



Guide to Interseeding Cover Crops into Corn Systems in the Northeast



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Guide to interseeding cover crops into corn systems in the Northeast

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Introduction

From erosion protection to nutrient retention to building soil health, incorporating cover crops into your production system can provide a multitude of benefits. Seeding cover crops at the optimal time can be challenging. This Guide to Interseeding Cover Crops into Corn Systems in the Northeast will cover the agronomic strategies and considerations of interseeding cover crops into silage corn systems. This includes variety selection, timing, light considerations, seeding rates, equipment, row spacing, and available resources.

Interseeding is the practice of establishing a cover crop into an already growing cash crop. This can be done anywhere from early growth stages prior to canopy closure up to harvest. Many cover crops planted after corn silage harvest will not reach their maximum potential growth before the winter. Interseeding maximizes a short growing season by allowing these species to reach maturity, providing year-round ground coverage, and producing more cover and/or forage biomass.

Interseeding cover crops, while beneficial, comes with its own set of challenges. Other demands from farm operations and weather conditions can make it hard to grow a successful cover crop. One common challenge that farmers face when trying to implement interseeding is establishing cover crops into dense rows of corn. Fortunately, there are resources and equipment available to help meet these challenges.

Much of the information in the guide is based on research conducted by the University of Vermont (UVM) Extension Northwest Crops and Soils Program (NWCS). You can find links to our research reports as well as additional resources at the end of this guide and at <https://www.uvm.edu/extension/nwcrops>.

Benefits of Interseeding Cover Crops

Numerous studies have shown the multitude of benefits that cover crops can provide. Cover crops work best when added into other sustainable cultural practices like no-till, diverse rotations, and integrated cropping systems. In turn, these sustainable practices are also more effective with cover crops.

Potential benefits of cover crops can include:

- *Cutting fertilizer costs:* Cover crops take nitrogen from the soil and atmosphere and retain it for the next crop.
- *Reducing the need for herbicides:* Cover crops can suppress weeds and encourage the growth of populations of beneficial microbes, insects, and nematodes.
- *Conserving soil moisture:* Killed cover crops increase soil water infiltration and reduce water lost to evaporation, which lessens water stress during droughts.
- *Improving soil health and water quality:* Cover crops hold soil in place and build soil aggregation and stability. Better soil aggregation increases soil aeration and water infiltration, which prevents runoff and decreases compaction. The addition of organic matter adds more nutrients to the soil, encourages beneficial soil microbial life, and increases infiltration and water holding capacity. Over time, nutrient retention and cycling is enhanced.

Cover crop biomass can hold high quantities of nutrients, especially if the cover crop is able to obtain sufficient growth prior to termination. UVM research shows that 50% of manure nitrogen was available for corn to scavenge from a fall-planted cover crop, as compared to 15% of manure N available to corn without a cover crop. This is shown below in Figure 1. For more information, see the [NWCS 2013 Corn Interseeding Trial Research Report](https://www.uvm.edu/extension/nwcrops/research) on our Research Reports web page – <https://www.uvm.edu/extension/nwcrops/research>

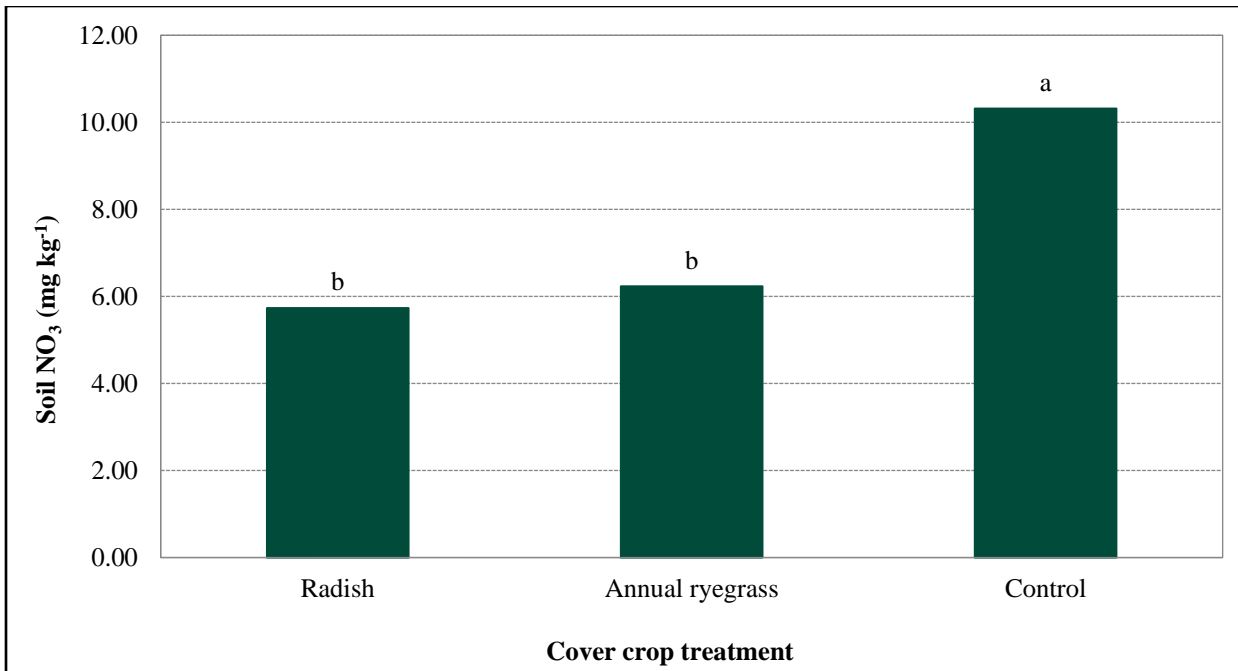


Figure 1. Effects of cover crop treatments on nitrate levels in soil, Alburgh, VT, 2013. Treatments that share a letter were not statistically different from one another ($p=0.10$).

Interseeding cover crops before harvest gives cover crops time to establish and grow before cold winter months. Cover crops planted after corn-harvest may establish, but growth is often poor, and good soil coverage is not provided, leaving the field susceptible to erosion by winter snow melt and spring rains. Protecting soil on the fields is even more challenging when faced with increasingly unpredictable weather due to climate change. Image 1 shows the growth and ground cover provided in late October from winter rye planted from early to late September.



Image 1. Winter rye in late October planted 2-Sep, 15-Sep, and 30-Sep (left to right).

Interseeding allows cover crops to be planted in a cash crop like corn silage starting in late June (V4 stage) up to 2 weeks prior to harvest, which gives more flexibility to plant before prohibitive weather conditions. In terms of farm schedules and changing local climates, interseeding can buy a farmer valuable time. Planting dates may also be directed by your farm's participation in state and federal cost-share programs.

Selecting the Right Cover Crop

Species Selection

Interseeding opens new doors for cover crop choices in the cold climates of northern New England. Seeding in the summer instead of late fall can both improve establishment and growth of commonly used cover crop species but also diversify the available species to provide additional benefits to your system. Cover crops to consider include small grains (triticale, rye, wheat), annual ryegrass, brassicas (tillage radish, turnips, rapeseeds), and legumes (red clover, alfalfa, hairy vetch, peas).

Popular traditional covers for silage corn include: a) cereal grains like winter rye, oats, triticale, wheat, and barley; and b) bunch grasses like annual ryegrass. They tend to germinate quickly and can produce adequate biomass under different growing conditions. This allows them to be great for erosion control, adding organic matter, scavenging nitrogen, and suppressing weeds. Within 3 months, grain or grass cover crops can absorb up to 71 lbs. nitrogen per acre. They can be used as a forage crop as well providing high-quality forage for grazing into the late fall or for grazing or harvest the following spring. When planted timely, winter cereal grains can produce about 1 ton of dry matter per acre in the fall and up to 3 tons per acre in the spring. This forage is of exceptional quality if grazed or harvested prior to seedhead emergence. While this practice is not yet widely utilized in this region, it has the potential to add substantial forage value to a corn silage system while providing the nutrient scavenging and soil retention benefits of a cover crop through the winter. Of all the cover crops used in silage corn plantings, winter or cereal rye (Image 2) has been the most popular in our region because of its reliability and versatility. However, other cereal grains can provide similar benefits and may also present additional advantages over winter rye depending on your cover cropping goals. For example, if spring forage is a goal of yours, timely harvest prior to seedhead formation is critical. Winter rye typically matures 1-2 weeks earlier than winter triticale or winter wheat. Selecting one of these other cereal grains could provide a wider spring harvest window in which to maximize the forage value of the cover crop.



Image 2. Winter rye seed



Image 3. Spring alfalfa growth following interseeding into corn.

Brassicas and legumes are also excellent choices if you're hoping to use your interseeded cover crop as a forage. Brassicas are very high in nutritional quality (high dry matter digestibility), can scavenge nitrogen, and some have deep taproots that break up compaction. Common brassica cover crops include mustards, rapeseed, turnips, and radishes. Legumes can also provide high-quality forage and fix nitrogen from the atmosphere, increasing nitrogen available in the system. Legumes include clovers, cowpeas, field peas, alfalfa, and vetch. Recently there has been increasing interest in utilizing perennial forage legumes, such as alfalfa, as interseeded cover crops to reduce the time between corn silage and perennial forage crops while also capturing benefits of a traditional cover crop.

When corn is at the V4-V7 stage (knee-high, around July), legumes like red clover, crimson clover, alfalfa, and hairy vetch establish well. Radish and annual ryegrass have also performed well and established good fall ground cover in Vermont. You may not want to plant large-seeded legumes (peas, beans) if you are broadcasting, because seed to soil contact is poor and germination will be low.

At the V8 stage or later, legumes like peas perform better; also consider annual ryegrass, brassica, clovers, hairy vetch, and winter cereal grains. To avoid cash crop damage at these later growth stages, more specialized high-clearance equipment will be needed (see *Equipment Considerations* on page 10).

In selecting the right cover crop for interseeding, you must also consider how you will manage cover crop termination. Winter cereal grains and perennial legumes that overwinter can produce a lot of spring biomass, which may be an advantage for your cover cropping goals, but this also makes it hard to terminate in the spring. If you utilize this biomass for forage, less residue will be left to manage prior to planting the next cash crop. Incorporating legumes into the soil can be an effective termination strategy that can also provide 50-150 lbs. ac⁻¹ of nitrogen for the subsequent cash crop. Brassicas and oats will winterkill and while brassica residue will break down rapidly after snow melt, oats can leave a lot of biomass to work into the soil which can tie up nutrients early in the season for the subsequent cash crop. Some species, including crimson clover, annual ryegrass, and winter barley, may overwinter in years with mild temperatures and substantial snow cover. If you select one of these species and intend for winterkill to terminate them, have a backup plan in the event that they survive.

Table 1. Beneficial roles of some common cover crops used in Vermont silage corn systems.

Species	Nitrogen Scavenger	Soil Builder	Erosion Control	Weed Management	Forage Crop
Winter rye	Excellent	Excellent	Excellent	Excellent	Fair
Triticale	Very good	Excellent	Excellent	Excellent	Excellent
Oats	Very good	Good	Very good	Excellent	Good
Red clover	Good	Very good	Good	Good	Excellent
Annual ryegrass	Very good	Very good	Very good	Very good	Good
White or alsike clover	Fair	Good	Very good	Good	Excellent
Hairy vetch	Fair	Very good	Good	Good	Fair
Forage radish	Excellent	Very good	Very good	Excellent	Good

Adapted from “Managing Cover Crops Profitably”

A cost and benefits table is available at:

https://www.uvm.edu/sites/default/files/media/Cover_Cropping_Costs_and_Benefits_FINAL.pdf, which shows the financial costs by cover crop, seeding rate, application and termination methods, and the net financial benefits from increased yield, erosion reduction, and nutrient credits. The NRCS Cover Crop Economics Tool takes into account a variety of factors including planting and termination costs and soil health benefits. The tool is available as a free downloadable excel file: <https://www.nrcs.usda.gov/wps/portal/nrcs/ia/technical/dma/econ/NRCSEPRD385825/>

Mixtures and Cover Crop Diversity

Cover crop mixtures also can provide multiple benefits. For example, if you want to increase nitrogen fixation and suppress weeds, you may choose to plant a mixture of red clover and radish. Mixtures also increase diversity and support the soil microbe community. Many pre-mixed seed mixtures are available as “cover crop cocktails” on the market. Table 2 shows some cover crop mixes that have been tested in Vermont growing conditions and are approved for use in USDA Natural Resources Conservation Service (NRCS) cover crop programs. When choosing cover crops or cover crop mixtures, consider what goals you want to achieve, and what planting and termination dates are realistic for your seasonal workload. Tools like the species selector tool developed by the Northeast Cover Crops Council (<https://northeastcovercrops.com/decision-tool/>) can help you define your goals, consider your limitations, and identify the best species and mixtures for your farm.



Image 4. Mixture of radish, annual ryegrass, and clover.

Table 2. Common Vermont cover crop mixes.

Annual Ryegrass and Tillage Radish
Triticale and Dwarf Essex Rape
Oats and Tillage Radish
Winter Rye, Red Clover, and Forage Brassica
Annual Ryegrass and Red Clover
Winter Wheat and White Clover
Triticale, Annual Ryegrass, Crimson Clover, Hairy Vetch, and Tillage Radish
Annual Ryegrass, Crimson Clover, and Tillage Radish
Oats, Red Clover, and Tillage Radish

Seeding Rates

Seeding rate depends on the seeding method and cover crop species. In general, higher seeding rates will be recommended for broadcast seeding than incorporating with a drill or other equipment. Brassica seeding rates should be kept low, especially in mixtures as they will dominate the mix and potentially reduce germination of other cover crops through competition. Participation in specific state and federal programs may also dictate seeding rates. For example, NRCS currently offers cost-share rates for establishing cover crops through Environmental Quality Incentives Program (EQIP), Agricultural Management Assistance (AMA), and Conservation Stewardship Program (CSP) with specific guidelines on seeding rates.

The following tables display the minimum seeding rates for common cover crops and mixes, as specified by Vermont NRCS in the *Cover Crop Specification Guide Sheet 340 (2020)*.

Table 1b - VT 340	Min. Seeding Rate (lbs/acre)		Seeding Depth	Latest Seeding Dates* (USDA Hardiness Zones 3b - 5a)				Primary Purpose**			Termination Method				
	Broadcast (includes aerial apply)	Drilled or incorporate		Inches	Broadcast Winter Cover	Drilled or Incorporate Winter Cover	Spring Cover	Summer Cover	Erosion	Nitrogen Fixation	Nutrient Scavenge	Mow	Till	Crimp	Winter
Cool-Season Grains															
Winter Rye	100***	75***	1 to 2	Oct 1	Oct 10	NA	NA	x		x	x	x	x		x
Winter Triticale/Wheat/Spelt	100***	75***	1 to 2	Oct 1	Oct 10	NA	NA	x		x	x	x	x		x
Spring Wheat, Triticale, Barley	100	75	1 to 2	Sept 15	Sept 15	April 15	June 1	x		x	x	x	x	x	x
Forage Oats	112	75	1 to 2	Sept 15	Sept 15	May 15	June 1	x		x	x	x	x	x	x
Warm-Season Grains															
Buckwheat	70	60	½-1½	Aug 15	Aug 15	June 1	June 1	x		x	x	x		x	x
Sorghum/Sudangrass	50	35	½-1½	Aug 15	Aug 15	NA	July 1	x		x	x	x		x	x
Japanese/Foxtail Millet	40	25	½-1½	Aug 1	Aug 1	June 1	July 1	x		x	x	x		x	x
Pearl Millet	30	20	¼-½	Aug 1	Aug 1	June 1	July 1	x		x	x	x		x	x
Teff	8	5	0-¼	Aug 1	Aug 1	June 1	July 1	x		x	x	x		x	x
Legumes															
Red Clover	12	10	¼-½	Aug 31	Aug 31	April 15	May 15		x			x			x
White or Alsike Clover	10	8	¼-½	Aug 31	Aug 31	April 15	May 15		x			x			x
Berseem Clover	18	10	¼-½	Aug 31	Aug 31	April 15	May 15		x			x		x	x
Sweetclover	15	8	¼-½	Aug 31	Aug 31	April 15	May 15		x		x	x			x
Crimson Clover	25	20	¼-½	Aug 31	Aug 31	April 15	May 15		x			x	x	x	x
Subterranean Clover	25	15	¼-½	Aug 31	Aug 31	April 15	May 15		x			x			x
Alfalfa	20	15	¼-½	Aug 15	Aug 15	April 15	May 15		x			x			x
Hairy Vetch	35	20	½-1½	Sept 15	Sept 15	April 15	May 15		x		x	x	x		x
Field Pea/Winter Pea	100	65	½-1½	Sept 1	Sept 1	April 15	May 15		x		x	x		x	x
Soybean	120	90	1 to 2	NA	NA	NA	July 15		x		x	x		x	x
Sunn Hemp	50	30	½-1	NA	NA	NA	July 15				x	x	x	x	x
Cowpea	100	60	¾-1½	NA	NA	NA	July 15		x		x	x		x	x
Brassicas															
Forage Brassica (Radish, Turnip, Winter Rapeseed)	15	10	¼-½	Sept 15	Sept 15	April 15	May 15	x		x		x		x	x
Mustard	10	6	¼-½	Sept 1	Sept 1	April 15	May 15	x		x		x		x	x
Winter Canola	10	6	¼-½	Sept 1	Sept 1	April 15	May 15	x		x		x			
Grasses															
Annual Ryegrass	30	20	0-½	Sept 1	Sept 1	April 15	May 15	x		x		x		x	x
Perennial Ryegrass	35	25	0-½	Sept 1	Sept 1	April 15	May 15	x		x		x			x

*Locations in USDA Hardiness Zone 5b may plant up to 5 days later for the Winter Cover dates.

** Other purposes may also be accomplished, but this is meant to help you select cover crops to address the primary resource concern in the conservation plan.

***Planting rate before Oct. 1 can be reduced to 75 lbs. for broadcast and 50 lbs. for drilled or incorporated.

Table 1d - VT 340	Min. Seeding Rate (lbs/acre)		Seeding Depth	Latest Seeding Dates* (USDA Hardiness Zones 3b - 5a)				Primary Purpose**		
	Broadcast (Includes aerial apply)	Drilled or incorporate		Inches	Broadcast Winter Cover	Drilled or incorporate Winter Cover	Spring Cover	Summer Cover	Erosion	Nitrogen Fixation
Cover Crop Mixes*** (3-Species Mixes)										
2-1: Winter Killed Mix***										
Forage Oat	40	30	1-1½	Sept 15	Sept 15	April 15	May 15	x	x	x
Field Pea	30	25								
Radish	5	3								
2-2: Marginally Winter Hardy***										
Annual Ryegrass	15	12	½-1	Sept 1	Sept 1	April 15	May 15	x	x	x
Winter Pea	30	25								
Radish	5	3								
2-3a: Winter Kill & Winter Hardy (Brassica)***										
Forage Oat	50	40	1-1½	Sept 15	Sept 15	NA	NA	x		x
Winter Rye	50	40								
Radish	5	3								
2-3b: Winter Kill & Winter Hardy (Legume)***										
Forage Oat	50	40	1-1½	Sept 15	Sept 15	NA	NA	x	x	x
Winter Rye	50	40								
Hairy Vetch	15	10								
2-4: Winter Hardy, Low Spring Biomass***										
Winter Rye	50	40	1-1½	Sept 15	Sept 15	NA	NA	x	x	x
Winter Pea	30	25								
Turnip	5	3								
2-5: Winter Hardy, Moderate Biomass***										
Winter Rye	50	40	½-1½	Aug 31	Aug 31	NA	NA	x	x	x
Crimson Clover	12	10								
Red Clover	5	3								
2-6: Winter Hardy, High Spring Biomass***										
Winter Rye	100	75	½-1½	Sept 15	Sept 15	NA	NA	x	x	x
Hairy Vetch	15	10								
Winter Rapeseed	5	3								

*Locations in USDA Hardiness Zone 5b may plant up to 5 days later for the Winter Cover dates.

**Other purposes may also be accomplished, but this is meant to help you select cover crops to address the primary resource concern.

***To substitute species in a mix listed above, or create your own mix, use seeding rates in Table 1e (only to be used in mixes that contain three different species).

Table 1e - VT 340	Seeding Rate (in a three-way mix) (lbs./acre)	
	Broadcast (Includes aerial apply)	Drilled or incorporate
Grasses & Grains		
Winter Rye	50	40
Winter Wheat	50	40
Winter Triticale	50	40
Spring Grain	50	40
Forage Oats	50	40
Annual Ryegrass	15	12
Legumes		
Red/White Clover	8	6
Crimson Clover	12	10
Berseem/Sweet Clover	10	8
Field Pea	30	25
Winter Pea	30	25
Hairy Vetch	15	10
Brassicas		
Radish	5	3
Turnip	5	3
Rapeseed	5	3

Termination Strategies

Termination strategies for cover crops that aren't winterkilled include herbicide, harvest, plow down, rolling with a roller crimper, or a combination of these methods. Your chosen strategy will depend on the equipment you have available, time during the season there is labor available, and your cover cropping goals. For example, if you would like to utilize/harvest the cover crop for forage, you may want to wait longer before termination to increase yield, then terminate it via harvest.

- Tillage may take several passes, which may be undesirable for soil conservation.
- Crimping provides a long-lasting mulch to control weeds and retain moisture.
- Planting into a living nitrogen-fixing cover crop provides more nitrogen for a succeeding corn crop.
- Herbicide termination should be done about 2 weeks before corn planting. Consider soil fertility and residue management and read all labels and directions. Challenges can arise if the soil conditions become saturated after the cover crop is terminated but before the crop is planted. The added cover will make drying the soil surface more difficult in this case and may delay planting. Check your crop insurance for required termination dates.

For more information on cover crop varieties, see NWCS's *Under Cover: Integrating Cover Crops into Silage Corn Systems Guide*, SARE's *Managing Cover Crops Profitably*, and NRCS's *A Comprehensive Guide to Cover Crop Species Used in the Northeast United States*. The NRCS guide contains specific information such as shade tolerance, biomass yields, carbon to nitrogen ratios, cost estimates, winter-kill temperatures, and more. Links for these guides are available in the resources section at the end of the document.

Cultural Practices: Selecting the Right Agronomic Methods for your Goals

Timing: Early vs. Late Interseeding

When it comes to interseeding, timing is key. In a cold northern climate, establishing cover crop growth after the cash crop can be difficult. However, if a cover crop is planted too early, it may compete with the cash crop, not survive to the end of the season or, if it is not winter terminated, it may be harder to terminate in the spring. Planting a cover crop too close to the planting of the cash crop, such as into corn in the V2–V3 stage, tends to decrease cash crop yields due to competition (Curran et. al 2018, Uchino et. al 2009).

Early Interseeding

Corn silage can be interseeded prior to canopy closure (about V4-V6 stage) to about two weeks before harvest. This range generally spans July and August, allowing flexibility for the farmer. However, the planting date will determine how well the cover crop establishes and/or overwinters.

The first potential window to establish a cover crop is just prior to canopy closure of the corn. This commonly occurs near the time of top dress or between the fourth and sixth leaf stage of corn development. Interseeding before the V4 stage can result in the cover crop competing with the corn. At this time, cover crops can be broadcast or drilled. Seed can be broadcast using a tractor-mounted seeder (Image 5) or mixed with fertilizer and applied at the time of top dress. New equipment like the Penn State interseeder (Image 6) has been developed to drill cover crops at the same time other field operations like N top dress and herbicide application are occurring.

If you plan to apply the seed with a broadcast spreader while fertilizing, pay close attention to your spread pattern; lighter seed will not spread in the same pattern as fertilizer and heavier seed. If these weight differences are not taken into account, you may see a banding effect in your fields where the lighter-weight seed did not uniformly cover the field. Adjust by reducing your spread pattern (i.e., travel 35 feet between passes instead of 50 feet) and/or adjust fertilizer rates accordingly to prevent over-fertilization.



Image 6. Interseeding Technologies “Penn State” Interseeder

Late interseeding

Another window of opportunity to plant cover crops occurs in the late summer, approximately one month to two weeks prior to corn harvest. Current equipment available for cover crop seeding at this point in the corn crop growing season is for broadcast only. This method has less seed to soil contact than drilled plantings and as a result, cover crop germination

Vegetative Stages of Corn

“V” is used to describe the vegetative stages of corn. Subdivisions of the V stages are called V1, V2, V3, etc., where the number indicates the number of leaf collars up to the time of tasseling. The tasseling stage is called “VT”.



Image 5. Tractor-mounted broadcast spreader.

If you plan to use a cultivator to improve soil-to-seed contact, take care to avoid burying the seed more than the recommended depth. If the seed is over-incorporated and/or there is too little moisture, it may not germinate. Some farmers choose to apply larger seeded cover crops prior to cultivation while smaller seeded species are applied just following cultivation.

is often lower. Furthermore, a challenge to establishing cover crops at this point is securing the equipment needed to interseed into mature corn.

However, an advantage to planting cover crops at this time is that it does get seed on the ground and reduces post-harvest workload and provides the cover crop with more time to grow. New equipment innovations to apply seed above the corn plants are being introduced to our region. An example is the “highboy,” a high clearance air seeder with drop tubes that deliver the seed to the soil (Image 7).



Aerial seeding has also been utilized as a cover cropping strategy in this region. This practice was implemented widely in the 1980s but fell to the wayside when cost share dollars for implementation became less available. More recently, the seeding of cover crops into standing corn by helicopter has addressed some of the equipment and timing issues of getting cover crops planted on large acreages during the busy time of the year (Image 8).

To be effective, aerially applied winter rye should be planted by late August or early September to give the cover crop a chance to become established, yet not fully mature to a degree that would interfere with corn


harvest. Timing seeding with a rain event is integral to good cover crop establishment using the aerial seeding method. Another consideration for aerial seeding is the rate. Aerial application seeding rates are often higher than other seeding methods for a variety of reasons. Seed can often get caught in the corn leaves and the amount of seed actually making it to the ground can vary widely depending on flying conditions, pilot procedures (flying close to the corn using rotor wash to “push” seed to the ground versus flying high above the corn), and the specific seeding equipment used. When applying seed in unfavorable conditions, application rates may need to be adjusted to ensure adequate establishment rates.



Image 8. Aerial seeding cover crop by helicopter.

New technologies, including use of unmanned aerial vehicles (UAVs) or drones to apply cover crop seed have the potential to provide further flexibility in applying cover crop seed successfully in-season.

Cover crop options for corn



				A		B		C	
Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	
Legumes					Non-legumes				
A	Berseem clover	A[†], B[†]	Annual ryegrass						
A, B	Crimson clover	C	Barley						
A, B	Mammoth red clover	A, B	Buckwheat						
A, B	Medium red clover	B	Oats						
A, B	Sweet clover	B	Oilseed radish						
A, B	White clover	B	Rape/Turnip						
A, B	60/40 mix	B, C	Rye						
A[†], B[†]	Hairy vetch	C	Triticale						
A	Medic annual	C	Wheat*						

A = Overseed corn at vegetative stages V4 - V8
 B = Overseed corn by air or highboy
 C = Overseed corn by air or highboy, seeded as a cover crop
 † = Not recommended if being planted to wheat
 * = After Hession fly free date

Timing also depends on the cover crop variety you choose to plant. Early planted species may need to be able to withstand drought stress, and late planted species may need to be able to tolerate frost. If your schedule changes and you have to interseed later in the season, you will want to evaluate your variety selection to ensure it will reach maturity. The diagram to the left (Image 9) shows planting date ranges for several cover crops commonly interseeded into corn systems. The letters to the left of the species indicate the planting date range, where ‘A’ is June-July, ‘B’ is August-September, and ‘C’ is mid-September to mid-October.

Image 9. Cover crop interseeding timings by species.
 Dr. Dale Mutch, Michigan State University Extension

Corn Maturity

Even if you are seeding earlier in the season, you will still want to harvest the corn by October so that the cover crop has time to grow without the cash crop shading it. Consider the maturity of both your corn and cover crops. If you are hoping to use your cover crop as a forage, you won't want to plant a long season corn or leave corn standing into October. Earlier season corn hybrids, which are often shorter and have earlier dry down, can benefit cover crop growth by allowing better light penetration earlier in the fall. Research trials by Northwest Crop and Soils Program have seen a small difference in average yields between long and short season varieties. The average yields at 35% dry matter from 2011-2019 were 24.4 tons ac⁻¹ for short season varieties, and 25 tons ac⁻¹ for long season varieties. Corn yield will be primarily influenced by variety selection. Identify a variety that provides adequate yield and quality but also fits your cover cropping goals.

Equipment Considerations

Fertilizer Spreaders (Image 10):

- Convenient method to plant cover crops as no new seeding equipment is needed.
- Banding may occur when planting cover crop mixes with seed of different weight and size. For example, lighter, smaller seed does not spread as far as heavier seed. The fertilizer spreader may need to be calibrated to account for different seed weights and sizes. Additionally, using coated seed for smaller seeds can help reduce the difference in seed size and weight. Making narrower passes can help make more uniform applications.
- Mud can coat the spreader wheels.
- Seed is not incorporated so prolonged dry conditions can reduce germination and establishment. Time of application is limited by corn height.



Image 10. Fertilizer spreader

No-till Drills/Seed Incorporation Planting Methods:

- Ensures seed to soil contact, enabling better germination and establishment prior to corn canopy closure. Seeding rates can be reduced in many cases due to a higher germination rate from greater seed to soil contact.
- Seed depth must be calibrated and special consideration should be made for multi-species mixes.
- Soil moisture can be a problem if too wet (plugging) or dry (too hard to penetrate soil).
- Can help incorporate fertilizer if timed correctly.
- More labor intensive and slower than other methods.
- Time sensitive due to corn height restrictions.

High Clearance/“Highboy” Seeders:

- Has a wider range of seeding potential than other ground driven processes due to the height of the machine.
- Better placement than aerial seeding, as it applies the seed under the canopy through drop tubes.
- In-field hazards must be identified (such as washouts, rocks, etc.) as the operator will not be able to see the ground from mid-season on.
- Studies show highboy seeding only damages ½ of 1% (0.5%) of the corn, mostly on the end rows.
- Seed is not incorporated, so prolonged dry conditions can reduce germination and establishment.

Aerial Seeding:

- Most versatile method of seeding due to lack of impediment by crop growth or poor soil conditions.
- Weather, particularly wind, must be considered when aerial seeding. It can adversely affect the placement of seed.
- Landing zones must be established beforehand so the helicopter can safely operate.

- Seeding rates may need to be adjusted to account for seed caught in the leaves of crops preventing the seed from reaching the ground. This is particularly important if number of seeds on the ground must meet standards placed by government contracts for payment.
- Banding of seed can occur and if various types of seed are spread at the same time.
- Seed is not incorporated, so prolonged dry conditions can reduce germination and establishment.

Technical Assistance

If you want to get started with interseeding and have technical questions, you can contact UVM Extension for more information. UVM Extension’s Northwest Crop and Soils Program can be reached at 802-524-6501, which serves Franklin, Grand Isle, and surrounding counties, and NWCS’s technical assistance agronomy specialist Jeff Sanders can be reached at 802-524-6501 or jeffrey.sanders@uvm.edu.

Local service providers include:

Highboy Seeders: Lawes Ag. Services Brandon, Vermont (802) 247-6874

Aerial Services: Mansfield Heliflight Milton, Vermont (802) 893-1003
 JBI Helicopter Pembroke, NH (603) 225-3134

Interseeding: Bourdeau Bros. Sheldon, Vermont (802)-933-4581, Middlebury, 388-7000
 Oliver Seed Co. Milton, Vermont (802) 893-1241

NRCS may provide an additional list of contractors who provide these services. Please contact UVM Extension at 802-524-6501 if you wish to be added to this list.

Corn Planting Considerations

Wide Rows & Challenges with Interseeding Dense Corn

Traditionally, corn is planted in dense 30-inch rows to maximize yields and decrease weed pressure, but the density of corn plants can be difficult to seed or establish cover crops. One solution is to plant corn in wider rows to allow for easier interseeding. Wider rows allow for more sunlight to reach the cover crop allowing more vigorous growth (Figure 2). To offset potential impact of yield, increased spacing of rows is often compensated for with a higher in-row seeding rate, maintaining the same population on a per acre basis.

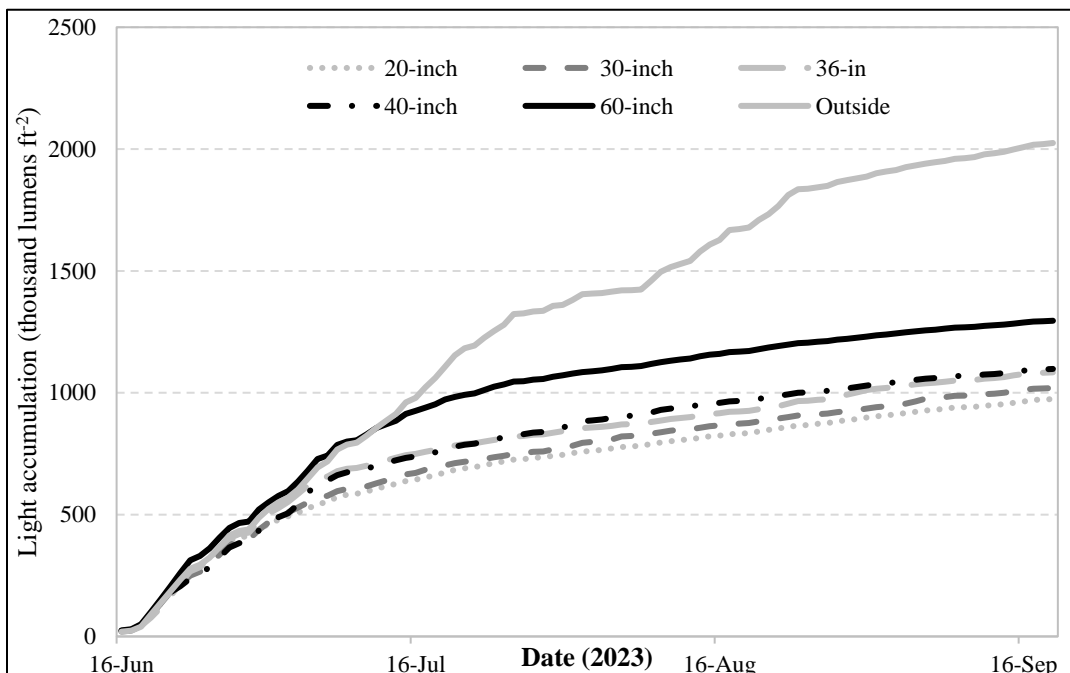


Figure 2. Light intensity under the corn canopy at different row spacings.



Image 9. Interseeded cover crops in wide row corn, Alburgh, VT, 2019.

The practice of planting cover crops into wider row corn to accommodate cover crop growth is relatively new in corn silage systems and research is currently being conducted to better understand best practices and the impact of this method on corn silage yield, quality, cover crop biomass, and weed biomass. Research is being conducted in other areas of the country as well. In 2018, Practical Farmers of Iowa conducted on-farm research trials to study the effect of wide rows (60-inch) on corn grain yields and cover crop biomass, and researchers saw mixed results (Gailans, 2018).

From 2019-2022, UVM Extension research found corn silage yields were reduced by an average of 25% when row spacing was increased from 30 inches to 60 inches but per acre corn populations were maintained (Figure 3). However, in some years yields were more similar than others indicating promise for the practice.

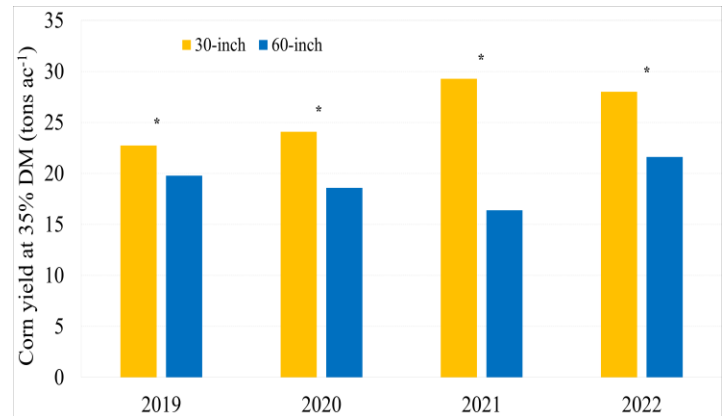


Figure 3. Corn silage yields in 30- and 60-inch rows 2019-2022.
* Significant difference between treatments for a given trial year ($p=0.10$).

Cover crop biomass was 3-4 times greater in 60-inch rows compared to 30-inch rows depending on the cover crop species or mixture used. Higher light infiltration in the wide rows was likely the reason the wider rows had higher cover crop biomass. However, this same sunlight benefit is also afforded to weeds. If cover crops establish better in wider rows, as has been observed in this research, then cover crops can be a viable weed control strategy. Strategies to off-set weed pressure will include methods that increase cover crop ground cover at an ideal time to utilize the weed suppression benefits of cover crops.

An unforeseen consequence of more distance between corn rows is that the plants were not able to support each other to stand upright in periods of inclement weather. For example, in on-farm trials, some farmers saw goose necking in 60" rows after high winds.

Corn Populations

Higher densities of corn population can impact cover crop growth, weed pressure, and corn yield.

Research indicates that increasing corn populations can result in reduced cover crop growth (Baributsa et. al 2008., Youngerman et. al 2018). A 2018 study with 16 sites in New York, Pennsylvania, and Maryland, was conducted to examine the impact of grain corn populations on an interseeded cover crop (Youngerman et. al 2018). The cover crop was a mixture of cereal rye, annual ryegrass, hairy vetch, and red clover. Higher corn populations had reduced cover crop growth, and generally higher grain yield, and higher weed density. At two of the sites there was no difference in yield by corn population. The study concluded that to optimize cover crop biomass in an organic corn system, corn seeding rates could be reduced 5-10% to achieve more cover crop growth and subsequent weed control without compromising on yield. This is possible because there is less competition for nutrients in the field, so the corn can grow larger, compensating for fewer plants.

UVM Extension research has found that corn silage yields generally increased with increasing seeding rate until approximately 32,000 seeds per acre, after which corn yields declined slightly and cover crop growth increased. Therefore, similar corn silage yields may be achieved with less seed, saving money while enhancing cover crop establishment and performance.

Plant Structure

When choosing corn hybrid varieties, take note of the leaf structure. Hybrid corn has upright, semi-upright, semi-pendulum or pendulum leaf options; these structures impact how much light is able to penetrate the corn canopy and reach the ground between rows. Many corn hybrids have been developed to maximize light the corn receives, like those with pendulum leaves, resulting in increased shading of the ground. While this is desirable for corn growth and weed control, too much shading will impede adequate cover crop growth. Upright-leaf hybrids allow more sunlight to penetrate the canopy, and are generally used when populations are high, while pendulum leaves are suited for lower populations. Planting upright and semi-upright corn hybrids in an interseeded system will allow light to reach the cover crops through the canopy.

Additional Factors & Concerns

Yields

Many farmers are concerned that interseeded cover crops will compete with the corn for moisture and nutrients resulting in reduced yields. Research conducted at Michigan State University (Baributsa et. al 2008), Pennsylvania State University (Curran et. al 2018), the University of Guelph, Ontario (Belfry, K., & Van Eerd, 2016), and the University of Vermont (Darby et. al 2020) has shown no negative impact on corn yield from interseeding cover crops when they are seeded at the appropriate time. There will be competition between the corn and cover crops if the cover crop is planted before the V3 growth stage or earlier.

Herbicides Programs for Corn

It is extremely important to pay attention to your herbicide program when interseeding! Herbicide programs must be modified to avoid terminating your cover crop or preventing germination altogether. This is especially true if the cover crop to be seeded is a broadleaf like radish or clover as they are especially sensitive to many corn herbicide residues. Herbicides must be applied prior to interseeding. Work with your herbicide applicator and/or crop consultant to make sure that there will be no damaging residues that may harm the cover crops. The following tables from Pennsylvania State Extension provide information on herbicides, half-lives, and their potential to harm different cover crop species.

Cover crop tolerance to common post-emergence corn herbicide residues.

Tolerant cover crops	Active ingredient	Trade name
Grasses, legumes, brassicas	Bentazon	Basagran
Grasses, legumes, brassicas	Bromoxynil	Buctril
Grasses, legumes, brassicas	Carfentrazone	Aim
Grasses	Dicamba	Clarity/Banvel/Status
Grasses	flumetsulam + clopyralid	Hornet
Grasses, legumes, brassicas	Fluthiacet	Cadet
Grasses, legumes, brassicas	Glufosinate	Liberty
Grasses, legumes, brassicas	Glyphosate	Roundup or other glyphosates
Grasses	Halosulfuron	Permit
Grasses	halosulfuron + dicamba	Yukon
Grasses	Mesotrione	Callisto
Grasses	rimsulfuron + thifensulfuron	Resolve Q
Grasses, legumes, brassicas	Thifensulfuron	Harmony

Common corn and soybean herbicides, estimated half-lives, and their potential to injure fall cover crops.

Herbicide	Active Ingredient	Half Life (Days) ¹	Tolerant Cover Crops	Intolerant Cover Crops	Other Information
2,4-D 4S	2,4-D	7	All grasses	Wait 30 days before planting sensitive broadleaves	Amine formulations more water soluble and can leach into seed zone
Accent 75DF/Steadfast75DF	Nicosulfuron/nicosulfuron + rimsulfuron	21	Fall cereal grains, ryegrass	Small seeded legumes, mustards, sorghum	More persistent in high pH soils (> 7)
Atrazine 4L	atrazine	60	Sorghum species	Cereals, ryegrass, legumes, and mustards	More persistent in high pH soils (> 7). Rates < 1 lb/acre can allow more flexibility
Balance Pro 4L	isoxaflutole	50-120	Fall cereals grains	Cereals, Ryegrass, legumes, and mustards	15" cumulative precipitation required from application to planting except soybean, barley, wheat, sorghum, and sunflower
Callisto (includes Lumax, Lexar, Halex GT)	mesotrione	5-32	All grasses	Small seeded legumes, mustards	Sequential applications (PRE fb POST) increase the potential for injury
Clarity/ Banvel 4S (Distinct and Status)	dicamba	5-14	All crops	Only at high rates or less than 120 days after application	Anything can be planted after 120 days with 24 fl. oz/acre or less
Dual II Mag 7.62E/Cinch	metolachlor	15-50	Almost anything	Annual ryegrass or other small seeded grasses	Higher rates and later applications more of a potential problem
Capreno 3.45SC	tembotrione + thiencazzone	50-120	Wheat, triticale, rye	Small seeded legumes, mustards, sorghum	15" cumulative precipitation required from application to planting rotation crops except wheat
Corvus 2.63SC	isoxaflutole+ thiencazzone	50-120	Wheat, triticale, rye	Small seeded legumes, mustards, sorghum	15-30" cumulative precipitation from application to planting for sensitive crops
Harness 7E (Degree, Warrant)	acetochlor	10-20	Most crops should be fine	Food or feed residues rather than crop injury may be a concern	Nonfood/feed winter cover crops are allowed after corn harvest
Impact 2.8SC	topromesone	14	Wheat, barley, oats, & rye are allowed after 3 mo. Ryegrass should also be OK	Although many broadleaves are restricted, Impact does not have much soil activity	We have not seen this herbicide carryover in PA.
Laudis 3.5SC	tembotrione	14	Cereal grains after 4 mo.	Unknown - Small seeded legumes, mustards could be a problem	Other crops may be seeded after a successful field bioassay.
Peak 57WG (& Spirit)	prosulfuron	9-152	Cereal grains and sorghum are labeled, other grasses	Small seeded legumes, mustards	More persistent in high pH soils (> 7)

Herbicide	Active Ingredient	Half Life (Days)¹	Tolerant Cover Crops	Intolerant Cover Crops	Other Information
Permit/Sandea 75DF	halosulfuron	9-27	Cereal grains and sorghum after 2 mo. and other grasses	Small seeded legumes, mustards	Halosulfuron also an ingredient in Yukon
Resolve 25DF (Resolve Q)	rimsulfuron	2-4	Based on the short halflife, most fall cover crops should be OK in PA	None	
Simazine 4L (Princep)	simazine	60	Sorghum species	Cereals, Ryegrass, legumes, and mustards	Soil pH > 7
Stinger 3S (Hornet and Surestart)	clopyralid	40	All grasses	Small seeded legumes	
Glyphosate 4L	glyphosate	47	All	None	
Gramoxone 2S	paraquat	1000	All	None	
Harmony 50WDG	thifensulfuron	12	No restrictions for wheat, barley, and oats	None with 45 day waiting interval	
Liberty 2.34L	glufosinate	7	All	Food or feed residues rather than crop injury may be a concern	
Outlook 6E	dimethenamid	20	Most crops should be fine	Food or feed residues rather than crop injury may be a concern	
Prowl H2O 3.8CS	pendamethalin	44	Cereal grains	Small seeded legumes and annual ryegrass	
Python 80WDG (Hornet and Surestart)	flumetsulam	14-120	Cereal grains	Small seeded legumes, mustards, annual ryegrass	
Metribuzin 75DF (Sencor)	metribuzin	14-60	Cereal grains and ryegrass	Slight risk for small seeded legumes, mustards	
Sharpen 2.85SC (Verdict and Optill)	saflufenacil	7-35	All	None	

Potential for interseeded cover crop injury from residual corn herbicides (Pennsylvania Guidelines).

Herbicide Treatments	Product Rate	Label Rate	App Timing	Annual Ryegrass	Red Clover	Grass-Legume Mix
SUs (2)						
Resolve 25 DF	0.5 oz	½X	PRE	L	L	L
Resolve 25 DF	1 oz	1X	PRE	L	L	L
Triazines (5)						
Atrazine (4L)	1 pt	½X	PRE	L	M	M
Atrazine (4L)	2 pt	1X	PRE	M	M	M
Atrazine (4L)	3 pt	1 ½X	PRE	H	H	H
Metribuzin 75 WG	4 oz	1X	PRE	H	L	M
Chloroacetamides (15)						
Dual II Mag 7.64 EC	1.67 pt	1X	PRE	H	M	H
Zidua 85 WG	2.5 oz	1X	PRE	H	M	H
Harness 7 EC	1 pt	½X	PRE	M	L	M
Harness 7 EC	2 pt	1X	PRE	M	L	M
Outlook 6 EC	½ pt	½X	PRE	L	L	L
Outlook 6 EC	1 pt	1X	PRE	M	L	M
Dinitroanilines (3)						
Prowl H2O 3.8 CS	1.5	½X	PRE	L	L	L
Prowl H2O 3.8 CS	3 pt	1X	PRE	H	M	H
PPOs (14)						
Sharpen 2.85 SC	1.5 fl oz	½X	PRE	L	L	L
Sharpen 2.85 SC	3 fl oz	1X	PRE	M	M	M
HPPDs (27)						
Balance Flex 2 SC	5.3 fl oz	1X	PRE	M	M	M
Callisto 4 SC	5.4 fl oz	1X	PRE	L	H	H
Impact 2.8 SC	0.75 fl oz	1X	POST	M	H	H
Mixtures						
Keystone LA NXT	2 pt	½X	PRE	L	L	L
Prowl + Atrazine	1.5 pt+1 pt	½X	PRE	M	M	M
Harness + Resolve	1 pt+0.5 oz	½X	PRE	L	L	L
Verdict 5.57 EC	8 oz	½X	PRE	L	L	L
Lumax EZ 3.67 SE	1.35 qt	½X	PRE	H	H	H
Acuron 3.44SC	1.25 qt	½X	PRE	H	H	H

Potential for Cover Crop Injury (% Fall Biomass Reduction)

<15% = LOW (L) 15-30% = MODERATE (M) >30% = HIGH (H)

Conclusion

Interseeding cover crops has numerous benefits and gives farmers more options to meet their cover cropping goals. Interseeding requires considering your specific goals, cover crop varieties, corn population density and row width, equipment availability, timing, and farm schedule. While there are also challenges and considerations, there is a plethora of resources available, from articles to Extension agents who can help you with navigating integrating interseeding into your operation. Additional resources are listed below, as well as the contact information for the UVM Extension Northwest Crops and Soils Program. You can also contact your regional Extension office. This project was funded through a USDA SARE grant award no. LNE18-361 and ONE21-386.

Northwest Crops and Soils Program | 278 So. Main Street, Suite 2 | St. Albans, VT 05478-1866

802-524-6501 or 1-800-639-2130 (toll-free in VT)

[uvm.edu/extension/nwcrops](https://www.uvm.edu/extension/nwcrops)

For more guides, fact sheets, research trial results, as well as information on field days & seminars, see our website at <https://www.uvm.edu/extension/nwcrops>.

Resources

Clack, Andy. *Managing Cover Crops Profitably*, 3rd Edition. (2012). Sustainable Agriculture Research & Education (SARE) program, USDA. <https://www.sare.org/wp-content/uploads/Managing-Cover-Crops-Profitably.pdf>

Clark, Shawna. (2011). *A Comprehensive Guide to Cover Crop Species Used in the Northeast United States*. Plant Materials Program, NRCS, USDA. Big Flats Plant Materials Center. Corning, New York. Sept 21, 2011. https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/nypmcpu10645.pdf

Cover Crop Interseeder: Improving the Success in Corn. (2017). Pennsylvania State University Extension. Prepared by Roth, G., Curran, B., Wallace, J., Ryan, M., Mirsky, S. <https://extension.psu.edu/cover-crop-interseeder-improving-the-success-in-corn>

Cover Cropping Costs and Benefits Table, Northwest Crop and Soils, University of Vermont Extension. https://www.uvm.edu/sites/default/files/media/Cover_Cropping_Costs_and_Benefits_FINAL.pdf

Curell, C. (2012). *Overseeding cover crops*. Michigan State University Extension. https://www.canr.msu.edu/news/overseeding_cover_crops

Evaluation of Residual Herbicides for Interseeding in Corn. (2017). Pennsylvania State University Extension. Prepared by Wallace, J, Curran, W. <https://extension.psu.edu/evaluation-of-residual-herbicides-for-interseeding-in-corn>

Northeast Cover Crop Council webpage: <https://northeastcovercrops.com/>

Pennsylvania State University Extension Cover Cropping webpage: <https://extension.psu.edu/forage-and-food-crops/cover-crops>

Under Cover: Integrating Cover Crops into Silage Corn Systems Guide. (2015). Northwest Crops and Soils, University of Vermont Extension. https://www.uvm.edu/sites/default/files/media/UnderCoverGuideAug2015_FINAL.pdf

USDA Natural Resource Conservation Service, *Cover Crop Economics Tool*: <https://www.nrcs.usda.gov/wps/portal/nrcs/detail/null/?cid=nrcseprd385825>

Vermont Natural Resource Conservation Service (2020). *Cover Crop Specification Guide Sheet 340*.

Other References

- Baributsa, D., Foster, E., Thelen, K., Kravchenko, A., Mutch, D., & Ngouajio, M. (2008). Corn and Cover Crop Response to Corn Density in an Interseeding System. *Agronomy Journal*, 100(4), 981-987.
- Belfry, K., & Van Eerd, L. (2016). Establishment and Impact of Cover Crops Intersown into Corn. *Crop Science*, 56(3), 1245-1256.
- Curran, W., Hoover, R., Roth, G., Wallace, G., Dempsey, M., Mirsky, S., Ryan, M.R., Ackroyd, V., Dempsey, M., Pelzer, C.J. (2018). Evaluation of cover crops drill interseeded into corn across the mid-Atlantic region. *Agronomy Journal*, 110(2), 435-443.
- Darby, Heather, Harwood, Hannah, Burke, Conner, Cummings, Erica, Monahan, Susan. (2013). 2013 Corn Interseeding Trial. Northwest Crop and Soils, UVM Extension. Report available at: https://www.uvm.edu/sites/default/files/media/2013_corn_interseeding_trial.pdf
- Darby, Heather. Ziegler, Sara., Luke, Ivy., Malone, Rory. (2020). 2019 Interseeding Cover Crops into Wide-Row Corn Silage. University of Vermont Extension. Report available at: https://www.uvm.edu/sites/default/files/Northwest-Crops-and-Soils-Program/2019_wide_row_corn_report.pdf
- Gailans, S. 2018. Planting corn in 60-in. row-widths for interseeding cover crops. Practical Farmers of Iowa Cooperators' Program, Ames, IA. <https://practicalfarmers.org/research/planting-corn-in-60-in-row-widths-for-interseeding-cover-crops/>
- Uchino, H., Iwama, K., Jitsuyama, Y., Yudate, T., & Nakamura, S. (2009). Yield losses of soybean and maize by competition with interseeded cover crops and weeds in organic-based cropping systems. *Field Crops Research*, 113(3), 342-351.
- Youngerman, C., DiTommaso, A., Curran, W., Mirsky, S., & Ryan, M. (2018). Corn Density Effect on Interseeded Cover Crops, Weeds, and Grain Yield. *Agronomy Journal*, 110(6), 2478-2487.