A PRACTICAL GUIDE TO NO-TILL & COVER CROPS

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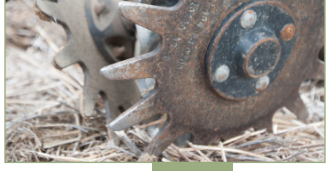
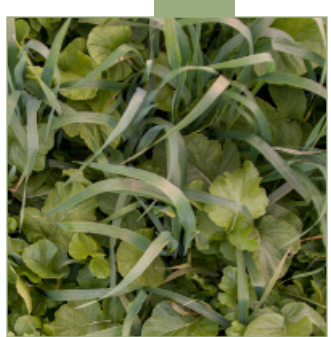
Developed by North Jersey RC&D

We are a non-profit dedicated to community needs through conservation. North Jersey RC&D promotes sustainable agriculture through partnerships, education, and innovation. Learn more at www.northjerseyrcd.org





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Edwin Remsberg
and USDA-SARE

Photo credit: Edwin Remsberg and USDA-SARE.

TABLE OF CONTENTS

Conservation isn’t easy.

Access to well-informed agricultural service providers and clear unbiased education materials will simplify the transition to sustainable agriculture, reduce uncertainty, and increase the likelihood of success.

FORWARD

No-till and cover crops are among the most cost effective tools to reverse soil and carbon loss and improve soil health; the economic, agronomic and environmental benefits of these practices are well known within the farming community.

Transitioning from conventional farming to no-till and incorporating the use of cover crops requires a higher level of management and demands a substantial investment in time to learn the information necessary to succeed. Farmers face hurdles including field soil preparation, equipment purchasing decisions, and management of other impacts on agronomic practices. For many farmers, lack of knowledge is a barrier to implementation.

This manual is designed to help agricultural service providers and farmers as they strive to implement new practices. It is designed for individuals already convinced of the merits of no-till and cover crops but unsure how to implement these practices.

This is a how-to manual

This manual contains...

precise instructions and equipment configuration recommendations. Although this information is usually best sourced from a knowledgeable crop consultant or peer, this manual furnishes the reader with a strong foundation from which to begin.

This information was sourced from a combination of research results, crop consultant recommendations, and most importantly, farmers' insights.

This manual does not contain...

research summaries, detailed cover crop species comparisons, nor any soil health or soil science data showing the benefits of these practices.

The recommendations within are not based on federal or state regulations. Those wishing to obtain financial support towards practices from those agencies will need to follow agency specific practice requirements.

NO-TILL AND COVER CROP RESOURCES

AG PROFESSIONALS

Professionals selling and servicing farmers with equipment and supplies are often a knowledgeable resource.

Crop Consultants

Crop consultants can answer questions on soil fertility, precision agriculture, seed varieties and herbicide use. The $4-8/acre fee for a crop consultant is usually worth the investment.

Seed Dealers

Seed dealers will be knowledgeable about what varieties are best for your soil conditions and goals. Be sure to let them know you are switching to no-till.

Nutrient and Chemical Dealers

No-till farming requires a different suite of nutrients, herbicides, insecticides, and fungicides; suppliers can help guide your selection.

Equipment Dealers

Many equipment dealers will have staff that are knowledgeable about equipment setup, maintenance and use.

FARMER MEETINGS

Pennsylvania No-till Alliance

PANTA is one of the nation's leading no-till farmer groups. Their goal is to promote the successful application of no-till and cover crops through shared ideas, experiences, education and new technology. They typically hold two or more field days annually that target farmers.

https://panotill.org/

National No-till Conference

The National No-till conference, is a one-of-a-kind learning experience assembling the most renowned no-tillers, agronomists and researchers together in one location to share cutting edge ideas and strategies to improve the profitability and efficiency of your no-till system.

https://www.no-tillfarmer.com/nntc

FARMER GROUPS

Facebook Groups

Facebook groups contain a wealth of information and inspiration; they are a good venue for troubleshooting.

Join Facebook Groups:
Everything Cover Crops

Online Forums

Many on-line forums are an excellent sources for information including:

https://talk.newagtalk.com/

ONLINE RESOURCES

SARE No-till Learning Center

Visit SARE's Topic Rooms for in-depth resources on important topics in sustainable agriculture

https://www.sare.org/learning-center/no-till

Exapta Solution Inc.

Expata authors an excellent library of in-depth articles and guides on drill and planter use.

https://www.exapta.com/working-knowledge/

Penn State Extension

https://extension.psu.edu/

Cover Crop Stategies

https://www.covercropstrategies.com/

Northeast Cover Crop Council

www.northeastcovercrops.com/

Rodale Insitute

http://rodaleinstitute.org

BOOKS & MAGAZINES

No-till Farmer

This monthly magazine contains in-depth interviews and insights from farmers around the country.

https://www.no-tillfarmer.com/

Managing Cover Crops Profitably (SARE)

Available as a hard copy book and as a free download at:
https://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition

Photo credit: Edwin Remsberg and USDA-SARE.

PART ONE
NO-TILL

It is not enough to simply stop tilling... No-tilling is a process.

Photo credit: Edwin Remsberg and USDA-SARE.

NO-TILL BASICS

NO-TILL / ZERO TILL

No-till practices leave crop residues on the soil surface and protect soil structure; in doing so, they build soil organic matter and increase water infiltration.

For thousands of years, traditional agricultural production systems relied on significant soil modification to prepare the soil for seeding: tillage equipment like plows and disks turned over the top 6-10 inches of the soil, blending it with residues and fertilizer, to create a loose, soft, uniform, aerated soil profile.

The tillage process, however, destroys the soil's natural structure.

Loose and crumbling topsoil is prone to erosion and compaction. The oxygen introduced during tillage accelerates organic matter decomposition. Ultimately, the soil becomes more and more dependent on physical and chemical inputs to maintain productivity.

No-till farming doesn't disturb the soil's surface. Residues from previous crops remain on the soil surface and seeds are planted in narrow slits using specialized equipment.

No-till farming is different: No-till aims to encourage the soil's natural processes.

Two features differentiate no-till farming

1. Residues from cover crops or previous crops remain undisturbed on the soil surface.
2. Crops are planted without disturbing surrounding soil.

PROS & CONS OF NO-TILL

The choice to transition to no-till is never an easy one. Farmers can face steep upfront equipment costs and the prospect of lower yields and profits during the initial transition process. Those interested in making the commitment to no-till do so with the long-term interest of their soil health and farm resilience in mind.

PROS

Reduces Fuel Cost

No-till typically uses 2 to 4 gallons per acre less diesel fuel compared with conventional tillage.

Reduces Labor Costs

By removing the need to plow, disk, and cultivate, farmers save time and labor costs.

Reduces Soil Erosion

By leaving the soil mostly undisturbed and leaving high levels of crop residues behind, no-till farming techniques greatly reduce soil erosion from wind and water.

Reduces Compaction

No-till soils are less vulnerable to compaction by heavy equipment traffic and will not develop a plow pan.

Increases Infiltration

Rainfall will percolate through continuous no-till fields faster than fields in continuous tillage. This means no-till soils capture more rainwater and lose less nutrients and soil through erosion during large storm events.

Increases Soil Carbon

No-till farming minimizes soil disturbance, which slows the breakdown of soil organic matter and builds soil carbon content. Soils with greater soil carbon content can hold more water and nutrients.

More Drought Resilience

Crop residue creates a layer of organic matter that keeps soils cooler and protects the soil from drying out.

Less Yield Variability

No-till will help reduce annual ups and downs in crop yields, in large part due to better water management and more natural nutrient cycling.

Higher Long-term Yields

Most farms report higher yields under long-term no-till management. In national corn and soybean competitions, no-till fields consistently yield more than conventional.

Higher Long-term Profits

Fuel and labor savings usually result in lower costs for no-till farms.

EXPERT TIP
NO-TILL WITHOUT COVER CROPS IS NOT A COMPLETE SYSTEM

To achieve all of the benefits of no-till, it is critical that farmers incorporate cover crops into the crop rotation. The living roots of the cover crop feed the soil organisms that cycle nutrients and create soil structure. Their strong fibrous roots create pores deep into the soil profile through which rainfall percolates. They capture carbon from the atmosphere and nutrients from the soil throughout the fall, winter, and spring, increasing the soil's productive potential.

Farmers won't realize full soil health gains without cover crops. **No-till without cover crops is still a dead soil.**

- Jim Hershey
PA No-Till Alliance President
Hershey Farms, Elizabethtown

CONS

Requires Specialized Equipment

No-till management requires the use of no-till drills and planters as well as specialized equipment attachments depending on soil conditions. Even if this cost is eventually absorbed into day-to-day operational savings, it's a significant upfront expense.

Nutrient stratification

Continuous no-till, particularly when fertilizers are surface applied, will result in a higher concentration of non-mobile nutrients (phosphorous and magnesium) on the soil surface. Thus, to supply the necessary nutrients, farmers need to band fertilizer or apply starter when planting; not all planters or operations are equipped to apply nutrients in this manner.

May Increase Herbicide Use

Without relying on plowing to disrupt weed growth, no-till farmers typically use herbicides to control weeds. However, as fields become more adapted to no-till, farmers can usually decrease herbicide use; without tillage, weed seeds aren't transported to the soil surface where they can germinate and cover crops will shade out emerging weed seedlings.

> **Cover Crops can help:** Cover crops will decrease spring weed pressure reducing reliance on herbicides.

Cooler Spring Soils

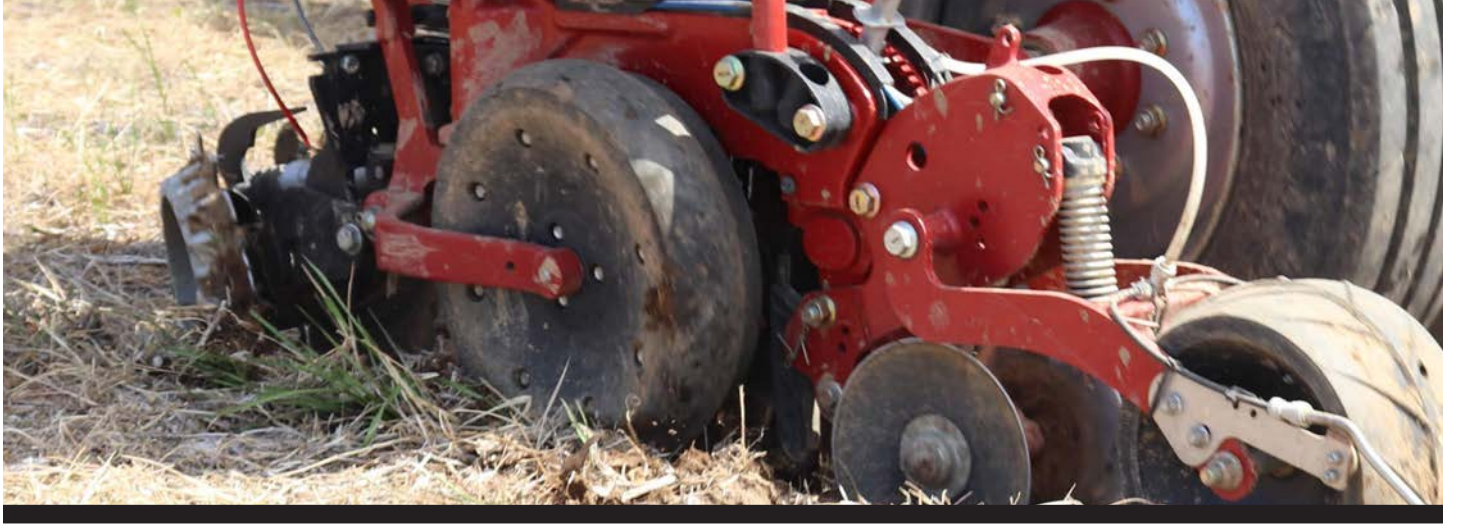
Farmers may have to delay planting because of lower spring soil temperatures and greater moisture under heavy residue. However, there is evidence that surface residues keep soils warmer during cool evenings preventing large soil temperature fluctuations.

> **Cover Crops can help:** Cover crops will dry out wet soils faster in the spring, allowing farmers to plant sooner.

Decreases Short-term Yield

As soils are "weaned" from tillage, farmers typically experience a yield decline of about 10% for upwards of 3 years.

> **Cover Crops can help:** Cover crops will improve soil structure and function. The short-term yield declines associated with a transition to no-till can be reduced with the use of cover crops.



NO-TILL EQUIPMENT

No-till planters and drills are unique in their ability to plant into undisturbed soils with large amounts of crop residues on the soil surface.

HOW IS NO-TILL EQUIPMENT DIFFERENT

Requires more pressure

Conventional equipment is designed to plant into a nicely manicured "fluffy" seedbed. Conversely, in no-till, the ground is firmer and usually covered in a thick residue from the previous year's crop. Penetrating the soil and residue requires more down-pressure. This pressure is achieved with more ballast (heavier no-till planters), adding weights on the planters, or by having pneumatic or hydraulic systems on the planters & drills that apply downward pressure.

Requires more residue moving and cutting

Conventional equipment is designed to plant into bare soil. No-till equipment has the added work of making sure the seed can reach the proper depth in the soil. This often involves moving residues to the side or away from the seed trench and adjusting equipment depth settings.

TWO BASIC TYPES OF NO-TILL EQUIPMENT

Drills

No-till drills plant crops in narrow rows. The planting units are staggered to enable row widths as narrow as four inches. Drills are typically used to plant smaller legumes, small grains, and cover crops.

Planters

Row units on precision planters (sometimes referred to as corn planters) are typically spaced thirty inches apart. These planters are designed to plant larger seeded crops and achieve greater accuracy and precision with a more consistent soil seeding depth and spacing than drills.

RIGHT TOOL FOR THE RIGHT CROPS

Some crops, such as soybeans, can be planted effectively with either a drill or a planter, given certain modifications. However, other crops can only be successfully planted with one or the other. See the following page for an equipment comparison.

EQUIPMENT COMPARISON

NO-TILL DRILLS vs PLANTERS

Grain drills and seed planters are complex machines that (1) deliver seeds at a metered rate, (2) place them at a consistent depth in the soil, and (3) close the seed trench and produce light compaction to provide good seed to soil contact.

Understanding the basic operation of these machines and their strengths and weaknesses is critical in determining which planter is best suited to meet the desired goals of the planting.

	DRILL	PLANTER
ROW SPACING	Typically 5.5" to 7.5"	Typically 30" or 20" *Split row and narrow row planters can plant 15" rows*
CROPS DESIGNED FOR	Cover Crops, Grasses, Legumes, Oats, Wheat, Rye, Barley, etc. *Soybeans with modifications*	Corn, Sorghum, Sunflowers, Soybeans, and Cotton
SEED METERING	Mass Flow	Singulate seeds
DEPTH	1/8" to 1.5"	1/8" to 4"
ROW CLEANERS	Not typical	Yes, although typically after-market
DOWN PRESSURE	Lower	Higher
FRAME	Rigid	Flexible
POPULAR BRANDS	Great Plains Haybuster John Deere Case IH Esch	Case IH John Deere Kinze

HOW DOES NO-TILL WORK?

1

RESIDUE SPREAD

Implement(s) Involved

Combine or other Harvesting Equipment

Action

Combines process and distribute the previous crop's residues on the soil surface during crop harvest.

2

RESIDUE MOVED

Implement(s) Involved

Row Cleaners

Optional but common on no-till planters; atypical on drills

Action

Row cleaners push aside residue to make it easier to create the seed trench and accelerate soil warming and drying.

3

SOIL FRACTURED

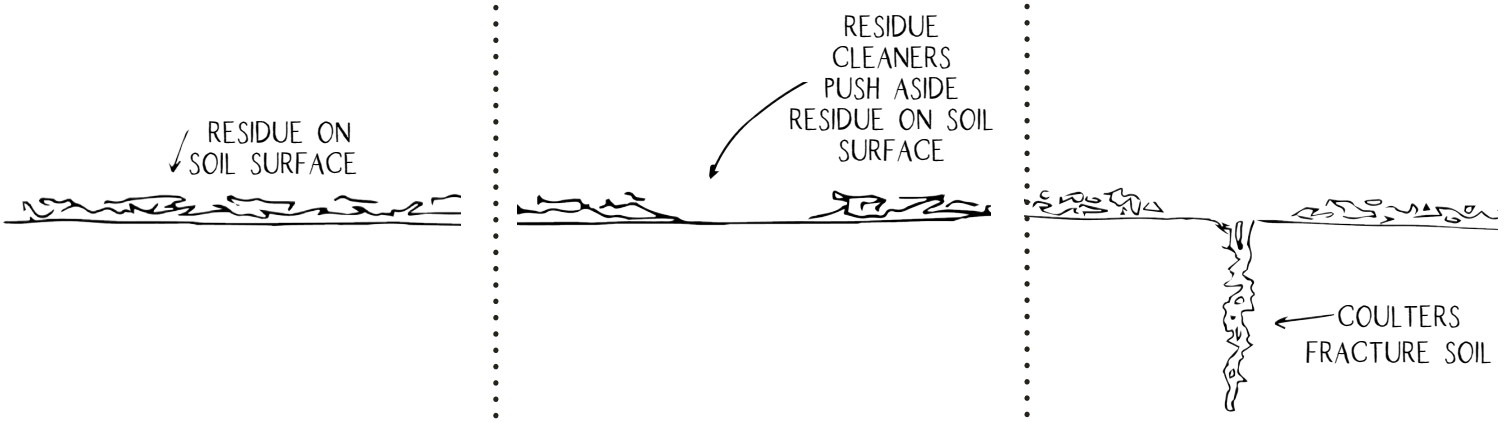
Implement(s) Involved

Coulters

Optional but common on no-till drills and planters

Action

Coulters cut remaining residues and fracture and loosen the soil.



No-till equipment (planters and drills) move residue aside, create a seed trench, plant the seed, and close the seed trench in a series of rapid actions.

4

CREATE SEED TRENCH

Implement(s) Involved

Opening Disk(s) or other opening mechanism

Action

Opening disk(s) create a seed trench into which a seed is dropped.

5

FIRM SEEDS IN TRENCH

Implement(s) Involved

Seed firmer
Optional but common on no-till drills and planters

Action

Lightly press the seed deeper into the seed trench to improve seed to soil contact.

6

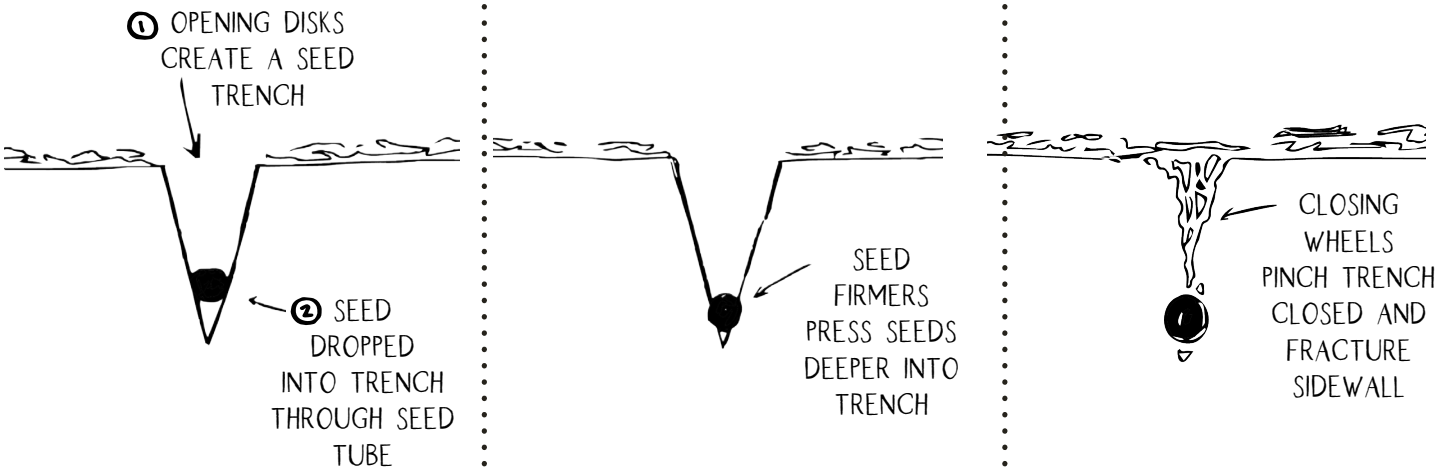
CLOSE TRENCH

Implement(s) Involved

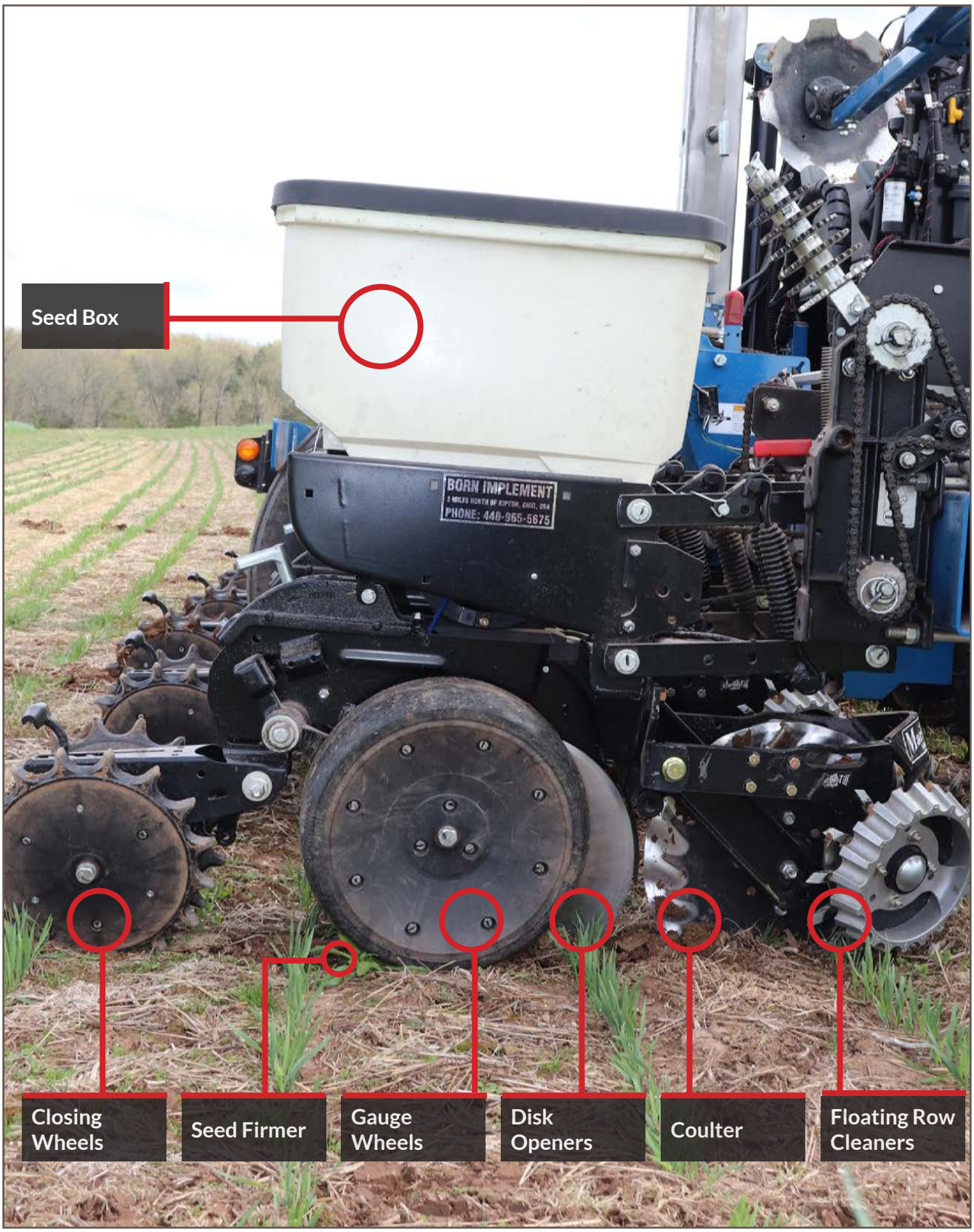
Closing wheels

Action

Closing wheels pinch the trench closed and fracture the trench sidewall.



NO-TILL PLANTER COMPONENTS


Seed Box
BORN IMPLEMENT
PHONE: 440-965-5675
Closing Wheels
Seed Firmer
Gauge Wheels
Disk Openers
Coulter
Floating Row Cleaners

NO-TILL DRILL COMPONENTS


Large Seed Box
Coulters
Drive Wheel
Opening Disks

Photo credit: Edwin Remsberg and USDA-SARE.

SUCCESSFUL TRANSITION TO NO-TILL

Transition to no-till management on cropland is a multi-staged process that requires planning, preparation, and substantial equipment modifications. Success hinges on being prepared.

Before beginning, keep in mind some key points:

Preparation for no-till begins the year before.

Fix nutrient imbalances and drainage concerns before starting no-till. Initial soil sampling and analysis is key to long-term success.

Cover Crops are important to long term successful no-till implementation.

Cover crops can make the ground softer and can help dry out wet soils in the spring. They also contribute organic matter that encourages microbial activity and nutrient cycling.

Transition takes time.

Fields can take up to 5 years before showing signs of better tilth and biological activity. Soils will improve much faster when cover crops are integrated into the rotation.

In the long run you won't regret it.

The first years of no-till can be challenging. But in the long run, soil under no-till management will be healthier, more resilient, and require less chemical and mechanical inputs.

1 FIELD SELECTION

Farmers should not aim to transition all fields to no-till at once. Start in fields that are well drained, have good soil structure, higher residue cover, and adequate soil nutrient levels. These soils will respond most favorably to no-till, reducing the potential for yield decline in the first few years.

START IN FIELD WITH LIVING ROOTS

Farmers should aim to transition fields that have a longer history of year-round living roots. These soils will generally have higher biological activity, better soil structure, and be generally softer and easier to plant in.

NEVER START IN FIELDS COMING OUT OF HAY OR ALFALFA: Some of the worst fields to start with are those coming out of a perennial crop, such as hay or alfalfa. If you need to transition a field from perenials to no-till, fall kill grass hay. Never take off first cutting of hay before planting.

FIELDS WITH A LONGER HISTORY OF COVER CROPS: Cover crops keep a living root in the soil year-round. In doing so, they break up compaction layers, create "softer" soil surface, and nourish soil organisisms (bacteria, fungi, and invertbrates) that are important to a healthy soil ecosystem. The longer the history of cover crop use, the easier a field will be able to transition to no-till.

FIELD SELECTION IS KEY

FIELDS WITH GOOD PH

Only transition into no-till fields where pH is already good -- ideally between 6.5 and 7.

Raising the pH of an acidic soil with limestone can take many years and multiple limestone applications. Limestone moves very slowly, taking years to move down a few inches of soil; it's difficult to raise the pH of an acidified soil without tillage.

NO PLANNED EROSION CONTROL CONSTRUCTION

Re-examine your Soil Conservation Plan to be sure that no contour strips or waterways are planned or required.

Earth moving activities are best designed and implemented in your fields before starting your no-tilling.

WELL DRAINED FIELDS

Farms with poorly-drained soils should install tile before transitioning to no-till.

Improved subsurface soil drainage provides a good return on investment regardless of tillage system, but it is particularly important in no-till because soils are not worked to create a dry surface.

EXPERT TIP
CONSIDER TAKING WETLAND SOILS OUT PRODUCTION

Re-evaluate especially poorly draining fields. Depending on the soil type, they may better suited as a natural feature. Federal program, including the Conservation Reserve Enhancement Program (CREP) will fund the establishment of permanent trees and bushes and pay farmers an annual rental rate.

-Kristen Meistrell
New Jersey Audubon

2 PREPARING FOR NO-TILL

CONSIDER SIGNING UP FOR NRCS EQIP

USDA-NRCS Environmental Quality Incentives Program (EQIP) offers a per acre financial incentive to offset the cost of transition.

Farmers should consider contacting their local NRCS office to enroll the year before starting no-till.

Farmers can receive as much as $12.00 to $17.00 each year, for three years, for every acre they commit to no-till or strip till.

SPREAD LAST CROPS' RESIDUE

Swaths of heavy residue will result in cooler and wetter soil conditions causing unevenness in germination. Uniform residue distribution and sizing leads to more uniform nutrient distribution (from residues), soil temperature, and moisture.

See "Improving Residue Distribution" on page 30.

DON'T GUESS! SOIL TEST

Adjust pH and fix nutrient imbalances. Consider intensive soil sampling of your fields. If soil test results call for the addition of nutrients or lime, incorporate throughout the top six to eight inches of soil during a final tillage operation.

EXPERT TIP
LIME AND PHOSPHOROUS AMENDMENTS

Lime and phosphorous are fairly immobile in the soil profile. It is crucial to address low soil pH and low soil phosphorous before transitioning to no-till.

Photo Credit: Swaths of heavy residue impeded corn germination.

NO-TILL PLANTING STARTS AT HARVEST

ONE LAST TILLAGE TO BREAK UP COMPACTION

Farms with soils containing a plow pan or other restrictive layers should strongly consider deep tillage or subsoiling before transition to no-till.

See "Breaking up Compaction Layers" on page 32.

EXPERT TIP
FINDING RESTRICTIVE LAYERS

Contact your local NRCS office to request a free soil investigation to determine if your soil profile contains restrictive layers.

LEVEL AND EVEN FIELDS

Uneven fields with ridges, old dead furrows, or just general unevenness should be levelled using a field cultivator or similar implement. To avoid ridges, run disks and cultivate at a diagonal (at least 20 degrees) to the direction of planting.

EXPERT TIP

Field levelness or uniformity is very important. I have seen dead furrows cause erosion in long-term no-till or transition on our own farm.

- Joel Myers
  Myers Farm and former
  Pennsylvania State Agronomist

PLANT A COVER CROP

To prepare a field for life without tillage, plant a cover crop. A winter cover crop will break up soil compaction and soften the soil surface in the spring. This is particularly true in heavy, wet, clay soil that resists drying.

EXPERT TIP
ADDING COVER CROP

Farmers don't need an expensive multi-species mix. Winter cereal rye is the most economical cover crop and can be planted late into the growing season.

Oats, applied at 50 to 75 lbs per acre, are a particularly excellent transition cover and will greatly improve no-till success.

Programs through USDA-NRCS and state department of agriculture can offset the initial implementation costs.

Photo credit: United Soybean Board

IMPROVING RESIDUE DISTRIBUTION

Residue distribution is extremely important and often overlooked. A heavy band of residue right behind the combine can cause a decrease in next year's crop stand by 20% to 30%. Here are some steps you can take to improve residue distribution during crop harvest.

NO CHOPPING HEADS

Chopping heads, such as the Calmer Corn Head ,crush and pulverize corn stalks. The residue left behind is much smaller and should decompose faster.

Farmers in the northeast have found the small pieces can create a mat on top of the soil, particularly on wet soil and transitioning no-till ground. Also the finely chopped fodder is more likely to be blown away during winter storm events. When transitioning to no-till leave corn fodder in longer pieces.

EXPERT OPINION
CHOPPING HEADS

My experience with chopping (sizing) stalks with the combine head, has been that they create more wind and water erosion. The smaller pieces also create more of a mat over winter, thus, making it harder for water to infiltrate and for the soil to warm and dry in the spring. For these reasons, I no longer own or use a chopping head.

- Jim Hershey
PA No-Till Alliance President
Hershey Farms, Elizabethtown, PA

CHAFF SPREADER

Combines need to be outfitted with a chaff spreader to evenly distribute the chaff. Chaff spreaders are typically rotating rubber paddles that scatter residue that's not distributed by the original chopper or spreader.

CHOPPING HEIGHT

CORN ONLY: Chop corn stalks as high as possible to reduce the accumulation of residue on the soil surface. In the spring, these stalks will be brittle and cut easily.

BREAKING UP COMPACTION LAYERS

Soil compaction may not repair itself under no-till management. Natural freeze-thaw cycles can help alleviate surface compaction, however, deeper compaction usually requires other interventions.

COVER CROPS

The roots of cover crops help break up hardpan and crusted soil that could have otherwise impeded water from soaking into the soil.

Fibrous rooted species like annual ryegrass are effective at loosening compacted soils with hardpans and fragipans.

Photo credit: Edwin Remsberg and USDA-SARE.

Tap-rooted species like tillage radish can penetrate up to 20” to 30” to break moderate severity hard-pans.

Cover crops can be very effective on sandy and loamy soils however, rich clay soils will likely require mechanical intervention.

DEEP RIPPING

Deep ripping (deep tillage) uses deep working shanks that penetrate the compacted soil to mechanically break up and shatter the soil hardpan.

Deep tillage can worsen soil conditions if not performed correctly.

- Ripping shanks must penetrate below the compacted soil layer
- Soil should not be overly moist or wet. The tines will cause smearing without fracturing and shattering the soil.
- Consider a roller or soil packer behind the deep ripper to minimize the risk of a rough soil surface and soil softness.
- Loosened soils can be more susceptible to compaction; leave deep ripped soil to settle for at least two weeks before sowing.

EXPERT TIPS

SUBSOILER SELECTION

Soil tends to 'blow out' behind deep ripping shanks (especially when run at higher speeds). I suggest using a subsoiler with wheels next to the shanks to prevent soil from being inverted and causing the need for additional tillage. These attachments push soil back to create a suitable seedbed ensuring that crops can be planted immediately after subsoiling without secondary tillage.

- Joel Myers
  Myers Farm
  Former Pennsylvania State Agronomist

Photo credit: Edwin Remsberg and USDA-SARE.

DEEP RIPPING

The biggest mistake farmers make when using a deep ripper is they don't wait until the soil is dry enough to rip. They use the tool to dry out the soil which creates even more compaction.

- Jim Hershey,
PA No-Till Alliance President
Hershey Farms, Elizabethtown, PA

MAKING DEEPER FREEZE-THAW IMPACTS

If fairly dry soil conditions are present in the fall, a no-till subsoiler without attachments will aid in rainwater infiltration and subsequent freezing and thawing will occur at greater depths.

- Michael D. Braucher

3 OFF-SEASON NO-TILL PREPARATIONS

ROW CLEANERS

Row cleaners clear residue away from the seed trench ahead of the opening disks, reducing the risk of residue hairpinning and poor slot closure. By exposing the bare soil, they accelerate soil warming and drying.

Farmers transitioning to no-till need row cleaners. For most farmers, the ideal set-up is some form of floating row cleaner outfitted with offset trash wheels with swept-back teeth. Row cleaners often need to be adjusted in each field, each year according to the type and depth of residue layer.

See "Row Cleaner Options" on page 72 for more information.

NEW DISK OPENERS

Keep disk openers sharp and at factory recommended specifications.

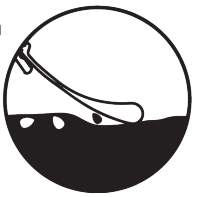
Sharp disk openers are crucial for slicing through tough residue and reducing the amount of necessary down-pressure. Under no-till management, anticipate disk openers wearing down faster.

See "Seed slot openers" on page 78 for more information.

EXPERT TIP
REPLACE DISKS FREQUENTLY

Disk openers under no-till will typically need to be replaced after 500 acres or less -- most farmers will need a new set each year. A rule of thumb is to replace disk openers either when (1) disks begin "stubbing back," (2) after 1/2" of wear, or (3) if they wobble or shake indicating worn bearings.

- John Nance
  Prescription Tillage



SEED FIRMERS

The use of a seed firmer will improve seed-to-soil contact. This inexpensive plastic device pushes seeds to the bottom of the V-trench or slot. Firmers may need to be replaced each season due to wear.

Be aware that some manufacturers, including Case IH do not recommend seed firmers.

See "Seed Firmers (optional)" on page 66 for more information.

THE BEST TIME TO BEGIN PREPARATIONS FOR NO-TILL IS THE YEAR BEFORE.

ADEQUATE CLOSING WHEELS

No-till often requires more aggressive closing wheels to collapse the sidewall. Some farmers remove factory rubber closing wheels in favor of iron closing wheels. The advice provided by most experts would be to replace them with some type of spiked closing wheels.

See "Closing wheels / Press wheels" on page 84.

EXPERT TIP
SELECTING CLOSING WHEELS.

Try several types of closing wheels before committing a big investment to outfit the entire planter. Different styles of closing wheel will perform differently on varying conditions. It is best to go with a wheel that works well under a wide variety of conditions rather than a wheel that works great in perfect planting conditions.

- RJ Fulper
  Fulper Family Farms,
  Lambertville, NJ

IMPROVED DOWNFORCE SYSTEMS

No-till planting equipment requires significantly more down-force to penetrate hard soil surfaces and cut tough residues. Farmers should consider adding additional down-force to row units through either weights, springs, pneumatic air-bags, or hydraulic cylinders.

See "Downforce / down-pressure" on page 60 for more information.

SELECT THE RIGHT SEEDS

Select crop varieties with good vigour, cold tolerance, and disease resistance. Many no-till soils will initially be poorly drained and cooler than tilled soil. It is important to select a seed variety that has the best chance to perform well under cooler and wetter conditions.

Ask your seed dealer for cold germination test scores. Most seed companies routinely reject seed lots that test less than 85 percent cold germination. For no-till, consider rejecting seed lots whose cold "germ" ratings are less than 90 percent.

Seed treatments of fungicides and insecticides are important, especially for early planted seed in cooler, wetter soils and in no-till soils that may remain cooler longer in the planting season. For a comprehensive list of seed coatings for corn and soy, see "What's on your seed" from the University of Wisconsin.

4 PLANTING

TERMINATE COVER CROP SEVERAL WEEKS BEFORE PLANTING

If planting into a field with cover crops, follow these guidelines to reduce potential planting problems:

1. Don't let cover crops get too large, particularly when starting out. Cover crops less than 6" tall shouldn't wrap around equipment.
2. Wait 10 to 14 days after termination before planting the cash crop! Plant when dead cover crops are dry and easier to cut through, reducing potential problems with hair-pinning.

EXPERT TIPS
PLANTING GREEN

There are other strategies for managing spring cover crops. "Planting Green" is a new technique of planting cash crops into a green cover crop that has been terminated a few days before or after planting. However, these practices are best suited to farmers with more experience.

PLANTING DATE

Rely on field conditions and extended weather forecast, instead of calendar date, to determine when to plant. Soils should be moist, but not wet, to ensure proper seed trench closure.

EXPERT TIPS
AVOID PEST DAMAGE

Delaying the planting date is important for quick plant development to reduce slugs and grub damage.

- Michael D. Bracher

WHEN TO PLANT

Do not plant ahead of a cold rain. Corn seeds prefer warmer soil conditions, particularly in the first 24 hours after planting.

- Jim Hershey
PA No-Till Alliance President
Hershey Farms, Elizabethtown, PA

INCREASE SEEDING RATE

Seed germination under no-till is less consistent during transition; consider increasing seed population 10% to 20% over past rates. Exact seeding rates are dependent on soil types, yield goals and planting conditions; consult your agronomist or seed dealer for more advice regarding plant population.

EXPERT TIP
SEEDING RATE

If the planter/drill is set up correctly for no-till and planting conditions are good it should not be necessary to increase seeding rate.

- RJ Fulper
Fulper Family Farms,
Lamberville, NJ

SUCCESSFUL NO-TILLERS ARE "ADJUSTERS", CONSTANTLY REFINING THE NO-TILL PLANTER

REFINE SEED DEPTH

Farmers transitioning to no-till may want to adjust their seeding depth.

Producers often plant no-till corn too shallow, thinking they're placing the seed in a warmer environment for quicker emergence. Planting deeper does place seeds in slightly cooler soils, but temperatures are usually more uniform and buffered by residue from nighttime lows. The result is more uniform emergence.

PLANTING DIRECTION AND SPEED

Be thoughtful about row arrangement. Avoid planting through the previous year's root balls and stalks by planting down the previous year's row center or planting at a diagonal to the previous years' planting.

Traveling too fast often causes one or more of the planter parts to work poorly, resulting in poor depth control or insufficient seed-to-soil contact.

A no-till planter can rarely be driven faster than 5 mph and still plant effectively. Most often, 3 to 4 mph should be the maximum speed.

USE A STARTER FERTILIZER

Farmers that were accustomed to incorporating fertilizer and manure using tillage should consider in-furrow starter fertilizer at time of planting.

Applying starter fertilizer in no-till systems helps overcome slow growth because of low soil temperatures at the early growth stages. Some no-till planters use liquid starter fertilizer solutions that are delivered to the seed furrow through a tube that feeds through the seed firmer.

EXPERT TIP NITROGEN RECOMMENDATION

Early nitrogen is very important. Apply starter nitrogen at 20 to 30 pounds per acre. In-furrow "pop-up" fertilizer can be an especially helpful tool for early season germination and growth.

- RJ Fulper
  Fulper Family Farms,
  Lamberville, NJ

Corn no-till planted into wet soils. Although the seed trench initially closed during planting, as the soil dried, the seed trench opened up, causing uneven germination, and poor root growth.

Photo credit: B. Hilshey, North Jersey RC&D

SOIL MOISTURE CONTENT AND PLANTING

One of the most challenging (and most important) elements of no-till is determining if the soil moisture is right for planting. Planting in soil that is too wet or too dry will decrease yields.

WHY SOIL MOISTURE MATTERS

If the soil moisture content is near field capacity and the soil molds easily in your hand, it is probably too wet for planting. Under wet soil conditions, the seed slot will not close properly and the sidewalls of the slot will smear or cause side -wall compaction. That can reduce seed to soil contact or develop a hard side wall that is difficult for young roots to penetrate.

Too Wet

- Residue is difficult to cut
- Risk sidewall compaction
- Increased prevalence of soil diseases
- Risk poor slot closure
- Increase potential for slug damage

Too Dry

- Harder to penetrate soil
- Risk poor slot closure if proper depth is not achieved

There are several methods for assessing planting conditions:

1

Collect a handful of soil from your desired planting depth and squeeze the soil in your fist. If moisture and soil cling to your palm, the soil is too wet.

2

Take a similar soil sample and form it into a loose ball and drop it to the ground from about waist-high. If the ball remains mostly intact or breaks into only a few pieces, the soil is too wet.

Photo credit: United Soybean Board

PLANTING DEPTH CONSIDERATIONS

Differences in fields due to soil types, moisture conditions, previous tillage and residue levels can affect the depth and operation of the planter in different ways. Seed depth should be checked at the beginning of each new field and throughout the day, particularly when changes are suspected in field conditions.

ADJUSTING PLANTING DEPTH

Accurate and uniform seeding depth is critical to successful no-till implementation. Seeds planted at uneven depths will be exposed to different soil temperature and moisture levels; this results in uneven germination and significant yield loss.

Plant corn between 2 and 3" in depth and plant soybeans between 1 and 1.5" in depth. The optimal seeding depth within those ranges will differ across sites and time.

Plant shallower under the following conditions:

- Cool soil
- Heavy clay soils
- Moist soil
- High residues
- When planting earlier in the season

Plant deeper under the following conditions:

- Dry soils
- Course soils
- When planting later in the season
- Hair-pinning of residue is a problem

EXPERT TIP
REFINING DEPTH IN HEAVY RESIDUES

The quantity of residue can change drastically from one part of the field to another. Under most no-till conditions, do not account for residue depth when setting planting depth; row cleaners should remove most resides are the path of a gauge wheels.

Under very heavy residues (corn on corn) farmers should account for the height of residues on the soil surface when setting planter depth; plant-depth gauge should be set slightly deeper as depth gauge wheels ride on some residue.

- RJ Fulper
Fulper Family Farms,

5 FERTILIZE APPROPRIATELY

APPLICATION TIMING

Fertilizers can be lost through a myriad of natural processes. Increase nutrient use efficiency and prevent nutrient losses by always applying nutrients to either (1) actively growing plants or (2) as close as possible to crop seeding date.

When possible, split nitrogen applications. Dividing total nitrogen application into two or more treatments can help growers enhance nutrient efficiency, promote optimum yields and mitigate the loss of nutrients.

INCREASE NITROGEN APPLICATION RATE AT FIRST

Bacteria will tie-up nitrogen fertilizers broadcasted on carbon-rich crop residues. Although the nitrogen is still in the soil, it won't be available to plants until later in the season, when more residues have decomposed. When transitioning to no-till, consider applying up to 20 percent more nitrogen than recommended. After a few years, soil organic matter content and biological activity will increase such that extra nitrogen is not required.

PROVIDE SEEDLINGS WITH NUTRIENTS NEAR THEIR ROOTS

Always apply some form of nutrients near the seeds. Banding fertilizer 2 inches below and 2 inches to the side of the seed ("2" x "2") is ideal; banding enables farmers to apply fertilizer in high quantities without risking damage to the seedling.

Farmers may not be equipped to band fertilizer below the soil surface. The use of pop-up or starter is an excellent alternative. Pop-up cannot supply all the crop fertilizer needs, so more than one application of fertilizer will be necessary. On some no-till planters , liquid starter fertilizer can be applied through the seed firmer.

Slow-release fertilizers pellets prevent nitrogen losses

FOLLOW SOIL TEST RECOMMENDATIONS

PROTECT NITROGEN

Nitrogen broadcasted on the soil surface is prone to being converted into nitrogen gas by soil bacteria, or lost in stormwater runoff.

Subsurface application of nitrogen fertilizers

To prevent nitrogen losses, try to inject or apply nitrogen below the soil surface using banding or manure injection.

When Broadcasting

When you cannot inject or band nitrogen below the soil surface, apply fertilizers and manure 1 to 2 days before a light rain (non-runoff-producing rainfall event). Urea will dissolve in the rainwater, and trickle into the soil where it is more available to plants and less likely to escape to the atmosphere. Also, consider using non-urea-based fertilizers such as ammonium nitrate or ammonium sulfate, coated urea, or nitrogen stabilizer-coated fertilizers, which are less prone to being converted into nitrogen gas.

APPLY EXTRA LIME AND TEST SOIL SURFACE ACIDITY

No-till operations that rely on broadcasting manure and fertilizer to supply nutrients require more frequent lime applications. Check the surface pH annually by collecting a soil sample from the uppermost 2" of the soil profile.

GASEOUS LOSSES ON NITROGEN
Under worst-case conditions (wet and warm soils with high biological activity) this loss can be rapid and significant. Research studies have found greater than 50% of applied fertilizer nitrogen lost to the atmosphere.

USE A COVER CROP!

Cover crops can produce, absorb, and recycle soil nutrients. They are an important tool for improving nutrient use efficiency.

Producing Nutrients

Legume cover crops (clover, peas, and vetches) capture and convert atmospheric nitrogen to organic nitrogen.

Absorbing Nutrients Year round

Cover crops capture soil nutrients throughout the winter and spring that would otherwise be lost through leaching or surface runoff.

Recycling Nutrients

Cover crops can act like slow release fertilizers. They will readily capture the nutrients from spring applied manure and fertilizer, converting them and storing them in their tissue as organic matter. When the cover crop is terminated, the nutrients are slowly released back into the soil for crop use and uptake.

HOW DOES NO-TILL INFLUENCE NUTRIENT MANAGEMENT

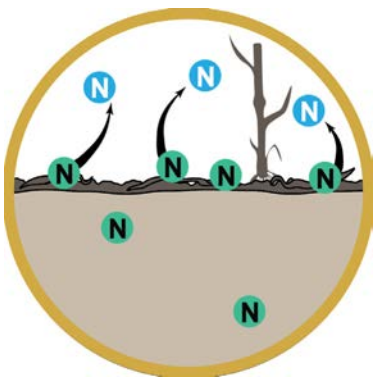
Under no-till management, fertilizer and manures are typically broadcast on the soil surface and residues are not incorporated. These practices have a number of profound impacts to nutrient cycling and availability, described below.

PLANT AVAILABLE NUTRIENTS

- **P** Phosphorous
- **K** Potassium
- **N** Nitrogen
  Ammonium or Nitrate

NOT AVAILABLE TO PLANTS

- H^+ Acidifying Hydrogen Ions
- **N** Nitrogen Gas
  Atmospheric Nitrogen & Ammonia Gas
- **N** Organic Nitrogen
  Nitrogen tied up in Organic Matter



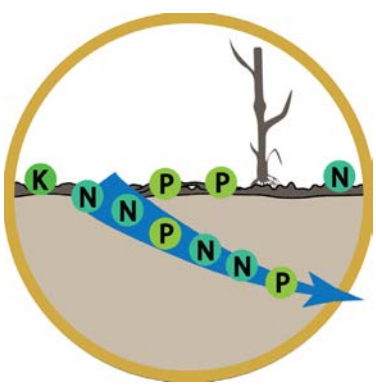
Surface applied N is lost to the atmosphere

WHAT

As much as 50% of the nitrogen in urea-containing fertilizers and manure will be lost to the atmosphere (as ammonia gas) when not incorporated into the soil.

SOLUTION

- ☐ Use fertilizer with lower urea content
- ☐ Consider adding a urease inhibitor
- ☐ Inject or apply N subsurface whenever possible
- ☐ Surface apply N before a light rain



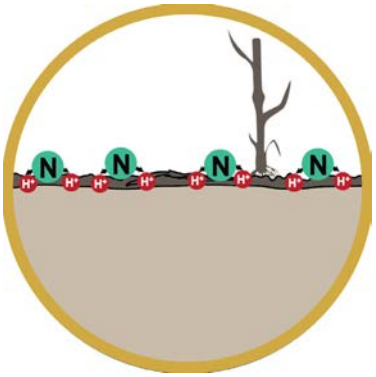
Surface applied nutrients can run-off in storm events

PROBLEM

Surface applied nitrogen and phosphorus will wash away in storm-water runoff, either dissolved in rainwater or stuck to sediments.

SOLUTION:

- ☐ Avoid spreading fertilizers and manure before large storm events
- ☐ Inject or apply N subsurface when possible
- ☐ Apply nutrients to a growing cover crop to prevent run-off



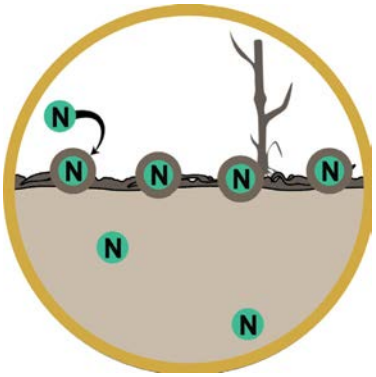
Acid layer in top 2-3 inches

PROBLEM

When ammonium nitrogen breaks down in the soil, it releases acidifying hydrogen ions into the soil surface. Low surface soil pH can impede germination and damage seedlings.

SOLUTION

- ☐ Apply lime more frequently
- ☐ Check the surface pH annually
- ☐ Inject or apply N subsurface whenever possible



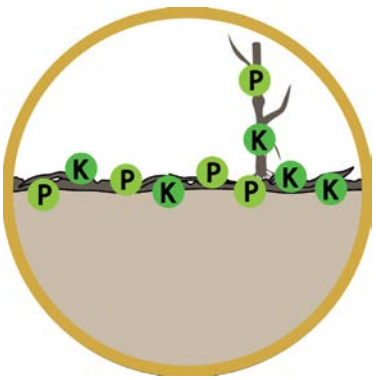
Carbon-rich residues tie up N (Carbon-penalty)

PROBLEM

When applying nitrogen to carbon-rich residues (ie. corn), soil microbes decomposing the residues will outcompete crop seedlings for the nitrogen. Substantial amounts of nitrogen won't be available to the growing crops until previous residues are decomposed.

SOLUTION

- ☐ Provide the microbes with extra nitrogen to accelerate the breakdown of residues early in the growing season
- ☐ When possible, inject or apply N subsurface near the plant where it is available in the early growth stage



P and K build up on soil surface

PROBLEM

Non-mobile nutrients, like phosphorus and potassium, concentrate on the soil surface when fertilizers and other nutrient-rich residues are not incorporated into the soil. Seedlings cannot access nutrients on the soil surface.

SOLUTION:

- ☐ Band fertilizer (ideally two inches below and to the side of seed) during planting and/or use pop-up (starter to supply seedling roots with nutrients)

Photo credit: United Soybean Board

SOIL SAMPLING NO-TILL SOILS

No-till management affects soil nutrient cycling. Top-dressed ammonium based fertilizers and manures acidify the uppermost few inches of the soil through naturally occurring chemical reactions.

Non-mobile soil nutrients like phosphorous and potassium become highly concentrated at the top of the soil profile. As a result, farmers practicing continuous no-till should adjust their soil sampling protocol to accurately assess soil chemical properties.

Tilled Soils

In conventionally tilled systems, nutrients are generally evenly distributed to the depth of the plow disturbance.

Collect soil samples from the uppermost 6-inches

No-till Soils

In no-till systems, the soil surface will be both more nutrient-rich and more acidic. The effect will be particularly pronounced during the first few years of transition, when large soil organisms, like worms, aren't present in high concentrations to "mix" the soil.

Farmers should still collect a soil sample from the uppermost 6-inches for fertilizer and lime recommendations. It is very important that the soil sample be a 6-inch deep composite; a shallower sample will make the soil appear more nutrient rich than it really is!

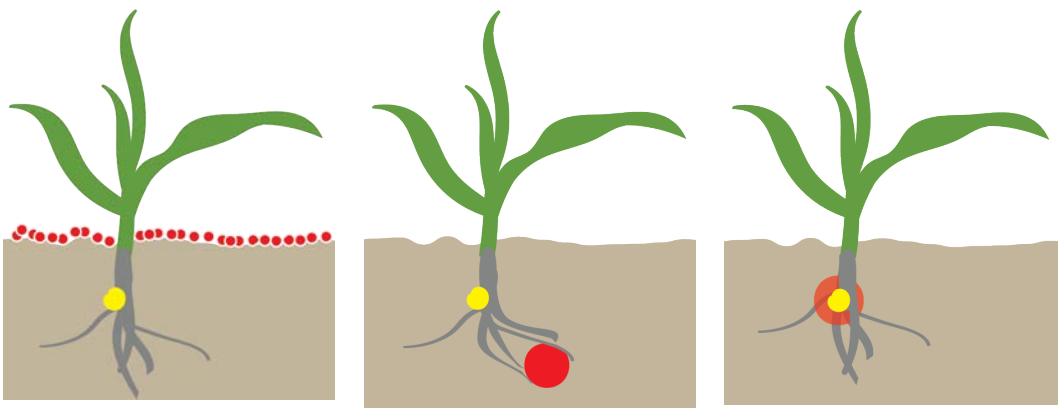
If the P and K levels in the 6-inch sample are low or very low, then injecting phosphorus and potash with the planter or a separate fertilizer injector is recommended. These nutrients may be in higher concentration in the uppermost 2 inches, but seedlings won't be able to access the nutrients.

Also collect a sample of the uppermost 2 inches to monitor surface acidity. In long-term no-till fields, surface fertilizer application and accumulation of organic matter concentrates acidity at the soil surface. These no-till fields may have surface soil pH in the 4.0-5.0 range, which can cause aluminum toxicity for young seedlings and poor performance of some herbicides.

FERTILIZER PLACEMENT OPTION IN NO-TILL

No-till management impacts how farmers apply nutrients. Farmers accustomed to incorporating fertilizers will need to either broadcast, band, or apply in-furrow fertilizer.

NO-TILL FERTILIZATION PLACEMENT OPTIONS



PRE-PLANT OR AT-PLANTING APPLICATION

BROADCASTING
Broadcast fertilizer application refers to a uniform distribution of material on the soil surface.

SUB-SURFACE BANDING
Banded fertilizer is placed at least 2 inches below and to one side, or on both sides of the seed at planting.

STARTER (POP-UP)
Starter or pop-up is a fertilizer added in the furrow, at time of planting, in contact with the seed.

AFTER PLANTING

TOPDRESS
When applied after planting, a broadcast application is often referred to as a topdress application.

SUB-SURFACE SIDEDRESS
A subsurface banding treatment after the crop is planted is referred to as a side-dress application (knifing-in).

BROADCASTING / TOPDRESSING

PROS

- Uniform distribution
- Easy and fast

CONS

- Greatest potential for nitrogen losses via volatilization, denitrification, and run-off
- Relies on rainfall to move nitrogen into root zone
- Non-mobile P and K remain on soil surface and unavailable to seedling root systems

TIP

Apply immediately before a light rain to move nitrogen into the soil, or use slow release fertilizers.

When using liquid manure, never plant until manure is dry. When using semi-solid, solid manure, or bedded pack manure, row cleaners on the planter are important to moving manure aware from the seed trench.

BANDING / SIDE-DRESSING

PRO:

- Places fertilizer or manure where young roots can access the nutrients
- Can apply at high rates without damaging plants
- Least nutrient loss potential

CONS

- Requires most costly equipment and/or equipment modifications
- Application is time consuming

STARTER POP-UP

PRO:

- Places fertilizer where young roots can use the nutrients.
- Promotes early growth in low temperature soil.

CONS

- Requires more than one application to meet the crop's fertilizer requirement

TIP

Pop-up can be hugely advantageous to no-till. However over-application threatens seeds with injury if the fertilizer is too concentrated. Apply no more than 30 lb/acre of N+K+S for solid and 50 lbs/acre of N+K+ S for liquid.

Fertilizer material used for starter typically contains an increased amount of phosphorus to promote early season growth. Phosphorus does not contribute to salt injury and therefore over-application is not an agronomic concern. However, when soil test-phosphorous levels are above 75-100 ppm, choose a starter without phosphorous.

6

WHAT TO EXPECT IN THE BEGINNING (FIRST 3 YEARS)

No-till relies on a thriving soil ecosystem. Under no-till and cover crop management, soil organisms accomplish the actions previously performed by tillage. Earthworms and other beneficial soil invertebrates break down and incorporate residues deeper into the soil profile. Soil microorganisms and fungi excrete glue-like substances that create soil aggregates and soil structure.

It takes a few years for soil organism populations to build up to high enough levels to accomplish all of these important functions. As a result, most soils will take a few years to function optimally.

WETTER SOILS & WORSE INFILTRATION

At first, the soil particles may clog soil surface pores in the uppermost few inches of the soil profile. Farmers should expect water infiltration rates to temporarily slow, resulting in wetter, poorer draining soils.

RESIDUE BUILDUP

After transitioning to continuous no-till, residue will build up on the soil surface. The existing biological systems that breakdown residues, such as earthworms, soil invertebrates, and soil fungi will not be initially sufficient to decompose the increased quantities of soil residues. It takes a few years for populations of these organisms to grow to the quantity needed to decompose residues in a timely fashion.

Committing to no-till means committing the time required to understand the system and realize benefits.

SLOWER GERMINATION

Slower and uneven germination can be an outcome of no-till at first.

Germination can be delayed as much as 7-10 days in no-till vs tilled fields because of cooler soil conditions.

NUTRIENT STRATIFICATION

Phosphorous (P) and Potassium (K) will build up in the upper few inches of no-till soils when surface applied nutrients aren't incorporated and as roots translocate nutrients from deeper in the soil profile to the leaves of plants.

Stratification of P and K in the top few inches of the soil's surface should not be a concern except under drought conditions. Under normal conditions, the largest percentage of root growth in no-till is in the top three inches of the soil where P and K concentrations are highest.

STRATIFICATION OF P IS A WATER QUALITY CONCERN when soil P concentrations are extremely high and soils are poorly drained. Under these conditions, P will dissolve in surface run-off in the form of orthophosphate: a leading cause of harmful algal blooms in surface waterways.

NUTRIENT STATIFICATION REDUCTION Applying P below the soil surface (as a 2x2 subsurface application or in-furrow) reduces the potential of environemtnal and agronimic problems associated with P statification. See "Fertilizer placement option in no-till" on page 48.

POTENTIAL DECREASED YIELDS

With proper preparation it is very possible to have no yield loss during transition to no-till.

However, be prepared for a potential 10% decrease in corn yield. Yield losses with soybeans and other crops are less dramatic.

Cost share programs through NRCS EQIP and other state agencies are available to offset the potential income loss.

7

WHAT TO EXPECT IN THREE TO FIVE YEARS

THRIVING SOIL LIFE

A few years without tillage will change soil biology. Mycorrhizal fungi will proliferate, creating strong micro-aggregates that lead to a loose, crumbly soil structure.

Earthworm populations will skyrocket to as many an 120,000/acre, creating pores up to five feet deep through which plant roots can grow to access water and nutrients.

In the absence of tillage, residue decomposition within the soil profile slows, enabling organic matter concentration to increase.

It becomes a living soil.

BETTER NUTRIENT AVAILABILITY

Approximately 75% of nutrient cycling is biologically driven. Bacteria and mycorrhizal fungi break down residues and manure, releasing nutrients into the soil for plant uptake. Higher soil biological activity increases nutrient availability.

Increased organic matter and soil organic carbon concentration will improve soil cation exchange capacity (CEC). Higher CEC increases a soil's ability to hold and store nutrients and buffer against changes in pH.

Nutrient exchanges between organic matter, water, and soil are essential to soil fertility and need to be maintained for sustainable production purposes.

LESS SOIL COMPACTION & GREATER INFILTRATION

The higher organic matter content and biological activity characteristic of no-till soils makes the soil more resistant to soil compaction.

Residue protects the soil surface from the impact of raindrops and reduces soil crusting, which in turn increases infiltration rates and gas exchange.

Over time, no-till soils develop a well drained, loose, crumbly structure through which rainfall easily percolates and the seedbed will become softer and more forgiving.

NO-TILL SOILS ARE RESILIENT

LESS EROSION

Residues on soil surface will protect soil from soil erosion. Under no-till management, erosion rates typically decline by more than 60%; fields accustomed to losing many tons of topsoil per year through erosion will experience minimal soil loss.

IMPROVED DROUGHT RESISTANCE

Reduced Evaporation

No-till management leaves plant residues on the soil surface, keeping soil cooler. Cooler soils experience less evaporative loss from sun and wind exposure. The lower soil temperature reduces evapotranspiration rates of cash crops during hot weather, thus further conserving soil moisture.

Every 1% increase in organic matter results in as much as 25,000 gallons of available water per acre

Source: Kansas State Extension Agronomy e-Upates, Number 357, July 6, 2012.

MORE PLANT-AVAILABLE WATER: The increase of organic matter in no-till soil is a two-fold benefit when it comes to water. First, the organic matter wicks more water down into the soil, providing for better rainfall capture and less loss to runoff. Secondly the organic matter holds more moisture in the soil increasing the water holding capacity.

MORE PROFITS

Yield will typically rebound to the same levels achieved under conventional management a few years into the n0-till transition.

At the same time, input costs under no-till management are typically lower. Less tillage means less fuel use. Lower soil disturbance reduces weed pressure and the need for herbicides. More microbial activity leads to more efficient nutrient uptake and lower nutrient inputs. All together, long-term no-till management systems are more profitable.

EXPERT TIP
NO-TILL FIELDS WIN YIELD CONTESTS

In national corn-growing competitions, no-till fields have consistently beat conventionally tilled fields in the non-irrigated crop category.

TOP 10 REASONS NO-TILL FAILS

While many people are convinced no-till is the way to farm, many others are convinced it does not work. Clearly, no-till farming can work, but failures typically occur because of one or more of these 10 reasons:

1 Selecting the wrong seed variety

No-till seedlings may experience cooler and wetter seedbeds. Planting varieties that tolerate these conditions is important.

2 Lack of equipment

The main equipment needed is a no-till planter and a sprayer. The technology of both of these has improved significantly in the past decade. If you don't have access to high quality equipment, custom planting may be a good way to start.

3 Failure to correct nutrient deficiencies before starting

Fertilizer and lime can be surface-applied, but they don't move much below the top 1 inch of soil without some type of tillage. Ideally, soil nutrient levels should be adequate throughout the rooting depth and not just in the top inch of soil; yields may suffer if the levels aren't sufficient.

4 Lack of crop rotation

Crop rotation is important to break up disease, insect and weed cycles. A field must grow a different crop at the same time of year in consecutive years to be in a rotation.

5 Trying to reduce inputs too quickly.

Producers often try to cut back on herbicide and fertilizer use too quickly.

Farmers should only consider scaling back inputs after several years of continuous no-till AND cover cropping. Cover crops are extremely important to reducing nutrient loss and weed pressure.

6 Failure to leave enough residue

Residue and cover crops serve many important functions, such as catching precipitation, feeding beneficial soil microorganisms, preventing topsoil and nutrients from eroding, preventing soil crusting and covering bare soil so weeds have difficulty germinating .

Photo credit: Edwin Remsberg and USDA-SARE.

7 Not having equipment properly adjusted

Since herbicides for burn-down are heavily relied upon in no-till, sprayers must be properly equipped, calibrated and operated. Likewise, pressure on disk openers and closing wheels on planters and drills must also be properly adjusted to achieve accurate and consistent depths.

8 Lack of attention to detail

To illustrate this point, consider this example: a plow controls all small weeds equally well, but pesticides are more selective. Spraying at the right time and right rate with the best equipment does no good if the wrong pesticide is used for the target weed or other pest. Everything must be done correctly to ensure success.

9 A failure to commit to making it work

This is the reason for most no-till failures. If a producer doesn't think no-till will work and doesn't want to make it work, it probably won't. **No-till farming is a commitment to a long- term process of soil management.** The production benefits of no-till are greater in year 20 than in year two.

10 Lack of knowledge

No-till farming is not the same as conventional farming. It requires different skill sets and thinking to optimize all the required inputs and practices. Successful no-till farmers have identified peers, mentors, and partners to help them with their transition.

COMPONENTS & RETROFITS

Selecting the right upgrades and after-market accessories can greatly improve no-till success. The following section will describe the different elements of a no-till planter and drill and how each can be optimized to improve performance for specific field conditions.

WHY IS NO-TILL EQUIPMENT DIFFERENT?

1

Requires more down pressure

Conventional equipment is designed to plant into a nicely manicured "fluffy" seed bed. Conversely, in no-till, the ground is harder and usually covered with thick residues from the previous crop. Penetrating the soil and residue requires a lot more down pressure.

2

Requires more residue moving and cutting

Conventional equipment is designed to plant into soil. No-till equipment has the added work of making sure the seed can reach the soil. This often involves cutting and moving residues.

PLANTER SEED HOPPERS

Seed hoppers store seed used during planting. Seed can be stored either in smaller seed hoppers mounted above each row unit or a single large seed storage box that uses air pressure to distribute seeds to each row unit.

ROW MOUNTED HOPPERS

Most planters have one or two seed hoppers located on each row-unit. Each unit holds between 1 and 3 bu of seed, and therefore, must be refilled frequently.

Seeds within the box are typically gravity fed to a metering device, although newer models will use a vacuum to draw seeds from the hopper into the seed meter.

IMPORTANT NOTE
BOX WEIGHT IMPACTS DOWN PRESSURE

A 3-bushel seed-box may weigh from 120 to 200 pounds per row when full; down-pressure on row units will change as seed-boxes empty.

CENTRALLY MOUNTED BULK FILL PLANTERS

Centrally mounted bulk fill planters are an alternative to traditional row-unit mounted seed boxes. They use an air distribution system to convey seeds to small seed hoppers on each row unit that feed precise metering systems.

PROS: Bulk fill seeders can handle bulk quantities of seed and fertilizer and are well adapted to planting large acreages very efficiently. Downforce on the row units is more consistent because the small seed hopper is always full.

CONS: The increased weight of the extra seed on a bulk fill planter may need to be considered when planting in wetter soils.

MAINTENANCE

Ensure seed boxes don't "wiggle." Excessive seed box motion will cause seed meters to improperly drop seed into the seed tube.

Seed boxes need to be checked regularly for buildups of seed treatments, graphite, or talc, which can cause problems with seed flow to the seed meters.

DRILL SEED-BOXES

Seed boxes on drills can come in three configurations: standard, legume, and native grass (fluffy) seed. Each box is designed to handle specific seed and can usually be calibrated independently of one another. Some drills only have one seed box, some have two, and some have all three.

STANDARD SEED BOXES

Standard seed boxes are designed to handle large, smooth seed such as soybeans, peas, wheat, oats, etc. They generally rely on the smooth nature of the seed and gravity to feed the planting mechanism.

NATIVE SEED BOX

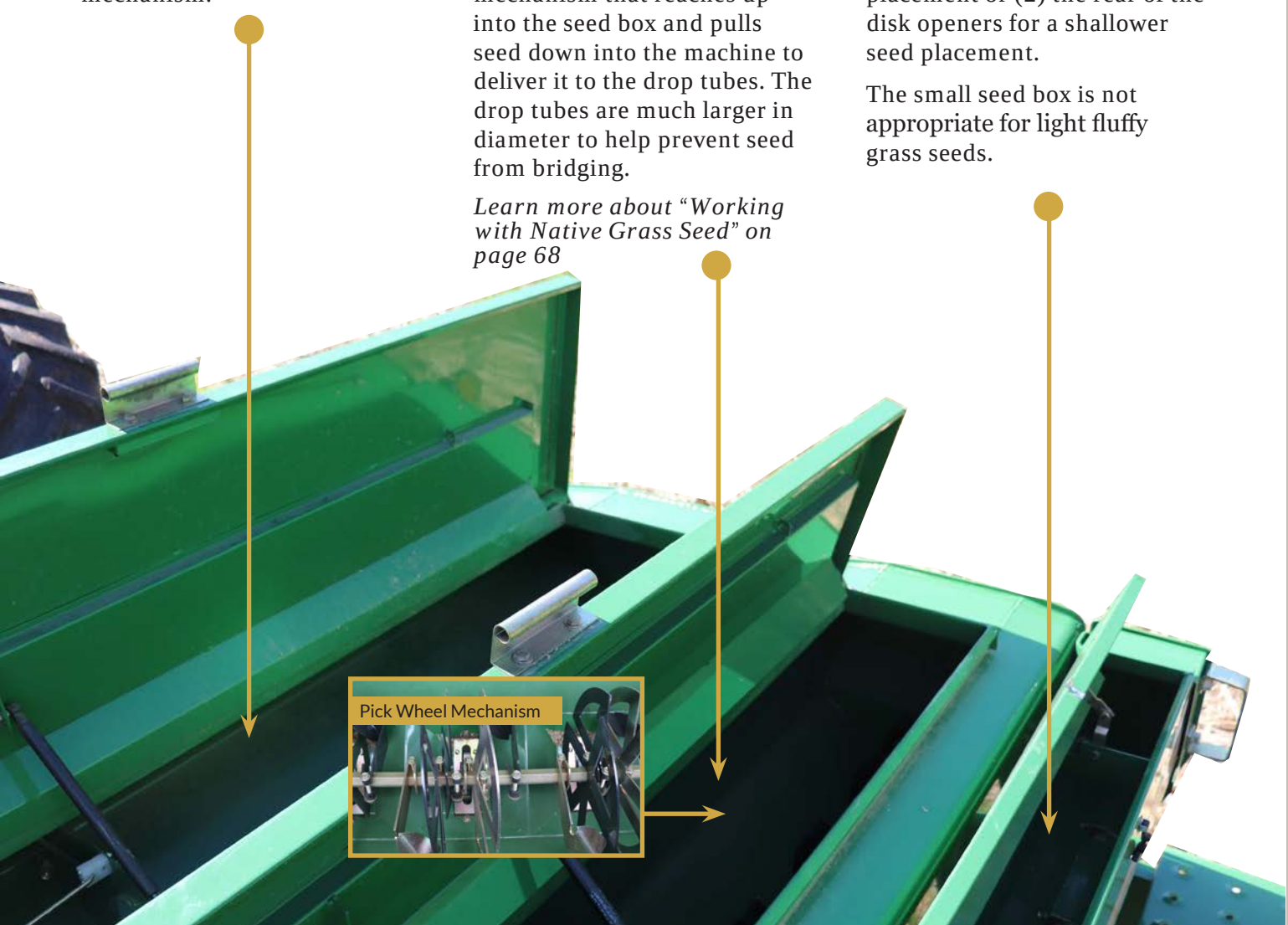
The native or fluffy seed box is similar to the standard seed box, but has some form of aggressive agitation within the box to keep seed moving so it doesn't bridge on itself. Many will have a "pick" wheel mechanism that reaches up into the seed box and pulls seed down into the machine to deliver it to the drop tubes. The drop tubes are much larger in diameter to help prevent seed from bridging.

Learn more about "Working with Native Grass Seed" on page 68

SMALL SEED BOX

The small seed box, sometimes called a legume or grass-seed box, is optimized for small seed crops. The tubes from the small seed box can be directed to either (1) the bottom of the seed slot for a deeper placement or (2) the rear of the disk openers for a shallower seed placement.

The small seed box is not appropriate for light fluffy grass seeds.



DOWNFORCE / DOWN-PRESSURE

A planter or drill's ability to cut through tough residue, penetrate the soil, and maintain consistent depth across a field relies on a properly managed downforce system to provide downward pressure on independent row units.

THE IMPORTANCE OF DOWNFORCE

It is essential to find the right balance of pressure to provide adequate seed-to-soil contact, but without causing over-compaction.

IF TOO LITTLE DOWN FORCE IS APPLIED, planting depth can vary and seed-to-soil contact may not be adequate.

EXCESSIVE DOWN FORCE, particularly in wet conditions, causes soil compaction and sidewall smear.

FACTORS THAT IMPACT DOWNFORCE

Field variability, soil types, farming practices, and soil moisture levels all impact how much pressure should be used in a particular area of a field. The amount of down-force required will vary from field to field and day to day.

Factors that increase the amount of down-force necessary include:

- Dull opening blade
- Dull coulter
- Compact soil
- Dry soil
- Too many soil engaging components on the row units
- Too many row units on the implement (Drills commonly have difficulty applying adequate down force.)

HOW DO YOU KNOW IF DOWNFORCE IS CORRECT?

Check Seed Depth Frequently!

Check seed depth during planting in areas with drier, harder soil and wetter, softer soil. If the seed depth between the two soil conditions are different, your drill or planter may not be capable of applying sufficient downforce to penetrate the soil.

HOW TO ADD MORE DOWNFORCE WITHOUT INVESTING IN A NEW SYSTEM

Add Weight

Many planters will need extra ballast on the tool-bar to transfer enough force onto the row units. Consider filling insecticide hoppers on the planter that you're not using with sand for more weight. Alternatively, you can add iron suitcase weights or water drums to the frame or individual row units.

Remove or Adjust Coulters

Coulters, especially wide and wavy coulters, require a lot of downpressure to penetrate the soil. More pressure can be made available to the opening disks to penetrate soil by removing or switching coulters.

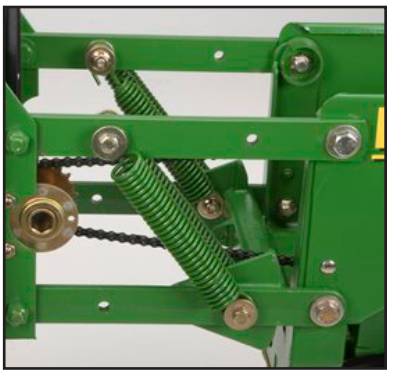
Replace Opening Disks

Sharper, newer opening disks will penetrate the soil easier than dull worn, opening disks.

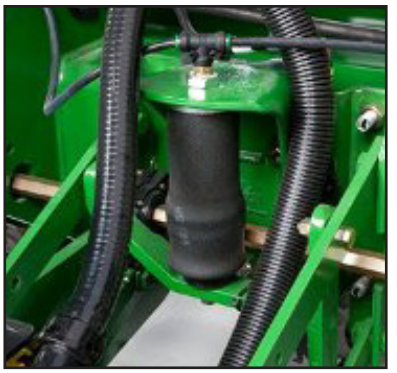
DOWNFORCE SYSTEMS

Downforce systems can only redistribute the planter or drill weight; when the unit weight is insufficient, the springs may physically lift the metered drill wheel off the ground.

THREE WAYS TO APPLY DOWN PRESSURE



1 SPRINGS



2 PNEUMATIC AIR BAGS

3 ACTIVE HYDRAULIC CYLINDERS

RATES

Spring-based downforce systems can be set to apply a range of downforce pressure within set increments. By comparison, pneumatic and hydraulic downforce systems offer infinitely adjustable downforce from 0-500 pounds.

CONTROL AND ADJUSTMENT:

Springs are manually controlled and adjusted based on planting situation and periodic seed depth checks. As conditions within the field change, operators will need to manually adjust downpressure at each row unit. In pneumatic air bags and active hydraulic systems, a compressor can be mounted in the tractor cab for automatic on-the-go adjustment.

METERING DEVICES, DRIVES AND CLUTCHES

Metering mechanisms are designed to drop the same number of seeds per unit length regardless of variations in seed size and shape, travel speed, and slopes.

SEED METERS

Meters On Drills

Mass flow seed meters deliver an even volume of seeds. These are designed for small seed and for situations where singulation is not important.

The most common mass flow meters use fluted roller and seed cups to deliver batches of 3-10 seeds at a time. Belted meters use belts with single seed-sized cells to deliver seeds approximately one at a time.

Meters On Planters

Precision meters are designed to meter out single seeds at an exact spacing.

VACUUM AND BRUSH METERS rely on interchangeable plates, called seed disks, designed for different seed sizes and populations, to singulate seeds. Vacuum meters can plant all major commodity crops, including corn, soybeans, and wheat. They use a vacuum to draw and singulate seeds against the seed disk. Simpler brush meters are dependable, low-maintenance, and provide accurate singulation of soybeans.

FINGER PICKUP METERS use small hooks to singulate seeds. They are the most common and accurate system for metering corn and sunflowers.

METERING DRIVES

CONTACT METER DRIVES are the simplest way to control the meter. The faster the planter wheel spins, the faster the meter runs. This system is smooth, reliable, and easy to operate.

HYDRAULIC METER DRIVES are ideal for variable seed rate prescriptions and allow farmers to change rates on-the-go from the seat of their tractor.

ELECTRIC METER DRIVES allows control of each row. When going through waterways and entering headlands, each row unit can be turned on and off as needed to stop the flow of seed.

Electric meter drives also provide curve compensation; the motor speed adjusts when the planter turns so that every row across the width of the planter has the same seed spacing. Shaft driven motors do not have this capacity; when the planter turns, seed spacing on the inside rows will be too close. Along outside rows, seeds will be spaced too far apart.

AUTOMATIC ROW SHUT-OFFS

Some planters are equipped with automatic row shut-offs that use GPS technology to control each row or a section of rows separately. When planting the outside of the fields to establish your ends, a computer working with GPS guidance tells the planter where it has already been so the row units can automatically shut off when needed.

GPS technology saves money by preventing overlaps in already planted areas.

TYPES OF SEED METERS

Seed meters are specific to seed types and equipment.

TWO BASIC TYPES OF SEED METERS

MASS FLOW
Mass flow meters do not attempt to meter individual seeds but rather will meter a consistent volume of seed per unit of time.

PRECISION FLOW meters are designed to separate out single seeds (singulate) and deliver them at a preset time interval. This is known as singulation.

	MASS FLOW	PRECISION
Typically found on	Drill	Planter
Controlled by	Metering is driven by the ground wheels -- the faster the equipment is driven the faster the seed flows.	Metering can be driven by a motor or by meter wheel.
Seed Types	Designed for cereal grains and grasses and legumes -- crops where precision singulation is less important.	Typically used for corn, sorghum, sunflower and soybeans.
Common types	Fluted Rollers Seed Cups Belted	Plateless systems: *(Finger Pickup and Vacuum Disk)* Plate Systems: *(Brush assisted and Mechanical)*

SEED TUBES AND GUARDS

Seeds travel down seed tubes before being deposited in the bottom of the seed trench. Seed tube guards are common retrofits that protect seed tubes from wear.

SEED TUBE FUNCTION

After leaving the seed meter, seeds travel down a seed tube, typically located between or beside the opening disks.

Seed tubes are engineered to (1) deliver seeds in a uniform spacing and (2) deposit seed at the bottom of the seed trench, typically 1 to 2 inches below the end of the seed tube.

TYPES OF SEED TUBES

Seed tubes are designed for specific seeds and soil types.

CURVED TUBES are the most common design. They are designed to propel the seed backward to help overcome the forward travel speed of the planter.

STRAIGHT TUBES deposit seed closer to the opener and may work better in light sandy soils, which tend to close quickly.

SEED TUBE GUARDS

Seed tubes in no-till management are subject to more wear than seed tubes on conventional planters. The seed tube actually extends below the soil surface and will rub against the walls of the trench.

Seed guards attach to the bottom of the seed tube. They reduce seed tube wear and opening disk blade flex.

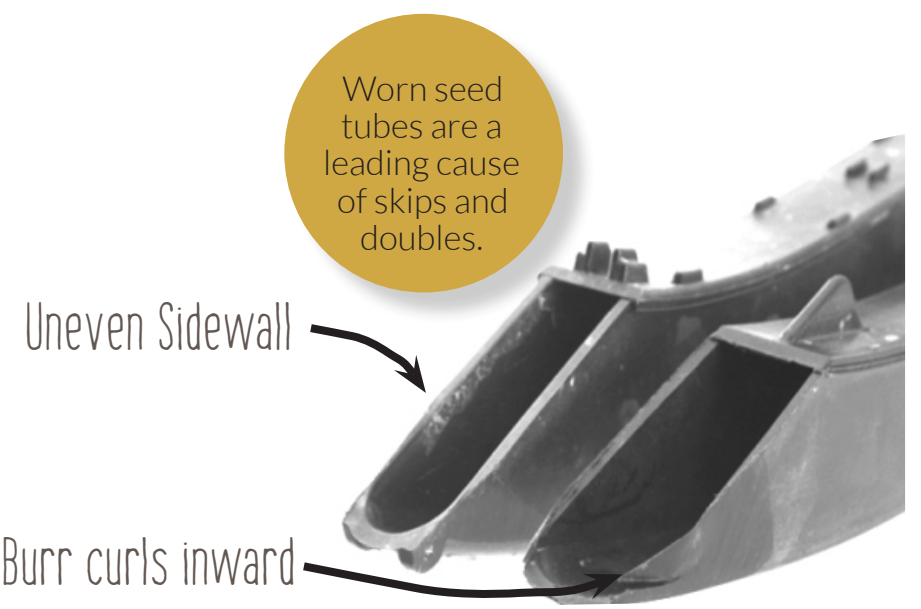
SEED TUBE FAILURES

Common reasons for seed tube failure include:

PLASTIC BURS can form on the end of the seed tube. When turned in, they can interfere with the seed as it drops. This causes problems with spacing and depth.

SEED TUBE GUARDS wear down to 1/2" by the end of an average season. The majority of the wear occurs early in the season. As guards become worn and the slot becomes narrower, planting depth decreases and becomes more erratic.

PLANTING OVER 5 MPH causes seeds to ricochet in the tube, causing uneven seed spacing, doubles, and skips.



RK Products Seed Tube Guards- Fertilizer Tube Assembly

SEED FIRMERS (OPTIONAL)

Seeds that do not reach the bottom of the trench will have an air pocket beneath them that slows uptake of moisture and leads to late germination and emergence, and ultimately loss of yield. Seed firming devices gently press the seed into the bottom of the trench.

Seed Lock Wheel

Seed lock wheels are narrow, in-slot, tapered wheels designed to press the seed into the bottom of the seed trench. They are common on older no-till drills.

Always opt for larger diameter wheels (9 or 10 inches) as these will accumulate less mud and dirt.

In heavy and wet soils, soil can stick to the seed-lock wheel causing seed drag.

Seed Firmer

A thin piece of tough plastic that slides down the seed trench, trapping seeds as they exit the seed tube and firming them into the bottom of the seed slot. Common brands include Keeton and Flo-Rite.

Seed firmers are recommended for farms transitioning to no-till. In heavier, wet ground, seed firmers frequently build up with mud and drag the seed.

MOJO WIRES are an optional attachment many farmers add to their seed firmer. The Mojo increases the downward pressure on the seed firmer more than five times. However, the addition of a mojo wire also increases the risk of dragging seed and will wear out the firmer more quickly.

Seed Presser

Rebounders have a concave spoon-shape design that funnels seed to the bottom of the slot.

These tend to work well in wet conditions and are well suited to soil that is more adapted to no-till.

Seed firmers press seed into the soil, dramatically increasing seed to soil contact.

Friends of the Prairie Learning Center and Neal Smith NWR

WORKING WITH NATIVE GRASS SEED

Native grass seed species can be difficult to plant due to variability in seed size, weight, and shape. Little Bluestem, Indiangrass, and Big Bluestem all have light, fluffy/chaffy seeds. Switchgrass has a small hard seed that may have several hundred thousand seeds per pound, and eastern Gamagrass has a large irregularly shaped seed.

WHEN PURCHASING SEED

Most of the seed on the market contains typically 20 to 40 percent chaff (stems and leaves). Chaff sources include seed that has not been debearded (had the awns and hairs removed) or contains high percentages of inert matter (stems and leaves).

Non-debearded seed and seed with a high chaff content will clog seed delivery tubes and will require constant monitoring.

SEEDING RATE

Warm season grasses require much lower seeding rates -- sometimes as low as 4lbs per acre. Switchgrass can quickly overtake a field if seeded greater than 6 lbs/acre in a mix.

WHEN SELECTING A DRILL

Drills need to be outfitted with the following to effectively plant native grass seed.

Native Seed Box

Seed box dedicated to small fluffy seeds. Usually contains specialized "picker wheels" and agitators to mix, stir, and meter fluffy chaffy seeds.

Agitator

Agitators, located in seed boxes, mix, stir, and meter fluffy chaffy seeds.

Picker Wheel

Picker wheels, located in the bottom of the seed boxes, extract seed and send them down an oversized drop tube designed to avoid seed bridging.

WHEN PLANTING SEED

In most cases, planting will be most sucessful during the dormant period in late November through December, especially when including forbs that may bloom earlier in the season. Warm season grass species can also be successfully established late April through the beginning of June. As a rule of thumb, warm season grasses follow the same planting schedule as corn.

Bulking Agent

Fillers can be used to increase the bulk weight of native grass and forb seed if a drill cannot achieve the recommended seeding rate. Clay cat litter can be added to the small-seed box; vermiculite can be added to the native grass seed box.

COST CONSIDERATIONS

Because of the seed cost and the establishment considerations, the native grass seed species should be considered for CREP (Conservation Reserve Enhancement Programs) and other conservation programs including buffers and other areas that are foreseen to be maintained in a longer term soil management program. It is typically not economical or practical to incorporate the native grass species in a shorter term agronomic or vegetable rotation, but they can fit in well for buffers and conservation areas.

ROW/RESIDUE CLEANERS

Row cleaners move residue and clods out of the way of the disk openers and gauge wheels without disturbing the soil. In doing so, row cleaners accelerate soil warming, prevent hair-pinning, and reduce row unit vibration or bounce.

BENEFITS OF ROW CLEANERS

Row cleaners are an optional no-till attachment designed to move residue out of the seed trench without moving soil. They are typically on the front of no-till planters and drills. Benefits of row cleaners include:

- Reduce vibrations and bounce
- Accelerate soil warming by exposing soil to the sun
- Prevent hair-pinning when residues becomes pinched in the soil trench

Row cleaners move only residues --- never soil.

ROW CLEANER OPTIONS

TOOTHED WHEELS known as trash wheels are the most common row cleaners.

See "Row Cleaner Options" on page 72 for more information.

RAKE TINES drag along the soil surface, creating a vibrating action which keeps short light residue (such as chopped wheat straw) out of the coulter or seed opener's path. But in long heavy residue, (such as corn stalks), this device may actually drag the residue.

TWO DISCS, set in a "V" shape and placed in front of the coulters, will cut some residue and move it to the side. This system, mounted with a shield in front, is often used when "planting green."

EXPERT TIPS

PREVENTING WRAPPING

Wrapping occurs when residues wrap around cleaning wheels, quickly rendering them useless. Use shark-toothed or curved spoke type row cleaners with short teeth and treader attachments to avoid wrapping. In some conditions, consider installing a bayonet stripper to cut long residues building up on residue cleaners.

Shark tooth row cleaners with depth bands are very effective in thick residues.

Photo credit: Edwin Remsberg and USDA-SARE.

ROW CLEANER OPTIONS

TYPES OF ROW CLEANERS

There are three basic configurations for row cleaners:

(1) fixed row cleaners,

(2) floating row cleaners, and

(3) combo-row coulters

In 90% of cases, floating row cleaners will be most effective at removing residue without gouging soil.

1

Fixed Row Cleaners

Fixed row units are set to a certain depth and do not adjust to changing field conditions.

TRASH WHEELS sweep crop residue away from the seed-bed.

Choose larger diameter trash wheels when possible.

TYPES OF ROW CLEANING WHEELS / TRASH WHEELS

Straight tooth

This cleaner is designed to aggressively bite into trash/ residue and is commonly used in a no-till or minimum till environment.

Swept Back tooth

This wheel design prevents wrapping when no-tilling in wheat stubble or when planting green.

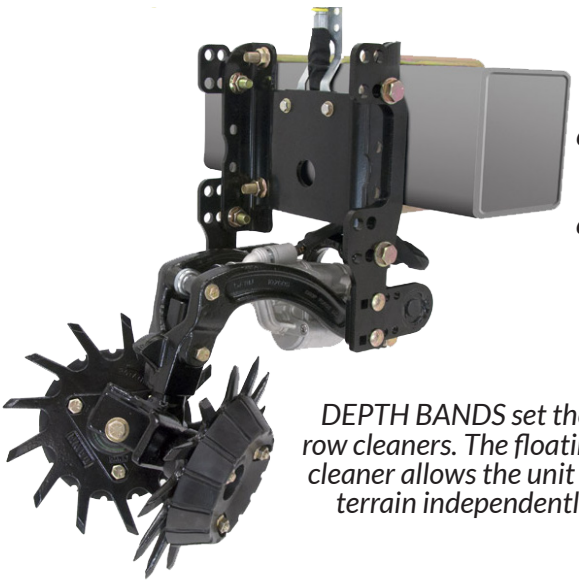
Shark Tooth

The most aggressive row cleaner. It will remove nearly all residue from area above the seed trench. Shark tooth are excellent choice in high residue or when planting green.

2

Floating Row Cleaners

Floating row cleaners are increasingly popular. Their height is controlled by depth bands enabling them to float and follow the contours of the ground much better than the fixed design.



IN-CAB CONTROLLER Some units are equiped with in-cab controls which allow farmers to adjust up and down pressure and raise and lower units as need.

DEPTH BANDS set the depth of floating row cleaners. The floating ability of the row cleaner allows the unit to adapt to varying terrain independently of the row unit.

3

Combo-row coulter

Combines the residue clearing of a row cleaner with the soil loosening action of a unit mounted coulter.

CONFIGURATION

Row cleaners can be configured to be set intersecting or offset right and left.

Intersecting trash wheels have interlocking teeth designed to clean 100% of residue.

Offset trash wheels leave some residue on soil surface which can prevent crusting.

Single trash wheels are available for planters and drills with row spacings less than 22”

Intersecting Offset Single

COULTERS (OPTIONAL)

Coulters are used to cut residue and fracture soil within the seed trench. There are a wide variety of coulters .

COULTERS

Coulters are a vertically mounted cutting tool, typically mounted before the opening disks.

No-till coulters loosen the soil in front of the disk openers. In doing so, coulters protect disk openers from excessive wear. By fracturing the soil, they generate more loose soil in the slot.

Coulters, particularly wider coulters, require more down-pressure to get the unit in the ground.

EXPERT TIPS

PITFALLS OF COULTERS

The biggest danger of coulters is the potential for them to operate below the seed trench and create a false bottom. They also tend to lift cool damp soil up into the seed zone which can have a negative effect on germination.

- *Jim Hershey*
  PA No-Till Alliance President
  Hershey Farms, Elizabethtown, PA

SELECTING COULTERS:

There are a wide variety of coulters on the market. Narrow, smooth coulters will disturb soil less and require less down-pressure compared to wider, more rippled coulters.

See "Selecting coulters" on page 76 for more information

Despite the wide variety of coulter options, there is little difference between the ability of smooth, rippled, notched, and fluted coulters to prepare the seedbed.

SIZING COULTERS

Large diameter coulters are more effective at cutting residue but require more weight, or down pressure, to penetrate the soil.

Most farmers recommend using the largest diameter available (that fits the planter) because they have the best angle for cutting residue.

COULTER USE

If not set correctly, coulters can do more harm than good.

Setting the depth

Operate slighly shallower than the seeding depth to avoid excessive soil throwing at high operating speeds and to limit the formation of air pockets below the slot. If the coulters run too deep, they can create a "false bottom" in the seed trench, leading to improper seed depth.

Ensure adequate down-pressure:

Planters fitted with coulters may need to have about 500-pounds of down-pressure per row to penetrate the soil and cut residues. *See "Downforce / down-pressure" on page 60 for more information.*

Keep Coulters Sharp

Coulters on no-till planters should be sharpened as needed. A sharp coulter will be much more effective at cutting residues, particularly when soft and wet.

COULTERS IN LONG-TERM NO-TILL

We have not used a coulter for the past 3 years and will probably never go back. Newer planters with pneumatic and hydraulic downforce can easily penetrate the ground under most conditions. In some of our mellow no-till ground, the coulter was actually causing premature sidewall collapse, which in turn affected seed depth. Not having a coulter is also one less wear item to worry about.

- RJ Fulper
  Fulper Family Farms

Photo credit: Bridgett Hilshey, North Jersey RC&D

SELECTING COULTERS

PREFERRED FOR CUTTING RESIDUES

Smooth
Coulters with a smooth surface and sharp edge are designed for cutting heavy, tough residue. However they are prone to causing sidewall smear.

Toothed
Coulters with toothed blades are very effective at cutting residues. The toothed design drives the blade rotation resulting in less smearing and improved sidewall fracture.

Rippled with Smooth Edge
The rippled coulters with a smooth edge cuts well, loosens a narrow band of soil, and helps the coulter rotate through the soil.

TILL NARROW STRIP

Directional Wave

Coulters with directional waves shed off soil at the backside. These are a favorite among long-term no-tillers.

Bubble

Bubble coulters open a slot. It provides excellent soil penetration and residue cutting, but is only recommended in sandy or very dry soils. These coulters will cause sidewall compaction in heavy loam and clay soils.

Wavy

Wavy coulters create large chunks of soil and often interfere with closing the trench. They also require significantly more downpressue to operate.

EXPERT TIP

13-wave coulters minimize issues caused by coulters with less waves and are commonly used when a wavy coulter is desired.

- Joel Myers
  Myers Farm and former
  Pennsylvania State
  Agronomist

SEED SLOT OPENERS

No-till drills and planters typically rely on angled metal disks to create a "V" slot in the soil into which the seed is dropped.

CREATING A SEED SLOT

The major function of seed slot openers is to create a well-defined groove in the soil where the seed can be placed at the proper depth.

The ideal seed slot meets the following criteria:

RIGHT ANGLE AND SHAPE: Slots should be "V" shaped and just narrow enough for a large seed to drop into bottom of the slot. If the trench is too narrow, the seed will become hung up on the side-walls at an improper depth and with an air pocket below. If the trench is too wide, it won't close properly.

FRACTURED SIDEWALL: The walls of the trench (side-walls) should be fractured to allow water to flow in and out of the trench as needed.

DISK OPENERS

The vast majority of conservation tillage equipment uses disk openers to create the seed slot or trench. Disks can cut through residue and reduce potential clogging problems. Disks vary in thickness from 3mm to 4mm, are beveled along the outer edge, and rotate freely on a roller bearing.

DOUBLE DISK OPENERS: Most modern equipment uses double-disk openers. Double disk openers consist of two smooth disks angled in a "V" formation.

They are a wide array of disk arrangements. *See "Opening Disk Arrangement" on page 80 for more information.*

EXPERT TIP
WHEN TO REPLACE BLADES

Many farmers rely on blade diameter to decide when to replace opening disks. It is essential to also consider bevel length.

Replace planter blade when the bevel is between 3 to 4 mm in length, even if the blade has not worn down 1/2". Replace drill blades when bevel is worn down below the 10 to 12mm.

When blades get to 5mm, the cutting ability is lessened by 30%. At this stage they don't cut well and cause massive sub furrow compaction, and roots can't go down.

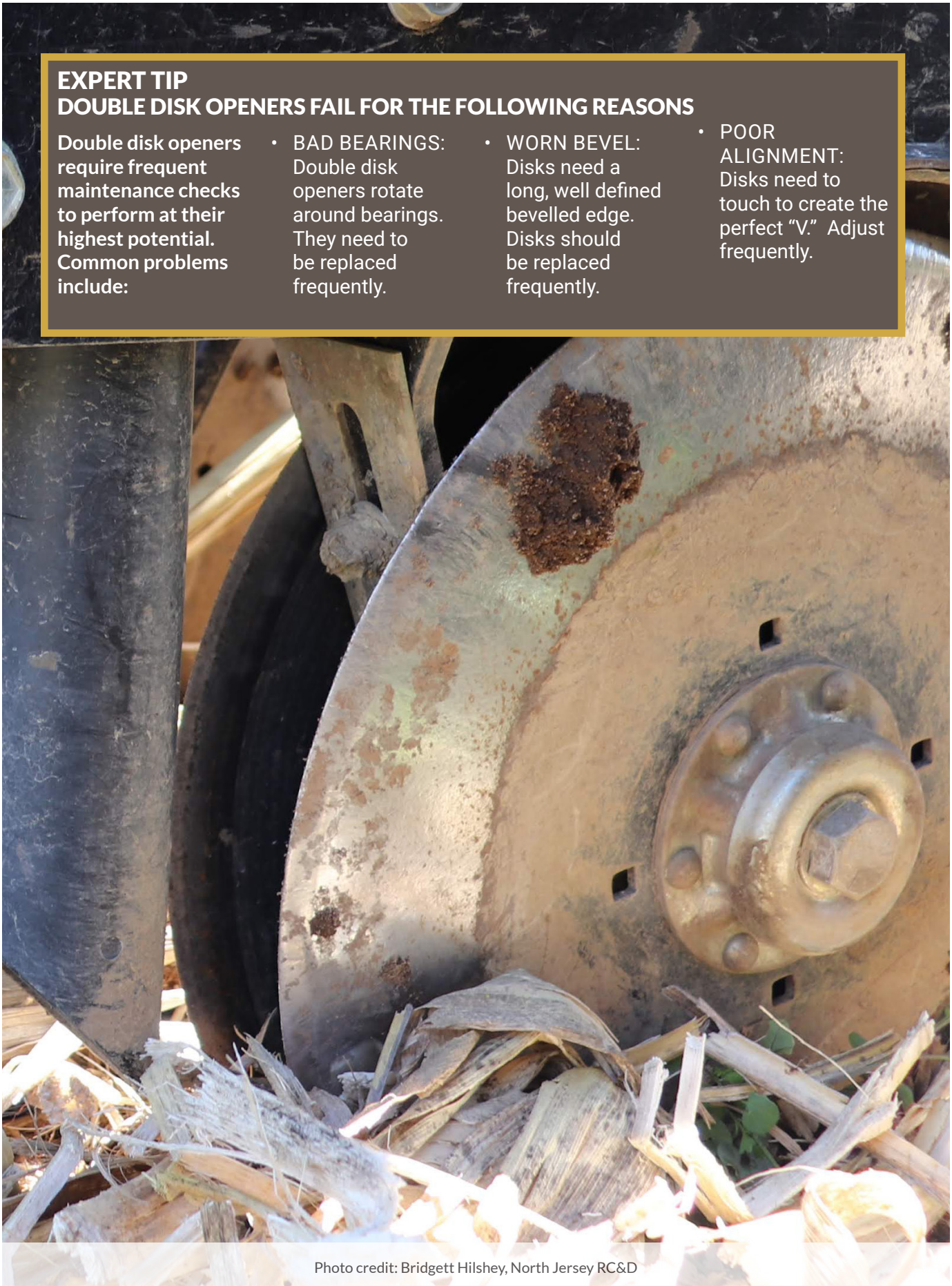
- John Nance
  Prescription Tillage

DOUBLE DISK OPENING BLADE SHOULD TOUCH!

Disk opening blades should have a 1.5" to 2" contact area. To measure the contact area, slide 2 business cards between the blades -- one in from the top, and the other from the bottom. The space between the cards should be about 2".

WHEN BLADES ARE TOO TIGHT, they generate too much side load on the bearings and fail prematurely.

WHEN THE BLADES ARE TOO LOOSE, the trench will loose its "V" shape and instead look more like a "W". Seeds will not fall to the bottom of the trench, causing inconsistent seed depth.



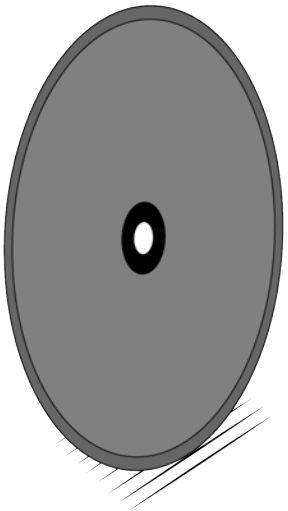
EXPERT TIP
DOUBLE DISK OPENERS FAIL FOR THE FOLLOWING REASONS

Double disk openers require frequent maintenance checks to perform at their highest potential. Common problems include:

- BAD BEARINGS: Double disk openers rotate around bearings. They need to be replaced frequently.
- WORN BEVEL: Disks need a long, well defined bevelled edge. Disks should be replaced frequently.
- POOR ALIGNMENT: Disks need to touch to create the perfect "V." Adjust frequently.

Photo credit: Bridgett Hilshey, North Jersey RC&D

OPENING DISK ARRANGEMENT

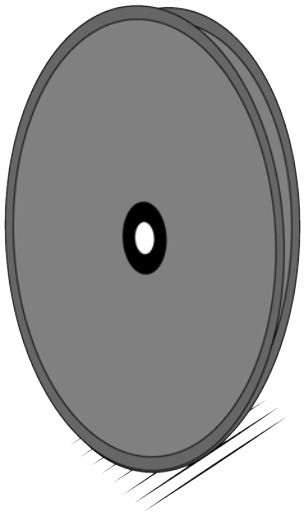


SINGLE DISK

Drills Only

These openers usually consist of a single concave 16 to 22-inch disk, run at a slight angle to the direction of travel with depth controlled by a gauge wheel beside the opener. Single-disc openers rely on soil cohesion to prevent soil from falling ahead of the seed.

This system is common on drills.



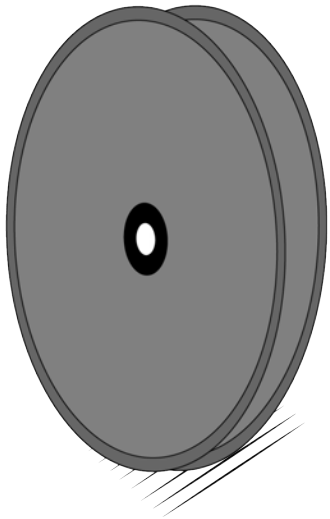
DOUBLE DISK ALIGNED

Kinze, John Deere and White Planters

The most common disk arrangement in which double-disks of the same size and with no fore/aft offset create the seed slot.

MAINTENANCE CHECK: They should have about two inches of blade contact on the leading edge. When blades are too tight, they generate too much side load on the bearings and fail prematurely. When the blades are too lose, the trench will loose its "V" shape and instead look more like a "W".

ADVANTAGE: Performs better than the offset configuration in wet ground. Blades and bearings last longer.



DOUBLE DISK OFFSET BLADES

Case IH, Deutz Allis, and Landoll Planters

With this design, the leading edge of one disk runs slightly ahead (0.5 to 1.5 inches) of the other. In some cases, the trailing disk is a smaller diameter than the leading disk.

The leading disk cuts the residue and soil and the trailing disk helps open the seed slot.

MAINTENANCE CHECK: The rear disk should be tucked in behind the leading disk, just touching it.

ADVANTAGE: This design is better for cutting residue, creates a narrower seed trench, requires less down-pressure, and results in less sidewall compaction.

BEVEL

Blades are bevelled along the outer edge to create a sharper edge. The sharpened edge reduces the amount of down-pressure necessary to penetrate the soil and improves residue cutting.

BLADE THICKNESS

Blades vary in thickness from 3mm to 4mm (3.5 being the most common). 3 mm blades are simply too flexible for no-till and often results in pinched slots. Thicker blades will wear less but require more down-pressure to penetrate the soil and can dull quickly.

BLADE DIAMETER

Drill blades range from 14 to 16 inches in diameter. Planter blades range from 18 to 19 inches in diameter. Larger diameter blades are better at cutting tough residue.

Replace blades after 0.5 inches of wear -- typically every year, or after 500 acres.

EDGE

Most blade edges are smooth although some manufactures offers a toothed opening disk that helps drive bade rotation.

BEARING

Disks rotate on bearings which can quickly become worn and sloppy as the flange becomes loose.

Replace disk if there is ANY blade wiggle.

NO-TILL TIP: Double roller bearings last longer and will prevent the trench from narrowing.

GAUGE /DEPTH WHEELS

Gauge wheels roll along the soil surface and are responsible for setting the depth of the planting unit and seed openers.

GAUGE WHEELS

Gauge wheels are typically located alongside the opener blade(s). Gauge wheels serve the following important functions:

Depth Control

Gauge wheels run along the soil surface to control the planting depth; ideally gauge wheels should be as close as possible to where the seed drops to get the most precise depth control.

Prevent Sidewall Blowout

Locating the gauge wheel alongside the blade prevents soil from being thrown out of the slot by the opener blades. Keeping soil close to the slot improves slot closure.

WALKING GAUGE WHEEL

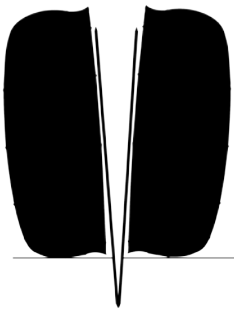
Walking gauge wheels allow a single gauge wheel to raise, rather than both wheels, when a rock, root ball or hard dirt clod is encountered. With only one wheel raising, the depth control of the row unit is much more precise. High amounts of residue can provide challenges in properly gauging seed depth. The walking gauge wheel option allows the gauge wheels to walk over root balls, cloddy soils and residue with lessened impact on depth control than rigid gauge wheels.

EXPERT TIP

Adjusting gauge wheels for the amount of residue in the field is important. In the case of heavier cover crop mats, gauge wheels will need to be adjusted so that the disk openers cut the seed furrow to the appropriate depth in the soil underneath the residue. Although the row cleaners are designed to clear the residue from the seed planting row, the residues and/or cover crop mats to the left and right of the seed furrow may be enough to ride the depth gauge wheel up higher. This results in the disks not cutting a deep enough furrow in the soil.

- Dave Wilson, Agronomist
  Penn State Extension Educator

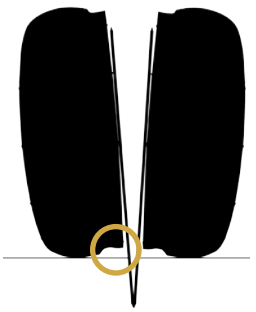
GAUGE WHEELS



STANDARD GAUGE WHEELS

Standard Gauge wheels are about 4.5" wide.

Standard width gauge wheels distribute the weight of the planter resulting in less compaction.



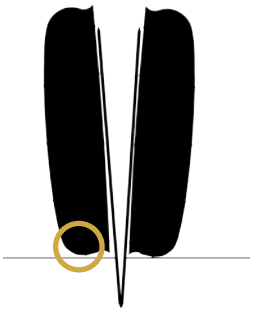
REDUCED INNER DIAMETER (RID)

RID gauge wheels have a narrow footprint with an indentation near the disk openers designed to let the sidewall bulge upward while the blade exits the soil.

PRO: In heavy clay soils they may reduce compaction along the edge of the seed slot.

CON: This lifting effect that can create air pockets in the trench.

While RID wheels are designed to reduce sidewall compaction, most experts agree that the solution to sidewall compaction is reducing down-pressure.



NARROW GAUGE WHEELS

Narrow (skinny) gauge wheels are about three inches wide.

PRO: Narrow gauge wheels operate in a more narrow swath. They are less likely to be disrupted by bouncing over root balls and corn stalks and enable producers to use more narrow row cleaners. They also provide more accurate depth control in fields with undulating, uneven soil surface.

CON: Narrow gauge wheels concentrate planter weight and downforce pressure closer to the seed slot, increasing the potential for more sidewall compaction.

RUBBER OR URETHANE MATERIALS

Rubber wheels tend to take shock out of the planter row unit, shed mud better, and cause less sidewall compaction. The urethane gauge wheels have tremendous wear-life.

EXPERT OPINION:
If you've got really good soils, high organic matter and no infiltration problems, then urethane is probably a good option -- otherwise, urethane may not be a good choice.

CLOSING WHEELS / PRESS WHEELS

The row-unit closing systems close the seed slot and properly pack the surrounding soil around the seed, ensuring proper seed-to-soil contact and uniform emergence.

CLOSING THE SLOT IN NO-TILL

In conventional tillage systems, soil tends to naturally tumble into the slot. The closing wheels simply firm the soil above the seed.

Seed closing systems in conservation tillage must have some method of moving soil back into the seed slot. This often involves chopping the sidewall.

SEED CLOSING SYSTEMS

CLOSING WHEELS: Most planters and drills use closing wheels, often mounted in a V-shaped configuration, to close the seed slot and firm the seedbed at the same time. See "Closing Wheels Comparison" on page 86.

PRESS WHEELS: Press wheels firm the soil around the seed after it has been covered. This is not effective in most no-till scenarios.

DRAG CHAINS

Drag chains drag a hand-full of soil, levelling the seed zone and dropping loose soil into any unclosed areas of the seed slot.

EXPERT TIP
ADD DRAG CHAINS

Drag chains are a simple and economical addition to a planter that can significantly add to its performance. However, sometimes excess residues can build up in the drag chains.

KEYS TO CLOSING THE SLOT

1 COVER THE SEED W/ LOOSE SOIL

This creates the moist environment essential for good germination.

Seed slots should be closed from the bottom up. This prevents air gaps from forming around the seed.

Air pockets around the seed will lead to soil drying around the seed and delayed germination.

2 AVOID PACKING

Closing systems should not compact the soil above or beside the seed; compaction will delay germination and stunt root development.

3 CRUMBLE THE SIDEWALL

Closing systems should aim to crack or crumble the side walls of the slot.

This ensures (1) seed roots can easily penetrate the surrounding soil and (2) water can freely diffuse in and out of the slot.

Sidewalls that are not shattered may open up as the soil dries.

4 MUD/STALK CLEANING

Many closing systems build up with mud or crop residues reducing their effectiveness.

Closing wheels should be able to shed mud and stalks.

5 DEPTH LIMITED

It is essential that closing wheels not dislodge seeds. Some closing systems will have a tendency to dig deeper in certain areas and move seeds out of or along the seed trench.

CLOSING WHEELS COMPARISON

TYPE	SMOOTH	SHORT SPIKED	LONG SPIKED
DESCRIPTION	Traditional Wheels; can be rubber or cast iron wheels	Short notched spikes composed of iron or plastic. Least aggressive of spiked wheels	Long Spikes composed of cast iron or steel. Most Aggressive of spiked wheels
SET-UP	1.5" to 1.75" across the bottom		2..25 to 2.5" wide at across the bottom
IDEAL CONDITIONS	Tilled soils	Typically no-till soils with good soil structure	Heavy clay and wet soil
TRENCH CLOSING	POOR	GOOD	GOOD
FIRMING SOIL	GOOD	FAIR	POOR
SIDEWALL CRUMBING	POOR	GOOD	GOOD
AVOIDS PACKING	POOR	FAIR	GOOD
MUD AND STALK CLEANING	GOOD	FAIR	GOOD
DEPTH LIMITING	GOOD	GOOD	POOR
COMMENTS		Shorter spikes won't ever flip seed out of the trench	May wrap up cover crops

CLOSING WHEELS COMPARISON

CURVED SPOKE	CAGE TYPE	DOUBLE DISK	COMBINATION
Unique curved teeth to chip-in side wall compaction without ejecting soil from the seed zone	Close trench from the top. Designed to reduce air pockets.	Inverted double disks followed by a single press wheel.	Combination of spiked closing wheel and smooth closing wheels.
Typically no-till soils with good soil structure	Strip till or conventional till	Dry, course textured no-till soils	Minimum tillage situations and medium to dry soils
GOOD	FAIR	FAIR	
FAIR	GOOD	FAIR	FAIR
FAIR	POOR	FAIR	
POOR	POOR	GOOD	
POOR	POOR	GOOD	
FAIR	GOOD	GOOD	

TROUBLESHOOTING NO-TILL

EVEN THE BEST LAID PLANS CAN FAIL

Don't wait for seedlings to emerge to discover planting problems. It is crucial, especially during the first few years of transition to no-till, to get off the tractor and check seed placement frequently!

WHAT TO LOOK FOR AND TAKE NOTE OF:

1

Residue Cleaners

Are row cleaners digging into the soil? Are long lengths of cover crops or wheat residues getting tangled? Are residue cleaners moving the right amount of residue away from the seed slot?

2

Slot Closure

Is the seed slot fully closed with loose soil or is there a gap? It is important to check in a variety of soil conditions.

3

Seed Slot Sidewall

Gently move away the soil above the seed slot and examine the slot sidewall. Is the soil smeared and smooth? Is the soil hard? If so, the slot may fill with water and roots may have trouble penetrating.

4

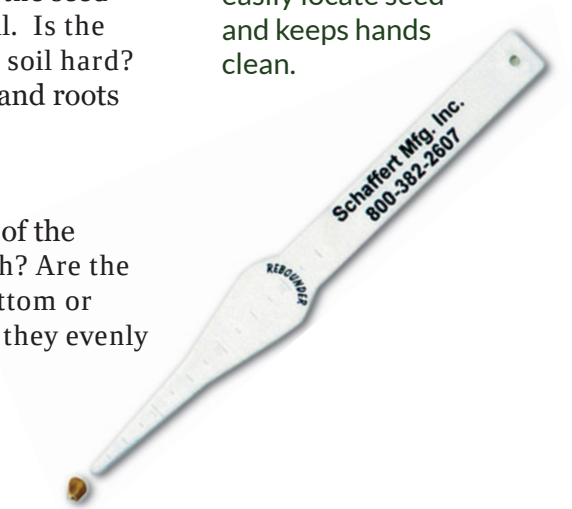
Seeding Depth and Position

Move away soil to find the depth of the trench. Is it the anticipated depth? Are the seeds within the trench at the bottom or hung up along the sidewall? Are they evenly spaced along the trench?

EXPERT TIP
FINDING ELUSIVE SEEDS

Searching for seed is the last thing most farmers want to do at the start of a busy day.

The job can be made easier using a Dig-It Tool. It allows producers to more easily locate seed and keeps hands clean.



SEEDS ON SOIL SURFACE

Seeds will be present on the soil surface when the opening disk cannot penetrate the soil. This is commonly observed when drilling grains.

AGRONOMIC IMPACTS

Uneven and poor germination due to seed exposure or dry soil conditions.

CAUSES

- Not enough down-pressure
- Compact and/or dry soil
- Dull/worn opening disks

SOLUTIONS

PLANT A COVER CROP THE YEAR BEFORE: A cover crop will soften the surface of most soils; cover crops prevent crusting and many farmers will plant cover crops specifically for this benefit during the transition to no-till.

ADD DOWNPRESSUE: It can be difficult to achieve adequate down-pressure, particularly on drills and older planters. Consider retrofitting a down-pressure system or adding weights to row units.

REMOVE OR ADJUST COULTERS. Coulters, particularly wide and wavy coulters, can use up a lot of the total down-pressure available to the row unit. Consider (1) sharpening coulters, (2) replacing wide coulters with narrower coulters or (3) removing the coulter altogether.

REPLACE OPENING DISK. Opening disks should have a long, well defined bevel; as they become worn, they lose their bevel and will have difficulty penetrating the soil surface. Opening disks need to be replaced at least every 50 acres (per row unit).

WAIT FOR WETTER SOIL CONDITIONS. It is important to be aware that dry soils are difficult to penetrate. This is often a problem when planting small grains and cover crops in the late summer and fall.

SIDEWALL SMEAR

Sidewall compaction includes all soil compaction and soil smearing in and around the seed slot.

AGRONOMIC IMPACTS

Compacted soil around the seed reduces seed to soil contact and makes it difficult for the seedling roots to penetrate the soil. This causes reduced or uneven germination and stunted plants with restricted root masses.

CAUSES

Wet Soil

Under wet soil conditions, the seed slot will not close properly and the sidewalls of the slot will will smear, causing side-wall compaction. This can reduce seed to soil contact or develop a hard side wall which is difficult for young roots to penetrate.

Furthermore, the seed trench can be difficult to adequately close when wet; producers will sometimes compensate by adding extra pressure on the closing devices, potentially causing sidewall compaction above the seed.

SOLUTION

WAIT FOR DRIER SOILS IF POSSIBLE: See “Soil Moisture Content and Planting” on page 38 to determine if your soil is dry enough to plant.

ADJUST CLOSING WHEELS: Consider adding spiked closing wheels to shatter the sidewall rather than increasing down-pressure. One popular closing wheel configuration staggers one spoked wheel with one solid closing wheel, with the spoked leading.

REDUCE DOWN PRESSURE: Reduce the down pressure on both the gauge wheels and the closing wheels to reduce the potential to over-pack moist soils.

INCREASE BLADE ROTATION: When opening disks or coulters are dragged through the soil, they will smear the sidewall rather than rotating freely. Notched or toothed coulters and opening disks will improve blade rotation and fracture sidewalls.

HAIR-PINNING

Coulters and disk openers are supposed to cut through crop residues, however, during certain conditions, they will push the residue into the bottom of the seed slot.

AGRONOMIC IMPACTS

Residues in the seed slot impede seed to soil contact resulting in poor and uneven germination.

CAUSES:

- Wet residues (from previous crop or cover crops)
- Dull coulters and worn opening disks
- Too much surface residue
- Ineffective row cleaners

SOLUTIONS

WAIT FOR RESIDUES TO DRY: Residues are much easier to cut when they are dry and "crispy".

WAIT AT LEAST TWO WEEKS AFTER TERMINATING COVER CROP WITH HERBICIDE BEFORE PLANTING: Drying cover crops can be incredibly tough and difficult to cut. Most farmers recommend waiting to plant at least two weeks after terminating, when they are completely brown. If that is not an option, farmers can consider "planting green".

MODIFY ROW CLEANERS: Consider floating row cleaners which will more closely follow the soil surface. Some trash wheels are also more aggressive than others; shark tooth and swept-back toothed wheels will move a greater quantity of residue from the seed trench.

SHARPEN COULTERS AND REPLACE OPENING DISKS. Sharp coulters and opening disks are much more effective at cutting through tough residues.

IMPROVE RESIDUE MANAGEMENT. Retrofit combine with a Calmer head (or equivalent) to cut residue into smaller pieces. Raise combine height to leave taller corn stalks standing.

CONSIDER PLANTING GREEN: Green cover will cut easier than any other residue.

UNEVEN DEPTH

Seeds within a field should be planted at a uniform depth to encourage even emergence.

AGRONOMIC IMPACTS

Uneven depth is the main cause of uneven emergence. Competition from the larger, early-emerging plants will decrease the yield of smaller, late-emerging plants; this effect is particularly pronounced for corn.

CAUSES

- Improper levelling of the lanter
- Inadequate down-pressure
- Planter speed is to0 fast

SOLUTIONS

SLOW DOWN! Traveling too fast is the number one cause of uneven seed depth, skips and doubles. Keep the planter speed below 5 MPH, especially during the transition from conventional to no-till management.

ADJUST PARALLEL ARMS: Make sure bolts are tight on parallel arms. There should be no wiggle on row units. Replace bushings and bolts if there is any wear. Adjust the parallel arms until they are completely level with the soil surface.

ADD DOWNPRESSUE: When the planting equipment cannot supply adequate down-pressure, disk openers may not be able to penetrate deep enough -- particularly in areas of the field with drier soil conditions or more residue. The ideal solution is pneumatic down-pressure units that can supply variable rates of down-pressure depending on soil conditions, however they may be cost prohibitive. Adding weights or heavy duty springs will also add downpressure.

POORLY CLOSED SLOT

Ideally, the seed slot should be barely visible after planting. When poorly closed, a narrow trench is clearly visible.

AGRONOMIC IMPACTS

Open side slots cause poor seed to soil contact.

POSSIBLE CAUSES:

- Planting too wet: When planting during wet conditions, the slot may sometimes appear closed, but as the soil dries the soil will shrink and open.
- Improper closing wheels for soil conditions

SOLUTIONS

WAIT FOR DRIER SOIL CONDITIONS: Trouble closing the slot is a primary symptom that the soil is too wet to plant in.

ADJUST DOWN-PRESSURE ON CLOSING WHEELS: Although farmers can increase down-pressure on closing wheels, the practice is generally not recommended as it can compact the soil above the seed. Experts often advise retrofitting the planter with different closing wheels.

RETROFIT PLANTER WITH SPIKED CLOSING WHEELS: Changing closing wheels from steel or rubber to spiked wheels helps close the slot and break up the sidewall, even in marginal planting conditions.

SEED NOT REACHING BOTTOM OF TRENCH

Seeds should be firmly pressed into the bottom of the seed slot with substantial seed-to-soil contact on either side.

AGRONOMIC IMPACTS

Seeds hung up on the sides of the seed slot will be planted at an improper depth with poor seed-to-soil contact and an air pocket beneath.

POSSIBLE CAUSES:

- Narrowing of the seed trench
- No or poorly functioning seed firmer
- Worn seed tube guard

SOLUTIONS

ADJUST AND SHIM SEED OPENERS. Seed opening blades should be able to turn with resistance by hand. Check the blade contact distance using 2 business cards; place one card at the top and one card at the bottom of the two blades, and then pull in until they can go no further. The distance should be 1.5”-2” with heavy blades.

REPLACE BEARINGS ON SEED OPENERS. Modern seed openers, particularly openers with a leading blade, place a huge strain on opening disk bearings. These bearings may need to be replaced more frequently than opening disks. Consider purchasing double bearings which will have a longer life.

ADD OR REPLACE SEED FIRMERS. Most no-till farmers rely on seed firmers to supply a few pounds of pressure to push seeds into the bottom of the trench. Seed firmers typically need to be replaced annually.

Photo Credit: Ken Wise, New York IPM

INSECT PEST: SLUGS

Slugs can cause substantial damage to no-till crop-fields, particularly soybeans. The moist residues on the soil surface create the ideal environment for slugs to thrive.

HOW TO TELL IF IT IS SLUG DAMAGE:

Slugs create irregularly shaped holes in leaves. The slime trails they leave behind are often tell-tale signs of their presence.

One simple tool to determine the extent of the slug population is to place a shingle or piece of wet cardboard in the field overnight. In the morning check underneath it. If the shingle or cardboard is covered in slugs, there is a substantial slug population.

SOLUTIONS TO SLUGS

There is no perfect solution to slugs, but farms can make small changes to their operation to reduce slug populations and alleviate the potential for damage.

Planting Later

Wait to plant until soils are warmer and drier. Not only will the soil surface be less conducive to slugs, but cash crop growth will be more vigorous and capable of out-pacing any slug damage.

EXPERT TIP
USE FORECASTS TO PLAN PLANTING

A longer (10-day) forecast of warmer weather prior to planting will help to promote faster growth of crops past the time-frame when plants are most susceptible to slug damage.

- Michael D. Braucher

Remove Residue from Around the Seed Trench

Consider using very aggressive (like shark tooth) row cleaner to remove all of last year's residue from a wide swath (3-4 inches) above the seed trench. Slugs will avoid ground without residue cover.

Improve Trench Closure

A poorly closed seed trench with gaps is the perfect cool, moist environment for slugs to thrive. Slugs will actually travel down the seed slot eating one seedling after another.

Using a spiked closing wheel and avoiding planting through wet soils will improve closure of the seed slot, impeding the slug population

Experiment with Planting Green

Planting green (planting into standing cover crop 6-12" tall) may alleviate slug damage. In theory, the abundant mat of cover crops will distract slugs from the emerging seedlings. The selection and use of cover crop that slugs prefer over the planted crops continues to be researched.

Do not use Neonicotinoids

Slugs are unaffected by neonicotinoid insecticides; as they consume vegetation containing neonicotinoids, the slugs concentrate the chemical in their tissue. Slugs that have ingested the neonicotinoid will impair or kill the beneficial predator insect that consumes them. Ultimately, this leads to reducing natural slug predator populations.

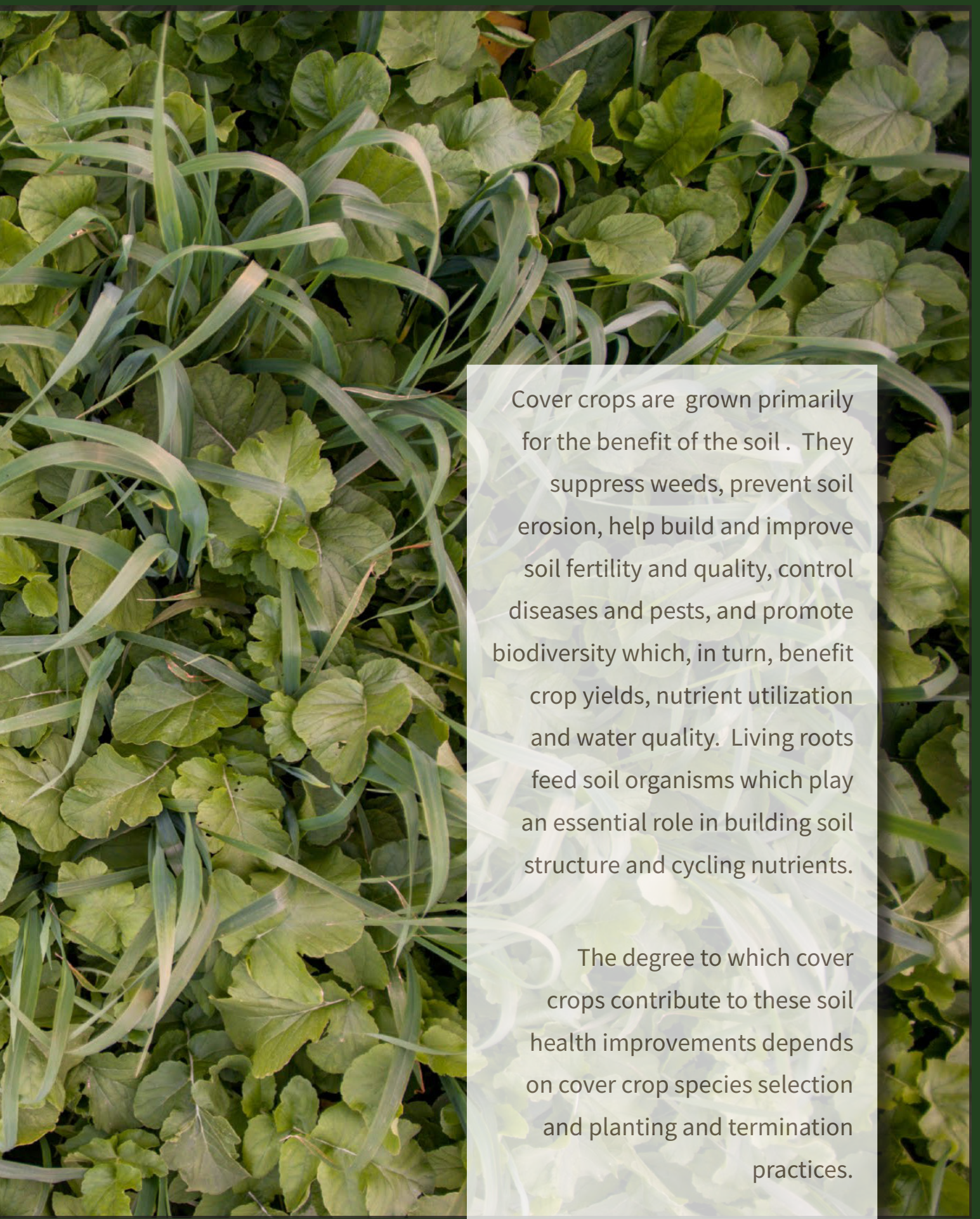
Slug Bait

Certain baits are designed to kill slugs present in the fields. Always use a bait containing iron chelate as the active ingredient (such as Ferroxx). Iron chelate baits are natural, safe, and will quickly poison slugs without impacting other organisms in the soil. Note that these baits are typically used after a slug population is established and the infestation threatens a crop; they are too cost prohibitive to be used as a preventive measure.

PART TWO

COVER CROPS

Soil is meant to be covered



Cover crops are grown primarily for the benefit of the soil . They suppress weeds, prevent soil erosion, help build and improve soil fertility and quality, control diseases and pests, and promote biodiversity which, in turn, benefit crop yields, nutrient utilization and water quality. Living roots feed soil organisms which play an essential role in building soil structure and cycling nutrients.

The degree to which cover crops contribute to these soil health improvements depends on cover crop species selection and planting and termination practices.

SEED & SPECIES SELECTION

Photo credit: Bridgett Hilshey, North Jersey RC&D

4 TYPES OF COVER CROP

GRASSES
Annual Ryegrass, Pearl Millet, Sorghum-Sudangrass

CEREAL GRAINS
Barley, Oats, Cereal Rye, Triticale, & Wheat

LEGUMES
Vetch, Clovers, Sun Hemp, and Peas

BRASSICAS AND FORBS
Radish, Mustards, Turnips, Rape, and Buckwheat

Choosing a cover crop can seem daunting. Farmers may feel pressure to select a species mix perfectly tailored to their soils and agronomic needs. Although this sort of meticulous selection can provide great benefits, it can also be overwhelming.

This chapter attempts to simplify cover crop selection. Rather than compare cover crop species based on their specific soil health building traits, this manual will recommend species and rates that, for most common farming scenarios, will be successful.

COVER CROP SEED COMPANIES

SERVING THE MID-ATLANTIC

Green Cover Seed

Clifton Seed

Kings AgriSeeds

Nutrien Ag

Growmark

Lancaster Seed Sales

Seedway

Note: Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement by North Jersey RC&D is implied.

5 PRACTICAL CONSIDERATIONS

TO SELECTING COVER CROPS

Although there are many benefits to selecting a cover crop species mix that is made for specific soil types and needs, in practice, cover crop species selection is driven by more practical considerations: including cost, availability, seeding date, seeding method, and termination method.

1 COST

How much do you want to spend? Cereal grains, such as rye and wheat, and ryegrass are typically the least expensive cover crops.

For tips on reducing seed costs see “Tips for reducing the cost of cover crop” on page 108.

2 AVAILABILITY

How much work will you put into securing seed? Local grain mills and seed suppliers will typically only carry cereal grains, ryegrass, crimson clover and, sometimes radish.

Other less common species and mixes may need to be special ordered, increasing cost and wait-time.

3 SEEDING DATE

When are you planning to plant? Warm season species are typically reserved for (1) after small grains and certain vegetable harvests and (2) when a field is fallowed for an entire season.

Cool season species are the most common cover crops. Multi-species covers are typically only worth the investment when planted very early in fall. Some legumes and most brassicas won’t grow well during frosty and cool conditions of October.

When planting in mid-late fall, the only viable option is typically cereal rye, triticale, or winter wheat.

4 SEEDING METHOD

How are the seeds being established? Seeds that are broadcast should be heavier for better ballistics. However, seeds that are too large won’t germinate well on the soil surface. Drills and other methods that incorporate seeds within the soil are often more successful and can achieve excellent germination of any cover crop species.

5 TERMINATION METHOD

How will the cover crop be killed? Organic operations need species that reliably winter kill or can be effectively killed through tillage or mowing. When using herbicide, pay attention to which seeds/varieties have greater herbicide resistance. Only certain covers can be effectively killed by crimping.

WANT TO DELVE DEEPER...

HTTPS://SMARTMIX.GREENCOVERSEED.COM/

Check out the online smart-mix calculator by SmartMix Green Covered Seed. It is an excellent resource for farmers interested in optimizing their cover crop seed mix.

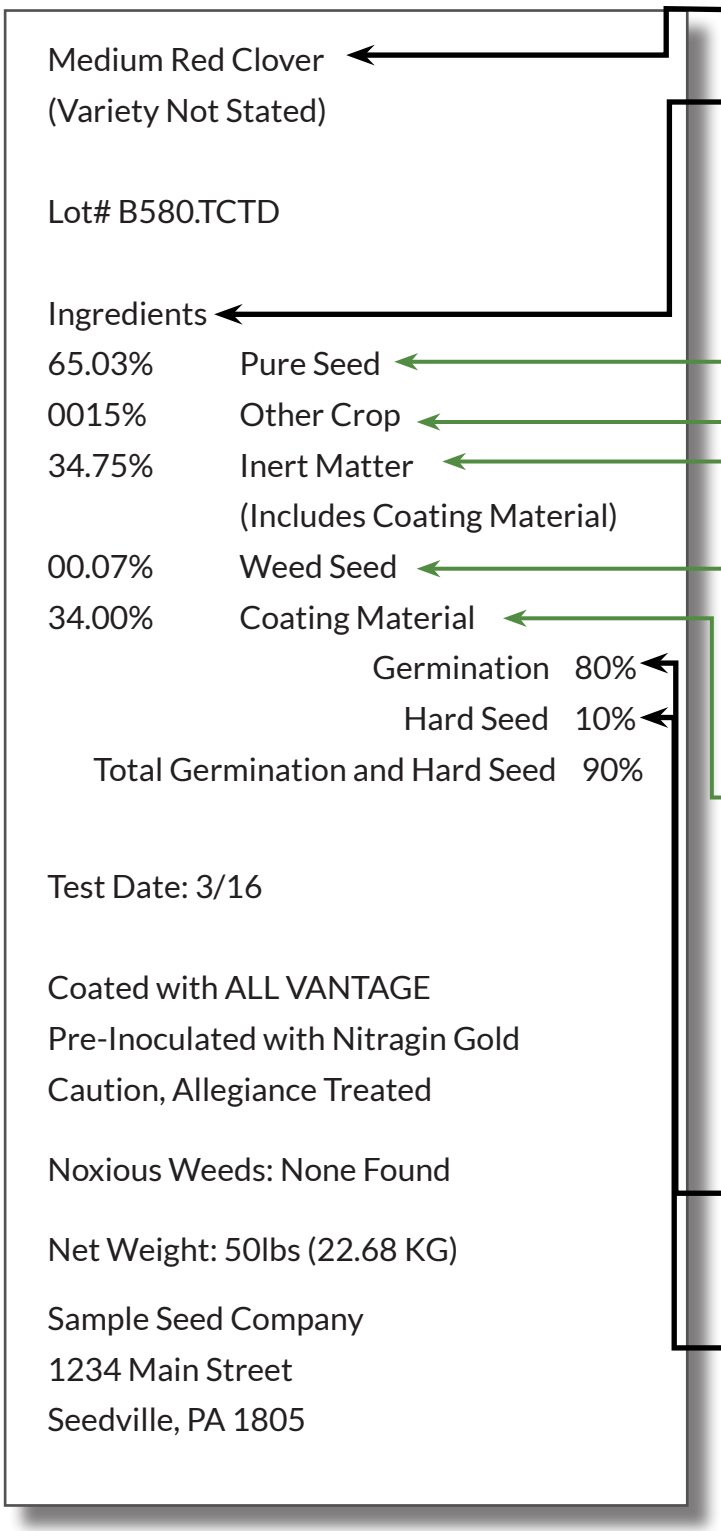
SEED CLASSES

Seed classes are designated based on (1) the seed class of the parent plants and (2) results of field and laboratory based testing.

	CERTIFIED	UNCERTIFIED OR COMMON	VNS (VARIETY NOT STATED)	BIN RUN
TAG COLOR				
VARIETY STATED	Yes	Yes	No	No
PURITY REQUIREMENT	Yes, *strict purity requirements for pure seed, inert matter, weed seed, germination, etc.*	Some, *free of noxious weed seed*	None	None
THIRD PARTY INSPECTION	Yes, *usually state officials*	No	No	No
SEED TAG	Yes	Yes	Yes	No
COST COMPARISON	Most expensive			Market price or below
SUMMARY	Certified seed variety identity and purity is verified by a third-party inspector. It must be grown from "Registered" or "Foundation" seed and must meet rigorous purity requirements.	Common seed or unverified seed is a specific variety that either (1) did not meet rigorous purity or germination standards, (2) was not grown using registered seed, or (3) was not certified (usually in order to reduce costs).	VNS seed hasn't gone through the rigors and expense of classifying it as a variety. Seeds are classified VNS when either (1) varietizing a seed simply isn't worth the expense (~$50,000), or (2) to get rid of old or odd seed lots that don't meet original variety specs. In some cases, unscrupulous companies steal varieties from competitors and sell it as VNS.	Bin run is harvested by a farmer, stored, and planted in the fall. Untested bin run seed may contain noxious weeds. In lieu of having the bin run seed tested, at a minumum, samples are visually inspected for cracked and damaged seed, and the presence of weed seeds.

UNDERSTANDING SEED TAGS

Seed tags provide the information needed to verify the quality and components of seed for sale.



KIND AND VARIETY: - Species or common name, and cultivar or variety name of the plant.

INGREDIENTS (% PURITY): A purity test separates pure seed, inert matter, other crop seed, and weed seed.

Pure Seed + Inert Matter + Weed Seed+ Other = 100%

PURE SEED: Purity expresses the composition of the seed lot and its degree of contamination by unwanted components.

OTHER CROPS: Seeds from other plants that are not considered weeds.

INERT MATTER: Inert matter includes dirt, plant parts, and damaged seeds. Non-coating inert matter can interfere with drill function.

WEED SEEDS: Includes seeds of all plants that are considered to be undesirable, troublesome, or not wanted. The amount of common, restricted, and noxious weed seed found in the lot will be listed separately.

COATING MATERIAL: Seed coating may contain fertilizer, growth promoters and/or seed treatment as well as an inert carrier and a polymer outer shell.

- **LEGUMES** are typically coated with rhizobium to improve N fixation
- **SMALL GRASSES** are coated with a clay to improve seed to soil contact, moisture wicking and improve ballistics when aerial seeded.

GERMINATION – (% GERMINATION) a germination test determines the capability of a seed lot to produce normal seedlings under controlled conditions

HARD SEED / DORMANT SEED: Includes the portion of the seed sample that doesn't germinate during the seed test but it can germinate later. Dormant seed contains properties that inhibit germination; dormancy is common in vetch, annual ryegrass and crimson clover.

CALCULATING PURE LIVE SEED (PLS)

Cover crop seed quality and cost can vary greatly. Calculate the percent "Pure Live Seed" (PLS) to determine the amount of viable seeds in a lot of bulk seed. PLS indicates the amount of seed in the lot that is capable of developing into seedlings.

The amount of seed required to compensate for poor purity and germination can be determined by calculating percent pure live seed (PLS).

To calculate percent PLS for this seed, multiply pure seed and germination and then divide by 100 (example below). The result is the percentage of pure live seed for this bag of seed.

PURE LIVE SEED (PLS) CALCUATION

$$\frac{(\text{Purity} \times \text{Percent Total Germination})}{100} = \%\ \text{Pure Live Seed (PLS)}$$

To calculate the amount of seed needed to meet seeding rate, divide 100 by the value for PLS.

LB. OF SEED ACTUALLY NEEDED TO MEET SEEDING RATE

$$\frac{100}{\%\ \text{Pure Live Seed (PLS)}} = \text{lb. of Seed Needed per lb. Seed Specified}$$

To calculate the true cost of the seed, given its impurities and anticipated germination, multiply amount of PLS seed needed by the cost of the seed.

TRUE COST OF SEED

$$\text{lb. of Seed Needed per lb. Seed Specified} \times \text{Cost per lb.} = \text{Cost per lb. of Pure Live Seed (PLS)}$$

PURE LIVE SEED PERCENT AND SEED COSTS

Seeds with a low purity and test germination rate are often sold at a reduced price. Often, “bargain” bulk seed with a low PLS percentage will end up costing more to appropriately seed a project than a higher priced bulk seed with a higher PLS percentage.

SEED LOT A

$2.75 / LB.

95% Pure Seed
90% Germination

(95 x 90) / 100	=	85 %
100 / 85	=	1.17 lbs
1.17 lbs x 2.75	=	**$ 3.21 / lbs.**

SEED LOT B

$2.00 / LB.

85% Pure Seed
70% Germination

(85 x 70) / 100	=	59.5 %
100 / 59.5	=	1.68 lbs
1.68 lbs x 2.00	=	**$ 3.36 / lbs.**

WHICH IS A BETTER DEAL?

Seed Lot A is less expensive per lb. of viable seed.

KEY

TIPS FOR REDUCING THE COST OF COVER CROP

Here are some ways to keep the cost of cover crops down, especially for farmers planting a lot of acres.

KEEP IT SIMPLE

Single species rye, wheat, or oats can be an excellent option for many farms. Single species cover crops are cheaper and typically easier to terminate.

For those interested in multi-species cover crops, opt for ready-made mixes, which are less expensive and have also gone through rigorous testing to ensure the components are well balanced within the mix.

PAY ATTENTION TO PERCENT LIVE SEED (PLS)

Seeds with a low purity and test germination rate are often sold at a reduced price.

"Bargain" bulk seed with a low percent live seed (PLS) rating may end up costing more in the long run.

See "Calculating Pure Live Seed (PLS)" on page 106 for more information.

CONSIDER BIN RUN

Bin run seed is harvested by a farmer, stored, and planted in the fall. Bin run cover crops can cost as little as $5.00 to $10.00 an acre.

If you plan to buy a bin run seed, strongly consider having it professionally tested first. If improperly stored, the seed may not germinate well. It may be contaminated with noxious weed seeds.

EXPERT TIP
TEST BIN RUN SEEDS

States often offer their own testing services. In New Jersey, the NJ Department of Agricultural Plant Laboratory Services will test germination, purity, and noxious weeds for $55.00 per sample. In Pennsylvania, the Department of Agriculture's Seed Testing Laboratory offers a wide variety of seed testing services.

At a minimum, conduct your own germination test placing 10 seeds inside a wet paper towel in a ziploc bag in a warm location. Check to see if they have germinated after a couple of days.

CERTIFIED OR VNS

Variety Not Stated (VNS) seed can be a good low cost option. Sometimes VNS seed has the best genetics for the area.

But be wary, as it can also have noxious weeds and lower germination rates.

INCORPORATION SAVES MONEY

To get a full stand of cover crop through broadcasting, you need to apply nearly twice as much seed. Even with a much higher application rate, surface application of cover crop seed may result in spotty germination.

Drilling the seed takes more time and can require renting/ using a drill. However, it will ultimately reduce the total price per acre.

Another good option is to lightly incorporate the seed in the upper 1/2" of the soil profile using some form of vertical tillage or rotary hoe.

DID YOU KNOW?
LOW COST DRILL RENTAL OPTIONS

Many soil conservation districts and agricultural non-profits have no-till drills available for rent at a reduced rate. Examples include North Jersey RC&D, New Jersey Audubon, and Team Habitat.

TAKE ADVANTAGE OF VOLUNTEERS

Cover cropping after a small grain crop is the easiest place to start. Allow volunteer small grain seed to grow, add a legume, and terminate broad leaf weeds.

SCIENCE AND MERITS OF RHIZOBACTERIA

Legume cover crops will convert atmospheric nitrogen gas into a form of nitrogen that plants can use through a process known as nitrogen fixation. This complex chemical reaction relies on soil bacteria, known as rhizobacteria. Legume roots colonized by the appropriate rhizobacteria will form root nodules. When the plants are actively fixing atmospheric nitrogen, the inside of the nodules will actually turn bright red!

Legumes that form symbiotic relationships with rhizobacteria produce lots of nitrogen-producing nodules, which in turn, will create stronger, healthier plants.

Legume nodules: Rhizobia, a type of root colonizing bacteria that supply nitrogen to legumes, reside in protective nodules formed by the plant. The bright red color of the opened nodule is an indication of healthy rhizobia inside. (Penn State University;)

SEED TREATMENTS & COATINGS

LEGUME SPECIFIC COATINGS

Legume seeds are often coated with a compound containing live beneficial bacteria. The bacteria will form a symbiotic relationship with the clover, vetch or bean plant and supply nitrogen to the plant. These bacteria may not be naturally present within the soil, therefore legume cover crop seeds are often coated with this important inoculant.

Keep in mind there is no such thing as "universal" inoculant. Since each legume needs a specific strain of rhizobia bacteria, be sure to buy the right inoculant. Products that are a blend of bacteria are not as effective.

EXPERT TIP ADDING YOUR OWN INOCULATANT

If a legume doesn't come coated with inoculant, consider purchasing it separately. Inoculants are a loose powder that can be sprinkled onto legume seed in the small seed box.

EXPERT TIP: IS THE INOCULANT NECESSARY?

Purchasing legumes coated with a inoculate is generally worth the expense.

Plants will only form a symbiotic relationship with a specific species of rhizobateria. Bacteria specific to a soybean plant won't form a relationship with clover or vetch cover crop. Therefore, although many strains of Rhizobium may be present in the soil from previous inoculated legume crops, they may not be compatible with the legume cover crop being planted.

FORGO THE TREATMENT when you purchased the inoculated seed before and are planting the same species of legume, year after year. Rhizobia will be present in the soil for about one year without a host plant.

Cover crop seeds are often marketed with coatings or seed treatments designed to either supply beneficial bacteria in the soil, supply nutrients, improve germination, or facilitate easier application. Two types of seed typically receive seed treatments: legume seeds and small seeds (grasses and brassicas).

SMALL SEEDS SPECIFIC COATINGS:

Small grass and brassica seeds often are coated with some combination of calcium carbonate, clay, and other chemical compounds. These coatings can more than double the size and weight of seed. Coatings have a number of benefits for small seeds including:

IMPROVED BALLISTICS: Small, irregularly shaped seeds (such as ryegrass) are prone to being blown with the wind when broadcast (either with a spreader or aerial applicator). Furthermore, many drills are not equipped to plant light fluffy grass seeds.

Seed coating doubles the bulk density of the seeds making them easier to manage. When aerially applying, this converts to an improved accuracy of the drop, and greatly reduces the amount of wind drift once the seed leaves the plane.

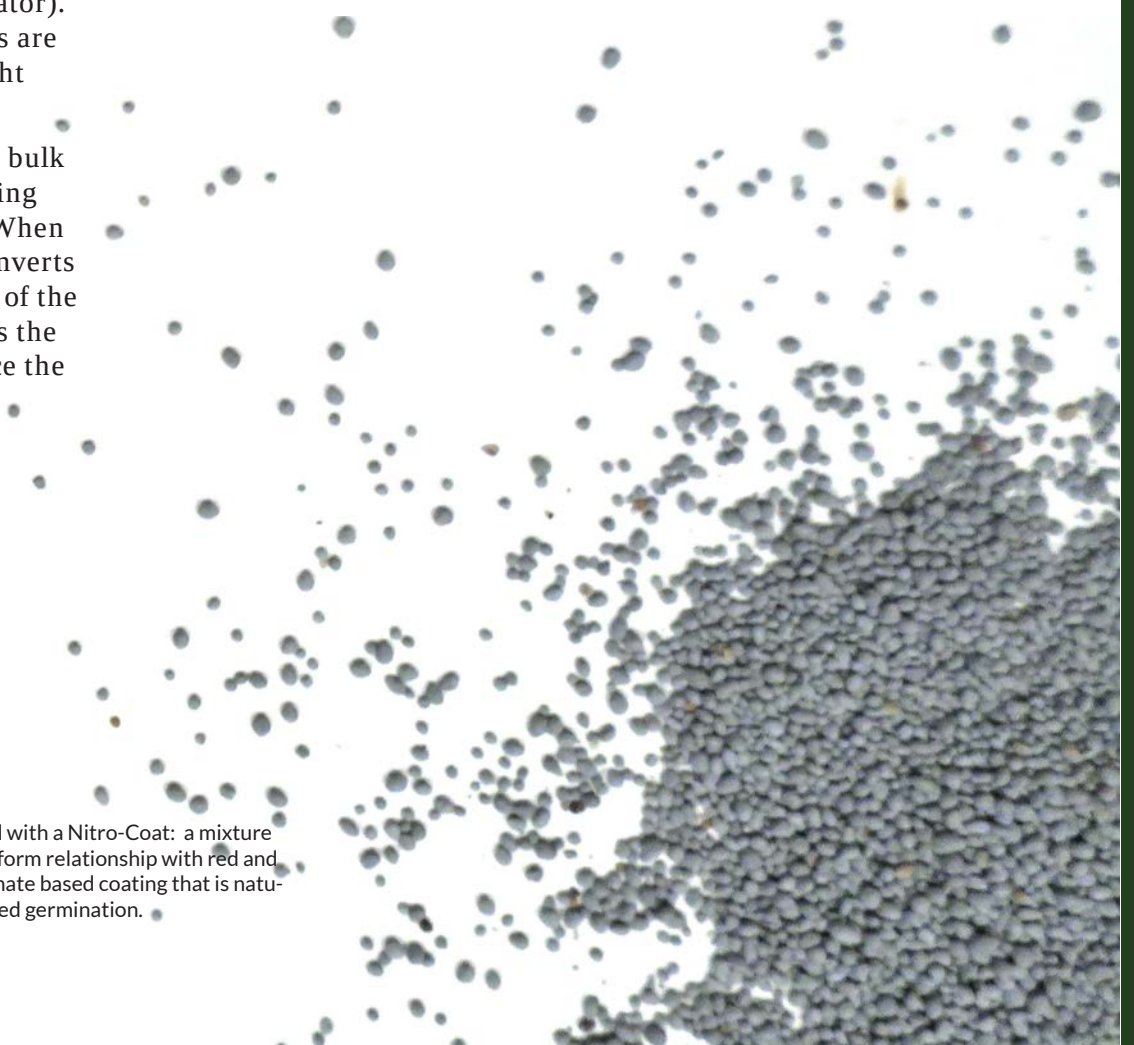
IMPROVED SEED TO SOIL CONTACT: Once on the ground, coated seed has a much greater surface area than uncoated seed, which greatly increases seed to soil contact and therefore, increases that seed's opportunity for establishment.

MOISTURE WICKING: Seed coatings tend to absorb water, providing a more consistent level of moisture for germination.

EXPERT TIP
IS THE COATING NECESSARY?

If you are broadcasting small grass and brassica seeds, particularly using a plane or helicopter, the coating is essential.

If your drill is not equipped with a fluffy seed box or some type of seed agitator, the coating greatly improves the ease of seed flowing more evenly through the drill.



Red and white clover seed coated with a Nitro-Coat: a mixture of the specific rhizobacteria that form relationship with red and white clover and a calcium carbonate based coating that is naturally water absorbing to speed seed germination.

COVER CROP SPECIES COMPARISON

Type	Species	Seed Size	Costs			Planting Time		
			Cost per lbs.*	Cost per Acre *	Cost per 1 Million seeds*	Summer	Early Fall	Fall
GRASSES	Annual Ryegrass		**$0.90**	**$15.30**	$4.74	✓	✓	
	Sorghum Sudangrass		**$1.40**	**$30.80**	$77.78	✓		
CEREAL GRAINS	Cereal Rye		**$0.26**	**$23.40**	$11.30		✓	✓
	Winter Wheat		**$0.24**	**$21.60**	$17.14		✓	✓
	Spring Oats		**$0.27**	**$24.30**	$18.00	✓	✓	✓
	Triticale		**$0.28**	**$25.30**	$18.60	✓	✓	✓
LEGUMES	Red Clover		**$2.05**	**$14.35**	$11.13	✓	✓	
	Crimson Clover		**$1.50**	**$22.50**	$13.99	✓	✓	
	Berseem Clover		**$2.25**	**$24.75**	$16.79	✓	✓	
	Hairy Vetch		**$1.90**	**$34.20**	$125.00	✓	✓	
	Winter Peas		**$0.55**	**$35.75**	$137.50	✓		
	Cow Peas		**$1.00**	**$55.00**	$243.90	✓		
FORBS	Dikon Radish		**$1.65**	**$11.55**	**$66.00**	✓	✓	
	Buckwheat		**$0.70**	**$31.50**	**$38.89**	✓		
	Rape		**$1.00**	**$6.00**	**$5.71**	✓	✓	

* Costs are general approximation based on 2019 cost tables; actual prices will fluctuate greatly from year to year.

Seeding Method		Termination Method				Notes
Broad-cast	Drill	Chemical	Mowing	Tillage	Winter Kill	
✓	✓	–		–		! Chemical termination successful only during warm sunny application
	✓	–		✓	✓	
–	✓	✓		✓		
–	✓	–		✓		
–	✓	✓		✓	✓	
–	✓	–		✓		
✓	✓	–		–		Difficult to terminate chemically
✓	✓	✓	✓	✓		Often a favorite legume
✓	✓	–		✓		
	✓			✓		! Never plant in a field before a cereal grain crop
	✓	✓	✓			
	✓	✓	✓	✓	✓	
	✓	✓	✓	✓	✓	
	✓	✓	✓	✓	✓	
	–			✓		! Difficult to terminate chemically

SCIENCE OF HERBICIDE BREAKDOWN

Most herbicides are either broken down in the soil by microbes or acid-based chemical reactions. These processes are generally more rapid as temperature and soil moisture increase.

FACTORS THAT INHIBIT HERBICIDE BREAKDOWN INCLUDE:

DRY SOIL: Herbicide molecules will tightly adhere to dry soil particles thus inhibiting breakdown.

CLAY SOILS: Herbicide molecules will tightly adhere to clay particles in soil, thus inhibiting breakdown.

NEUTRAL OR BASIC SOIL: In soils with a pH above 6.8, the chemical reaction that breaks down triazine and sulfonylurea won't occur.

SOIL WITH LOW MICROBIAL ACTIVITY: The rate of herbicide breakdown is slower in soils with few microbes and less microbial activity. These are typically soils with less organic matter subject to frequent application of synthetic fertilizers and chemicals.

HERBICIDE CARRYOVER

Some herbicides will remain in the soil for months after application; these residual herbicides can significantly harm subsequent cover crop stands. When selecting cover crop seeds, pay attention to potential for herbicide damage.

The potential for herbicide carry-over damage depends on (1) weather and soil conditions that influence the rate of herbicide breakdown, (2) cover crop species sensitivity and (3) and how long it takes a particular herbicide to break down.

In general, herbicides with crop rotation restrictions of 4 months or less should be safe.

Be wary of planting sensitive cover crop species (see the following page for more information) following a dry growing season or within four months of applying a herbicide.

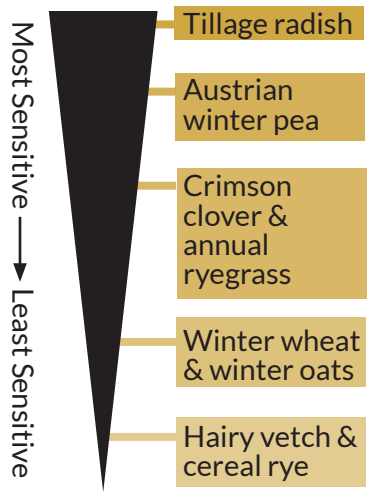
Farmers concerned about potential carryover of herbicides should usually opt for cereal rye. Cereal rye is much less likely to be impacted by herbicide residuals. However, even cereal rye isn't a sure bet.

WHAT COVER CROPS ARE MOST SENSITIVE

Research by the University of Missouri evaluated the sensitivity of fall-seeded cover crops to carryover from common pre-emergence and post-emergence corn and soybean herbicides.

Results indicated that tillage radish, winter pea, crimson clover and annual ryegrass are among the most sensitive, common cover crop species.

Hairy vetch, cereal rye, winter wheat, and winter oats are less sensitive.



WHAT HERBICIDES ARE MOST LIKELY TO IMPACT FALL COVER CROPS

Research by the University of Missouri found that certain common pre-emergence and post-emergence corn and soybean herbicides are more likely than other herbicides to negatively impact cover crops stand development, particularly sensitive species.

Soybean herbicides that may inhibit growth of a fall-seeded legume or radish.

- fomesafen (Flexstar, Prefix, Reflex)
- pyroxasulfone (Zidua)
- imazethapyr (Pursuit)
- acetochlor (Warrant)
- sulfentrazone (Authority)
- chlorimuron (Classic, Canopy, Cloak, etc.)

Corn herbicides that inhibit fall a seed ryegrass growth:

- pyroxasulfone (Zidua)
- metolachlor (Dual, etc.)

Corn herbicides that may inhibit growth of a fall-seeded legume or radish.

- mesotrione (Callisto, Halex)
- flumetsulam (Python)
- clopyralid (Stinger)
- topramezone (Impact),
- isoxaflutole (Balance Flexx)
- nicosulfuron (Accent Q, etc.

Adapted from "Using herbicides and cover crops in corn and soybean" by Lizabeth Stahl, Extension educator; Jeff Gunsolus, Extension weed scientist and Jill Sackett-Eberhart, former Extension educator

PLANTING RESTRICTIONS FOLLOWING COMMON HERBICIDES

GLYPHOSATE: None

PARAQUAT (GRAMOXONE): None

DICAMBA: Dicamba can be a concern when applied at high rates or planting cover crop less than 120 days after application; cover crop planted 120 days after dicamba application with 24 fl oz/acre or less should not be impacted.

2-4D: Wait at 30 days after 2-4D application before planting sensitive broadleaves; amine formulations are more water soluble and can leach into the seed zone.

GLUFOSINATE (LIBERTY): Glufosinate should not cause cover crop injury. However, be aware that glufosinate should not be applied to food or feed residues within 45 days of harvest.

ATRAZINE: Herbicide carryover from atrazine is a concern for cereals, ryegrass, legumes, and mustards. Atrazine is more persistent in high pH soils. At rates less than 1 lb/acre, Atrazine impact will be minimal; half-life of Atrazine in the Mid-Atlantic probably close to 30 days.

Adapted from "Corn Herbicides and Rotation to Cover Crops" and "Soybean Herbicides and Rotation to Cover Crops" by Dwight Lingenfelter, Senior Extension Associate – Weed Science Penn State Extension (2017)

COVER CROP APPLICATION

Photo credit: Bridgett Hilshey, North Jersey RC&D

Not long ago, the seeding options for cover crops were limited primarily to a drill. The recent explosion in use of cover crops has led to a plethora of seeding innovations, each with its own advantages and challenges. The following pages outline how to implement each practice and the associated pros and cons. While exploring cover crop application methods, take into consideration the following questions:

1

Is having a legume to fix nitrogen essential?

If so, farmers will need to consider a method that allows you to apply the cover crop well before the last frost. In vegetable and silage operations, this may not be an issue, however most grain corn farmers will need to consider an option that interseeds cover crop into standing cash crops.

2

Do you want near perfect coverage?

If so, farmers will need to establish good seed to soil contact through light incorporation or drilling. Any form of cover crop broadcasting will result in spotty coverage.

3

How much time and money are you willing to spend?

Some application methods are more time consuming than others. Drilling cover crop is a slower process but uses less seed per acre, whereas other options that broadcast seed over the surface are a lot faster but require using higher seeding rates to obtain uniform coverage.

COVER CROP APPLICATION METHODS

	INTERSEEDING BEFORE CASH CROP HARVEST			
	Interseeding	**Row intercrops/ Alternating Crop/ Skip Row**	**Interseeding High Clearance Sprayer**	**Aerial**
DESCRIPTION	Specialized seed drill designed to drill cover crops in standing row crops Suitable for corn only.	Alternating row of cash crop and cover crop Most common in corn crops.	Modified high clearance sprayer drops cover crop seeds on standing crops	Fixed wing airplane, helicopter or drone drops cover crop seeds into standing crops
COVER CROP APPLICATION TIMING	Early Summer	Spring - Early Summer	Early Fall	Early Fall
TYPICAL SEEDING RATE	Very Low	Very Low	High	High
EQUIPMENT NEEDS	Requires specialized interseeding equipment	Requires drill and precision planting equipment	Requires specialized equipment, typically rented	Requires contract with aerial applicator
TIME REQUIREMENTS (ASSUMING MEDIUM SIZE 10' EQUIPMENT)	Slow	Fast	Fast	Very Fast
POTENTIAL FOR CROP DAMAGE	Some	None	High	None
OTHER	Not compatible with all widths and types of corn planters		Modifications needed. Varying spread width. Dependent on rainfall	Timing, crop maturity and rainfall forecasted is imperative
EFFECTIVE SOIL COVER	Poor to fair	Depends on row arrangement	Fair to Good	Fair to Good

AFTER CASH CROP HARVEST				
Broadcast During Combine	**Slurry Seeding**	**Broadcast**	**Broadcast & light Incorporate**	**Drill**
Modified combine broadcasts cover crop seed during crop harvesting	Shallow injection of cover crop seed mixed with liquid manure in spreader tank	Cover crop seeds broadcast on soil surface after crop harvest	Cover crop seeds broadcast on soil surface and incorporated into top 1” after crop harvest	Cover crop seed sown using a no-till drill after crop harvest
Fall - Early Winter (At Harvest)	Fall - Early Winter (Post Harvest)	Fall - Early Winter (Post Harvest)	Fall - Early Winter (Post Harvest)	Fall - Early Winter (Post Harvest)
High	High	High	Low	Low
Requires modified combine	Requires liquid manure injector or speader			Requires a seed drill
Very Fast	Slow	Fast	Fast	Slow
N/A	N/A	N/A	N/A	N/A
	Efficient options for swine and dairy operation injecting liquid manure	Dependent on rainfall and soil moisture		
Fair to Good	Fair to Good	Fair to Good	Excellent	Excellent


60” CORN ROWS
ROW ARRANGEMENT OPTIONS
Corn
Cover crop
30 60 30 60
ROW SPACING
30”
60”
30”
60”
60” ROW
SPACING
60”
60”
60”

ROW INTER-CROPS/ ALTERNATING CROP/SKIP ROWS

Cover crops are grown between 60-inch corn rows during the summer growing season. When the corn is harvested, strips of cover crop remains to protect the soil during the winter.

CASH CROPS

SILAGE CORN: Row inter-crops are most suited to corn silage operations. In this scenario, the silage is removed in early fall, opening up the potential for a fall harvest of cover crop for forage.

GRAIN CORN: Choose an early maturing variety (96 to 100 day). It is important that the corn tassels before the cover crop is large enough to compete for water and nutrients.

Some farmers increase in-row seeding rates by 50-100%- the equivalent of 68,000 seeds per acre based on a 30" row setting.

Anticipate at least a 5% to 7% yield reduction per acre, or greater.

CROP AND ROW ARRANGEMENT

Plant crops in either a 30-60 30-60 row spacing or a straight 60-inch rows with cover crop between each of the 60-inch rows. *See diagram on opposite page.*

The 60-inch rows are formed by simply disengaging every other row unit on a 30-inch planter, so no special equipment is required.

SEEDING RECOMMENDATION

Seed cover crop in early to mid- June (approximately v4 growth stage). Depending on available equipment, cover crop can be drilled with an inter-seeder or broadcast and lightly incorporated.

The ideal species for row inter-crops are cool season, drought and shade tolerant and are relatively easy to establish.

Try a multi-species mix containing

- Orchardgrass - 10lbs/acre
- Berseem Clover - 4lb/acre
- White Cover - 4lb/acre
- Radish - 1 lb/acre

A mix of annual ryegrass (20 lbs/acre) and crimson clover clover is also a good shade tolerant option.

PROS

Great at reducing erosion during the growing season and improving soil health; can provide a sizable double crop of forage

CONS

Yield reduction of cash crop

Increased weed pressure

BOTTOM LINE

Typically only worthwhile if you are harvesting the cover crop for feed in the late fall or if soil health gains are a primary cropping goal.

30” CORN ROWS

ROW ARRANGEMENT

Corn

Cover crop

INTERSEEDING ROW SPACING

30” 30” 30” 30” 30” 30”

INTERSEEDING

An interseeder is a specialized seed drill designed to sow cover crops in standing row crops. The cover crop grows under the standing corn crop until harvest.

TIMING

Interseeding generally occurs when corn is between the V3 and V7 stage; cover crop interseeded into V4 to V5 corn is typically the most successful.

At this stage, the potential for injury from short residual pre-emergence herbicides is reduced and the timing is good for sidedress nitrogen. Furthermore, post-emergent glyphosate or glufosinate could also be applied at this time, if necessary, to control escaped weeds prior to cover crop emergence.

EXPERT TIP
GRAIN CORN ONLY

This practice is typically recommended for grain corn fields where a fall seeding window is often limited. For corn silage fields, a better cover crop stand is usually achieved by drilling post harvest.

-Lisa Blazure
Soil Health Coordinator at Stroud Water Research Center

EQUIPMENT

Interseeding requires a specialized seed drill that sows cover crop into standing corn rows. Interseeders are typically designed to sow 2 to 3 rows of cover crop between 30" corn rows.

Manufacturers of Interseeders include:

- Hershey Farms LLC & BZ Manufacturing
- Hiniker Drill
- Interseeder Technologies
- Dawn – DuoSeed Cover Crop Inter-Seeder

Cost to purchase a new interseeder ranges from $12,000 to $45,000 depending on width and capacity.

Most equipment can be used to drill cover crop after harvest, as well. Some equipment will simultaneously apply a post-emergent herbicide and/or fertilizer.

SEEDING RECOMMENDATION

The ideal species for interseeding are those that are cool season, somewhat drought and shade tolerant, and relatively easy to establish. A low cost option is 20 lbs/A annual rye grass.

For greater soil health gains consider the following mix:

- **10 lbs/acre Orchard-grass**
- **5 lbs/acre Cereal Rye**
- **5 lbs/acre Crimson Clover**
- **5 lbs/acre Daikon Radish**

EXPERT TIP
ORCHARDGRASS

Although not typically used as a cover crop, orchardgrass tolerates shade and looks great!

- Jim Hershey
PA No-Till Alliance President
Hershey Farms, Elizabethtown, PA

PROS

Cover crop protects against erosion between crop rows in growing season

CONS

Expensive equipment required

Typically poor cover crop coverage post harvest

BOTTOM LINE

In New Jersey, Pennsylvania, and Maryland, most farmers find interseeding isn't effective. Farms in northern latitudes may have more success.

Photo credit: Edwin Remsberg and USDA-SARE.

INTERSEEDING WITH HIGH CLEARANCE SPRAYERS

Modified high clearance sprayers can broadcast cover crops between corn and soybean rows. The cover crops grow under the standing cash crop until harvest in mid-fall.

TIMING

Farmers can use high clearance sprayers to broadcast seed through corn in V4 to V5 vegetative growth stages (early summer) or corn and soybeans during the end of their reproductive stages (early fall).

EARLY SUMMER APPLICATION causes less crop damage but is generally not recommended. Broadcast cover crop seeds in the summer will struggle to germinate; those that do will be shaded-out by the surrounding corn canopy.

EARLY FALL APPLICATION is optimal but requires highly specialized equipment that is not available in many regions. Aim to seed soybean fields when when the first yellow appear and corn fields after tasselling.

EQUIPMENT

High clearance sprayers, also called Highboys, can be modified to plant cover crop. The Hagie Cover Crop Interseeder allows applicators to convert high clearance rigs for cover crop seeding at a costs of $40,000.

Most producers tend to hire custom operators , at the rate of $8 and $15 per acre, to seed cover crop using a high clearance sprayer.

Farmers should anticipate substantial crop damage through head-rows. Level fieldd will have substantially less damage.

EXPERT TIP
WHERE TO FIND A HIGH CLEARANCE INTERSEEDER

- Bradford County (PA) Soil Conservation District

SEEDING RECOMMENDATION

Grasses are more adapted to germinate on the soil surface. Their young roots are smaller than those of legumes, so they can penetrate the surface crust easier. Small seeded brassicas will also establish well so long as soil temperatures are greater than 45° F.

Expert Recommendation

- **10 lbs/acre ryegrass**
- **5 lbs/acre crimson clover**
- **5 lbs/acre dikon radish**

PROS

- Lowest cost option to establish cover crop in standing corn and beans
- More exact placement than aerial

CONS

- Requires access to very specialized equipment
- Potential for larger amount of crop damage, especially in soybeans.

BOTTOM LINE

Great option if (1) your field is set up for a Hagie and (2) you have an operator in your area. Most farmers will find this type of equipment is rare.

USDA Photo by Lance Cheung.

Photo credit: Bridgett Hilshey, North Jersey RC&D

AERIAL APPLICATION

Fixed-wing airplanes, helicopters, and drones can drop cover crops into standing row crops. The cover crops grow under the cash crop until harvest in mid-fall.

TIMING

The timing of seeding is crucial to successful germination. Early to mid-September is generally the ideal time-frame for the mid-Atlantic region.

SEED INTO SOYBEANS when the plant achieves 10% leaf drop or yellowing. The leaves that fall after seeding will act as mulch and provide good soil protection and moisture conservation.

SEED INTO CORN after plants begin drying down and more light can penetrate the corn canopy.

EXPERT TIP: POOLING FARMERS FOR EASIER APPLICATION

Aerially seeding is logistically difficult and expensive. Farmers can save money and resources by arranging or partnering with other neighbors' farms, nonprofits, NRCS or Conservation Districts.

EQUIPMENT

Hire an aerial applicator to apply seed. Optimum seed drop is from a height of 50 to 60 feet above the canopy.

Airplanes are faster and can hold larger seed loads but may have trouble seeding small, irregularly shaped fields. An average airplane can seed 300 to 600 acres a day.

Helicopters are slower but more maneuverable and do a better job along end rows and headlands. The turbulence from the helicopter blades may dislodge seed caught in the crop canopy, improving seed to soil contact. Helicopters can seed about 150 acres a day.

Some farmers are experimenting with drones, applying 10-12 lbs of grass, although the practice is uncommon and not yet considered economical by most.

Aerial applicators charge between $20 and $35 per acre in the most Mid-Atlantic regions.

SEEDING RECOMMENDATION

Grasses are more adapted to germinate on the soil surface. Their young roots are smaller than those of legumes, so they can penetrate the surface crust easier. Ryegrass should be coated when aerially seeded. See "Small seeds specific coatings" on page 111.

Cereal grains may be easily established by aerial seeding if moisture and soil conditions are suitable. Small seeded brassicas will also establish well so long as soil temperatures are above 45° F.

EXPERT TIP AERIAL SEEDING MIX

The following mix works great aerially seeded and qualifies farmers for reimbursement through NRCS for multi-species cover crop.

- 38 lbs. Winter Rye
- 9 lbs. Annual Ryegrass (uncoated)
- 8 lbs. Crimson Clover
- 4 lbs. Coated Annual Ryegrass
- 3 lbs. Medium Red Clover

PROS

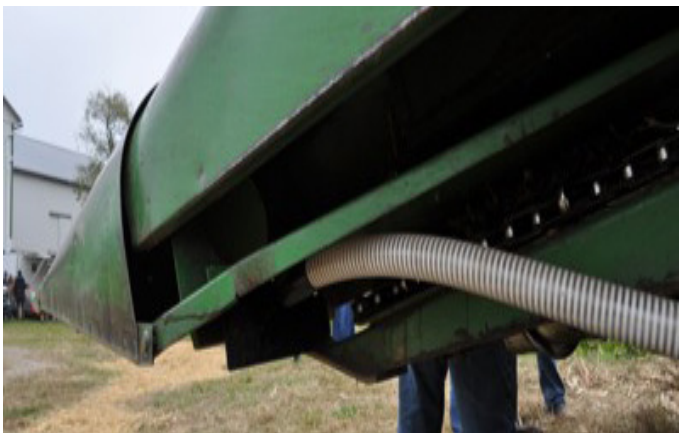
- Efficient option to cover crop large amounts of grain corn and soybeans

CONS

- Expensive
- Successful germination depends on weather
- Not effective in clay soils

BOTTOM LINE

Great option for grain/bean farmers interested in multi-species cover crop; more effective in lighter textured soils.



Gandy Air Seeder mounted to a combine. Photo Credit Steve Groff, Cover Crop Coaching, LLC

BROADCASTING DURING HARVEST

Combines can be outfitted with a small air seeder that broadcasts cover crop seed during combining.

TIMING

Agricultural producers should plan to complete the bulk of crop harvest by mid-fall to allow adequate time for cover crop to establish before winter.

For producers who wait to harvest until late fall or winter, this cover crop application method may not be appropriate.

EQUIPMENT

Air seeders installed onto combines can seed cover crops during harvest. Installation will require substantial creativity and ingenuity; there are no kits designed for this purpose.

The seeder can be manually calibrated or controlled by a variable-speed drive. Ideally, the seeder automatically adjusts seed volume based on the speed of the combine to achieve an even application rate. Plastic tubing routed under the combine transports ryegrass seed from the seeder to the soil surface where it is subsequently covered up by straw and chaff from the corn head.

Anticipate an initial investment of at least $15,000 for seeding equipment, although lower cost options do exist.

SEEDING RECOMMENDATION

The ideal cover crop species will be cold hardy and aggressive enough to establish under and through thick residues. Coated annual ryegrass and cereal grains are suitable for a later season broadcast application.

PROS

- One pass through the field minimizes fuel cost and soil compaction
- Very low cost

CONS

- Harvest will be interrupted by need to refill cover crop seed hopper
- It is difficult to achieve even seed distribution over headlands and end rows

BOTTOM LINE

For farmers who are good with mechanics, like to tinker, and can accept somewhat spotty cover crop establishment, this is a good, low cost option that saves time and additional field passes.


NoTill 5512
Esch

NO-TILL DRILLING

No-till drills place cover crop seed in the ground with minimal disturbance to the topsoil or surface residue. The seeds achieve uniform seeding depth and excellent seed-to soil-contact. No-till drill is the most common means of establishing cover crops.

TIMING

Drill cover crops as soon as possible after harvesting the cash crop.

DID YOU KNOW?
LOW COST DRILL RENTAL OPTIONS

Many soil conservation districts and agricultural non-profits have no-till drills available for rent at a reduced rate. Examples include North Jersey RC&D, New Jersey Audubon, and Team Habitat.

EQUIPMENT

No-till drills use opening disks to create a narrow slot into which the cover crop seed is dropped. The slot is firmed or closed by some form of closing mechanism. When considering purchasing or borrowing a drill to plant cover crop consider the following:

SIZE: Drills travel slowly -- not more than 3-5 mph depending on soil conditions. A wider drill will enable the farmer to cover more acres faster.

WEIGHT: Increase drill weight to improve soil penetration and residue cutting.

ATTACHMENTS: Replace disk-opener blades when the diameters are worn ½ inch from original size. Consider upgraded closing wheels.

SEEDING RATE

Cover crops seeded with a no-till drill have uniform seeding depth and adequate seed to soil contact. As a result farmers can expect excellent germination from all cover crop species regardless of seed size.

LOW SEEDING RATE: Seeding rate should be kept on the lower end to prevent cover crops from becoming too thick and creating problems when it's time to plant the primary crop -- especially annual ryegrass — because it can be overwhelming and choke other crops.

Expert Recommendation

- **10 lbs/acre Ryegrass**
- **30 lbs/acre Cereal Rye**
- **3 lbs/acre Crimson Clover**

PROS

- Excellent germination and stand for most species
- Requires lowest seeding rate

CONS

- Slow -- depending on drill size, farmers can expect to only plant 100-200 acres a day.

BOTTOM LINE

Drilling is the most reliable and most common tool to establish cover crop.

On this no-till drill, seed from the standard seed box is directed between the opening disks. Seed from the native seed box (largest tube) and legume box (smallest tube) is directed to the soil surface behind the opening disks, resulting in a much more shallow seed placement. The closing wheels will generally push the seed, on the soil surface, into the soil.

HOW TO DRILL A MIXTURE OF DIFFERENT SIZED SEEDS

A diverse cover crop mixture often contains large seeds (peas), medium seeds (cereal grains, vetch, and radish) and very small seeds (clover and ryegrass). Each species has a specific optimal seeding depth -- typically between 0.25 to 1.5 inches. To successfully establish a diverse cover crop mixture, farms can plant different seeds at different depths using multiple seed boxes or plant all seed at a single “average” depth. Both methods can be successful.

WHEN USING A GRAIN DRILL WITH MULTIPLE SEED BOXES

Place large seeds (cereal rye, wheat and triticale) in the large box, sometimes called the grain box. The drop tubes from the large box will direct seeds to the deepest point in the slot created by the disk openers.

Place smaller seeds (legumes, forbs, and brassicas) in the small box, sometimes called the legume box. The drop tubes from the small seed box can be directed to drop seed at the rear of the disc openers, resulting in a shallower seed placement. The drop tubes from the small box can also be left hanging straight down to dribble seed on the soil surface.

Planting mixtures in one pass by splitting the species according to seed size and planting depth has been the most effective strategy for obtaining optimum seeding depths for various species in a mixture.

WHEN USING A GRAIN DRILL WITH A SINGLE SEED BOX OR A PRE-MIXED SEED MIXTURE

Mix all the seed of all species in one drill box (usually the large seed box) and set the seeding depth to approximately 0.75 to 1 inch.

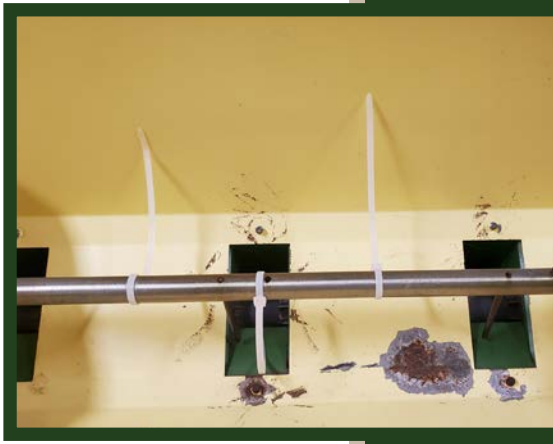
It has been theorized that in a mixture, the larger seeded species planted at such a depth will break open the seed slot as they germinate and allow the smaller seeded species to then emerge.

When using this strategy, try to get a drill with an agitator that will mix the seeds to avoid the larger, heavy seed segregating to the bottom of the box. Drilling at slower speeds may reduce seed size stratification. For drills without an agitator, it may also be necessary to stop periodically and hand mix the seed.

EXPERT TIP IMPROVE SEED MIXING

Adding zip ties across the agitator bars to increase the "fingers" can aid in the mixing.

- Michael Yacovelli
Farm Foreman
NRCS Cape May Plant Materials Center



Adapted from *"Making the Most of Mixtures: Considerations for Winter Cover Crops, Charles White and Mary Barbercheck, Penn State Extension, 2017.*

DRILL SETTINGS FOR COVER CROPS

Some drills may not specify a calibrated setting for the specific cover crop being planted. The following basic guidelines are designed to help farmers select an appropriate drill rate setting.

IF BUSHEL WEIGHT IS KNOWN, calibrate the drill using the crop setting with the most similar bushel weight.

IF BUSHEL WEIGHT IS UNKNOWN follow these basic guidelines:

- If you're using a mixture of seed that is dominated by one product then just use that seed for the setting. For instance, if planting a mixture of cereal rye, clover and radish, use the setting appropriate for cereal rye; the clover and radish are such a minor percentage of the overall weight that they don't make a difference for the setting.
- For mixes dominated by oats and barley, use the barley setting.
- For warm season mixes with everything from millet to sunflower to corn, use the milo setting.

U.S. COMMERCIAL GRAIN BUSHEL SIZES

Commodity	Weight per bushel
Grass *(Blue, Smooth Brome, Orchard & Redtop)*	14 lb
Sunflower (oil type)	28 lb
Sudan grass	28 lb
Oats	32 lb
Grass, Timothy	45 lb
Barley	48 lb
Millet	50 lb
Sorghum, forage	50 lb
Corn, shelled	56 lb
Rye	56 lb

Commodity	Weight per bushel
Sorghum, grain	56 lb
Alfalfa	60 lb
Clover *(Sweet, Alsike, Crimson, Ladino, Red, and)White*	60 lb
Flax	60 lb
Rape	60 lb
Soybeans	60 lb
Trefoil, Birdsfoot	60 lb
Corn, ear	56 lb
Vetch	60 lb

TO CALIBRATE the drill, collect and weigh the material from one of the seed meters for the distance equal to 1,000th of an acre (6" row = 87 ' 1"; 7" row = 74' 8"; 7.5" row = 69 '8"; 15" row = 34' 10") which will give a no-tiller an idea on how to set it.

TIPS FOR DRILLING INTO HEAVY CORN RESIDUE

Heavy corn residues on the soil surface can make establishing cover crops difficult. Below are some tips to increase success.

DURING CORN HARVEST

IMPROVE RESIDUE DISTRIBUTION: A chaff spreader will more evenly distribute the residues over the soil surface.

DO NOT PROCESS CORN STALKS INTO SMALLER PIECES: Chopping heads slice stalks into smaller, more manageable pieces. This can make it more difficult for a no-till drill to cut or penetrate through the heavy mat.

LIMIT RESIDUE ACCUMULATION ON THE SOIL SURFACE: Raise combine head to chop corn stalks as high as possible.

SEE "IMPROVING RESIDUE DISTRIBUTION" ON PAGE 30 FOR MORE INFORMATION

DURING COVER CROP ESTABLISHMENT

SOW COVER CROPS ON A DIAGONAL TO PREVIOUS CORN ROWS: By sowing cover crop diagonal to the previous crops, farmers are more likely to have a uniform cover crop establishment.

SOW COVER CROPS WHEN RESIDUES ARE DRY AND BRITTLE: Well maintained opening disks should be able to slice through dry, brittle corn stalks. Wet stalks and residues are much more difficult to cut through.

Photo Credit: Sious County Soil and Water Conservation District; Broadcasting Seeding Cover Crops
Broadcasting Seeding Cover Crop by Farmers Coop

BROADCAST SEEDING

Seed may be broadcast into light residue crops without seedbed preparation. If the seeds receive adequate rainfall, broadcasting can achieve an adequate winter cover.

TIMING

Broadcast cover crops as soon as possible after harvesting the cash crop.

Wind speed should be 10 mph or less when broadcasting light seed such as annual ryegrass.

Rainfall after broadcast planting is critical.

EQUIPMENT

Multiple types of common farm equipment can be retrofitted to broadcast cover crops.

- **Spinner**
- **Drop Tubes**
- **Air Pressure**

Accurately metering seed, particularly mixes, can be a challenge. Make sure the seeding pattern is appropriate for complete and even ground cover.

SEEDING RECOMMENDATION

RATES: Increase seeding rates by 20% to 50% when broadcasting; soils with higher clay contentb or those prone to drying or crusting should receive higher seeding rates.

AVOID SEED MIXTURES containing a wide variety of seed sizes. Spread patterns for seeds will vary based on their respective weights; heavier seeds spread further than lighter seeds.

Mixing seed with pelletized lime or fertilizer is a great option for saving time; seed blended with fertilizer should be immediately spread to prevent damage to the seed.

PROS

Fast and cheap application method

CONS

Requires much higher seeding rates, increasing seed costs

Not appropriate for large seeds as they don't germinate well

Varying seed sizes and densities could result in uneven stands

BOTTOM LINE

An excellent option for farmers with loamy soils who need to seed a lot of acres quickly.

Example of an implement mounted air seeder:
https://fyi.extension.wisc.edu/covercrop/planting/

BROADCAST WITH LIGHT INCORPORATION

Shallow incorporation of broadcasted cover crop seeds greatly improves cover crop stand development.

TIMING

Broadcast cover crops as soon as possible after harvesting the cash crop.

Wind speed should be 10 mph or less when broadcasting light seed such as annual ryegrass.

Rainfall after broadcast planting is critical.

EQUIPMENT

Cover crops can be broadcast onto a field, followed by a light tillage pass to incorporate, or seeds can be spread and incorporated with a seeder mounted directly on the vertical tillage implement.

Implements should be set to run no deeper than 1". Run straight coulters on the vertical tillage implement. Avoid cupped or concave blades, as these invert the soil and bury the cover crop too deep. Common options include:

- Rollerpacker
- Vertical Tillage
- Rotary Hoe
- Fluffing Harrow

EXPERT TIP
DON'T GO TOO DEEP!

When using vertical tillage to incorporate seeds, most farmers go too deep, disturbing too much soil.

SEEDING RECOMMENDATION

The light incorporation of cover crop seeds dramatically improves seed to soil contact, over broadcasting alone. As a result farmers can expect excellent germination from all cover crop species regardless of seed size.

PROS

Fast and cheap application method

CONS

Increase potential for erosion, particularly when surface residues are incorporated.

May require two passes through a field depending on available equipment

BOTTOM LINE

A good option for farms using some form of tillage regularly- particularly when seeds are applied early enough to establish winter soil cover in lieu of surface residues.

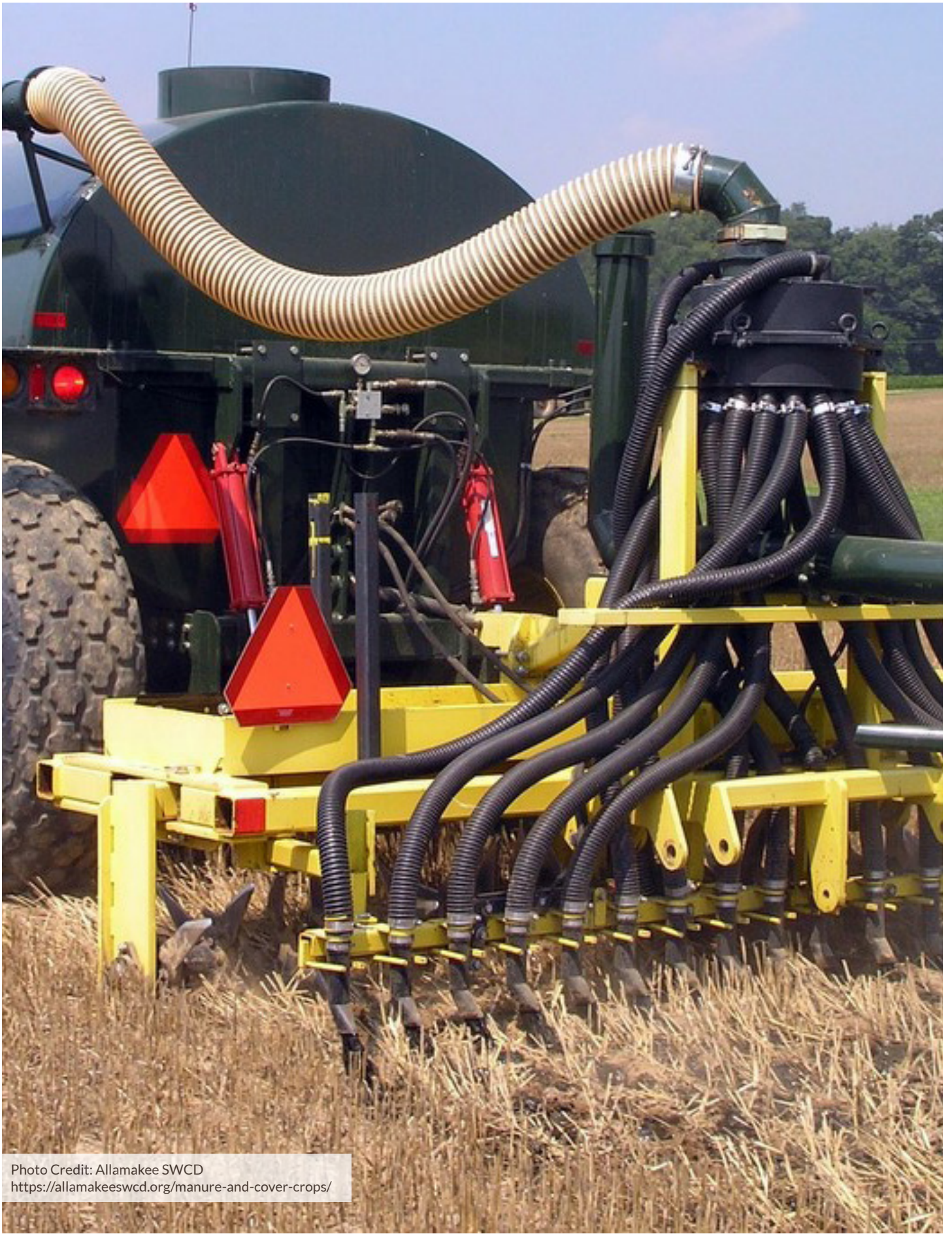


Photo Credit: Allamakee SWCD
https://allamakeeswcd.org/manure-and-cover-crops/

SLURRY SEEDING

Cover crop seed can be mixed into a tank with liquid swine or dairy manure; the mixture can then be dripped onto fractured soil surface during manure slurry application.

APPLICATION CONSIDERATIONS:

Slurry seeding is most effective on fairly level ground; seed may not be spread evenly when going up or down hills. Manure should be continuously agitated for best results.

EQUIPMENT

This method requires manure injection equipment. Cover-crop seed is mixed directly with liquid manure in a commercial manure tanker. Bypass flow from the PTO pump agitates the manure and keeps the seed suspended in the slurry. Seed-laden slurry is delivered through drop tubes to the fractured and loosened soil behind the aeration tines.

SEEDING RECOMMENDATIONS

High ammonia concentrations within manure will have an inhibitory effect on the germination of some cover crop seeds. Cereal rye is least impacted by ammonia. Avoid using crimson clover.

- Increase seeding rate at least 30% to account for poor germination.
- Keep periods during which cover crop seed is mixed with manure to less than 1 hour
- A rainfall event or irrigation within the first week after slurry seeding may be critical in order to achieve a good establishment of the crop.

PROS

Limits the number of field passes because the manure application and cover crop seeding are done in a single pass

CONS

Poor seed germination necessitates higher seeding rates

BOTTOM LINE

A viable option for those already injecting liquid manure. However, cover establish better if manure spreading is performed independent of planting cover crops.

Photo by Kyle Spradley, Curators of the University of Missouri; Hundley-Whaley Superintendent Bruce Burdick shares the center in Albany's recent study that involves what time to terminate cover crops. Burdick has killed the crops at different heights to see which process effects ground temperature and moisture in the spring.

COVER CROP TERMINATION

Cover crops need to be terminated (killed) before or shortly after the cash crops are planted. If termination is incomplete, the cover crops act as weeds, robbing the cash crops of moisture, sunlight, and nutrients.

There are a wide variety of cover crop termination solutions suited for a wide range of operations, experience levels, and goals. The following section will broadly outline the most common termination practices, associated advantages and disadvantages, and tips to increase success.

NATURAL

Several cover crop species cannot survive colder winters. These cover crops will die over the winter (winter-kill) without the need for mechanical or chemical intervention.

- **Winter-Kill**

MECHANICAL

Uprooting cover crop using tillage or mechanically damaging or cutting the aboveground vegetation can be an effective method of cover crop termination. These methods rely heavily on species selection and termination timing to be effective.

- **Mowing**
- **Tillage**
- **Roller Crimping**
- **Grazing**

CHEMICAL

The most common tool to control cover crops is herbicides such as 2,4-D, glyphospate, and Gramaxone.

Chemical control can either occur before planting or, with certain herbicide resistant cash crops, during or after planting.

- **“Brown and Down” Chemical Control**
- **Planting Green: Chemical Control**

COVER CROP TERMINATION SUMMARY OF OPTIONS

The following table roughly summarizes the basic characteristics of each termination method. More detailed information about each method can be found on the following pages.

PRACTICE NAME	WINTER KILL	DOWN AND BROWN: CHEMICAL CONTROL	PLANTING GREEN: CHEMICAL CONTROL
PRACTICE DESCRIPTION	Warm season cover crops are naturally killed by winter frosts	Cover crops terminated using herbicide 10 -14 days prior to planting	Cover crops terminated using herbicide during or after planting cash crops
TYPICAL TIME-FRAME	Oct-Dec	March-April	May
VEGETATION HEIGHT	Varies depending on planting date	1-3”	6-60”
COVER CROP SPECIES CONSIDERATIONS	Oats, Berseem clover, oilseed radish and annual medics.	Most Species	Most Species
TERMINATION TIMING CONSIDERATIONS		Most effective during vegetative growth stage and during sunny, warm conditions	Most effective during vegetative growth stage and during sunny, warm conditions
EQUIPMENT REQUIRED	None	No specialized equipment	Specialized closing wheels, opening disks, and residue cleaners will help prevent wrapping
DIFFICULTY	Easy	Easy	Easy to advanced depending on cover crop height.
ESTIMATED STARTUP COST	None	Most farmers can use existing equipment	$1000-$8000 depending on planter size and needs
SOIL HEALTH BENEFIT	Fair	Good	Very Good
ORGANIC APPLICABLE	Yes	No	No

MOWING	TILLAGE	ROLLER CRIMPING	COVER CROP GRAZING
Cover crop is cut or shred.	Soil is overturned, damaging the cover crop root systems causing desiccation	Cover crops stem is crimped along their lengths causing desiccation	Cover crops intensively grazed by livestock; most above ground biomass is consumed
May	March-April	Mid-May through Early June	Early June
6-12”	Varies	3’ - 6’	Varies
Legumes and some forbs only; grasses and cereal grains will regrow after mowing	Most species: Avoid clovers -- they will be more difficult to manage with tillage alone.	Hairy vetch, winter peas, barley, triticale, or cereal rye	Most species, although cool season cereals have the greatest nutritive quality and digestibility
Only effective when cover crops are flowering or in early reproductive phase		Only effective when cover crops are flowering or in early reproductive phase	Won’t result in complete termination
Flail mowers are more effective	Any tillage equipment	Pull behind, front mounted or planter mounted roller crimpers	Fence and moveable water supplies
Easy	Moderate	Advanced	Moderate
Most farmers can use existing equipment	Most farmers can use existing equipment	$6,000 - $30,000 depending on type	Hugely variable depending on operation size and needs
Very Good	Poor	Excellent	Excellent
Yes	Yes	Yes	Sometimes

TERMINATION IS A BALANCING ACT

Each spring, growers in the northeast need to decide when to terminate their cover crop. This decision is a balancing act between maximizing biomass production to enhance soil quality benefits and minimizing potential risk to cash crop planting and emergence.

When determining an ideal cover crop termination date, agricultural producers need to consider the growing season of the cover crop, soil moisture, soil temperature, N management, allelopathy/ weed suppression, and equipment under a variety of different climatic patterns and crop rotations.

Poor termination can result in cover crops becoming "weeds" and impeding cash crop germination, and in turn, significantly reduce yields and profit. All termination decisions impact profitability and the potential for economic gains or losses.

EARLY TERMINATION:

The choice to terminate early, for most farmers, is a practical one. In cover crop only a few inches tall, termination and subsequent planting is relatively straightforward and requires little specialized equipment and supplies. Moreover, early termination paves the way for early planting.

Agronomically easier with less risk to cash crops

DELAYED TERMINATION:

Delayed termination is a practice with both significant potential risks and large potential rewards. Termination needs to be timed to maximize soil health gains without compromising crop yields. When executed correctly, innovative termination strategies accelerate soil organic matter formation, reduce weed and pest pressure, reduce the need for chemical inputs, and increase water conservation.

More significant potential for soil health gains

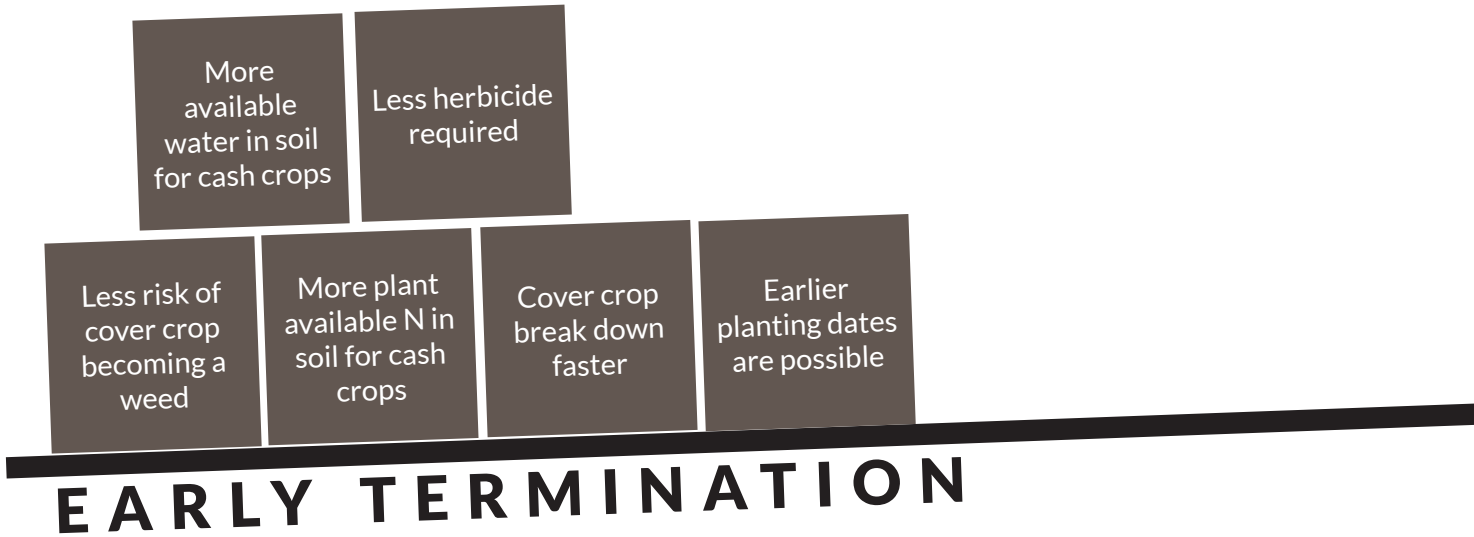
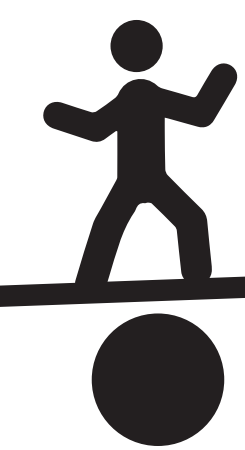


Photo Description: Farmers planted corn in both sides of this field the day before this picture was taken. In the "control" (left side) the cover crop was terminated early, weeks before planting. The "treatment" field (right side) has 4 foot tall cover crop into which cash crop was "planted green".

DELAYED TERMINATION



For farmers getting started with cover crops, deciding how and when to terminate cover crops can be a challenge.

- Reduced evaporation during growing season
- Enhanced soil erosion protection during growing season
- Slower release of N from crop residues
- Lower soil temperatures during summer
- More weed suppression
- Deeper, larger roots counteract more compaction
- Higher soil biological activity
- More N fixation from atmosphere
- More above and below-ground carbon biomass

Photo Credit: Edwin Remsberg
John Deere tractor spraying a cover crop field with herbicides.

Photo Credit: Bridgett Hilshey

EXPERT TIP
BE PREPARED FOR SLOWER SOIL DRYING

Soil will be slower to dry out after the cover crop is terminated. Dead cover crops don't pull moisture out of the soil like a living cover crop and can shade the soil.

- Jim Hershey
PA No-Till Alliance President
Hershey Farms, Elizabethtown,

CHEMICAL CONTROL BEFORE PLANTING

Herbicide is the most common tool to terminate cover crop. It is fast, generally very effective, and uses equipment that most farmers already own.

COVER CROP SPECIES

Most cover crops are fairly easy to control in a burn-down program as long as you pay attention to detail. Keep in mind the following details:

- Multi-species mixes can be challenging to terminate and generally require a multi-faceted herbicide program as each species will respond best to a different herbicide and will be at a different phase of development.
- Cover crop varieties will differ in their susceptibility to herbicide; talk to your seed dealer about how it responds to herbicide.
- More seed is not always better: dense seeding rates necessitate higher herbicide application rates -- particularly when relying on contact herbicides.
- Red clover and vetch are notoriously difficult to terminate.
- Winter wheat is more difficult to kill than cereal rye.
- Follow special recommendations to kill annual ryegrass.

TERMINATION TIMING

Target termination for when the plants are in a vegetative stage and the weather conditions are fair and conducive to growing. During these conditions, herbicides are more effective.

Target termination for:

- **GRASSES** before they joint
- **LEGUMES** before stems elongate and become woody.

EXPERT TIP
OVER-MATURE COVER CROP

When cover crop reaches reproductive stage (the boot stage in grass and bud stage in legumes) consider switching to a contact herbicide to burn the vegetation down. When a regrowth occurs, the plant will be easier to control with a systemic or contact herbicide.

If you terminate a cover crop after it has gotten too big, the dead cover crop can turn into a thick mat that will keep the ground from drying out. Terminate early or be prepared to plant green.

- RJ Fulper
Fulper Family Farms

PLANTING AFTER TERMINATING

Thick cover crop residues can be a nightmare to plant into. The long stems will bind and wrap around residue cleaners and closing wheels. The residues can create a slimy mat, particularly after rain events. Consider the following to reduce potential problems:

- Don't let cover crops get too large, particularly when starting out. Cover crops under 6" tall shouldn't wrap around equipment
- Plant when dead cover crops are dry. Dry cover crop residue is easier to cut through, reducing potential problems with hair-pinning.

EXPERT TIP
WAIT FOR COVER TO BE BROWN AND CRISPY

It is critical to wait 10 to 14 days after termination before planting the cash crop! Newly killed cover crop leaves will be difficult to cut through, dramatically increasing hair-pinning. Planting through cover crops that are brown and crispy will be easiest.

TRANSLOCATED HERBICIDES:

GLYPHOSATE ● 2,4-D ● DICAMBA

Translocated herbicides are absorbed by the foliage (and in some cases green stems), and moved throughout the plant to stems, roots, and underground storage tissues.

Ideal for killing plants with well-developed perennial root systems.

Common Examples

- Glyphosate (Round-up) is the most effective burndown herbicide for grass cover crops in cool and variable spring conditions
- 2,4-D is used to control broadleaf cover crops and legumes
- Dicamba (Banvel/Clarity) is used to control broadleaf cover crops and legumes
- Clopyralid (Stinger) is used to control broadleaf cover crops and legumes

Increasing Effectiveness

Apply translocated herbicide when plants are actively growing -- sunny days when daytime temperatures are above 55°F and nighttime temperatures stay above 40°F. Ideally air temperatures should be mild/warm before, during, and after herbicide application.

Apply translocated herbicides in the early morning to early-afternoon. After 2PM, effectiveness will sharply decline.

Always read and follow

CONTACT HERBICIDES

PARAQUAT ● GLUFOSINATE

Contact herbicides affect only the parts of the plant they come into contact with.

Ideal for small, annual plants and mature cover crops in reproductive phases.

Common Examples

- Paraquat (Gramoxone SL) can be used as an alternative to glyphosate for termination of grass cover crops but is generally less consistent.

Increasing Effectiveness

Increase spray volume to a minimum of 20 GPA to improve coverage when encountering dense canopies.

Be aware that it is more difficult to achieve complete coverage with a contact herbicide in a mixed cover crop stand due to the species being different in size and shape. This may result in inconsistent termination. Plan accordingly.

Use flat fan nozzle tips that produce a uniform spray pattern and thorough coverage. Be sure to include an appropriate nonionic surfactant.

the label instructions

GENERAL TIPS

1 Always check rotation restrictions

Some crops cannot be planted a certain number of days before or after herbicide application. Be aware of any restriction when developing a termination plan.

2 Apply herbicides to actively growing cover crop

Most herbicides will be substantially more effective when applied during warm, sunny conditions. As the plant actively undergoes photosynthesis, the herbicide is transported through the plant, maximizing impact.

3 Terminate cover crop prior to flowering when possible

Plants that have reached their reproductive phase are more difficult to control with herbicides.

Adapted from "Important reminders for chemically terminating cover crops" by Erin Hill, Michigan State University Extension, Department of Plants, Soil and Microbial Sciences (2017)

CHEMICAL COVER CROP CONTROL CONSIDERATIONS

CEREAL RYE & OTHER CEREAL GRAINS

DIFFICULTY TERMINATING: Easy

MOST EFFECTIVE HERBICIDE: Gramoxone or glyphosate

APPLICATION TIPS: Cereal rye is one of the easiest cover crops to control using herbicide. Before boot stage, cereal rye can be effectively terminated with glyphosate.

After boot stage, gramoxone, or a mixuture of gramoxone and glyphosate, is more effective.

Winter wheat can be somewhat more challenging and may require the addition of atrazine or metribuzin to effectively control.

ANNUAL RYEGRASS

DIFFICULTY TERMINATING: Somewhat Difficult

MOST EFFECTIVE HERBICIDE Glyphosate

APPLICATION TIPS: Annual ryegrass has a reputation for resisting termination. Always apply glyphosate during warm, sunny conditions in the morning or early afternoon.

Under cool conditions, it may take two to three weeks to kill the ryegrass and a second application of herbicide may be necessary.

If cold, wet and cloudy weather conditions persist, farmers can burn the field down with Gramoxone to achieve about 70% control. Then apply the standard rate of glyphosate or another application of Gramoxone to fully terminate.

EXPERT TIP
BE WARY OF VNS RYEGRASS

VNS annual ryegrass can contain a mix of varieties that respond to herbicides differently and break dormancy at different time periods. This can complicate termination.

VETCHES

DIFFICULTY TERMINATING: Somewhat

MOST EFFECTIVE HERBICIDE: 2,4-D, dicamba, clopyralid, or mixes

APPLICATION TIPS:
For control of most clovers or other legume cover crops, glyphosate alone is generally not effective, but is useful in a mixture with other herbicides.

A 2,4-D ester or dicamba formulation will effectively control hairy vetch and field peas.

EXPERT TIP
AVOID USING VETCH IN ROTATIONS WITH SMALL GRAINS

Vetches have a high proportion of hard seed. Even when effectively terminated with herbicide in the spring, dormant seeds will continue to germinate in-field for years. This can be extremely problematic for small grain production.

CLOVERS

DIFFICULTY TERMINATING: Somewhat. Depends on species and varieties. Red clover is harder to terminate than crimson, balansa or alsike varieties.

MOST EFFECTIVE HERBICIDE:
Dicamba

APPLICATION TIPS:
Only crimson clover can be effectively controlled with glyphosate or gramozone alone. For other clover varities, dicamba, atrazine or metribuzin should be added to increase performance.

EXPERT TIP
BEWARE OF RED CLOVER

Red clover can take up to three weeks to die compared to crimson clover which will be dead in five days.

BRASSICAS

DIFFICULTY TERMINATING: Somewhat. Depends on species and varieties.

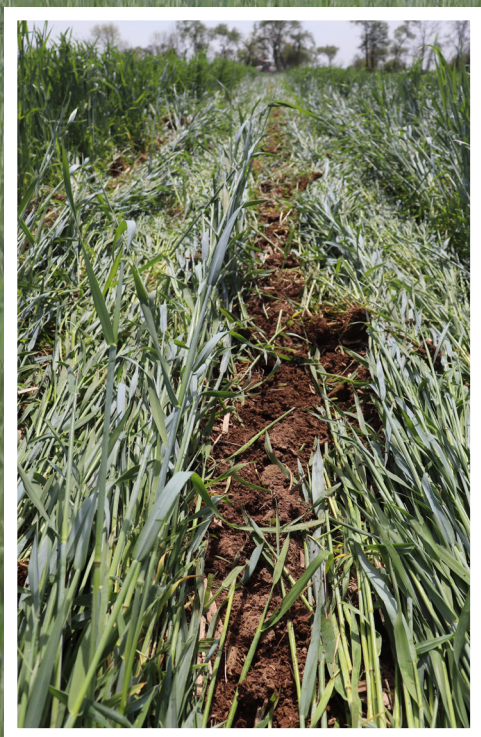
MOST EFFECTIVE HERBICIDE: 2,4-D

APPLICATION TIPS:
Some brassicas, like rapeseed, are especially difficult to kill with glyphosate, requiring a higher than normal rate of application and possibly multiple applications.

Radish, mustard, and turnip can be killed using a full rate of gramoxone, multiple applications of glyphosate, or glyphosate plus 2, 4-D.

Adapted from "Cover Crop Control Considerations" by Dwight Lingenfelter, Senior Extension Associate – Weed Science, Penn State Extension (2016)

Photo credit: Bridgett Hilshey



CHEMICAL CONTROL AFTER PLANTING:

Cover crops can be terminated during or after cash crop planting using herbicide. Glyphospate and other herbicides can be safely applied to GMO (ie. Roundup Ready) crops before or shortly after emergence.

COVER CROP SPECIES

EASY TO KILL COVER CROP VARIETIES: Select cover crops that are relatively simple to kill using herbicide and are slower to mature and enter the reproductive phase. (Cover crops in reproductive phases are more difficult to terminate with herbicide.)

REDUCE SEEDING RATE: Reducing cover crop seeding rate by 30%, especially if applying manure. Some farmers planting green seed rye as low as 30 lbs/A.

PLANTING CASH CROPS

Although there are many forms of "planting green," the most typical method is to terminate the cover crop in a vegetative growth stage (3-8 inches) at the same time as planting a genetically modified cash crop that will not be impacted by the herbicide.

It is not uncommon for experienced farmers to describe challenging experiences planting green. Tall covers can quickly wrap and bind around the many rotating elements of a planter or drill. Inadequate termination may leave cash crops struggling to complete against cover crops.

See "How to Plant Green Using Chemical Control" on page 166 for more detailed instruction.

TERMINATION TIPS

TIMING: Most farmers aim to terminate cover crops within seven days of planting cash crops and before emergence. The termination scenario adheres to NRCS and FSA recommendations and ensures the crop is eligible for crop insurance.

Do not plant green when the long term weather predictions call for a dry planting season.

PROS

Enables farmers to plant during wetter conditions; maximizes the cover crop growth for greater soil health benefits.

CONS

Potential for poor termination, planter problems, and reduced cash crop yields, particularly in corn production systems or in a dry spring when covers can rob moisture from the cash crop.

BOTTOM LINE

Great for farmers, already comfortable with cover crops and no-till and interested in pushing their soil health gains to the next level

TWO TYPES OF ROLLER CRIMPERS

Water Filled Drum

OR

Planter Mounted

Photo credit: Edwin Remsberg and USDA-SARE.

ROLLER CRIMPING

Roller crimpers are round drums, typically with angled fins in a chevron pattern, that are designed to knock over tall cover, kinking the stems and thus damaging the vascular system of the plant.

SUITABLE SPECIES:

PLANT EARLY FLOWERING GRAINS:
Not all cover crop species are suited to termination using a roller crimper. Elbon cereal rye, the earliest flowering commercial rye cultivar, is the most common cover crop choice for farmers interested in using a roller crimper to terminate.

Triticale may also be used, however, it won't reach maturity until five to seven days later than Elbon rye, further delaying cash crop planting.

Hairy vetch is the only legume suited to termination using a roller crimper. Conveniently, it also reaches reproductive maturity around the same time as cereal rye.

METHOD OF ROLLER CRIMPING

There are two common types of roller crimpers available:

PULL/PUSH DRUM ROLLER CRIMPERS: The original roller crimper, water filled drums are either pushed in front of or pulled behind a tractor.

PLANTER MOUNTER CRIMPERS: Roller crimping units can also be added to the front of planters, enabling planters to crimp and plant in a single pass. Manufactures include:

- Dawn Underground Agriculture ZRX - Zone Roller
- Yetter 5500 Devastor

CRIMPING AND PLANTING

TIMING IS CRUCIAL for successful termination with a roller-crimper. Grass cover crops should be roller-crimped after they start flowering (anthesis). Legumes such as hairy vetch should be roller-crimped after they start to produce pods.

EXPERT TIP
WHEN TO ROLLER CRIMP

In my experience the stem should snap in my hand to let me know if it will crimp well. A mower on the rear can cut down whatever pops back up if not you are not towing a seeder.

- Michael Yacovelli
  NRCS Plant Materials Center

If using an independent drum roller crimper, it is critical to plant in the same direction as the crops were crimped.

PROS

Enables farmers to plant in wetter conditions; maximizes the cover crop growth for greater soil health benefits; creates a vegetative mat that protects soil; higher N fixation when using hairy vetch.

CONS

Delays planting date until May or June for most farms; potential for poor termination, planter problems, reduced cash crop yields, particularly in corn production systems.

BOTTOM LINE

This advanced practice can enable farms to cut back on herbicide and fertilizer inputs increasing profits, but farmers should be prepared for troubleshooting and yield declines.

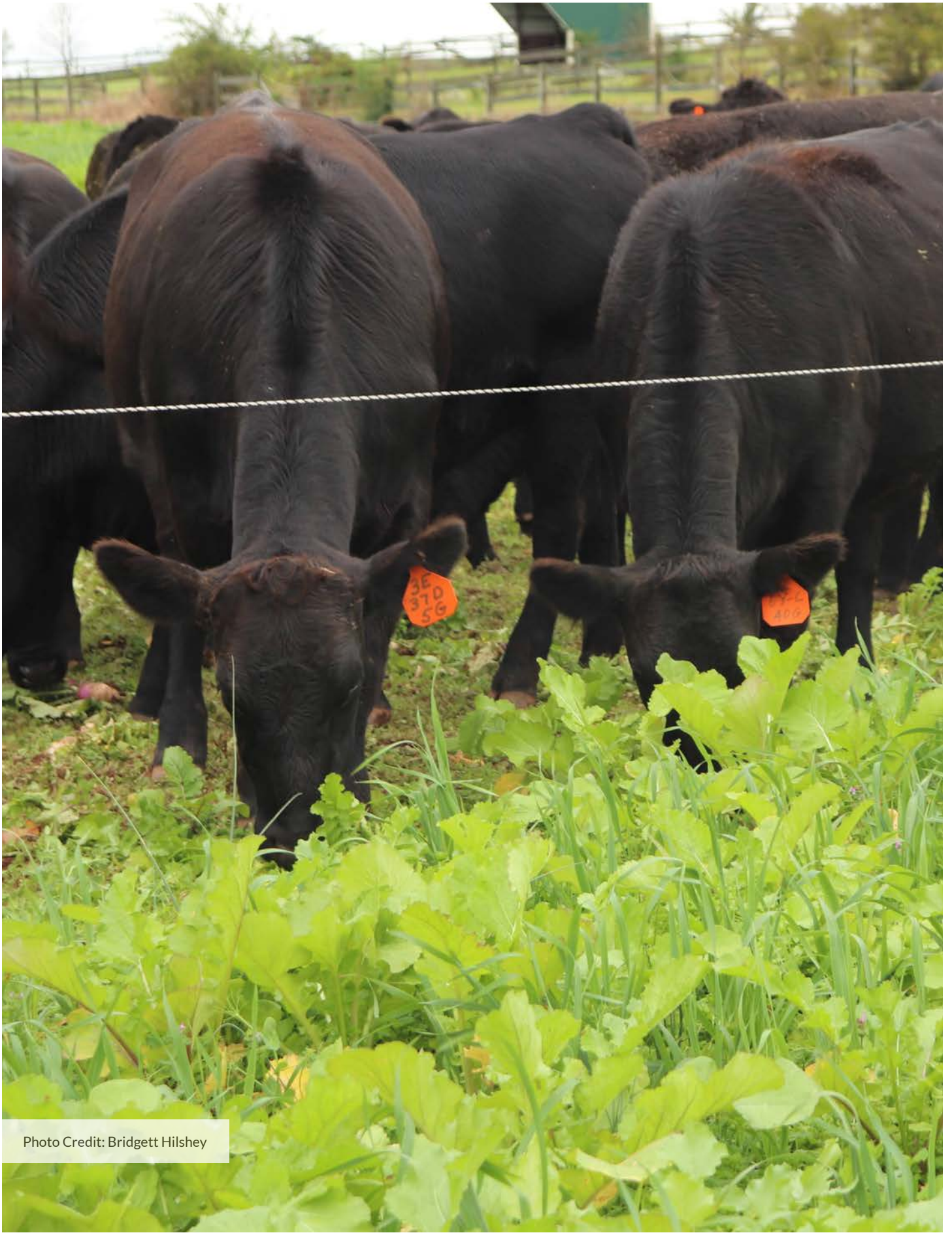


Photo Credit: Bridgett Hilshey

GRAZING COVER CROPS

Most cover crops can double as a high quality forage for livestock during the early spring or late fall; integrating livestock into crop systems accelerates soil health improvements.

COVER CROP SPECIES

SUMMER PLANTING FOR FALL GRAZING: Plant warm-season cereal grains such as sorghum sudan and pearl millet in July after harvesting winter grains.

If delaying planting until after mid-August, plant oats and peas. The yield will be lower for the oats, but because warm-season grains tend to be lower in digestibility, the forage quality of the oats will be higher than that of the sorghum sudan or millet. After a frost, the cool-season cereals like oats and barley wilt and discolour, but the forage retains its quality.

FALL PLANTING FOR SPRING GRAZING: Cool season cereals (winter wheat, oats, barley, and triticale) are popular for spring grazing. Cereal rye is the best choice if you're looking for a grass that comes on early in the spring, although the forage quality of cereal rye will decline rapidly as it matures.

EXPERT TIP
FALL GRAZING BRASSICAS

Forage brassicas (turnips, radishes, forage rapes and hybrid forage brassicas) can be planted along with the summer annual grasses (forage sorghum, sorghum-sudangrass, sudangrass and millet). Put the grass seed in the large box and the brassicas in the small box of the drill, keep the seeding rate of the brassica's low at 2 to 5 lbs./acre. The brassicas are one of the few crops that will compete with the fast-growing summer annual grasses. They will grow underneath the canopy of the summer annual grasses and you will have two levels of grazing, the summer annual grasses higher with the brassicas underneath. The brassicas will provide a higher portion of protein in the grazing mix. If the cattle have not grazed brassicas in the past, they may take a few days to get used to them, after that they will consume them readily.

- Dave Wilson, Agronomist
  Penn State Extension Educator

SEEDING RATE

Cover crops slated for grazing should be seeded at a 1.5 to 2x higher rate.

TIMING OF GRAZING

When grazing cover crop with cattle consider whether this is a milk, producing animal or a beef cattle. Dairy cows should have fiber from cover crops that is more digestible in order to ensure their high milk production. Beef production is different. Typically, with dairy cows, we graze the cover crops at an earlier stage of growth when the cover crop has more digestible fiber compared to later grazing with higher levels of fiber that can be done with beef producing cattle. Dry cows and heifers can graze the more mature cover crops.

CAUTIONS

RESIDUAL HERBICIDES

Many post emergence herbicides used in corn, and particularly in soybean, production prohibit using cover crops established in these fields for feed.

See “Herbicide use may restrict grazing options for cover crops” by Iowa State University for more information.

SATURATED SOIL CONDITION

Allowing animals to graze wet fields can negate potential soil health gains. Wet soil compacts easily; pugging can easily ruin a no-till field. Heavy corn residues will protect the field to some extent, but always remove cattle from saturated soil.

FORAGE TOXICITY CONCERNS

Nitrates concentrate in cover crops during cool, cloudy conditions to create toxic nitrate levels, particularly in the stem or stalk. Prussic acids can be a concern in warm season annuals after frosts and when plants are young or there is new regrowth following grazing or frost.

GRAZING COVER CROPS (CONTINUED)

GRAZING

When grazing cover crops, farmers aim to provide nutritious forage AND severely stunt vegetative growth through intentional over-grazing. This is best accomplished through mob grazing or other forms of intensive rotational grazing wherein livestock are confined with small temporary paddocks at high stock rates for a short amount of time.

Animals can be confined using either temporary or permanent fence:

PERMANENT FENCE: Most permanent fence consists of three to five strands of electrified wire. Anticipate installation costs between $1.50 and $3.00/ ft.

TEMPORARY FENCE: Temporary fence is a more cost effective option for (1) livestock well trained to hot wire, (2) rural areas and (3) when animals are not likely to cause a threat to human safety should they escape.

HARVESTING HAY OR HAYLAGE?

Farmers who don't have the option of installing fence or grazing can harvest the cover crops as a second spring crop.

Cover crops will create high quality forage with large income potential. However, the harvest and removal of the above ground biomass reduces potential soil health gains.

EXPERT TIP
TREAT YOUR COVER CROP LIKE A CASH CROP!

Farmers removing cover crop should "treat their cover crops like their cash crop" and ensure the field receive appropriate fertilizer/manure to compensate for lost nutrients.

PLANTING AFTER TERMINATION

Grazing will not fully terminate cover crops. Grazing severely reduces the above ground biomass and stunts the crop's growth. However, farmers will need to employ a secondary termination strategy to achieve full termination. Most farmers will use a light application of herbicide or tillage to terminate the remaining cover crop.

EXPERT TIP
FOR FARMERS WITHOUT LIVESTOCK

Grazing cover crops provides economic and soil health benefits to row crop acres. However, not every crop farmer has livestock, and not every livestock farmer grows crops. With adequate planning, it is possible to develop an arrangement between two farms so that cover crops can be utilized to benefit both parties. Search "Contracts for Grazing Cover Crops" for assistance developing agreements.

PROS	CONS	BOTTOM LINE
Accelerates soil health gains and maximizes profit potential	Requires substantial management and large initial fencing expenses; grazing saturated soil can cause compaction	A good source of secondary income for farmers with livestock nearby, but it needs to be carefully managed.

Photo Credit: Edwin Remsberg, USDA SARE
Winter-killed cover crops

WINTER KILLED COVER CROPS

Winter frosts will naturally kill certain annual cover crop species. The mat of cover crop residues offer some protection from erosion during the winter.

COVER CROP SPECIES:

Winter killed cover crops differ in their tolerance to frost.

HIGHLY FROST SENSITIVE:
Some species, like sorghum sundangrass, buckwheat, field pea, and oilseed radish, will die after the first hard frosts.

SOMEWHAT FROST HARDY SPECIES

Other species, like oats and some brassicas, when sown in summer, will put on a lot of growth and often maintain active growth into early November, dying slowly after several hard frosts.

To maximize biomass production, winter killed crops should be seeded in mid- to late-summer. Oats may be seeded as late as mid-September in milder climates.

PLANTING AFTER

Most winter killed cover crops will have begun to decompose by planting season in the spring. The nitrogen rich residues may even accelerate the decomposition of other brown residues from the previous season.

Decomposing residues on the soil surface may delay soil drying and warming in the spring.

EXPERT TIP
DECOMPOSING RADISHES

When radishes die and begin to decompose, they give off an odor similar to mercaptan, a chemical additive put in propane and natural gas. When large fields have a high density of radishes, the small can be so strong, neighbors have reported propane leaks to the authorities!

PROS

Zero termination related expenses

Enables farms to plant cash crops early in growing season

CONS

Cover crops need to be established earlier to achieve adequate growth before winter-killing; lack of living roots in the soil during winter and spring months leaves soil vulnerable to leaching and erosion

BOTTOM LINE

Most common option for organic operations. Great low risk option for beginning cover croppers

Photo Credit: Edwin Remsberg, USDA SARE
Tillage into mixed cover crop in preparation for planting Chestertown Maryland

TILLAGE

Tillage uproots cover crops and integrates their biomass into the soil while preparing the seed bed.

SUITABLE SPECIES

Tillage is generally effective at terminating most species of cover crops.

Cover crops with extensive root systems, such as annual ryegrass and perennial clover, like sweet clover and red cover, are notoriously difficult to terminate and may require multiple tillage passes.

TERMINATION TIPS

Farmers don't need aggressive tillage or multiple tillage passes to effectively terminate most cover crops. Farmers should practice conservation tillage and leave at least 30% residue on the soil surface. The remaining residue should be incorporated into the uppermost 2 to 4 inches of the soil surface.

There is a wide variety of tillage tools. Common examples include:

- Rototiller
- Chisel Plow
- Disc
- Spring Tooth Harrow
- Moldboard (not recommended)

EXPERT TIP
RENTING EQUIPMENT

Many dealers will rent different types of tillage equipment by the hour or acres. Before making any large purchases, farmers should try the equipment on their land to be sure it meets their needs and goals.

PROS

Compatible for organic operations; uses equipment that most farmers have on hand, prepares a seed bed

CONS

Tillage exposes soil carbon to oxygen, accelerating soil organic matter decomposition. Tillage distroys soil structure and creates conditions for soil crusting. Exposed soil from tillage is prone to erosion

BOTTOM LINE

Most common option for organic operations, especially vegetable operations and operations that require a smooth even seed bed.

Photo Credit: Kara Pittman, VA

MOWING

Timely mowing can be an effective tool to terminate some cover crops without disturbing the soil or using herbicides. Mow-killing is only effective for certain cover crop varieties at certain times of their growth cycle.

COVER CROP SPECIES

The following winter hardy annuals can be effectively killed through timely mowing:

- Barley
- Cereal rye
- Hairy vetch

Many forbs and brassicas can also be effectively terminated through mowing. However, as they also tend to winter kill, such interventions are typically not necessary.

EXPERT TIP
MULTI-SPECIES MIXES

Multi-species mixes will flower at different times. Because of this, farmers will not be able to mow at full bloom and termination will be less effective.

TERMINATION TECHNIQUE

Mowing is ONLY effective, as a termination tool during early reproductive phases (flowering). During this phase in plant development, plant energy is concentrated into producing seeds and the plant will generally die when mowed.

Rotary mowers can lead to wind-rowing of crops making some strips hard to plant with the uneven residue. A flail mower is more ideal if the biomass gets to high. Another less common option is the Undercutter roller which is designed too slice shallowly through the soil and cut cover crop roots underground.

EXPERT TIP
MOWING AND HERBICIDE

Do not attempt to mow prior to using herbicide. If you mow and then decide to use herbicide, the effectiveness of most herbicides will decline.

PLANTING AFTER TERMINATION

Planting with a planter or drill may be very difficult after mowing. The plant stems, detached from the roots, will tend to bind or wrap. The mowed stems will face in many different directions. As a result, the use of mowing to terminate cover crops should be reserved to situations where cash crops will be planted by hand or the stems will be lightly incorporated into the soil.

EXPERT TIP:
PLANTERS AND DRILLS

Never attempt to seed cash crops using a drill or planter through mow-killed cover crops unless the crops were harvested and removed. The loose stalks will quickly bind row cleaners and closing wheels.

PROS	CONS	BOTTOM LINE
Compatible for organic operations; uses equipment that most farmers have on hand, potential for substantial above-ground biomass production	Planting must be delayed until late spring; fields are not suited to planting using a planter or drill after mowing	Great option for small vegetable and speciality crop operations that don't mind waiting until late spring to begin planting.

PART THREE:
ADVANCED SOIL HEALTH PRACTICES

Photo credit: Bridgett Hilshey

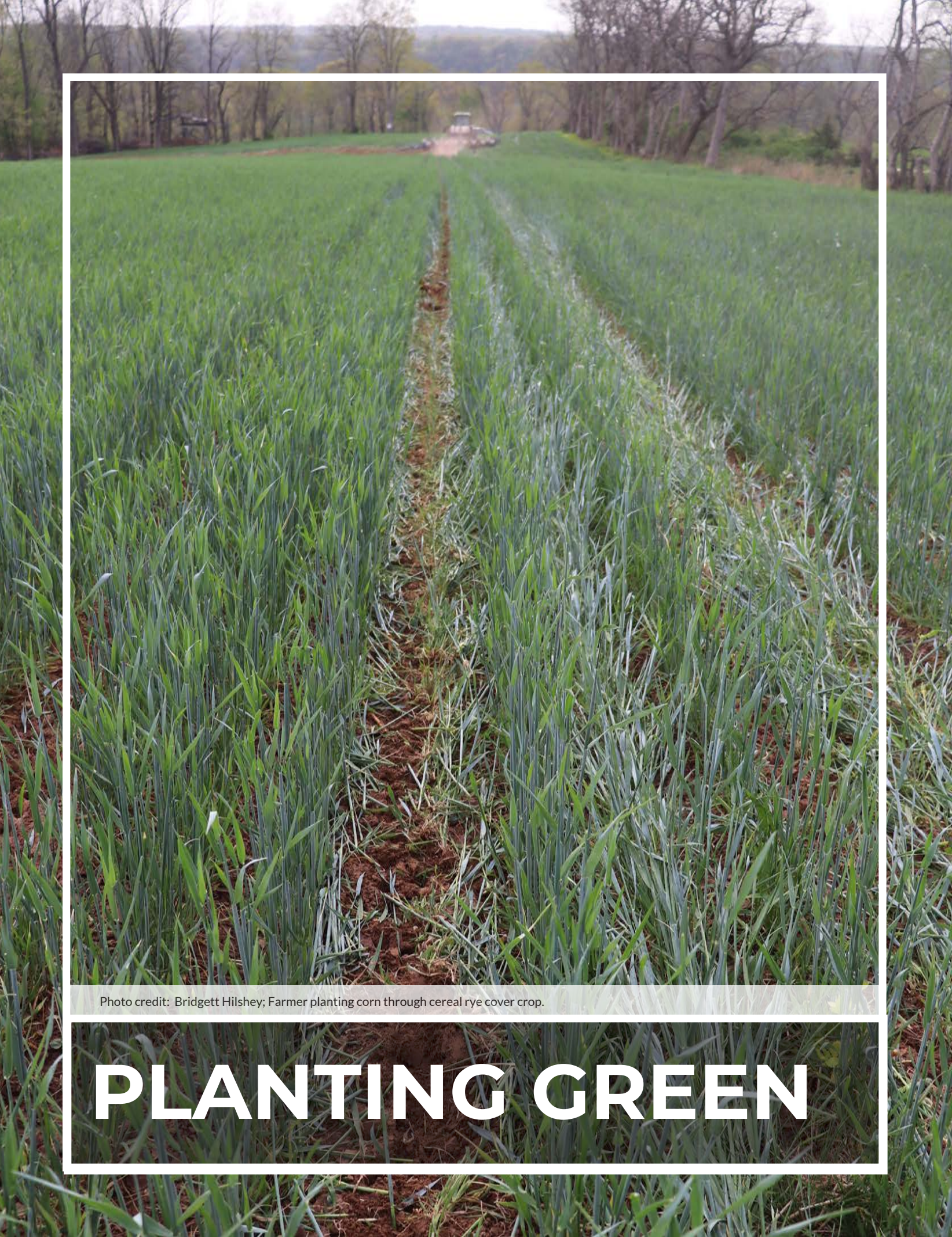


Photo credit: Bridgett Hilshey; Farmer planting corn through cereal rye cover crop.

PLANTING GREEN

TAKE YOUR NO-TILLING & COVER CROPS TO THE NEXT LEVEL

"Planting Green" refers to no-till planting a primary crop into an actively growing cover crop before killing it with an herbicide. This advanced soil health practice allows cover crop to grow longer, maximizing above and below ground biomass.

BENEFITS OF PLANTING GREEN

Planting green has agronomic and soil health benefits. By allowing cover crops to grow longer, farmers can take advantage of their soil health building traits.

PLANT EARLIER WHEN COVER CROPS CAN'T BE TERMINATED UNTIL LATER

A wet spring may prevent farmers from entering fields to terminate cover crops until later in the growing season. Having to wait an additional 2-3 weeks for the cover crops to die and dry out will push-back cash crop planting late into the year.

Farmers cannot plant into dying cover crop; as cover crop slowly dies, the above ground biomass stays moist and difficult to cut through, opening up the potential for excessive hair-pinning.

By planting green, farmers don't have to wait for cover crops to dry down and can plant weeks earlier. Well maintained planting equipment will slice through living cover crop.

FIX MORE ATMOSPHERIC NITROGEN INTO THE SOIL

Cover crops selected for their ability to fix atmospheric nitrogen will fix substantially more when allowed to grow longer. Peak legume N2 fixation occurs after flowering, so delaying termination a few weeks can drastically increase nitrogen additions to the soil.

BUILD UP SOIL ORGANIC MATTER FASTER

Cover crop residues within a more mature vegetation have a higher C:N ratios, and are more resistant to decomposition. As these residues are incorporated into the soil and decompose, significant enhancements are seen to soil biological activity, biological diversity and potential soil carbon sequestration and soil organic matter gains.

Photo Credit: Bridgett Hilshey
Cover crops can accumulate large amounts of carbon-rich residues that, as they decompose, will feed soil microorganisms and build soil organic matter.

LESS DEER AND SLUG DAMAGE

When planting green, the green cover crop residue may serve as a food source for pests like deer and slugs, reducing potential damage to cash crops.

REDUCE COMPACTION WHEN PLANTING

Actively growing cover crop can dry the soil faster during wet growing seasons. This allows farmers to enter fields earlier for planting and reducing the potential for compaction. Cover crop roots will grow deeper, increasing water infiltration and reducing soil compaction.

CREATE A THICK SOIL MULCH

Large mats of cover crop biomass on the soil surface cools the soil, improving soil moisture conservation and reducing plant transpiration during the growing season. The mulch can also reduce (or eliminate) the need for post emergence herbicide.

EXPERT TIP

CLEANER & HEALTHIER PRODUCT FOR SPECIALTY VEGETABLE OPERATIONS

A dense residue mat will reduce ground contact for crops like pumpkin, winter squash, processing tomatoes, and u-pick operations. The physical barrier can result in cleaner, more attractive, marketable crops that are more likely to be free from ground contact defects.

Photo Credit: Edwin Remsberg
Pumpkins growing after planting into rye cover crop in Western Maryland USA

RISKS AND WARNINGS FOR PLANTING GREEN

Planting green opens farmers up to the potential of significant planting problems and yield losses when not implemented correctly.

NITROGEN TIE-UP

Mature cover crop has a high carbon to nitrogen ratio. It is essential to apply extra starter fertilizer (in-slot and/or knifed in beside seed slot) and/or additional nitrogen during planting.

The overall nitrogen requirement is typically not higher when planting green, however, more of the nitrogen should be applied at planting or earlier in the crop's growth.

NEVER MOW FIRST!

Planting green works well when the cover crop remains intact and attached to the roots. When the cover crop is mowed, the stalks will become entwined in the residue cleaners, coulters, opening disks, and closing wheels.

Furthermore, herbicides are much less effective when applied on cover crop that has been mowed.

DURING DRY CONDITIONS...

Be wary of planting green during a dry spring, or if a dry period is anticipated! Actively growing cover crops can rob moisture from cash crops, inhibiting germination and growth.

If a dry spring is underway or drought is in the forecast, consider "pulling the plug" on the winter annual cover crop and kill it early instead of letting it grow longer in the spring. This will conserve limited moisture in the soil in droughty conditions.

EXPERT TIP
DRY CONDITIONS WON'T IMPACT HIGH FUNCTIONING SOILS AS MUCH

Soils under long-term no-till and cover crop management typically won't have a plowpan or other restrictive layer and should have a higher capacity to hold and store water. These high functioning soils are more resilient against doughty conditions.

Photo Credit: Bridgett Hilshey
Yellowing lower leaves on corn plants is indicative of a nitrogen deficiency, exacerbated by the carbon-rich, heavy cover crop residues.

CORN IS PRONE TO YIELD LOSSES

Corn seedlings are sensitive to competition for light and moisture. Farmers trying to plant green should always start with soybeans, which don't tend to be strongly impacted by the presence of surrounding cover crops.

WON'T WORK IN ALL CROPPING SYSTEMS

Planting green is not appropriate for crops that depend on early planting and early maturity.

EXPERT TIP
ALLELOPATHIC EFFECTS

Cereal rye releases compounds that can inhibit seed germination; these chemicals are often cited as a reason for the yield decline most farmers experience when planting corn into growing cover crops. It is more likely the nitrogen tie-up is the cause of yield decline. Although small-seeded weeds definitely are inhibited by allelopathy, large seeded weeds and crops like corn, are minimally impacted. Most allelopathy studies that have shown otherwise were performed in the laboratory setting where differences between sterile media versus soil impacts results.

- Heidi Reed
  Penn State University.

PLANTING GREEN AND CROP INSURANCE

For cash crops following cover crops, Risk Management Agency (RMA), Natural Resources Conservation Service (NRCS), and the Farm Service Agency (FSA), organized an interagency work-group to develop a consistent cover crop policy across the three agencies. The interagency group developed the NRCS Cover Crop Termination Guidelines, with the guiding principle that cover crops maximize conservation benefits and increase management flexibility, while minimizing yield reduction risk in the insured crop.

The 2020 federal guidelines for terminating cover crop in New England and Mid-Atlantic Regions:

> Terminate cover crop at or within 5 days after planting, but before crop emergence. If the cover crop is part of a no-till system, termination can be delayed up to 7 days from the above termination period guideline, but terminated prior to crop emergence.

TWO OPTIONS FOR PLANTING GREEN

The term, “planting green” refers to two very different practices: one uses herbicide to terminate cover crop in a vegetative growth stage and the other uses roller-crimpers to terminate cover crop in a reproductive/flowering stage.

1 WITHOUT ROLLER CRIMPERS

In this scenario, cover crops in the vegetative growth stage are terminated with only herbicide during or shortly after planting.

PROS: Requires no specialized roller crimping equipment; suitable for a wider diversity of cover crop species; enables earlier cash crop planting.

CONS: Potential for cover crop to wrap on planter wheels and disks; requires more herbicide than a roller crimper.

2 WITH ROLLER CRIMPERS

“Rolling” is a means of mechanically terminating cover crops by crushing and/or snapping the stems using heavy drums or rollers.

PROS: Suitable for organic and non-GMO operations; requires little to no herbicide; cover crop will form an excellent mulch.

CONS: Requires specialized and often expensive equipment; more mature cover crop breaks down slowly, tying-up nitrogen; prohibits earlier cash crop planting.

Hitch Mounted Roller Crimper

Most roller crimpers are water-filled drums mounted with chevron-patterned blades pushed in front of or pulled behind the tractor.

PLANTING AFTER CRIMPING

Crops usually need to be planted in the same direction of travel as the crimper traveled.

EXPERT TIP
PLANTING DIRECTION AFTER ROLLING

Although planters should usually plant in the same direction that crops were rolled, there is one exception. Yetter shark tooth coulters work very well planting in the opposite direction as the cover crop was rolled. Do NOT try to plant crosswise over rolled cover crop.

- Jim Hershey
PA No-Till Alliance President
Hershey Farms, Elizabethtown, PA

Termination methods associated with planting green are suited to a specific blend of cover crop at a specific growth stage - so it is important to plan accordingly.

Planter Mounted Roller Crimper

FRONT OR BACK MOUNTED

When pulling a rear 3-point hitch mounted roller crimper, the tractor tires push cover crops down prior to contact with the blades, resulting in uneven crimping in the wheel tracks. Front mounting the crimper eliminates this problem; farmers can crimp and plant in a single pass. While front mounting is recommended, a Laforge Systems front 3-point hitch may cost more than a roller crimper.

EXPERT TIP
MOUNTING ON PLANTERS

Most of the tine rollers (hitch-mounted) do not match up to some planters. Be aware, farmers may need to be creative in order to attach a roller to a planter.

PLANTER MOUNTED OPTIONS

Dawn Equipment and Yetter manufacture a planter mounted cover crop roller crimper, which allows farmers to easily crimp tall cover crops and plant in a single pass. As of 2020, they are not compatible with all planters.

PROS: Mounting a roller on the planter enables operators to terminate cover crop and plant in a single pass.

CONS: Cover crops can only be crimped during planting. In certain years it may be advantageous to terminate cover crops 1-2 weeks before planting to avoid cover crops growing out of control. Cover crop termination may also be uneven behind the wheel tracks.

Planter mounted roller-crimpers can not be mounted on split row planters and therefore can not be used in 15” soybean systems.

HOW TO PLANT GREEN USING CHEMICAL CONTROL

This practice is not recommended for new no-tillers. Those with more experience with conservation tillage and cover crops are more likely to be successful with this practice.

WHO SHOULD PLANT GREEN?

Farmers with more than three years of experience with no-till and cover crops should consider experimenting with planting green.

Planting green and terminating with herbicide is a good choice for the following scenarios:

- Situations where cover crop grew too large and farmers don't want to wait 2-3 weeks for the plant to dry before planting.
- Farms looking to dramatically boost soil organic matter
- Farms looking to reduce compaction deeper in the soil profile
- Farms that routinely have substantial slug and deer damage to seedlings
- Farms with substantial erosion between rows during the growing season.

FIELD /CROP SELECTION

START WITH SOYBEANS: Start out with a small field slated for soybeans. Research has shown that soybeans are more adaptable to this practice; soybeans tolerate being shaded and starting with a legume crop minimizes potential challenges with nitrogen tie-up by mature cover crops.

HEAVY WET SOILS: This practice is best suited to high-clay soils that are slow to dry. Actively growing cover crops will lap up rainfall, drying wet soils faster and enabling farmers to plant earlier.

SOILS WITH A LONGER HISTORY OF NO-TILL AND COVER CROP. Soils should be accustomed to no-till with a healthy population of soil microorganisms that will aid in the breakdown of cover crop residues and the release of nutrients.

COVER CROP

EASY TO KILL VARIETIES: Select cover crops that are relatively simple to kill using herbicide and are slower to mature and enter reproductive phase. (Cover crops in reproductive phases are more difficult to terminate with herbicide).

REDUCE SEEDING RATE: Reduce cover crop seeding rate by 30%, especially if applying manure.

EXPERT TIP

COVER CROP SPECIES AND RATE

The following mix would be a good choice for delayed termination and planting green:

- 5 lbs/acre Crimson Clover
- 15 lbs/acre Annual Ryegrass
- 3 lbs/acre Winter Peas

Crimson clover is the easiest legume to terminate and grasses are slower to reach maturity in the spring compared to other cereal grains.

Photo credit: Bridgett Hilshey

OUTFIT PLANTERS

Use a planter, rather than a drill, for establishing soybeans. Planters are better suited for planting through thick residues.

ROW CLEANERS: Row cleaner will wrap with residues. Strongly consider either adding an aggressive stripper (such as the Dawn Bayonet Stripper) or remove the row cleaners all together.

OPENING DISKS: It is crucial that opening disks be sharp with a well defined bevel! Replace opening disks at least every 50 acres (per row unit) to make sure they are sharp enough to cut green residues.

CLOSING WHEELS: Use short spiked closing wheels. These are less prone to wrapping but should also be able to adequately close the trench. Smooth iron wheels are also effective on loamy and sandy soils.

PLANTING

When starting out with planting green, aim to plant cash crops when cover crops are between 5" and 10" tall.

PLANT DEEP

Consider planting a little deeper to cleanly cut the cover crop residue and avoid "hair-pinning" when planting corn.

STARTER FERTILIZER

As cover crop matures, it contains less nitrogen per unit of carbon. As a result, mature cover crop decomposes slower and ties up soil nitrogen. To compensate, be sure to add extra starter N if planting corn or other non-leguminous crops.

Anticipate being able to cut back on side-dress N application later in the season.

EXPERT TIP
STARTER FERTILIZER

Ideally, add a 28% N starter using a 2-by-2-inch fertilizer applicator. A 32% N starter can burn seed and negatively impact germination.

HERBICIDE SELECTION AT RATE.

Most importantly, make sure you burn down the cover crop right away after planting green so that the cover will die as quickly as possible, especially when starting out with this new practice.

EXPERT TIP
HERBICIDE

A full rate of glyphosphate on a sunny, warm day should be adequate to terminate cover crop. As much as possible, aim to apply herbicide in the morning after most dew has evaporated.

HOW TO PLANT GREEN & TERMINATE USING A ROLLER CRIMPER

This practice is not recommended for the beginning no-tillers. Those with more experience with conservation tillage and cover crops are more likely to be successful with this practice.

FIELD /CROP SELECTION

START WITH SOYBEANS: Start out with a small field slated for soybeans. Research has shown that soybeans are more adaptable to this practice; soybeans tolerate being shaded and starting with a legume crop minimizes potential challenges with nitrogen tie-up by mature cover crops.

HEAVY WET SOILS: This practice is best suited to high-clay soils that are slow to dry. Actively growing cover crop will lap up rainfall, drying the soils faster and enabling farmers to plant earlier.

SOILS WITH A LONGER HISTORY OF NO-TILL AND COVER CROP. Soils should be accustomed to no-till with a healthy population of soil microbes, flora, and fauna that will aid in the breakdown of cover crop residues and the release of nutrients.

COVER CROPS

PLANT EARLY FLOWERING GRAINS:
Not all cover crop species are suited to termination using a roller crimper. Elbon rye is the earliest flowering commercial rye cultivar. Triticale may also be used. However, it won't reach maturity until five to seven days later than Elbon rye.

EXPERT TIPS

SPECIES FOR ROLLER CRIMPING

In order to obtain adequate kill with a roller, only use "winter annual cover crops" such as winter grains, hairy vetch, crimson clover and winter peas. All of these can be killed by rolling after flowering or early pod formation. For organic production don't use perennial clovers like medium red clover or white clover or biennial clover like sweet clover. These will not kill by mechanical rolling alone. Annual ryegrass, although an annual, is not a good candidate for mechanical kill in organic systems.

- Dave Wilson, Agronomist
  Penn State Extension Educator

EXPERT TIPS

WHAT TO PLANT

To start out with, 1.5 bu/acre cereal rye is a good choice for roller crimping. When relying on cover crop for weed suppression, consider 2+ bu/acre.

HAIRY VETCH

Adding hairy vetch to the seed mixes slated for roller crimping can be problematic. Hairy vetch has a large proportion of hard seed which can remain viable in the soil for years to come.

Waiting until full bloom when using a roller crimper to control hairy vetch it is critical; the practice limits seed production and minimizes volunteer problems. However, cereal rye will mature earlier than hairy vetch, making optimum rolling timing more complicated for mixtures containing both species.

If you do plan to try hairy vetch, triticale can be a better companion crop because it matures at the same time as hairy vetch.

Photo credit: Bridgett Hilshey

OUTFIT PLANTERS

Use a planter, rather than a drill, for establishing soybeans. Planters are much more suited to planting through thick residues.

Different types of roller crimpers are best suited to different situations. See "Roller Crimpers" on page 78 for more information.

ROW CLEANERS: Row cleaners will wrap with residues. Strongly consider either adding an aggressive stripper (such as the Dawn Bayonet Stripper) or remove the row cleaners altogether. Another good option are concave disks that part the cover crop without the danger of crop wrapping.

OPENING DISKS: It is crucial that opening disks be sharp with a well defined bevel! Replace opening disks at least every 50 acres (per row unit) to make sure they are sharp enough to cut green residues.

CLOSING WHEELS: Use short spiked closing wheels. These are less prone to wrapping but should also be able to adequately close the trench.

COVER CROP TERMINATION

TIMING IS CRITICAL! The ideal time to roller crimp any cover crop is during flowering. At this stage crimping consistently kills the cover crop before viable seeds are produced.

HERBICIDE: For reliable weed suppression, roller crimpers can be used in combination with herbicides. Burn-down herbicide at rolling suppresses perennials, germinated annuals, and terminates cover crops more uniformly and efficiently.

ORGANIC TERMINATION: To improve the control of the cover crop in organic systems, consider rolling cereal rye twice -- once approximately one week before planting and again on the day of planting.

Photo Credit: Bridgett Hilshey
Thick cover crop residue alone will not suppress weeds in an organic setting.

PLANTING

PLANTING DEPTH: Consider adjusting gauge wheels to account for the extra biomass. Many producers also recommend planting deeper to reduce hairpinning and potential negative impacts from decaying rye residues.

STARTER FERTILIZER: As cover crop matures, it contains less nitrogen per unit of carbon. As a result, mature cover crop decomposes slower and ties up soil nitrogen. To compensate, be sure to add extra starter N if planting corn or other non-leguminous crops.

Anticipate being able to cut back on side-dress N application later in the season.

EXPERT TIP
STARTER FERTILIZER

Ideal starter fertilizer should contain:

- 30 lbs of N 2x1 or dribbled behind closing wheels or 5 gallons 7-21-7 starter in furrow.

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A collaboration between farmers, crop consultants, and agricultural specialists across the mid-Atlantic.

SOILS ARE MEANT TO BE COVERED

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