A Guide to Implementing No-till Cropping Systems in the Northeast

A Publication of the University of Vermont Extension Northwest Crops and Soils Program

THE UNIVERSITY OF VERMONT EXTENSION

NORTHWEST CROPS & SOILS PROGRAM

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Introduction

Tillage has been a long tradition in Vermont. The heavy textured, cold, and wet soils that are predominant throughout the state have been a reason to get out and fall plow. The need to terminate the old hay field, incorporate the manure, and get a jump on an already short growing season are often the reasons we have all used to keep the steel moving through the field year in and year out. However, over time we are all learning that this intense, frequent tillage also reduces many critical functions of the soil. Constant disturbance through tillage reduces soil particle aggregation, thereby increasing susceptibility to erosion and reducing porosity and tilth. Reduced soil aggregation also leaves soil organic matter subject to degradation and can reduce the biological activity in the soil impeding nutrient cycling. Conversely, when soils are left undisturbed, such as in no-till cropping systems, soil structure and biological activity are protected, providing the soil with the air, water, and nutrients needed to support healthy, high yielding crops while sequestering more carbon. This also allows for the reduction in labor and other costs associated with those field operations.

Can we successfully grow crops in Vermont without tillage? Vermont farmers are having success with no tillage systems, however, making the transition to a no-till cropping system isn't as simple as removing tillage activities. Every aspect of crop and soil management must be considered and adjusted for optimal results; you're transitioning your management system, not adopting a singular practice. This guide is intended to help farmers understand the considerations that need to be made before trying no-till and strategies for continued monitoring and adaptation to support successful implementation of no-till cropping systems.

Image 1. Successful no-till corn planting in Vermont.

Assessing if no-till is right for you

As with any management change, doing your best to consider if it is right for you and your farm *before* making the change can help avoid running into unforeseen challenges and better position you for success. There are important considerations for both the manager and the land that should be critically assessed before changing management; not everyone and every field is well-suited to no-till.

Are you ready for no-till?

Making significant management changes on a farm always takes time, commitment, both financial and personal investment, attention to detail, and a willingness to learn and adapt. No-till is no exception. Recognizing whether you are willing and able to make these commitments is critical. Your expectations and attitude also play a major role in your decision making and ultimately your success. It is important that you maintain a critical but open mind as you explore no-till. If you change your goals and principles guiding

your management, as you will with implementing no-till, then you need to properly adjust your expectations and definitions of success to match this new system. Farmers who neglect to do this are often dissatisfied with their outcomes, not because the outcomes were necessarily bad, but because they did not meet their unreasonable expectations. Therefore, it can be very helpful to learn as much about no-till and what is reasonable to expect from experienced farmers and other professionals. Farmer-to-farmer learning opportunities, such as field days, workshops, and demonstrations, are great ways to gain practical advice and ask questions. Learn from others' mistakes before you make your own! Furthermore, be willing to admit to yourself where you may need more information and education. Simply forging ahead without addressing critical knowledge and skill gaps will not set you up for success. As with any new technology, no-till has its own learning curve. Additional educational resources can be found at the end of this publication.

Are you fields ready for no-till?

Just as no-till isn't a good fit for every manager, not every field is up to the challenge either. For fields you are considering for no-till, you must first consider their status in terms of soil condition, fertility, management, and water quality concerns.

What is the soil texture and drainage? - Producers growing on heavy clay soils typically rely on tillage as a means of mitigating surface compaction. Under no-till management, these soils have the potential to become severely compacted, complicating planting and limiting crop performance. The use of cover crops and good internal drainage (subsurface tile) systems can help mitigate this limitation. Saturated soils limit oxygen, microbial activity, nutrient availability, and thus impact crop performance. Begin to implement no-till on fields that are moderately-well to well-drained.

How rocky is the soil? - Rocky fields can be difficult to manage in tillage systems as substantial time must be invested in picking rocks and preparing a smooth seedbed. These fields may be better suited to no-till as no-till will help facilitate crop rotations out of perennial sod. However, be aware that rocks also pose significant wear and tear on no-till equipment.

Image 2. Soil sampling.

What is the current soil fertility? - Soils with underlying nutrient deficits are not well-suited to no-till. Start by soil testing the fields in question and amend as recommended to bring soil nutrients to optimal levels before you transition them to no-till. Soil pH should fall between 6.2 and 6.8 for most field crops. Adjusting soil pH is quicker when liming agents are mixed directly into the soil. Hence, tending to lime needs of a field should occur prior to transition to no-till. It should be noted, that over time no-till systems can lead to stratification of nutrients after years of only applying nutrients to the surface. Nutrients like phosphorus attach to the soil near the surface. This could be a consideration in some fields that have a high risk of runoff to surface waters. Adjusting soil pH and nutrients to optimum levels before converting to no-till is also critical for long term success.

What is the field history? - Considering what crops, tillage, and other management practices have occurred on the field in recent history can help judge whether additional improvements should be made prior to the conversion to no-till. Continuous annual cropping systems with intensive tillage, for example, are difficult to transition to no-till immediately. Greater success is seen when these fields are transitioned first to perennial sod for a few years prior to converting to no-till. This can help make the transition more slowly and prevents dramatic changes in crop performance as the system is being adjusted. Starting with old

perennial sods may be a good starting point if pH and fertility requirements are met. It is also important to consider past pest and disease pressures including weeds. Tillage often helps mitigate some of these pests and therefore could become more challenging under no-till management.

How steeply sloped and close to water is the field? - Steep fields and those close to sensitive surface waters may be good candidates for no-till management as tillage in these situations poses significant risk to sediment and nutrient losses through erosion. Ensure that the proper buffers and setbacks along surface waters are employed to protect them from potential nutrient losses prior to converting to no-till.

Cropping system changes

Rotations

As farmers feel pressures to cut costs and increase production efficiency, pressure on fields to produce the maximum amount of feed tons year after year has led to a significant reduction in the use of effective crop rotations in corn silage systems. Rotating crops, particularly between annual and perennial crops, can help alleviate compaction, enhance nutrient cycling, and break up some pest and disease cycles. Reaping these benefits is critical in no-till systems where these factors, if left unaddressed, can pose significant challenges to crop success. In the northeast, several rotation options exist, however, the most common would be to rotate between corn silage and perennial forages. Without tillage, previous crop and weed residues must be managed through mechanical and/or chemical means. It is important to recognize that these changes may further impact other management decisions. For example, herbicides for terminating previous perennial crops and controlling weeds must be carefully selected as to not interfere with the establishment of the subsequent cash crop or cover crop. Where crop rotations are not possible, stacking practices, such as cover cropping, no-till planting, and manure injection, can lead to significant improvements in soil quality and reductions in environmental risk.

Varietal selection and seeding rate

One of the main challenges in no-till crop establishment is obtaining an adequate and uniform population of the cash crop. Without tillage, the amount of residue, soil moisture, and soil temperature at planting can vary widely across the field. Selecting varieties that have early seedling vigor and are well-adapted to a wide range of growing conditions can help increase your chances of establishment success despite such variation. Depending on your management style, corn varieties can be selected with traits that allow for post-emergence herbicide applications to help manage weed pressure. Additionally, consider compatibility with other management practices such as cover cropping. Varieties with a more vertical leaf architecture may be more conducive to interseeded cover crop success whereas varieties with shorter relative maturities will provide more time to establish a cover crop post crop harvest. Regardless of the variety, increasing seeding rate to 10% above your target population can also help ensure you obtain a more even, adequate stand. It is critical in no-till systems to make sure your planter is placing seed at adequate depth. Planter adjustment and maintenance is key to no-till success.

Fertility management

Another component of early season vigor and establishment is fertility. Ensuring your establishing crop has access to adequate fertility from day one is crucial. The high residue nature of no-till systems, especially those that utilize cover crops, presents challenges for early season fertility management. Incorporating nutrients, whether from cover crops, manure, or fertilizer, into the soil profile allows direct contact with soil microorganisms to aid in and expedite the mineralization process while also protecting nutrients from losses due to volatilization or other loss risks. Without tillage, however, this decomposition process is significantly slowed making critical nutrients, such as Nitrogen (N), less available for your crop. For example, studies conducted at UVM, have shown lower concentrations of soil nitrate-N over the growing

season in conventional and no-till soybeans grown following a winter rye cover crop (Figure 1). The soil nitrate-N content increased more quickly in the spring and remained higher in the tillage system compared to the no-till system.

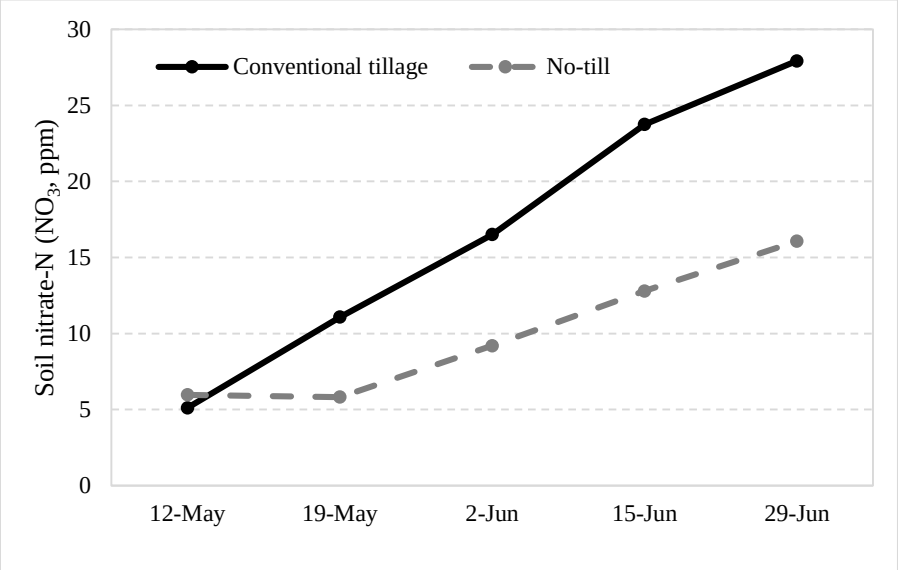

Figure 1. Soil nitrate content under conventional tillage and no-till management in soybeans following a winter rye cover crop.

Additionally, surface applied manure in no-till systems exposes the available N to volatilization and other losses. According to the Nutrient Recommendations for Field Crops in Vermont, as little as 40% of the available N and 25% of the organic N may be available to the crop when surface applied. This is in stark contrast to more than 70% of the available N and 35% of the organic N when incorporated into the soil within 8 hours of application. If manure injection equipment is available, up to 95% of the N in manure, depending on soil type and drainage, can be protected from these losses thereby increasing the amount available to the crop and lowering the additional fertilizer needed. In Vermont, farms that have adopted no-till systems with injected manure and cover crops have nearly eliminated or minimized the need for topdress N applications in their corn crops. In addition to the injectors designed for use in annual crops, specialized models exist for use on perennial forage stands.

Image 3. Manure injectors for use in no-till cropping systems
Image source: https://i0.wp.com/blog.uvm.edu/cvcrops/files/2018/06/Injector2.jpg

Given the nutrient availability limitations under no-till management, it is beneficial to provide 30-50 lbs. N per acre at corn planting. Ideally, the planter would be set up to dribble or band in nitrogen, however, broadcasting nitrogen before planting and working it into the ground with the planter is also an option.

To avoid negative impacts on crop yield, additional fertility beyond what would typically be used in a conventional tillage system may be required. Another study comparing no-till and conventional corn silage following cover crops, showed mid-summer soil nitrate levels to be twice as high in the conventional tillage system compared to the no-till system after both received manure (Figure 2). Based on these levels, an additional 40 lbs of N ac^{-1} would be recommended in the conventional tillage system compared to 80 lbs N ac^{-1} in the no-till system for the same target yield.

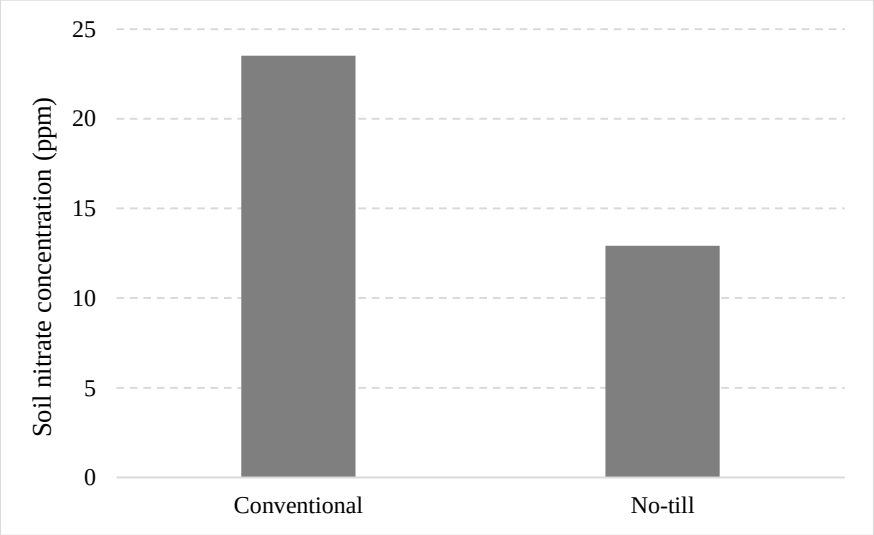

Figure 2. Soil nitrate content at topdress under conventional tillage and no-till management in corn silage following a winter rye cover crop.

The use of the Pre-Sidedress Nitrate Test (PSNT) can help guide additional fertility application needs. This can help avoid over-fertilization, which can delay crop maturity and thus can delay harvest into times in the year where weather conditions become more variable.

Pest management

Insects, diseases, and weeds can all impact crop performance. Tillage can be an effective strategy for minimizing populations of these pests that reside on crop residue or in the soil at least for some duration of their life cycle. In no-till systems, if left unchecked, populations of pests can increase over time and pose significant issues to crop. In addition to managing for existing pests, the high residue nature of no-till systems can also provide opportunities for new pests to emerge. Slugs and armyworms (Image 4) are two common pests that tend to be more prevalent and potentially devastating in no-till systems compared to conventional tillage systems. These pests thrive in environments with high residue that protects them from predators and other pest management strategies. Scouting crop fields for pests throughout the season is a critical strategy for monitoring pest populations and evaluating pest management strategies.

Image 4. Slug damage in no-till corn.

Scouting requires special attention to detail and should be conducted on a regular basis by trained staff who allocate sufficient time to conducting thorough observations on sufficient acreage of the farm. Neglecting to invest the time needed to observe the crop will only prevent you from responding to a serious pest outbreak, potentially causing significant crop losses. Make sure you understand how to identify key pests associated with your crop at various stages in their life cycle and that you know when and where to look for them. Additional information on pest management can be found at the end of this publication.

Cover cropping in no-till systems

The foundation of a successful no-till system is a healthy, high functioning, high quality soil. Cover crops are a critical component in supporting healthy soils and therefore, are a perfect companion to no-till. Research has shown that the addition of a winter cover crop to a no-till corn silage system can increase soil respiration and aggregate stability without compromising yields (Table 1). Furthermore, while no-till alone provides some increase in soil health, the combination of both no-till and cover crops provides significant improvement in soil health over conventional tillage with no cover crop. However, integrating cover crops into a no-till system presents unique challenges.

Table 1. Corn silage yield and soil health metrics in conventional and no-till systems over three years.

Treatment	Corn yield	Respiration	Aggregate stability
	tons ac^{-1}	mg CO_2 g $soil^{-1}$	%
No-till with cover	18.0	0.749	38.4
No-till no cover	18.0	0.689	34.4
Conventional tillage with cover	19.6	0.727	34.3
Conventional tillage no cover	21.6	0.638	30.8

Cover crop planting

The two major distinguishing factors between no-till and conventional tillage systems are higher levels of plant residue and unprepared soils. Anytime you are using equipment to place seed, fertilizer, or some other material into the soil, your equipment will need to be able to overcome these challenges. Using equipment that is not specifically designed or modified for these conditions will likely result in failure. Timing and other management changes may also be required to better suit no-till conditions. For example, broadcasting seed will be much less successful in a no-till system given there is much lower of a chance for the seed to make its way onto bare soil. However, planting the cover crop with a drill following the cash crop harvest may be more successful in a no-till system because less time is required to get the cover crop in the ground once tillage is eliminated. A variety of options for cover crop seeding equipment can be utilized:

- Standard grain drills or no-till drills
- InterSeeder™
- Homemade interseeders
- Dawn® Biologic Interseeder
- Air seeders
- Broadcasters
- Helicopter
- Highboy

What is important is that you consider the strategy that fits your system the best and offers the highest chance of success. Consider the timing, residue level, herbicide impacts, cover crop seed varieties, and cover cropping goals when choosing a strategy and align it with the appropriate equipment for your situation.


Image 5. Some cover crop equipment options including the InterSeeder™ (left) and Highboy (right).

Cover crop termination

Planning how to terminate the cover crop is equally as important as getting it established. If you are unprepared to terminate it effectively, your cash crop may suffer due to competition and other impacts. Several strategies for cover crop termination exist including 1) only selecting species that winterkill, 2) mechanically harvesting or grazing as forage, 3) rolling and crimping the biomass, or 4) applying an herbicide. Each of these strategies has pros and cons that you will need to consider in order to find the right strategy for your operation (Table 2).

Winterkill

Species such as oats and radishes, will be terminated with the onset of winter weather conditions. While these will provide soil coverage and stability through the winter, additional mechanical or chemical termination methods are not needed prior to cash crop planting. However, be aware that some species, such as annual ryegrass, can unexpectedly overwinter in some regions if mild winter conditions are experienced (Image 6). Therefore, in these cases you should be prepared with a backup termination method in the event that you need it. Consult your local Extension office for more information for your area.

Image 6. Overwintered annual ryegrass.

Grazing or harvesting forage

Research has shown that winter grains planted by mid-September in the Northeast can produce 1-3 tons of dry matter per acre the following spring depending on seeding rates, planting dates, and fertility (Darby et al., 2015; Kilcer, 2021). These species, if harvested in the vegetative or boot stages prior to seed head development, can provide dairy-quality forage. Generally, this can occur 1-2 weeks earlier than perennial

cool season pastures are ready to graze depending on conditions. However, species vary in their maturation time significantly (Figure 3). Be sure to select a species and variety that meet your timing needs.

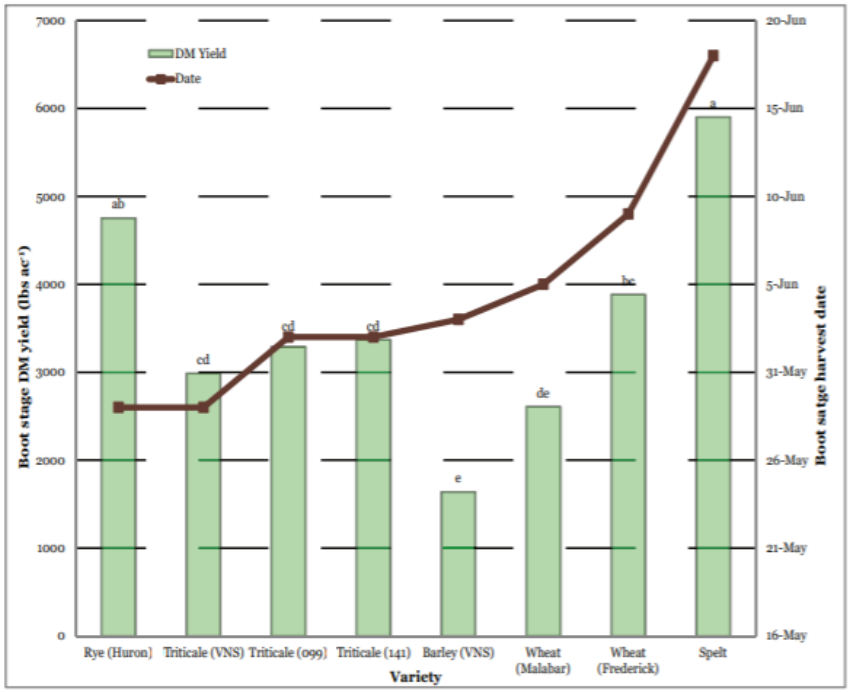

Figure 3. Dry matter yield of small grains at the boot stage (Darby et al., 2015)

Roller Crimping

A roller crimper (Image 7) is a specialized piece of equipment designed to crimp the stem of growing cover crops, disrupting the vascular system that transports water throughout the plant ultimately resulting in death. Although it is not a highly complicated piece of equipment, timing of termination with a roller crimper can be challenging. If you roll over the crop when it is too young, the plant stems will be too flexible and will bend but not adequately stop the transport of water. In these situations, the cover crop keeps growing, standing back up in the field and requires additional termination steps. However, you can also wait too long to use a roller crimper. If you wait until the crop is very mature, the biomass may be too great or may produce viable seed, both of which can interfere with crop planting and establishment. These mistakes are costly in additional time, money, and potential delays or impacts to establishing your cash crop. To successfully terminate with a roller crimper, the cover crop needs to be in the flowering stage. Since cover crop species and even varieties vary in maturity, proper selection is key to avoid additional costs and delays.

Image 7. Roller crimper.
Image source: croproller.com

Table 2. Pros, cons, and special considerations of cover crop termination strategies.

Termination strategy	Pros	Cons	Special considerations
Winterkill	No living vegetation to terminate	-Higher C:N ratio can tie up N for subsequent crop instead of release available N -Require earlier planting to fully realize benefits compared to overwintering species	This will result in the lowest residue situation leading into the cropping season which could be simpler early in the transition phase. This option may be best if the timing of using one of the other termination methods will be challenging for your operation.
Mechanical harvest	Provides additional forage	-Timing to harvest high quality forage can be difficult early in season when many farm operations compete for time -Additional equipment impact on soil compaction	Winter grains vary in their timing to maturity in the spring. Winter wheat and winter barley can be 1-2 weeks behind winter rye, making them easier to harvest on-time.
Grazing	Provides additional forage without equipment impact on soil compaction or fuel	-Field needs to be accessible by grazing herd -Additional fencing infrastructure needed	Winter grains vary in their timing to maturity in the spring. Winter wheat and winter barley can be 1-2 weeks behind winter rye, making them easier to manage for high quality.
Roller-crimper	Provides weed suppression for cash crop	-Increased residue and moisture around cash crop can increase pest pressure -Specialize equipment required	Timing of crimping is critical in adequately terminating the cover crop. If done too early the stem will bend instead of break resulting in a need to also terminate via herbicide. If done too late, viable seed may be produced and can impact the establishment of the cash crop. Late planting may also impact the maturity of the annual crop and can then also impact subsequent cover crop establishment.
Pre-plant Herbicide	Minimal disturbance to cover crop and soil	-Increased residue and moisture around cash crop can increase pest pressure	Consider using herbicides without long term residuals if you intend on cover cropping the field again as these can interfere with cover crop germination and establishment.
Post-plant Herbicide	Minimal disturbance to cover crop and soil	-Increased residue and moisture round cash crop can increase pest pressure -Difficult to see row markers when planting into living cover	Consider using herbicides without long term residuals if you intend on cover cropping the field again as these can interfere with cover crop germination and establishment. Make sure your cash crop is herbicide tolerant.

Corn planter design and modification considerations
Planting crops in a no-till system requires that the planter can accomplish these three basic steps:

1. Slice through the soil and residue to create a furrow
2. Place and firm the seed into the furrow
3. Close the furrow

These steps are essential to creating adequate seed to soil contact to support uniform and successful crop emergence and establishment. To address these needs, no-till corn planters include several components that can be adjusted to fit your system's needs (Image 8).

Floating row cleaners- these toothed disks ride along the surface of the soil and are angled so that residue on the soil surface is pushed aside creating a clean strip of soil where a furrow can be created without interfering residue. Fixed row cleaners also exist but can present issues where uneven terrain will cause them to dig too deep into the soil in some places and completely miss in others. More uniform stands will be achieved with floating row cleaners most of the time.

Coulters- these disks come in a variety of designs from spiked to wavy and are intended to help loosen the soil surface ahead of the openers. However, these may cause more problems than they're worth under some field conditions. If the soil is wet, they may remove chunks of soil from the area where the furrow will be created leading to uneven seeding depth. In dry or compacted conditions, they may prevent the openers from penetrating the soil. In our research and experience working with farmers adopting no-till systems, coulters do not provide any additional benefits to the system and should be removed.

Vee openers- these disks are designed to slice through the soil surface to create a v-shaped furrow in the soil where the seed will be placed. Heavy duty (3.5mm thickness) openers are more likely to be successful across a variety of soil and residue conditions.

Fertilizer systems- fertilizer can be applied either in a band or dribbled near the seed. Placing nutrients, particularly N, near the seed at planting without burning the seed is important to making up any N deficit that may occur due to N tie up from residue decomposition. Do not exceed recommended N rates as this will increase the risk of seed burn or environmental loss.

Seed firmers- seed firmers push the seed down making sure it gets placed at the bottom of the trench at the right depth. Maintaining adequate down pressure is necessary for attaining good seed to soil contact.

Closing wheels- these wheels close the furrow over the seed and come in many designs that can be fitted to your soil type and conditions. In general, spoked wheels work better in heavier soils while rubber wheels work better in fine, dry, light soils.

Weight – Due to the nature of no-till planting systems it is important to make sure the planter is heavy enough to put enough down pressure on the row units to penetrate the soil to the proper planting depth. Depending on field conditions, weight may need to be added to the planter to ensure proper planting depth. Weight can be added to the row units or to the tool bar depending on what is available to place on the planter. An example of a hydraulic down pressure system can be seen in Image 9.

With variable field conditions, careful attention must be given to setting up and monitoring the equipment as you go, adjusting to the conditions.

1. Floating Row Cleaners
2. Vee openers
3. Fertilizer system
4. Seed firmer
5. Closing Wheel

Image 8. Parts of a no-till corn planter row unit.

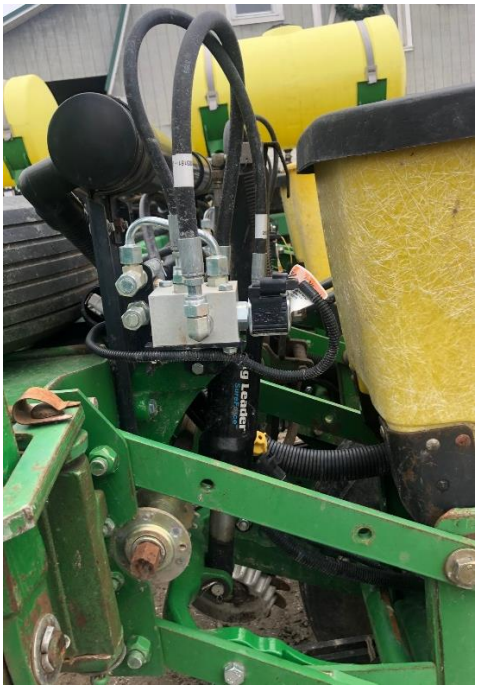

Image 9. Hydraulic down pressure system on a no-till corn planter.

Economics

The input costs affected by tillage are fuel and labor. Obviously if you remove a step-in field prep you save the labor and fuel it would have taken. However, as stated in the introduction, converting to no-till isn't as simple as not tilling. Although the labor and fuel spent on tillage operations may decrease, other factors may increase. For instance, without tillage as a tool for insect and weed pest management, expenditures on herbicide may increase, especially where there are overwintering cover crops and herbicide is needed for termination. In field trials conducted in 2021, pre-planting herbicide termination of cover crops added an additional $22-$30 per acre to the cost of production of the cash crop. These issues may be addressed by improving the farm's crop rotations, but in the short-term transition period, pesticide use may be necessary. Furthermore, as discussed in the fertility management section, lower nitrogen availability in no-till systems may require higher fertilizer costs to attain the same yields. There are also costs to the equipment or equipment modifications as previously described.

Another cost of no-till, at least in the short term, is the potential reduction in yield. In a long-term corn silage cropping systems trial in Vermont, it was found that the continuous no-till corn silage treatment experienced on average a 1.94 ton per acre yield reduction compared to continuous corn with conventional tillage. However, these treatments did not always differ statistically indicating that no-till yields can be comparable to those in conventional tillage systems. Some farmers do not experience such yield reductions, however, since it is possible it is best to be prepared. A reduction in yield must be offset either by purchasing more feed, or increasing dry matter yields elsewhere on the farm. One way this could be done is by utilizing cover crops for forage. Small grains like winter rye, winter wheat, and triticale, make excellent high-quality forage early in the spring and can be grazed or harvested. The opportunity to double crop in this way, especially when these cover crops are already being utilized, can help recover some of the potential dry matter reduction experienced when transitioning to no-till.

Conclusion

No-till cropping systems have excellent potential to improve and protect soil health and reduce other environmental impacts associated with tillage. Adoption of no-till can also reduce labor requirements and improve resilience of crop yields over time. A successful transition starts with an open mind, a willingness to learn and try, and an observant eye constantly monitoring and adjusting. Although it isn't as simple as selling the plow, with a little dedication and some careful management adjustments, you can begin to create effective rotations utilizing no-till management that enhance crop productivity while protecting natural resources.

Acknowledgments

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