize) nitrogen, making it less available for weeds. Furthermore, cover crops can release phytotoxic compounds that affect small-seeded weeds. Species selection and management of cover crops determine the effectiveness in weed suppression.

Introduction

A cover crop is a plant that is grown in a cash crop field at times when a field would otherwise be fallow. Cover crops are multifunctional tools that provide a variety of agroecosystem services beyond weed suppression (Hartwig and Ammon 2002). They support crop productivity and farm profitability by providing better erosion control, tighter nutrient cycling, and greater water infiltration than bare ground. They also can increase organic matter and biodiversity in the soil when compared to bare ground. The recent interest in cover crops for weed management is the result of the time and cost of weed management in all cropping systems, the challenges associated with controlling weeds in organic systems, and the development and spread of herbicide-resistant weeds.

In the Northeast, some common winter annual cereal cover crop species include cereal rye, wheat, and triticale. Common winter annual and perennial legumes include hairy vetch, crimson clover, and medium red clover. All of these plants are winter annuals that are established in the fall after corn or soybean harvest. Medium red clover, a perennial, also can be frost-seeded into wheat. Brassica species such as forage radish or canola/rapeseed are often planted in the fall, although radish usually does survive the winter. Other cover crops, such as sorghum-sudangrass and millet, can be sown in the early spring prior to planting summer vegetables.

Cover crop implementation and management directly and indirectly suppresses weeds at multiple weed life stages (Figure 12.1). Live cover crops suppress weeds by competing with them for space, nutrients, water, and light.

Weeds also are directly suppressed at the time of cover crop termination. Weed suppression, particularly for summer annual weeds, is proportional to cover crop biomass levels: as cover crop biomass increases, weed biomass decreases (Mohler and Teasdale 1993). Good ground cover early in the spring reduces weed germination and emergence by reducing light at the soil surface and lowering soil surface temperatures (Figure 12.2).

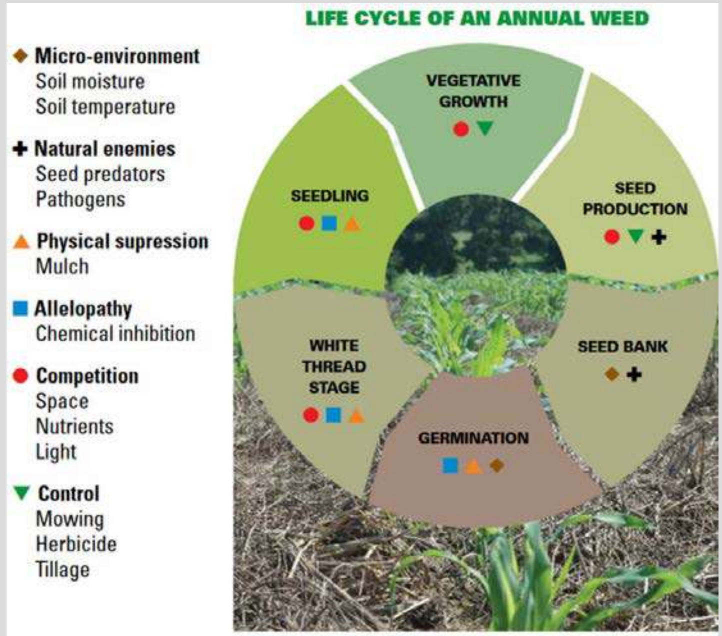

Figure 12.1. Cover crops can target all stages of the annual weed life cycle. For optimal weed control, select and manage cover crops that align with the life stages of the targeted weeds (Diagram used with permission of Nord, et al. 2010 UC210, Penn State).

Management strategies that influence a cover crop's ability to suppress weeds include cover crop species and mixture combination selection, seeding rate, planting and termination timing and method, and application timing, type, and rate of nutrients. Cover crop management decisions also should weigh the specific weed problem. For example, perennial weeds are less affected than annual weeds by cover crop residues (also called mulch) (Mirsky et al. 2011; Mirsky et al. 2012). However, implementing cover crops in conjunction with other cultural practices, such as narrow cash crop row spacing, can have synergistic effects on perennial weed management. Carefully managing cover crops in combination with other cultural practices can manage existing weed populations, slow the development of new weeds, and provide other ecological services (see Chapter 10: *Cultural Control*) (Gallagher et al. 2003).

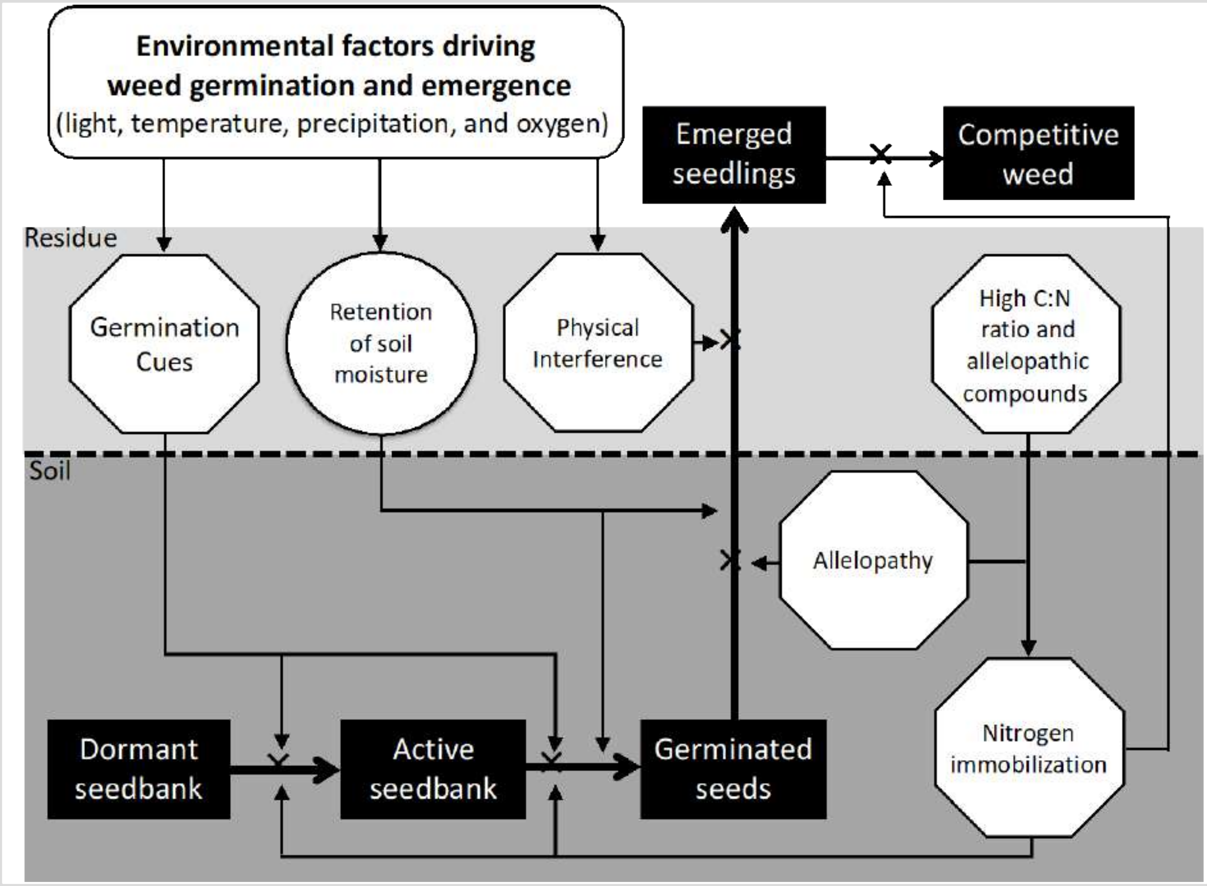

Figure 12.2. Cover crop residue (mulches) have complex effects on the weed seedbank. Cross marks in arrows indicate points at which cover crop mulches affect weed germination or emergence.

Crop Rotations and Cover Crop Integration

Cover crop species are categorized as

- fall planted that survive the winter (overwinter),
- fall planted that winter kill,
- biennial and perennial, and
- summer planted with winter kill.

Fall-planted winter-kill cover crops like spring oats and forage radish quickly establish dense ground cover and can control fall-emerging weeds like horseweed (or marestail) and chickweed better than winter-hardy cover crop species that establish more slowly. Fall-planted winter-hardy cover crops like cereal rye and red clover produce most of their biomass between spring green-up (when the plants break dormancy and begin growing again) and termination. This spring growth is crucial to control spring-emerging winter annual weeds and early-emerging summer annual weeds. Delaying cover crop termination typically increases biomass for ground cover and smothers competing weeds. Cereal grains are typically planted at one to two bushels per acre, and legumes like hairy vetch and clovers should be planted at about 20 pounds per acre. Seeding rates will vary, depending on climate and soil (Mirsky et al. 2017).

Cover crops can be successfully established throughout the fall. Species selection varies by planting schedule and targeted weeds (Figure 12.3). Winter-kill cover crops like spring oats can produce prolific biomass to control winter annual weeds if the cover crops are planted early in the fall after small grain harvest. Winter-hardy cover crops, such as cereal rye or triticale, better target spring-emerging winter annuals and produce enough residual mulch to help suppress summer annual weeds. If herbicides are an option, the field should be sprayed with a preplant ("burndown") herbicide before planting late summer or early fall cover crops to better manage winter annual weeds and volunteers from the previous cash crop.

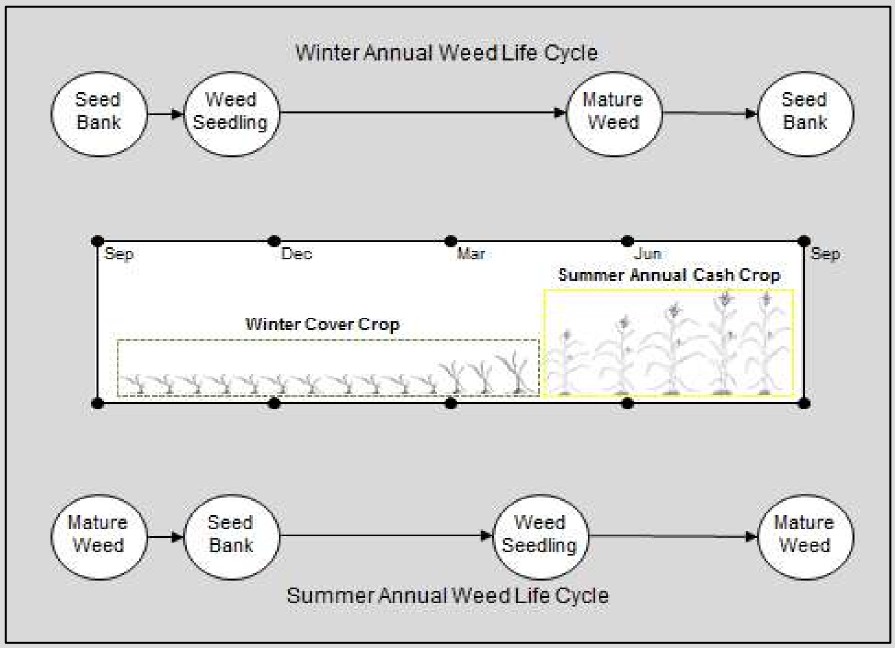

Figure 12.3. Fall-planted cover crops affect weed species differently, depending on weed life cycles. Winter-killed cover crops can control winter annual weed seedlings, while winter-hardy cover crops can control both winter and summer annual weeds (Diagram used with permission from J. Wallace).

Grazing cover crops or harvesting them for forage has several weed suppression benefits. Annual, biennial, and perennial forages or hay crops can serve as both a cover crop and forage. These plants suppress summer annual weeds, particularly broadleaf species – frequent grazing, mowing, and harvesting prevents weed seed production and exhausts the root reserves of problematic perennial weeds.

Combining intensive cover cropping with tillage also can greatly impact weeds. In Pennsylvania, Mirsky et al. (2010) demonstrated that combining tillage with cover cropping during a summer fallow can result in 98%, 85%, and 80% reductions of germinable seedbank for foxtail (giant and yellow), common lambsquarters, and velvetleaf, respectively. Cover cropping strategies that stimulate weed seed germination as well as suppress weed growth and limit seed production results in the greatest weed seedbank declines.

Although they are less common in the Northeast, summer annual cover crops like sorghum-sudangrass and millet can be used as part of an intensive weed management strategy. Research in Illinois reported that Canada thistle shoot density and biomass were greatly reduced over the course of two growing seasons by using either sorghum-sudangrass or a mixture of sorghum-sudangrass and cowpea (Bicksler and Masiunas 2009).

Cover Crop Mixtures for Weed Control

The goal for selecting and managing a cover crop mixture for weed control is to optimize the mixture for high biomass, ground cover, and duration of living cover crop in the field. Plant the mixtures at recommended times with a seeding method that ensures good seed-to-soil contact and stand establishment, such as drilling. High fertility sites with a history of manure use, excess nitrogen from preceding cash crop, and high soil organic matter will support grass or broadleaf cover crop growth to the possible detriment of legumes, which are less competitive in a high nitrogen environment. On sites with low nitrogen levels, legumes compete more readily with other species in the mixture. Regardless, weed suppression increases with greater cover crop biomass levels.

Cover crop biomass quality (i.e. carbon to nitrogen ratio) impacts both weed suppression and the performance of the subsequent cash crop. Using cover crop mixtures provides multiple benefits. For example, cereal cover crops high in carbon can scavenge residual soil nitrogen and further immobilize nitrogen when terminated. A mulch that limits nitrogen availability is good for weed suppression in legumes like soybean but is problematic in crops like corn that need a lot of nitrogen. Legume cover crops are a good source of nitrogen for the following cash crop but provide limited weed suppression. In fact, legume cover crops may even stimulate weed emergence and performance (Figure 12.4). Combining grass and legume cover crops can result in higher biomass levels and weed suppression while continuing to provide nitrogen for the subsequent corn crop. Work completed in Maryland demonstrated that even mixing low levels of cereal rye (~20%) with hairy vetch can maximize weed suppression (Finney et al. 2016). Cereal rye provides a trellis for hairy vetch to climb, which keeps vetch off of the soil surface. This relationship delays the start of hairy vetch decomposition, increases the overall carbon to nitrogen ratio, and keeps the soil surface drier than a pure hairy vetch cover crop. Because water and nitrogen stimulate weed emergence, manipulating these factors with cover crops can delay and reduce weed emergence. Cover crop mixtures provide farmers the opportunity to maximize the nitrogen content in a cover crop mixture while not impacting its ability to suppress weeds as a mulch (Figure 12.4). If a farmer has multiple cover crop goals, selecting a mixture of two or more species may be the best choice.

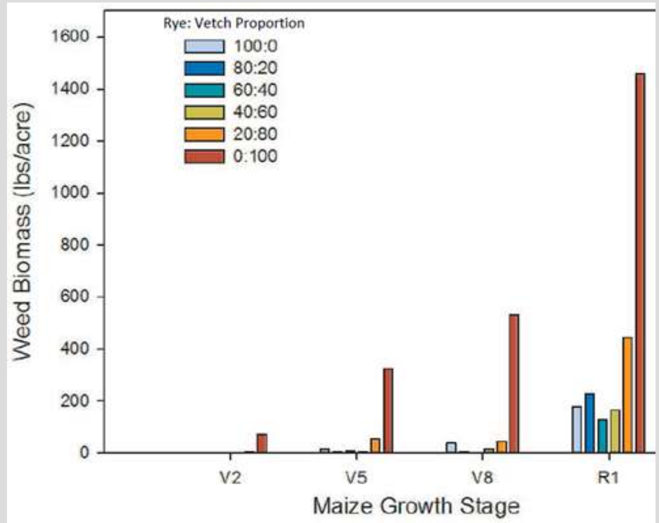

Figure 12.4. When planted as cover crops before corn, cereal rye and cereal rye mixed with hairy vetch suppress weeds better than hairy vetch alone (Reproduced from Finney et al. 2016).

Cover Crop Termination for Weed Control

Cover crop termination represents another disturbance throughout a crop rotation. Which cover crop termination methods are used depends on the goals and constraints of the cropping system. There are "natural" methods (e.g. winter weather kills a non-hardy cover crop such as forage radish and oats), chemical methods (e.g. herbicide application), and mechanical methods (e.g. tillage, mowing, or roller crimping).

Not all cover crop termination methods will kill weeds present in the field at the time of termination. Tillage and herbicide applications are the most effective means of cover crop termination and have the most impact on emerged weeds. Mowing and roller crimping for cover crop termination are less effective at controlling emerged weeds than herbicides and tillage. Their effectiveness depends both on cover crop species and termination timing (Mirsky et al. 2009; Mirsky et al. 2011; Mirsky et al. 2017, Mischler et al. 2010).

Prevent Cover Crops from Becoming Weeds

Cover crops add diversity to cropping systems and can be used in combination with other cultural practices to control and slow the development of herbicide-resistant weeds. However, some cover crops like buckwheat, annual ryegrass, and hairy vetch are notorious for becoming weeds themselves if they are not effectively terminated before seeds are formed (Curran et al. 1994; Hoffman et al. 1993). Such cover crops should be terminated at the appropriate time (according to local recommendations) to prevent seed production.

However, herbicide-resistant cover crops complicate termination and become an ongoing weed problem if allowed to go to seed. Jasieniuk et al. (2008) reported herbicide resistance in annual ryegrass. To prevent cover crops from developing into weed problems, use high quality certified cover crop seed and known crop varieties. Seeds listed as variety not stated (or VNS), variety mixtures, bin-run seed, and lower quality seed can potentially introduce a weed problem. Be sure your seed source is free of weeds seeds.

Take care to ensure complete control and prevent cover crop seed production of potentially problematic species. Tillage can completely terminate a cover crop when herbicides are not sufficient. Crop rotations that allow for multiple possible control methods also can help with long-term management of hard-seeded cover crops. For example, planting a small grain like winter wheat, in which broadleaf herbicides can be used, provides additional opportunity to control hairy vetch.

Cover Crop Mulch for Weed Control

Increasing levels of cover crop mulch generally results in better weed suppression. Cereal rye cover crop should produce a minimum biomass of 5,000 to 7,500 pounds per acre to decrease summer annual weed emergence by 75% in the Northeast (Mirsky et al. 2011; Ryan et al. 2011b). Unfortunately, cover crops in the northern portion of the Mid-Atlantic do not consistently produce these high biomass levels; 4,000 to 6,000 pounds per acre are more typical rates. Providing livestock manure or fertilizer can enhance cover crop growth, especially when the plants follow a productive cash crop that requires heavy nitrogen application, such as corn. For example, applying nitrogen (20 to 40 pounds nitrogen per acre) to a cereal rye cover crop in the early spring to increase biomass production can improve weed suppression.

Delaying cover crop termination is another strategy to increase cover crop biomass. As cover crops reach their late-vegetative stages, they are rapidly accumulating biomass. Delaying by 2 to 3 weeks until early reproductive stages of the cover crop often allows maximum biomass production (Mischler et al., 2010b; Teasdale et al., 2004). Delaying cover crop termination not only allows more biomass production, but the tissue is more resistant to breakdown/decay. Cereal crops provide much more tissue that contains lignin that persist on the soil surface.

A Multifaceted Approach

Combining cover crops with cultural or mechanical weed control tactics is an important step toward implementing integrated weed management (Mirsky et al. 2013; Teasdale et al. 1991). A cover crop mulch in combination with high in-row crop population densities (e.g. soybean at 200,000 seeds per acre) and/or narrow-row cash crop planting (e.g. soybean row spacing decreased from 30 to 15 or 7.5 inches), herbicides, or tillage can effectively suppress weeds. Ryan et al. (2011a) found that increased soybean seeding rates compensated for low cereal rye biomass, ensuring acceptable suppression of summer annual weeds (Figure 12.5). The cereal rye mulch hindered early-season weed growth, giving the high-density soybean planting enough time to close its canopy, hindering weed growth in the middle and late season. In a greenhouse study, the combination of metolachlor (Dual®) and hairy vetch residue enhanced the control of smooth pigweed (Teasdale et al. 2005). Nord et al. (2011) found that a postemergence herbicide application more effectively decreased weed biomass than cultivation in soybean planted into a cereal rye mulch.

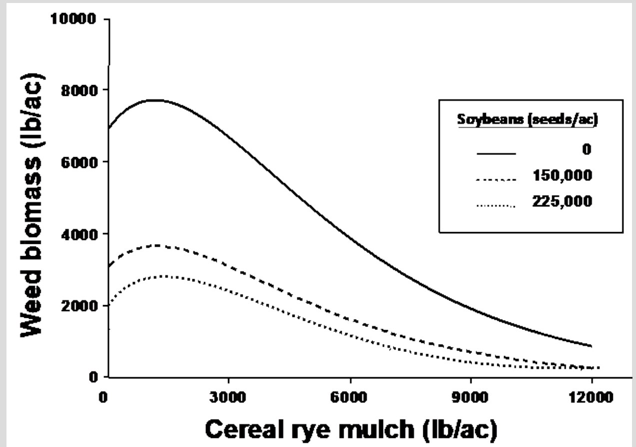

Figure 12.5. Weed biomass across a range of cereal rye mulch and soybean seeding rates.

Mechanical control tactics also can be used in combination with cover crops (Teasdale et al. 1991). In reduced tillage systems, technological limitations make cultivation difficult. However, cultivation is now possible in these systems by using high-residue cultivators that neither invert the soil nor drag residue through the field. High-residue cultivators, when used in combination with cover crop mulches, can control weeds in fields with large weed seedbanks.

Cover crops are plants that are typically grown when the ground would otherwise be bare. Cover crops compete with weeds for nutrient, space, and light when alive. After termination, cover crop mulch reduces weed seed germination and smothers weed seedlings. Cover crop mixtures can be particularly effective for weed control. Methods for cover crop termination include "natural" (i.e. cold weather), mechanical (i.e. mowing or tilling), and chemical (i.e. herbicides). Cover crops must be terminated completely in order to prevent them from becoming weeds themselves. Ultimately cover crops are one tool among many for weed suppression.

Key Points

- Living cover crops outcompete weeds for space, light, water, and nutrients.
- The effect of cover crops on weeds varies by cover crop species, weed species, and time of establishment.
- Perennial weeds are less affected than annual weeds by cover crops.
- Maximize weed suppression by maximizing cover crop biomass.
    - Establish a dense cover crop stand
    - Delay cover crop termination to increase weed suppression.
- Implementing cover crop mixtures can achieve multiple farmer goals, such as nitrogen and weed management.
- Both the cover crop termination process and the remaining residue control weeds often are not a "stand-alone" tactics, rather they complement other weed management strategies.

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