UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

# 2017 No-Till & Cover Crop Symposium

February 16, 2017

Sheraton Hotel & Conference Center | Burlington, Vermont

# CONFERENCE PROCEEDINGS

# WELCOME

***Real Challenges + Positive Change***

The commitment for lasting changes in Vermont agriculture is your personal decision. Not mine, not the politicians, not your neighbor, and certainly not the naysayers who constantly remind us that "it can't be done that way". When I see a sweeping change in Vermont agriculture such as we have seen in the past few years with no-till, cover crops and a renewed commitment to improve our environment, you are making a positive change in our state. Positive change is hard and negative criticism is easy, that is why today is important to me. Positive energy to move forward with new ideas that we can share.

There are so many choices or directions to take in farming each year, and yes, we are proud to be a part of this exciting journey you are on with conserving soil, building soil, feeding the soil to support your farms. To farm in good faith that these changes in crop production will help your business, family, and the place we live in takes courage, strong convictions and the positive attitude that defines success each day. The challenge is real, but the rewards can be great when you have made it through the transition to a new way of conducting your business of growing the food, feed and fiber that we so depend on. I was very impressed by the positive attitude of nearly 1,000 farmers at the National No-Till Conference in St. Louis last month who truly believe that this is a truly transformative process for all of Agriculture.

Look around and see who is with us today. Recognize the vast support we have for farmers within our own ranks of industry, agency and education. It is far too easy to fight, much harder to find the common ground we all have under our feet. Look around again, this is your support, for no-one can do it alone without support and the help of friends.

**ENJOY THE SYMPOSIUM!!**

***Jeff Carter, UVM Extension Agronomist***

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**Cover Photos** *(all photos by UVM Extension)*:
**Top:** no-till corn in winter rye residue in Vermont
**Right:** cover crops at the Farr Farm *(Richmond, Vt.)*
**Bottom:** earthworm castings in a no-till cornfield at Dorset Peak Jerseys *(Danby, Vt.)*
**Left**: Beef cattle grazing a no-till summer annual field at Lucas Cattle Co. *(Orwell, Vt.)*

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University of Vermont Extension

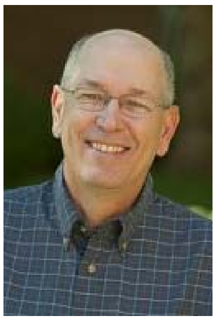
# AGENDA: February 16, 2017

| Time | Session | Speaker | Topic |
|---|---|---|---|
| 8:30 | *Registration Opens* | *Check in, get coffee/snacks,* ***visit our Exhibitor Fair and Poster Session*** | |
| 9:00 | *Opening Session* | *Jeff Carter, UVM Extension* | *Visit with our exhibitors as you find your seat and get the day started.* |
| 9:30 | *Managing Manure in No-Till Systems* | *Dr. Douglas Beegle, Penn State University Extension* | *Inject, surface apply, aerate, dragline? Dr. Beegle will help us weigh the costs and benefits of managing manure in a no-till system.* |
| 10:30 | ***Break—Exhibitor Fair—Poster Session*** | | |
| 11:00 | *University of Vermont Extension: Research & Findings from the Field* | *Jeffrey Carter, Champlain Valley Crop, Soil, Pasture* | *Soil Health, No-Till, Cover Crops, Crop Rotations, Manure and more...Highlights from local UVM Extension research and practical application of these practices in Vermont and what's in store for 2017.* |
| 11:30 | | *Dr. Heather Darby, Northwest Crops & Soils* | |
| 12:00 | *****Lunch***** | | |
| 12:45 | *Innovation in Action* | *Mark Anderson, Landview Farm LLC* | *Walk with Mark through the good, the great, and the sometimes ugly of no-till & cover cropping on his farm in Eagle Bridge, NY.* |
| 1:30 | ***Break—Exhibitor Fair—Poster Session*** | | |
| 2:10 | *Pest Management in High Residue Cropping Systems* | *Dr. John Tooker, Penn State University Extension* | *Dr. Tooker will share his cutting edge work looking at crop pests in high residue situations, their natural enemies and strategies for keeping your pests in check while maintaining yields.* |
| 3:00 | *Farmer Panel:* Tools That Make the System Work | **Jeff Sanders, UVM Extension** *Farmer Panel:* **George Foster, Foster Bros. Farm** **Scott Bessette, Bessette Farm** | *Jeff will share his experience successfully adapting conservation practices on Vermont farms. He will then lead a panel discussion to learn from local farmers about the benefits, barriers and techniques on their farms.* |
| 4:15 | *Closing Session* | *Kirsten Workman, UVM Extension* | *Recap the day and join us for a little surprise to send you out ready to no-till and cover crop in 2017.* |

# Our Speakers

## DR. JOHN TOOKER | *The Pennsylvania State University* *(University Park, PA)*

Dr. John Tooker is an associate professor of insect ecology and extension specialist in the Dept. of Entomology at The Pennsylvania State University. He studies relationships among plants, insect herbivores, and natural enemies to understand factors that regulate populations of herbivorous insects. He is interested in both plant- and natural-enemy -mediated factors and how they influence insect behavior, community composition, and herbivore mortality. The long-term goal of his lab is to exploit the ecology/biology of our study organisms to provide strategies and tactics for more sustainable insect pest management.



## DR. DOUGLAS BEEGLE | *The Pennsylvania State Univ.* *(University Park, PA)*

Dr. Douglas Beegle is Distinguished Professor of Agronomy at The Pennsylvania State University. His work includes Extension education programs, plant nutrition, soil testing, manure management, and whole farm nutrient management. Research in soil test evaluation and calibration, fertility management (N, P, K, S), starter fertilizer management, development of nutrient management systems, and management of agricultural phosphorus and the environment. Advisor to state and federal government agencies and other organizations on nutrient management and agriculture related water quality issues.

## MARK ANDERSON | *Landview Farms LLC* *(White Creek, NY)*

Mark Anderson farms in Partnership with Rody, Jane, and Randy Walker in White Creek, New York. The Farm milks 1350 cows, and they moviedin to a new milking facility in March 2016. Landview Farms LLC has been using no-till and cover crops on their 2300 acres for years. They are now learning how to use these practices together to increase soil health and ultimately farm profitability.



## GEORGE FOSTER

### *Foster Bros. Farm* *(Middlebury, VT)*

George and Debbie Foster are one of seven family members of Foster Bros Farm Inc. of Middlebury Vt. They operate a 2200 acre dairy farm and have been doing no till with cover crops on corn and soybeans for the past four years. They presently cover crop with cereal rye on 700 acres. The Fosters in partnership with UVM Extension have experimental field test plots researching multiple cover crop varieties and tillage practices on clay soil.

## SCOTT BESSETTE

### *Low View Farm* *(Highgate Center, VT)*

Scott farms with brother in northwest Vermont they have a milking herd of 380 mature cows and raise 390 young stock. They grow 630 acres of corn, about half for silage half for grain. This spring, 80 percent of their corn ground will be under either no-till or minimum till management. The balance of their acreage consists of 300 acres of alfalfa/grass mix and another 70 acres of winter rye grown for seed.

# Our Speakers

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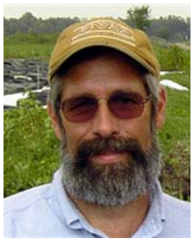
## *UVM Extension Agronomy*



### JEFFREY CARTER | *Agronomist: Field Crops & Nutrient Management*

Jeff Carter has worked with farmers all around Vermont regarding crop production including corn, alfalfa, pasture, Christmas trees and wildlife food plots. For more than 30 years he has provided information on using fertilizer, manure and pesticides; how to grow crops and take care of the soil and; nutrient management planning to meet farm regulations. Jeff works with commercial farmers, backyard growers and public officials to promote agriculture. As a UVM Extension Faculty member, Jeff leads the Champlain Valley Crop, Soil & Pasture Team out of the Middlebury Extension office. He procures grant funding, provides direction for the team and is the foundation for the work the team does to serve the needs of agricultural producers in the Champlain Valley and beyond.



### DR. HEATHER DARBY | *Professor of Agronomy*

Heather Darby is a Soils and Agronomic Specialist for the UVM Extension. She received her MS from the University of Wisconsin in Agronomy and her Ph.D. in Crops and Soils at Oregon State University. Being raised on a dairy farm in Northwestern Vermont has allowed her to play an active role in all aspects of dairy farming as well as gain knowledge of the land and create an awareness of the hard work and dedication required to operate a farm. These practical experiences complemented by her education have focused her attention towards sustainable agriculture and promotion of environmental stewardship of the land. Heather is involved with implementing research and outreach programs in the areas of fuel, forage and grain production systems in New England. Outreach programs have focused on delivering on-farm education in the areas of soil health, nutrient management, organic grain and forage production, and oilseed production. Research has focused on traditional and niche crop variety trials, weed management strategies and cropping systems development.

# Our Speakers

UNIVERSITY OF VERMONT EXTENSION

## *UVM Extension Agronomy*

### JEFF SANDERS | *Agronomy Outreach Specialist*

Jeff spends much of his time working with farmers in the northern Lake Champlain Basin as an Agronomy Outreach Professional with UVM Extension's Northwest Crop and Soils Program, as well as the Agronomy and Conservation Assistance Program (ACAP). The focus of his work is to help foster best management practices on dairy farms to address water quality issues. He works hard to demonstrate how no-till/reduced tillage techniques can be implemented successfully on a wide variety of soil types and conditions. Jeff also focuses a significant amount of time helping farmers develop and implement different cover cropping techniques across the Champlain Basin, and he helps educate farmers about available funding sources and programs to help offset the cost of implementing these practices. His expertise is in reduced tillage systems, cover cropping practices, soil health, and interseeding, and he provides on-farm technical assistance to farmers statewide. Jeff is always looking for innovative ways to address water quality issues on farms through the use of technology and common sense. He has had 20 years of experience in the dairy industry as a farmer working with clay soils, and he understands the risks and struggles of "change" on dairy farms. When Jeff is not working for UVM he is usually working on something related to farming, family, or food plots.

### KIRSTEN WORKMAN | *Agronomy Outreach Specialist*

***Conference Coordinator***

Kirsten works with farmers to implement practices that improve crop production and protect water quality in her role with UVM Extension's Champlain Valley Crop, Soil & Pasture Team and Agronomy Conservation Assistance Program (ACAP). She started her career in Washington state, and after 10 years of working with West Coast farmers, she joined the UVM Extension Middlebury in 2011, where she aims to provide practical information that farmers value. She helps farmers understand , prepare and implement comprehensive nutrient management plans. She also helps farmers access cost-share funding to implement Best Management Practices on their farms. A major focus of her work has been on improving and implementing cover cropping systems on Vermont farms. Kirsten is currently working on a master's degree in Plant & Soil Science (Agronomy) at the University of Vermont. Her research focuses on to providing farmers with information about successful cover cropping systems that make the most of their livestock manure while reducing nutrient runoff and increasing soil health.

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## University of Vermont Extension:
## Helping farmers in Vermont put knowledge to work!


**WE WOULD LIKE TO THANK THE ORGANIZATIONS THAT HAVE PROVIDED LONG-TERM FUNDING AND SUPPORT FOR OUR WORK:**

**Support for the Agronomy Conservation Assistance Program (ACAP) and other assistance programs**

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# University of Vermont Extension:
# Helping farmers in Vermont put knowledge to work!

**The two UVM Extension teams that bring you this symposium are proud to share our work with you. Here is a little bit more information about us.**


The Champlain Valley Crop, Soil & Pasture Team is a group of UVM Extension professionals and their partners working to provide technical assistance to Vermont Farmers in the Lake Champlain Watershed. We strive to bring you research-based knowledge that has practical applications on your farm, such as: Quality Forage & Crop Production, Soil Health, Grazing Management and Pasture Production, Cover Crops, No-Till Agriculture, Nutrient Management, Water Quality and more.

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The mission of the UVM Extension Northwest Crops and Soils Team is to provide the best and most relevant cropping information, both research-based and experiential, delivered in the most practical and understandable ways to Vermont farmers.

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Reprinted with permission from Crops & Soils magazine and the American Society of Agronomy. From the May-June 2011 edition. TITLE: "Manure Incorporation in No-Till Systems"

Photo shows manure banded with an aerator. Courtesy of Peter Kleinman.

No-till agriculture can reduce costs, improve soil quality, and benefit the environment. However, if manure is applied to the surface of no-till fields, the nutrients can be lost to volatilization or runoff. Therefore, incorporating the manure into the soil may be the best practice. This month's feature highlights technologies that can incorporate manure into no-till fields, while retaining most of the benefits of no-till practices.

**By Madeline Fisher**
Lead Writer
*Crops & Soils* magazine
mfisher@sciencesocieties.org

It's hard to argue with the benefits of no-till agriculture: In addition to reducing the fuel costs and time associated with tilling, the practice can reduce erosion, increase organic matter, and improve water retention in soils. But no-till farming also presents a dilemma that Doug Beegle, Distinguished Professor of Agronomy at Pennsylvania State University, knows well. As an extension agronomist, Beegle has trained farmers for years to write nutrient management plans that include incorporating manure, rather than leaving it on the soil surface, to conserve nutrients that might otherwise be lost through volatilization or runoff. At the same time, roughly half the cropland in Pennsylvania is now no-till, says Beegle, who is a Fellow of both the American Society of Agronomy (ASA) and the Soil Science Society of America (SSSA).

"So, we've always had this conflict when we're doing nutrient management planning. How do we deal with manure in no-till systems?"

That question sent him and a group of collaborators searching for technologies that can incorporate manure into no-till fields, while retaining most of the benefits of no-till practices. They've since studied a range of methods, including shallow disk injection, which uses familiar equipment, and a sophisticated, high-pressure injector from Norway. Overall, the technologies do offer environmental benefits over surface application of manure, Beegle reports; for example, they've been found to reduce nuisance odors and nutrient losses, while causing minimal soil disturbance.

But, just as important, they've also proven practical and economical to use, although some more so than others. The team is now working to get the equipment out to farmers. "That's the next step," Beegle says. "People need to see these in action in the real world, not just in a research plot."

What drives the work is Pennsylvania's role in the water quality of the Chesapeake Bay—the United States' largest estuary—whose watershed also stretches over parts of Delaware, Maryland, New York, Virginia, West Virginia, and the District of Columbia. No part of Pennsylvania actually abuts the bay; however, the state still contributes more than half of the Chesapeake's water via the Susquehanna River, Beegle says. As a result, sediments, nitrogen, and phosphorus from Pennsylvania farms also wind up in the bay, helping to fuel a dead zone of oxygen-starved water that extends for hundreds of square miles each summer.

That reality makes better manure management a top concern, says ASA and SSSA member Peter Kleinman, who leads watershed research in the USDA-ARS Pasture Systems and Watershed Management Research Unit at Penn State. "Working manure into the ground is a needed step in order to ensure that the nutrients in manure serve as a resource and not a liability."

Manure incorporation is nothing new, he adds, and some techniques that the team evaluated have been around for quite awhile. But the practice is new to many Pennsylvania farmers, in part, because older incorporation methods are mostly suited to flat, even soils, like those in the Midwest, rather than the steep, rocky farmlands of Pennsylvania.

"So Doug and I went after a number of grants to buy different applicators that could inject manure, but not too deeply, and could handle the steep and stony soils," Kleinman says. They also resolved to examine not just one or two variables, such as crop response or phosphorus runoff, but an entire suite of factors, with "an emphasis on tradeoffs," he says. "It really involves trying to come up with the 'sweet spot.' Where is the optimal usage? Because inevitably, you end up having a benefit in one area, and a cost in another."

In Virginia, too, most farmers still surface-apply manure because "historically it has been the cheapest, fastest thing to do," adds SSSA member Rory Maguire, an associate professor of nutrient management at Virginia Tech University who collaborates frequently with Kleinman and Beegle. But, as Kleinman points out, there is also a major cost to surface application, which the scientists are now targeting: Typically, 30 to 50% of ammonia nitrogen volatilizes from manure within 24 hours.

"With dairy manure, you can actually lose half your plant-available nitrogen with surface application through loss of ammonia into the air," Maguire says. And because some of this volatilized nitrogen eventually returns earthward in rainfall, the Chesapeake Bay loses, as well, Beegle adds. Atmospheric deposition is, in fact, a major source of nitrogen to the bay that manure incorporation could also help curb.

**Shallow disk injection.** Photo originally submitted with the *Journal of Environmental Quality* article "Environmental and Economic Comparisons of Manure Application Methods in Farming Systems," by C.A. Rotz et al. (40:438–448).

## Five main approaches to manure incorporation

Although there are many variations in actual equipment, five main approaches exist today for incorporating liquid manure into the ground with minor soil disturbance: disk injection, chisel injection, high-pressure injection, aeration, and surface banding, the last of which is sometimes performed with a "sleigh foot" or traveling shoe on standing forages.

Disk injectors typically include a set of coulters that cut crop residues and make furrows in the soil; drop hoses for placing manure in the furrows; and an implement, such as a pressing wheel, to close the furrows afterward. The method is often called "shallow" disk injection because it typically injects manure into just the top 4 to 6 inches of soil. Chisel injectors are similarly configured, except that they drag C-type shanks through the soil to create furrows, usually causing more disturbance. They can also be set to inject manure over a wider range of depths.

A higher-tech variation on the same theme is high-pressure injection. Developed in Scandinavia to incorporate liquid manure into stony soils used for pasture or sod farming, these injectors employ a specialized pump that pressurizes manure slurry. The pressure is then used to create discrete, manure-filled cavities under the soil surface that resemble upside down mushrooms. Aeration, in contrast, takes a very different approach. Rather than introducing manure directly into the ground, aerators produce holes or pits in the soil. Manure is then applied to the soil surface afterward.

Aeration is thought to help manure infiltrate soils by creating holes into which it can seep. But much of the manure remains exposed to air, rather than being covered by a layer of soil as with injection. The same holds for surface banding. In this approach, farmers surface-apply manure in strips rather than covering the entire soil surface. On forage crops, a sleigh foot or other equipment is used to apply the strips under the plant canopy.

Research indicates that chisel and disk injection can reduce ammonia losses by 40 to nearly 100% compared with surface application, while high-pressure injection in one study cut ammonia emissions by 60%. Results with surface banding and aeration, meanwhile, have been more variable, and aeration so far isn't well studied. Surface banding of manure in forages is known to decrease ammonia volatilization in cases where the plant canopy lowers wind speeds over the manure. But, in general, Maguire says, injection does a better job of conserving nitrogen than techniques that leave manure exposed to air.

"We find that if you get manure onto the soil and then close the slit where you put the manure, that's very good at capturing nitrogen and stopping your ammonia loss," he says. "And it's also very good at stopping odor." A study led by Robin Brandt, director of the Penn State Odor Assessment Laboratory, for example, found that the shallow disk and high-pressure injection cut odor emissions by 50 to 70% compared with surface application.

## Shallow disk holds most promise for Chesapeake Bay

These two technologies have also performed similarly in other tests by the researchers. Still, the high-pressure injector has become less of a focus over time, mainly because it suffers from some "practical problems" in Pennsylvania cornfields, Beegle says. Originally designed to pump manure into grasslands, high-pressure injection tends to "blow out" soils not covered by heavy thatch, for example, and is apt to gather up corn stover, creating piles of residue in front of the machine. As a "fairly sophisticated" device, Beegle adds,

Direct ground injection (DGI) high-pressure injector. Photo by Peter Kleinman.

**Left:** Chisel injector with sweeps, which includes a disk to cut surface residue. **Right:** An aerator set up to band liquid manure over the injection slots. Photos originally submitted with the *Journal of Environmental Quality* article "Manure Application Technology in Reduced Tillage and Forage Systems: A Review," by R.O. Maguire et al. (40:292–301).

it's also prone to mechanical problems, making the simpler shallow disk injector a clear winner—at least in the Chesapeake Bay region.

"Based on our research, the shallow disk injection systems seem to be the most promising," he says. "They do a good job getting the manure incorporated with very minimal disturbance. The disturbance we get from our injector is pretty similar to what you'd get from a no-till planter."

But as the scientists have started demonstrating the technique, a lot of farmers have expressed concern that it's too slow. Farmers who surface-apply manure can broadcast it across a 50-ft width of field, Maguire says, while shallow disk injection covers about half that width, suggesting it could be roughly two times slower. However, some commercial manure applicators who perform injection in Pennsylvania have found it's usually not as slow as people assume, Beegle says. Besides, many farmers are already taking a second look at injection now that fuel prices have spiked—taking fertilizer prices with them.

"That increased interest [among farmers] a lot," Maguire says, "in terms of being able to capture the extra value of the nitrogen that's in the manure."

Along these lines, a study led by Al Rotz, an agricultural engineer with the USDA-ARS unit at Penn State, weighed the environmental benefits of four liquid manure application methods (surface application, shallow disk injection, aeration followed by surface banding, and traditional tillage) against the economics of using them. The research tool he employed was the Integrated Farm System Model, a program that simulates farm processes—such as growth of crops, harvesting processes, and feeding of animals—and how they vary through time given the vagaries of weather. The idea is to extrapolate results obtained under highly controlled experimental conditions to the complex and changeable circumstances found on real farms.

"What happens in a research plot is one thing," says Rotz, who did the work with Beegle, Kleinman, and others. "But how does that really apply when you're applying the manure in an actual farming system?"

Using 25 years of weather data, Rotz simulated manure application on three very different farm types in Pennsylvania: a swine and beef cattle farm under grass production, a mixed confinement and grazing dairy farm, and a full-confinement dairy farm where cows were fed corn silage and alfalfa. Not surprisingly, manure incorporation reduced phosphorus and ammonia losses compared with surface application on all three farms. It also cost more. But the scientists were pleasantly surprised to find that nitrogen conservation offset the added cost when shallow disk injection was used, Beegle says.

On the grass-based beef and swine farm, for example, shallow disk injection increased production expenses by 4% over surface application because it took longer and the equipment was more expensive. But disk injection also improved the yield and nutritive content of the forage, yielding a 5% increase in farm income. In other words, "our study found that shallow disk injection and surface application were pretty close economically—a few dollars either way, but they were close," Beegle says, "And if it's close to a break-even, I've found that farmers will try things."

The researchers got similar results when they modeled disk injection on the dairy farm where cows grazed grass part of the year and ate corn silage the rest. However, the group

# Quantifying odor reduction of manure incorporation methods

For those hoping to control nuisance odors from surface-applied manure, integrating manure into the soil rather than leaving it exposed seems like a matter of common sense. At the same time, practitioners and scientists need to confirm that manure incorporation actually curbs odors. Robin Brandt is helping to do just that.

As director of the Pennsylvania State University Odor Assessment Lab, Brandt studies ways to quantify agricultural odors—a surprisingly complex task, given how easily the human nose detects these aromas in the first place. The "gold standard" technique involves collecting large bags of malodorous air in the field, bringing them back to the lab, and using a sophisticated machine to dilute the samples with pure, odorless air.

A panel of expert "odor assessors" are then given whiffs of the diluted samples—starting with the most dilute and working toward the least—reporting each time whether they smell a difference between the diluted sample and two samples of purified air. The trial ends when an assessor first detects a difference, yielding the detection threshold.

The method does a good job of quantifying differences in odor concentration that would otherwise be very subjective; for example, a smell that's detectable when diluted 1,000-fold (1 part odor sample to 1,000 parts pure air) is four times stronger than one that's only detectable at a 250-fold dilution. But the technique is also expensive, time consuming, and uses whole-air samples that can become tainted by the sample bag itself. So, when Brandt began working with Doug Beegle and Peter Kleinman at Penn State on manure incorporation, he used a less costly field technique and a device called a Nasal Ranger Field Olfactometer.

Although it's used in the field, the Nasal Ranger allows odor assessors to evaluate serial dilutions of air samples through the device, just as they do with the laboratory machine. Similar to the lab method, too, the assessors report when they can first smell a difference between a diluted ambient sample and a purified puff of air, producing a detection value called dilutions-to-threshold (D/T).

Where field olfactometry differs substantially from the lab technique, though, is in its efficiency. In his manure incorporation study, for example, Brandt collected many more data points by employing multiple assessors equipped with Nasal Ranger units than he did with the laboratory method. And those extra data gave him the statistical power to identify subtle variations in the performance of four incorporation techniques: aeration, chisel injection, shallow disk injection, and high-pressure injection.

For instance, although aeration cut manure odors significantly over surface application (as did all the incorporation methods), it was significantly outperformed by chisel injection. Chisel injection, meanwhile, was statistically less effective at reducing odors than were shallow disk and high-pressure injection—both of which performed equally well.

The Nasal Ranger allows odor assessors to evaluate serial dilutions of air samples in the field. Photo courtesy of Robin Brandt.

What the findings suggest, Brandt says, is that field olfactometry offers a robust, sensitive, and less costly alternative to the lab method for those who need to measure farm odors precisely. Not that it can be done completely on the cheap, he adds. Odor assessors are paid for their time, and checking out the health of their noses also costs money.

"So, it's not without expense—it costs something. To do this in a regulatory mode I think would be a challenge," Brandt says. "But in high-value situations like research, I think it works beautifully."

didn't see the same economic benefit in the full-confinement system because alfalfa grown in rotation with corn already boosted soil nitrogen, making the added nitrogen from manure less important.

This suggests that those who are thinking of adopting manure injection need to consider the whole farm system, Rotz says. "It's really hard to make a blanket statement, saying, 'If you use this technology, this is what you're going to get from it,'" he says. "It's going to vary with the crops grown and how [manure injection] fits with the other parts of the farm."

Kleinman agrees, adding that questions also remain about site-specific environmental performance. Most research on manure injection has been performed so far in well-drained systems, but at least one study suggests the practice doesn't curb nutrient losses nearly as well in poorly drained soils. Evidence also suggests that while injecting manure cuts ammonia losses, it may boost denitrification rates and nitrate leaching, although so far the benefits of conserving ammonia appear to outweigh these possible downsides.

Another complexity has to do with no-till standards, which can vary at the state and federal levels and from state to state. The NRCS, for example, offers funds through its Environmental Quality Incentives Program (EQIP) to purchase no-till machinery, and since shallow disk injectors meet the NRCS no-till standard, they can be bought with EQIP money. But aerators aren't eligible for the same funds because they can perform full-width tillage in addition to aeration. All the manure injection technologies meet NRCS conservation tillage standards, on the other hand, and can be purchased through that program, Beegle says.

## Making injection equipment available to farmers

In the meantime, he and Kleinman have been bringing manure injection to farmers in a different way. Individual farmers, they reasoned, might not be willing to invest in manure injection equipment. But they might be willing to pay for the practice if someone else carried it out. So in a project led by ASA member Heather Karsten, an associate professor of crop production at Penn State, and funded by an NRCS Conservation Innovation Grant, the team bought four shallow disk injectors and gave them to a group of commercial manure haulers to try out.

The strategy has so far been working much as planned. In using the equipment on a range of farms, commercial haulers have not only demonstrated the technique widely, but have also been discovering what works and what doesn't, Beegle says. Moreover, the injectors seem to be creating new business opportunities for haulers, Kleinman adds. Because shallow disk injection reduces phosphorus runoff, for example, the method allows haulers to specialize in applying manure in landscapes sensitive to phosphorus pollution.

> "The great thing about manure injection is that ... you can get manure off the soil surface and you may help the farmer's financing because he's capturing a lot more nitrogen."

But even more important is the reduction in nuisance odors, Kleinman adds. "The custom haulers are developing a niche where they use manure injection on fields near neighbors who might otherwise be offended by the odors."

In Virginia, Maguire, too, has been working on a grant to bring injection equipment to farmers so that they can "play around with the practicalities." For example, rather than driving the injector off the field to get new loads of manure, his group has been experimenting with "nursing": ferrying manure out to the injector in regular tanker trucks that are cheaper and easier to drive and maneuver.

A number of other practical issues remain to be solved before manure injection becomes a well-established practice, Maguire says. Still, like Kleinman and Beegle, he's optimistic about the approach, especially compared with other conservation practices, such as riparian buffers and stream-bank fencing.

"The great thing about manure injection is that many best management practices cost money, whereas with this, you can get manure off the soil surface and you may help the farmer's financing because he's capturing a lot more nitrogen," Maguire says. "So this is something that will pay off for the environment and will hopefully pay off for the farmer, too."

## Further reading

For more on this topic, see the special section that was published in the March–April 2011 issue of the *Journal of Environmental Quality*. Visit www.agronomy.org/publications/jeq/tocs/40/2.




## *EVALUATING THE USE OF FORAGE RADISH TO ENHANCE WINTER RYE COVER CROPS*

*2016 Report of Activities*

This research project assesses the potential of forage radish (Raphunus sativus L. var. longipinnatus) to enhance performance of Winter Rye (Secale cereale) cover crops after corn silage on northeastern dairy farms that utilize manure applications in the fall. Objectives are to determine the effects of combining forage radish with winter rye cover crops in a manured field situation and evaluate if it the addition of forage radish has impacts on the overall performance of the cover crop for improved nutrient uptake in the fall, percent cover and biomass in fall and spring, and spring nutrient cycling .

This study will quantify the economic impacts of this combination and basic agronomic recommendations for seeding rates and establishment methods. Plots were no-till drilled and broadcast after timely corn silage harvest and then received one application of liquid dairy manure immediately after planting. Measurements occurred the fall after planting and the subsequent spring. Results were shared with farmers and ag service providers in Vermont and around the northeast. There is a large Extension/outreach component to this project. This project is part of a larger USDA-NIFA project.

**Objective 1:** Determine the effects of combining forage radish with winter rye cover crops and evaluate if the addition of forage radish has impacts on: overall performance of the cover crop, improved nutrient uptake and enhanced ecosystem services.

***Progress to date:*** *Spring data was collected from the 2015-2016 plots. This included percent cover, plant height, biomass yield, plant tissue mineral analysis, soil nitrogen, regular soil chemistry analysis, soil temperature, air temperature, soil moisture, soil compaction and pictures. Preliminary analysis shows that planting method has more impact on cover crop performance than the presence/absence of the forage radish. However, more analysis will happen in the following months to dig into that data.*

**Objective 2:** Establish the proper seeding rates and planting methods for a forage radish/winter rye cover crop in a corn silage system with manure.

***Progress to date:*** *All plots had good emergence and establishment in Fall 2015. With a mild fall and winter, spring results were good for all plots. Again, initial analysis of data seems to show that when planted well, in early to mid-September, all three rates of winter rye (with and without radish) performed similarly. If further investigation finds this to be valid, lower seeding rates could be recommended when planting under these conditions.*

THANK YOU FARMERS
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NORTHEAST SARE
Sustainable Agriculture Research & Education

USDA
United States Department of Agriculture
National Institute of Food and Agriculture


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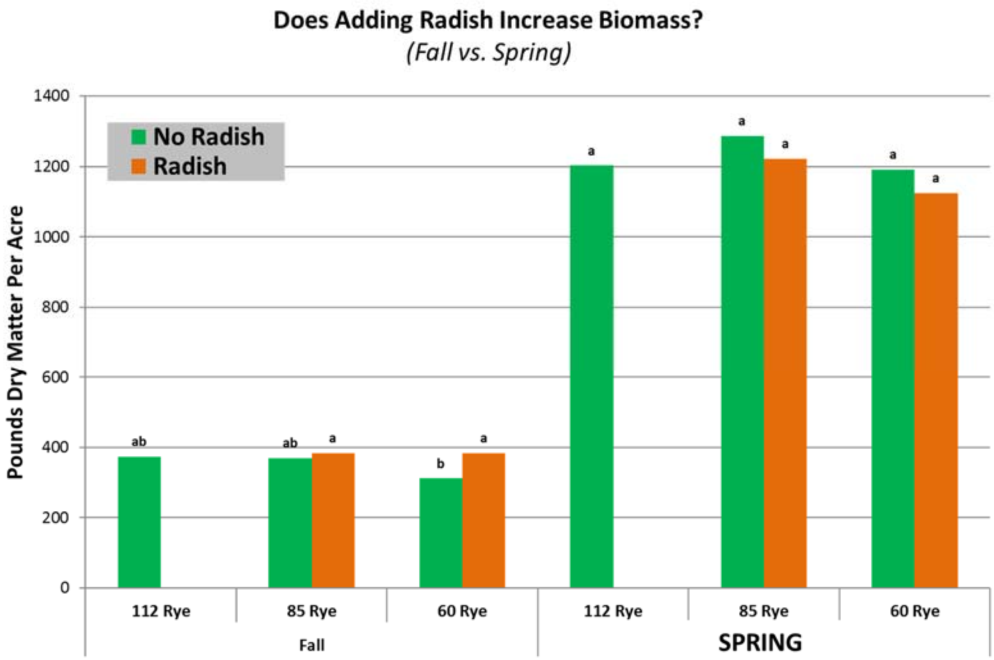
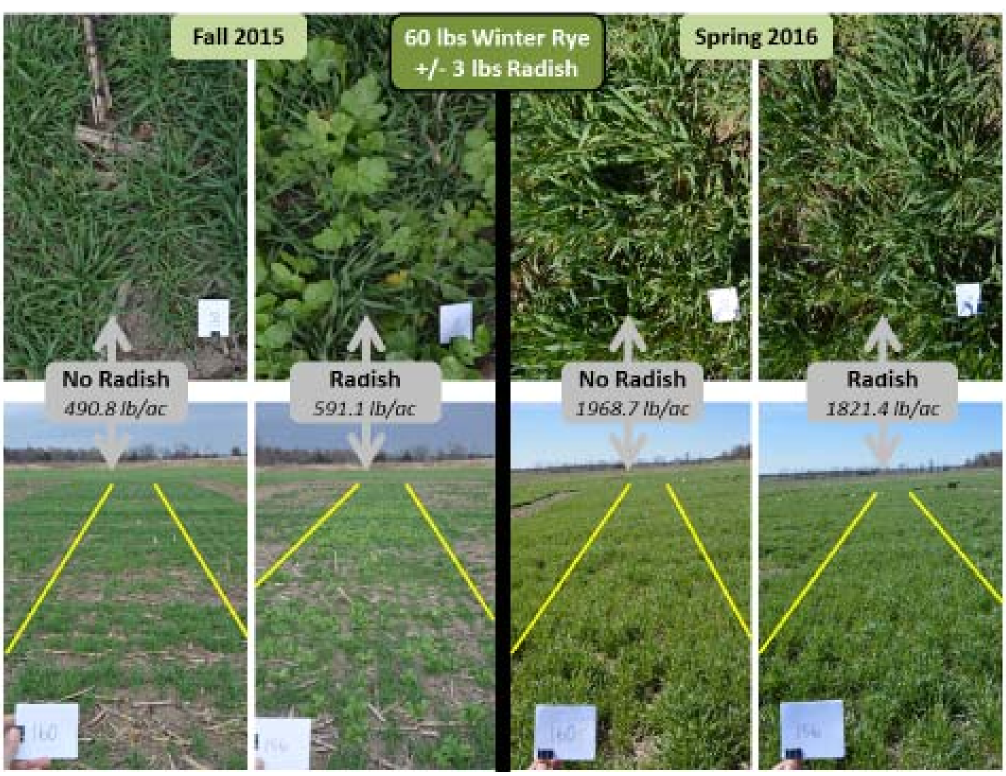
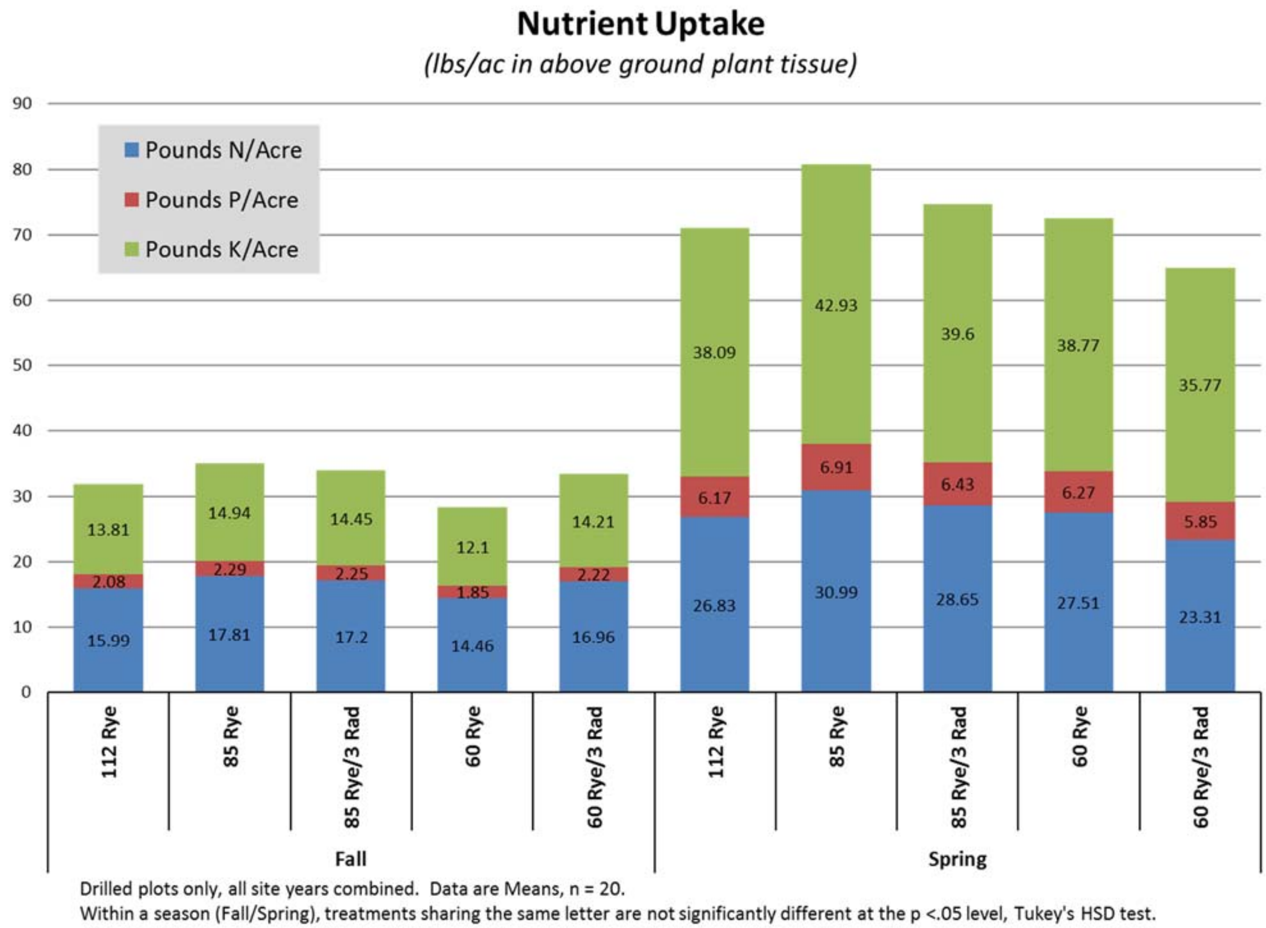
**Objective 3:** Quantify the economic impact of different cover crop treatments, both seeding rates/composition and application methods.

***Progress to date:*** *Seed cost data and establishment costs are being monitored. Once final data is completely processed and analyzed, we will be able to compare the economic ramifications of those results in conjunction with costs of cover crop establishment for each treatment.*




Drilled plots only, all site years combined. Data are Means, n = 20.
Within a season (Fall/Spring), treatments sharing the same letter are not significantly different at the p <.05 level, Tukey's HSD test.






**Objective 4:** Promote and increase the use of cover crops and share project findings through direct farmer outreach with field days, newsletter articles, social media, Extension fact sheets and presentations. Provide research-based data to support of modify existing cover cropping specifications being used by technical service providers and cost share funding agencies.

***Progress to date:*** *Spring 2016 marked the end of the field research portion of this project. In 2016 we were able to continue providing outreach in the following ways:*

- *Project information was shared with the 175 attendees (75 were farmers) at the 2016 Vermont No-Till and Cover Crop Symposium. Project Coordinator, Kirsten Workman, presented work from this project and other cover cropping projects in her presentation titled, "Multi-Species Cover Crop Mixtures". (February 2016|Burlington, Vt.)*
- *A similar presentation was given at the New England Certified Crop Adviser In-service hosted by University of Maine Extension faculty and staff. Roughly 60 CCAs and University/Extension professionals attend this regional event. (February 2016|Portsmouth, NH)*
- *A Cover Crop Field Day was held at the research plots located on Vorsteveld Farm. Eighteen (18) total attendees participated in the event which included seven (7) farmers and eleven (11) service providers, agency staff, and university faculty/staff. We discussed*

*the project and focused a lot of the discussion on soil health and the difference between the broadcast plots and those that were drilled. An event summary and handouts from the field day are attached. (April 2016 | Panton, Vt.)*

- *A Cover Crop Field Day for Technical Service Providers was held in May. The field day was held at three different research projects, in four different fields at two different farms. One of the farms/fields was the research plots for this project at the Clifford Farm. In addition, NRCS Conservation Innovation Grant projects dealing with cover cropping, compaction and soil health were also highlighted. Twenty-three (23) people attended. Because this field day was specifically targeted to technical service providers, they made up the majority of attendees (22). Many NRCS and Vermont Agency of Agriculture staff, alongside local agricultural business representatives were able to have a good training looking at effective ways to implement innovative approaches to cover cropping. An event summary and handouts from the field day are attached. (May 2016 | Middlebury and Starksboro, Vt.)*
- *Jeff Carter, project participant/advisor, presented results from this project at a USDA National Institute for Agriculture professional development meeting in Virginia. The majority of this project is funded through USDA-NIFA project and Mr. Carter was presenting the work from that project, titled "Sustaining Rural Farm Communities in Vermont" (USDA-NIFA Award 2014-68006-21864). This project comprised roughly 25% of that presentation. (September 2016 | Virginia)*

## ***BETTER COVER CROP MIXES IN VERMONT***

**USDA NRCS Vermont State Conservation Innovation Grant # 69-1644-13-5**

2013 - 2016

Water quality in Lake Champlain and soil health are major priorities for Vermont NRCS, UVM Extension agronomy professionals and farmers in Vermont. This project was designed to demonstrate and investigate an innovative approach to cover cropping, a known practice to improve water quality and increase soil health. Winter rye is by far the most common cover crop grown in Vermont. While it is reliable and effective, many farmers are looking for information on other species of cover crops and mixtures of cover crops as an alternative to winter rye. This project entailed planting a series of cover crop mixes in side-by-side demonstration plots on farm fields from Richmond to Orwell in the Lake Champlain watershed in Vermont. These mixes included grasses/grains, legumes and brassicas and were planted into corn silage and soybean fields at two or three different times, including interseeding into standing crops and planting after harvest.


The goal of this project was to provide local information about the use of alternative cover crop species and mixtures, from both agronomic and ecosystem service standpoints, thereby increasing cover crop adoption on Vermont farms by providing alternatives to monoculture winter rye cover cropping.

In order to accomplish this, several objectives were outlined.

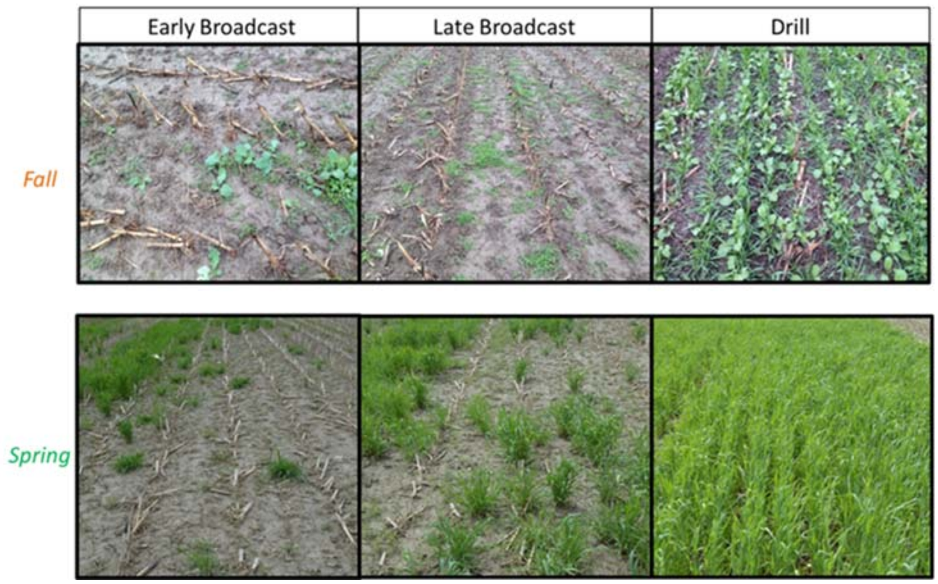
- Establish cover crop demonstration plots on multiple farms in dairy/field crop situations over the course of two years to evaluate cover crop mixtures that include a grass or grain, a legume and a brassica.
- Demonstrate this practice throughout the southern half of the Lake Champlain basin on varying soil types, landscape positions and microclimates.
- Share results of these demonstrations with farmers, agronomists, and service providers directly and through educational resources.
- Advise NRCS practice standards to include specific guidance on cover crop mixtures.

This project accomplished the following over the course of two growing seasons:

- 15 different three-species cover crop mixtures (and winter rye standard) were planted and evaluated. This equated to 29 different planting events with a total of 319 different plots.
- These cover crop mixtures were evaluated for 11 different parameters: percent cover (fall), percent cover (spring), height (fall), height (spring), biomass (fall), biomass (spring), Nutrient (N, P, K) content (fall), Nutrient (N, P, K) content (spring), soil temperature, soil moisture, and soil compaction.
- 10 farms participated as demonstration partners, allowing the use of 13 different fields as demonstration sites in 7 Vermont towns.

- At least 12 different field days and 6 presentations directly contacted 829 people with information generated from this project.  In addition, seven newsletter articles and 5 Across the Fence episodes indirectly reached thousands more.
- Valuable data was collected assessing cover crop performance in Vermont
- A new fact sheet was developed and an existing fact sheet was updated
- Recommendations were made to improve existing NRCS practice guidance

The most striking result was not the difference between mixes but the difference between broadcast inter-seeding and drilling. The first year we had four farms with corn silage in our trials, and of those broadcasting was only moderately successful on one farm and failed on the other three. The other three did not work. In the second year we had five corn silage farms in our trial; on one farm it was a failure, on another it was minimally successful and on the three others it was moderately successful. There was variation in mix performance broadcasting, and also by year. Adjustments to increase success of establishment of broadcasting the second year included being more diligent in making sure herbicide applications were compatible with inter-seeding. We also adjusted our seeding protocol. Nevertheless broadcast inter-seeding is limited by lack of seed to soil contact, shading, limited moisture, and post-harvest traffic.




•	Broadcasting can work in situations where conditions are ideal; getting the right conditions can be more difficult and NRCS requires higher seeding rates to make up for this fact. However, even with higher seeding rates results should be monitored to determine if this method will work on your farm. Brassicas or annual ryegrass may be more successful this way.

•	Drilling is a consistent way to establish a cover crop. In order to effectively establish a cover crop, timely corn silage harvest is required. In the fall, drilling cover crops may at first have less biomass than broadcast cover crops, but will quickly catch up to and surpass broadcast cover crops under many conditions.

•	Spring biomass, particularly with drilled cover crops, will need to be monitored in the spring so that cover crops do not get unmanageable. Choosing the right mix that will depend on the objective – for example mixes the performed “the best”, like Mix 9 and 10, may or may not be ideal depending on whether maximum biomass is desired. Mixing a winter killed cereal with a winter hardy cereal like Mix 6 or 7, may be an approach to balance fall cover and spring biomass. Many different cover crops can provide soil conservation purposes; adding a legume cover crop can maximize nitrogen benefits, but must be planted early enough in order for those benefits to pay, based upon the seed costs.

**Draft Recommendations to VT NRCS for multi-species cover crop for EQIP program.**

| Table 1d - VT 340 | Min.Seeding Rate (lbs/acre) | | Seeding Depth | Latest Seeding Dates* (USDA Hardiness Zones 3b - 5a) | | | | Primary Purpose** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Cover Crop Mixes ‡** *(3-Species Mixes)* | Broadcast (includes aerial) | Drilled | Inches | Fall Cover | Winter Cover | Spring Cover | Summer Cover | Erosion | Nitrogen Fixation | Nutrient Scavenge |
| **2-1: *Winter Killed Mix* ‡** | | | | | | | | | | |
| Forage Oat | 40 | 30 | 1-1½ | Aug. 15 | Sept. 1 | April 15 | May 15 | x | x | x |
| Field Pea | 30 | 25 | | | | | | | | |
| Radish | 5 | 3 | | | | | | | | |
| **2-2: *Marginally Winter Hardy* ‡** | | | | | | | | | | |
| Annual Ryegrass | 15 | 12 | ½-1 | Aug. 15 | Sept. 1 | April 15 | May 15 | x | x | x |
| Winter Pea | 30 | 25 | | | | | | | | |
| Radish | 5 | 3 | | | | | | | | |
| **2-3a: *Winter Kill & Winter Hardy* (Brassica) ‡** | | | | | | | | | | |
| Forage Oat | 50 | 40 | 1-1½ | Aug. 15 | Sept. 15 | NA | NA | x | | x |
| Winter Rye | 50 | 40 | | | | | | | | |
| Radish | 5 | 3 | | | | | | | | |
| **2-3b: *Winter Kill & Winter Hardy* (Legume) ‡** | | | | | | | | | | |
| Forage Oat | 50 | 40 | 1-1½ | Aug. 15 | Sept. 15 | NA | NA | x | x | x |
| Winter Rye | 50 | 40 | | | | | | | | |
| Hairy Vetch | 15 | 10 | | | | | | | | |
| **2-5: *Winter Hardy , Low Spring Biomass* ‡** | | | | | | | | | | |
| Winter Rye | 50 | 40 | 1-1½ | Aug. 15 | Sept. 15 | NA | NA | x | x | x |
| Winter Pea | 30 | 25 | | | | | | | | |
| Turnip | 5 | 3 | | | | | | | | |
| **2-6: *Winter Hardy, Moderate Biomass* ‡** | | | | | | | | | | |
| Winter Rye | 50 | 40 | ½-1½ | Aug. 15 | Sept. 1 | NA | NA | x | x | x |
| Crimson Clover | 12 | 10 | | | | | | | | |
| Winter Rapeseed | 5 | 3 | | | | | | | | |
| **2-7: *Winter Hardy , High Spring Biomass* ‡** | | | | | | | | | | |
| Winter Rye | 100 | 75 | ½-1½ | Aug. 15 | Sept. 15 | NA | NA | x | x | x |
| Hairy Vetch | 15 | 10 | | | | | | | | |
| Winter Rapeseed | 5 | 3 | | | | | | | | |

**Table 1e - VT 340**

| ‡ Seeding Rates (in a three-way mix) Pounds/Acre | | |
|---|---|---|
| **Cover Crop Species** | **Broadcast** | **Drilled** |
| **Grasses & Grains** | | |
| Winter Rye | 50 | 40 |
| Winter Wheat | 50 | 40 |
| Winter Triticale | 50 | 40 |
| Spring Grain | 50 | 40 |
| Forage Oat | 50 | 40 |
| Annual Ryegrass | 15 | 12 |
| **Legumes** | | |
| Red/White Clover | 8 | 6 |
| Crimson Clover | 12 | 10 |
| Berseem/Sweet Clover | 10 | 8 |
| Field Pea | 30 | 25 |
| Winter Pea | 30 | 25 |
| Hairy Vetch | 15 | 10 |
| **Brassicas** | | |
| Radish | 5 | 3 |
| Turnip | 5 | 3 |
| Rapeseed | 5 | 3 |

*These rates are in pure live seed (PLS):*

*% PLS = % germination x % pure seed/100*

*To determine actual seeding rate, divide desired PLS seeding rate by your seeds' % PLS*

*Example: To achieve a 50 lb/acre PLS seeding rate with seed that has 85% PLS*

*50 ÷ 0.85 PLS = 59 lbs/acre actual seed*

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

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

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

## ***SOIL HEALTH DEMONSTRATION FARM ON CLAY SOIL***

**USDA NRCS Vermont State Conservation Innovation Grant # 69-1644-13-4**
2013 - 2016

This project was designed to demonstrate on local farms that reduced tillage systems including vertical tillage, deep zone tillage (zone-till), surface band strip-till, and no-till planting systems that include cover crops. Other farmers could evaluate these options for annual row crops on heavy clay soils in the Champlain Valley as an alternative method to conventional fall plowing of soils annually after fall crop harvest. A whole-farm shift to greatly reduce tillage and include cover crops was implemented on a commercial cash crop farm in Addison, Vermont growing corn grain, soybean and winter rye with no manure inputs. The project was expanded to include eleven (11) additional farms who were direct participants in implementing field scale research and demonstration trials at their farm, allowing data collection and field tours to disseminate findings and share collective experiences between farmers. Four of the additional field sites were added to the project as long-term “Discovery” style research fields in Panton, West Addison, Orwell and East Middlebury to include production of no-till corn silage with cover crops with applications of dairy manure. Data collected on crop production constraints, tillage practice and cover crop effects, and improvements in soil health helped inform design of concurrent field investigations and provide cost to benefit evaluations for other farmers.

Demonstration field days for farmers and other agricultural professionals were conducted at farm field sites providing high quality direct transfer of information and opportunities for in-depth conversations between farmers and other attendees. Summary field data from demonstration field sites was provided as field workshop handouts; training conference presentations and handouts; in written articles, factsheets and project updates distributed to farmers and agriculture professionals in Vermont and New England; through our Champlain Valley Crop, Soil and Pasture Team newsletters, Facebook, Website and Blog postings; and personal contacts.

The project was based on a theme of using adaptive management in farming using replicated treatments to inform farmer decisions about effect of a transition to a new crop production method at the field level before full farm transition. The farmers chose the appropriate conservation practices to meet resource protection goals for soil, water and the farm business. There was a positive overall impact on crop production and soil health indicators as a result of reduced tillage and cover crop practices at all of these demonstration sites. Reducing tillage was shown to consistently improve soil health assessment scores at all farm sites. Each farm site produced a unique response to a particular field practice change reinforcing that any prescribed recommendations for implementation should be customized for each site with allowance for flexibility to modify the schedule of practices several times during a single season.

Several projects compared no-till, strip till and conventional tillage and planting; cover crop single and multi-species mixes; dairy manure applications, methods and effects; soil health assessments and on-farm measurements; equipment setup and modifications; nutrient management inputs; conservation crop rotation changes. We made many “accidental discoveries” and management corrections along the way, just as adaptive management should imply.

## *Comparison of No-Till and Conventional Full-Tillage Corn Silage with Manure*

In 2015, a total of five (5) different farms were included in this demonstration project as a preliminary examination of tillage type and yield. All farms had no-till fields and fields with high clay content, though soil type did vary. One farm also had a sandier loam field. Four farms had a comparison of no-till and conventional tillage. A fifth farm had a comparison of no-till and reduced-till aka 'scratch-till' treatments. One of the farms also compared continuous corn field to corn the first year in rotation after perennial sod. Treatments were analyzed using a Students paired t-test (adjustments for normal variance considered, alpha level 0.05 or 0.1).

**2015 Yield Estimates Based Upon Hand Sampling Method**

Average of 3 - 4 Replications

| | Tillage Practice | Soil Type | Corn Variety Days to Maturity | Planting Date | Population In Thousands Per Acre | Yield Corn Silage Ton/Ac @ 35% DM | Comparison |
|---|---|---|---|---|---|---|---|
| Farm A | No-Till | Cv (VgB): Clay | 96 | 24-May | 29 | 15.39 | greater |
| | Conventional | Cv: Silty Clay | 96 | 8-May | 36 | 14.57 | |
| Farm B | No-Till | Cw | 94 | 25-May | 31 | 16.02 | less |
| | Conventional | MnB | 105 | 18-May | 36 | 23.59 | |
| Farm C | No-Till | VgB: Clay | 96 | 29-May | 35 | 22.43 | greater |
| | Conventional | VgB: Clay | 96 | 23-May | 30 | 17.92 | |
| Farm D | No-Till ContC | VgB: Clay | 92 | 24-May | 28 | 22.53 | less |
| | Conventional ContC | VgB: Clay | 100 | 17-May | 34 | 28.75 | |
| | No-Till C1 | VgB: Clay | 92 | 24-May | 29 | 19.64 | greater |
| | Conventional C1 | VgB: Clay | 92 | 24-May | 23 | 15.49 | |
| Farm E | No-Till | VgB: Clay | 96 | 3-May | 33 | 17.17 | greater |
| | Reduced-Till | VgB: Clay | 96 | 3-May | 34 | 14.00 | |
| | No-Till | ElB: Sandy Loam | 108 | 6-May | 31 | 20.23 | equivalent |
| | Reduced-Till | ElB: Sandy Loam | 108 | 6-May | 27 | 20.35 | |
| | | | | | No-Till Av. | 19.06 | |
| | | | | | All Other Av. | 19.24 | |

There was no statistical differences in the yields between no-till and full tillage practices with comparisons made including and excluding the sandier field, and the reduced tillage fields. The average yield for no-till was 19.1 tons/acre, and average yield for conventional and reduced till was 19.2 tons/acre (@ 35% DM). Maturity range differences of corn hybrids in two of the treatments most likely led to the only greater yields for conventional.

No-till corn yields were greater than conventional till on three of the five farms and lower on the other two farms. Comparing no-till to reduced-till, no-till yield was higher per acre on clay ground and essentially equivalent on sandier soils. On the one farm that had both continuous corn and first-year corn, no-till performed better than conventional in the field with hay crop in rotation, but not on the continuous corn. In the only other case with lower yields on the no-till field, the fields did not have the same soil type.

The no-till fields had a higher overall Cornell Soil Health Score than conventional and reduced tilled fields, however it was not statistically significant. All biological measures of the soil health test were also greater on average for no-till fields. The only factor that was statistically significant was ACE Soil Protein, which is a measure of organic nitrogen. The no-till fields that had greater yields also had greater biological soil health scores (Farms A, D and E). Conventional and reduced tilled fields had less surface and subsurface compaction but this was not statistically significant (unless a higher threshold of 0.1 is used, in which case surface compaction applies). There is a moderate correlation between corn yield and ACE Soil Protein.

## *Prevented Planting Field Renovation with Subsoiling, Cover Crops and No-Till*

In 2015 the extreme weather with record rainfalls in June prevented many local farmers from planting their corn and soybean crops. The two farms used the opportunity to renovate these fallow fields with mechanical sub-soiling and contour fitting prior to initiating a no-till corn/soy/cover rotation management strategy. A duplicate trial of eight (8) different cover crop mixes were no-till planted at both field sites to compare results from a cash crop farm (Farm A) with no livestock, and a dairy farm (Farm B) using annual manure applications. The Vergennes soil type, slope and field aspect, soil nutrient levels, cultural practices and mechanical tillage methods were very similar and presented a unique comparison between the two different farming systems. In 2016, no-till soybeans were planted on the first day of September directly into the growing cover crop at Farm A (cash crop), and no-till corn was planted fifteen days later at the dairy farm site (Farm B).

| Farm A (cash crop) : Planted 09/01/15, Sampled 4/20/16 | | | | | | | % Cover Measured 4/20/16 |
|---|---|---|---|---|---|---|---|
| | | Seeding Rate | Dry Matter Basis Lbs/Acre | | | | Average % |
| Plot # | Treatment | Lbs/Acre | DM Yield | N | P | K | Soil Cover |
| 1 | Winter Rye + Radish | 85 + 3 | 863 | 22.38 | 2.50 | 17.78 | 83 |
| 2 | Winter Rye + Radish | 85 + 6 | 571 | 16.26 | 1.54 | 12.22 | 67 |
| 3 | Winter Rye + Radish | 60 + 3 | 852 | 21.25 | 1.79 | 14.56 | 69 |
| 4 | Winter Rye + Radish | 60 + 6 | 367 | 10.98 | 0.73 | 7.52 | 56 |
| 5 | Winter Rye + Oats + Radish | 50 + 50 + 4 | 801 | 23.34 | 2.08 | 17.07 | 82 |
| 6 | Oats + Rad | 60 + 4 | Winter Killed | | | | 57 |
| 7 | Spring Triticale + Radish | 75 + 4 | | | | | 70 |
| 8 | Buckwheat + Radish | 50 + 4 | | | | | 49 |

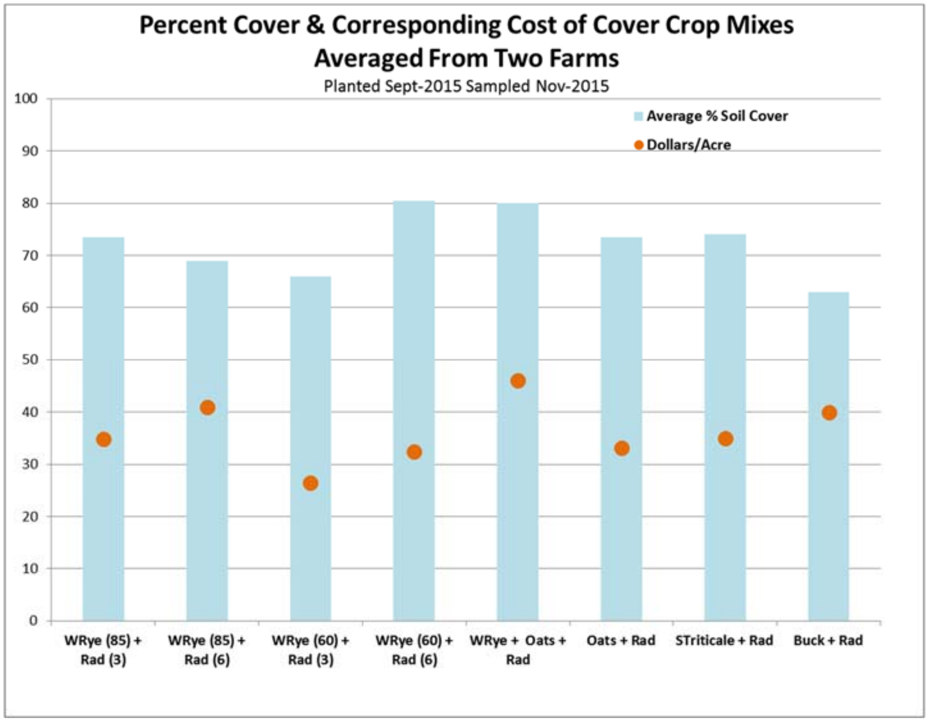
On this farm, winter rye at a higher rate was not as important as radish at a higher rate in affecting biomass, though actual nutrient uptake was affected. Results suggested either increasing radish or increasing winter rye but not both. Specifically, Winter Rye(60) - Radish (6) is probably the best option. Spring nutrient uptake of N, P, K lbs. per acre is shown in table. All cover crop mixes were at or exceeded 49% ground cover as measured by string/bead method.

| Farm B (dairy) : Planted 09/16/15, Sampled 5/23/16 | | | | | | | % Cover Measured 5/10/16 |
|---|---|---|---|---|---|---|---|
| | | Seeding Rate | Dry Matter Basis Lbs/Acre | | | | Average % |
| Plot # | Treatment | Lbs/Acre | DM Yield | N | P | K | Soil Cover |
| 1 | Winter Rye + Radish | 85 + 3 | 3790 | 98.24 | 18.19 | 130.00 | 96 |
| 2 | Winter Rye + Radish | 85 + 6 | 4706 | 116.70 | 22.12 | 167.99 | 94 |
| 3 | Winter Rye + Radish | 60 + 3 | 5061 | 136.04 | 24.29 | 178.65 | 97 |
| 4 | Winter Rye + Radish | 60 + 6 | 4534 | 116.81 | 21.31 | 151.00 | 95 |
| 5 | Winter Rye + Oats + Radish | 50 + 50 + 4 | 4285 | 117.23 | 21.00 | 148.68 | 95 |
| 6 | Oats + Rad | 60 + 4 | Winter Killed | | | | 80 |
| 7 | Spring Triticale + Radish | 75 + 4 | | | | | 80 |
| 8 | Buckwheat + Radish | 50 + 4 | | | | | 80 |
| (Note a later sampling date than at Farm A) | | | | | | | |

Spring nutrient uptake of N, P, K pounds per acre is shown in table. All cover crop mixes were at or exceeded 80 % ground cover as measured by string/bead method. Note that biomass, and accordingly nutrient uptake, was much greater at dairy in comparison to cash crop farm.

However this was both due to greater production and a later sampling date. The farmer decided to cut the cover crop to utilize it as forage and make the field more manageable because of the high biomass production.

Although the cost of seed was the same for both sites, average dry matter yield of the above ground portion of cover crops was 36% higher across all treatments at Farm B site with manure application prior to planting. Correspondingly, the accumulation of nutrients was greater by 63% for N and 82% for P and K at the manured site.




The following yield data for 2016 corn silage was at the manured dairy farm site.

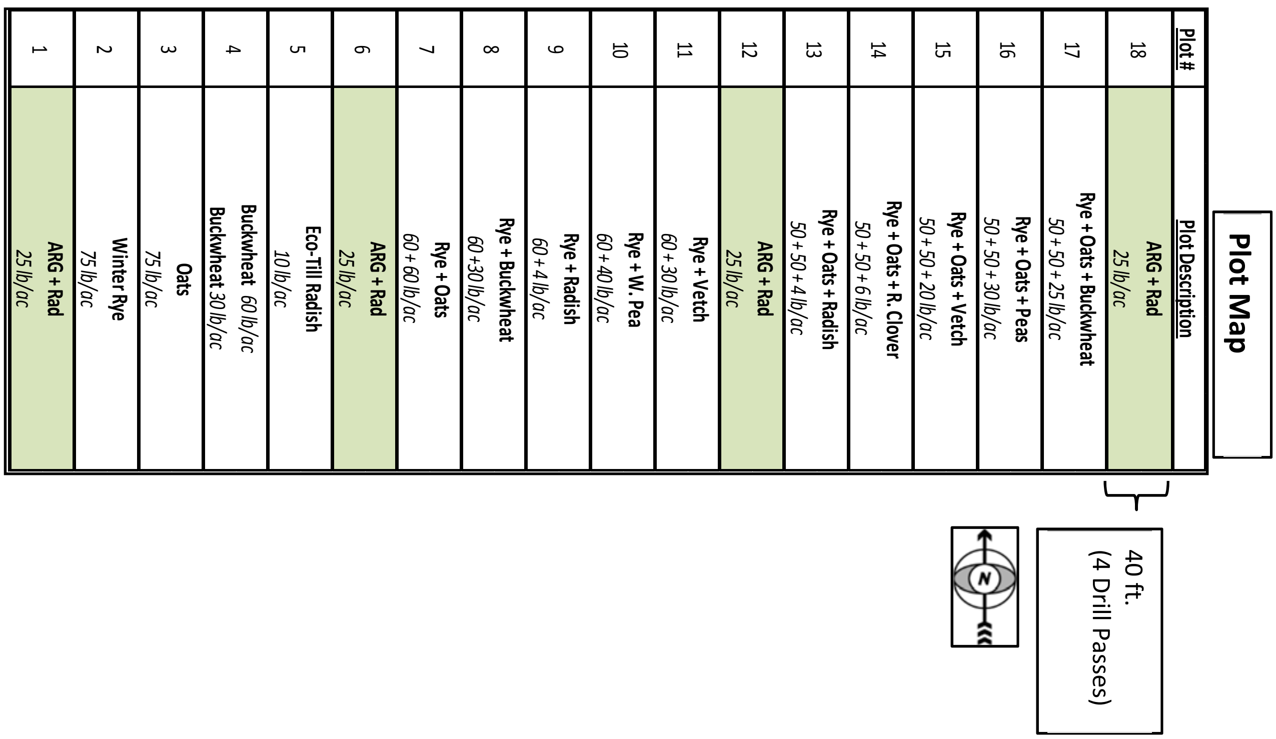
**Corn Silage Yield at Farm B (dairy) - Fall 2016**

| Mix | Rep | *Population 1/1000 ac* | *Harvested Yield (ton/ac)* | *% Dry Matter* | *DM Yield (ton/ac)* | *Silage Yield @ 35 % DM (ton/ac)* |
|---|---|---|---|---|---|---|
| 1 | Average | 29 | 19.3 | 41.3 | 8.0 | 22.8 |
| 2 | Average | 30 | 20.7 | 40.0 | 8.3 | 23.7 |
| 3 | Average | 29 | 22.5 | 39.6 | 8.9 | 25.4 |
| 4 | Average | 30 | 23.0 | 36.9 | 8.5 | 24.3 |
| 5 | Average | 30 | 22.2 | 39.1 | 8.7 | 24.8 |
| 6 | Average | 32 | 21.6 | 41.5 | 9.0 | 25.6 |
| 7 | Average | 32 | 24.8 | 40.2 | 10.0 | 28.5 |
| 8 | Average | 32 | 21.2 | 39.7 | 8.4 | 24.0 |
| 9 | Average | 31 | 24.2 | 38.6 | 9.3 | 26.7 |

## *Cover Crops in a No-Till System: Impact on Soil Health and Corn Yields*

**Project Summary:**

In 2015 a field of no-till corn was damaged by glyphosate herbicide injury and we contacted the farmer about hosting a soil health demonstration site with early planted cover crops. One-half of the field was planted to strips 40’ x 100’ with 6 single species, 6 dual-species, and 6 tri-species “Soil Health” cover crop mixes using a Haybuster no-till grain drill in late August of 2015 and then again in fall 2016. Late fall and early spring data was collected on percent cover, biomass accumulation and nutrient uptake of each cover crop mix. The following spring in 2016 no-till corn was planted across the cover crop treatments to observe effects of these cover crop mixes on the primary corn crop and soil response. The field design of the strip trial included one replicated treatment of annual ryegrass plus daikon radish for evaluation of field variability across the field.




Cover Crop mixes planted into early harvest no-till corn silage field. Planted August 20, 2015. This site was used for the soil health field day May 3, 2016 and was highlighted along with our other CIG project looking at cover crop mixes. Data and forage samples were collected in April on cover crop plots. Spring nutrient uptake of N, P, K lbs per acre is shown in table below. All cover crop mixes were at or exceeded 74 % ground cover as measured by string/bead method.

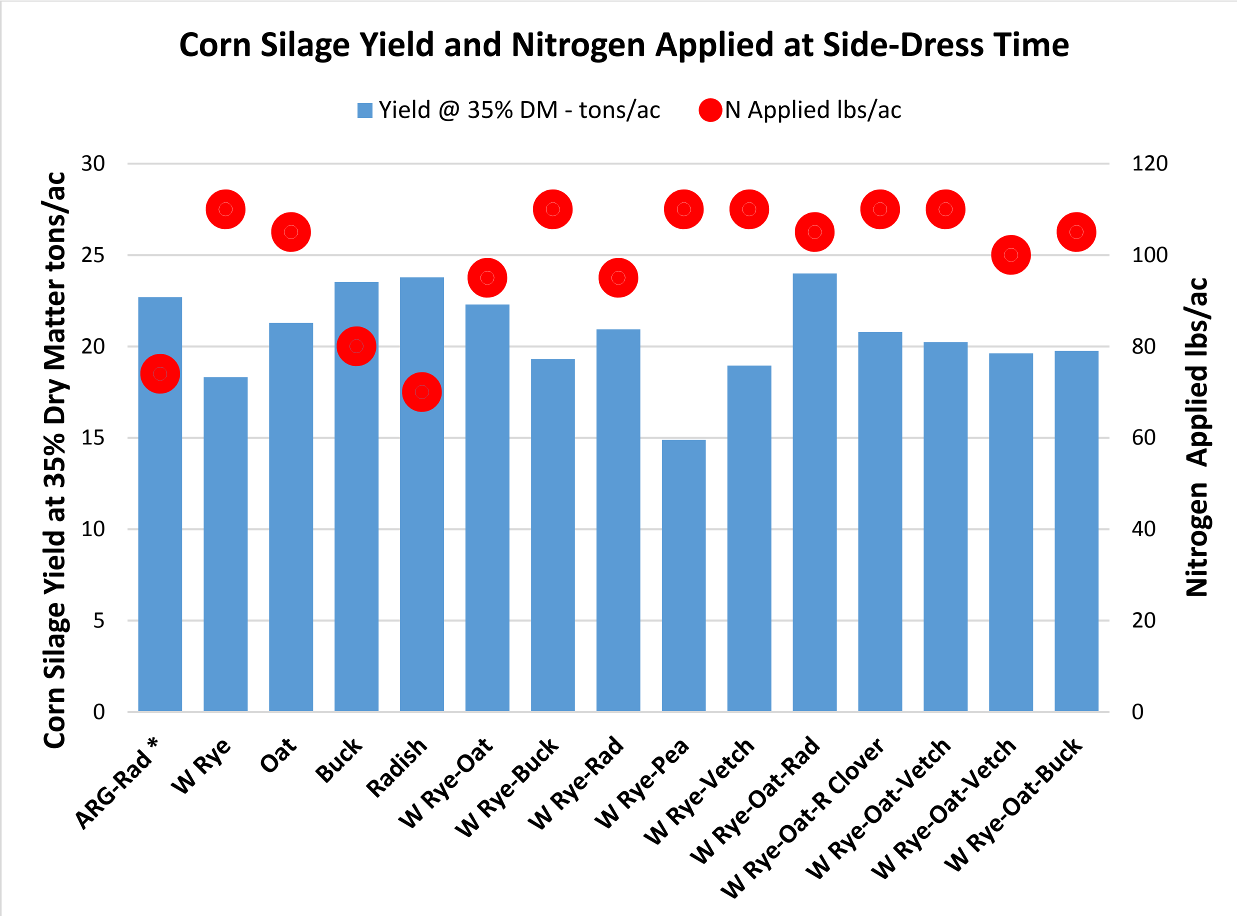
No-till corn was planted in 2016 and measurements were taken in June, along with PSNT samples and corn plant samples. At this farm, as well as observed on other farms in the area, this year more abundant cover crop biomass did not lay down. There was concern about whether the cover crop was inhibiting the corn, and if so whether that was due to physical or chemical soil conditions. After PSNT, we applied nitrogen fertilizer at the recommended rate by plot. Moisture and temperature were measured in April and June. The same cover crop mixes planted were planted again in fall 2016 to be evaluated again after the conclusion of this grant.

In June 2016 the corn plants were noticeably affected by the different cover crop mixes with winter rye residue suppressing corn plant growth (6/24/16). The residual effects of different cover crop mixes were measured using the UVM Pre-Sidedress Nitrate Test (PSNT) to determine appropriate rates of N fertilization to add to the growing crop to mitigate the effects of N immobilization by the decomposing cover crop plant residue. N fertilizer (Urea) was applied according to UVM recommendations to meet a uniform yield goal of 20 ton/ac corn silage. As illustrated above, the early season corn biomass was much less in plots that had winter rye, as opposed to plots that were winter killed. The annual ryegrass plus radish mix, radish, and buckwheat consistently provided higher recovered N availability for early season corn plant growth; while the plots with winter rye required high rates of N applied sidedress to meet UVM recommendations for a comparable yield goal.

**Farm, Soil Samples 6/24/16, Measurements 6/28/16**

| Plot | CC Treatment | 10 Plants<br>Corn Biomass (g) | PSNT ppm<br>Nitrate-N | %<br>Moisture | Temp @ 4.5 in. |
|---|---|---|---|---|---|
| 1 | Annual Ryegrass / Radish | 52.0 | 20 | 34.2 | 70.2 |
| 2 | Winter Rye | 16.0 | 5 | 42.6 | 68.5 |
| 3 | Oat | 31.2 | 6 | 42.0 | 70.8 |
| 4 | Buckwheat | 35.5 | 13.5 | 33.0 | 71.3 |
| 5 | Radish | 42.2 | 15 | 39.8 | 71.1 |
| 6 | Annual Ryegrass / Radish | 43.2 | 17 | 34.9 | 70.9 |
| 7 | Winter Rye / Oat | 18.8 | 9 | 41.7 | 70.3 |
| 8 | Winter Rye / Buckwheat | 13.8 | 4 | 36.4 | 68.9 |
| 9 | Winter Rye / Radish | 27.4 | 9 | 37.5 | 70.8 |
| 10 | Winter Rye / Winter Pea | 14.6 | 5 | 39.2 | 69.1 |
| 11 | Winter Rye / Hairy Vetch | 10.8 | 4 | 42.1 | 69.1 |
| 12 | Annual Ryegrass / Radish | 37.9 | 10 | 36.2 | 70.5 |
| 13 | Winter Rye / Oat / Radish | 21.6 | 6 | 42.1 | 70.3 |
| 14 | Winter Rye / Oat / Red Clover | 16.2 | 5 | 40.9 | 69.9 |
| 15 | Winter Rye / Oat / Hairy Vetch | 13.8 | 6 | 40.7 | 70.2 |
| 16 | Winter Rye / Oat / Winter Pea | 17.9 | 7 | 39.1 | 70.0 |
| 17 | Winter Rye / Oat / Buckwheat | 15.9 | 6 | 43.1 | 70.3 |
| 18 | Annual Ryegrass / Radish | 37.6 | 10 | 41.1 | 70.2 |

Final corn silage yields for 2016 compared to the amount of applied sidedress Nitrogen is shown in the following chart.




In Summary, the cover crops did not perform consistently across all measures. Percent soil coverage in all plots, including the winter killed plots, was high in the spring (=>73%, including residue), and well above conservation targets. The first year of this case study, the cover crops were established much earlier than a normal post-corn silage planting. Due to this, tillage radish had vigorous growth and also outcompeted annual ryegrass (ARG) in the ARG-Rad plots. Buckwheat also had ample time to establish well and the winter rye-buckwheat plot had the most spring biomass. Winter rye with buckwheat or winter pea seemed to more evenly capture both fall and spring P. Radish by itself had the most fall N and P pounds per acre in the plant, and it appeared with decomposition to be more readily available to the plant in the spring. However, this might also mean it could be lost to the environment. Of all the plots, the winter rye-oat-radish plot had the greatest corn yield. However, it required more nitrogen per the PSNT than the straight radish plot. The PSNT was not well correlated with either moisture or temperature, but there was weak (R=0.53) relationship with spring cover crop biomass. The soil health test did not demonstrate one clear “winner” across all categories of the test; the overall score was ‘medium’ for all plots. Finding the right mix that maximizes both fall and spring nutrient uptake and translates into corn silage yield needs further exploration. However, we believe the combination of winter rye with oats and radish is of particular promise and we will continue to explore these relationships and best seeding rates. Tillage radish results will likely perform differently when planted at the normal post-harvest time.

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UNIVERSITY OF VERMONT EXTENSION

NORTHWEST CROPS & SOILS PROGRAM

# 2015 Cover Crop Mix in Corn Silage Trial

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**2015 COVER CROP MIX IN CORN SILAGE TRIAL**

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## INTRODUCTION

While growing corn silage, it is important to plan for soil health management during the season. Cover cropping is one way to prevent soil erosion, maintain and/or improve soil nutrients, improve soil aggregation, prevent nutrient loss from runoff, and increase water retention. Such soil improvements can promote conditions that add resiliency to a crop, especially in light of extreme weather patterns that may affect yields. It can be challenging to grow cover crop into corn silage without having proper interseeding equipment, or correct timing, so that the cover crop will be able to survive. In this trial, our goals were to evaluate the effect of cover crop seeding dates within corn silage varieties of differing relative maturities and harvest dates. An additional goal was to evaluate a variety of cover crop mixes for biomass production and percent cover. The trial consisted of three corn varieties at 85, 96, and 110 relative maturity (RM) each, planted with nine cover crop mixes in order to assess management strategies for establishing a robust cover crop and maintaining corn yields.

## MATERIALS AND METHODS

The cover crop mix in corn silage trial took place at Borderview Research Farm in Alburgh, VT. General plot information is shared in Table 1. Three varieties of corn, Mycogen TMF2R198 110 day RM, Mycogen TMF2Q413 96 day RM, and Mycogen TMF2H699 85 day RM were planted on 5-May (Table 1). Corn was harvested from the 110 day corn on 23-Sep, the 96 day corn on 15-Sep, and the 85 day corn on 2-Sep.

Nine cover crop mixes were interseeded in each variety of corn (Table 2). On 19-Jun the 110 day corn was interseeded with each cover crop mix using the Penn State Interseeder (Figure 1). The 96 day corn was interseeded on 16-Sep and the 85 day corn on 4-Sep, both using a grain drill (Table 1).

Photos of the cover crop were taken on 28-Oct in order to assess the percent of cover from the cover crop, as opposed to bare ground. Photos were taken in all three corn silage plantings, however, cover crop did not establish in the 110 day corn. Cover crop mixes were sampled on 26-Oct to determine biomass only for the 85 day corn planting, since the 96 day planting did not have a substantial amount of cover crop growth. The samples were weighed and dried till they reached a stable weight.

**Table 1. General plot management, 2015.**

| Trial Information | Borderview Research Farm<br>Alburgh, VT |
|---|---|
| Soil Type | Benson rocky silt loam<br>8-15% slope<br>Covington silty clay loam<br>0-3% slope |
| Previous crop | Corn |
| Varieties | Mycogen TMF2R198, 110 RM<br>Mycogen TMF2Q413, 96 RM<br>Mycogen TMF2H699, 85 RM |
| Corn planting dates | 5-May |
| Harvest date | 23-Sep, 15-Sep, 2-Sep |
| Corn seeding rate | 34,000 seeds $ac^{-1}$ |
| Tillage methods | Disk and spike tooth harrow |
| Cover crop planting dates | 19-Jun in 110 RM<br>16-Sep in 96 RM<br>4-Sep in 85 RM |

**Figure 1. The Penn State Interseeder.**

**Table 2. Cover crop mixes, Alburgh, VT 2015.**

| **Cover Crop Mixes** |
|---|
| Mix 1: Fria Ryegrass and Eco-Till Radish (pre-mixed) (18 lbs/acre) |
| Mix 2: Tri-Cal Triticale (60 lbs/acre) and Dwarf Essex Rape (3 lbs/acre) |
| Mix 3: Everleaf Oats (60 lbs/acre) and Groundhog Radish (3 lbs/acre) |
| Mix 4: Winter Rye (40 lbs/acre), Milvus Clover (5 lbs/acre), and T-Raptor Brassica (2 lbs/acre) |
| Mix 5: Prince Brand Rye Grass (12 lbs/acre) and Milvus Clover (6 lbs/acre) |
| Mix 6: Winter Wheat (60 lbs/acre) and Ladino Clover (6 lbs/acre) |
| Mix 7: Soil Builder - TriCal Triticale, MOI & KB Supreme ryegrass, Crimson Clover, Hairy Vetch, and Daikon Radish (120 lbs/acre) |
| Mix 8: Indy Mix - Tillage Root Max Ryegrass, Crimson Clover, and Tillage Radish (18 lbs/acre) |
| Mix 9: Everleaf Oats (40 lbs/acre), Dynamite Clover (5 lbs/acre), and Vivant Radish (2 lbs/acre) |
| Mix 10: Control |

Variations in yield and quality can occur because of variations in genetics, soil, weather and other growing conditions. Statistical analysis makes it possible to determine whether a difference among varieties is real, or whether it might have occurred due to other variations in the field. At the bottom of each table, a LSD value is presented for each variable (i.e. yield). Least Significant differences (LSD's) at the 10% level of probability are shown. Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two varieties. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk. In the following example, A is significantly different from C but not from B. The difference between A and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these varieties did not differ in yield. The difference between A and C is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that B was not significantly lower than the top yielding variety.

| Variety | Yield |
|---|---|
| A | 6.0 |
| B | 7.5* |
| C | 9.0* |
| **LSD** | **2.0** |

The p-value is another statistical marker that is given. This value represents the probability that the difference between treatments happened randomly by chance. For example, a trial comparing the nutritive quality of forage A and forage B has a p-value of 0.01. That means that there is a 1% chance that the difference in quality between the two forages was a random occurrence and there is a 99% chance that the difference in quality was due to the difference in the forages themselves.

## RESULTS AND DISCUSSION

Seasonal precipitation and temperature was recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT. June was a wet month with 2.73 more inches of precipitation than normal (Table 3). The remainder of the summer was relatively dry with 9.92 fewer inches of precipitation than normal over July, August, and September. Temperature varied with May and September being much warmer than the 30 year average. Overall, there were an average of 2523 Growing Degree Days (GDDs) accumulated this season which is 311 more than the 30-year average.

**Table 3. Seasonal weather data[1] collected in Alburgh, VT, 2015.**

| Alburgh, VT | April | May | June | July | August | September |
|---|---|---|---|---|---|---|
| Average temperature (°F) | 43.4 | 61.9 | 63.1 | 70.0 | 69.7 | 65.2 |
| Departure from normal | -1.4 | 5.5 | -2.7 | -0.6 | 0.9 | 4.6 |
| | | | | | | |
| Precipitation (inches) | 0.09 | 1.94 | 6.42 | 1.45 | 0.00 | 0.34 |
| Departure from normal | -2.73 | -1.51 | 2.73 | -2.70 | -3.91 | -3.30 |
| | | | | | | |
| Growing Degree Days (base 50°F) | 22 | 376 | 399 | 630 | 626 | 470 |
| Departure from normal | 22 | 177 | -75 | -10 | 45 | 152 |

[1]Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

All three corn varieties yielded well for the 2015 season (Table 4).

**Table 4. Yields from corn silage of varying relative maturity, Alburgh, VT, 2015.**

| Corn varieties, planted 5-May | | Moisture content at harvest | Yield at 65% mst | Corn harvest | Cover crop planting |
|---|---|---|---|---|---|
| Relative maturity | Name | % | Tons/acre | Date | Date |
| 110 day | Mycogen TMF2R198 | 59.7 | 30.5 | 23-Sep | 19-Jun |
| 96 day | Mycogen TMF2Q413 | 54.9 | 43.9 | 15-Sep | 16-Sep |
| 85 day | Mycogen TMF2H699 | 66.6 | 35.4 | 2-Sep | 4-Sep |

Percent cover in the 85 day corn was significantly higher than percent cover in the 96 day corn (p = <.0001) (Figure 2). When comparing percent cover crop mixes from the 85 day corn only, mix 4 of winter rye, milvus clover, and t-raptor brassica was the top performer. Mixes 9, 1, 3, 7, and 8 did not perform significantly lower than the top performing cover crop, LSD (0.10) = 16.5%. When comparing dry matter yield from the 85 day corn only, mix 1 of fria ryegrass and eco-till radish had the greatest yield. Mixes 9, 8, 4, 3, and 7 did not perform significantly lower than the top performing cover crop mix, LSD (0.10) = 279.5 (Figure 3).

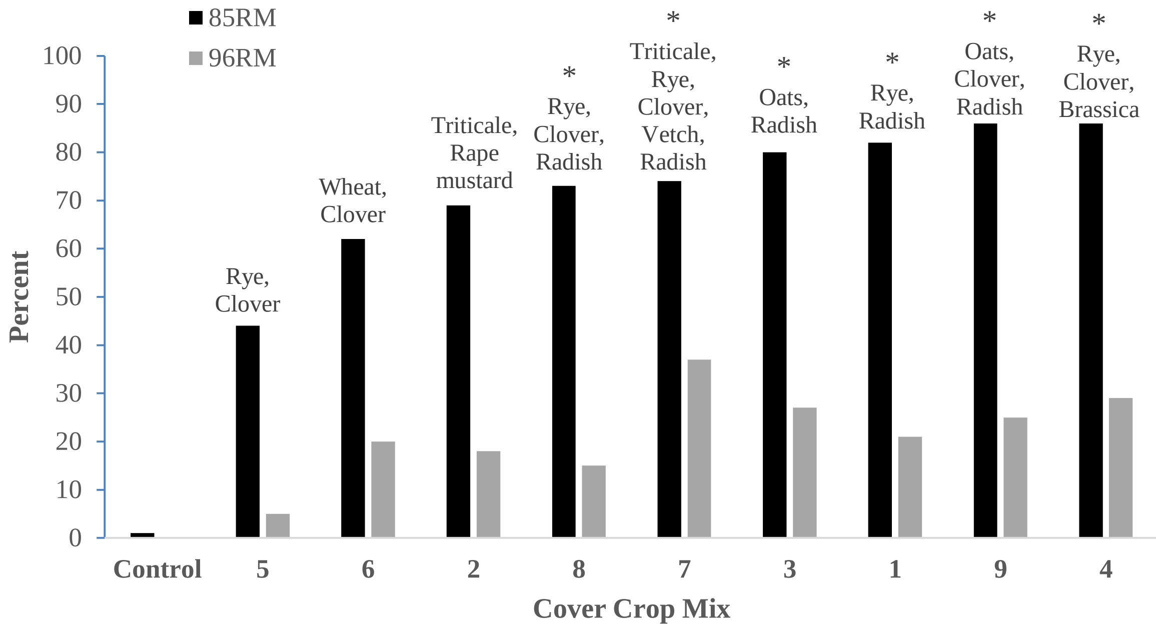


**Figure 2. Percent cover from the cover crop mixes in the 85 and 96 relative maturity corn silage, Albugh, VT 2015. Percent cover varied significantly based on corn relative maturity (p = <.0001). Cover crop mixes from the 85 day corn indicated with an asterisk did not perform significantly lower than the top performing cover crop mix, LSD (0.10) = 16.5%.**

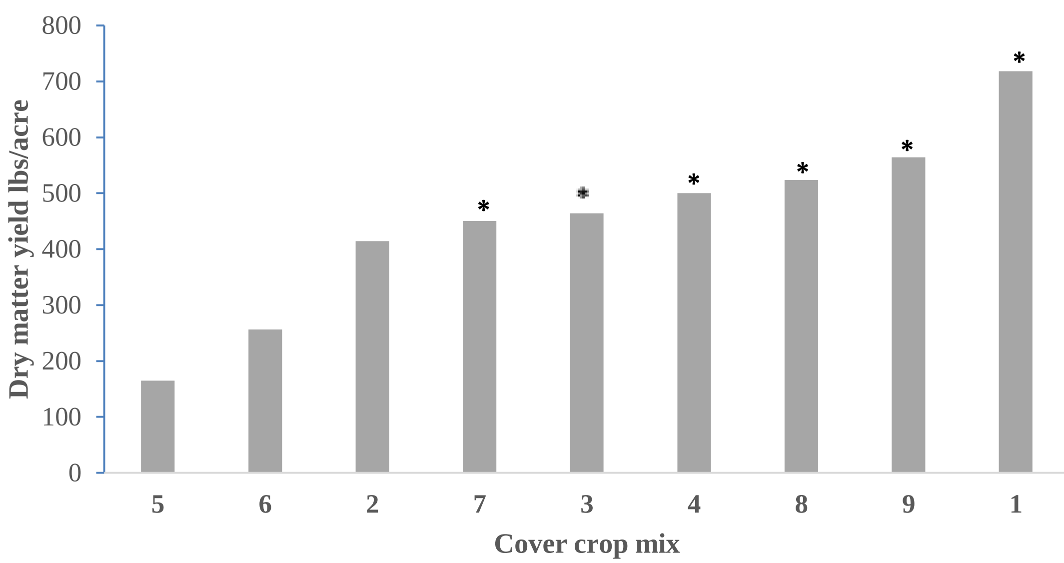


**Figure 3. Cover crop mixes dry matter yield from the 85 day corn. Cover crop mixes indicated with an asterisk did not perform significantly lower than the top performing cover crop mix, LSD (0.10) = 279.5.**

## ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Team would like to thank Northeast Extension Risk Management Education for funding this research. Special thanks to Roger Rainville and the staff at Borderview Research Farm for their generous help with the trials. We would like to acknowledge Julija Cubins, Hillary Emick, Lindsey Ruhl, and Dan Ushkow for their assistance with data collection and entry. This information is presented with the understanding that no product discrimination is intended and neither endorsement of any product mentioned, nor criticism of unnamed products, is implied.

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NW CROPS & SOILS PROGRAM

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# 2016 Corn Cropping Systems to Improve Economic and Environmental Health


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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

**2016 CORN CROPPING SYSTEMS TO IMPROVE ECONOMIC AND ENVIRONMENTAL HEALTH**

**Dr. Heather Darby, University of Vermont Extension**
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In 2016, UVM Extension's Northwest Crops & Soils Program continued a multi-year trial at Borderview Research Farm in Alburgh, VT to assess the impact of corn cropping systems on overall health and productivity of the crop and soil. Yields are important and they affect the bottom line immediately and obviously. Management choices involving crop rotation, tillage, nutrient management, and cover crops also make differences in the long term. Growing corn with practices that enhance soil quality and crop yields improves farm resiliency to both economics and the environment. This project evaluated yield and soil health effects of five different corn rotations: continuous corn, no-till, corn planted after perennial forage, corn planted after a cover crop of winter rye, and a perennial forage fescue.

## MATERIALS AND METHODS

The corn cropping system was established at Borderview Research Farm in Alburgh, VT. The experimental design was a randomized complete block with replicated treatments of corn grown in various cropping systems (Table 1).

**Table 1. Corn cropping system specifics for corn yield and soil health, Alburgh, VT, 2016.**

| Crop | Management method | Treatment abbreviation |
|---|---|---|
| Corn silage | Continuous corn, tilled | CC |
| Corn silage | New corn (3$^{rd}$ year), in tilled alfalfa/fescue w/ cover crop | NC |
| Corn silage | No-till in alfalfa/fescue | NT |
| Corn silage | Winter cover crop, tilled | WCCC |
| Perennial Forage | Fescue | PF |

The soil type at the research site was an Amenia silt loam with 0-2% slopes (Table 2). Each cropping system was replicated 4 times in 20' x 50' plots. Soil samples were taken on 28-Apr for Cornell Soil Health analysis. Ten soil samples from five locations within each plot were collected 6 inches in depth with a trowel, thoroughly mixed, put in a labeled gallon bag, and mailed with 2-day shipping on blue ice. Compaction was measured at 0-6 inch depth and 6-12 inch depth by penetrometer twice at the same 5 stops the soil samples were collected. The compaction measurements and soil types were used by the Cornell Nutrient Analysis Laboratory to calculate surface and sub-surface hardness (psi).

Percent aggregate stability was measured by Cornell Sprinkle Infiltrometer and indicates ability of soil to resist erosion. Percent available water capacity was measured by placing soil samples on ceramic plates that are inserted into high pressure chambers to determine field capacity and permanent wilting point. Percent organic matter was measured by loss on ignition when soils are dried at 105$^{o}$ C to remove water then ashed for two hours at 500$^{o}$ C. Active carbon (active C mg/soil kg) was measured with potassium permanganate and is used as an indicator of available carbon (i.e. food source) for the microbial community. Soil proteins (N mg/soil g) are measured with citrate buffer extract, then autoclaved. This measurement is used to quantify organically bound nitrogen that microbial activity can mineralize from soil organic matter and make plant-available. Soil respiration ($CO_2$ mg/soil g) is measured by amount of $CO_2$ released over a 4 day incubation period and is used to quantify metabolic activity of the soil microbial community.

The corn variety was Mycogen's TMF2Q419, which has a relative maturity (RM) of 96 days. The NC, CC, and WCCC treatments were plowed on 7-May. Corn was seeded in 30" rows on 10-May with a John Deere 1750 corn planter at 34,000 seeds per acre. At planting, 200 lbs per acre of a 10-20-20 starter fertilizer was applied.

**Table 2. Agronomic information for corn cropping system, Alburgh, VT, 2016.**

| Location | Borderview Research Farm – Alburgh, VT |
|---|---|
| **Soil type** | Amenia silt loam, 0-2% slope |
| **Previous crop** | Corn or Alfalfa/Fescue |
| **Plot size (ft)** | 20 x 50 |
| **Replications** | 4 |
| **Management treatments** | Tilled continuous corn (CC), tilled rye cover crop (WCCC), tilled fescue (NC), no-till (NT), perennial forage (PF) |
| **Corn variety** | Mycogen TMF2Q419 (96 RM) |
| **Seeding rates (seeds ac$^{-1}$)** | 34,000 |
| **Planting equipment** | John Deere 1750 corn planter |
| **Plow date** | 7-May |
| **Planting date** | 10-May |
| **Row width (in.)** | 30 |
| **Corn Starter fertilizer (at planting)** | 200 lbs ac$^{-1}$ 10-20-20 |
| **Chemical weed control for corn** | 3 qt. Lumax® ac$^{-1}$, 17-May |
| **Additional fertilizer (corn topdress)** | 19-Jun, based on plot recommendation (Table 6) |
| **Forage 1st cut date** | 31-May |
| **Forage 2nd cut date** | 19-Jul |
| **Forage 3rd cut date** | 7-Sep |
| **Corn harvest date** | 16-Sep |

On 17-May, 3 quarts of Lumax® were applied per acre for weed control on corn plots. Corn was topdressed with nitrogen fertilizer by broadcast according to Pre-Sidedress Nitrite Test (PSNT) recommendations on 17-Jun (Table 6). The PSNT soil samples were collected with a 1-inch diameter Oakfield core to 6 inches in depth at five locations per plot. The samples were combined by plot and analyzed by UVM's Agricultural and Environmental Testing Laboratory using KCl extract and ion chromatograph.

Corn was harvested for silage on 16-Sep with a John Deere 2-row chopper, and weighed in a wagon fitted with scales. Corn populations were determined by counting number of corn plants in two rows the entire length of the plot (50 feet). Corn borer and corn rootworm populations were based on number of damaged plants observed per plot. Dry matter yields were calculated and yields were adjusted to 35% dry matter. Silage quality was analyzed using the FOSS NIRS (near infrared reflectance spectroscopy) DS2500 Feed and Forage analyzer. Dried and coarsely-ground plot samples were brought to the UVM's Cereal Grain Testing Laboratory where they were reground using a cyclone sample mill (1mm screen) from the UDY Corporation. The samples were then analyzed using the FOSS NIRS DS2500 for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), 48-hour digestible NDF (NDFD), total digestible nutrients (TDN), and Net Energy-Lactation ($NE_L$).

Perennial forage first cut biomass samples were harvested by hand with clippers in an area of 12' x 3' section in fescue treatments on 31-May, second cut biomass samples were cut using the same procedure on 19-Jul, and third cut biomass samples were cut using the same procedure on 7-Sep. Perennial forage moisture and dry matter yield were calculated and yields adjusted to 35% dry matter. An approximate 2 lb subsample of the harvested material was collected, dried, ground, and then analyzed at the University of Vermont's Cereal Grain Testing Laboratory, Burlington, VT, for quality analysis.

Mixtures of true proteins, composed of amino acids and non-protein nitrogen, make up the CP content of forages. The CP content of forages is determined by measuring the amount of nitrogen and multiplying by 6.25. The bulky characteristics of forage come from fiber. Forage feeding values are negatively associated with fiber since the less digestible portions of plants are contained in the fiber fraction. The detergent fiber analysis system separates forages into two parts: cell contents, which include sugars, starches, proteins, non-protein nitrogen, fats and other highly digestible compounds; and the less digestible components found in the fiber fraction. The total fiber content of forage is contained in the neutral detergent fiber (NDF). Chemically, this fraction includes cellulose, hemicellulose, and lignin. Because of these chemical components and their association with the bulkiness of feeds, NDF is closely related to feed intake and rumen fill in cows. In recent years, the need to determine rates of digestion in the rumen of the cow has led to the development of NDFD. This in vitro digestibility calculation is very important when looking at how fast feed is being digested and passed through the cow's rumen. Higher rates of digestion lead to higher dry matter intakes and higher milk production levels. Similar types of feeds can have varying NDFD values based on growing conditions and a variety of other factors. In this research, the NDFD calculations are based on 48-hour in vitro testing.

Net energy for lactation ($NE_L$) is calculated based on concentrations of NDF and ADF. $NE_L$ can be used as a tool to determine the quality of a ration, but should not be considered the sole indicator of the quality of a feed, as $NE_L$ is affected by the quantity of a cow's dry matter intake, the speed at which her ration is consumed, the contents of the ration, feeding practices, the level of her production, and many other factors. Most labs calculate $NE_L$ at an intake of three times maintenance. Starch can also have an effect on $NE_L$, where the greater the starch content, the higher the $NE_L$ (measured in Mcal per pound of silage), up to a certain point. High grain corn silage can have average starch values exceeding 40%, although levels greater than 30% are not considered to affect energy content, and might in fact have a negative impact on digestion. Starch levels vary from field to field, depending on growing conditions and variety.

Milk per acre and milk per ton of harvested feed are two measurements used to combine yield with quality and arrive at a benchmark number indicating how much revenue in milk can be produced from an acre or a ton of corn silage. This calculation relies heavily on the $NE_L$ calculation and can be used to make generalizations about data, but other considerations should be analyzed when including milk per ton or milk per acre in the decision making process.

Yield data and stand characteristics were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and hybrids were treated as fixed. Hybrid mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$).

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among hybrids is real or whether it might have occurred due to other variations in the field. At the bottom of each table a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown. Where the difference between two hybrids within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure that for 9 out of 10 times, there is a real difference between the two hybrids. Hybrids that were not significantly lower in performance than the highest hybrid in a particular column are indicated with an asterisk. In the following example, hybrid C is significantly different from hybrid A but not from hybrid B. The difference between C and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these hybrids did not differ in yield. The difference between C and A is equal to 3.0 which is greater than the LSD value of 2.0. This means that the yields of these hybrids were significantly different from one another. The asterisk indicates that hybrid B was not significantly lower than the top yielding hybrid C, indicated in bold.

| **Treatment** | **Yield** |
|---|---|
| A | 6.0 |
| B | 7.5* |
| C | **9.0*** |
| **LSD** | **2.0** |

# RESULTS

**Weather Data**

Weather data was collected with an onsite Davis Instruments Vantage Pro2 weather station equipped with a WeatherLink data logger. Temperature, precipitation, and accumulation of Growing Degree Days (GDDs) are consolidated for the 2016 growing season (Table 3). Historical weather data are from 1981-2010 at cooperative observation stations in Burlington, VT, approximately 45 miles from Alburgh, VT.

Temperatures through June and July of the growing season were near historical averages, with warmer than normal temperatures during May, August, and September of the growing season. April was colder than usual. Rainfall through the growing season was less than normal – a total of 7.53 inches below normal from April through September. There were a total of 2562 Growing Degree Days (GDDs) for corn for May through September—268 GDDs more than the historical average. There were a total of 3984 GDDs for forages for April through September— 195 GDDs more than the historical average (Table 4).

**Table 3. Consolidated weather data and GDDs for corn, Alburgh, VT, 2016.**

| Alburgh, VT | May | June | July | August | September |
|---|---|---|---|---|---|
| Average temperature (°F) | 58.1 | 65.8 | 70.7 | 71.6 | 63.4 |
| Departure from normal | 1.80 | 0.00 | 0.10 | 2.90 | 2.90 |
| | | | | | |
| Precipitation (inches) | 1.50 | 2.80 | 1.80 | 3.00 | 2.50 |
| Departure from normal | -1.92 | -0.88 | -2.37 | -0.93 | -1.17 |
| | | | | | |
| Corn GDDs (base 50°F) | 340 | 481 | 640 | 663 | 438 |
| Departure from normal | 74 | 7 | 1 | 82 | 104 |

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

**Table 4. Consolidated weather data and GDDs for perennial forage, Alburgh, VT, 2016.**

| Alburgh, VT | April | May | June | July | August | September |
|---|---|---|---|---|---|---|
| Average temperature (°F) | 39.8 | 58.1 | 65.8 | 70.7 | 71.6 | 63.4 |
| Departure from normal | -4.9 | 1.8 | 0.0 | 0.1 | 2.9 | 2.9 |
| | | | | | | |
| Precipitation (inches) | 2.6 | 1.5 | 2.8 | 1.8 | 3 | 2.5 |
| Departure from normal | -0.26 | -1.92 | -0.88 | -2.37 | -0.93 | -1.17 |
| | | | | | | |
| Perennial forage GDDs (base 32°F) | 154 | 543 | 745 | 919 | 942 | 681 |
| Departure from normal | -52 | 68 | 1 | 1 | 82 | 95 |

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

## Soil Data

On 25-Apr, before planting corn, soil samples were collected on all plots (Table 5). Overall treatments that were in PF had superior soil quality when compared to any of the corn cropping systems. The PF and NT treatments had significantly higher aggregate stability with 61.7% and 54.5%, respectively. Surface hardness was lowest in the NC treatment, with the WCCC treatment statistically the same. Percent organic matter was highest in the PF (4.23%) treatment.

**Table 5. Soil quality for five corn cropping systems, Alburgh, VT, 2016.**

| Corn cropping system | Aggregate stability % | Available water capacity (m/m) | Surface hardness psi | Sub-surface hardness psi | Organic matter % | Active carbon ppm | Soil proteins (N mg/ soil g) | Soil respiration ($CO_2$mg/ soil g) |
|---|---|---|---|---|---|---|---|---|
| CC | 30.4 | **0.203** | 165 | 336 | 3.48 | 533 | 8.18 | 0.425 |
| NC | 47.0 | 0.198 | **129*** | 352 | 3.80 | 529 | 8.43 | 0.550 |
| NT | 54.5* | 0.190 | 187 | **310** | 3.70 | 547 | 8.43 | 0.500 |
| WCCC | 30.4 | 0.200 | 137* | 333 | 3.50 | 511 | 7.93 | 0.500 |
| PF | **61.7*** | **0.203** | 200 | 358 | **4.23*** | **605** | **9.63*** | **0.850*** |
| LSD (0.10) | 10.6 | NS | 19.1 | NS | 0.42 | NS | 1.19 | 0.069 |
| Trial Mean | 44.8 | 0.199 | 137 | 338 | 3.70 | 545 | 8.52 | 0.565 |

* Treatments with an asterisk did not perform significantly lower than the top-performing treatment in a particular column. Treatments shown in **bold** are top-performing in a particular column.
NS – No significant difference was determined among the treatments.

On 17-Jun, soil samples were collected for PSNT analysis (Table 6). The mean soil nitrate-N ($NO^{-3}$) among the treatments was 8.06 ppm. The NT treatment had significantly lower soil nitrate-N and higher N amendment recommendation than the other cropping systems. Nitrogen, in the form of urea, was applied to the corn treatments based on their respective PSNT results.

**Table 6. Soil nitrate-N and N recommendations for medium and high yield potential, Alburgh, VT, 2016.**

| Corn cropping system | $NO^{-3}$-N (ppm) | N recommendation for 25 ton ac$^{-1}$ corn |
|---|---|---|
| CC | 10.5* | 111* |
| NC | 9.35 | 118 |
| NT | 6.35 | 131 |
| WCCC | **11.8*** | **103*** |
| LSD (0.10) | 2.35 | 12.6 |
| Trial Mean | 8.06 | 120.5 |

* Treatments with an asterisk did not perform significantly lower than the top-performing treatment which is shown in **bold**.

### Corn Silage Results

On 16-Sep, data was collected on corn silage populations and plots were harvested to determine moisture and yield (Table 7). Corn populations ranged from a low of 29,403 plants per acre (WCCC) to a high of 32,706 plants per acre (CC). The WCCC treatment had significantly lower populations than the other treatments. Yields (adjusted to 35% dry matter basis) ranged from 23.1 to 28.1 tons per acre. The WCCC treatment had the highest yield, with the NT treatment being significantly lower than the others. (Figure 1).

Pest and disease scouting occurred on 3-Jun (data not shown). Pest were scouted at harvest but no pest damage was identified. No foliar diseases were identified. Pests identified included corn borers, cut worms, and corn maggots. The CC treatment had the highest number of pests per plot (an average of 2.50 pests per plot). The other treatments had similar pest populations (an average of 2.0 pests per plot for the NC treatment, and an average of 1pests per plot for the WCCC and NT treatments).

**Table 7. Corn silage population, harvest dry matter and yield by treatment, Alburgh, VT, 2016.**

| Corn cropping system | Harvest population plants ac$^{-1}$ | Harvest dry matter % | Yield at 35 DM t ac$^{-1}$ |
|---|---|---|---|
| CC | **32,706** | **37.7** | 27.8* |
| NC | 32,489* | 35.8 | 27.1* |
| NT | 31,327* | 34.9 | 23.1 |
| WCCC | 29,403 | 37.2 | **28.1*** |
| LSD (0.10) | 2288 | NS | 2.11 |
| Trial mean | 31481 | 36.4 | 26.5 |

* Treatments with an asterisk did not perform significantly lower than the top-performing treatment in a particular column. Treatments shown in **bold** are top-performing in a particular column.
NS – No significant difference was determined.

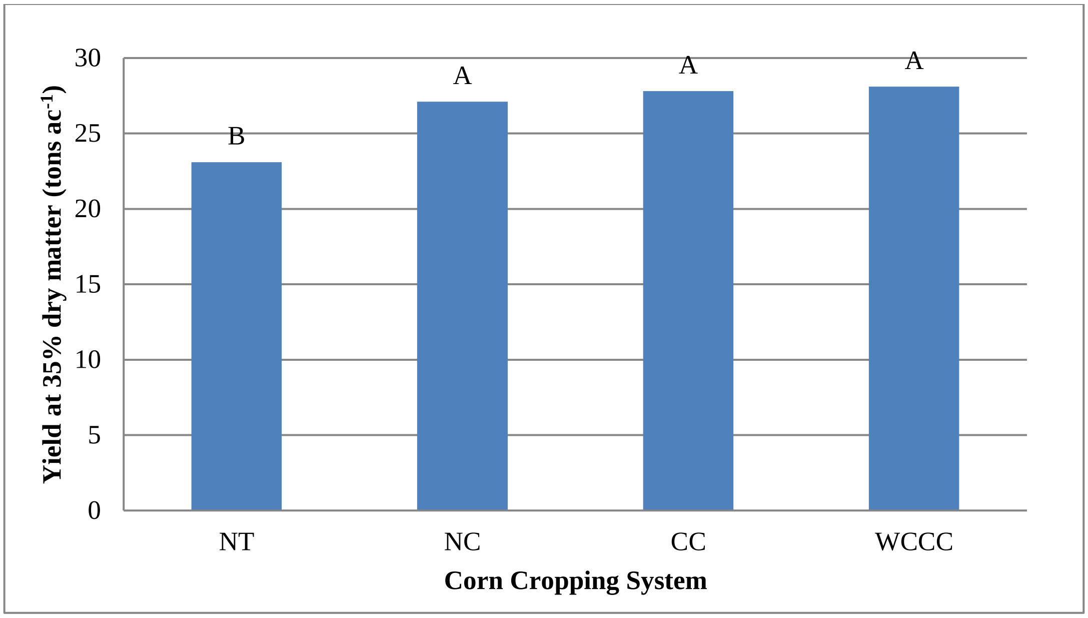


**Figure 1. Dry matter yields of corn cropping systems in tons per acre, Alburgh, VT, 2016. Treatments that share a letter were not significantly different from one another (p=0.10).**

Standard components of corn silage quality were analyzed (Table 8). There were a few significant differences in quality between cropping systems. The NT treatment had the highest crude protein, significantly more than any other treatment. The NT treatment also had significantly lower milk production in terms of milk per acre than the rest of the treatments. There were no significant differences in terms of the ADF, NDF, TDN, $NE_L$ and milk per ton. The NT treatment had the lowest ADF and NDF. The WCCC treatment had the highest TDN, $NE_L$, and milk production in terms of both milk per ton (reflecting only feed quality) and milk per acre (reflecting both feed quality and yield).

**Table 8. Impact of cropping systems on corn silage quality, 2016.**

| | | | | | | Milk | |
|---|---|---|---|---|---|---|---|
| Corn cropping system | CP % of DM | ADF % of DM | NDF % of DM | TDN % of DM | $NE_L$ Mcal $lb^{-1}$ | lbs $ton^{-1}$ | lbs $ac^{-1}$ |
| CC | 7.43 | **24.0** | 48.8 | 72.7 | 0.693 | 3284 | 31999* |
| NC | 7.48 | 26.3 | 51.4 | 72.6 | 0.690 | 3271 | 31033* |
| NT | **8.20*** | **24.0** | **47.8** | 73.3 | **0.703** | 3355 | 27049 |
| WCCC | 7.35 | 24.2 | 48.3 | **73.7** | **0.703** | **3360** | **32772*** |
| LSD (0.10) | 0.53 | NS | NS | NS | NS | NS | 2673 |
| Trial mean | 7.61 | 24.6 | 49.1 | 73.0 | 0.697 | 3317 | 30713 |

* Treatments with an asterisk did not perform significantly lower than the top-performing treatment in a particular column. Treatments shown in **bold** are top-performing in a particular column.

NS – No significant difference was observed between treatments.

### Perennial Forage Data

The perennial forage plots were analyzed for basic quality parameters (Table 9). The second cutting had the highest protein level at 22.0%. The first cutting was lowest in protein at 15.3% of dry matter. The first cutting was highest quality in terms of ADF and NDF. The 2nd cut had highest yield at 8.55 tons per acre.

**Table 9. Impact of harvest date on perennial forage quality, 2016.**

| Alfalfa/Fescue cutting | CP % of DM | ADF % of DM | NDF % of DM | NDFD % of NDF | Yield at 35 DM t ac$^{-1}$ |
|---|---|---|---|---|---|
| 1st cut 31-May | 15.3 | 33.2 | 64.4 | 57.2 | 8.47 |
| 2nd cut 19-Jul | 22.0 | 30.3 | 58.2 | 60.2 | 8.55 |
| 3rd cut 7-Sep | 19.2 | 32.3 | 59.0 | 58.5 | 6.96 |
| Trial mean | 18.8 | 32.0 | 60.5 | 58.6 | 7.99 |

**Multi-year comparison**

Figures 2-5 compare yields and soil health characteristics over the past two years of the trial. Overall, yields were relatively the same between the two years, with the exception being the PF treatment, which had a much lower yield in 2016 compared to 2015. The trends among yields for the corn cropping system were similar to 2015. The NT corn treatment had consistently lower yields compared to corn grown in tillage treatments. There was little observed yield difference between CC, NC, and WCCC.

Active carbon went down from 2015 to 2016 across all treatments (Figure 2). Soil proteins went up from 2015 to 2016 across all treatments (Figure 4). The treatments maintained the same ranking in terms of most soil health characteristics (including organic matter, Fig 2). The PF treatment was consistently the best in terms of soil quality characteristics ranking the highest in organic matter, active carbon, proteins, and respiration. The NT and NC treatments were general second and third in terms of soil health, with the WCCC and CC treatments performing at the bottom.

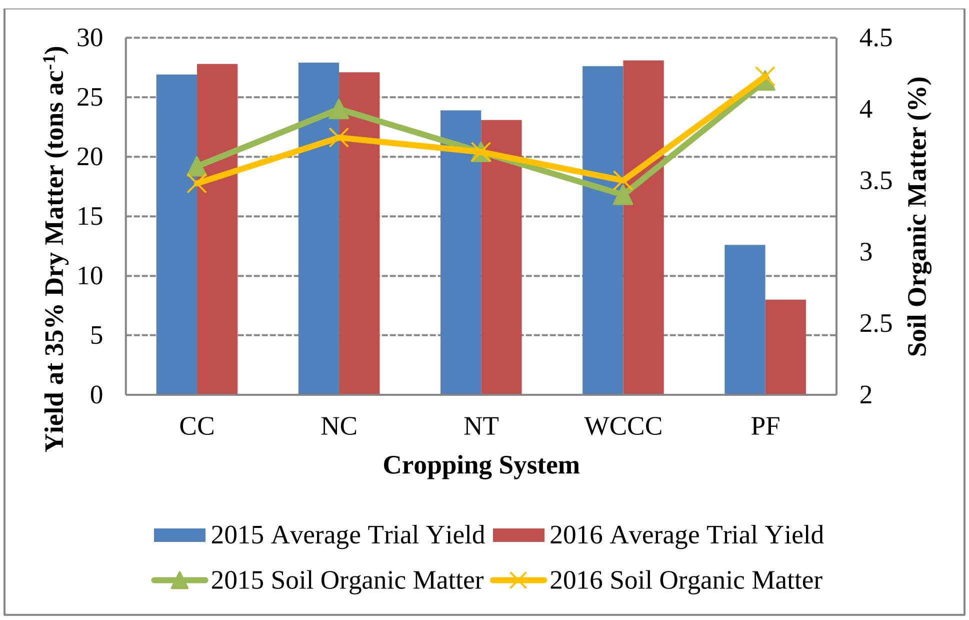


**Figure 2. Comparison of cropping systems yields and soil organic matter in 2015 and 2016, Alburgh, VT.**

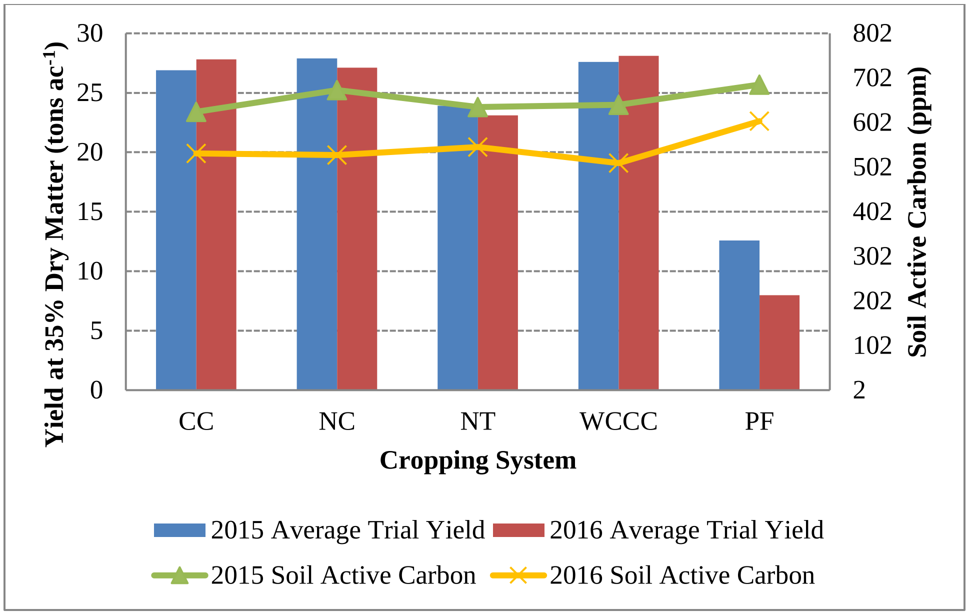


**Figure 3. Comparison of cropping systems yields and soil active carbon in 2015 and 2016, Alburgh, VT.**

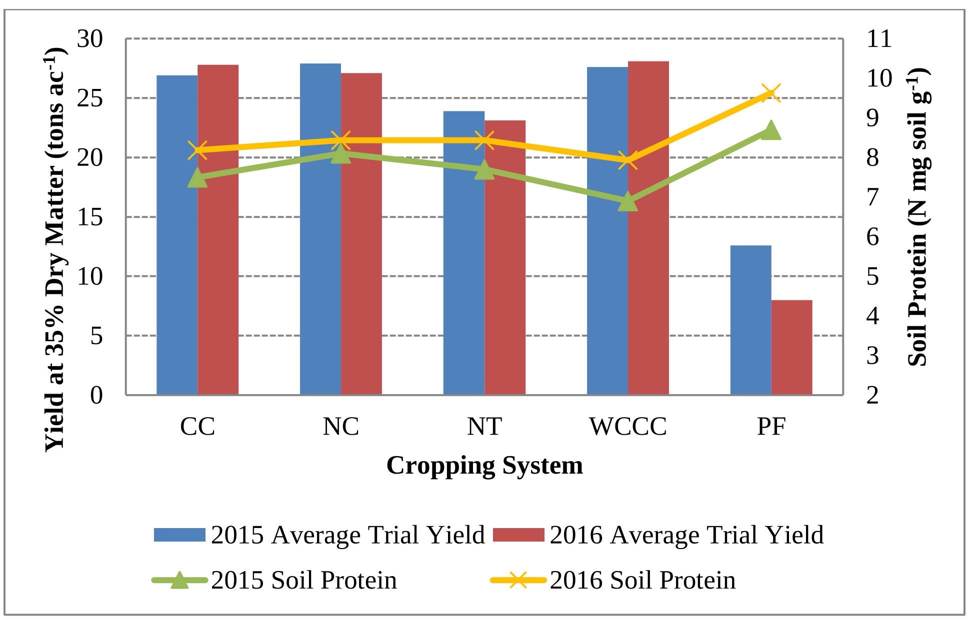


**Figure 4. Comparison of cropping systems yields and soil protein in 2015 and 2016, Alburgh, VT.**

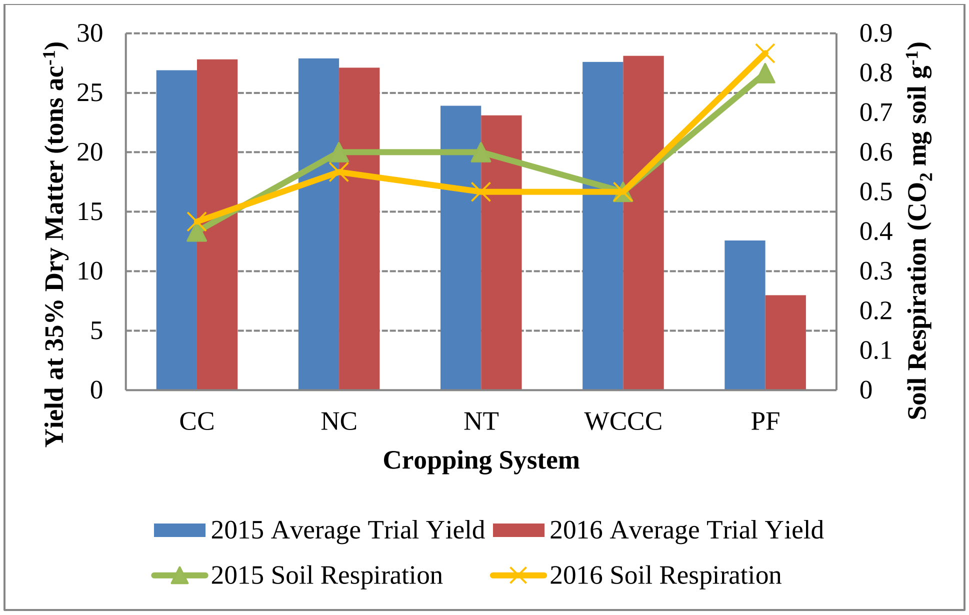


**Figure 5. Comparison of cropping systems yields and soil respiration in 2015 and 2016, Alburgh, VT.**

## DISCUSSION

The goal of this project is to monitor soil and crop health in these cropping systems over a five year period. Based on the analysis of the data, some conclusions can be made about the results of this year's trials. In terms of soil quality, PF systems performed best overall, with the exception of both surface and subsurface hardness, where it was the lowest performing treatment, same as last year. This makes sense to some extent as the soil has not been aerated in these plots compared to other treatments. It also indicates that perennial forage crops may benefit from soil aeration to help alleviate soil compaction and improve nutrient cycling, water infiltration, and yields. We would expect fields with tillage to have less compact surface layers. The NC and WCCC treatments had the lowest surface compaction.

There were some soil quality benefits observed from not tilling the soil. The NT corn and PF treatment had the best soil structure as indicated by aggregate stability and would be less prone to erosion and runoff. The NT treatments were transitioned from PF to corn 5 years ago and the lack of soil disturbance is reflected in many of the soil quality measurements. This treatment clearly reflects the potential for NT corn to maintain soil quality during the corn years of a rotation. However, we continue to observe a yield drag in the NT corn treatment compared to other corn treatments with tillage. The CC treatment had the lowest aggregate stability as would be predicted knowing that constant tillage will significantly impair the structure of the soil. WCCC had a small impact on aggregate stability and did not seem to improve it over CC. Corn in a short rotation with sod (NC) was still maintaining higher levels of aggregate stability even after its third year of tillage. Biological properties also remained quite high in this system. The CC treatment performed near the bottom, in soil quality in all areas except soil hardness and available water. This system has the least potential to reduce erosion and nutrient runoff.

The CC had the highest corn populations although statistically similar to NC and NT. WCCC had significantly lower populations although the highest in terms of yield. Interestingly, the WCCC consistently provides slightly higher yields than other corn treatments but very few shifts in soil quality parameters. The NT treatment was the lowest performer in terms of yield, significantly less than the other three treatments. All treatments performed well in terms of population and yield, reflecting a good corn season with warm temperatures and a high number of growing degree days through the growing season.

The perennial forage cuttings had overall similar quality and yield. The quality of the forages was very high through the season. Yields were much lower than the corn yields with the average forage yield about a third that of the average of the corn yields. The PF treatment however had the highest soil quality and will be an important component of the overall corn rotation to build soil productivity prior to continuous corn production.

## ACKNOWLEDGEMENTS

UVM Extension would like to thank Roger Rainville and his staff at Borderview Research Farm in Alburgh for their generous help with the trials. We would like to acknowledge Erica Cummings, Kelly Drollette, Hillary Emick, Julian Post, Lindsey Ruhl, and Xiaohe "Danny" Yang for their assistance with data collection and entry. This study was funded by the Vermont Integrated Research and Extension Competitive Awards and by the Ben & Jerry's Caring Dairy Program. Any reference to commercial products, trade names, or brand names is for information only, and no endorsement or approval is intended.

*UVM Extension helps individuals and communities put research-based knowledge to work.*

# Pest Management in High Residue Cropping Systems

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> **"No-till, cover-cropped fields also have the benefit that their stability allows populations of beneficial invertebrates to grow, and these animals can help crop production."**

No-till crop production is typical in Mid-Atlantic States. Flat fields are uncommon in our region, and the rolling topography renders many fields erosion prone. No-till farming has also been widely promoted by governmental agencies and conservation districts to reduce agricultural run-off (soil, nutrients, and pesticides) into waterways that lead to the Chesapeake Bay. In Pennsylvania, according to the most recent state report, approximately 70% of corn and soybean acres were not tilled and another 17% were grown using other reduced-tillage methods. Complementing this widespread adoption of no-till has been increasing use of cover crops, which provide numerous benefits including reducing erosion risk and minimizing agricultural run-off.

When farmers move into no-till cover crop production, many assume that pest challenges will be worse than those found in tilled fields. From an invertebrate perspective, this fear is not very well founded. It is certainly the case that the pest complex shifts in the move from till fields to no-till/cover crop fields, but it is not that the pests are more problematic; they just pose a different risk. In no-till fields, farmers can expect a slightly higher risk from these pest species: black cutworm, true armyworm, stalk borer, wireworm, and slugs.

Fortunately, no-till, cover-cropped fields also have the benefit that their stability allows populations of beneficial invertebrates to grow, and these animals can help crop production. The most obvious among these invertebrates are earthworms that improve soil quality through their burrowing activity. Less recognized are beneficial arthropods that contribute to nutrient cycling and pest management. Our research has focused on the predatory arthropods, mostly insects and spiders, that can accumulate in no-till fields, and the value that these predators can provide for pest suppression.

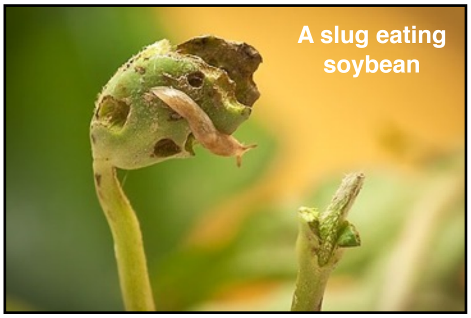
Predatory arthropods can help farmers reduce their input costs by stopping or slowing growth of pest populations, avoiding the need for insecticides. Importantly, this sort of value only emerges when insecticide use is governed by Integrated Pest Management (IPM); that is, insecticides (all types: foliar- and soil-applied insecticides and seed treatments) are used only when it makes economic sense. Typically, this means that insecticides are not used preventatively. Rather, they are used based on scouting and an understanding of local pest populations, and then only deployed when those in-field pest populations exceed published economic thresholds, which are the population sizes or amounts of damage that research has revealed to be economically relevant. Growers that rely on IPM improve the chances that meaningful predator populations will build in their fields and will be able to keep pest populations in check. Should insect pest populations escape control by predators, IPM then provides opportunities for rescue treatments to knock back these pest populations.

Our research indicates that no-till, cover cropped fields are capable of harboring populations of predatory arthropods that can provide effective levels of pest control. To take advantage of these predators, farmers need to commit to IPM, which helps deploy insecticides based on need informed by scouting fields regularly.

## SEED-APPLIED NEONICOTINOID INSECTICIDES EXACERBATE SLUG DAMAGE[1]

### Slugs, a challenge for Mid-Atlantic no-till farmers

No-till farming benefits field and forage crop production by reducing soil erosion, conserving water, improving soil health, and reducing fuel and labor costs. One challenge of no-till in the Mid-Atlantic region, however, is slugs, which are mollusks (not insects) that thrive in the stable environment provided by no-till fields and can be particularly hard on corn, small grains, and soybeans, attacking seedlings and significantly reducing yields.




### Neonicotinoid seed treatments disrupt biological control of slugs

Neonicotinoids are systemic insecticides that are often applied to soybean seeds to prevent damage from sporadic early-season insect pests. Our research, led by PhD candidate Maggie Douglas, reveals that these seed-applied insecticides can indirectly increase slug damage to crops by poisoning insects that eat slugs. In laboratory experiments, slugs were not affected by neonicotinoids, but ingested them; then, when predators attacked slugs, they were poisoned or killed. In the field, plots with neonicotinoid-treated seed had fewer predators, more slugs, and lower yield than plots without these insecticides.


Some ground beetle species eat slugs

**Significance for no-till farmers:** Farmers can improve slug control by growing crops without neonicotinoid seed treatments. Untreated seeds, and avoiding other unnecessary insecticide applications, will conserve predator populations and the control they provide. Sparing use of these seed treatments should also improve biocontrol of insect pests, and decrease concerns associated with pollution of surface water and negative impacts on wildlife, such as pollinators.

[1]Douglas, MR, Rohr, JR, and Tooker JF. Neonicotinoid insecticide travels through a soil food chain, disrupting biological control of non-target pests and decreasing soybean yield. Published online in Early View of Journal of Applied Ecology, DOI: 10.1111/1365-2664.12372. Available upon request.

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# Adaptation of Conservation Practices: How to do it successfully

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> "There are no fields on your farm that could not be more profitable by the proper adaptation of cover cropping and other soil health building practices."

Jeff Sanders is has been an agronomist outreach professional with UVM Extension for nearly 5 years. During this time he has focused much of his efforts and helping farmers implement conservation practices, mainly cover cropping and reduced tillage techniques, on thousands of acres in Vermont, Northern New York, and New Hampshire. The focus of this presentation is to provide the audience with a general overview of what must be considered to have the best opportunity to successfully adapt these practices onto local farms.

The presentation is based on the premise that "There are no fields in on your farm that could not be more profitable by the proper adaptation of cover cropping and other soil health building practices." Two terms need to be more precisely defined for your business.

**What is Profit?**
Is profit simply money? Time with family? Time doing things you enjoy? Is it the combination of these that provide the farmer with a sense of overall comfort?

**What is adaptation?**
Does this mean 100% implementation 100% of the time or a subset of this based on management practices, weather conditions, labor situations, or other variables on your operation.

How you manage these **six key factors** that will determine the degree of success with regard to adaptation of cover crops and reduced tillage practices :

- **Psychological**
- **Educational**
- **Agronomic**
- **Mechanical**
- **Environmental**
- **Financial**

**Managing these factors will allow you to overcome perceived barriers such as:**

- *Soil Type*
- *Government financial assistance (cost share)*
- *Government Regulations*

**Psychological Factors**
Attitude is everything ... and cover cropping and reduced tillage is no different. You need to be "in it to win it'. One will not be successful or profitable without the determination to be both. You, the farmer, must learn to understand the system you are implementing and know when to be patient and when to push and be prepared to do both.

**Educational Factors**
Some of these practices will require a change from what your father and grandfather did and how they taught you. It doesn't mean it will not work. It just means you must push yourself to understand what you are trying to do and why and then put the pieces in place to make those goals a reality. Use Grants from NRCS, VAAFM, and others to offset risks. Seek out universities or private sector field trials and put them on your farm. Do your own research by using check strips and trials to figure out what works on your farm. Go to meeting like this one and attend farmer to farmer meetings. Gain experience and track results so that you and remain committed to the goals.

*Build off the successes and failures of others.*
The reason the younger generation must answer to the older generation is because businesses cannot afford to make the same mistakes again. Learn from the experiences of others and then utilize that information in your own business.

**Agronomic Factors—Cover Cropping**
Understand your cropping system and what improvements can be made there. For example, you might weigh a continuous corn vs. utilizing more intensive rotations which will provide long term increased yields.
What are your plans to terminate cover crops in the spring?
What method of cover cropping do you intend to utilize? Do you have access to right equipment?
Does the herbicide program, corn leaf architecture (vertical leaf vs. horizontal leaf) being utilized in your system?
What is the current condition of your field with respect to weed pressure? Early season interseeding with minimal residual herbicide may not be profitable on weedy fields.

Have you selected the right relative maturity variety corn for your cover crop program. One day in Sept. is like four days in October for growing cover crops. Flex ear corn vs. fix ear for corn yields and seeding rates based on methods of seeding for cover crops.
*Is your crop over fertilized?* Corn not drying down due to excessive N in the plant tissue which will push back harvest and increase silage moisture at harvest.
Soil to seed contact with cover crops is a key to success. Does your method increase or decrease the likelihood of good soil to seed contact.
Seeding Rates on cash crop and seeding rates on cover crops matter for establishment and profitability.
*Seed Varieties on Cover Crops.* VNS seed is cheap but can be unreliable leading to variability in the success of your cover cropping program.

*You need to identify problems in your fields that cover crops can help address then implement a program to successful grow cover crops which address those problems which will make you more profitable.*

**Agronomic Factors— No-Till**

The goal of planting no-till corn is simply get 99% of the corn seedlings to uniformly emerge from the ground within 24 hours of each other.

The goal of planting no-till corn is simply get 99% of the corn seedlings to uniformly emerge from the ground within 24 hours of each other.

*Weather*

Soil temp must be 50+ degrees with somewhat dry soil.

*Nitrogen*

It is recommend to add 30-50 units at planting, especially during your initial transition. If a corn plant turns yellow it is the not the plant's fault, there is a management practice on that field which is deficient and should be corrected. It could be nutrient based, drainage based, or some other factor but it is not the fault of the no-till planter.

*Hybrid Selection*

Select for seedling vigor as well as other factors. One ear of corn per 1000 is 7 bushel corn per acre. Consider Vertical leaf varieties if planting cover crops into standing crops. The shading out of the row is extremely stressful on growing cover crops in most conditions.

*Rotations*

Rotations are critical in no-till systems. Corn on corn degrades soil health much quicker than diversified rotations.

*Plant Populations*

You should increase population 10% above target depending on conditions at planting and equipment preparedness.

*Tillage*

The less tillage you use in your system the more you should invest in your planter. Soil to seed contact very important in planting corn.

**Mechanical Factors—Corn Planter Specific to get 99% ear Potential**

- Properly maintained planter
- Down pressure systems
- Floating row cleaners
- Heavy duty True-Vee openers 3.5 mm
- Know there is singulation of seed.
- Firm seed in trench.
- Use proper closing wheels (crumble sidewall fill trench).
- Use available technology.
- Apply in-furrow starter in less than ideal conditions.
- Apply additional Nitrogen at planting to replace N lost by not tilling the land.

**Mechanical Factors—Cover Crop Interseeding**

- Home made interseeders
- InterSeeder™ Technologies Interseeders
- Dawn® Biologic Interseeder
- Broadcast Equipment
- Helicopter
- Highboy
- Spreader

**Mechanical Factors—Cover Crop Planting (after harvest)**

- Drills
- Vertical tillage
- Chain Harrow
- Air Seeders

**Environmental Factors**

*Field Level*
The pH level should be balanced for crops (6.2 – 6.8 for corn).
Increased soil health will result in better root growth and nutrient uptake and microbiologic activity.
Better drained fields are better suited to implementing conservation practices.
Reduce compaction where ever possible and try to start reduced tillage systems in fields that are in great environmental condition to start with.
Do not attempt to begin no-till on a continuous corn fields. Try to rotate them to hay then begin no-till coming out of sod.

*Farm Level*
You should be in position to properly fertilize and condition the land.
You will need a strategy to handle *manure* (modified no-till).
Learn how to implement these practices without jeopardizing your business. If you have limited land base and you need 110% yields based on cow numbers be careful about how you implement your strategy.
Be sure and manage risk.

*Watershed/Ecosystem Level*
Soil type, proximity to water, surface and subsurface drainage all play a role in your success.
A properly implemented conservation program can benefit the farm, the community and the watershed.
Good soil health as a result of your conservation practices can yield very well, infiltrate more rainfall, reduce nutrient and soil loss, sequester more carbon, use less fossil fuel and be a more efficient and highly functioning system.

**Financial Factors**
Once you are committed to being successful, invest where it makes the most sense for your business. Start with the planter first for no-till, then move to seed and application equipment for cover crops.
Do not forget to calculate the termination costs associated with cover crops.
You must look at how these practices fit into your overall business model, set goals and expectations, then work to reach them. For example, reducing fuel and time to plant by 70% may be a goal which translates into money—which must be balanced against any lost yield to see if it was truly financially sustainable.
KEEP RECORDS...you cannot measure success at any level without solid information. Track costs, time, labor, yields, and whatever else you are using to gauge success.

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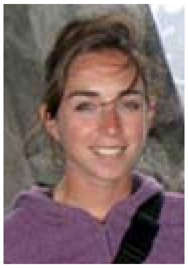
# POSTER SESSION ABSTRACTS:

**The following graduate students have their research highlighted in our poster session exhibit. Please stop by, take a look, and ask them about their research.**



## SARAH COLEMAN | *Plant & Soil Science, University of Vermont*

**The Value of Soil Health: Bottom-Up Adaptive Management?**

"Soil health" receives ongoing attention as a critical element in being able to sustain agricultural production and avoid continued environmental degradation. But a challenge is that "soil health" encompasses a diverse and complex set of indicators and it cannot easily be prescribed to individual farm operations. Its achievement requires knowledge and a long-term commitment to a holistic and adaptive approach combining practices over time. This research addresses the question, "to what extent do agricultural producers value soil health, and monitor soil to inform decisions about production and management practices?" A second phase of a 2013 farmer survey in Lamoille and Missisquoi watersheds in Vermont was conducted in 2016. The importance of soil health information and its use in farmer management decision-making is being examined in the context of soil and water resource concerns, production systems, farmer attributes, and adoption of best management practices (BMPs) using the 2016 survey data. This research seeks to understand biophysical feedback reflecting soil health information as an adaptive management tool, its role in informing decisions, and its relationship to BMP adoption at the farm level. Examining the relative importance and use of soil health information as a factor for management decisions can identify and amplify opportunities to simultaneously meet agricultural production and environmental protection objectives. With soil health objectives at the root of so many agriculture initiatives, the findings from this research about soil health knowledge and management can be a valuable resource for technical assistance and policy networks to effectively address natural resource concerns, and target BMPs at the farm and watershed scales.

## JULIE STULTZ FINE | *Plant Biology, University of Massachusetts*

**Winter-killed cover crop mixtures for no-till sweet corn production in New England**

Multi-species cover crop mixtures are increasingly promoted for their diverse benefits. While fall-planted forage radish (Raphanus sativus L. var. longipinnatus) cover crops have shown successful weed suppression and nitrogen scavenging, research is lacking on effects of forage radish as a member of a multi-species winter cover crop mixture. This experiment evaluates nutrient cycling, fall biomass production, effect on spring soil temperature, spring nitrate, and sweet corn yield in a no-till system following cover crop mixtures that include forage radish. The experiment was conducted in 2014-15, and repeated in 2015-16. In late August 2014 and 2015, three different cover crops were seeded: forage radish (FR), oat/forage radish (OFR), and pea/oat/forage radish (POFR) and no cover crop (No CC). All cover crops winter-killed. Early maturity sweet corn was no-till planted in May of the following year. Three nitrogen fertilizer treatments examined the synchrony between nitrogen release from decomposing cover crops and N-uptake by sweet corn. Fall cover crop aboveground biomass was greater in POFR and OFR mixtures, compared with FR and No CC. Sweet corn yield improved with additional nitrogen fertilization of 25 lbs N/acre at side-dress, however additional N fertilizer at planting was not effective in increasing yield. Sweet corn yield following all three cover crop treatments were statistically greater than yield following no cover crop. Results suggest that a mixture of oat and forage radish (OFR) provides cost-effective nitrogen recycling to sweet corn while reducing fall nitrate leaching.

## KEEGAN GRIFFITH | *Plant & Soil Science, University of Vermont/Miner Institute*

**Double Cropping with Cereal Rye and Corn Silage: Impacts on Nutrient Efficiency and Forage Production**

*(co-authored with E. Young)*

As dairy farms increase in size, the public has been paying more attention to what is happening on the farm, particularly when it comes to environmental issues. In the Lake Champlain Basin phosphorus (P) is a major concern. Winter cereal cover crops have been used to lessen some of the nutrient runoff from agricultural fields under continuous corn. The objectives of our project included: 1) Determine yield and basic forage quality of winter rye planted in the fall after corn and harvested at the boot stage in the spring, 2) Quantify nitrogen (N), Phosphorous (P), and sediment loading differences in surface runoff and subsurface tile drainage from corn plots with and without a winter rye cover crop. After corn harvest and an application of approximately 5 tons/acre of semi-solid dairy manure, the cereal rye was drilled in on October 7th 2015 at a rate of 100 lb/ac. Rye was terminated and corn no-tilled into standing rye on May 24th 2016. Plots are ¼ acre in size with two replicates per treatment. Flow was continuously monitored using v-notch weirs and pressure transducers in 5-gal buckets. Runoff samples were collected for nutrient analysis when rainfall events were sufficient to produce runoff. For surface runoff, 65% of the SRP , 58% of the TP, 78% of the nitrate, 72% of the TN, 80% of the TSS, and 68% of the TSS load came from the plots with no cover crops . There were fewer differences in nutrient loads for tile drainage, though TP and TSS loads were greater for rye plots for some events. The impact of rye on runoff water quality was variable, but did appear to reduce sediment and P loss in surface runoff for some of the events. Rye plots had consistently lower nitrate-N and total N loading for events during early spring and the growing season, suggesting rye plots sequestered more N, either through greater total N uptake or N immobilization in biomass or the microbial pool. The relatively dry year likely contributed to the high variability among plots.

*Abbreviations: SRP (Soluble Reactive Phosphorus), TP (Total Phosphorus), TN (Total Nitrogen), TSS (Total Suspended Solids)*

## RACHEL MASON | *Plant & Soil Science, University of Vermont*

**Resilience and viability of dairy farms in a warmer, wetter Vermont.** *(co-authored with J. Gorres, S. Merrill)*

Vermont's climate is expected to become warmer and wetter in the next few decades, and we are likely to experience heavier rain and more frequent flooding. What effect might this have on the resilience and viability of dairy farms in the area? To find out, we are carrying out simulations of crop yield, hydrology, and economics in conventional and rotational grazing systems for both recent and projected Vermont climates. This will allow us to predict how these systems will fare in terms of finances and environmental impact in the coming years. We are in the early stages of this project, and we would appreciate your thoughts about how it can be made most useful and relevant to the community.

# NOTES: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**The two UVM Extension teams that bring you this symposium are proud to share our work with you. Here is a little bit more information about us.**


The Champlain Valley Crop, Soil & Pasture Team is a group of UVM Extension professionals and their partners working to provide technical assistance to Vermont Farmers in the Lake Champlain Watershed. We strive to bring you research-based knowledge that has practical applications on your farm, such as: Quality Forage & Crop Production, Soil Health, Grazing Management and Pasture Production, Cover Crops, No-Till Agriculture, Nutrient Management, Water Quality and more.

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The mission of the UVM Extension Northwest Crops and Soils Team is to provide the best and most relevant cropping information, both research-based and experiential, delivered in the most practical and understandable ways to Vermont farmers.

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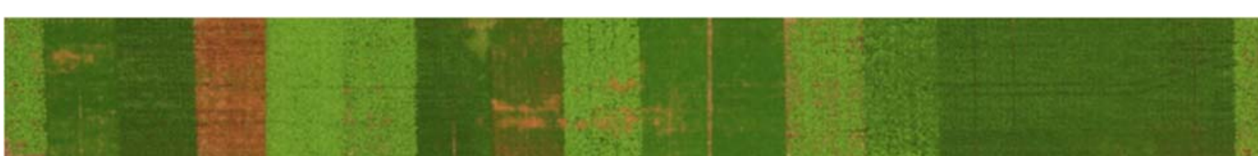

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