UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2016 No-Till & Cover Crop Symposium

February 17, 2016

Sheraton Hotel and Conference Center | Burlington, Vermont

CONFERENCE PROCEEDINGS

WELCOME

Zero to 60 in 8.0 seconds flat. I had a car like that once – long ago.

It seems like the Vermont farmer goal should be 0 to 60 in 8 years. I mean the number of acres that are protected by winter cover crops. The goal of 60,000 acres of annual cover crops in Vermont corn fields is where we need to be headed within a couple years. The state of Vermont produces about 85,000 acres of corn silage and 7,000 acres of corn for grain each year. Already, folks are estimating over 20,000 acres of cover crops were planted this past fall. That is quite a jump from a few years ago.

I am amazed that long-term field data from Vermont shows a 1 ton per acre yield increase just from using Winter Rye cover crop in corn silage. That could be an additional 85,000 tons of corn production in the state to produce milk and meat with the same acres. At $30/acre for seed and $60/ton for corn silage, maybe this is a good Return on Investment (ROI) for the business minded, and a real shot in the arm for farmers who understand that winter cover improves soil and allows for better crop yields.

This is our third big No-Till and Cover Crops Symposium. A dynamic setting where you can talk about new management decisions with other farmers and support businesses about the move to no-till farming and cover crop systems for your farm. No two farms are alike, and there must be several different ways to get there. The agri-business community has brought you equipment, seed, plant protectants, harvest aids and new ideas. The University agronomy research, the NRCS Soil Health initiative and the state support for new practices that protect water quality should empower you to make bold changes on your farm.

Show me the data you say. We want to be a part of testing and proving the worth of these practices to save soil, conserve plant nutrients and protect our streams, rivers and lakes. Meet some new people today and get some new ideas to take your farm business to the next level.

ENJOY THE SYMPOSIUM!!

Jeffrey E Carter

Jeffrey E Carter
UVM Extension Agronomist

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AGENDA: February 17, 2016

Time	Speaker	Topic
8:30	Check in, get coffee & snacks, visit our Exhibitor Fair	
9:00	**Jeff Carter, UVM**	Welcome
9:20	**Odette Menard** **Quebec Ministry of Agriculture**	Fighting for Soil Health: Identifying strategies to build soil health, increase yields, improve economics and reduce erosion
	Break & Exhibitor Fair	
10:40	**Heather Darby, UVM**	Soil Health, No-Till, Cover Crops, & Crop Rotations The latest research results for Northeast Cropping Systems
11:20	**Kirsten Workman, UVM**	Cover Crops in the Champlain Valley: Highlights from this year's cover crop mixture research and on-farm applications of cover cropping in Vermont.
12:00	* * * LUNCH * * *	
12:45	**John Kemmeren** **Angelrose Dairy, New York**	Straight Talk & Crooked Rows: 40 Years of No-Till Changes and Challenges on our Dairy Farm
	Break & Exhibitor Fair	
2:00	**Mark Anderson (NY)** **Kevin Kocsack (NY)** **Larry Gervais (VT)** **Brad Thomas (VT)**	**Farmer Panel (*moderated by Jeff Sanders, UVM*):** Local farmers and service providers recap what's new on their farms this year with no-till & cover cropping. They will share the tools they use to make their systems work.
3:30	**Dr. Kevin Bradley, Univ. Missouri**	A Weed Scientist's Perspective on Cover Crops: Herbicide carryover on cover crops, successful termination of cover crops, and what cover crops do for weed control.
4:30	**Jeff Carter, UVM**	Closing Remarks

Our Speakers

ODETTE MÉNARD | Québec Ministry of Agriculture, (QC, Canada)

Charles Darwin said: "The plow is one of the oldest and most important inventions of the man. But long before man existed himself, the land was plowed, and continues to be, by the earthworms." When reducing soil tillage, earthworm population may increase by as much as 100%, the soil biological activity will also be significantly modified. This will also change soil structure itself. By understanding this phenomenon, we can increase agriculture efficiency, not only by reducing the production costs, but also by increasing the yield.

I graduated from McGill University with an agricultural engineering degree, and then a master in engineering sciences. I also obtained a master in business administration. I have been working in soil and water conservation since 1988 for the ministry of agriculture, food and fisheries of Québec. In 2005, I became member of the Soil and Water Conservation Hall of Fame of Canada. In Fall of 2014, I received the Medal of the Order of Agricultural Merit of Quebec.

My observations on earthworm behavior and soil improvement under no-till with the combination of cover crops helped a lot of agricultural producers to implement no-till with success . The key to the actual agriculture's challenge is to believe in these soil living organisms, and all the microorganisms responsible to maintain high soil health. But it also prepares our soils for tomorrow's challenge: energy costs, soil conservation, climate changes.

JOHN KEMMEREN | *Dairyman, AngelRose Dairy (Bainbridge, NY)*

Faced with farming Highly Erodible hill ground and a desire to improve their soils, productivity and way of life, this past year marked the 40 th year No-Tilling on the farm of John and Dianne Kemmeren.

The Bainbridge N.Y. Dairyman will explain the challenges they face and the ways they handle manure from their 200 head dairy farm, along with their three year hay, corn crop rotation and using cover crops to keep the soils covered 365 days a year. They have successfully renovated pastures, interseed hay ground and planned and set up numerous food plots for deer and other wildlife. The Kemmerens have achieved tremendous crop yields due in part to healthy, high organic matter soils and so have been able to cut fertilizer inputs by 75%.

Not to be set in their ways the Kemmerens set aside a portion of their farm every year to do on farm research. As well as double cropping trials, growing grazing corn, interseeding legumes into sudangrass, and the use of Italian ryegrass as a nurse crop. If it is possible they probably will try it. They have worked in conjunction with Cornell University on cover crop trials and also by hosting a no till field day. The Kemmerens were honored to have won the Champion Grass Hay at the World Dairy Expo this past year as well as being chosen as one of three recipients of the Responsible Nutrient Management Practitioner award at the National No-Till Conference in Indianapolis in January 2016.

DR. KEVIN BRADLEY | *Associate Professor, University of Missouri (Columbia, MO)*

Dr. Kevin Bradley is an Associate Professor and State Extension Weed Scientist in the Division of Plant Sciences at the University of Missouri. Kevin is a native of Virginia and received a B. S. degree in Agriculture from Ferrum College and a Ph.D. in Weed Science from Virginia Tech. Dr. Bradley's faculty appointment includes extension and research responsibilities in the area of weed management in corn, soybean, wheat, pastures, and forages. Dr. Bradley also teaches a graduate level class in herbicide mechanism of action. In addition to evaluating new herbicides and weed management techniques, Dr. Bradley's applied research program focuses on the development of programs for the prevention and management of herbicide-resistant weeds, on the interaction of herbicides and weeds with other agrochemicals and pests in the agroecosystem, and on the effects of common pasture weeds on forage yield, quality, and grazing preference. By far, the largest percentage of Dr. Bradley's research and extension efforts are directed towards the development of strategies for the management of glyphosate- and multiple herbicide-resistant weed biotypes. You can find out more about his work here: http://weedscience.missouri.edu

Our Speakers

Local Farmer Presenters

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 are moving in to a new milking facility in March 2016.

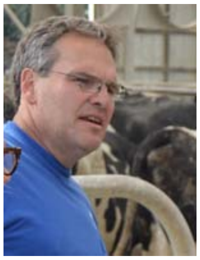
Landview Farms LLC has been using no-till and cover crops on their 2300 acres for years. They are now learning how to use these practices together to increase soil health and ultimately farm profitability.

KEVIN KOCSAK, *Salem Farm Supply* *(Salem, NY)*

Kevin is the Precision Farming Specialist at Salem Farm Supply. He graduated from SUNY Cobleskill with a degree in Agricultural Engineering in 2013 and was hired by Salem Farm Supply. Kevin sells, installs, and services precision farming equipment along with precision planting and corn planting equipment. Salem Farm Supply is a single store, family owned dealership located on State Route 22 in Salem NY. They carry Case IH, Kinze, Krone, Steiger, Kuhn, and Precision Planting along with many other product lines.

LARRY GERVAIS, *Gervais Family Farm (Bakersfield/Enosburg, VT)*

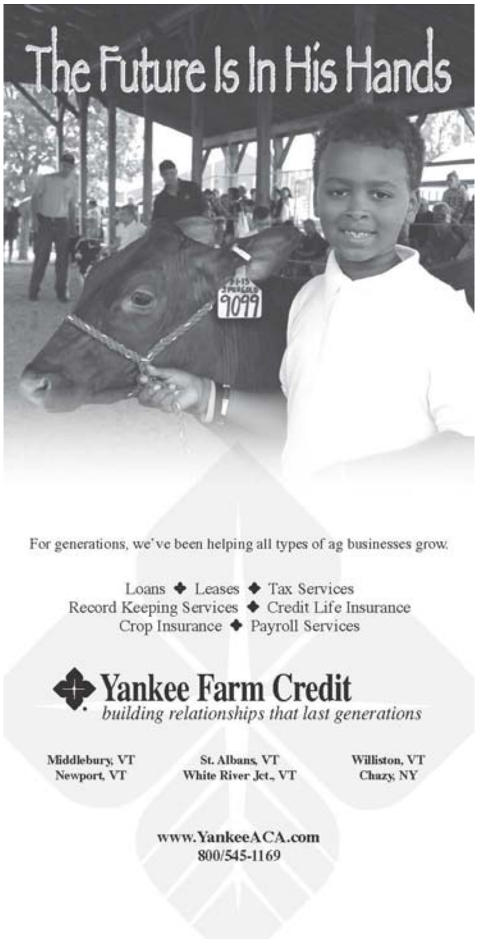
Larry grew up on the family dairy farm in Bakersfield and graduated in 1984 from VTC with an Associates Degree in Agricultural Science. The family farm went through many transitions over the years. In 1995, parents Robert & Gisele along with sons; Charles, Larry, Paul and Clement formed Gervais Family Farm Inc. In 2008, another dairy was purchased in Enosburg by Charles, Larry, Paul and Clement forming Gervais Family Farm No. 2, LLC. Since 1995, the dairy has grown from milking 350 cows to approximately milking 1850 today between both dairies. A manure digester was installed in 2008 on the Bakersfield dairy with a manure separator which provides bedding for both dairies. Larry is the feed and crop manager for approximately 3000 acres of cropland. He has been trying different methods of establishing cover crops such as aerial, highboy and no-till drilling. The farm has been using a dragline for the past three years to inject manure into corn land and is currently looking to modify the toolbar to enable less movement of soil. The goal is to be able to inject manure and plant corn with a no-till planter into soil with a well established cover crop. Larry is Vice Chairman of the Franklin/Grand Isle Watershed Alliance as well as Chairman of the Enosburg Select board.



BRAD THOMAS, *Jillian Holsteins*
(Orwell/Rutland, VT)

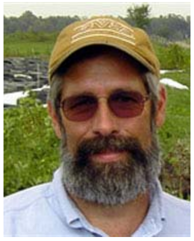
Brad Thomas is a sixth generation dairy farmer growing up and working on Thomas Dairy in Rutland, Vermont. Brad is a Dairy Management graduate of Vermont Technical College in Randolph, Vermont. He managed Thomas Dairy farm for 10 years and then managed "Why Not Farm" in Shoreham, Vermont for several years. In 1993 the opportunity to operate on a farm in Orwell began with buying 80 cows and 20 replacement animals. The herd has doubled in size and improved in quality; it is now a 100% registered Holstein herd. It is a family farm with his wife Jill and three children Amanda, Amber and Ashton.

In 2000 Brad was named the Outstanding Young Breeder in Vermont and New England; a tribute to his ability to improve herd genetics with progressive tools such as in vitro fertilization and embryo transfer. In 2014 the farm began transitioning to a no-till cropping system. With a progressive mind set, the farm will be 100% no-till in 2016. He is a member of the Champlain Valley Farmers Coalition, Holstein Association, and active in cattle showing with his family.



Our Speakers

UVM Extension Agronomy Presenters



JEFFREY CARTER | *Agronomy Specialist: Field Crops & Nutrient Management*

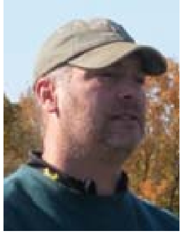
Jeff Carter has worked with farmers all around Vermont regarding crop production including corn, alfalfa, pasture, Christmas trees and wildlife food plots. For more than 30 years he has provided information on using fertilizer, manure and pesticides; how to grow crops and take care of the soil and; nutrient 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 | *Associate Professor of Agronomy*

Heather Darby is an agronomic and soils 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 also 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 many 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.

KIRSTEN WORKMAN | *Agronomy Outreach Specialist*

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.



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.

EXTENSION

AGRICULTURE

SOIL BIOLOGY

UVM Extension Fact Sheet: Champlain Valley Crop, Soil and Pasture Team

The Living, Breathing Soil: Farming with Soil Biology

by Kristin Williams, Agronomy Outreach Professional

Soil health is the cumulative soil condition based upon chemical, physical and biological properties. While measures of soil often focus on chemical properties, and to a lesser extent physical properties, biological properties may be overlooked. However, your soil is alive! One cup of soil may hold as many individual bacteria as there are people on Earth! *The complex of living organisms in soils plays a critical role in the processes that create and maintain soil health and impact crop yields, quality and vigor.*

∗ Carbon cycling and retention:

Organic matter is the foundation of the soil food web which is constantly being transformed through soil organisms. Many kinds of soil organisms are involved in the process of shredding and decomposing complex plant residues into constituent parts. Different soil organisms are particularly adapted to process different kinds of organic matter.

∗ Nutrient cycling and retention:

When soil organisms decompose plant residues, nutrients such as nitrogen and phosphorus may also become more available to plants. Decomposers transform plant matter and release nitrogen, which is subsequently transformed by other bacteria and chemical processes (see Figure 1). Organisms are like a slow release fertilizer. Soil fauna that consume bacteria often consume and excrete excess nitrogen, thereby transforming it into plant available forms (either ammonium or nitrates). Organisms also hold nutrients in their bodies which are released upon death – this can help hold nutrients in the soil, particularly during periods of slower crop uptake.

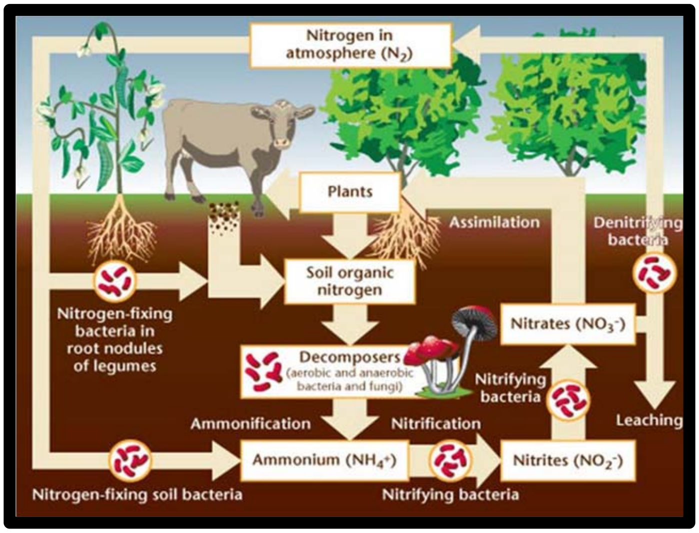


Figure 1. The Role of Soil Organisms in the Nitrogen Cycle. Source: Washington State University - http://cahnrs.wsu.edu/alumni/connections/nspire/

∗ Soil physical properties:

As biota transform and ingest soil organic matter, soil particulates, and other organisms, biota exude sticky binding agents (polysaccharides and glomalin) which hold soil particles together and create spaces in the soil. Soil biota can increase soil aggregation and porosity, and therefore can improve both infiltration and water-holding capacity, providing a more habitable environment for plant roots.

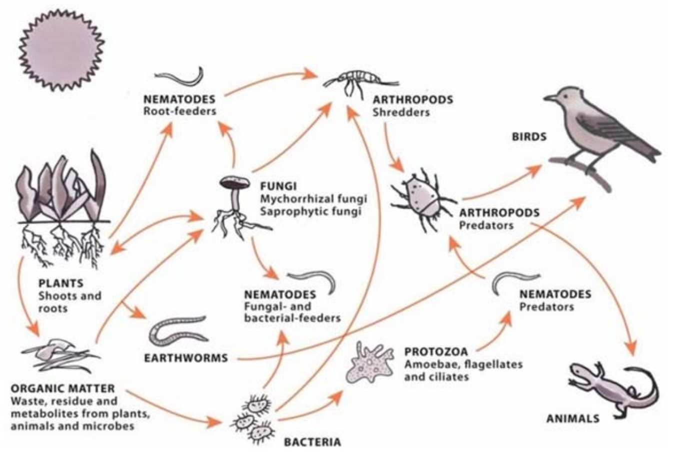
∗ Disease Suppression and Plant Health:

It's easy to get into the trap of thinking of soil biota as "enemies" because we are often focused on agricultural pests. However, most organisms are beneficial to crops. Beneficial soil biota can aid plant health both indirectly and directly. Indirectly, they can create a better growing environment for crops through the processes described above. Directly, soil organisms have been shown to stimulate root growth and development. Soil organisms can also compete with and prey on pest species.

- Environmental protection:

Healthy soil provides many functions that are of great service to both farmers and the larger human communities that agriculture supports. Soils are an important source of biodiversity, which serve many functions in creating stable ecosystems. Soil biota are involved in soil-water filtration; soils can retain and break down pollutants before they reach surface or ground waters. Soil biota are also part of the long term process of soil formation.

A Review of Soil Biota: Food webs are a way to envision how nutrients and energy are transmitted and recycled from one group of organisms to another (see Figure 2). Trophic level is how many steps a group is from the primary producer. The base of the soil food web is plant litter, exudates, roots and animal residues. Soil food webs are composed of bacteria and fungi (soil flora, or soil microbes), and many types of soil animals (soil fauna) including protozoa, nematodes, earth worms, and arthropods.



Original source: NRCS, http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_049822.jpg
Adapted from: http://www.agriculturesnetwork.org

Figure 2. An Illustration of the Soil Food Web.

Bacteria: Bacteria are miniscule, single celled organisms with a big function in soil. Many bacteria are decomposers, breaking down organic matter into simpler substances. *Rhizobium* bacteria form a species specific symbiosis with leguminous plants, creating nodules in the roots that transform nitrogen from the soil-air into usable forms for plant growth. While some bacteria obtain energy from carbon, other bacteria use and transform substances containing nitrogen, hydrogen, sulfur, or iron. Some bacteria must have oxygen, others are somewhat flexible, and still others can only exist without oxygen. While some bacteria cause disease in plants, others cause disease in other organisms. The classic example is the bacteria *Bacillus thuringiensis (Bt)* which creates an insecticide utilized by agriculturalists. Still other bacteria create compounds that inhibit fungal diseases or stimulate plant growth.

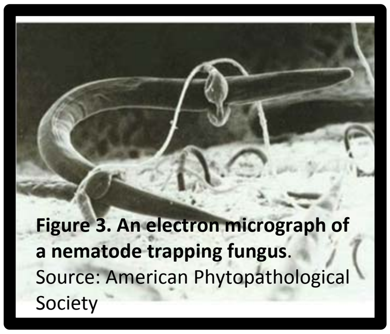


Figure 3. An electron micrograph of a nematode trapping fungus.
Source: American Phytopathological Society

Fungi: When you think of fungi, you might think of the mushroom you had for dinner. However, the mushroom is the fruiting body (reproductive part) of the fungi. Underground, or in the growing medium, these fungi produce many hyphae – thin root-like structures that extend out in search of food. Some of the largest organisms on Earth are actually fungi! In contrast other fungi, such as yeasts, exist as single celled organisms. Fungi provide an important part of decomposition, breaking down more resistant forms of organic matter. Specific fungi can usually survive drought conditions more than bacteria. Fungi generally require oxygen, meaning that saturated soils are usually hostile to them. While some fungi are detrimental crop diseases others prey on soil pests. A great example is the nematode trapping fungus (see Figure 3). Mycorrhizae fungi form a special symbiosis with plants, transporting phosphorus and other nutrients and water (potentially) through their hyphae to plants roots (in exchange for photosynthetic carbon from the plant). In effect mycorrhizae extend plant roots. Hyphae also bind soil particles together and enhance soil structure. Most agricultural crops form these associations (canola and some vegetables such as the cabbage family and beets excluded), and these fungi may create 'hyphae highways' between different crops.

Protozoa: Protozoa are single celled animals that graze on microbes in the soil and sometimes other protozoa and organic materials. Protozoa are grouped by cell structure, which is related to mobility: amoeba, which have a unique blob-like movement with "pseudopods" or finger-like projections of their cell; flagellates, with whip or tail-like projections; and ciliates, with many fine hair-like projections. Protozoa are important in particular for nitrogen cycling; in grazing on bacteria they consume more nitrogen than needed for their growth, and therefore excrete excess ammonium-N, creating up to a 10 fold difference in nitrogen mineralization. Because biological activity is often near plant roots, this nitrogen then becomes available for plant uptake as well as for other organisms. By grazing on microbes, protozoa can also help control plant diseases.

Nematodes: While the most well-known nematodes are pests occupying and feeding on plant roots (such as the lesion nematode and the soybean cyst nematode), in fact most nematodes are beneficial organisms. Nematodes are extremely important because they consume a diverse array of food sources, which places them at multiple trophic levels in the soil food web. Nematodes are mostly microscopic, and occupy water pores in soil but also rely on air pores for diffusion. Nematodes are a diverse group of animals, and can be found in almost all soil types and climates including Antarctica. Some nematodes consume bacteria and others fungi. Like protozoa, nematodes have a role in nitrogen mineralization, disease control of microbes, and root growth stimulation. Still other nematodes are opportunistic or omnivorous and feed on a variety of food sources including protozoa. Specific nematodes are used in biological application to consume the larvae of invertebrate pests (e.g. Japanese beetles). Still other nematodes are specifically predators, feeding exclusively on other nematodes. Due to this nature, scientists use nematodes as biological indicators in soil. Nematode community measures are related to the structure of the entire food web and also reflect both chemical and physical disturbances.

Earthworms: Earthworms have many benefits and are also the easiest indicator of biology because they do not require a microscope for observation. Earthworm burrows create increased soil structure and porosity, and habitat for other soil organisms. Earthworms digest substantial quantities of organic matter, turning it into more available nutrients. Earthworm burrows are areas of high activity for other organisms. Different earthworms occupy different places in the soil profile; therefore earthworm diversity is important in maintaining soil health. Interestingly, earthworms are actually not native to Vermont due to past glaciation, and there has been some recent debate of potential drawbacks with earthworm communities particularly around macropore movement of nutrients.

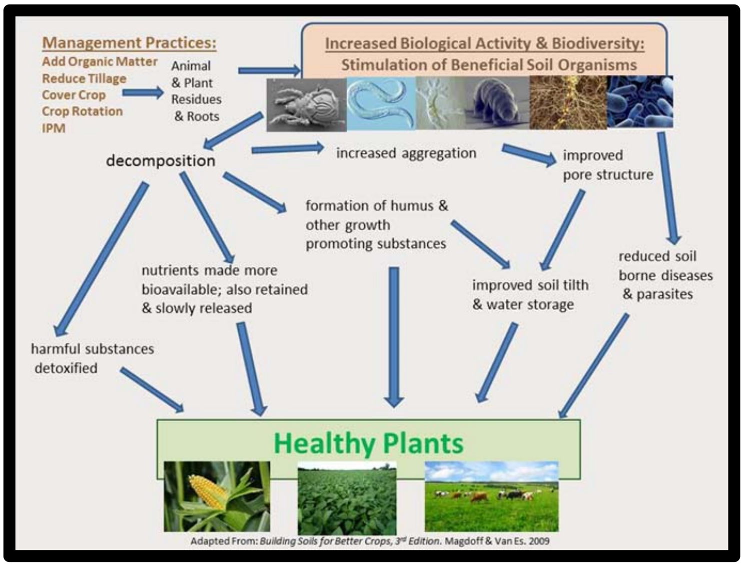
Other Soil Organisms: Other soil fauna include arthropods, potworms (also called enchytraeids) and water bears (also called tardigrades). Soil arthropods may spend all or only a part of their life in the soil. While some are pests, many are strictly shredders, breaking down plant litter as they feed on microbes, and like earthworms, enhance soil structure with their fecal pellets and burrows. Some also have a role in nitrogen mineralization (e.g., collebolans). Larger, mobile arthropods actually function to move smaller soil organisms around, dispersing them into new settings where they can then assist in decomposition. Potworms are native, somewhat common, small, light colored worms and serve similar functions to earthworms, but affect smaller pore structure. Like nematodes, water bears live in soil water and through a unique kind of suspended metabolism (crytobiosis) can withstand substantial stresses of moisture loss, temperature extremes, high pressure and even the vacuum of space . They feed on plant residues, algae and small invertebrates, playing a role in nutrient turnover.

How Management Practices Can Impact & Enhance Soil Biota

The great news is that the actions we take to remediate phosphorus pollution or enhance nitrogen uptake can also benefit soil biology. Both physical and chemical disturbances can affect the abundance and diversity of soil organisms, and in particular soil fauna that are higher up on the food web. The complexity and type of a soil food web can vary substantially from one soil and management practice to another. Generally speaking agricultural soils tend to have a greater population of bacteria, and therefore more soil organisms that feed on bacteria, in comparison to forest soils, which tend to have a greater number of fungi and soil organisms that feed on fungi. However, within agricultural soils, management practices can shift the dynamics of the soil food web over time in either direction. Complexity is an important concept in studying soil biology, because it relates to how many kinds and groups of organisms there are. More complex and diverse food webs usually confer more benefits to plants.

Increasing quantity and complexity of soil habitat and food sources, and maintaining water-air balance generally increases biological complexity. For example, providing a diverse array of food sources from organic matter applications, plant rotations and cover crops allows for more diversity in soil biota that feed on the organic matter. Similarly, decreasing compaction and increasing soil structure encourages soil biota. This is both due to increased water infiltration and to diversity in soil pores – allowing for a range of pore sizes that support a range of soil biota. Owing to the fact that soil organisms are so tiny and soil is complex, physical space is a really important piece of maintaining soil biology. Places of high biological activity in soil are mainly near plant roots, in plant litter and earthworm and arthropod burrows. Therefore, increasing soil quality for root growth development can also benefit soil biota. Also, if your soils are permanently saturated only anaerobic organisms- those that do not need oxygen to survive – will be able to live there. This is important for nitrogen cycling because lack of oxygen can lead to denitrification. Many organisms, including nematodes, live in water films; if you have a soil that is in serious drought conditions on a regular basis, many will die, or go into a kind of temporary stasis until more water is available. Soil organisms can also be sensitive to chemical disturbances and low pH to differing degrees by species; however earthworms and other soil animals are usually more sensitive.

While tillage can lead to a bloom of soil activity as organic matter is incorporated into the soil, this activity is generally bacterial in nature and short lived. Every time you till the soil, you are shifting back the soil community either by direct damage or by homogenization of the habitat. Reducing tillage can have positive effects on biology and in particular fungi and larger animals. Reducing tillage leaves more roots intact, and allows more stable, slowly decomposing organic matter and physical structure to develop through time. While a no-till system might not be ideal or practical in all farming situations, reduction and better management of tillage can benefit soil biology. Research has suggested that reducing tillage and increasing plant residues may be a mechanism for suppression of plant disease by supporting a complex food web with organisms that compete with or control the pest of concern.



Adapted From: *Building Soils for Better Crops*, 3rd Edition. Magdoff & Van Es. 2009

Figure 4. Management techniques that lead to healthy plants are mediated by soil biota.

In summary: Practices that increase the quantity and quality of organic matter and physical habitat have beneficial impacts on soil biota. *A diverse array of foods and habitats generally leads to a more complex and stable food web.*

Supply diverse sources of organic matter *– which provides both food and habitat for soil biota.* Practices that increase diversity of food sources, encourage beneficial biota, and interrupt pest cycles include:

- applying compost & manure
- planting cover crops and legumes (using species specific *Rhizobium* inoculation)
- utilizing increased crop rotation
- planting a diversity of crops or forages
- maximizing plant residues

Protect the soil habitat. *Soil organisms need space to live, and they need a balance of air & water. Soil organisms also need intact root structures.* Practices that can preserve and improve soil habitat include:

- reducing tillage
- minimizing compaction
- maximizing living roots (perennials & overwintering plants)
- improving drainage (in wet soils) or supplying moisture or cover (in dry soils)
- managing pesticides & fertilizer use (IPM & NMP)
- optimizing pH (as with agronomic crops)
- managing grazing to increase plant root biomass

Developing healthy soil biota in your soil is a feedback process on your farm. When conditions are more favorable for soil biota they will begin to sustain and enhance their own habitat and provide conditions more conducive to other organisms. The long term biological goals on agricultural soils would be to establish a set of management practices that maintain a semi-stable condition for soil biota, so that the community is less affected by more extreme conditions that farmers cannot control – like a drought or flood. Management would focus first on the farm or field specific soil properties that are most limiting for soil biota. A healthy soil community – just like a healthy agricultural community – will be more capable of bouncing back from a disturbance than one that is already highly stressed before the disturbance occurs.

Measuring Soil Biology:

Estimations of soil activity can be made through indirect means that measure activity (e.g., enzymes or respiration), the community as whole (e.g., DNA or RNA), or direct extraction and identification of individuals (usually requires a microscope). Unlike soil chemistry, there is no 'standard' test for soil biology, and testing usually costs more money. Research and development is still underway to make soil health and soil biology tests more accessible to farmers. Being attentive to pH and organic matter in a basic soil test can be useful. There are a number of laboratories that estimate microbial biomass based upon respiration, and many also give an assessment of nitrogen and carbon, as well as other soil properties (e.g. Cornell, U. of Maine, Dairy One, Ward Labs, Wood Ends Lab; many of which use Haney/Solvita ®). We appreciate Cornell's soil health test because of the lab protocol of assessing chemical, physical and biological properties. Physical properties can be limiting in heavy clay or compacted soils (lab conditions may artificially stimulate microbial growth). Thus far we have found it more useful to compare management changes in one field over years, rather than to compare fields with different inherent properties. Measuring soil biology and soil health is still an evolving process and UVM Extension is in the process of determining the most useful approach.

On-Farm Tests:

Respiration sticks, slake test (simple aggregate stability), soil moisture probes, and penetrometers (soil compaction) can all be used on site. Being attentive and observant to how much and what kind of plant residue is left on the field can be very informative. Visual field observations of organic matter and manure decomposition rates can also give you a qualitative understanding of soil biology activity. Visual inspection of soil for earthworms and their burrows and casts is another simple way to get a qualitative understanding of soil biology.

More Reading:

NRCS Soil Biology Website: http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/biology/

Building Soils for Better Crops (Chapter 4: The Living Soil), (2010) online at: http://www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition

Cornell Soil Health Website: http://soilhealth.cals.cornell.edu/

University of Minnesota, Extension Service Website: http://www.extension.umn.edu/agriculture/tillage/soil-management/soil-management-series/soil-biology-and-soil-management/

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2015 Corn Cropping Systems to Improve Economic and Environmental Health

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2015 CORN CROPPING SYSTEMS TO IMPROVE ECONOMIC AND ENVIRONMENTAL HEALTH

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In 2015, 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, 2015.

Crop	Management method	Treatment abbreviation
Corn silage	Continuous corn, tilled	CC
Corn silage	New corn (2nd 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 0-25% slopes (Table 2). Each cropping system was replicated 4 times in 20' x 50' plots. This site has been in a cropping systems study for the last seven years. 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° C to remove water then ashed for two hours at 500° 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 TMF2L395, which has a relative maturity (RM) of 94 days. The NC, CC, and WCCC treatments were plowed on 4-May. Corn was seeded in 30" rows on 7-May with a John Deere 1750 corn planter at 34,000 seeds per acre. At planting, 250 lbs per acre of a 10-20-20 starter fertilizer was applied.

Table 2. Agronomic information for corn cropping system, Alburgh, VT, 2015.

Location	Borderview Research Farm – Alburgh, VT
Soil type	Amenia silt loam, 0-25% 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 TMF2L395 (94 RM)
Seeding rates (seeds ac^{-1})	34,000
Planting equipment	John Deere 1750 corn planter
Plow date	4-May
Planting date	7-May
Row width (in.)	30
Corn Starter fertilizer (at planting)	250 lbs acre^{-1} 10-20-20
Chemical weed control for corn	3 qt. Lumax® acre^{-1}, 17-May
Additional fertilizer (corn topdress)	19-Jun, based on plot recommendation (Table 6)
Forage 1st cut date	4-Jun
Forage 2nd cut date	17-Jul
Forage 3rd cut date	4-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 19-Jun (Table 6). The PSNT soil samples were collect 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), 30-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 4-Jun, second cut biomass samples were cut using the same procedure on 17-Jul, and third cut biomass samples were cut using the same procedure on 4-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 30-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 example below, 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 2015 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 most of the growing season were near historical averages, with warmer than normal temperatures at the beginning and end of the growing season (May and September). Rainfall through the growing season was much less than normal – a total of 11.42 inches below normal from April through September. The one exception was the month of June that was well below normal for temperature and much wetter than average. Adverse weather during this month likely impacted early season corn growth and had longer lasting effects on end of season yields. There were a total of 2577 Growing Degree Days (GDDs) for corn for May through September—366 GDDs more than the historical average. There were a total of 4065 Growing Degree Days (GDDs) for forages for April through September— 362 GDDs more than the historical average (Table 4).

Table 3. Consolidated weather data and GDDs for corn, Alburgh, VT, 2015.

Alburgh, VT	May	June	July	August	September
Average temperature (°F)	61.9	63.1	70.0	69.7	65.2
Departure from normal	5.5	-2.7	-0.6	0.9	4.6
Precipitation (inches)	1.94	6.42	1.45	0.00	0.34
Departure from normal	-1.51	2.73	-2.70	-3.91	-3.30
Corn GDDs (base 50°F)	416	416	630	624	492
Departure from normal	218	-58	-10	43	174

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, 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
Perennial forage GDDs (base 32°F)	191	655	669	908	903	740
Departure from normal	77	178	-75	-10	41	152

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 28-Apr, before planting corn, soil samples were collected on all plots (Table 5). The PF and NT treatments had significantly higher aggregate stability with 56.2% and 50.5%, respectively. The PF treatment also had the highest available water capacity at 0.25 m per meter of soil. This was statistically the same as the CC, NC, and NT treatments. Surface hardness was lowest in the WCC treatment, with only the PF treatment significantly higher. Sub-surface hardness was lowest in the CC treatment although there was no significant difference between treatments. Percent organic matter was highest in the PF (4.2%) and NC (4.0%) treatments. These two treatments were also highest in active carbon although there was no significant difference between the other treatments. Mineralized nitrogen was highest in the PF treatment, which was statistically similar to the NC and NT treatments. Soil respiration was highest in the PF treatment, which was significantly different from all other treatments.

Table 5. Soil quality for five corn cropping systems, Alburgh, VT, 2015.

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_2mg/ soil g)
CC	23.9	0.24*	145	**262**	3.6	626	7.5	0.4
NC	45.7	0.25*	153*	282	4.0*	675	8.1*	0.6
NT	50.5*	0.24*	158*	268	3.7	637	7.7*	0.6
WCCC	32.7	0.21	**123**	276	3.4	642	6.9	0.5
PF	**56.2**	**0.25**	196	284	**4.2**	**687**	**8.7**	**0.8**
LSD (0.10)	10.2	0.02	35	NS	0.34	NS	1.11	1.78
Trial Mean	41.8	0.24	155	274	3.8	653	7.8	0.6

Treatments shown in **bold** are top-performing in a particular column.

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

NS – No significant difference was determined.

On 17-Jun, soil samples were collected for PSNT analysis in corn crop plots (Table 6). The mean soil nitrate-N (NO^{-3}) among the treatments was 7.38 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, 2015.

Corn cropping system	NO^{-3} -N (ppm)	N recommendation for 25 ton ac^{-1} corn
CC	**8.93**	123*
NC	8.79*	**115**
NT	4.55	138
WCCC	7.25*	129*
PF	N/A	N/A
LSD (0.10)	2.63	14
Trial Mean	7.38	126

Treatments shown in **bold** are top-performing in a particular column.

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

Corn Silage Data

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 26,245 plants per acre (CC) to a high of 29,621 plants per acre (NC). The CC treatment had significantly lower populations than the other treatments. Yields (adjusted to 35% dry matter basis) ranged from 23.9 to 27.9 tons per acre. While the NC treatment had the highest yield, there was no significant difference between treatments (Figure 1).

Pest and disease scouting occurred on 3-Jun (data not shown). Pest were scouted at harvest but no pest damage was identified. While some ribboning was noted, no foliar diseases were identified. Pests identified included corn borers, cut worms, and corn maggots. The NT treatment had the highest number of pests per plot (an average of 8.75 pests per plot). The other treatments all had much lower pests populations (an average of 2 pests per plot for the CC and NC treatments, and an average of 2.25 pests per plot for the WCCC treatment).

Table 7. Corn silage population, harvest dry matter and yield by treatment, Alburgh, VT, 2015.

Corn cropping system	Harvest population plants ac^{-1}	Harvest dry matter %	Yield at 35 DM t ac^{-1}
CC	26,245	41.9	26.9
NC	**29,621**	42.7	**27.9**
NT	28,532*	42.9	23.9
WCCC	29,512*	**43.7**	27.6
LSD (0.10)	2332	NS	NS
Trial mean	28,477	42.8	26.6

Treatments shown in **bold** are top-performing in a particular column.

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

NS – No significant difference was determined.

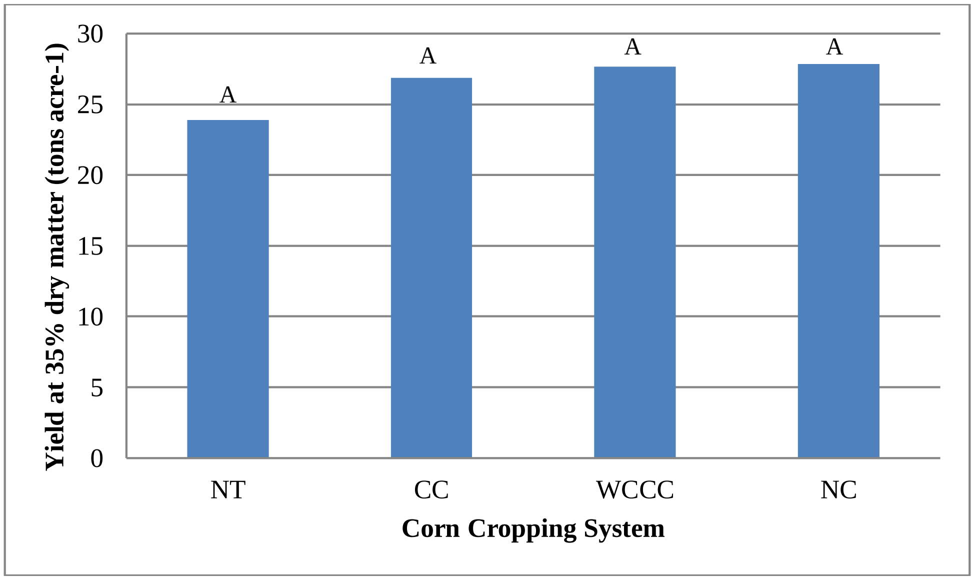

Figure 1. Dry matter yields of corn cropping systems in tons per acre, Alburgh, VT, 2015. Treatments that share a letter were not significantly different from one another (p=0.10).

Standard components of corn silage quality were analyzed (Table 8). There was no significant difference in quality between cropping systems. The WCCC treatment had the highest crude protein. The NT treatment had the highest ADF and NDFD. The CC treatment had the highest NDF. The NC 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, 2015.

Corn cropping system	CP % of DM	ADF % of DM	NDF % of DM	TDN % of DM	NE_L Mcal lb^{-1}	Milk lbs ton^{-1}	Milk ac^{-1} lbs
CC	7.3	25.7	**47.0**	63.2	0.64	2,785	26,123
NC	7.4	25.0	45.7	**64.4**	**0.65**	**2,872**	**27,995**
NT	7.5	**26.2**	47.0	63.9	0.64	2,836	23,943
WCCC	**7.5**	25.3	46.7	63.3	0.64	2,796	27,008
LSD (0.10)	NS	NS	NS	NS	NS	NS	NS
Trial mean	7.4	25.5	46.6	63.7	0.64	2,822	26,267

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 20.1%. The first cutting was lowest in protein at 14.7% of dry matter. The third cutting was highest quality in terms of ADF and NDF. The harvest yields improved throughout the growing season, more than doubling between the first and second cutting dates.

Table 9. Impact of harvest date on perennial forage quality, 2015.

Alfalfa/Fescue cutting	CP % of DM	ADF % of DM	NDF % of DM	NDFD % of NDF	Harvest Moisture %	Yield at 35 DM t ac^{-1}
1st cut 4-Jun	14.7	31.6	57.1	64.3	65.6	7.12
2nd cut 17-Jul	20.1	32.7	60.0	68.5	77.9	14.59
3rd cut 4-Sep	16.0	38.0	66.2	58.1	71.3	16.07
Trial mean	16.9	34.1	61.1	63.6	71.6	12.59

Multi-year comparison

Figures 2-5 compare yields and soil health characteristics over the past two years of the trial. Overall, yields were higher in 2015 than in 2014. It is interesting to note that while yields were higher within each treatment, the ranking of each cropping system did not change between years. NC had the highest yield for each year, followed by WCCC, CC, NT and PF. The treatments maintained the same ranking in terms of most soil health characteristics (including organic matter, Fig 2). The NC and PF treatments were consistently the best in terms of soil quality characteristics. In 2014, the NC treatment was the highest in terms of active carbon, soil proteins and soil respiration, with PF a close second, while in 2015 PF was the highest ranked in these characteristics with NC a close second. The PF treatment showed the greatest increase in active carbon, soil respiration, and soil proteins between 2014 and 2015.

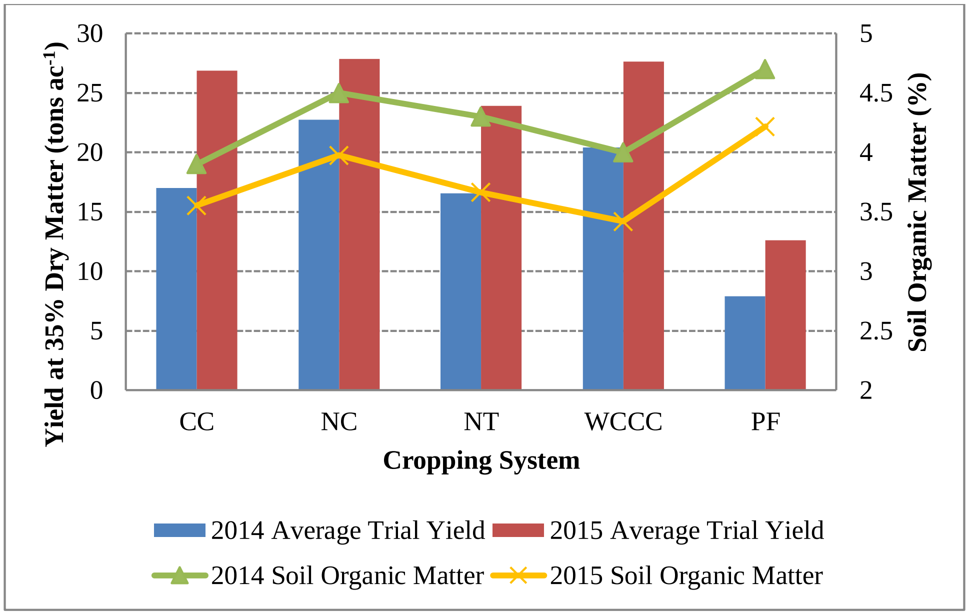

Figure 2. Comparison of cropping systems yields and soil organic matter in 2014 and 2015, Alburgh, VT.

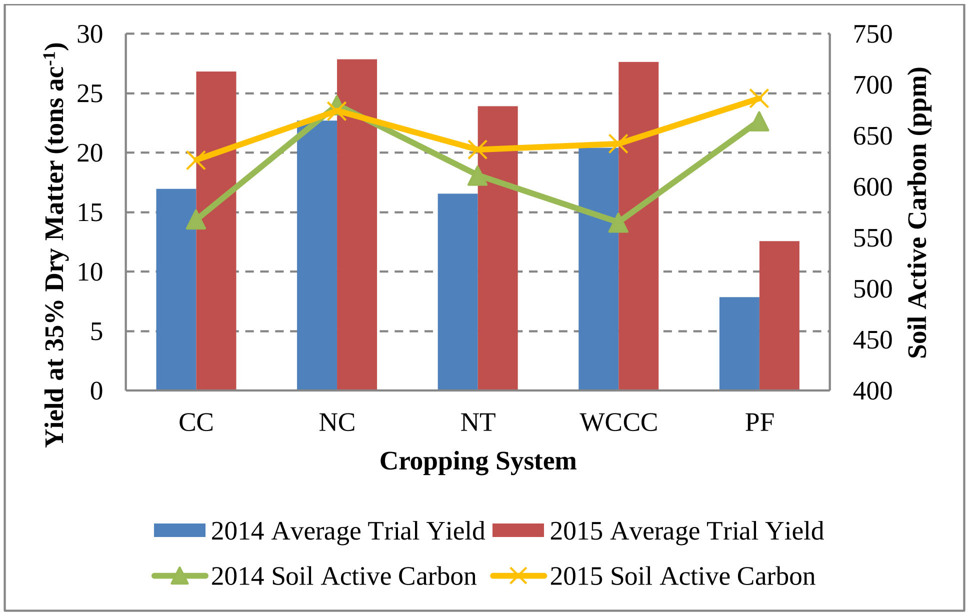

Figure 3. Comparison of cropping systems yields and soil active carbon in 2014 and 2015, Alburgh, VT.

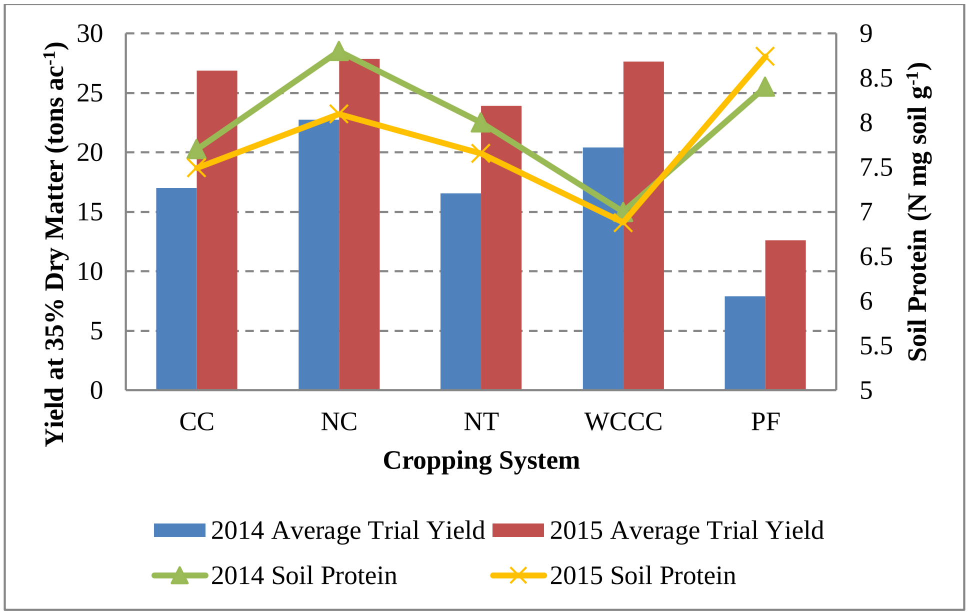

Figure 4. Comparison of cropping systems yields and soil protein in 2014 and 2015, Alburgh, VT.

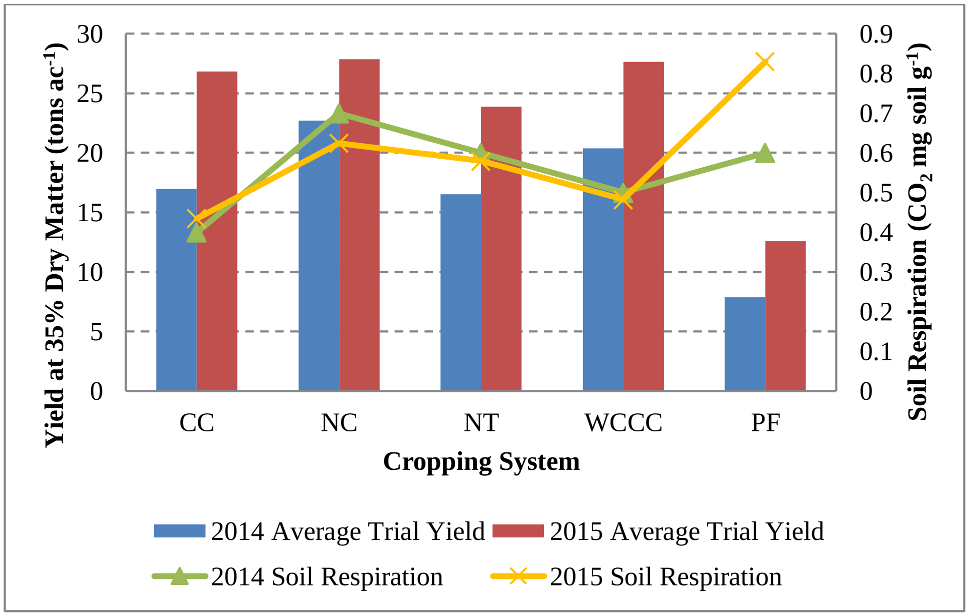

Figure 5. Comparison of cropping systems yields and soil respiration in 2014 and 2015, Alburgh, VT.

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. 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. Interestingly, the WCCC treatment had the lowest surface compaction which indicates that cover crops can help improve the aeration of the soil. The WCCC also had the lowest available water capacity compared to other treatments. Given the dry spring that occurred in 2015, the addition of a growing cover crop would have further dried out the soil profile. In a wet spring, a cover crop can dry out the soil profile but this quality might have a negative impact on the subsequent crop in a dry year.

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. The soil quality of the NT treatments closely rivaled the PF and NC. This treatment clearly reflects the potential for NT corn to maintain soil quality during the corn years of a rotation. 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 but did seem to improve it a bit over CC. Corn in a short rotation with sod (NC) was still maintaining higher levels of aggregate stability even after its second year of tillage. Biological properties also remained quite high in this system. The CC treatment performed worst in soil quality in all areas except soil hardness. This system has the least potential to reduce erosion and nutrient runoff.

The NC had the highest corn populations and highest yield in this year’s trial, although all treatments had statistically similar yields. 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. Corn pests were present in all treatments and particularly prevalent in the NT treatment. The NT treatment also had the lowest yield in the trial, but it is difficult to determine if the lower yield was actually due to the higher prevalence of pests in this treatment.

The perennial forage first cutting had overall lower quality and yield than the second and third cuttings. The quality of the forages was very high through the season. Even the lowest quality first cutting was higher quality than any of the corn systems. Yields, however, were much lower than the corn yields with the average forage yield about half 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.

Overall, the NC cropping system was the highest performing corn cropping system in terms of yield and feed quality, although there was no significant difference between treatments, and performed very well in terms of soil quality. The perennial forages outperformed the corn treatments in terms of both feed quality and soil quality although their yields were far lower than the corn treatments. The NT treatment performed very well in soil quality but yield drag was still an issue with this system. Special attention in the early season crop fertility may help ameliorate this issue. The winter cover cropping corn system did appear to improve soil quality of the CC system. The high soil quality, feed quality and yields of the NC cropping system suggests that years of established perennial forages will improve soil quality, crop yield, and provide the forage that winter cover crop does not necessarily produce. It is clear that the soil health benefits of the NC were beginning to diminish in its 2nd year of tillage, however yields were still excellent with lower pesticide and fertility inputs required compared to the other cropping systems.

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 Julija Cubins, Lindsey Ruhl, and Dan Ushkow 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.

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CULTIVATING HEALTHY COMMUNITIES

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MULTI-SPECIES COVER CROP MIXTURES

Kirsten Workman, Agronomy Outreach Specialist, UVM Extension
No Till and Cover Crop Symposium (Burlington, Vt.)

February 2016

Champlain Valley Crop, Soil and Pasture Team

If it aint broke...why fix it?

picture taken November 16, 2013

Why Mixtures?

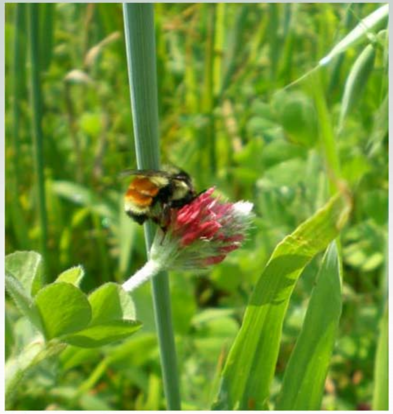

Photo: L. Ruhl

- Soil Health
- Transition to No-Till
- Maximize diversity & rotations
- C:N Ratio…*stop tying up N*
- Management Objective
  - Nutrient (N,P,K)
  - Weed Control
  - Pollinators
  - Compaction
  - Forage Quality
  - Disease
- Better cost share $$

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Management Challenges in New England

Agronomic

Challenge →	*Solutions*
Sourcing seed	Grow your own, Better suppliers already
Different seed sizes can be difficult to mix together	Coated seed, narrower pattern Different boxes in the drill
Often cover crops/mixes require different equipment	Custom Service Providers, new technology You wanted a new drill anyway, didn't you?
How to fit it in the rotation (timing)	Add a small grain to your rotation, Interseeding into cash crops, Be aware in vegetable rotations
Herbicides: Carryover impacts on emergence Good termination	Keeping residuals in check…work with your suppliers Glyphosate may not be enough

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Management Challenges in New England

Climatic

- Short growing season
- Cold winters
- Soil temperatures
- Unpredictable weather at establishment and termination

Solutions:

- Shorter RM Corn
- Interseed
- Pay attention to details
- Quality seed
- Seed treatments

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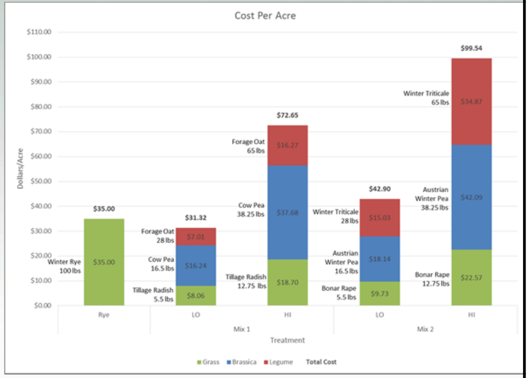
Management Challenges in New England

Economic

- Some species can make your mix significantly more expensive.
- The good news: usually these are the species you can use very little of.
- LEGUME$
invest in C:N ratio



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Better Cover Crop Mixes for Vermont

2014-2015 Mixes

Mix	Grass	Legume	Brassica
CTRL	W. Rye		
1	Oat	Pea	Radish
2	Triticale	W. Pea	Rapeseed
3	ARG	W. Pea	Radish
4	W. Wheat	W. Pea	Radish
5	ARG	Berseem	Radish
6	Triticale	Crimson	Radish
7	Oats	Vetch	Mustard
8	Triticale	Vetch	Mustard
9	W. Rye	W. Pea	Turnip
10	W. Rye	Crimson	Rapeseed

2015-2016 Mixes

Mix	Grass	Legume	Brassica
CTRL	W. Rye		
1	Oat	Pea	Radish
2	Triticale	W. Pea	Rapeseed
3	ARG	W. Pea	Radish
4	W. Rye*	W. Pea	Radish
5	ARG	Berseem	Radish
6	W. Rye/Oat*		Radish
7	W. Rye/Oat*	Vetch	
8	Triticale	Vetch	Turnip*
9	W. Rye	W. Pea	Turnip
10	W. Rye	Crimson	Rapeseed

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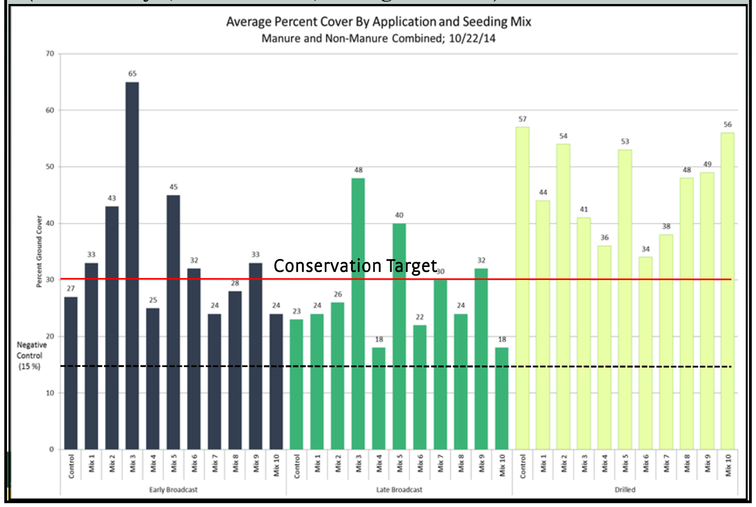
USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service
Conservation Innovation Grants

Fall 2014: Mixes Better Drilled, Except Mix 3

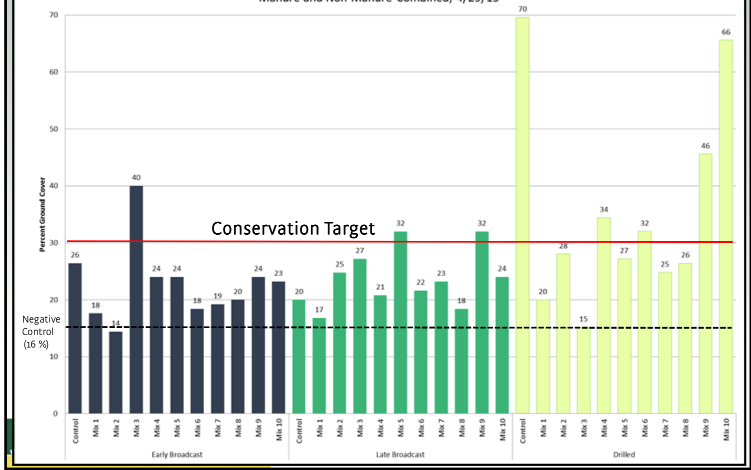
(Annual Rye, Winter Pea, Tillage Radish)



Spring 2015: Winter Rye, Mix 9 & 10 Drilled
Mix 3 Early Broadcast – dead residue

Average Percent Cover By Application and Seeding Date

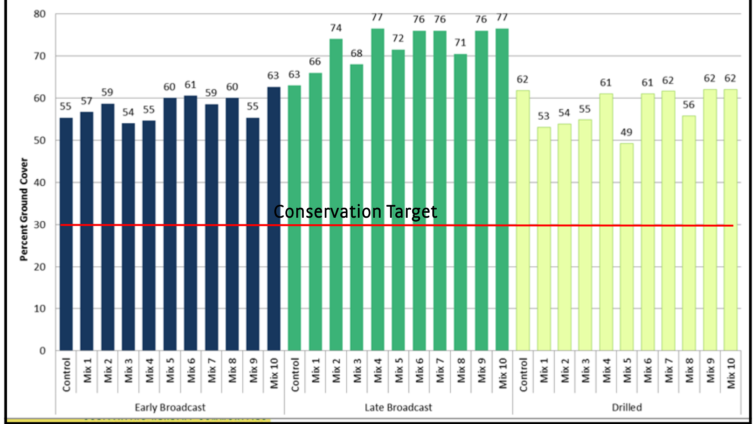
Manure and Non-Manure Combined; 4/29/15



Better Cover Crop Mixes for Vermont

Average Percent Cover By Application and Seeding Date

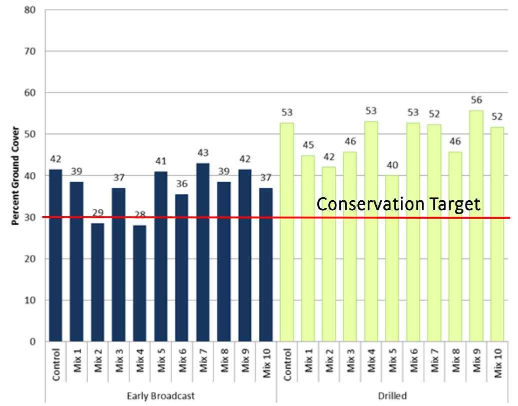
Fall 2015 (All Corn Silage Fields)



Better Cover Crop Mixes for Vermont

Average Percent Cover By Application and Seeding Date

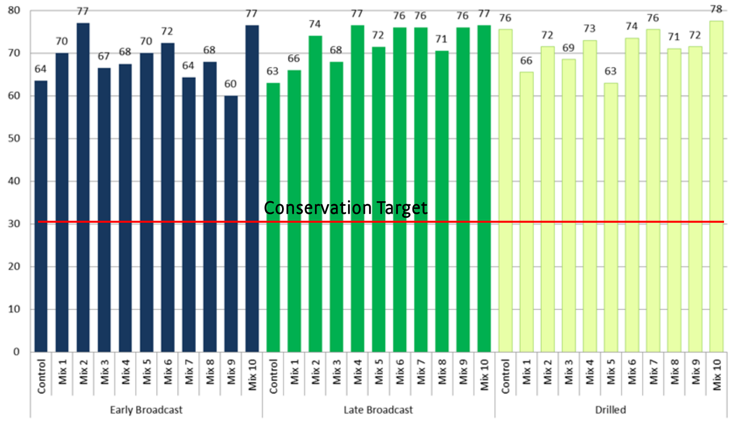
Fall 2015: *Conventionally Tilled Corn Silage Fields*



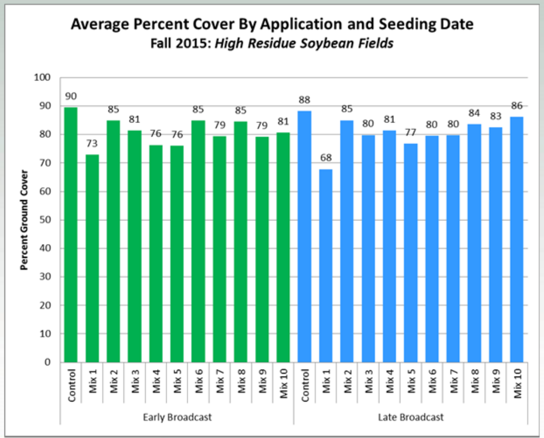
Better Cover Crop Mixes for Vermont

Average Percent Cover By Application and Seeding Date

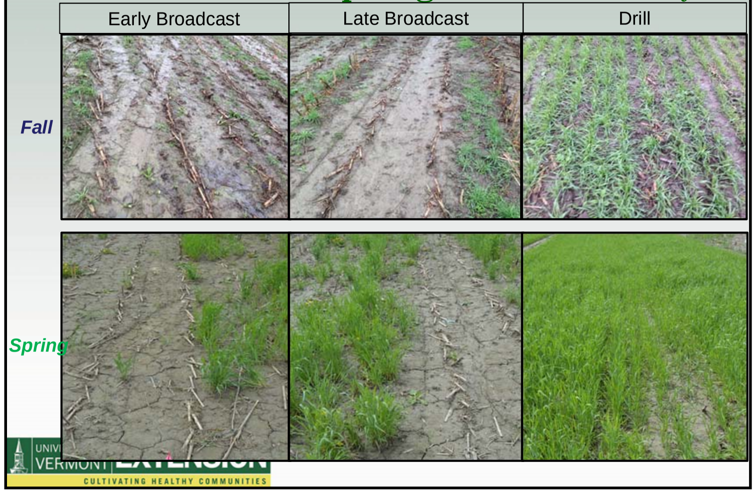
Fall 2015: *No-Till Corn Silage Fields*



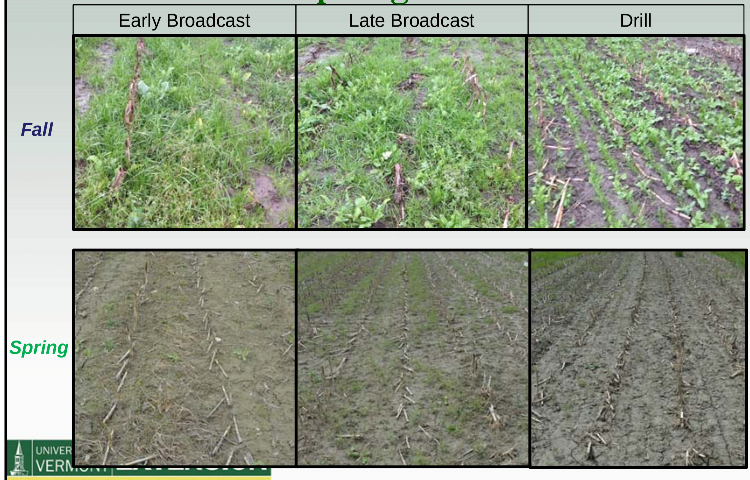
Better Cover Crop Mixes for Vermont



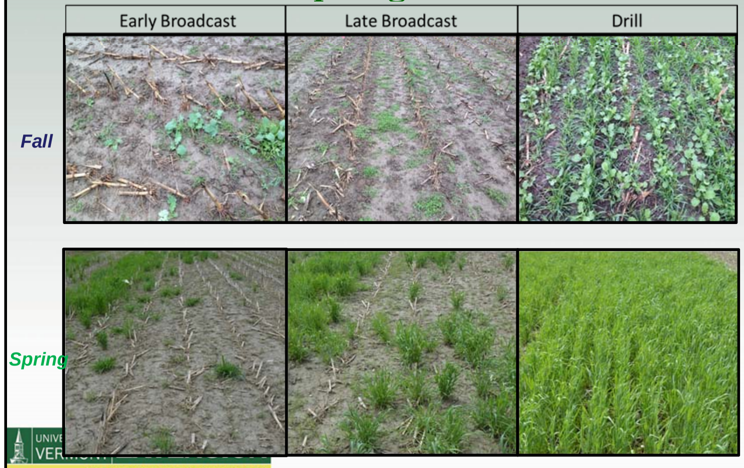
Control Fall & Spring: 100 lbs Winter Rye

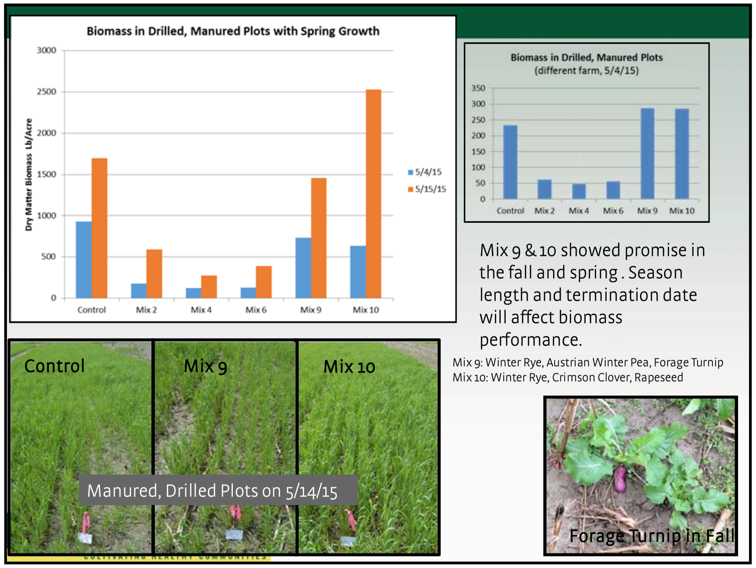


Mix 3 Fall & Spring: ARG+W. Pea+Radish



Mix 10 Fall & Spring: Rye + Crimson Clover + Rapeseed



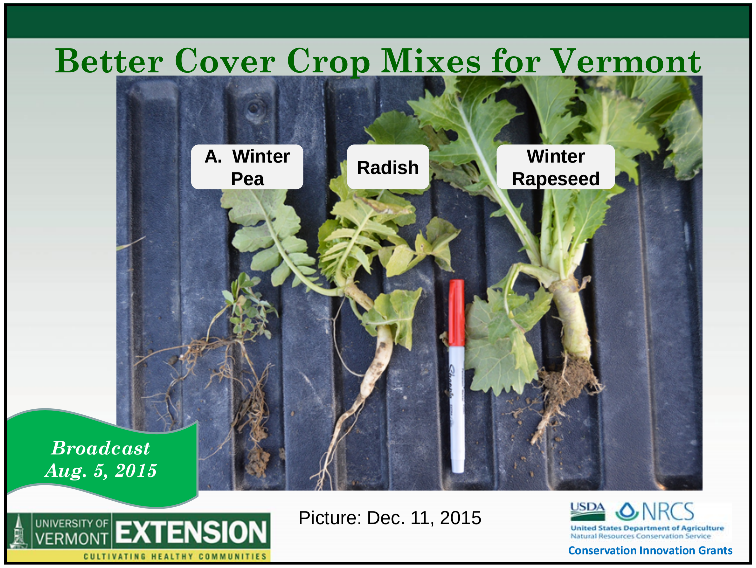


Manured, Drilled Plots on 5/14/15

Mix 9 & 10 showed promise in the fall and spring . Season length and termination date will affect biomass performance.

Mix 9: Winter Rye, Austrian Winter Pea, Forage Turnip
Mix 10: Winter Rye, Crimson Clover, Rapeseed

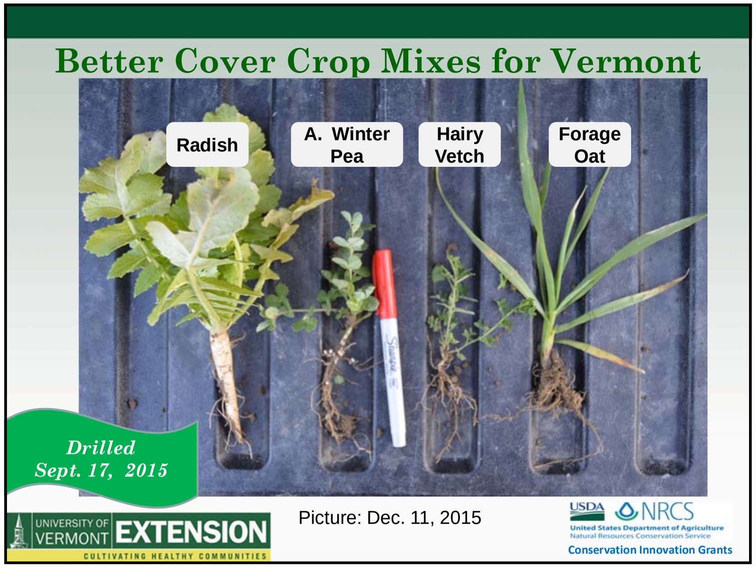
Forage Turnip in Fall



Better Cover Crop Mixes for Vermont

Broadcast
Aug. 5, 2015

Picture: Dec. 11, 2015



Better Cover Crop Mixes for Vermont

Drilled
Sept. 17, 2015

Picture: Dec. 11, 2015

OPENING A NEW WINDOW OF OPPORTUNITY FOR COVER CROP MIXES

Cereal Grains in the Rotation & Prevented Plantings

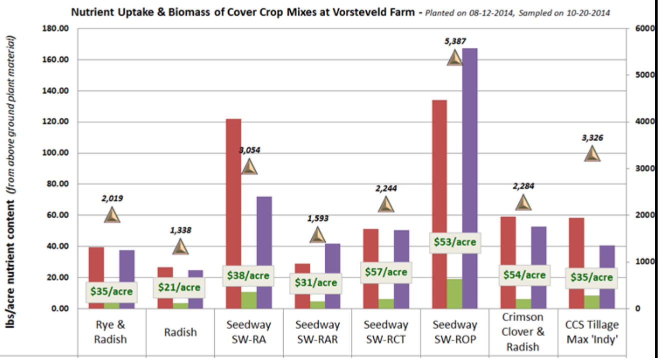
Vorsteveld Farm, Panton

CROP ROTATIONS:
Add a cereal grain to your rotation… open up a great cover cropping or rotation opportunity

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service
Conservation Innovation Grant

Cover Crop Mixes After Winter Rye Harvest

Nutrient Uptake & Biomass of Cover Crop Mixes at Vorsteveld Farm - *Planted on 08-12-2014, Sampled on 10-20-2014*

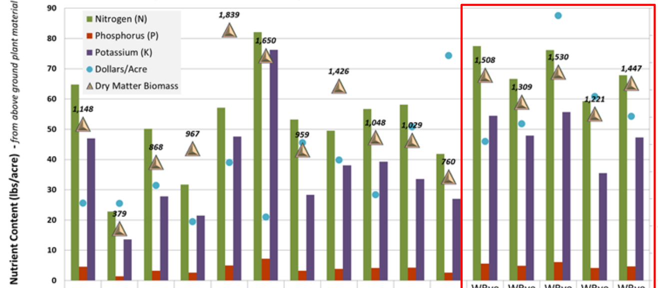


	Rye & Radish	Radish	Seedway SW-RA	Seedway SW-RAR	Seedway SW-RCT	Seedway SW-ROP	Crimson Clover & Radish	CCS Tillage Max 'Indy'
🟥 Nitrogen (N)	39.56	26.57	121.95	29.04	51.13	134.11	59.31	58.37
🟩 Phosphorus (P)	5.25	3.60	10.86	4.84	6.11	19.09	6.27	8.40
🟪 Potassium (K)	37.56	24.72	71.88	41.72	50.60	167.37	52.80	40.63
△ Dry Matter Biomass (lbs/ac)	2019	1338	3054	1593	2244	5387	2284	3326

Cover Crops in Prevented Plantings

Cover Crop Mixes in Prevented Plantings

Nutrient Uptake & Biomass of Cover Crop Mixes at Foster's Farm - *Planted 8-20-2015, Sampled 10-1-2015*



	(ARG) Rad	WRye	Oat	Buck 1/2	Buck	Radish	WRye Oat	WRye Buck	WRye Rad	WRye WPea	WRye Vetch	WRye Oat Rad	WRye Oat Clover	WRye Oat Vetch	WRye Oat WPea	WRye Oat Buck
🟩 Nitrogen (N)	64.82	22.76	50.11	31.71	57.08	82.11	53.23	49.51	56.70	58.13	41.85	77.44	66.62	76.14	59.21	67.83
🟥 Phosphorus (P)	4.59	1.44	3.21	2.61	4.97	7.26	3.26	3.85	4.19	4.22	2.66	5.58	4.84	6.12	4.15	4.63
🟪 Potassium (K)	46.94	13.54	27.85	21.46	47.63	76.24	28.28	38.08	39.31	33.55	26.99	54.43	47.92	55.70	35.54	47.31
● Dollars/Acre	$26	$26	$32	$20	$39	$21	$46	$40	$28	$51	$74	$46	$52	$88	$61	$54
△ Dry Matter Biomass	1148	379	868	967	1839	1650	959	1426	1048	1029	760	1508	1309	1530	1221	1447

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Elmwood Fine Sandy Loam

50 lbs Winter Rye
50 lbs Forage Oat
4 lbs Radish

Drilled September 10
Picture October 29

Will get spring manure

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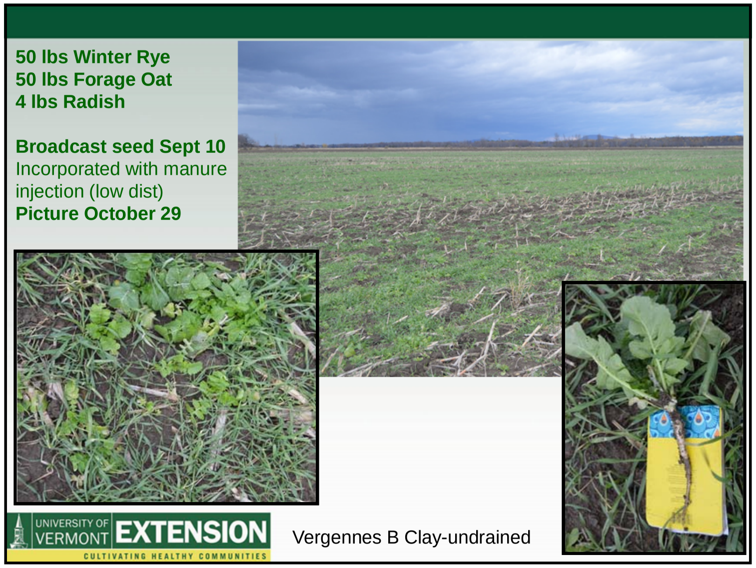
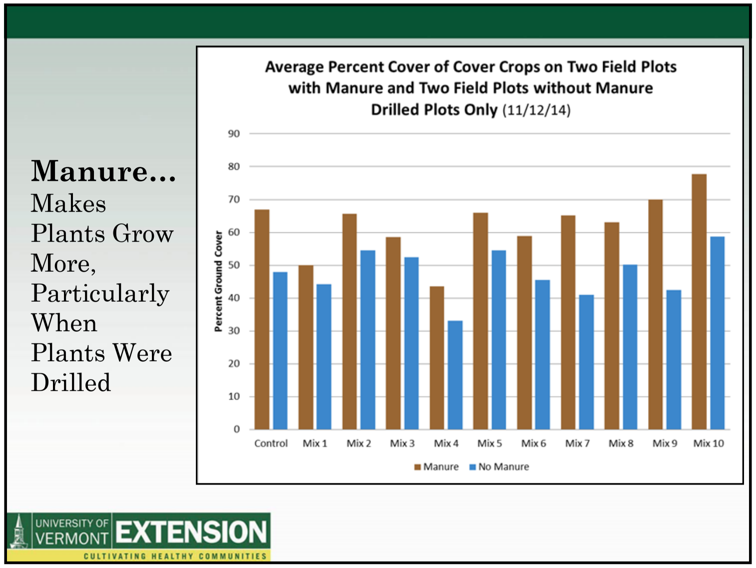


50 lbs Winter Rye
50 lbs Forage Oat
4 lbs Radish

Broadcast seed Sept 10
Incorporated with manure
injection (low dist)
Picture October 29

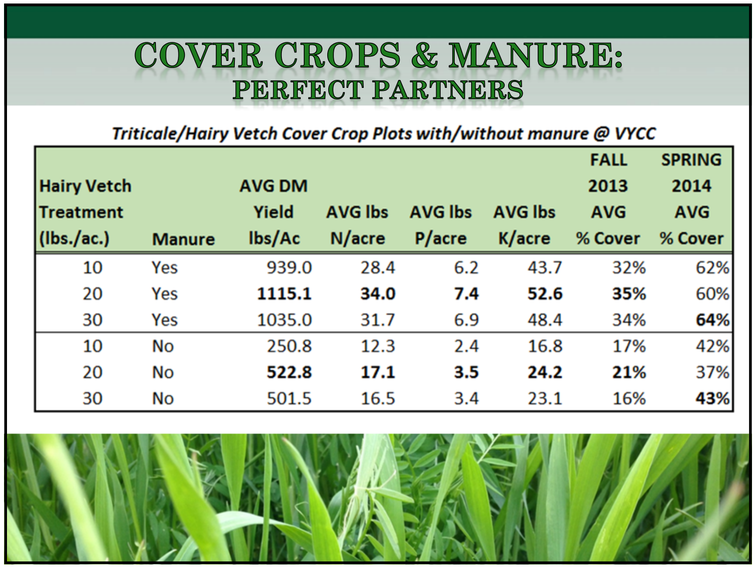
Vergennes B Clay-undrained

Pictures
Jan. 25, 2016



Manure…
Makes
Plants Grow
More,
Particularly
When
Plants Were
Drilled

Average Percent Cover of Cover Crops on Two Field Plots with Manure and Two Field Plots without Manure Drilled Plots Only (11/12/14)



COVER CROPS & MANURE:
PERFECT PARTNERS

Triticale/Hairy Vetch Cover Crop Plots with/without manure @ VYCC

Hairy Vetch Treatment (lbs./ac.)	Manure	AVG DM Yield lbs/Ac	AVG lbs N/acre	AVG lbs P/acre	AVG lbs K/acre	FALL 2013 AVG % Cover	SPRING 2014 AVG % Cover
10	Yes	939.0	28.4	6.2	43.7	32%	62%
20	Yes	**1115.1**	**34.0**	**7.4**	**52.6**	**35%**	60%
30	Yes	1035.0	31.7	6.9	48.4	34%	**64%**
10	No	250.8	12.3	2.4	16.8	17%	42%
20	No	**522.8**	**17.1**	**3.5**	**24.2**	**21%**	37%
30	No	501.5	16.5	3.4	23.1	16%	**43%**

Cover Cropping Costs and Benefits

Compiled by Jeffrey Sanders, University of Vermont Extension Northwest Crops & Soils Program, 11/2014, based on calculations from the USDA NRCS Cover Crop Economics Tool: http://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=stelprdb1252244&ext=xlsm

NRCS Planting Rates in Pounds of Seed	**Cereal Rye**	**Annual Rye**	**Triticale**	**Cereal Rye / Radish Mix**	**Annual Rye / Clover / Radish Mix**
Planted	75	20	75	60,3	12,5,2
Broadcast	112	30	112	85,4	18,6,4
Forage (added pounds of seed for forage production)	20	5	25	n/a	n/a
Seed Cost per pound (2014 Prices)	$0.25	$0.60	$0.50	$0.41	$1.86

Expenses

	Typical Values	SCENARIO 1 **Cereal Rye: Drilled, Plowed Down**	SCENARIO 2 **Annual Rye: Broadcast & Disked**	SCENARIO 3 **Triticale: Drilled & Harvested**	SCENARIO 4 **Cereal Rye & Radish Mix: Aerially Applied**	SCENARIO 5 **Annual Rye & Clover & Radish Mix: Broadcast / No-tilled**
Seed Costs		75# * $0.25 = $18.75	30# * $0.60 = $18.00	(75# + 25#) * $0.50 = $50.00	89# * $0.41=$36.49	28# * $1.86 = $52.08
Application Method (2014 Prices)						
Broadcast	$4.84		$4.84			$4.84
Broadcast/Disk	$19.17		$19.17			
Aerial Applied	$40.00				$40.00	
Drilled	$13.26	$13.26		$13.26		
Termination Costs						
Plow Down	$18.63	$18.63				
Disk	$17.35		$17.35			
Herbicide	$30.00				$30.00	$30.00
Crimping	$7.50					
Increased Time & Management	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50
Decreased Yield Costs (Price per ton at the bunk)	$55.00			3 * $55.00 = $165.00		

Continued next page

Benefits (Income)

	Typical Values	SCENARIO 1 **Cereal Rye: Drilled, Plowed Down**	SCENARIO 2 **Annual Rye: Broadcast & Disked**	SCENARIO 3 **Triticale: Drilled & Harvested**	SCENARIO 4 **Cereal Rye & Radish Mix: Aerially Applied**	SCENARIO 5 **Annual Rye & Clover & Radish Mix: Broadcast / No-tilled**
Nutrient Credits (2014 Prices)						
Nitrogen Credit	$0.40	$0.40 * 30 = $12.00			$0.40 * 30 = $12.00	$0.40 * 35 = $14.00
Phosphorus Credit	$0.46					
Potash Credit	$0.35					
Other Credits						
Herbicide Reduction						$30.00
Insecticide Reduction						
Yield Increase Credit (price per ton at the bunk)	$55.00	2 * $55.00 = $110.00			1* $55.00 = $55.00	
Erosion Reduction Credits						
Tons of topsoil (typically 2-3 tons per acre in Vermont)	$20.00	2 * $20.00 = $40.00	2 * $20.00 = $ $40.00	3 * $20.00 = $60.00	2 * $20.00= $40.00	1 *$20.00 = $20.00
Field maintenance reduction. Work done to fix erosion per acre	$5.00	$2.50	$2.50	$5.00	$5.00	$1.00
Effects of erosion to public Waters (per ton of lost soil)	$4.93	2 * $4.93 = $9.86	2 * $4.93 = $9.86	3 * $4.93 = $14.79	2 * $4.93 = $9.86	$4.93
Forage Credit (per ton of forage harvested)	$50.00			5 * $50.00 = $250.00		
Cost to Harvest Silage per Acre	$30.00			$30.00		
NRCS Cost Share	$62.00	$62.00	$62.00	$62.00	$73.00	$73.00

Totals		**Drilled Rye, Plowed down**	**Broadcast / Disked**	**Drilled Triticale for Harvest**	**Aerial Applied**	**Broadcast, No-Tilled**
Total Costs		($52.14)	($41.69)	($229.76)	($107.99)	($88.42)
Total Benefits		$236.36	$114.36	$421.79	$194.86	$142.93
Total Return		**$184.22**	**$72.67**	**$192.03**	**$86.87**	**$54.51**

NW CROPS & SOILS PROGRAM

UNIVERSITY OF VERMONT EXTENSION

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Tips for Interseeding Cover Crops

Interseeding cover crops has many benefits to the farmer. Like any new way of implementing an agronomic practice, there are certain considerations that should be addressed. This is a brief overview of those considerations. For a more detailed explanation, please refer to the UVM Extension Northwest Crop and Soils Program publication, *Under Cover: Integrating Cover Crops into Silage Corn Systems*.

Yield: Many farmers are concerned that interseeded cover crops will compete with the corn for moisture and nutrients resulting in reduced yields. Research conducted at Pennsylvania State University, McGill University and University of Vermont has shown no negative impact on the corn from interseeding cover crops. In fact, research in Pennsylvania has shown a slight yield boost to corn that has been interseeded with legumes.

Herbicides: Herbicide programs must be modified to accommodate the planting of a cover crop into the growing corn crop. This is especially true if the cover crop to be seeded is a broadleaf like radish or clover as they are especially sensitive to many corn herbicide residues. The farmer must work with the herbicide applicator and/or their crop consultant to make sure that there will be no damaging residues that may damage the cover crops. Please refer to Penn State University handout, *Herbicide Persistence and Rotation to Cover Crops by Bill Curran and Dwight Lingenfelter, Extension Weed Science, Penn State University, October, 2013.*

Proper Timing: Research shows that interseeding can be a cost effective way to establish cover crops in corn from the V6 developmental stage (normal time of fertilizer topdress) to roughly four weeks prior to corn harvest. When choosing cover crops, consider what soil health goals you want to achieve, planting date, and other labor demands at that time of year.

Special Considerations for Various Interseeding Methods

Fertilizer Spreaders:

- Convenient method to plant cover crops as no new seeding equipment is needed.
- Banding may occur when planting seed of different weight and size. For example, heavier, larger seed does not spread as far as light seeds. The fertilizer spreader may need to be calibrated to account for different seed weights and sizes.
- Mud can coat the spreader wheels and reduce accuracy of application.
- Seed is not incorporated so prolonged dry conditions can reduce germination and establishment. Time of application limited by height of the corn.

Interseeders / Seed Incorporation Planting Methods:

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

High Clearance / "Highboy" Seeders:

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

Aerial Seeding:

- Most versatile method of seeding due to lack of impediment by crop establishment or poor soil conditions.
- Weather, particularly wind, must be considered when aerial seeding. It can adversely affect the placement of seed.
- Landing zones must be established beforehand so the helicopter can safely operate.
- Seeding rates may need to be adjusted to account for seed caught in the leaves of crops and not reaching the ground. This is particularly important if number of seeds on the ground must meet standards placed by government contracts for payment.
- Banding of seed can occur depending on the seeding apparatus and if various types of seed are spread at the same time.
- Seed is not incorporated so prolonged dry conditions can reduce germination and establishment.

If you have any questions or concerns about interseeding cover crops into corn, please feel free to contact Heather Darby or Jeff Sanders at (802) 524-6501 or heather.darby@uvm.edu or Jeffrey.sanders@uvm.edu.

UVM Extension Fact Sheet:

Northwest Crops & Soils
Champlain Valley Crop, Soil and Pasture Team

No-Till Corn Planter Checklist: Planter Maintenance & Upgrades

by Jeff Sanders, Agronomy Outreach Professional

1) Planter tires, worn treads, correct psi

2) Hitch height should be between 14 and 15 inches from ground to bottom of hitch plate

3) Check tool bar for level- torpedo level needs to be level down in the field
    a. If not pulling up or pushing down on the planter

4) Parallel arms are tight and bushings good
    a. Bouncing around will affect how the planter works in the ground

5) Vee Openers- important for the creation of a good seed trench
    a. Replace at 14.5 inches
    b. Check with two pieces of paper 1.75 -2 inches 3mm
    c. Heavy duty 3.5mm openers should be about 1.25 inches
    d. Move shims achieve proper contact.
        i. If you can turn one against the other easily they are not shimmed properly
        ii. If you shim them to tight you will put additional stress on bearings

6) Check the Keaton Seed Firmers for wear and adjust as needed
    a. They should be snugged up with the adjusting screw
        i. NEVER back up with the planter down or they will be damaged

7) Check all drive chains make sure not bound up. Do not oil chains daily—dust and dirt will stick and bind up and shorten life of chains. Best is to remove and place into the seed boxes

8) Check shafts for alignment and bearing
    a. Problems will lead to skips

9) Check seed tubes for wear and breaks very important
    a. A leading cause of skips and doubles

10) Check rock guards
    a. Replace worn guards as your seed tubes will break and wear faster if you do not

11) Check downforce pressure
    a. Should be able to turn gauge wheels when planter is on the ground
    b. Too much down pressure will create sidewall compaction and impede root system
    c. If spring system check for broken springs
    d. Ideally you will want to run around 125 pounds of downforce on the planting unit

12) Gauge wheels need to checked for wear and bearings need to be checked for wear
    a. Gauge wheels need to rub on vee openers any gap will result in plugging and trench filling in resulting in problems
    b. Check scrapers at this time as well

13) Check closing system for true running
    a. Any slop in the bushings and arms will result in diminished performance
    b. Check distance between wheels 1.75 inches
    c. Check springs for wear and the mounting holes for wear and replace repair as needed

14) Check fertilizer system for problems
    a. Check lines for cracks
    b. Check monitoring system for leaks
    c. Check inline filters and screens
    d. Check hardware holding tanks well
    e. Make sure dry fertilizer tanks are cleaned make sure augers are put in correctly
    f. For dry fertilizer make sure the banding set up is correct (2X2) and all other
    g. Liquid fertilizer make sure the in row lines are dropping the fertilizer in the correct location or your vee openers will get wet or your keatons will get wet and plugging and dragging will result.
    h. Make sure the ground pump you are using to fill and hoses are all in good shape and the fittings are not busted.
    i. Make sure planter pump is calibrated so you do not burn your seed (in row) or misapply fertilizer.
        i. Tape a bottle to one hose, drive 136 ft each oz. is a gallon on 30 inch rows

15) Test seed meters
    a. Air meters need to check brushes, seals, etc…
    b. Fingers check belts and other components should be checked annually
    c. Lubricate seed drives annually
    d. Clean seed boxes and plates with warm soapy water

16) Check vacuum system on an air seeder check vacuum gauge
    a. When planting during the day depending on air temperature, humidity, hydraulic oil temp, this pressure will change and you need to keep track or the population will change

17) Check planter standards for cracks and repair as needed

18) Check electronic meter system before you head to the field
    a. Use dielectric grease on connection between planter and tractor

19) Make sure all hydraulic hoses are properly run and tied off so they do not get pinched or blown

20) Check marker arm measurement so that you row spacing is even and that the marker wheels bearings and guards are in good shape. Check fittings for tightness and leaks.

21) Follow planter recommendations for the seed you plant and use seed lubricant if recommended by the planter manual. Pay attention to seed weights and shapes and make the proper adjustments to planter to insure proper planting population.

For more information:

Please contact the UVM Extension Champlain Valley Crop, Soil & Pasture or Northwest Crops & Soils Programs

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Kemmeren's Angelrose Dairy:
Heatlhy Soil, Quality Crops, Healthy Cows

YIELD, QUALITY, SUSTAINABILITY

A High Producing Operation in NY

John and Dianne Kemmeren understand that high quality forage is the key to their operation. Together with their two children, Katy and Peter, the Kemmerens milk 90 cows and raise 550 acres on the operation they call Angelrose Dairy. Understanding the importance of diversity, the Kemmerens utilize various crops in succession that are either fed to the dairy herd or sold off the farm as high quality forage. Everything that the dairy cattle consume, with the exception of a little supplemental protein, is grown at Angelrose. Dianne explains, "Currently the milk cow ration contains Green Spirit Italian Ryegrass Baleage, HMC and Corn Silage as well as a small amount of mixed grass haylage, all grown right here." In addition to these, Angelrose also grows and markets rye straw as well as roughly 90 acres of alfalfa. However, according to Dianne, red clover seems to out-perform alfalfa in their climate. Despite the excess rain early on, the Angelrose had a tremendous year for dry hay. After the rain subsided, they harvested four cuttings off of almost all the fields in small squares to market.

What is the key to this forage production? Soil. "We take care of our soil like we take care of our cows," Dianne explained Having no-tilled for 40 years, the Kemmerens are no strangers to the effects of no-till and cover crops on soil health. Being recognized for their achievements in soil health through no-till and cover crops, John has been invited to speak on multiple occasions about the advantages of soil health. With soils reaching 6+ % organic matter, Angelrose has a good handle on soil improvement!

While overall yield and soil health are crucial components of Angelrose Dairy, forage quality is never overlooked. In 2015, Angelrose found their way to the top of the podium in the World Dairy Expo Forage Superbowl. Their hay sample of King's AgriSeeds Greenfast mixture took first place out of 38 total samples that were judged based on visual appearance as well as forage quality.

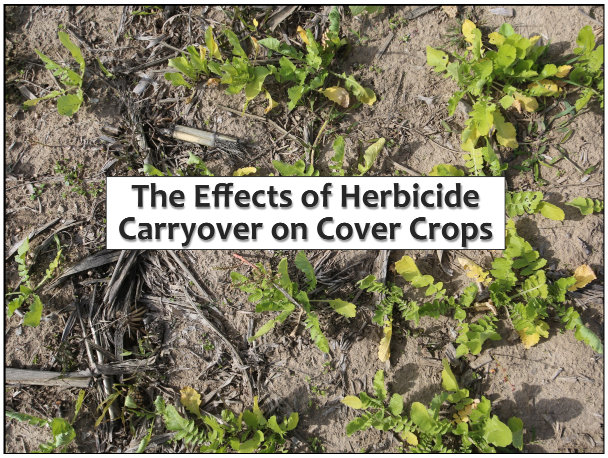
Angelrose Dairy has relied on King's AgriSeeds to provided high energy forages for many years. We thank them for their dedication to forage production and look forward to a productive 2016!

A Weed Scientist's Perspective on Cover Crops

Kevin Bradley and Cody Cornelius
University of Missouri

From a weed scientist's perspective…

1. We must be able to effectively kill whatever cover crop species we are planting.
2. We must have a real understanding of what cover crops actually do for weed control.
3. We must know which corn or soybean herbicides are most likely to carryover and cause injury to cover crop species.



The Effects of Herbicide Carryover on Cover Crops

Objective

To determine which corn and soybean herbicides are most likely to carryover and cause injury to cover crop species.

Cover Crop Carryover Research - Methodology

General: Field experiments were conducted in 2013-2015 in Columbia, MO. Corn and soybean were planted in May/June. All herbicide programs tested were POST applications and applied in late June to early July.

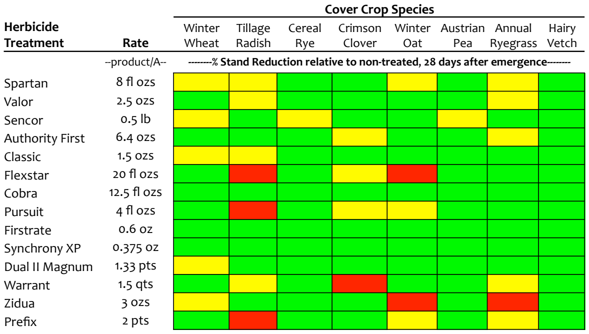
Cover Crop Planting Dates: Sept. 10 or 11, 2013-2014

Seeding Rates (lb/A):

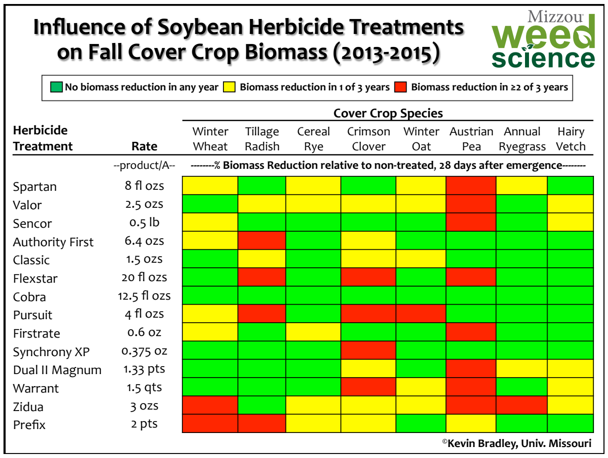
Wheat =	**120**
Cereal Rye =	**110**
Italian ryegrass =	**25**
Oats =	**70**
Crimson Clover =	**30**
Austrian Winter Pea =	**50**
Hairy Vetch =	**20**
Tillage Radish =	**8**

Influence of Soybean Herbicide Treatments on Fall Cover Crop Stand (2013-2015)

🟩 No stand reduction in any year 🟨 Stand reduction in 1 of 3 years 🟥 Stand reduction in ≥2 of 3 years



Herbicide Treatment	**Rate**	Cover Crop Species Winter Wheat	Tillage Radish	Cereal Rye	Crimson Clover	Winter Oat	Austrian Pea	Annual Ryegrass	Hairy Vetch
	--product/A--	--------% Stand Reduction relative to non-treated, 28 days after emergence--------							
Spartan	8 fl ozs	🟨	🟨	🟩	🟩	🟨	🟩	🟨	🟩
Valor	2.5 ozs	🟩	🟨	🟩	🟩	🟩	🟩	🟨	🟩
Sencor	0.5 lb	🟨	🟩	🟨	🟩	🟩	🟨	🟩	🟩
Authority First	6.4 ozs	🟩	🟩	🟩	🟨	🟩	🟩	🟨	🟩
Classic	1.5 ozs	🟨	🟨	🟩	🟩	🟩	🟩	🟩	🟩
Flexstar	20 fl ozs	🟩	🟥	🟩	🟨	🟥	🟩	🟩	🟩
Cobra	12.5 fl ozs	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Pursuit	4 fl ozs	🟩	🟥	🟩	🟨	🟨	🟩	🟩	🟩
Firstrate	0.6 oz	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Synchrony XP	0.375 oz	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Dual II Magnum	1.33 pts	🟨	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Warrant	1.5 qts	🟩	🟨	🟩	🟥	🟩	🟩	🟨	🟩
Zidua	3 ozs	🟨	🟩	🟩	🟩	🟥	🟩	🟥	🟩
Prefix	2 pts	🟩	🟥	🟩	🟩	🟨	🟩	🟨	🟩



Influence of Soybean Herbicide Treatments on Fall Cover Crop Biomass (2013-2015)

🟩 No biomass reduction in any year 🟨 Biomass reduction in 1 of 3 years 🟥 Biomass reduction in ≥2 of 3 years

		Cover Crop Species							
Herbicide Treatment	**Rate**	Winter Wheat	Tillage Radish	Cereal Rye	Crimson Clover	Winter Oat	Austrian Pea	Annual Ryegrass	Hairy Vetch
	--product/A--	--------% **Biomass Reduction relative to non-treated, 28 days after emergence**--------							
Spartan	8 fl ozs	🟨	🟩	🟨	🟩	🟨	🟥	🟨	🟩
Valor	2.5 ozs	🟩	🟨	🟨	🟨	🟨	🟥	🟩	🟨
Sencor	0.5 lb	🟨	🟩	🟩	🟩	🟩	🟥	🟩	🟨
Authority First	6.4 ozs	🟨	🟥	🟩	🟨	🟩	🟩	🟩	🟩
Classic	1.5 ozs	🟩	🟨	🟩	🟨	🟨	🟩	🟩	🟩
Flexstar	20 fl ozs	🟩	🟥	🟩	🟥	🟩	🟥	🟩	🟩
Cobra	12.5 fl ozs	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Pursuit	4 fl ozs	🟨	🟥	🟩	🟥	🟥	🟩	🟩	🟩
Firstrate	0.6 oz	🟨	🟩	🟨	🟩	🟩	🟥	🟩	🟩
Synchrony XP	0.375 oz	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩
Dual II Magnum	1.33 pts	🟩	🟩	🟩	🟨	🟩	🟥	🟨	🟨
Warrant	1.5 qts	🟩	🟩	🟩	🟥	🟨	🟥	🟩	🟨
Zidua	3 ozs	🟥	🟩	🟨	🟨	🟨	🟥	🟥	🟨
Prefix	2 pts	🟥	🟥	🟨	🟨	🟩	🟨	🟩	🟩

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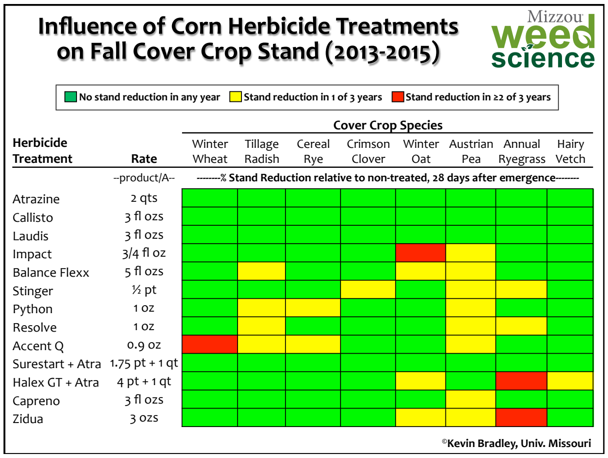

Influence of Corn Herbicide Treatments on Fall Cover Crop Stand (2013-2015)

🟩 No stand reduction in any year 🟨 Stand reduction in 1 of 3 years 🟥 Stand reduction in ≥2 of 3 years

		Cover Crop Species							
Herbicide Treatment	**Rate**	Winter Wheat	Tillage Radish	Cereal Rye	Crimson Clover	Winter Oat	Austrian Pea	Annual Ryegrass	Hairy Vetch
	--product/A--	--------% **Stand Reduction relative to non-treated, 28 days after emergence**--------							
Atrazine	2 qts	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Callisto	3 fl ozs	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Laudis	3 fl ozs	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Impact	3/4 fl oz	🟩	🟩	🟩	🟩	🟥	🟨	🟩	🟩
Balance Flexx	5 fl ozs	🟩	🟨	🟩	🟩	🟨	🟨	🟩	🟩
Stinger	½ pt	🟩	🟩	🟩	🟨	🟩	🟨	🟨	🟩
Python	1 oz	🟩	🟨	🟨	🟩	🟩	🟨	🟩	🟩
Resolve	1 oz	🟩	🟨	🟩	🟩	🟩	🟨	🟨	🟩
Accent Q	0.9 oz	🟥	🟨	🟨	🟩	🟩	🟨	🟩	🟩
Surestart + Atra	1.75 pt + 1 qt	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Halex GT + Atra	4 pt + 1 qt	🟩	🟩	🟩	🟩	🟨	🟩	🟥	🟨
Capreno	3 fl ozs	🟩	🟩	🟩	🟩	🟩	🟨	🟩	🟩
Zidua	3 ozs	🟩	🟩	🟩	🟩	🟨	🟨	🟥	🟩

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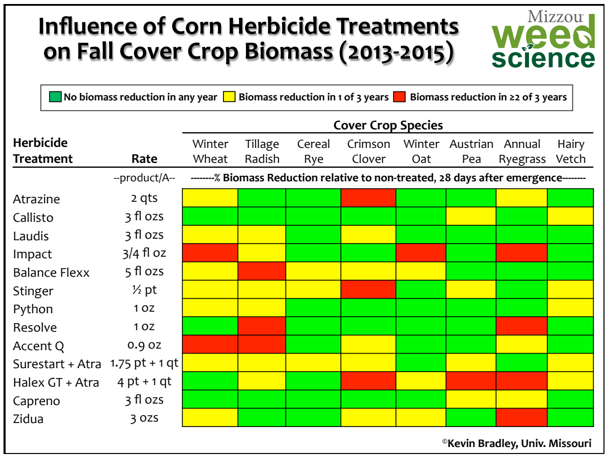

Influence of Corn Herbicide Treatments on Fall Cover Crop Biomass (2013-2015)

🟩 No biomass reduction in any year 🟨 Biomass reduction in 1 of 3 years 🟥 Biomass reduction in ≥2 of 3 years

		Cover Crop Species							
Herbicide Treatment	**Rate**	Winter Wheat	Tillage Radish	Cereal Rye	Crimson Clover	Winter Oat	Austrian Pea	Annual Ryegrass	Hairy Vetch
	--product/A--	--------% **Biomass Reduction relative to non-treated, 28 days after emergence**--------							
Atrazine	2 qts	🟨	🟩	🟩	🟥	🟩	🟩	🟨	🟩
Callisto	3 fl ozs	🟩	🟩	🟩	🟩	🟩	🟨	🟩	🟨
Laudis	3 fl ozs	🟨	🟨	🟩	🟨	🟩	🟩	🟩	🟩
Impact	3/4 fl oz	🟥	🟨	🟩	🟩	🟥	🟩	🟥	🟩
Balance Flexx	5 fl ozs	🟨	🟥	🟨	🟨	🟨	🟩	🟩	🟩
Stinger	½ pt	🟨	🟨	🟨	🟥	🟩	🟨	🟩	🟨
Python	1 oz	🟨	🟨	🟩	🟩	🟩	🟩	🟩	🟨
Resolve	1 oz	🟩	🟥	🟩	🟩	🟩	🟩	🟥	🟩
Accent Q	0.9 oz	🟥	🟥	🟩	🟨	🟩	🟩	🟨	🟩
Surestart + Atra	1.75 pt + 1 qt	🟨	🟨	🟨	🟨	🟩	🟨	🟩	🟨
Halex GT + Atra	4 pt + 1 qt	🟩	🟨	🟩	🟥	🟨	🟥	🟥	🟨
Capreno	3 fl ozs	🟩	🟩	🟩	🟩	🟩	🟨	🟨	🟩
Zidua	3 ozs	🟨	🟩	🟩	🟨	🟨	🟩	🟥	🟩

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Conclusions

Herbicide carryover injury on cover crop species is going to vary from year to year, largely due to rainfall and time of application

The general order of sensitivity of cover crops to herbicide carryover, from greatest to least sensitive: tillage radish > Austrian winter pea > crimson clover = annual ryegrass > winter wheat = winter oats > hairy vetch = cereal rye

Soybean herbicide treatments that were most injurious to cover crops: fomesafen (Flexstar/Prefix), pyroxasulfone (Zidua), imazethapyr (Pursuit), acetochlor (Warrant), sulfentrazone (Authority products)

Corn herbicide treatments that were most injurious to cover crops: topramezone (Impact), mesotrione (Callisto, Halex GT, etc.) clopyralid (Stinger, SureStart), isoxaflutole (Balance Flexx), pyroxasulfone (Zidua, etc.), nicosulfuron (Accent Q, etc.),

Evaluation of Herbicide Programs for the Termination of Cover Crop Species in the Spring

Materials and Methods

General: Identical field experiment conducted in Columbia, MO in 2013, 2014 and 2015

Planting Dates: September 11, 2012; September 11,2013 and September 13, 2014

Termination Dates: Early April and early May each year

Seeding Rates (lbs/A):

Wheat	120
Cereal Rye	110
Italian ryegrass	25
Oats	70
Crimson Clover	30
Austrian Winter Pea	50
Hairy Vetch	30
Cereal Rye+Hairy Vetch	70+30

Some species will winter kill….

Tillage Radish 12/3/2013
Columbia, Missouri

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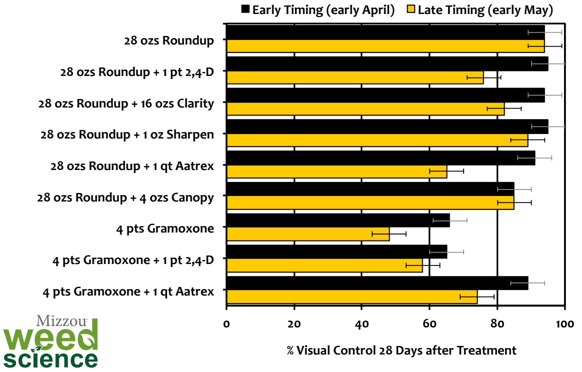
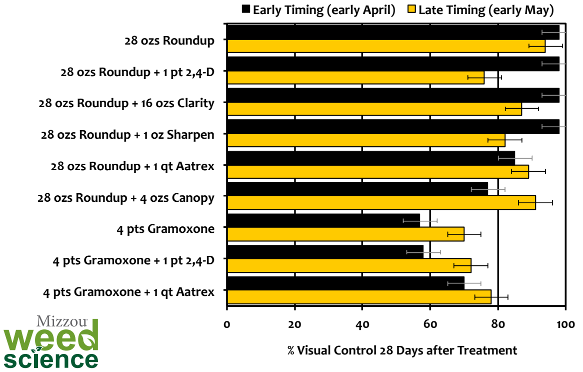
Influence of Herbicide Treatments and Application Timings on the Control of a Wheat Cover Crop (results averaged across 3 years)



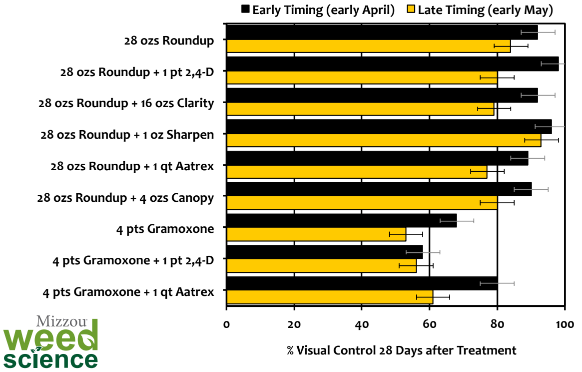
Mizzou weed science

Influence of Herbicide Treatments and Application Timings on the Control of a Cereal Rye Cover Crop (results averaged across 3 years)



Mizzou weed science

Influence of Herbicide Treatments and Application Timings on the Control of a Annual Ryegrass Cover Crop (results averaged across 3 years)

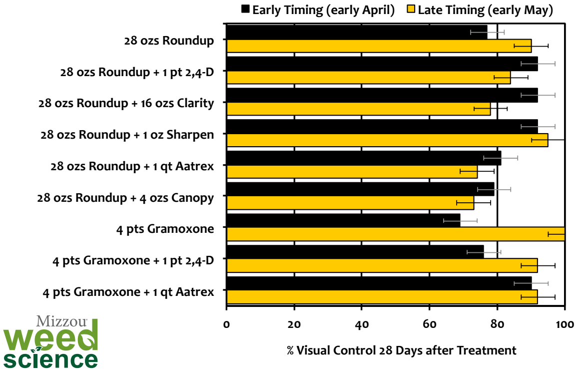


Mizzou weed science

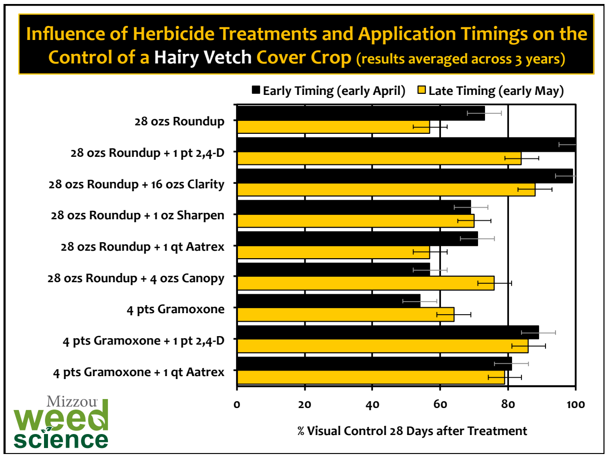
Influence of Herbicide Treatments and Timings on the Control of an Annual Ryegrass Cover Crop (2013-2015; Columbia, MO)

Herbicide Treatment	Rate	Application Timing Early (5-9”) Tillering	 Mid (12-20”) Pre-boot	 Late (28-36”) Boot/Heading
	---product/A---	--% Ann. Ryegrass Biomass Reduction 28 DAT--		
Roundup PowerMax	22 fl ozs	85	62	70
Roundup PowerMax	36 fl ozs	92	81	87
Roundup PowerMax + 2,4-D	36 fl ozs + 1 pt	94	81	89
Roundup PowerMax + Clarity	36 fl ozs + 1 pt	91	64	87
Roundup PowerMax + Sharpen	36 fl ozs + 1 fl oz	95	79	91
Roundup PowerMax + Aatrex	36 fl ozs + 1 qt	83	71	74
Roundup PowerMax + Canopy	36 fl ozs + 4 ozs	85	66	77
Roundup PowerMax + Basis Blend	36 fl ozs + 1.25 ozs	94	86	91
Roundup PowerMax + Select Max	36 fl ozs + 10 ozs	99	91	88
Roundup PowerMax + Select Max	36 fl ozs + 16 ozs	99	98	98
Gramoxone Inteon	4 pts	56	53	78
Gramoxone Inteon + 2,4-D	4 pts + 1 pt	63	52	78
Gramoxone Inteon + Aatrex	4 pts + 1 qt	68	64	74
Gramoxone Inteon + Sencor + 2,4-D	4 pts + 4 ozs + 1 pt	69	65	84
Liberty	29 fl ozs	14	27	41
$LSD_{0.05}$ (treatments x timings):		------------------------------- 7 -----------------------------		

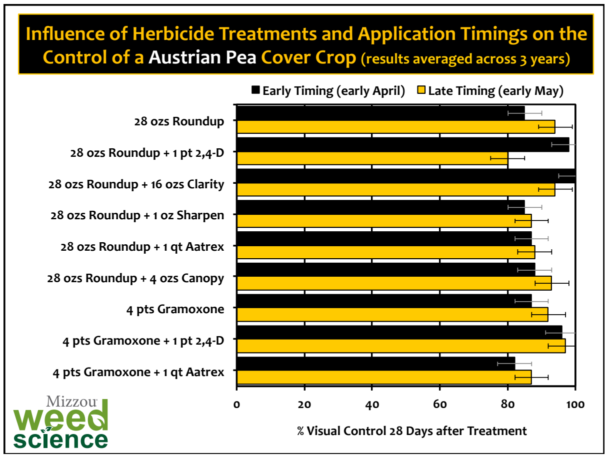
Influence of Herbicide Treatments and Application Timings on the Control of a Crimson Clover Cover Crop (results averaged across 3 years)



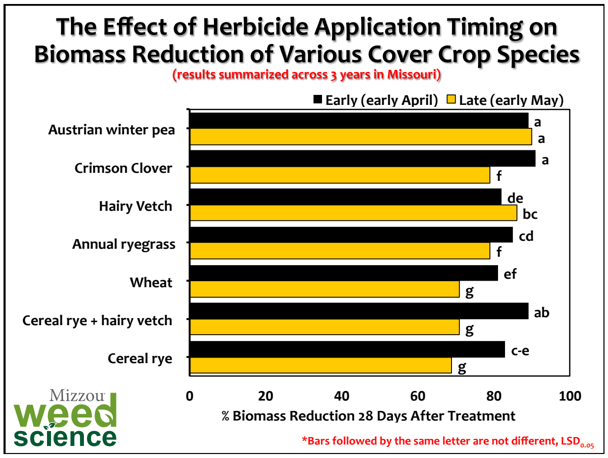
Mizzou weed science



Influence of Herbicide Treatments and Application Timings on the Control of a Hairy Vetch Cover Crop (results averaged across 3 years)



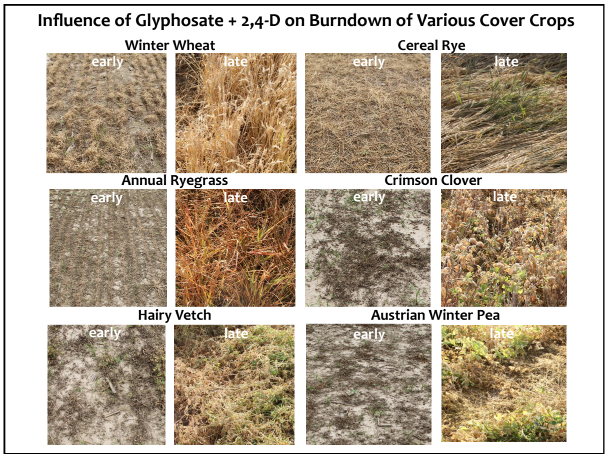
Influence of Herbicide Treatments and Application Timings on the Control of a Austrian Pea Cover Crop (results averaged across 3 years)



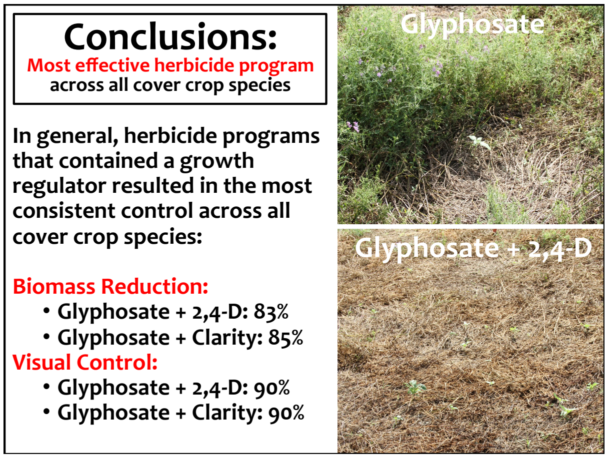
The Effect of Herbicide Application Timing on Biomass Reduction of Various Cover Crop Species

(results summarized across 3 years in Missouri)

*Bars followed by the same letter are not different, $LSD_{0.05}$



Influence of Glyphosate + 2,4-D on Burndown of Various Cover Crops



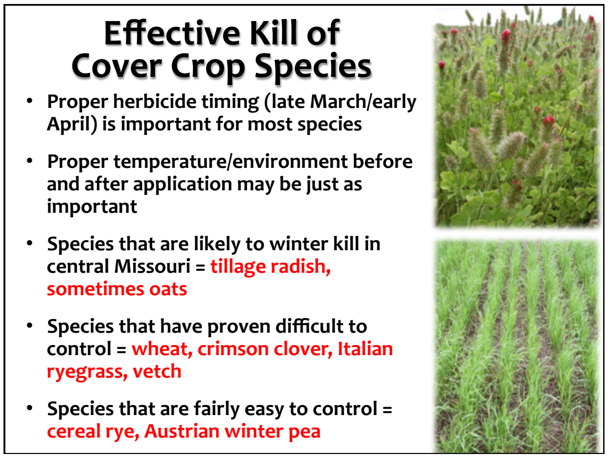
Conclusions:

Most effective herbicide program across all cover crop species

In general, herbicide programs that contained a growth regulator resulted in the most consistent control across all cover crop species:

Biomass Reduction:
- Glyphosate + 2,4-D: 83%
- Glyphosate + Clarity: 85%

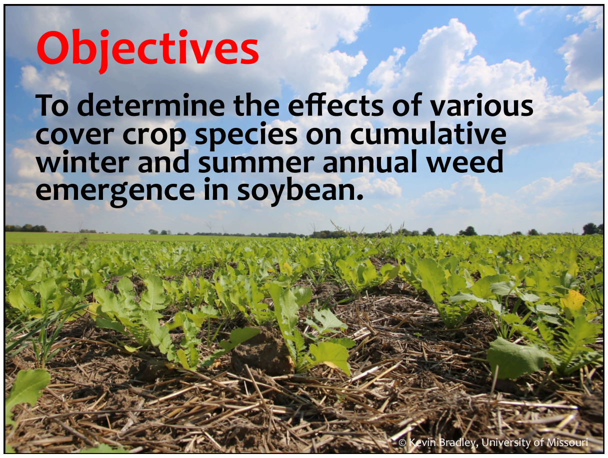
Visual Control:
- Glyphosate + 2,4-D: 90%
- Glyphosate + Clarity: 90%



Effective Kill of Cover Crop Species

- Proper herbicide timing (late March/early April) is important for most species
- Proper temperature/environment before and after application may be just as important
- Species that are likely to winter kill in central Missouri = tillage radish, sometimes oats
- Species that have proven difficult to control = wheat, crimson clover, Italian ryegrass, vetch
- Species that are fairly easy to control = cereal rye, Austrian winter pea

Influence of Various Cover Crop Species on Winter and Summer Annual Weed Emergence



Objectives

To determine the effects of various cover crop species on cumulative winter and summer annual weed emergence in soybean.

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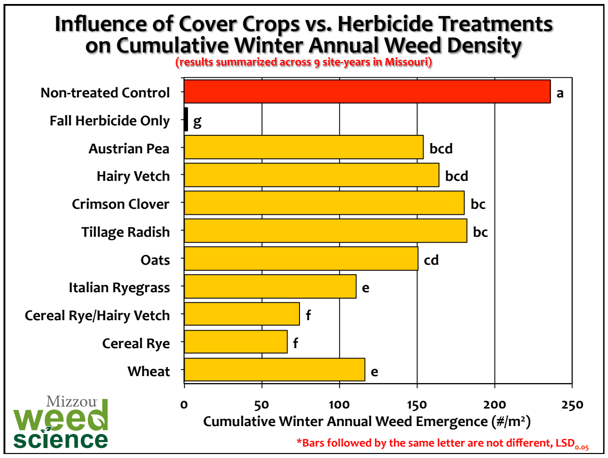
My Perspective

Based on our research and the results of other *PUBLISHED* studies, the ability of cover crops to reduce the emergence of WINTER ANNUAL weed species:

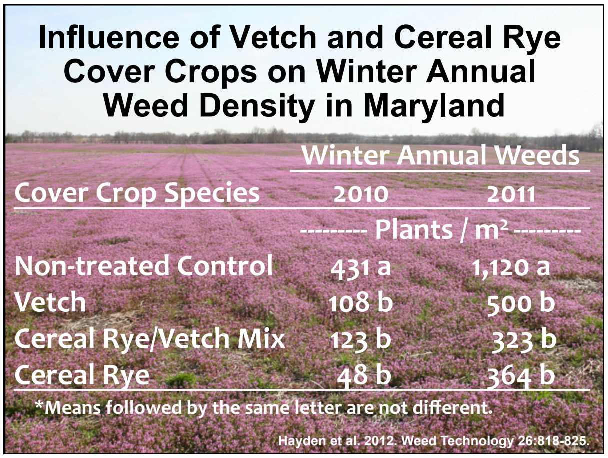
- Is variable and rarely 100%
- Is dependent on the time of winter annual weed emergence
- Is dependent on the cover crop species and/or mix selected



Influence of Cover Crops vs. Herbicide Treatments on Cumulative Winter Annual Weed Density

(results summarized across 9 site-years in Missouri)

*Bars followed by the same letter are not different, $LSD_{0.05}$

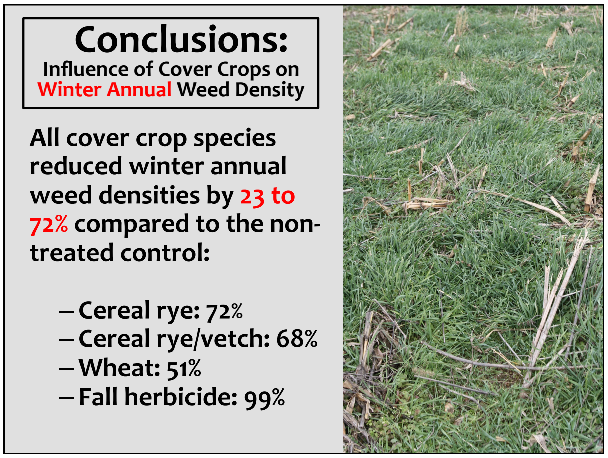


Influence of Vetch and Cereal Rye Cover Crops on Winter Annual Weed Density in Maryland

	Winter Annual Weeds	
Cover Crop Species	2010	2011
	--------- Plants / m² ---------	
Non-treated Control	431 a	1,120 a
Vetch	108 b	500 b
Cereal Rye/Vetch Mix	123 b	323 b
Cereal Rye	48 b	364 b

*Means followed by the same letter are not different.

Hayden et al. 2012. Weed Technology 26:818-825.

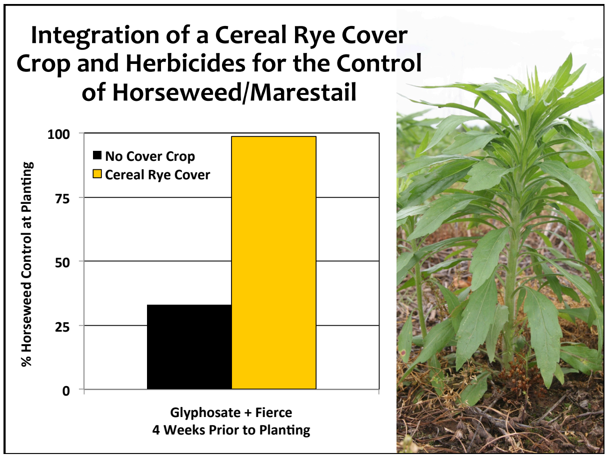


Conclusions:

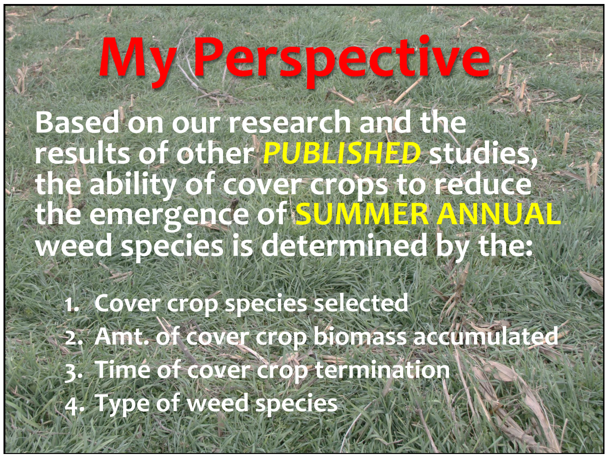
Influence of Cover Crops on Winter Annual Weed Density

All cover crop species reduced winter annual weed densities by 23 to 72% compared to the non-treated control:

- Cereal rye: 72%
- Cereal rye/vetch: 68%
- Wheat: 51%
- Fall herbicide: 99%



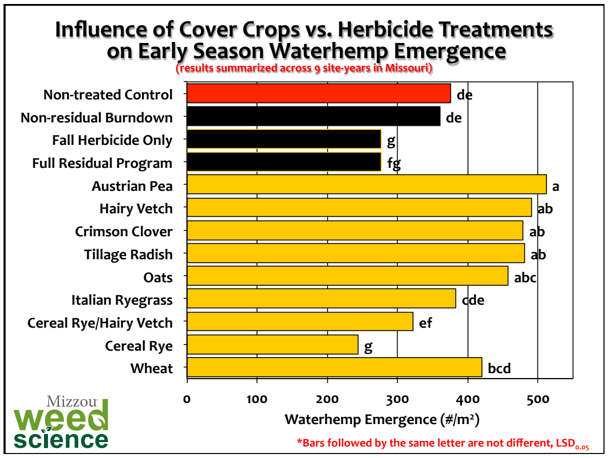
Integration of a Cereal Rye Cover Crop and Herbicides for the Control of Horseweed/Marestail



My Perspective

Based on our research and the results of other *PUBLISHED* studies, the ability of cover crops to reduce the emergence of SUMMER ANNUAL weed species is determined by the:

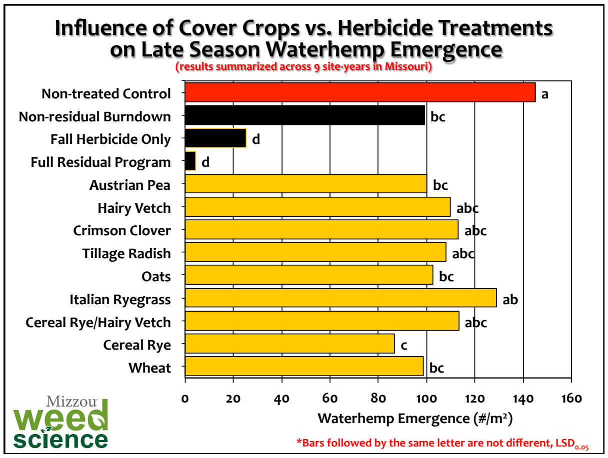
1. Cover crop species selected
2. Amt. of cover crop biomass accumulated
3. Time of cover crop termination
4. Type of weed species



Influence of Cover Crops vs. Herbicide Treatments on Early Season Waterhemp Emergence

(results summarized across 9 site-years in Missouri)

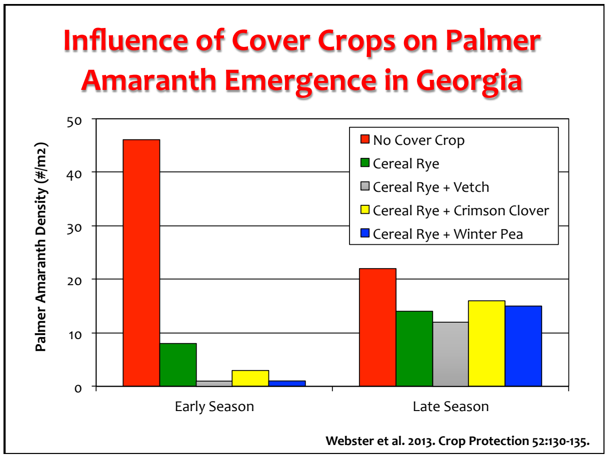
*Bars followed by the same letter are not different, $LSD_{0.05}$



Influence of Cover Crops vs. Herbicide Treatments on Late Season Waterhemp Emergence

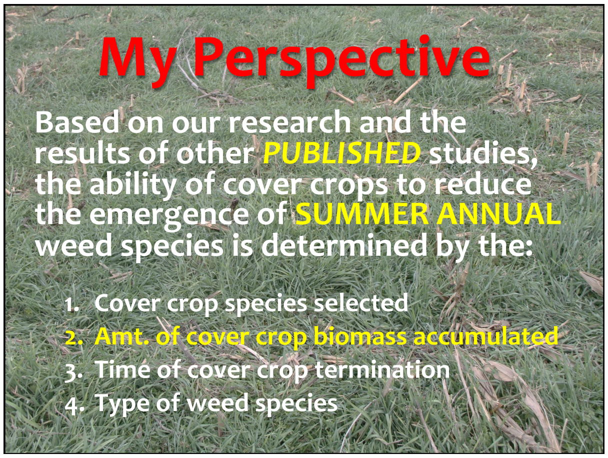
(results summarized across 9 site-years in Missouri)

*Bars followed by the same letter are not different, $LSD_{0.05}$



Influence of Cover Crops on Palmer Amaranth Emergence in Georgia

Webster et al. 2013. Crop Protection 52:130-135.



My Perspective

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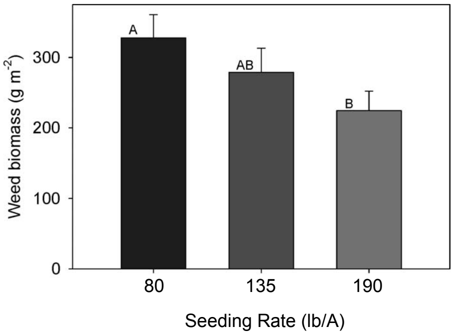
1. Cover crop species selected
2. Amt. of cover crop biomass accumulated
3. Time of cover crop termination
4. Type of weed species

Influence of Cereal Rye Seeding Rate on Weed Biomass 10 Weeks after Cereal Rye Termination



Mirsky et al. 2011. Weed Science 59:380-389.

My Perspective

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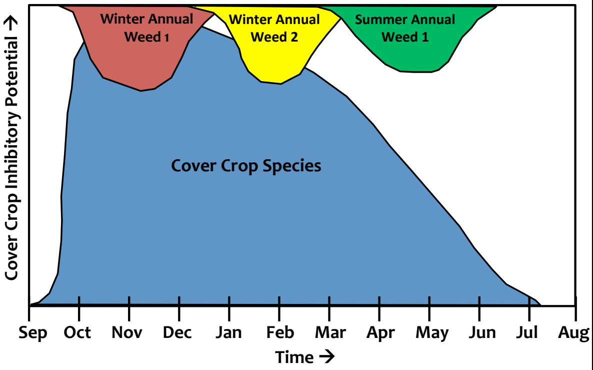
2. Amt. of cover crop biomass accumulated
3. Time of cover crop termination
4. Type of weed species

Relationship Between Inhibitory Potential of Cover Crops and Various Weed Species



Adapted from Kruidhof et al. 2010. Weed Research 51:177-186.

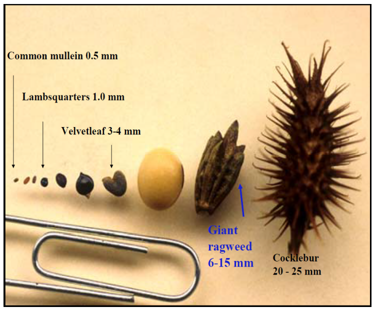
My Perspective

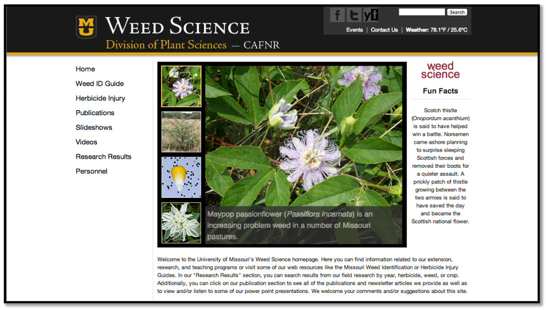
Based on our research and the results of other *PUBLISHED* studies, the ability of cover crops to reduce the emergence of **SUMMER ANNUAL** weed species is determined by the:

1. Cover crop species selected
2. Amt. of cover crop biomass accumulated
3. Time of cover crop termination
4. Type of weed species

Different Weed Seeds are Affected Differently by:

soil cover, light, temperature, soil depth, etc.





Scotch thistle (*Onopordum acanthium*) is said to have helped win a battle. Norsemen came ashore planning to surprise sleeping Scottish forces and removed their boots for a quieter assault. A prickly patch of thistle growing between the two armies is said to have saved the day and became the Scottish national flower.

Maypop passionflower (*Passiflora incarnata*) is an increasing problem weed in a number of Missouri pastures.

Welcome to the University of Missouri's Weed Science homepage. Here you can find information related to our extension, research, and teaching programs or visit some of our web resources like the Missouri Weed Identification or Herbicide Injury Guides. In our "Research Results" section, you can search results from our field research by year, herbicide, weed, or crop. Additionally, you can click on our publication section to see all of the publications and newsletter articles we provide as well as to view and/or listen to some of our power point presentations. We welcome your comments and/or suggestions about this site.

Website:	http://weedscience.missouri.edu
Email:	bradleyke@missouri.edu
App:	ID Weeds (free download)
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NOTES:

NOTES:

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

The University of Vermont Extension has a vast amount of resources available to farmers in Vermont and around the Northeast. Here are just a few that you mind find helpful.

Champlain Valley Crop, Soil and Pasture Team

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, and address many production related issues such as: Quality Forage & Crop Production, Soil Health, Grazing Management and Pasture Production, Cover Crops, No-Till Agriculture, Nutrient Management, Water Quality and more.

23 Pond Lane, Suite 300, Middlebury, VT 05753 | (802) 388-4969 | www.uvm.edu/extension/cvcrops

Jeff Carter, Agronomy Specialist: Field Crops & Nutrient Management | jeff.carter@uvm.edu

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Kirsten Workman, Agronomy Outreach | kirsten.workman@uvm.edu
Cheryl Cesario, Grazing Outreach | cheryl.cesario@uvm.edu
Kristin Williams, Agronomy Outreach | kristin.williams@uvm.edu
Nathaniel Severy, CVFC | nathaniel.severy@uvm.edu
Daniel Infurna, Research Field Tech. | daniel.infurna@uvm.edu

NORTHWEST CROPS & SOILS PROGRAM

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.

278 S Main Street, Suite 2, St. Albans, VT 05478 | 802-524-6501 | www.uvm.edu/extension/cropsoil

Dr. Heather Darby, Associate Professor of Agronomy| heather.darby@uvm.edu

Jeff Sanders, Agronomy Outreach | jeffrey.sanders@uvm.edu
Susan Brouillette, Program Manager | susan.brouillette@uvm.edu
Erica Cummings, Abha Gupta, Amanda Gervais, Susan Monahan, Deb Heleba, Lily Calderwood, Sara Zeigler, Julian Post, Scott Lewins

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MORE EXTENSION RESOURCES:

- **Sidney Bosworth,** Extension Associate Professor, University of Vermont
  Agronomy, Forages, Pasture Management | sid.bosworth@uvm.edu | 802-656-0478 | http://pss.uvm.edu/vtcrops
- **Daniel Hudson**, Assistant Professor: Agronomist & Nutrient Management Specialist
  St. Johnsbury Extension Office | daniel.hudson@uvm.edu | 802-751-8307 x356
- **University of Vermont Extension Agriculture Programs**| http://www.uvm.edu/extension/agriculture

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