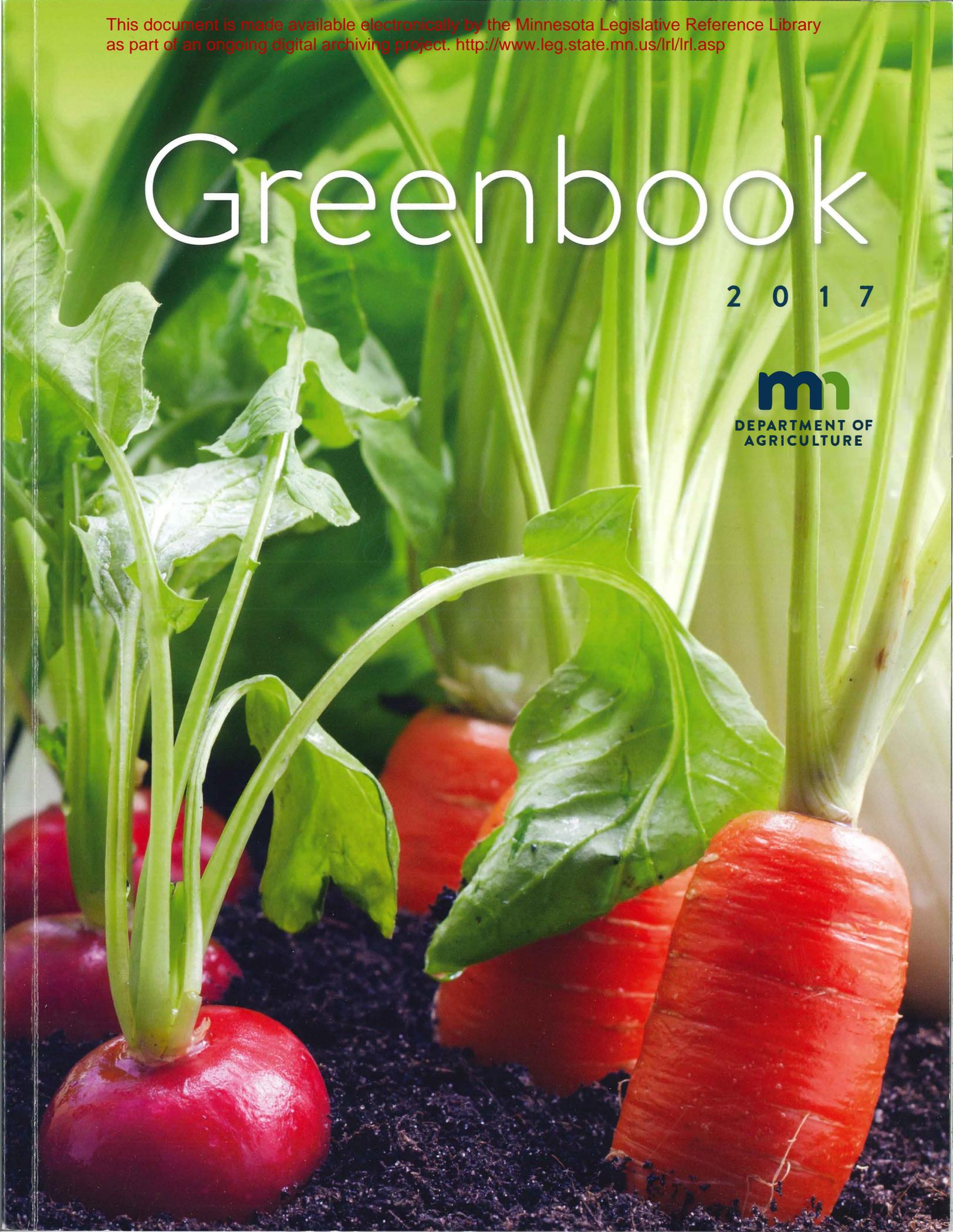


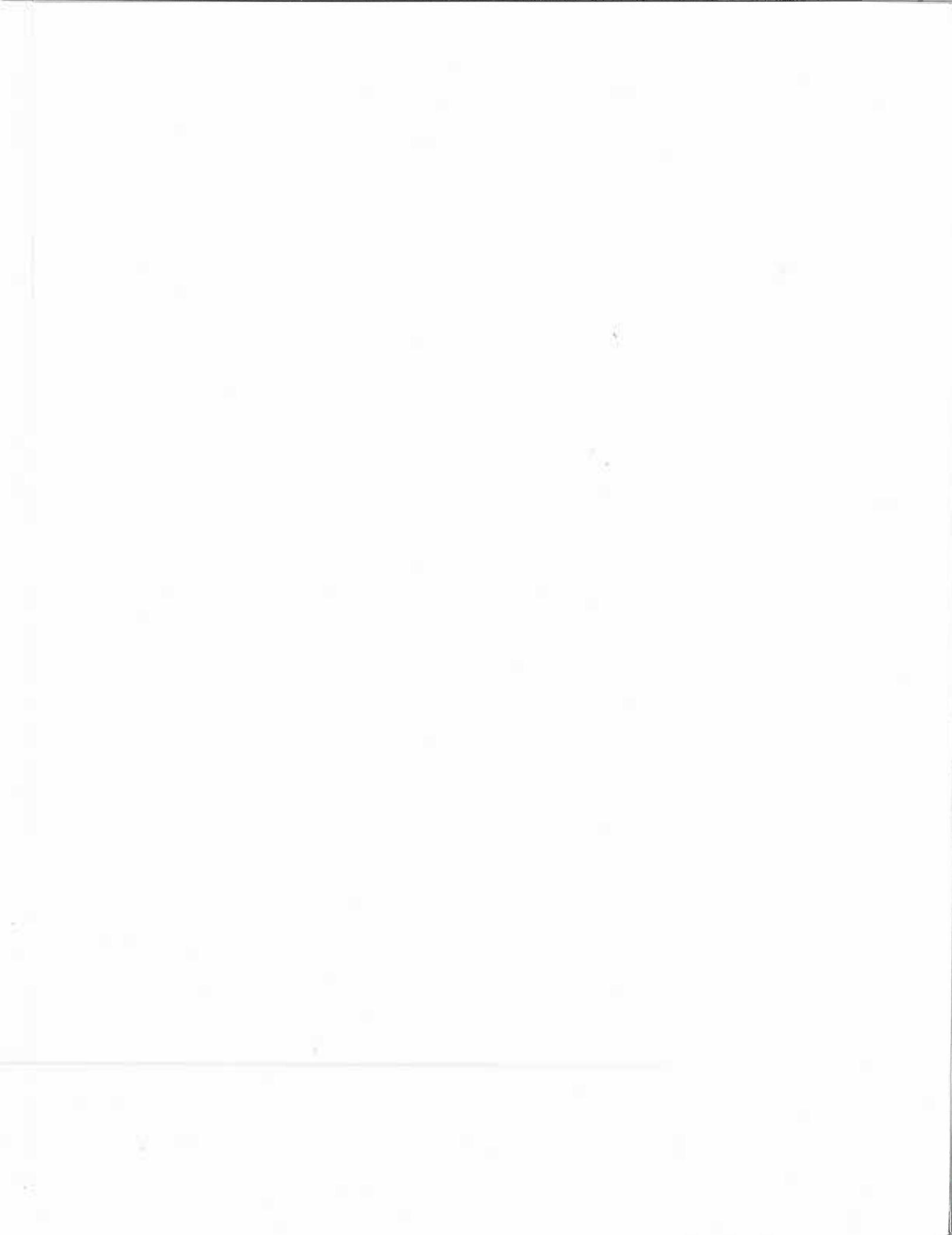
Greenbook

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DEPARTMENT OF
AGRICULTURE





Greenbook 2017

Program Vision Statement

Agriculture in Minnesota will be based on dynamic, flexible farming systems that are profitable, efficient, productive, and founded on ethics of land stewardship and responsibility for the continuing vitality of local rural communities. Minnesotans will strive to understand and respect the complex interconnectivity of living systems, from soil to people, so as to protect and enhance all natural resources for future generations. Minnesota agriculture will sustain an abundance of food and other products as well as meaningful, self directed employment that supports the quality of life desired by farmers and rural communities. Agriculture will foster diversity in all its forms of production, products, markets, and cultures.

Program Mission Statement

To work toward the goal of sustainability for Minnesota agriculture by designing and implementing programs that meet the identified needs and support the creativity of Minnesota farmers.

Inclusion of a trade name does not imply endorsement of that product by the Minnesota Department of Agriculture, nor does exclusion imply non-approval.

September 2017

Thank you to the MDA's Agricultural Marketing and Development Division Staff who helped to make Greenbook 2017 a reality. They include: Cassie Dahl, Jessica Del Fiocco, Alison Fish, Tori Hoepfner, Stephen Moser, and Meg Moynihan.



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Introduction to the Greenbook 2017

The Minnesota Department of Agriculture's annual Greenbook is back again with another great edition showcasing the creative projects funded by the Sustainable Agriculture Demonstration Grant Program. This year, we're highlighting 36 projects by farmers, ranchers, and researchers who have invested these grant dollars to explore practices that will make farming in Minnesota more sustainable. We are very proud of this program and the many ways it has impacted farmers and rural communities in Minnesota for the past 28 years.

New and better farming methods evolve through innovation. We believe the ideas these farmers and researchers are testing are integral to the future of agriculture. Many of the Sustainable Agriculture Demonstration Program's past projects have since become widely adopted such as integrated pest management and cover cropping.

In the *Greenbook*, you will find the results from currently funded demonstration projects. The grantees are focusing on ways to increase energy and labor efficiency, reduce purchased inputs, and improve both the environment and their bottom line.

Greenbook 2017 compiles all the farmers' research trials and their hard data into an informative and interesting read. To learn more about any of the projects, please don't hesitate to get in touch with the grantee. You'll find contact information listed at the beginning of each project summary.

The MDA funded 7 new projects and will be accepting applications again next fall, so if there's a sustainable farming idea you'd like to try, please keep that opportunity in mind

A handwritten signature in black ink, reading "Dave Frederickson". The signature is fluid and cursive, with a long horizontal flourish extending to the right.

Dave Frederickson, Commissioner

About the Staff

The *Greenbook* staff brings a broad range and many years of experience in sustainable agriculture areas. Each staff person focuses on individual topic areas where they have expertise and interest.

Cassie Dahl

Organic Specialist. Cassie administers the organic program at the Minnesota Department of Agriculture (MDA) including; the Minnesota Organic Conference and Organic Cost Share Program. In addition, she coordinates the Fruit Integrated Pest Management Newsletter for the department. Cassie has a MS in Sustainable Horticulture from the University of Minnesota and she joined the MDA in 2011.

Jessica DelFiacco

Agricultural Growth, Research, and Innovation (AGRI) Consultant. Jessica assisted the AGRI program at MDA in 2016 and 2017.

Tori Hoepfner

State Program Administrator; AGRI - Business Development and Tradeshow Support. Tori works with Minnesota food businesses to help expand their market access in the state and beyond. Tori joined the MDA staff in 2016.

Alison Fish

Administrative Support. Alison provides administrative support to the staff and the program. Alison joined the MDA staff in 1990.

Stephen Moser

Administrative Support. Stephen provides administrative support to the staff and the program. Stephen joined the MDA staff in 2013.

Meg Moynihan

Senior Advisor on Strategy & Innovation. Meg dreams up new programs and activities that will benefit farmers and rural communities, and helps other staff members keep their projects on the cutting edge. She has worked professionally as an educator and evaluator, and as a community development extension specialist with the U.S Peace Corps in northern Thailand. Meg works part-time for MDA and is also a certified organic dairy farmer with a 70-cow herd in Le Sueur County. Meg joined the MDA staff in 2002.

Table of Contents

Sustainable Agriculture Grant Program

Sustainable Agriculture Grant Program	7
New Demonstration Grant Projects 2017.....	8

Alternative Markets, Fruits & Vegetables, & Specialty Crops

Using Compost Tea in Organic Farming <i>Carlson, Becca - Seeds Farm</i>	12
Evaluating Different Depths and Types of Mulches in Blueberry Production <i>Connell, Kathy - Redfern Gardens</i>	18
Developing Profitable Apple Production along Lake Superior's North Shore of MN <i>Hale, Cindy - Clover Valley Farms</i>	22
<i>Maximizing Profitability in Modular Movable Hoop Houses</i> <i>Henry, Megan - Sundogs Prairie Farm</i>	29
Developing a Network for Environment and Weather Applications <i>Jacobson, John P</i>	34
Perennial Wheatgrass and Legumes for Cropping, Grazing, and Soil Health <i>Jorgenson, Mike</i>	39
Using Juneberries as a Cold Hardy Rootstock for Minnesota Pears <i>McCamant, Thaddeus - Central Lakes College</i>	41
Creating Beneficial Habitat for Management & Wildlife Enhancement on Farm Waste Land <i>Nelson, Melissa</i>	44
Preserving and Attracting Native Bees while Providing a Habitat that Adds Value to Small Acreage <i>Thomas, Noreen</i>	48
Evaluating Hybrid Hazel Wood Chips as a Mushroom Substrate <i>Wiegrefe, Sue</i>	52
Controlling Canada Thistle in Organic Blueberry Production <i>Wills, Aaron</i>	55

Cropping Systems & Soil Fertility

Raising Soil pH Effectively in Acid Soils <i>Abasz, David - Wolf Ridge Environmental Learning Center</i>	59
Soil Health Research in Southwest Minnesota <i>Ackermann, Jerry and Nancy</i>	64
Nitrogen Capture Using Cover Crops in a Cash Grain Rotation <i>Bronder, William - Sherburne County SWCD</i>	73

Developing Low-cost Planting Materials and Establishment Methods to Accelerate Agroforestry Adoption for Function and Profit <i>Chamberlin, Jim</i>	79
Demonstrating Vermicomposting for Soil Health in the Upper Midwest <i>Devaney, Caroline</i>	84
Evaluating Harvest Methods for Intermediate Wheatgrass as a Perennial Edible Grain <i>Fernholz, Carmen</i>	87
Inter-seeding Cover Crops and In Season Nitrogen Application in One Pass <i>Hartmann, Keith</i>	90
Inter-seeding Cover Crop into Standing Corn in June <i>Kraus, Alan</i>	93
Legume Cover Crops <i>Kruger, Paul</i>	96
Evaluation of Winter Annual Small Grain Cover Crop for Forage Production <i>Ley, Daniel</i>	99
Sub-surface Irrigation for Field Crop Profitability and Water and Fertilizer Efficiency <i>Martie, Russell V.</i>	102
How Much Can You Afford to Pay for Hay? <i>Mesko, John</i>	106
Cover Crops to Replace Fall Tillage in the Shakopee Lake Bed <i>Robin, Moore – Land Stewardship Project</i>	109
Three-crops in Two Years for Farm Profit and Water Quality: Winter Rye after Managed for Spring Forage <i>Patnode, Daryl</i>	113
No-till Cover Crop Rotation vs. Intensive Tillage in Corn Soybean Rotation <i>Rollofson, Chad</i>	116
Planting Short Season Corn for Cover Crop Success <i>van Schaik, Caroline</i>	122
Breeding, Assessing, and Selecting Nutrient Dense Corn for Poultry Production <i>Wika, Sue & Paige, Zachary</i>	127

Livestock

Goat Grazing During Winter in Minnesota: Ways to Control Vegetation on a Larger Scale While Saving on Supplemental Feed Costs <i>Beckwith, John</i>	132
Integrating Silvopasture Practices into Perennial Fruit Production <i>Hoch Orchard and Gardens</i>	134
Trials to Overwinter Nucleus Colonies with a Pause in Brood Rearing <i>Meyer, Joseph</i>	138
Acclimating Heifers to Improve Cow flow on Daily Farms <i>Sorge, Ulrike</i>	141
Utilization of Building for Multiple Livestock Species <i>Stassen, Steve</i>	145

Sustainable Agriculture Grant Program

Program Purpose

The Grant Program provides a unique opportunity for farmers, educational institutions, individuals at educational institutions, or nonprofit organizations residing or located in the state for research or demonstrations on farms across the state to work together to explore ways of enhancing the sustainability of a wide range of farming systems.

Program Description

The Department of Agriculture has received over 1,146 grant applications and approved over \$3.7 million in funding for 338 projects since the program began in 1989. Project categories include: Alternative Markets and Specialty Crops, Cropping Systems and Soil Fertility, Energy, Fruits and Vegetables, and Livestock. The current grant projects, located throughout the state of Minnesota, are described in the *Greenbook 2017*.

Grants provide a maximum of \$25,000 for on-farm demonstrations that last up to 3 years. The projects demonstrate farming methods or systems that increase energy efficiency, reduce agricultural chemical usage, and show environmental and economic benefits. A Technical Review Panel evaluates the applications on a competitive basis and makes recommendations to the Commissioner of Agriculture for approval. The Technical Review Panel includes farmers, university agricultural researchers, extension agents, and educators, with assistance from the Agricultural Marketing and Development staff.

Grant Summaries

The project summaries that follow are descriptions of objectives, methods, and findings of individual grant projects funded in 2017. To find out more details about these projects, contact the principal investigators directly through the listed telephone numbers, addresses, and email addresses.

Summary of Grant Funding (1989-2017)

Year	Number of Grants Funded	Total Funding	Average Grant Size	Ranges
1989	17	\$280,000	\$16,500	\$3,000-25,000
1990	14	189,000	13,500	4,000-25,000
1991	4	46,000	11,500	4,000-23,000
1992	16	177,000	11,000	2,000-25,000
1993	13	85,000	6,000	2,000-11,000
1994	14	60,825	4,000	2,000-10,000
1995	19	205,600	11,000	2,000-25,000
1996	16	205,500	12,900	4,000-25,000
1997	20	221,591	11,700	1,000-25,000
1998	19	210,000	11,100	1,000-24,560
1999	23	234,500	10,200	3,000-21,000
2000	17	150,000	8,800	4,600-15,000
2001	16	190,000	11,875	5,000-25,000
2002	18	200,000	11,000	4,300-20,000
2003*/2004*	---	---	---	---
2005	10	70,000	7,000	2,000-11,600
2006	8	70,000	8,750	4,600-12,000
2007	9	70,000	7,777	2,700-12,000
2008	10	148,400	14,800	4,500-25,000
2009	7	103,000	14,700	5,000-20,000
2010	11	77,000	7,000	3,600-10,000
2011*/2012*	---	---	---	---
2013	6	66,000	11,000	5,300-20,300
2014	13	205,000	15,770	7,800-25,000
2015	13	236,000	18,200	6,700-25,000
2016	11	\$177,030	\$16,094	\$9,765-24,980
2017	7	\$103,682	\$14,812	\$5,397-25,000
Total Funded	338	\$3,781,128	\$11,479	\$1,000-25,000

*No grants were awarded in 2003, 2004, 2011 and 2012.

New Demonstration Grant Projects 2017

Cropping Systems & Soil

Impact of Two Tillage Types on Yield, Economic Profitability, and Soil Health in Polk County, MN

Grantee: Grant Mehring, Minnesota Wheat Research and Promotion Council

Duration: 3 years

Award Amount: \$17,536

County: Polk

Project Objectives:

1. Our first objective is to determine if the conservation tillage practice called vertical tillage is economically viable compared with the conventional tillage practice of the region that is comprised of cultivation and chisel-plow. We aim to consider tractor passes (fuel and time), yield, and protein/oil to determine which treatment is the most economic.
2. Our second objective is to quantify soil health improving factors from the two tillage treatments including soil temperature, soil moisture, and soil compaction, visual signs of soil erosion during dry periods of the research, and visual signs of soil water runoff during wet periods of the research.

Using Precision Ag Data to Maximize Economic and Environmental Benefits

Grantee: Tanner Bruse, Pheasants Forever

Duration: 3 years

Award Amount: \$25,000

County: Statewide

Project Objectives:

1. By using precision business planning, we will identify revenue negative acres at the subfield level, to allow farmers to understand alternative land use options to increase their ROI. Previously there has been little consideration of the economic performance of conservation practices in conjunction with a landowner's willingness to enroll certain acres. We aim to build scenarios whereby producers can evaluate the financial impact of different practices before implementing.
2. In addition to existing USDA programs, we want to be able to provide an alternative option to farmers. They may be interested in doing something but are not interested in a 10-15 year CRP contract. Alternative working lands options, less restrictive (haying) and shorter contracts, may be lucrative to some producers. This will give guidance to the programmatic approach necessary for an effective new program for MN farmers that increase both economic performance and natural resource benefits.
3. The anticipated result of this combination is increased profitability through sustainable practices that provide soil, water, energy and wildlife benefits. An unprecedented level of cooperation will be required between production agriculture and conservation groups in showing how we can work together to achieve multiple goals while maintaining, and even enhancing, farmers' bottom lines.

Energy

Economic Feasibility of Spray Foam Insulation in a Hog Finishing Barn

Grantee: Ryan Vandendriessche

Duration: 3 years

Award Amount: \$7,909

County: Lyon

Project Objectives:

1. With the help of this grant, I will insulate my hog barn with closed cell spray foam insulation and test the effects the type of insulation has on propane usage in a hog finishing barn. Traditional batt style insulation will be used as a comparison while determining energy consumption differences.
2. I will determine the cost effectiveness of each type of insulation by comparing the amount of propane used in each barn. There are two very similar barns in the area insulated with batt style insulation that I will use for an energy consumption comparison. The testing will last for three years and each barn will have similar sized pigs for a similar duration. Also, each barn will have nearly three batches of pigs yearly, so the amount of time spent empty will be very similar.
3. Through this project, I will demonstrate to other farmers, contractors, and those seeking to build a hog finishing barn in the future whether or not spray foam insulation is worth the added cost. Energy consumption is an important factor in any building project and with hog barns being designed to last longer than in the past, insulation has become a critical decision.

Fruits & Vegetables

Developing an Annual Day-Neutral Strawberry Planting System with Biodegradable Mulches

Grantee: Steve Poppe, University of Minnesota

Duration: 2 years

Award Amount: \$23,212.50

Counties: Stevens, McLeod, Hennepin, Otter Tail

Project Objectives:

1. To support the expansion of extended season annual strawberry production, thereby boosting producer incomes and increasing the supply of locally grown strawberries, this project hopes to achieve the following four objectives:
 - a) Determine the performance of biodegradable mulches in an extended season annual strawberry production system.
 - b) Improve understanding of the effectiveness of a sustainable mulch between crop rows in an extended season annual strawberry system.
 - c) Increase the awareness of the benefits of the extended season annual strawberry system.
 - d) Increase awareness among farmers to help them establish extended season annual strawberry systems on their farms.

The objectives of this proposal will build upon the success of our previous grants and fulfilling certain aspects of the AGRI SADG program objectives including farm diversification, input reduction strategies, new marketing opportunities, season extension, conservation and profitability.

In our recent survey of regional farmers, we learned that conferences and field days are the preferred avenue for learning about farming techniques, followed by the internet. Therefore, we plan a multi-pronged approach to education and outreach. The project team and farmer-cooperators will present research findings at local and regional conferences. Our farmer-cooperators will host field days to educate other farmers on the system and provide guidance to those interested in adopting it.

Testing Different Training Systems and Varieties to Improve the Profitability of Gooseberries

Grantee: Andy Cotter, York Farm

Duration: 3 years

Award Amount: \$6,728.66

County: McLeod

Project Objectives:

1. Determine if gooseberries are an economically viable crop for Minnesota
2. Find the best varieties and best training systems for gooseberries
3. Learn which varieties and which baked goods consumers like best

Using Essential Oils to Repel Spotted Wing Drosophila in Blueberries

Grantee: Bev O'Connor, Blueberry Fields of Stillwater

Duration: 2 years

Award Amount: \$5,397.10

County: Washington

Project Objectives:

1. Determine if essential oils, specifically peppermint and lavender, and Jet-Ag can repel spotted wing Drosophila well enough to work as a replacement for insecticides
2. Determine if essential oils and Jet-Ag influence the flavor of the berries
3. Determine if essential oils and Jet-Ag are economically viable in field situations

Livestock

Testing Three Novel Sheep-Specific Pasture Types to Maximize Average Daily Gains in Lambs on Pasture

Grantee: Anna Johnson

Duration: 2 years

Award Amount: \$17,898.50

County: Sibley

Project Objectives:

1. We want to maximize average daily gains (ADGs) in lambs on pasture by testing three novel, sheep specific high quality forage mixes so that time to market will be reduced. Using management intensive grazing, we will compare our existing cool-season perennial pasture to three other pasture mixes. The first will be a diverse annual mix containing over 20 species of legumes, grasses, and forbs, to be grazed from the end of June through July when perennial pastures start to lose quality.
2. Because we have observed ADGs to drop in the summer heat, likely due to the lignification and subsequent reduction in digestibility of typical cool-season pasture plants, the second mix we will test is a non-lignifying, pasture mix designed based on our observations of sheep preferences. It will include chicory, plantain, alfalfa, white clover, red clover, with small amounts of meadow fescue, festulolium, orchardgrass, and timothy. This will be grazed for the months of July and August.
3. Because energy is considered the most limiting nutrient for finishing animals on pasture, we will test pasture where the sheep harvest their own grain. Sheep are quite good at harvesting oats without overindulging in grain. A strip of alfalfa mix will be established next to the oat plot in the year prior to the oats to provide protein for a balanced finishing ration.

Principal Investigator

Becca Carlson
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 Rice County

Project Duration

2014 to 2016

Award Amount

\$24,152

Staff Contact

Meg Moynihan

Keywords

biological activity, compost,
 compost tea, fruit,
 microorganisms, soil health,
 vegetables

Using Compost Tea in Organic Farming

Project Summary

We are testing the effects of compost tea on vegetables, fruit bushes, pasture, cover crops, and hay ground. Compost tea inoculates the soil with microorganisms, including bacteria, fungi, protozoa, and nematodes, enhancing the soil food web. The six farms participating in this project grow vegetables, fruits, or pasture/hay, and are each comparing treated areas (compost tea applied) to similar control areas (no compost tea applied). Our overall goal is to determine whether applying compost tea to our crops can improve farm profitability. Reducing fertilizer needs, increasing yields, and/or increasing produce quality are all possible benefits of compost tea, but we are particularly interested in the potential for reducing purchased fertilizer.

Project Description

Seeds Farm shared the following story that illustrates why so many of us perceive a need to boost soil microbial activity: A college student buried dead squirrels in our vegetable fields, a nearby forest, and a nearby prairie. When she dug the squirrels up at the end of the season she found that the squirrel in the vegetable field had only barely decomposed, while the squirrels that had been buried in the forest and prairie were completely decomposed. These results showed us that agricultural practices can discourage soil microbes.

Compost tea is a liquid produced by extracting bacteria, fungi, protozoa, and nematodes from compost. The idea is to extract and replicate the beneficial biology and diversity of compost in a liquid form. Nutrients extracted from the compost (and/or added to the tea) grow beneficial organisms. Tea (extract) can be applied directly to the leaf surface of a plant as a foliar spray or used as a soil drench to improve root systems. Together, the beneficial bacteria and fungi result in a variety of many different species in the compost tea.



Compost Tea Field Day at Little Hill Berry Farm July, 2016.

The value of compost tea is related to the importance of the soil food web. The soil food web is the community of micro-organisms living all or part of their lives in the soil, which includes bacteria, fungi, protozoa, nematodes, and earth worms. This community of organisms transfers nutrients through the soil, converts nutrients into forms plants can use, and helps protect crops from soil-borne pathogens. The very structure and health of our land is directly influenced by this complex set of biological and chemical interactions that decompose, retain, and recycle nutrients within the soil.

Compost tea works by putting beneficial microorganisms of the soil food web that your plant needs onto the leaf surface of the plant or the soil. To enhance this community of beneficials, the compost tea must remain aerobic.

The two key reasons to use compost tea are:

1. Impart microbial life into the soil or onto the foliage of plants.
2. Add soluble nutrients to the foliage or to the soil to feed the organisms and the plants present.

Note: The project leaders provided these descriptions of compost tea and the soil food web from information at rodaleinstitute.org and earthfort.com

This project includes six farms in the Northfield/Nerstrand Minnesota area. Each participating farm in the project chose one crop (vegetables, fruit bushes, pasture, cover crops, or a hayfield) to spray with compost tea (Table 1). We are leaving unsprayed areas to serve as a control so that we can observe and measure any effects from the compost tea. We are evaluating yield, brix levels, plant health (through

plant tissue analysis), and soil health (by analyzing the number of micro-organisms living in the soil).

Part of our project included figuring out how to brew and apply compost tea effectively and efficiently. Brewing consists of suspending a bag filled with biologically active compost in a container of water and using forced air to physically knock off the microorganisms and suspend them in the water. Bacteria, molasses, fish hydrolysate, kelp, steel cut oats, and/or humic acid, can be added to encourage these populations of microorganisms to grow. The tea must be kept aerobic and must be applied within 2 days of brewing. Foliar spraying, putting through drip irrigation lines, and gravity feeding behind a subsoiler can all be used to apply the compost tea, as we learned in year one of the project.

Results

Little Hill Berry Farm

Little Hill Berry Farm grows 4 acres of certified organic blueberries. We sell our berries primarily pick-your-own with 2016 being our fourth season open for picking.

In 2015 we applied compost extract to two varieties of blueberry plants, Patriot and Bluegold, (both 2 and 4-year old plants).

We made the compost tea by agitating 4 lb compost contained in a fine nylon mesh bag in 20 gal of water for 4 min. Our treatments included: control (no compost tea, no extra water), low (four applications between May-October), and high (11 applications between May-October). Each application consisted of one quart of compost tea poured at the base of each plant. Each variety/age pairing had five replicates of each treatment.

To quantify soil microbial activity we measured soil nitrogen mineralization. To quantify plant growth, we measured leaf carbon fractions. We found that N mineralization was higher in the “high” treatment compared to the control. We did not find a statistically significant difference in for the “low” treatment.

Neither variety nor plant age had any effect on N mineralization within treatments, and we found that compost extract alone (without any of the other ingredients frequently added, such as fish fertilizer, humic acid, kelp, molasses, etc.) produced a measurable increase in soil microbial activity.

The effects of compost extract on leaf carbon fractions were not as clear. We found the “low” treatment plants had less leaf carbon compared to the control, while the “high” treatment had no effect compared to control. We thought increased N mineralization by the soil microbes would lead to increased plant uptake of nitrogen and a corresponding increase in leaf carbon. The fact that we found no increase in the leaves may indicate that the microbes consumed the N before the plants could take it up. This nitrogen should be available to the plants in the future, so it is possible we will see an increase in leaf carbon next year.

In 2016, we experimented with two different methods of brewing compost tea. The first brewing method was to aerate the tea. We used Purple Cow Activated Compost in the tea and no other additions (i.e. fish, humic acid, etc.). The second method was to aerate the tea and add heat. We applied the tea weekly over the course of the growing season. All of the blueberry plants were the Patriot variety and 4 years old.

Preliminary results showed that heating and aerating the tea increased the protein content of leaf tissue by 10% over the control group. This increase suggests that plants in these treatments might have had greater access to nitrogen. Thus, the application of compost tea may increase plant-available nutrients and potentially serve as an alternative to other nutrient amendments in organic agriculture.

We measured microbial enzymes in the soils in the three different treatments but did not find any significant results. We were surprised that the change in leaf chemistry was not accompanied by any detectable change in the soil. Plant nutrient content reflects soil microbial activity and nutrient content. It may be that we were not testing the right things in the soil to capture the change in microbial activity.

Open Hands Farm

We grow certified organic annual fruits and vegetables, certified on 15 acres of silt loam. In rainy or humid years we have struggled with fungal and bacterial pathogens. Since 2012, we have been using a probiotic brew to enhance plant health and resistance to these pathogens.

Our first line of defense against pathogens is resistant varieties, plus crop rotation, soil-building, adequate irrigation and other cultural practices to reduce plant stress. When pathogens become a problem many organic growers turn to copper or other organic-approved fungicides. We do not use pesticides—even organic-approved pesticides—choosing a probiotic approach instead of an antibiotic approach. Our goal is to manage pathogens by supporting diversity and abundance in the microbial communities in the soil and on crop leaf surfaces.

In previous years we applied compost tea to the soil, testing the soil for microbial activity before and after application. The lack of measurable results in the soil was most likely due to our tillage activity, both deep plowing and shallow cultivation, destroying microbial populations. Without scalable methods for organic no-till vegetables, we continue to till; so this year we re-focused our probiotic efforts on crop leaf surfaces, with a foliar application experiment in carrots.

Leaf health in carrots is important to yield and to the functioning of a mechanical carrot harvester, which grabs the carrot by the leaves. Weaker leaves break when grabbed and leave carrots in or on the ground, whereas strong tops enable proper functioning of the machine. Conventional carrots often receive multiple fungicide treatments, sometimes right up to harvest time, to keep carrot tops healthy for the harvester.

We have struggled a little with *Alternaria* blight, the primary pathogen responsible for weak tops in carrots. We typically apply the probiotic brew (supplier and brewing details below) 3-4 times per planting for most crops, including carrots. For the experiment, we left one patch (0.2 acres) of the carrot variety Bolero untreated, while treating the rest of the planting with three foliar applications. Soil type and all fertilizer, irrigation and other treatments were identical. We observed carrot top health, functioning with the mechanical harvester, and yield.

After we found it difficult to replicate quality compost tea with high microbial activity, this year we decided to experiment with a probiotic brew we've had anecdotal success with over several years. We use the recipe and supplier info in the book *The Holistic Orchard* by Michael Phillips. The supplier of the "mother culture" is SCD Probiotics in Kansas City, MO. We use the "Probio Balance Original" culture, a laboratory bacteria culture. One Gallon of this "mother culture", fed with molasses and cultured 7-10 days, makes 21 gallons of activated brew.

We mixed this brew with water and fish hydrolysate, at a rate of 2 gal mature microbe brew and 2 gal fish per 100 gal water (we use a 100 gal sprayer, with a 50' boomless nozzle). (For heavy feeding crops and/or high-stress conditions we will sometimes use 4 gal of fish hydrolysate per 100 gal tank, but the base rate is 2 gal.) Applied at a rate of 33 gal/A, each tankful covers 3 acres. Therefore, from 1 gal of mother culture we brew 21 gal of activated brew; enough brew for 10 sprayer tankfuls, to apply to 30 acres worth of crops.

The control patch of Bolero carrots was clearly less healthy than the carrots that received compost tea; the control carrots had weaker tops and lower yields. In some places the tops were completely dead, and in the whole patch they were thinner and weaker, making mechanical harvest very difficult and requiring extensive hand gleaning behind the harvester. In the treated portions of the same planting, the tops were visibly strong and healthy, and mechanical harvest was effective, leaving behind very few if any carrots.

The treated areas, also had bigger carrots and higher yields. The yield comparison was approximately 21,000 lb/A in the treated sections, and less than 15,000 lb/A in the control. We suspected the weak and dying tops in the untreated section could not support the final stage of root growth – the final thickening and lengthening of the marketable portion of the plant.

The cost of 1 gal of mother culture (delivered) was about \$70, plus we used about \$20 worth of organic molasses and \$220 worth of fish hydrolysate, for a total materials cost of about \$310 for 30 acres of coverage. That's under \$11/A of materials cost for this probiotic brew, which can be made without special equipment (just a large stockpot, stovetop, and sleeping bag to keep it warm for a few days).

The labor and machinery cost of application is about \$12/A: for every 9 acres, we use 1 hour of brewing labor (\$15), 3 hours of application time (\$90).

For valuable specialty crops susceptible to fungal and bacterial pathogens, we find applying compost tea to be a very cost-effective practice. More study would help confirm this conclusion. For example, an experiment that included treatments with and without fish hydrolysate, and on other crops would be helpful. While the rate of fish hydrolysate application is very low compared to typical foliar applications and is primarily meant as a starter food for the microbes, it is also probably having a beneficial effect on the crop. But is the fish the primary, or only, cause of benefit? If the fish is causing the benefit and the probiotic compost tea is irrelevant, skipping the brewing would mean saving labor.

The Bolero variety of carrot is one with strong resistance to *Alternaria*. It would be interesting to study the effects and interactions of the tea on varieties that do **not** have resistance to this pathogen. Pathogens of particular concern on our farm are black rot in brassicas, *Septoria* and *Alternaria* in tomatoes, and downy mildew and bacterial leaf spot in leaf lettuce. We need more non-toxic tools to keep crops healthy in rainy and humid years.

Spring Wind Farm

We grow vegetables on 6 acres for our CSA members and several wholesale accounts. In 2015, we tested compost tea on six plots in a field that had been farmed conventionally the year before. We applied compost extract weekly to three plots in July and August, and applied water to three other plots as a control. We used the same "recipe" as Little Hill Berry Farm, put the compost in a mesh bag, and swirled it in the spray tank for 1 min. We applied the compost tea with a backpack sprayer in a single pass, trying to simulate the amount of spray that would have been applied with a tractor-mounted sprayer. We lightly incorporated the compost tea into the soil with a hoe.

After the last application, we took soil tests and had them tested for glyphosate. We were surprised to find the control plots had glyphosate levels of 67.75ppb while levels in the

treated plots were higher (80.42ppb). Last year's results were similar; soil samples from the control had 63.69ppb glyphosate and those that got the extract treatment had 84.17ppb. This is exactly opposite of what we expected; we thought that applying compost extract would boost soil microbial activity, and that this activity would reduce glyphosate levels. We've also begun to wonder if the higher rates of glyphosate on the experimental plots could suggest that there is glyphosate in our water. Our wells are 360' deep, so this is concerning; next year we will test the water.

This year, we experimented with spraying a brewed compost tea on our cherry tomatoes. We used the same brewing process and compost as Little Hill Berry Farm. We applied the tea with a backpack sprayer on the foliage of a 200' row of tomatoes once a week from June – August. We hoped that the application of the tea would reduce the amount of fungal disease in the tomatoes.

We did not see any visual difference in foliar disease between the rows of tomatoes in our trial. However, our cherry tomatoes did much better than our other tomatoes, which received no spray. We had 3 - 200' rows of cherry tomatoes, spraying the middle one with tea and using the outer two as the controls. So it is possible that the beneficial microbes from the tea spread to the outer two rows. I am excited to keep experimenting with foliar applications as a disease management tool.

Seeds Farm

We grow 6 acres of diverse vegetables at our farm. We want to know whether compost tea can be an effective tool to rejuvenate disturbed land. Our township is building a 10' deep pond across the road from our farm. The fill generated from digging the pond will be placed on our field (after the topsoil has been stripped) to raise the field 7' in some areas. The entire footprint of the disturbed land is 4 acres.

The pond project has been delayed and the soil had not yet been transported to our farm at the time we submitted the report for this article.

In the meantime, we brewed and applied compost tea on our farm four times this year: May 8, June 10, July 30, and November 26. We brew in a 275 gal tote with a ½ horsepower regenerative pump blowing air through a 1.5" tube through the bottom of the tote at full force, right underneath a suspended bag of high quality compost. We used 3 gal of activated compost, 0.5 gal fish emulsion, 16 oz kelp, 16 oz molasses, and 0.5 cup sea salt (with minerals). We brewed the mixture for 24 hr and applied at 20 gal/A with a 100 gal boom sprayer.

We sent a sample of our compost tea to Crop Services International in Michigan. They told us our compost tea was good quality, with bacteria, fungi, and protozoa all in the desired levels. The recipe and ingredients we used consistently produced a quality tea, but indicated a lack of nematodes. In the future we will use vermicompost in addition to the compost. Starting in spring 2017 we will apply compost tea to portions of our disturbed field (leaving portions as a control) to see if the tea we brew can be used to aid in rejuvenating the soil faster.

Woodskeep Orchard

Woodskeep Orchard joined the compost project as a new partner in 2015. We have a high density apple orchard with nearly 30 varieties that we grow primarily for cider. We are interested in becoming certified organic and want to see whether we can meet many of our fertility and disease management needs through foliar compost tea applications.

We brewed compost tea in a homemade brewer and sprayed two rows four times in 2015, leaving two rows of varieties unsprayed as a control. We compared soil tests, disease/general appearance, and fruiting in the treated and control rows.

We saw no differences between the treated and control rows for the same variety and location this year. However, apples are a perennial crop, and many of the benefits of compost tea may not be seen for a couple of years. We think the health of the orchard in general is very good, but it is difficult for us to quantify.

In 2016, we saw some differences between rows in the Sweet 16 block. There were no visual differences, and only insignificant soil differences. However, leaf analysis in August showed differences between the two rows of Sweet 16 rows in almost every measurable factor.

The sprayed rows had increased fertility in all but two measured elements, though this was just one test, and we would have more accurate results if compared to multiple tests over time.

The visual health was comparable. Due to a late frost, most of the fruit was killed and therefore there were none to compare. Apples are a perennial crop and many of the benefits of compost tea may not be seen for a couple of years. The health of the orchard in general is very good, but it is difficult to make definitive conclusions without long-term measurements.

Conclusions

A second project replicating Little Hill Berry Farm's method of spraying compost tea on the soil in perennial fields would help solidify our results. Testing across many different crops, including other perennials, would be the best way to determine whether or not applying compost tea is helpful.

Little Hill Berry Farm, Woodskeep Orchard, and Seeds Farm plan to continue their use of compost tea, since the results from this project indicate that it improves the health of crops. Little Hill Berry Farm expects that the benefits of spraying compost tea will increase each year over a period of 5 to 10 years. Though it may not entirely replace commercial organic fertilizer, it will likely allow them to reduce the amount of commercial fertilizer they use.

This project has given our group of farmers working on it more confidence in compost tea. We recommend the use of compost tea due to the minimal costs of applying and the potential gains. Applying compost directly at large rates on our fields would be ideal, but expensive. By brewing compost tea, we are instead growing the microbial populations that live in the compost and applying them to the field. This method is second best, and much more economical. Once a farm has set up a system to brew and apply compost tea, it is relatively easy to implement an application plan.

Management Tips

1. Compost tea's effectiveness depends on how it is brewed. Heating and aerating the tea during the brewing, seemed to produce a better result.
2. Don't take short cuts when making your brewer! Though it isn't a difficult process, it is important that it is done correctly. Pentair makes a great air pump for brewing the tea.
3. Plan ahead! This probiotic brew takes 7-10 days to mature. Adjust the amount of each brewing batch for the amount of acres you expect to cover in a week.
4. Watch the weather. Timing is crucial for foliar feeding, and spraying in inclement weather affects coverage.
5. Start your spray schedule as early as possible in the year in order to give your crops maximum coverage and exposure.

Cooperators

Dane Terill, Crop Services International, Portage, MI
Andrew Ehrmann, Spring Wind Farm, Northfield, MN
Molly Haviland, Living Soil Lab, Fairfield, IA
Dan Hernandez, Carleton College, Northfield, MN
Erin Johnson and Ben Doherty, Open Hands Farm, Northfield, MN

Tracy Jonkman and Nate Watters, Woodskeep Orchard, Dundas, MN
John Porterfield, Cherry Leaf Farm, Northfield, MN
Aaron Wills, Little Hill Berry Farm, Northfield, MN
Kathy Zeman, Simple Harvest Farm, Nerstrand, MN

Project Location

This project took place on several Northfield/Nerstrand, MN area farms. To reach any of the participants, contact

project leader Becca Carlson, whose information is provided on the first page of this article.

Other Resources

Phillips, Michael. 2012. *The Holistic Orchard: Tree fruits and berries the natural way*. Chelsea Green Publishing. White River Junction, VT.

Principal Investigator

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Project Duration

2014 to 2016

Award Amount

\$7,953

Staff Contact

Cassie Dahl

Keywords

blueberries, mulch, soil
health, weeds

Evaluating Different Depths and Types of Mulches in Blueberry Production

Project Summary

We examined two aspects of blueberry production while utilizing organic growing techniques. One aspect was the optimum depth of woodchip mulch and the other was a comparison of how woodchip mulch, chick litter mulch, and grass clipping mulch performed. We evaluated soil moisture retention, pH, fertility, temperature, and biological activity of the soil beneath the mulch.

We want to find ways to decrease and possibly eliminate herbicide usage, eliminate or reduce chemical nitrogen application, decrease wind and water erosion, and decrease water runoff. These will all benefit the environment. We believe it is important for the future that we maximize our farm and local resources in order to strengthen the sustainability of our farms. In addition, we believe we must share our experiences in order to strengthen our communities.

Project Description

Kathy Connell owns and operates Redfern Gardens, a small farm near Sebeka where she grows fruits and vegetables. For her demonstration project, Kathy planted blueberries using four different mulch treatments and compared to plant growth, moisture, soil effects, and weed pressure across them. While the winter of '14-15 killed more than half of her test plants, she was still able to make interesting observations about the mulch systems she tested.



Blueberry plants growing in different mulches. From left to right, woodchips, grass clippings, and chick litter.

2014 Results

We prepared the planting area, which took longer than we thought because of perennial weeds. We fertilized with blood meal, and planted six blueberry plants per bed.

There were four mulch treatments:

- 1) Wood shavings + a small amount of baby chick manure
- 2) Grass clippings
- 3) 3" wood chips
- 4) 6" wood chips

The plants did not do well after the first couple of weeks. Their coloring indicated the soil was not as acidic as we thought it would be. When we soil tested, we were surprised to find pHs of 6.8 - 7. We really don't understand how this happened and obviously should have checked the pH earlier. (Our original pH on this land was 5.5 and the area used has not had lime applied.) We had to acidify the area quickly in order to assure the survival of the plants, so we pulled back the mulch and applied iron sulphate to the soil, which is approved for organic use. After using this product, we will have to allow a transition period of 3 years before we can certify the crop as organic.

We used a moisture meter to track moisture and irrigated one of the beds reached 70%. The moisture test is very general, shown as a percentage of available moisture, but that should be good enough to allow us to compare one bed to another.

2015 Results

In 2015, we still had problems with quackgrass, especially in the woodchip beds.

But we also encountered a bigger problem. The unusual open winter damaged most of our plants severely. In our area we had little fall rain and no snow to speak of. I believe we continued to lose soil and plant moisture throughout the winter. We watered one last time in the beginning of November and covered all plants with Agribon 19 Fabric – even our mature blueberry plants that were 3' tall and as wide. In spring, I examined the plants and it was obvious that the stems were desiccated. As the weeks progressed, I noticed significant dieback in all plants, mature and immature. To say the least I was incredibly discouraged.

I hoped that plants would recover and come back from the roots but only 9 of my 24 project plants recovered. Some plants sent out small shoots, but they died mid-summer. Several times throughout the growing season I decided to stop the project, but then changed my mind. As the

In 2014, the first treatment to drop to 70% was the bed mulched with chicken litter, and we ended up irrigating only three times.

I expected the 6" of woodchip treatment would prove to be the most weed free. However, quack got into and thrived in the deep woodchips, and turned out to be the most vulnerable to that perennial.

On the other hand, the bed that had the least perennial and annual weeds was the bed mulched with grass clippings. The original 3" of clippings reduced to only about 1", but seemed to resist annual seed germination. In this bed, the plants grew (12-14").

In the grass clipping bed, we observed growth of 6-8". In the 3" woodchip treatment, the blueberry plants grew 12-14". In the 6" woodchip treatment, most grew 12" long or longer.

It may have been a fluke that the quack thrived in the woodchips but hopefully the next 2 years will help us determine this. If the grass clippings prove to be the most useful they will also be the least costly and most readily available. It also makes one consider the possibilities of planting a particular seed mix in the pathways, then mowing them for mulch. An exploration of which seed mix would be best would have to be done.

After year one, I was glad I had designed a three year project; it takes the first year just to get the kinks out!

season concluded I was glad I did. There was interesting information to share.

We applied blood meal to the surface of the soil twice, once in mid-April and once in mid-May. We weeded several times, on an as-needed basis, and watered with a sprinkler. After we found the pH was still a little high for blueberries, we applied small amounts of elemental sulfur to the surface of the mulch around all plants. We decided to replace the plants that had winterkilled.

Treatment 1 (shavings) only one plant survived this winter. The shavings seemed to shed water like shingles on a roof. I decided I will not use this product again on blueberries.

Treatment 2 (grass clippings) We tried to keep the layer at several inches thick but they matted and broke down quickly. Five plants survived the winter, which surprised me, since losses were so much higher in the other beds. Interestingly, this bed was also the most weed free of all

the beds. Weed seedlings did not germinate easily here and for some reason, perennial weeds were also easier to control in this bed. Maybe it was just a happy coincidence.

Treatment 3 (3" woodchips) In spring, it took one application to bring the bed back to the 3" level. However, only one plant in this bed survived the winter. We definitely had more problems controlling weeds in this bed, particularly quackgrass. No matter how much time we spent carefully hand digging out the roots, it came back with a vengeance.

We also did an extra soil test – the Solvita Carbon Burst Test – on bed 3. This test biological respiration – and, therefore, biological activity – in the soil. The test showed carbon dioxide at 4.69.

Treatment 4 (6" of woodchips) We added woodchips to bring it back to the 6" level this year. The plants in this bed sent more shoots up from the root systems than the other beds, making them thicker plants. Two of the six plants survived the winter in this bed. These two plants each had 18-24" of new growth.

Interestingly, organic matter increased the most in this bed and nitrogen was the lowest – yet these plants showed the most growth. This bed was a little easier to control the weeds in and it intrigued me to see what was going on

2016 Results

We replaced the plants that had winterkilled last year, applied bloodmeal again in 2016 and watered when soil showed about 70% moisture capacity. We weeded as needed, which turned out to be about three times during the growing season. We applied mulch twice to maintain the desired depths of 3" chick litter, 3" grass clippings, 3",

Soil Test Results

The Solvita Carbon Burst Test Report, showed the grass mulched bed to be most active, followed by the chick litter, the 6" mulch, and lowest, the 3" mulch.

Many of the issues we were looking at showed results all over the place and make it difficult to draw a conclusion. I will continue to use wood chip mulch, and will make it



Compost Tea Field Day at Little Hill Berry Farm July, 2016.

at soil level. I moved aside the mulch and was surprised to see about a 1" layer of broken down black material between the chips and the soil.

In 2015 we also did the Solvita Carbon Burst test in the same bed in the same place and the biological respiration measure was 41.5 (compared to 4.69 in 2014). This is a tenfold increase, and if I understand the concept correctly, it means there was a tenfold increase in carbon sequestration.

To say the least, 2015 was an interesting year.

and 6" wood chips. The winter of 2015 – 16 was far kinder and we had little winter damage to the blueberries that had survived 2014 – 15, even though we did not cover the plants. The pH appears to be stabilizing; no additional sulfur was added. Please see the chart for soil test results.

6" deep when possible. I intend to supplement this with sawdust on some of the plants when I can get enough to apply it at least several inches deep and will be interested in seeing how this compares to the wood chips.

Soil Test Results												
BED	1	1	1	2	2	2	3	3	3	4	4	4
DATE	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016
pH	6.8	5.3	5.8	7.2	5.4	5.4	7.0	4.8	4.3	6.8	4.1	4.3
Organic matter (ppm)	2.9	3.1	2.6	3.8	2.9	4.2	2.6	2.9	2.4	2.8	3.5	2.7
Phosphorus (ppm)	136	200	196	156	152	162	99	152	102	148	154	108
Potassium (ppm)	289	408	139	199	210	181	98	267	113	207	204	156
Nitrogen (lb/A)		312			150			200			138	

Management Tips

1. Soil test the year before you plant.
2. Make sure the planting site is as weed free as possible before planting.
3. On very sandy soil, overhead watering with a sprinkler system develops better root systems than drip irrigation.
4. Covering the plants may not protect them from winterkill if there is insufficient moisture, no snow cover, and episodes of warming and deep cold. In other words, sometimes nature wins.

Cooperators

Thaddeus McCament, Central Lakes College, Staples, MN

Eric Nelson, MN DNR, Brainerd, MN

Glen Borgerding, Ag Resource Consulting, Albany, MN

Project Location

Redfern Gardens is located at 18298-270th St. Sebeka, MN 56477. Take Cty. Rd. 12 from Sebeka and go east for 4 miles. At the intersection of Hwy. 23, turn right, or south. Go 1 mile to 270th St. and turn left onto 270th St. Go 1 mile and cross the Redeye River. The first driveway on the left after crossing the river is the farm.

Other Resources

eOrganic Website: www.eorganic.info

University of Minnesota Extension Website: www.extension.org

ATTRA. Blueberries, Organic Production. Website: www.attra.ncat.org

Principal Investigator

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Project Duration

2014 to 2017

Award Amount

\$18,074

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Keywords

apples, trellis, rootstock

Developing Profitable Apple Production along Lake Superior's North Shore of MN

Project Summary

Over 3 years, 11 trial orchards were established in nine sites along the shore of Lake Superior in northern Minnesota to demonstrate high-density trellised apple production and trial different rootstocks with modern and historic apple varieties.

The primary project

objective is to support production of apples using organic, sustainable, and Integrated Pest Management (IPM) strategies among small farmers in northeast Minnesota. We will emphasize strategies to maximize production and profit in consideration to the climate, soil, and landscape constraints and the reduced pest pressure that north shore growers experience. Production, climate, and IPM data will be collected annually at each site and shared through workshops, field days, Clover Valley Farms' website, and through collaborations with local and regional farming organizations.



Trees at Stan Bautch's orchard.

Project Description

Cindy Hale and Jeff Hall of Clover Valley Farms, LLC operate a small, diversified farm on 25 acres just north of Duluth. Enterprises on the farm include direct sales of pastured poultry, hogs, and sheep (fleece), a year-round solar greenhouse, and gardens and orchards for vegetable, herb, and fruit production.

High-density apple orchards, using cold-hardy super dwarfing rootstocks, can be used to develop profitable enterprises for small farmers along the north shore. Along the north shore, including St. Louis, Lake, and Cook counties, apple production was limited due to the unavailability of large tracks of land needed for traditional orchards. In addition, the soil and landscape conditions along the north shore did not create a desirable environment for apple production. A vibrant organic apple grower network in the region could support the development of local markets with the economic, ecological, and health benefits for farms and consumers, similar to benefits seen on the south shore in Bayfield, WI. Cindy, with the help of Diane Booth from Cook County Extension, is leading a three-year project to provide annual field based trainings on high-density apple production, implementing organic and IPM strategies, and assistance for producers to gain access to locally adapted apple varieties and other resources. These trainings will help to develop small-scale orchards, which are part of a more healthy and sustainable local food system.

Organically managed, trellised high-density orchards in other regions of the western Great Lakes are well established. Therefore, resources exist to help develop similar orchards along the north shore. Existing modern and heritage apple varieties provide disease resistance and fruit diversity for fresh eating and value-added products. Recently completed genetic work is beginning to identify undescribed, historic apple varieties that are well adapted to local conditions. However, a lack of grower support and organization has been an obstacle for small producers to implement high-density orchard systems and to acquire historic apple varieties.

At Farmer-to-Farmer Exchanges held by Cook County Extension, more than 30 local farmers gathered in Grand Marais to discuss local food system needs and opportunities for the area. There was particular interest in issues related to climate change for small-scale agriculture along the north shore. Five issues emerged that relate to the project:

1. There has been an increase of about 3 weeks to the fall growing season, which appears to be fairly uniform along the north shore. A longer fall season, with micro-climates tempered by Lake Superior, may allow for longer season apple varieties. Research and demonstration of how these changes can lead to profitable apple enterprises in this area is needed.
2. The most economically damaging pests in traditional apple growing areas of Minnesota are not present along the North Shore, including codling moth and plum curculio. Therefore, organic apple production, with fewer pesticide inputs and high quality products, may be easier to practice in this environment. However, as apple production increases and climate change continues, producers need a way to monitor and share information about production, pest and disease control in their area.
3. Producers and consumers want to increase profitable, local food production on small acreage farms in northeast Minnesota. Intensively grown apple trees fit this market niche well. For example, Cook County grows less than 1% of its food within the county while \$14 million is spent on food imported from outside the county. Capturing even a small portion of that market through local production would provide healthier, more sustainable food and more agricultural opportunities for those interested in food production.
4. Farmers are eager to share experiences and strategies that help them succeed respective to the unique challenges associated with growing food along the north shore. A regionally specific grower's network supporting high-density apple production and product marketing was highly recommended.
5. Conservation of energy and other resources would follow with the establishment of locally sourced apple products by reducing transportation costs associated with buying trees and getting fresh apples for local markets.

Project Objectives

- Develop high-density trial and demonstration orchards using modern and heritage apple varieties. This will include the collection of baseline data on production, climate, and pest and disease monitoring along the north shore. This information will be used to maximize production and profitability of apples used for fresh eating and value-added products.
 - Identify, describe, and distribute historic cold-hardy apple varieties that are well suited for high-density production along Lake Superior. These varieties might serve local niche markets for fresh fruit, cider, jelly, sauce, and other value-added products.
- Two existing orchards will provide baseline IPM and production data, including Clover Valley Farms with approximately 1 acre in apple production using M-7 and Bud9 rootstock with six modern and 12 heritage varieties. Ray Block, with a high-density orchard containing 1, 2, and 3 year old blocks (162 trees) using Bud9, G11, G16, and G30 stock with Honeycrisp, Zestar!, and Chestnut Crab on each.

Results 2014

IPM monitoring documented a very late and cold spring from which the region never fully recovered. Between April 1 and September 29, only 915 growing degree days (GDD) were documented at the Duluth site. Late establishment of the IPM data loggers in Grand Marais did not allow for seasonal GDD measurements. Anecdotal observations indicated a much cooler and shorter growing season in Grand Marais than was observed in Duluth. Apple scab models did not indicate high probability of infection until early June. Both established orchards chose not to spray for apple scab since little field evidence of primary scab infection existed and model predictions indicated that most of the scab spores had already been spent. Very low levels of primary and/or secondary apple scab were detected during summer scouting and fall harvest. This season, the most economically impactful pest issue was Lesser Apple Worm at the Duluth site. As an internal feeder, it is difficult to treat. Pest trapping indicated larger than average populations and at least two generations, which resulted in substantial damage to mature fruit. Future control options to address this pest need to be considered for future years. There were also very high populations and multiple generations of Oblique-Banded (OBLR) and Red-Banded Leaf Rollers. These pests were easily controlled with *Bt* sprays that were guided by trapping and GDD models to appropriately time applications. This resulted in no significant economic impacts.

Production in these orchards varied with the seasonality of the varieties that were old enough to produce. For example, Zestar! are present but not yet in production. Despite the challenging weather, all of the early season apple varieties, such as Honeycrisp and Norland Red, produced high quality, mature crops suitable for the fresh eating market. Later season varieties, such as Frostbite and Haralson, did not reach full maturity before cold fall temperatures. However, these crops were still able to be used in value-added products such as sweet cider and sauces.

Four new high density orchards were established in 2014 with a total of 174 trees planted. Due to the late spring and other issues starting the project, these orchards were planted at different times and later than ideal. Even with these circumstances, all of the orchards seemed well established by fall. Trellising the orchards will be completed in spring 2015. Trees used in these plantings included approximately 80 that were bench grafted in March 2014. The rest of the trees used were purchased from a regional nursery.

In mid-June, Clover Valley Farms planted 50 newly grafted trees on Bud9 rootstock. This included 15 described varieties (Redwell, Dutchess, Frostbite, St. Edmunds Russet, Hazen, Prairie Spy, Haralson, Northern Spy, Ashmed Kernal, Blue Permian, Black Oxford, Whitney Crab, Wealthy, Famuse Snow, Parkland, and Oriole) and four previously unnamed varieties (Allure's Wild Red, Barb's Bounty, Justin's Jewel, and Gitchee Gummi Golden). Paul Kotz and Susanne Hoderried, in Grand Marais, planted a total of 50 trees using eight described varieties on various rootstocks, including: Honeycrisp (on rootstock Bud9 and G-16), Zestar! (on Bud9 and G-11), Snowsweet (on G-30), Sweet 16 (on Bud9, G-16 and G-41), and Dolgo and Kerr Crab Apples. The orchard was planted in early July and was irrigated well throughout the summer. All trees appeared to be in good condition at the end of the season. Dave Williams, in Grand Marais, planted a total of 46 trees using five described varieties on various rootstocks including Honeycrisp (on rootstock Bud9 and G-16), Zestar! (on Bud9), Snowsweet (on G-30), Sweet 16 (on Bud9, G-16 and G-41), and Kerr Crab Apple. These trees were planted July 18. Several of the spring grafted trees that had failed spring grafts were bud grafted in August. All trees appeared to be in good condition at the end of the season. Stan Bautch, in Grand Marais, planted a total of 28 trees including Honeycrisp (on rootstock G-16), Zestar! (on Bud9), and Whitney Crab or Allure's Wild Red (on Bud9). These trees were planted on August 11. All trees appeared to be in good condition at the end of the season.

Results 2015

In addition to the IPM monitoring stations in Duluth, two more stations with data loggers and pheromone pest traps, have now been established in Grand Marais. Additional pest trapping data was collected by the City of Duluth and submitted to this project. Substantial differences in pest pressure and GDD were documented between Duluth and Grand Marais.

Pest trap data showed that codling moth was detected in Duluth, but not at Clover Valley Farms or Grand Marais, indicating that this pest remains geographically excluded from most of northeastern Minnesota. For the second year, large early summer populations of OBLR were detected in Duluth. Bt sprays were successful in limiting late season populations and preventing potential economic damage. Further, early detection of OBLR in Duluth gave Grand Marais growers the opportunity to watch out for early detections of the pest. Apple Maggot populations were low all season along the North Shore. However, it remains one of the most challenging pests to manage organically and poses one of the most substantial economic threats to fresh eating apple production in the area. Lesser Apple Worm, an internal feeder that is difficult to manage, was detected again this year in Duluth and Grand Marais. However, in 2015 there was less fruit damage than 2014 with similar trapping rates. Consideration for future monitoring and control options to address this pest is needed in the future.

In stark contrast to the late and cool 2014 growing season, Duluth experienced early warmth. The warmth continued into November, which resulted in 1,750 GDD. Grand Marais had approximately 1,300 GDD this growing season.

Annually, apple scab models indicated medium to high probability of infection starting in early June through September. However, the pattern of potential infection windows and spore levels predicted by the apple scab models varied greatly from the three data logger locations. This is valuable in predicting potential real infection windows and useful for directing management decisions (i.e. to spray or not spray). For instance, little apple scab was actually detected in Clover Valley Farms' orchards and no spraying for apple scab was done because 1) little field evidence of primary scab infection existed and 2) model predictions indicating that most of the scab spores had already been spent by the time periods of likely infection conditions were observed. Very low levels of primary and/or secondary apple scab were detected during summer scouting and fall harvest.

Production in the orchards, which are old enough to produce a crop, was early and abundant. In Duluth, early season varieties were ripe in July. Mid-season varieties, such as Honeycrisp, were ripe in late September. The late season varieties, such as Honeygold and Haralson, ripened in October and November. In Grand Marais, the late season apple, with a very long window of ripening, did not reach full maturity before cold fall temperatures. However, these crops were still used in sweet cider and sauces.

This season, 306 trees were established in seven orchards. There are five orchards in Grand Marais, one in Duluth, and one in Carlton County.

A total of 680 trees have been secured for this project so far, including the following:

- 500 trees that were bench grafted by project participants in February 2015;
- 80 trees that were bench grafted by Cindy Hale in 2014; and
- 100 additional trees that were purchased from a regional nursery.

The trees that were not planted are at Clover Valley Farms. They will be used by the project in 2016. Rootstocks that have been established in these demonstration orchards include Bud9, G-11, G-16, G-30, G-41, and G-935. For comparison, both Ray Block's orchard and Clover Valley Farms' orchards contain semi-dwarf M-7 stock with a range of varieties.

There are 24 described apple varieties that have been established in the demonstration orchards. The varieties include Ashmed Kernal, Black Oxford, Blue Permian, Brown Snout (cider apple), Chestnut Crab, Dolgo Crab, Dutchess, Famuse Snow, Frostbite, Haralson, Hazen, Honeycrisp, Kerr Crab, Northern Spy, Oriole, Parkland, Prairie Spy, Redwell, St. Edmunds Russet, Snowsweet, Sweet 16, Wealthy, Whitney Crab, Yellow Transparent, and Zestar!. Five previously unnamed historic varieties that have been established in the demonstration orchards include Allure's Wild Red, Barb's Bounty, Justin's Jewel, Gitchee Gummi Golden, and Northern Exposure. The previously unnamed varieties were identified in local historic orchards and genotyped in 2013. They did not match any known variety in the USDA database available, so they were assigned new varietal names. It is the intention of this project to continue propagation and distribution of these heritage varieties beyond the close of the study.

Heritage apple genetic samples were collected this year from 58 trees. They were submitted to Dr. Briana Gross at UMD for genetic typing. The objective is to identify historic apple trees, which are trees that are over 100 years old, that may be potentially valuable, locally adapted, unnamed

apple varieties that growers may want to propagate. Results are anticipated in spring 2016, which will give us the final year of the project to collect scions and preserve these historic apples.

Results 2016

Pest Trap Data showed that codling moth is regularly detected at low numbers in the city of Duluth but not at Clover Valley Farms or Grand Marias, indicating that this pest remains geographically excluded from most of northeast Minnesota. As with last year, large early summer populations of OBLR and LAW were detected in Duluth and Grand Marias. Organic Bt sprays were successfully used to limit late season populations of OBLR and potential economic damage. Further, early detection of OBLR in Duluth gave Grand Marais growers an opportunity to be on the watch for early detections of this pest. The large populations LAW this year turned out to not have significant ecological or economic damage to the apple crops, but provide good evidence that annual monitoring is important. Apple Maggot was nearly absent in trapping counts this year.

This year was another early and warm year with Duluth showing a total of over 1,800 GDD with a growing season that continued into early November. Early season apples in Duluth were harvestable in August and even later season apples reached good maturity by the end of the growing season. In contrast Grand Marias had a cooler and later spring than Duluth and finished the growing season in September at 1,190 GDD, again demonstrating that growing season is the most limiting factor for apple production in that area.

Apple scab models and observed levels of infection varied annually during the project. Apple scab appeared to be less of a problem in the newer, smaller, and more isolated orchards in Grand Marias than those in Duluth. This year, early wet and warm conditions predicted high likelihood of apple scab infection in June at Clover Valley Farms. Therefore, a sulphur-lime spray was used which appeared to largely control primary apple scab in that orchard. In other local orchards, and in the City of Duluth, where no spraying was done, apple scab infection was heavy leading to substantial crop damage and loss.

None of the trees planted as a part of this study were producing yet. However, establishment and growth of most trees was excellent and they look poised for a good first crop in 2017. In the two orchards, which had established trees prior to the start of this project (Clover Valley Farms and Ray Block) fruit production was again abundant. The quality of the fruit was exceptional, likely due to the “just right” combination of warmth and rain. Fruit load management will be important as the newly established orchards begin producing to prevent physical damage to trees from heavy crop loads. In Duluth, early season varieties were consistently ripe in late July to early August including, but not limited to, Yellow Transparent, Norland Red, Allure’s Wild Red; mid-season varieties (i.e. Honeycrisp, Zestar!) were ripe in September; and late season varieties (i.e. Honeygold, Haralson, Frostbite) ripened in October-November. In contrast, the general pattern for Grand Marias’ apples was a later start with trees blooming well into May. As a result later season apples with a very long window of ripening, had not reached full maturity before cold fall temperatures. However, these crops were still useable in value-added products. Ray Block has been experimenting with putting high tunnels over Zestar! and was able to get full bloom almost a month earlier than trees in the same orchard that were not under tunnels. By leaving the ends of the tunnels open, he had great pollination as the local pollinators found these trees and were very actively using them before the unprotected trees had bloomed.

Additional blocks of trees were added to two sites, including: three 20-30 tree blocks at Clover Valley Farms and approximately 100 new trees to the Stan Bauth orchard.

Heritage Apple Genetic Samples that were submitted to Dr. Briana Gross at UMD for genetic typing, found that four trees were identified as previously described varieties (i.e. 1- Beacon, 1-Yellow Transparent, 2-Oriole) and three undescribed varieties were represented in two to four different sites. These may represent local developed apples worthy of further description and propagation.

Management Tips

1. Contrary to popular belief, cold temperatures are not the primary limiting factor for apple production in northeast Minnesota. Most of the “near the lake” north shore area of Lake Superior is Zone 4 for winter hardiness. However, growing season length is a limiting factor especially since it relates to which varieties can reach maturity.
2. There are numerous apple varieties that are hardy enough for this region. However, even some of the most cold hardy, such as Frostbite, require a longer season to mature than is consistently available along the north shore.
3. A major take home message from the GDD data collected is that northeastern Minnesota growers need to be prepared for wide variations in the beginning of the growing season (i.e. bloom date vs. latest frost date), the number of annual GDD, and how these two factors may affect production in any given year. Diversity of apple varieties and a focus on early to mid-season apples is recommended.

Cooperators

Diane Booth, CC Extension, Grand Marais, MN

Anton Ptak, President, Organic Fruit Growers Assoc./Mary Dirty Face Farm, Downsville, WI

Dave Williams, Rosebush Creek Ranch, Grand Marais, MN

Ray Block, Lake Superior Orchard, Grand Marais, MN

David Bedford, Senior Research Fellow, Excelsior, MN

Paul Kotz and Susanne Holderried, Grand Marais, MN

Stan Bautch, Grand Marais, MN

Erik Hahn, Grand Marais, MN

Cameron Norman, Grand Marais, MN

John Peterson, Hovland, MN

Nick Wharton, Good Nature Farm, Grand Marais, MN

Rick Dalen, Northern Harvest Farm, Wrenshall, MN

Project Location

Please contact the owners if you'd like to see their orchards.

To the Clover Valley Farms site, take 35 north from Minneapolis/St. Paul towards Duluth. Exit onto MN-61. Turn left on Homestead Rd.

Stan Bautch's Orchard is in downtown Grand Marais and easily visible from the road. On the corner of 5th St. and Cty. Rd. 7 in Downtown Grand Marais, MN.

To the Lake Superior Orchard site, take 35 north from Minneapolis/St. Paul towards Duluth. Exit onto MN-61. Bear right onto E. Rosebush Ln.

To the Paul Kotz & Susanne Holderried site, take 35 north from Minneapolis/St. Paul towards Duluth. Exit onto MN-61.

To the Rosebush Creek Ranch site, take 35 north from Minneapolis/St. Paul towards Duluth. Exit onto MN-61. Turn left onto Fall River Rd.

To the Erik Hahn site, take 35 north from Minneapolis/St. Paul towards Duluth. Exit onto MN-61. Turn left on Cty. Rd. 14. Turn right onto Caspers Hill.

To the Northern Harvest Farm site, take 35 north from Minneapolis/St. Paul towards Duluth. Take exit 227 towards Mahtowa/Wrenshall. Turn right onto Cty. Rd. 4. Turn left onto Mahtowa Rd. Turn right onto Military Rd. Turn right onto Cty. Rd. 102.

Other Resources

University of Minnesota's Apples webpage:
www.apples.umn.edu

MN Dept. of Agriculture's IPM Program:
www.mda.state.mn.us/plants/pestmanagement/ipm

Michigan State University's IPM Program:
www.ipm.msu.edu

Organic Fruit Growers Association:
www.organictreefruit.org

University of Minnesota Extension Apples:
www.extension.org/apples

Cornell's Growers Guide to Organic Apples:
<https://ecommons.cornell.edu/bitstream/handle/1813/42886/organic-apples-NYSIPM.pdf?sequence=1>

National Sustainable Agriculture Information System:
www.attra.ncat.org

University of Wisconsin-Madison's Center for Applied Agricultural Systems: www.cias.wisc.edu

Principal Investigator

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Project Duration

2015 to 2017

Award Amount

\$18,642

Staff Contact

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Keywords

hoop house, mobile hoop house, season extension, vegetables

Maximizing Profitability in Modular Movable Hoop Houses

Project Summary

Sundogs Prairie Farm is testing a mobile modular hoop house to see if it can help maximize mixed vegetable production. Stationary hoop houses are already a proven method of increasing farm productivity and profitability. They maximize solar gain, reduce pest pressure, enhance yield and quality, and extend the growing season. However, a limiting factor is the small growing area that traditional stationary hoop houses provide. A recent innovation from grower Eliot Coleman's Four Season Farm in Maine are mobile modular hoop houses. These structures can be easily split into short segments, moved around the garden by hand, and reassembled in a new location. This unique mobility allows one structure to cover many field plots in the same growing season.

Project Description

We are inspired by Eliot Coleman's farming technique where mobile hoop houses have been used successfully for many years. Mobile modular hoops let growers move the structure, which greatly increases the options for placement (Photo 1). These structures mean growers can cover more total growing area each year, allowing them to plant more crop rotations, place the hoop house during critical growth stages of many crops in different locations on the farm, and greatly increase the overall farm benefits provided by the investment.

Sundogs Prairie Farm produces diverse vegetables on 5 acres for delivery to a local food hub, online market, two farmers markets, and several local restaurants. Before we started this project, we used a traditional hoop house, low tunnels, and row covers to extend our growing season and increase farm profitability. Our cropping system includes open field and plasticulture techniques depending on crop, market, and field conditions. We have an additional 50 acres of land in conservation programs, 17 acres of pollinator planting, and 60 acres of organic alfalfa rented by a neighbor. We employ extended family members for a significant portion of the labor on our farm and, depending on our needs, we hire up to five additional workers.



Photo 1. Mobile modular greenhouses are pretty easy to move.

In 2016 we added a farm stand and 2 acres of raised beds in the City of Alexandria. We found a location along a low-speed segment of a major roadway that our target market travels.

We hope the new location will better engage our local community, raise awareness of small farm viability, and demonstrate mobile modular hoop houses.

2015 Results

Our 2015 cropping strategies focused on maximizing fall crop yields, season extension, and profitability. We compared direct seeded plantings at 10 day intervals, with three treatments per planting. The three treatments were:

1. Outside planted crops that remained outside all season.
2. Outside planted crops covered with a mobile modular hoop house.
3. Crops planted inside a hoop house that stayed covered all season.

We monitored seedling establishment, plant condition and growth, re-growth, yield, and management complexity. The warm late fall probably helped plant growth and condition across all treatments through September and into October. With steady fall temperatures, the effects of shorter day length on growth were very apparent in October, and growth essentially in early November.

The crops we planted before September 10 performed well, but were occasionally difficult to establish due to wet soil. Protecting beds by covering them with old greenhouse plastic prior to planting stimulated weed seeds and maintained good seedbed conditions. We found that seedlings established more slowly when we direct seeded outdoors after early September. However, once established, outdoor plantings grew very well through late September. After that, growth of most crops slowed, and we covered some beds with the mobile modular hoop house.

We observed that the outdoor seedlings covered by the mobile modular hoop house generally had less disease and much better re-growth than the unprotected outdoor beds. This fast re-growth meant we could take an additional harvest of marketable spinach and leaf lettuce from the protected beds (Table 1). The protection provided by the mobile modular also allowed crops like Hakuri turnips to remain marketable much more than the outdoor beds.

Table 1. 2015 Spinach Growth Across Treatments (Spinach Planted August 10)

Treatment	1st Cutting	2nd Cutting	3rd Cutting	Total yield
Outside all season	Good	Fair	None	2nd
Outside, then mobile modular	Good	Fair	Fair	Highest
Hoop all season	None	Fair	Fair	3rd

Direct seeding in the main hoop house was surprisingly difficult in August. It proved to be a stressful environment for seedlings; those that did establish in August grew poorly until the weather got cooler. When we removed the main hoop house crop of tomatoes (around September 1), ventilation improved and seedlings performed better.

Many species germinated and grew rapidly in the short, cool, fall days. In September, all our direct seeded seedlings in the hoop house performed very well. Most species grew until late October – and some even later. Densely seeded kale and mizuna beds that we started on September 1 were harvestable by early October. They regrew enough for another harvest in late October/early November. Hoop house beds that we direct seeded on September 20 with

French Breakfast radishes, Tokyo Bekana, Mizuna, Arugula, and kales were harvested by November 1.

In 2015, our most profitable crops were planted outside and then covered with a mobile modular hoop house. We observed better plant establishment in the mobile modular houses, and growing conditions enabled those plants to regrow rapidly after harvests. Bed preparation, stale seedbed techniques, seeding, and watering were all significantly easier outside the hoop house, and saved a lot of management time and effort. Because we planted adjoining beds in a 10 day sequence, we were able to shift the mobile modular hoop house onto crops at the optimal growth stage.

2016 Results

This year we focused on three crop schemes that would complement our existing extended season production and reduce the frequency of planting brassicas in our main hoop.

Weather was a defining factor of 2016; we had the longest growing season ever at our location extending our fall into November. Our spring started off with a bang as high winds, structural flex, and hardware failure combined as two of



Photo 2. Big winds can mean disaster. After this catastrophe, we modified our anchoring system.

the three sections of our mobile modular greenhouse broke free and tumbled across the farm (Photo 2)! One section was destroyed but we were able to salvage the other one. When we looked closely, we saw that some of the fittings had failed. We also saw how the structure had shifted under wind load. We reassembled the structure with a modified anchoring system which attaches directly to the frame and pulls down and out in all directions to counter wind shifting (Photo 3).



Photo 3. We modified the earth anchor system to make the mobile modular hoop house sturdier. Note how soundly Kodiak is sleeping, confident that it won't blow away again.

Cropping Scheme 1

Our first cropping scheme this year was to plant early spring crops in the mobile modular, which we finished uncovered. We transplanted Chinese cabbage, bok choy, and lettuces on April 10. We direct seeded pre-germinated beets and carrots April 17. They emerged about 10 days later.

We removed the structure from these crops around May 15 in order to preheat the beds before plating tomatoes. The combination of heat and cold exposure triggered bolting in most of the Chinese cabbage and bok choy, making them unmarketable. The lettuces grew slowly but complemented our normal production and reached harvest 3 weeks earlier than the outdoor unprotected plantings.

The beets and carrots did well; both crops were ready to harvest in mid-June when our markets had no others available. The carrot yield was about 20% less than in our regular hoop house. (Our earliest carrots had been planted November 17

the year before, in our main hoop. We harvested those in mid-May, only 10 days before the February 14, 2016 planted mobile modular carrots were ready. Each 70' bed yielded 200 bunches of carrots, helping us beat other area growers to the markets. Creating strong connections with customers early in the marketing season increases traffic at our markets. It also draws purchasing power solidly, helping establish our revenue stream for the year.

Cropping Scheme 2

For cropping scheme two, we used warm season crops. We planted tomatoes into raised plastic-mulched beds and used dual drip tape. We timed planting to give us a chance to clear the early crop of determinate out of our main hoop house by September 1. Preparing the 3 beds, each 200' long, only took 20 minutes with a bed shaper-mulch layer I rented from another farmer.

We covered the first 35' of the beds with the mobile modular for a 2 week soil preheat starting May 15, then spread straw for mulch. On June 1, we transplanted 12" tomatoes into the beds – both in the mobile modular and beyond – into the outdoor bed. We used mainly 72 day varieties and 75 day heat set determinates, which worked well for us in the past.

The tomatoes grew rapidly in the mobile modular compared to the outdoor plants, whose initial growth was slow. We had planted similar varieties in the main hoop 3 weeks before, but the mobile modular tomatoes caught up; they were ready to harvest only 2 weeks after those in the main hoop. The mobile modular tomatoes were ready 20 days before the adjoining outdoor plantings.

We saw less disease and weed pressure in the mobile modular, probably due to the fact that the plants were protected from rain. The plants thrived in the mobile modular, producing the blemish-free 12 oz BLT slicing tomatoes our customers love.

Production in the mobile modular was very strong in September, which meant we could replant the main hoop earlier than planned, while maintaining the supply of quality tomatoes our customers expect. We harvested the last tomato from the mobile modular was on October 10.

The mobile modular protected our crops from the intense rainfall, damaging winds, and hail that damaged our 2016 outdoor tomato plantings. We sold most of what was marketable from the outdoor comparison plantings as canning tomatoes, cutting their value in half.

Cropping Scheme 3

The final cropping scheme we used in the mobile modular this year was production of fall greens. We transplanted fall lettuces into much of our main hoop house to extend availability. Ordinarily, we would have planted fall greens in the hoop house; we used the mobile modular for the greens instead.

We planted our final outdoor greens beds September 15. The mobility of the mobile modular was truly on display when two of us loaded it onto a trailer and hauled it 20 miles to our new site in town. On October 12, we dropped it onto the appropriate beds of greens to protect them from predicted cold weather.

We harvested greens on October 20 and again on November 3. We were able to harvest the mizuna, kale, and arugula beds a third time on November 18th (wet conditions in the mobile modular contributed to disease in the leaf lettuce, so we did not harvest lettuce).

First cut yields were high in the mobile modular at 0.5 lb/bed/ft. The 54' we harvested yielded 26 lb of Asian greens, leaf lettuce, and baby kales. We continued planting in the main hoop until November 5, when we planted the final bed for baby spinach. That baby spinach emerged 10 days later and will overwinter as seedlings for harvest in March of 2017.

We deemed our 2016 summer and fall crops in the mobile modular a success. They required minimal labor for the quality and yield they returned. The three crop schemes we demonstrated complemented our existing production. They provided a more consistent supply of carrots, beets, spinach, head lettuce, and tomatoes – which are all high demand items at our markets.

We found these schemes helped us maximize our productivity and maintain availability through our extended harvest without significant demands of labor or capital. This made our revenue stream more consistent and conditioned customers to plan on shopping at our Farm Stand. When customers can fill their basket with items they were hoping to buy everyone is happier.

In total, we spent \$2,500 on our 14' x 50' three-section mobile modular, which covers a 140' bed, while we spent \$9,000 on our 30' x 72' gothic hoop house, which covers a 440' bed. We are not satisfied with our bed efficiency in either structure – something we hope to address in 2017.

The mobile modular can be skidded by two people and moved most places by three so labor isn't a limiting factor. (Although our labor inputs were high in the spring of 2016 due to the wind incident and the Asian crops that bolted.) In fact, for many crops, actual labor per unit of yield was less in the mobile modular than either outdoors or in the permanent hoop house. While the mobile modular did experience some disease issues in late fall that we didn't have in the main hoop, others were comparable or reduced.

The mobile modular proved very adaptable in placement, allowing us to respond to actual conditions. If vegetable growers have concerns about short-term land leases the mobile modular may be a good option for them.

Management Tips

1. Position your end earth anchors outside the structure and attach the turnbuckles directly to the framework (Photo 3).
2. Scissor doors and roll up sides do not perform well in high winds. We changed our end walls leaving half of each end covered all summer and we did clamp the sides down. We experienced no additional wind damage and ventilation seemed adequate for the short tunnel we have.
3. Harvest or terminate crops promptly at maturity, even if they end up in the compost. Replanting immediately provides the opportunity for an additional harvest and maintains soil health.

Cooperators

Dave Birky, Ag Resources, Inc., Detroit Lakes, MN
Deep Winter Producers Association, online community
Local Harvest Market Online Cooperative, Alexandria, MN

Ryan Pesch, U of M Extension, Moorhead, MN
Stearns DHIA Labs, Sauk Centre, MN

Project Location

From Brandon, go north on Cty. Rd. 7 for 7 mi. Turn right (east) onto Cty. Rd. 5 and go 1 mile. Turn right (south) on Chippewa Heights Rd. and go 1.5 miles. Turn left (east) onto Burn Rd. which ends at Sundogs Prairie Farm, 10737 Burn Rd NW.

Sundogs Farm & Market Stand is in Alexandria, MN at 2200 N. Nokomis (Cty. Rd. 42), next to the Alexandria Golf Course and Voyager Elementary School.

Other Resources

Dr. John Biernbaum, Michigan State University.
www.hrt.msu.edu/john-biernbaum/pg4

Deep Winter Producers Association.
www.facebook.com/DeepWinterProducers

Eliot Coleman. www.fourseasonfarm.com

Jean-Martin Fortier workshop.
www.youtube.com/channel/UCFF20WbbyKSiYQe0J6a7HTQ/feed

Local Harvest Market Online Cooperative.
<http://localharvestmarket.co/>

The Market Gardener. www.themarketgardener.com

MOSES Conference Recorded Workshops.
www.mosesorganic.org

SARE Season Extension Topic Room. www.sare.org

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Project Duration

2015 to 2017

Award Amount

\$19,465

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Keywords

apple, climate, scab, codling
 moth

Developing a Network for Environment and Weather Applications

Project Summary

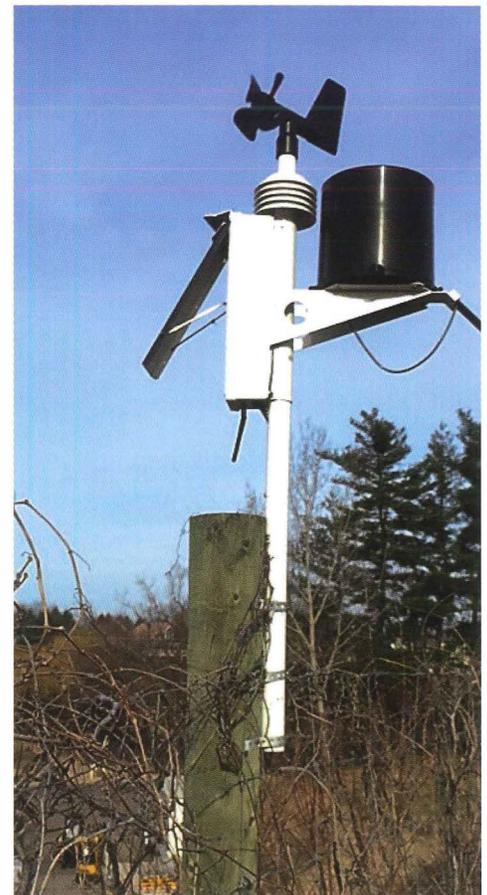
The Minnesota Apple Growers Association (MAGA) is currently evaluating the performance and efficacy of an electronic weather monitoring network that would standardize the data throughout Minnesota. In order to utilize the network 12 weather stations have been distributed to apple growers around the State. These stations connect to the internet via WiFi and upload data to the Network for Environment and Weather Applications (NEWA) website (www.newa.cornell.edu). Growers may then view the data collected by the weather station nearest their orchard and use the data to forecast different insect and disease models.

We are also evaluating the efficacy of the forecast models to determine if they can accurately predict insect life cycles and disease maturation in the different apple growing climates within Minnesota.

Project Description

Apple growers in Minnesota are located in many different growing regions across the state. For example, growers are located in La Crescent which is in the southeastern part of the State, Grand Rapids which is in the northern part, and many locations in-between. In the past, organizations have used weather stations to collect and evaluate data, but this is problematic. The data may have been formatted differently, corrupt if the weather station malfunctioned, or not shared for proprietary reasons. In order to best serve the growers, a publicly accessible and standardized weather collection system is needed.

The Rainwise weather stations are all calibrated and function identically. The stations connect via the internet to the NEWA network, and can be accessed by anyone. NEWA is maintained by Cornell University, an industry leader in insect and disease forecast models. These weather based forecast models allow the growers to predict different plant and insect diseases from emergence to maturation. Proper prediction allows the grower to use chemicals more effectively by applying them at times when the insect or disease is more susceptible to control.



Rainwise weather station.

The evaluation of these models is important for the apple growers in Minnesota. Since, the forecast models were developed in other areas of the United States they need to be researched for accuracy with Minnesota's climate. The weather stations automatically calculate and keep a running total of growing degree days (GDD). They are used to determine the emergence and maturation of plant and insect diseases. Growing degree days are calculated by taking the high temperature for the day adding it to the low temperature, dividing that by 2, and then subtracting the base temperature per the disease or insect. For example, codling moth egg laying occurs at 100 GDD and then first generation eggs hatch at 250 GDD, while the second generation starts at 1,060 GDD. The type of control a grower uses is based on the GDD total which lets the grower know whether to control for eggs, larva, or moths. In addition to using GDD we will use pheromone traps for codling moths and apple maggots, so we can compare the two.

Apple Scab (AS) is another pest that MAGA has been collecting and charting the ascospores for the past 20 years. The progress of the ascospores is done by placing last years infected leaves under an apple tree. Each week leaves are then collected and sent for scientific evaluation to chart the progress of the disease. In comparison, a grower using the NEWA weather network, can click on the weather station closest to their orchard and run the "Apple Scab" forecast model using the data collected by that station. The forecast model will then predict the current level of AS ascospores and recommend if the grower needs to act. The electronic process eliminates many variables in testing, including contamination of samples, improper handling, and delays in testing. The electronic process also allows the growers to check thresholds on a daily basis rather than weekly.

2015 Results

Scab Testing

During this first year of our study one of the issues we had with the NEWA model is that it relies on tree phenology when determining spore development and maturity instead of the dissection of a spore to do so. Crop protection is needed for AS when the disease reaches an activity level of 5% active spores or greater.

The NEWA model has the grower input the date at which McIntosh trees are at 50% Green Tip. This serves as the starting point for the predictive model. NEWA presents this data in a cumulative format. The grower would start protecting at pre-5% and proceed until 95% of the spores had been ejected. Versus the dissection method, which tells the grower the percentage of spores that are currently active on the leaf surface.

Typically the first cover spray would occur when the active spores reach around 3%, thinking that with the next rainfall disease maturity of 5% would be achieved. The grower will need to keep the crop protected until the levels drop back below 5%.

There are some fundamental differences in the analysis of these types of scab testing, both of which have positive and negative attributes. Leaf collection and dissection samples show "real-time" activity of spores, they do not show the potential risk for future infection periods. The spores mature during wetting periods, if it doesn't rain the spores do not mature. Looking at the table using the leaf collection method in Webster, it shows the spores jumped dramatically from 0.4% to 25.6%. This could have had severely damaging consequences if the grower had not anticipated a wetting period and the risk of severe infection. The NEWA model did not accurately predict the end of the scab season. As of 5/19/15 the NEWA model was predicting that 95+% of the scab spores had been released. However, the leaf collection samples proved that the active percentage of scab spores was still greater than 5%. Overall, analysis for more than one season is needed to provide a better basis of comparison.

Results from leaf collection and dissection testing (highlighted = currently active)

Location	4/15/15	4/21/15	4/28/15	5/5/15	5/12/15	5/19/15	5/27/15	6/2/15
Tree Stage	Green Tip	TC	Pre-Pink	Bloom	Full Bloom	Petal Fall	8-12MM	20-25MM
White Bear Lake	0.5	7.1	14.3	13.4	11.8	5.3	14.5	12.1
Webster	Na	1.4	2.2	0.4	25.6	16.9	32	10.7
La Crescent	0.3	2.5	11.6	14.1	26.1	19.8	1.7	0.5
Lake City	na	0	5.2	3.3	24.5	8.5	3	0.9

NEWA Scab forecast model (highlighted = cumulative percentage of mature spores released)

Location	4/15/15	4/21/15	4/28/15	5/5/15	5/12/15	5/19/15	5/27/15	6/2/15
Tree Stage	Green Tip	TC	Pre-Pink	Bloom	Full Bloom	Petal Fall	8-12MM	20-25MM
White Bear Lake	2%	6%	16%	41%	78%	95%	99%	NA
Webster	NA	7%	18%	59%	88%	97%	100%	NA
La Crescent	2%	6%	19%	54%	87%	97%	100%	NA
Lake City	2%	5%	13%	50%	85%	97%	100%	NA

Codling Moth Lifecycle Evaluation

A codling moth (CM) life cycle model has been developed, and used by growers in different areas across the country for many years. This model utilizes grower insect trap counts to determine a “biofix” date, as a basis to begin a GDD lifecycle tracking program. When a grower traps 5 CM the tracking begins. Using this model the grower can predict the hatch of the CM eggs. The eggs begin to hatch at approximately 220 GDD post biofix. Implementing this model into IPM practices, has allowed many growers to target CM during the peaks of their lifecycle changes. A grower can now target codling moth eggs, larva, or adults at the most opportune times, therefore only spraying the necessary insecticide.

The NEWA website asks the grower to input the date of their first CM catch and then begins running a GDD based model to track the CM lifecycle. While it does not predict how many moths you will catch in your trap, it does track GDD extremely well. It also provides accurate information about what lifecycle stage the insects are in and different pest management strategies.

Currently we are checking our insect traps once a week and recording the trap count numbers. If a grower has a trap with 3 CM on Monday morning, they may not re-visit the trap until next week and this could affect the biofix date. If there is a mid-week heat wave, more moths will emerge and there could be 5 CM by Thursday afternoon, but the biofix date will be the following Monday. In addition, there are many different factors that can influence grower trap counts, such as improper trap placement, pheromone mating disruption, or application of different pesticides. If these trap counts are interpreted improperly the efficacy of pest control will diminish. The NEWA website collects weather data many times throughout the day and applies it to the forecast model, therefore setting the biofix date more accurately. For CM, utilizing accurate weather data and then applying the forecast model may provide a better understanding of what is happening in the orchard.

Results from leaf collection and dissection testing (highlighted = currently active)

Location	4/12/16	4/19/16	4/26/16	5/3/16	5/10/16	5/17/16	5/24/16	6/1/16
Tree Stage	Green Tip	TC	Pre-Pink	Bloom	Petal Fall	4-7MM	8-12MM	20-25MM
White Bear Lake	3	15	21	28	16	12	23	1
Webster	NA	0	30	29	19	12	27	3
La Crescent	36	19	25	10	13.5	7	15	0
Lake City	NA	5	43	22	52	5	4	4

NEWA Scab forecast model (highlighted = cumulative percentage of mature spores released)

Location	4/12/16	4/19/16	4/26/16	5/3/16	5/10/16	5/17/16	5/24/16	6/1/16
Tree Stage	Green Tip	TC	Pre-Pink	Bloom	Petal Fall	4-7MM	8-12MM	20-25MM
White Bear Lake	0	4	10	31	51	79	96	99
Webster	0	3	10	32	76	91	98	100
La Crescent	-	-	-	-	-	-	-	-
Lake City	2	3	12	23	61	84	93	100

2016 Results

Scab Testing

This season the NEWA model correctly predicted the emergence of the apple scab fungus at three of our testing sites. The decline of the scab ascospores was charted and predicted accurately. There were a few minor discrepancies, but I feel that they were insignificant enough to cause any crop damage, if using the NEWA model alone. One of the issues we've had this year was maintaining the connection status of the weather stations. Severe weather, internet service interruptions, and NEWA server issues have played a part in technological breakdowns this year.

Codling Moth Lifecycle Evaluation

This year the NEWA website accurately tracked the evolution of CM throughout Minnesota. Using the grower supplied date of first trap catch, NEWA successfully charted the CM lifecycle. It is important to note that the NEWA model cannot predict the amount of pest pressure in the orchard. Growers who have had high-to-extreme pest pressure in the past, may have prolonged exposure, long after the model has run its course.

Management Tips

1. Run forecast models on multiple weather stations in your area. If you are in an area with more than one NEWA station, try running the programs on the other stations in the area to see if there are any differences.
2. Know your own history. Always keep accurate records of pest trap counts, and spray events. These can be a tremendous resource when evaluating pest pressures and chemical efficacy.
3. Scout, scout, scout. The best way to discover what is happening in the orchard is to go and look. Set out insect traps in areas you have avoided in the past, don't place them in the same tree year after year. Always maintain traps based on professional recommendations.

Cooperators

Weather Station Locations

Pine Tree Orchards, White Bear Lake, MN

Whistling Well Farm, Hastings, MN

Pepin Heights Orchard, Lake City, MN

Ocheda Orchard, Worthington, MN

Apple Jack Orchard, Delano, MN

Plum Crazy Orchards, Buffalo, MN

U of M HR Station-Grand Rapids, Grand Rapids, MN

Fruit Acres, La Crescent, MN

Pleasant Valley Orchards, Shafer, MN

Country Blossom Farm, Alexandria, MN

McDougall's Apple Junction, Hastings, MN

Nelson's Apple Farm, Webster, MN

Other Cooperators

Juliet E. Carroll, PhD, NEWA, Geneva, NY

Christopher Phillips, PhD, Entomologist, St. Paul, MN

Linda Treeful, PhD, Plant Pathologist, White Bear Lake, MN

Project Location

Please contact John Jacobson for directions to the many orchards.

Principal Investigator

Mike Jorgenson
 Jorgenson Family Farm
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 Big Stone County

Project Duration

2016-2018

Award Amount

\$10,000

Staff Contact

Meg Moynihan

Keywords

Intermediate wheatgrass,
 Kernza®, perennial

Perennial Wheatgrass and Legumes for Cropping, Grazing, and Soil Health

Project Summary

Intermediate wheatgrass, is a perennial cool season grain that reportedly can provide continuous living cover, produce an annual grain crop, and supply forage for grazing livestock. This project is evaluating the forage, forage quality, and grain yields of an intermediate wheatgrass crop inter-seeded with legumes. Can inter-seeding legumes into intermediate wheatgrass provide the nitrogen needed to both supply an annual grain crop and provide forage for beef cattle?

Project Description

Mike and his family operate a 317 acre diversified farm near Clinton, MN. They have 70 acres of rotationally grazed perennial pasture currently grazed by 85 head of Lowline Angus and Irish Dexter cattle. Another 40 acres (including the 5 acre test plot for this study) are certified organic and used for crop production. They also have 40 acres in transition to organic. The rest of the farm is in a conventional corn/soybean rotation.

The Jorgensons say that planting perennial crops has benefitted their land. They farm fine-textured, silty clay soil. Planting perennial crops has improved soil permeability and reduced soil erosion. The cover and improved soil permeability they provide are especially important during the frequent high intensity, 2"/hr rains common in western Minnesota. Mike and his family were also intrigued by the potential economic benefits of a perennial crop like intermediate wheatgrass, which might provide both a valuable annual grain crop and forage for their beef herd.

Researchers in Kansas started a breeding program for intermediate wheatgrass in 2003. They have patented the name of the grain it produces as Kernza®.

They asked University of Minnesota forage agronomist Craig Sheaffer to cooperate with them on this project. He provided the intermediate wheatgrass and legume seed and helped design the study. When the time comes, Dr. Sheaffer's lab will analyze forage yield and quality.

2016 Results

The Jorgensons fenced in the entire 40 acre certified organic field and installed interior fence around the 5 acre test plot. They put the cattle out on that plot and mob grazed the existing cover crop in August and again in September just prior to planting the intermediate wheatgrass. Since this field is certified organic, they could not burn the cover crop down with herbicide. Instead, they used intensive grazing to reduce competition for the intermediate wheatgrass they were about to seed.

Table 1. Baseline Soil Analysis

pH	CEC	OM (%)	Salts (%)	P-O (ppm)	K (ppm)	Mg (ppm)	Ca (ppm)
7.9	36.2	4.2	.4	25	427	998	5,350

Mike planted the intermediate wheatgrass test plot on September 29, using a tractor and the Big Stone County Soil and Water Conservation District's no-till drill. He had hoped to plant the intermediate wheatgrass in late August/early September, but their region received excessive amounts of rain beginning in early July and continuing through the entire fall. The rain delayed intermediate wheatgrass planting considerably. Since the planting date was much later than they expected, Mike and his family did not interseed the legumes with the intermediate wheatgrass in fall 2016. They will do that in spring.



We used a no-till drill to plant the intermediate wheatgrass into a well-grazed plot.

The Intermediate wheatgrass did not emerge until October 12, although near weekly rainfalls in October provided adequate moisture. Warmer than average temperatures in October and November helped the intermediate wheatgrass establish. In fact, the Jorgensons' beef cattle were able to graze on adjacent ground until November 26.

While the intermediate wheatgrass seed did eventually germinate, it is possible that the stand may have been affected by the cool, wet soil conditions. Then, two rainfall events in December encrusted the frozen field in a sheet of ice. When Mike submitted his annual report, it was the middle of winter. He and his family could only hope the intermediate wheatgrass stand would overwinter successfully.

Management Tips

A no-till drill works well to plant Intermediate wheatgrass seed. Many SWCDs have them available for rent.

Cooperators

Blayne Johnson, Big Stone County Soil and Water Conservation District, Ortonville, MN

Craig Sheaffer, University of Minnesota, Saint Paul, MN

Directions

From Clinton, MN, go 7 miles east on Cty. Hwy. 6. Then go south 2.5 mi on 660th Ave. to 33626 660th Ave. Driveway is on the left.

Other Resources

The Land Institute. Kernza® Grain: Toward a Perennial Agriculture. <https://landinstitute.org/our-work/perennial-crops/kernza>

Principal Investigator

Thaddeus McCamant
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Project Duration

2016 to 2018

Award Amount

\$14,120

Staff Contact

Cassie Dahl

Keywords

pear, juneberry, rootstock

Using Juneberries as a Cold Hardy Rootstock for Minnesota Pears

Project Summary

We are testing the viability of using juneberry plants as a rootstock for Minnesota pear varieties. Juneberries have the advantage of being exceptionally winter hardy, and there is some evidence that juneberry rootstocks will make the pear trees shorter and produce blossoms within two years after planting. We grafted seven pear varieties onto two species of juneberry rootstocks and two pear rootstocks. At the end of the summer, over half of the pears grafted onto juneberries survived, which was slightly lower than the success rate of pears grafted onto pear rootstocks.

Project Description

There are multiple varieties of high quality pears that are hardy enough to grow in Minnesota. Pears are marginally economical here due to a very long period between planting the tree and harvesting the first crop, and the shape of the trees. Pears naturally have an upright growth habit, but many of the hardy Minnesota varieties like Summercrisp have a columnar form similar to Lombardy poplar, which makes harvesting difficult. Upright growths are managed in other crops with dwarfing rootstocks, but the primary dwarfing rootstock for pears is quince, which is not hardy for Minnesota.

A researcher in Oregon found that juneberries or serviceberries (*Amelanchier* spp.) can be used as a dwarfing rootstock for pears, giving all the benefits of a dwarfing rootstock: small trees, the potential for high density plantings, and blossoming within two years after planting.

We wanted to determine if juneberries would be a compatible rootstock for Minnesota hardy pear varieties. We chose two species of native juneberries: the western serviceberry or saskatoon (*Amelanchier alnifolia*) and the apple serviceberry (*A. x grandifolia*). The saskatoon plants were purchased from Lawyer's Nursery in Plains, Montana. The *A. alnifolia* were seedlings of wild plants native to Montana and were highly variable in size, while the *A. x grandifolia* plants were all about ½" in diameter. For comparison, we used two pear rootstocks: Old Home x Farmingdale (OH x F) 87 and OH x F 97 that were purchased from Cummins Nursery in Geneva, New York. The pear rootstocks were relatively uniform in size.

We chose seven Minnesota hardy pear varieties (rated Zone 4 or hardier): Summercrisp, Harrow Sweet, Clara Frijs, Honey Sweet, Ewart, Luscious, and Gourmet. We grafted between 14 and 21 plants for each rootstock/scion combination.

The grafted trees were planted in 3 gal pots with potting soil for the summer at Stone Creek Farm near Taylor's Falls, and the trees were hand watered over the summer (Photo 1). In early November, all trees were planted in fields at the three participating farms. The three farms are Central Lakes Agriculture and Energy Center near Staples, York Farm near Hutchinson, and Stone Creek Farm near Taylor's Falls. The trees at York Farm and Stone Creek Farm were planted as high density orchards, and the trees will be trained to trellises (Photo 2).



Photo 1. Trees ready to be planted.



Photo 2. Planted trees with trellis system.

Results

All pear varieties successfully grafted onto juneberry rootstocks. Conditions were difficult during grafting, which may have lowered the success rate. About a third of trees that didn't survive died after grafted scions started growing. The plants died at the root level, which indicates poor survival was not due to graft compatibility.

The biggest differences in graft compatibility were not between the saskatoon and pear rootstocks, but between the different varieties of pears. Survival rates in Table 1 include both grafts that did not take and trees that died after grafting, and survival rates varied from 39% for the Harrow Sweet to 88% for Gourmet.

Table 1. Survival Rates for Each Different Scion/Rootstock Combinations at the End of the Growing Season				
	OHxF 87	OHxF 97	A. alnifolia	A. x grandifolia
Summercrisp	81%	52%	57%	67%
Harrow Sweet	38%	43%	43%	33%
Honey Sweet	52%	67%	43%	67%
Clara Frijs	57%	90%	57%	44%
Ewart	95%	71%	64%	56%
Luscious	86%	48%	50%	44%
Gourmet	100%	100%	100%	50%
Average	73%	67%	59%	52%

After grafting, the trees grew rapidly, and most trees grew between 2 and 3' tall by the end of the growing season. The growth rates varied a great deal between varieties, but not between rootstocks. The different growth rates appeared to be tied to leaf diseases, especially the disease pear scab, which killed about a third of the leaves on the most susceptible varieties. Clara Frijs, Honey Sweet, and Gourmet had almost no scab and good growth. Summercrisp, Harrow Sweet, and Lucious had pear scab and lower growth rates. Ewart had pear scab, but good growth.

The slightly lower survival rates of the juneberry rootstocks compared to the Old Home x Farmingdale rootstocks may not have any bearing on the compatibility of juneberry

rootstocks. We bought seedling *A. alnifolia* rootstocks, so some rootstocks were nearly $\frac{3}{4}$ " in diameter while others were close to $\frac{1}{4}$ " in diameter. Second, conditions were poor during grafting, which may have lowered the success rates.

During transplanting in the fall, we did notice a difference in root systems between the rootstocks. The two pear rootstocks and *A. x grandifolia* all had fibrous root systems, and nearly all pots were root bound. The roots of the *A. alnifolia* or saskatoon rootstocks did not fill the 3 gal pots. The different root growth on saskatoon plants could be due either to slower root growth or because the plant has a different type of root system, such as a taproot rather than a fibrous root system.

Management Tips

1. Pears can be successfully grafted onto juneberries.
2. Grafting in the spring and planting the grafted plants into pots for the growing season was a successful way to propagate plants.
3. Some varieties of pears are more susceptible to pear scab than others.

Cooperators

Dan Sheild, Stone Creek Farms, Taylor's Falls, MN

Irene Genelin, York Farm, Hutchinson, MN

Project Locations

Central Lakes College Agriculture and Energy Center, Staples, MN. From downtown Staples, go north on Airport Rd. to Cty. Hwy. 2. Take a left on Hwy. 2 for .25 miles. The pear trees are in the old agroforestry block just west of the driveway to the office complex.

York Farm, 21161 York Rd., Hutchinson, MN. From Hwy. 15, take Airport Rd. W. to York Rd. York Farms is on the south side of the road.

Stone Creek Farm is located between Taylor's Falls and Shafer. From Shafer, take Redwing Ave. northeast to 310th St. Take a right (east) on 310th St. Stone Creek Farm is on the north side of the road next to the solar farm.

Other Resources

Cummins Nursery. Website: www.cumminsnursery.com

Lawyer's Nursery. Website: www.lawyernursery.com

This project is in memory of Robert E. Lund, 1922-2016.

Principal Investigator

Melissa Nelson
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Big Stone County

Project Duration

2014 to 2017

Award Amount

\$12,573

Staff Contact

Tori Hoepfner

Keywords

pollinator, insect habitat,
underutilized land

Creating Beneficial Habitat for Management & Wildlife Enhancement on Farm Waste Land

Project Summary

My project will test methods to convert land that is generally not utilized on my farm, such as wooded areas, grass and weed areas around bins, and grass land into beneficial pollinator habitat. This project includes documenting the types and numbers of beneficial insects, which I hope will increase as a result of this project. The Monarch butterfly and bumblebee will be used as sentinel insects, but I also recorded recognized bug species as well. After the habitat is established, I will also document the best methods to prevent undesirable plant species encroachment on the habitats.



Monarch caterpillar found in year 2 pollinator habitat.

Project Description

My farm is currently a cattle grazing operation with limited cropland. In the past few years, I became concerned about the alarming decline in beneficial insects, especially pollinator species. Since I have underutilized “waste” land on the farm that is not amendable to be grazed, I decided to convert this land to long-term, permanent pollinator habitat.

This project consists of three zones of pollinator habitat. The zones are as follows:

Zone 1: This is an east-west strip alongside steel grain bins. Prior to converting this land to pollinator habitat, it consisted of a stand of brome grass and noxious weeds. This area is very hard to mow or properly maintain due to the bins, a hedgerow, and the current south boundary of fences.

Zone 2: This is another east-west strip, which adjoins Zone 1. It was primarily mowed prior to conversion into pollinator habitat. It had short grasses, so it was never hayed or grazed.

Zone 3: This is the wooded area between the current farm grove and the driveway.

In each zone, I measured out a random one square foot area for approximately every 100' by 20' area of pollinator habitat. In this one square foot area, I measured insect diversity. While measuring, I primarily concentrated on monarchs and bumblebees, but noted other insects in the sampled areas as well. I counted insects every month from May through October.

On my Facebook page (The Pollinator Project: www.facebook.com/thepollinatorproject), I actively update the community and other interested parties with project results.

Results 2014

As this year was a preparation year, I do not have any hard numbers to share for this project. I had people who generously volunteered their time to help clean up the toughest project site: the overgrown woodlot with a lot of dead trees.

This volunteer day took place on May 10, with a small follow-up day on May 11 to haul away remaining tree debris. On the first day, we cut down dead trees, chopped them up, and hauled the loads of lumber to a dump site on the farm. Buckthorn was chopped back as well and the debris hauled away. It was a long day to clear this spot. We were rewarded with the discovery of a couple of Viceroy butterflies—not the Monarch I am monitoring in the study but it was the first butterfly sighting of the year.

Prior to the first spray down in June, I took random samples of the plot to measure insect and plant diversity. Zone 1 had primarily brome and quack grasses and burdock weeds. I counted five honeybees in this zone. Zone 2 had primarily orchard and quack grasses, clover, and burdock weeds. I counted 14 honeybees and one bumblebee in this zone. Zone 3 had burdock and buckthorn weeds. The only insects were Asian beetles, in a bunch of approximately 35, and two Viceroy butterflies.

Results 2015

The biggest challenge this year was the timing of mowing and weeding in order to eliminate noxious weeds while encouraging the growth of the pollinator mix. At the beginning of the season, there was very little insect activity. I suspect that this was due to the disturbance of soil in the previous year, which caused few seeds to sprout. If I saw any insects at all, they were mainly flies and ants.

In June, I noticed some bumblebee activity in Zones 1 and 2. In August, I found Monarch butterflies in Zones 2 and 3. As the season progressed, I began to see more insect activity and plant growth, which was a good sign.

This year, Zone 1 was a resounding disappointment. Only a few Black-Eyed Susan plants struggled out of the heavy and persistent brome grass that failed to yield to any mowing or attempt to thwart. I hope that my pollinator seed mix will show itself in this zone next year.

The rest of the spring and summer was spent fighting the rains in order to timely apply herbicide that would kill off the predominant grasses (brome and quack) and weeds (cocklebur and buckthorn). I did manage to get a good kill down of these grasses and weeds by fall despite the rain issue. In early September I spotted a couple of large roosts of Monarch butterflies in the trees in Zone 3, which was a nice treat.

In late fall I used a disk harrow set at a shallow depth to lightly till the soil in the plots. After consultation with the experts at MN Native Landscapes, my seed supplier, I waited to broadcast seed the pollinator mix. I was timing it for a substantial likelihood of no chance of germination of the seeds; so I had to wait until November due to the warm days in October. Unfortunately, by the time the weather cooperated we had a major 12+ inch snowfall on November 10, followed by drifting snow. Therefore, my prepared habitat was covered by a heavy snow cover.

I was able to plow the snow off approximately half of the project area. The rest was impractical due to building layout and trees. Through the action of the sun melting the snow and de-frosting the top layer of the soil, I was able to broadcast seed on November 25. The rest of the habitat will be planted in early spring; as soon as the snow melts enough to safely plant the light seeds without fear of them blowing away in the harsh winds we receive out here.



Zone 1 Pollinator Habitat Year 2.

Zone 2 was successful with an abundance of Black-Eyed Susan plants making a showy appearance in late summer alongside some of the grasses. Honeybees frequented Zone

2, which was likely due to commercial hives on a neighboring farm. Abundant numbers of Sulfur butterflies and Cabbage butterflies were found in Zone 2 this year as well.

2015 Zone 1 Insect Counts by Month						
Insect Type	May	June	July	August	September	October
Monarch butterfly				1		
Bumblebee		3				
Honeybee		6	3	4		
Fly	3	9	7	6		
Ant	5		4	12	7	
Asian beetle						7
Cricket			1		1	
Grasshopper				1		1
Spider		1				

In Zone 3, I had some success in growing pollinator friendly plants. In September, there were Monarch butterflies overwintering in the trees in this area. In the previous year, I found a large roost of them, which I did not find this year. I am not sure why they were not there this

year. I only found one Monarch caterpillar on a milkweed plant in this zone as well. The milkweed did not grow well in this zone this year, which is why I am not comfortable with calling this zone a success. I am hoping that next summer and fall, I will have better results.

2015 Zone 2 Insect Counts by Month						
Insect Type	May	June	July	August	September	October
Monarch butterfly				3	5	
Bumblebee		2	1			
Honeybee		7	12	22	5	
Sweat bee			1			
Carpenter bee		2	4			
Sulfur butterfly				18	7	
Cabbage butterfly		2		6	4	
Fly	3					
Black carpenter ant			2		3	
Ant		17				
Asian beetle						4
Boxelder bug					3	1
Cricket		1				
Grasshopper					4	
Spider						1

Management Tips

1. If you have a heavy stand of noxious grasses or weeds, take an entire year to prepare the area. Thoroughly till the soil, allow roots and weeds to regrow, and then till again.
2. Since my Zone 1 planting was stymied by noxious grasses and weeds, I would recommend tilling the brome roots deeper and removing them by hand. The second year after planting, these plantings will look like a horrible weed plot. Do not be discouraged! All sources say the plants should take off in the third year.
3. Make sure that everyone who works on your farm is aware of the boundaries of your plot. One of my employees, who was mowing the lawn, almost took a small swath right through my planting. Luckily, I caught it in time before any real damage was done.

2015 Zone 3 Insect Counts by Month

Insect Type	May	June	July	August	September	October
Monarch butterfly				2	7	
Carpenter bee			1			
Sulfur butterfly				3	1	
Fly	2			4		
Black carpenter ant		1				
Ant	3		16		1	
Asian beetle				2		4
Boxelder bug					3	7
Junebug	2					
Cricket			2		1	
Spider		2	1	5	2	

Cooperators

Wendy Caldwell, National Program Coordinator, Monarch Joint Venture, St. Paul, MN

Project Location

From Ortonville MN intersection of Hwy. 12 and Hwy. 75: Travel north on 75 approximately 3 miles. Turn right

(heading east) onto Cty. Hwy. 12. Travel for 3½ miles to 700th Ave. Turn left. Travel one mile, farm is on the left.

Other Resources

Xerces Society: www.xerces.org

Pollinator Partnership: www.pollinator.org/pollination.htm

Monarch Joint Venture: www.monarchjointventure.org

U.S. Fish and Wildlife Service's Pollinator Page: www.fws.gov/pollinators

Principal Investigator

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Clay County

Project Duration

2014 to 2017

Award Amount

\$13,257

Staff Contact

Meg Moynihan

Keywords

pollinators, native bees,
insect habitat

Preserving and Attracting Native Bees while Providing a Habitat that Adds Value to Small Acreage

Project Summary

This was the final year of our 3-year study exploring ways to provide native bee habitat and add some financial benefit incentive to farmers at the same time. While programs like the USDA Natural Resources Conservation Service Environmental Quality Incentive Program (EQIP) provide financial assistance for establishing pollinator habitat, finding other financial payback is key. We planted herbs, wildflowers, lavender, pumpkins, squash, and annual zinnia flowers. We also constructed several wooden bee habitats for the bees to overwinter.

Project Description

Our farm is certified organic and located in the Red River Valley, near Moorhead, MN. We grow hay, wheat, oats, rye, barley, food grade soybeans, berries, and we are also starting a small acreage of apple and other fruit trees. We grow pumpkins for assisted living facilities in the area and provide access to our farm for hospice and assisted living patients. We have chickens and ducks. My son Carsten and environmental studies students from Concordia College in Moorhead all helped with the project.

Native bees have been around for millennia. People often confuse them with honeybees, which were brought to North America by the early settlers and produce honey. Native bees are some of the hardest working, lowest maintenance insects you can find. Unlike honeybees, which live in hives, native bees live in the ground, wood, and fields. There are more than 400 kinds of native bees in Minnesota, ranging in size from the large bumblebee to the very small green sweat bee.



A local Girl Scout troop helped with the project, too.

We think that it is important to encourage the use of native bees as pollinators. For farms in general, honeybees can be another layer of work at the peak of season with already heavy workloads. The honeybees are great for honey but buying bees and the equipment you need to raise them is expensive and overwintering them can be a challenge. On the other hand native bees are here naturally and they sting less.

We were curious about whether providing native bee habitat and plantings would have a positive impact on the environment and improve farm income. We wanted to know how much income we could generate by planting herbs, annual flowers, pumpkins, and, in this final year, squash and wildflower mixtures. We compared the outcome of what we saw in the different habitats and also what products we could introduce to the marketplace.



Zinnias were popular in bouquets.

2014 Results

The spring was cold, wet, and long. We bought both mason and leafcutter bees, and I think we released them too early. Waiting and keeping them in the refrigerator until later in the spring would have been better.

The wildflowers we planted had a higher amount of bumblebees than the other areas, and bumblebees were most abundant on bachelor buttons. Honeybees seemed

to move to the zinnias. We constructed several wooden bee habitats to overwinter the bees – but later stopped providing habitat for them to overwinter after we learned that solitary bees who nest together may have more disease issues.

2015 Results

The weather was good except for a late spring freeze, which caused some early flowers and most of our pumpkins to freeze, reducing the nectar available for the bees. The lavender did not come up well this year, either. We should have planted later or purchased hardier plants.

However, we saw even more bumblebees compared to the first year. They visited twice as many flowers as honeybees (and we're told they can work when the temperature is only 50°F). We found the most bumblebee activity in the zinnias, and saw the most native bees on the wildflowers. Chamomile, which blooms nonstop, attracted a constant amount of small beneficial bees. Peppermint was the least attractive to native bees. We think this might be due to the fact that it does not flower continuously.

Leafcutter bees were present in the spring and all through summer. We also saw leafcutters in the overwintering stage, which we had not seen before.

The income we generated is reported in Table 1. We sold a number of herbal teas ranging from a calming chamomile and mint mixture to herbs such as peppermint. The benefits of having herbs in a pollinator habitat is that the herbs can be dried and sold all year round. The dried herbs allow us to sell in the spring at farmers' markets and to have product to place in a Community Supported Agriculture box early in the season before many garden vegetables are ready to pick.

We found that blending the herbs generated more revenue. For example, we sold more peppermint when we combined it with chamomile. We also made more when we packed the teas in smaller amounts, such as 2 oz. sample amounts at farmers' markets. The 2 oz. packages sold for \$2.50 each, which equals \$40/lb. of dried herbs compared to \$12/lb. when sold in larger packaging.

We sold flowers, too. The zinnias were popular among brides looking for a rustic look. We made more money when we sold flowers in bouquets. Customers bought wildflower bouquets for \$12 to \$15 with little hesitation.

While the flowers were good income generators, timing is very important. When the flowers are ready to sell, the window of time to sell them is very small. We planted mostly perennial flowers. Zinnias are annuals, but you can save seed from the zinnias

When tour groups come out to the farm, the wildflowers and annuals bring a lot of joy, especially to senior assisted living residents. We also had several other tour groups visit and pick their own. Although this does not add money to the bottom line it really has given us a lift to know how much others appreciate the flowers.

Table 1. Revenue Generated by pollinator Plantings (\$)

	2014	2015	2016
Zinnias and mixed flowers	1,200	108	240
Tea			43
Wildflowers		96	144
Lavender			
Pumpkins	400		
Fresh peppermint and chamomile		42	
Dried chamomile, lemon balm, mint		42	
Peppermint			63
Chamomile			20
Total Income	\$1,600	288	\$510

Note: These numbers represent the average income received from a 6' x 5' area of habitat.

2016 Results

The weather was great and we found higher populations of native bees than we had ever seen before. Flowering shrubs nearby bloomed at the right time, which may have helped.

We grow Juneberries and chokecherries on our farm, and this year, our yields were record breaking. We think that was due to the increased presence of native pollinators.

Borage flowers and chamomile emerged well in spring, as did several areas of self-seeding annuals and perennial wildflowers. The wildflowers were thicker and more abundant than ever.

As with previous years, we found the highest native bee activity in the wildflowers, while zinnias attracted the most bumblebees. The always-blooming chamomile, attracted a constant number of small, beneficial bees. Peppermint was once again the least attractive to the native bees. The tea sales really took off in 2016. We sold blends like "Tension Tamer," which was a chamomile and mint mix, at the Red River Farmers Market in Fargo. People loved it!

As a result of doing this project, we have adapted some of these practices on our farm, such as planting several wildflowers around our fruit tree base and planting pumpkins for weed control around trees. We also plan on growing more herbs. Once established, they come back with little care, and are one of the first plants of the spring season.



Elders came on field trips several times and picked armloads of flowers.

Management Tips

1. Pay attention to the type of chamomile you are buying. The choice between annual and perennial chamomile can be expensive.
 2. Provide natural shelters such as wood, mud, leaves, and big items on the property, for native bees. In addition,
 3. Make sure to mark the area and have friendly talks with neighbors to avoid pesticide spray drift.
- reducing tillage allows the bees to have a habitat and overwinter in undisturbed soil.

Cooperators

*Bryan Bishop, Ph.D. Entomologist, Concordia College,
Moorhead, MN*

*Concordia College Environmental Study Students,
Moorhead, MN*

Carsten Thomas, Worker Bee, Moorhead, MN

Project Location

From the intersection of Hwys. 75 and 108, go ¼ mi straight west on Hwy. 108 in Kragnes township.

Other Resources

Minnesota Department of Agriculture:
www.mda.state.mn.us

University of Minnesota Bee Lab:
www.beelab.umn.edu

Principal Investigator

Sue Wiegrefe
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Mabel, MN 55954
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Project Duration

2016 to 2018

Award Amount

\$9,765

Staff Contact

Meg Moynihan

Keywords

Hazel, hybrid hazel,
mushroom, Shiitake,
substrate, Wine Cap

Evaluating Hybrid Hazel Wood Chips as a Mushroom Substrate

Project Summary

This project tests the idea of using of chipped hybrid hazelnut (*Corylus x*) branches as substrate for growing Wine Cap and Shiitake mushrooms. I am comparing hazel wood chips with standard substrates. I'm hoping to determine whether this by-product of the developing hybrid hazelnut industry can generate an additional income stream for producers and improve overall enterprise profitability.

Project Description

My farming operation, Prairie Plum Farm, is small-scale at 14.5 acres. In order for it to generate reasonable income, I need to produce items of high unit value. The entire property is planted to perennial ground cover forages, except for a 26' by 60' hoop house (and other buildings), and a 30' by 30' vegetable garden. I have integrated grazing animals, including registered Babydoll Southdown sheep, with the production of fruits, nuts, and vegetables. Part of my overall philosophy is to have the "waste" from any one enterprise provide useful inputs into another.

I am also a hazelnut grower. As I looked to the future management of my very young hazel planting, I searched for a use for the wood that is typically coppiced (cut back to ground level) periodically to maintain high nut yields. I deliberated about options including burning, burying, and chipping for mulch. I decided that using the wood to produce tasty, nutritious, and valuable food (mushrooms) would be a better option – IF it works biologically and economically. In addition, the spent mushroom compost could be another value-added product.

Hybrid hazel is a relatively new entity comprised of three component species: American, beaked, and European hazels. Both Wine Cap (*Stropharia rugosa-annulata*) and Shiitake (*Lentinula edodes*) mushrooms are known to colonize close relatives within the birch family, so I am optimistic that my idea of growing mushrooms on hazel wood chips will work.



Chipping hazel branches.

System	Substrates	Species
Ground bed (2016, 2017)	1) Hazel wood chips/straw 2) Boxelder wood chips/straw 3) Straw (Control)	Wine Cap
Sterilized substrate (2017)	1) Hazel chips/oak sawdust 2) Oak shavings/oak sawdust (Control)	Shiitake

In 2016, I concentrated on the Wine Caps. Table 1 shows the approaches I am testing. I plan to evaluate mushroom

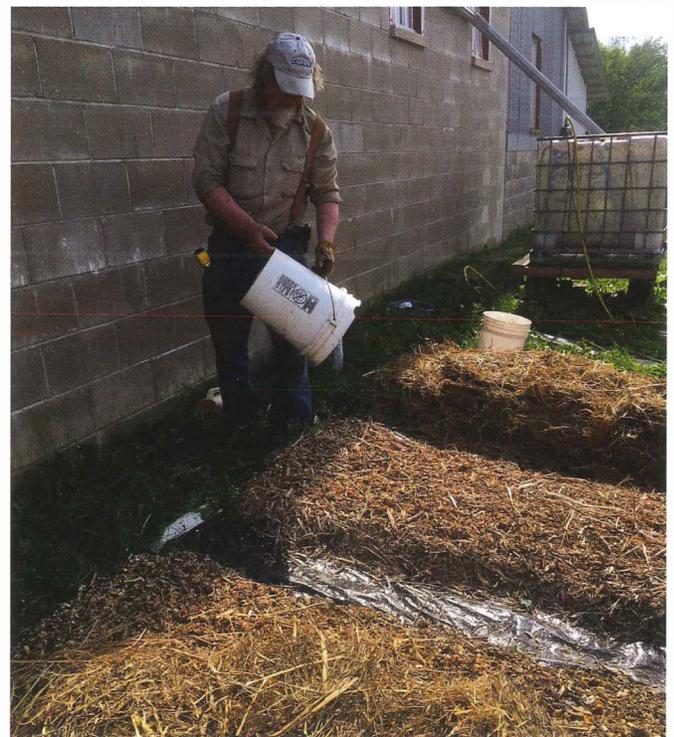
weights and time to harvest in each system.

2016 Results

The Wine Cap ground bed culture produced very spindly mushrooms on the straw beds and the hazel/straw beds. They were 3 weeks earlier than I anticipated and not even recognizable as Wine Caps, so I did not collect or weigh them. It is possible that the beds weren't deep enough (providing inadequate nutrition) or the spawn had deteriorated in storage.

The boxelder chips did not produce any mushrooms at all. I'd kept the chips in the bed of my covered, shedded pickup truck, but wild-type fungi colonized the chips. I used the chips anyway, to see what would happen. But after three days, the wild-type "feral" fungi had already produced extensive colonies. I suspect that the feral fungi may have prevented the establishment of the Wine Caps – if that's what those spindly mushrooms were. I'll know more when I repeat the experiment in 2017.

Mushroom cultivation references (Stamets, 2000) stress that it is very important to inoculate substrate blocks within hours of removing from the steam sterilizer in the bag-culture system (which I am going to try with Shiitake in 2017). So leaving the fresh boxelder chips in the bed of the truck for days was apparently not a good practice.



Watering the first three Wine Cap beds.

Management Tips

1. To prevent colonization of your substrate by wild fungi, either chip and construct beds of chips the same day as cutting OR cut the branches and allow them to age/dry as intact branches. Leaving the bark on while the branches dry should impede colonization by wild fungi.
2. To save time, either invest in a pump/pressurized system to expedite water delivery to the mushroom beds or arrange for a completely gravity-based drip or ooze hose irrigation system that can be put on a timer.
3. If you have free range chickens be sure to cover the beds with chicken netting. If you are producing mushrooms for sale, you'll have to exclude the birds entirely (for food safety reasons).
4. Timing and timeliness are critical when growing mushrooms. Before you begin, be sure you have scheduled enough time to reach a natural stopping point in the process.

Cooperators

Matt Ratliff, Owner of Ready2Fruit and Fruits, Nuts, and Vegetables, Fort Ripley, MN

Project Location

From Hwy 44 in Mabel, turn north on Hwy 43 for less than .25 mile. Turn left onto 120th St./Cty. Rd. 28. Farm is about 1.7 miles on right (north) side of road. Address/Fire number 42443.

Other Resources

Stamets, Paul. 2000. *Growing Gourmet and Medicinal Mushrooms, Third Edition*. Ten Speed Press, Berkeley, CA.

Principal Investigator

Aaron Wills
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 Rice County

Project Duration

2014 to 2016

Award Amount

\$8,413

Staff Contact

Meg Moynihan

Keywords

acetic acid, blueberries,
 Canada thistle, organic,
 vinegar, weeds

Controlling Canada Thistle in Organic Blueberry Production

Project Summary

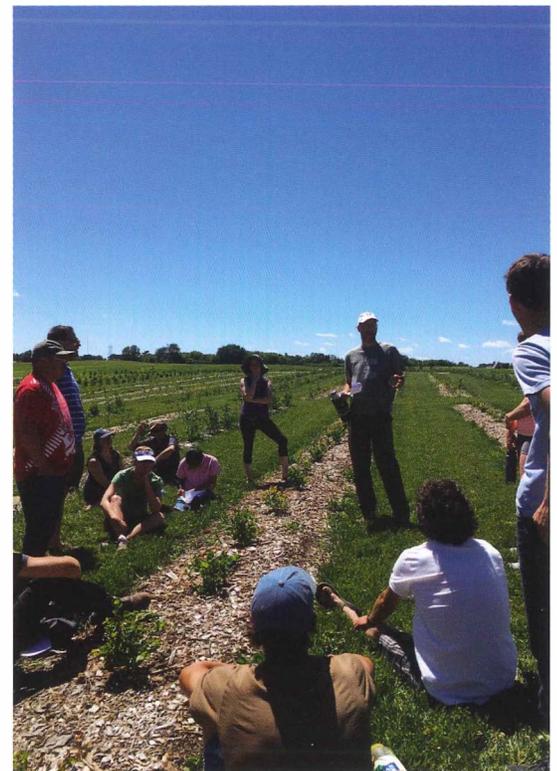
We compared three different methods for controlling Canada thistle on our certified organic blueberry farm in southeast Minnesota. Our goal is to find a thistle control strategy that has reasonable time requirements, is compatible with organic regulations, and significantly reduces Canada thistle pressure in our blueberry fields. When we considered labor and level of control, our preferred strategy turned out to be repeated applications of acetic acid.

Project Description

We farm near Northfield in Dakota County, where we grow 4 acres of certified organic “pick your own” blueberries. We planted our first blueberry field in 2011, and opened for picking in 2014. We plan to scale up to 7-10 acres of blueberries within the next couple of years.

In 2013, we spent 45 hours hand pulling Canada thistle *Cirsium arvense* (L.) in a new, 1 acre blueberry field. Even with that much labor, at times our blueberry plants were overgrown by Canada thistle. We realized this was an unsustainable situation (for both us and the blueberries) and that we needed to find a better strategy for Canada thistle control.

Canada thistle is a perennial weed. It has a unique life cycle that requires a different set of control strategies than annual—and even most perennial—weeds. Canada thistle spreads both by seed and by underground rhizomes, eventually forming a thick mat of sprouts called a *clonal patch*. Within a clonal patch, every sprout is genetically identical to the mother plant, and most sprouts are interconnected. The majority of thistle biomass exists below the ground in the form of roots and rhizomes. Canada thistle rhizomes grow very deep in the soil, beyond the reach of even moldboard plowing. Once a thistle clone becomes established, it can live for decades and is difficult to kill by cultivation or even with many conventional sprays.



Aaron explains thistle control options for young blueberry plants at a field day.

We tested three thistle control strategies that took into account Canada thistle's long life cycle. Our goal was to find a control strategy that has reasonable time requirements, is compatible with organic rules, and significantly reduced Canada thistle pressure in our blueberry fields over time. We tested the three control strategies within the 4' wide blueberry row. We planted the area between the rows to grass and mowed it several times each summer.

We tracked the time we spent per acre on each strategy, its cost per acre, and the associated reduction in thistle pressure. In order to estimate the reduction in thistle pressure, we monitored the size of shoots as they emerged from the ground. Sprouting shoots rely on stored carbohydrate reserves from underground roots rather than photosynthesis. Shoots that sprout from a weak root system have smaller leaves and grow more slowly than shoots sprouting from a healthy root system.



You can see the edge of a thistle clonal patch in this row.

Control Strategy #1- Vinagreen

We sprayed the Canada thistle repeatedly throughout the growing season with Vinagreen, a 20% acetic acid (concentrated vinegar) approved by our organic certifier for use in organic production. Acetic acid is a contact weed killer. We sprayed when the thistle sprouts were quite small, at approximately the four leaf stage (Figures 3 and 4). Using a backpack sprayer, allowed us to spray individual thistle sprouts without drifting onto and damaging the blueberry plants.

Control Strategy #2 – Landscape Fabric as a Weed Barrier

In 2014, we laid down DeWitt Weed Barrier Pro landscape fabric in the blueberry rows. We planted the blueberries first, and then installed the landscape fabric. This type of material is allowed in organic production as long as it is removed from the field before it decomposes. Its lifespan is approximately 15 years.

Control Strategy #3 – Hand Pulling

We allowed the thistle to grow to the flower bud stage (near the summer solstice, June 21) and pulled it just before it flowered. Pulling at this time is supposed to weaken the plant when it is most vulnerable. We then let the plant regrow until it formed flower buds and pulled it again. Depending on the growing season, we may need to pull the plants a third time.

Table 1. Project Treatments

#1 Vinagreen	Spray thistles repeatedly throughout the year with 20% acetic acid (concentrated vinegar).
#2 Landscape fabric	Install landscape fabric barrier in the planting row.
#3 Hand pulling	Allow the thistle to grow to the flower bud stage (around the summer solstice) and pull it just before it flowers. Pull it again a second time in early fall.

Results

Over the course our 3 year project, acetic acid continued to weaken the thistle plants and turned out to be our preferred strategy. Hand pulling did not weaken the thistle plants and is much harder work than spraying it. Landscape fabric provided total control. But while we did not observe any negative effects on the blueberry plants planted into landscape fabric compared to those in our normal mulched rows, we have concerns about how the fabric changes the growing environment and may affect soil health.

Costs of the three treatments are reported in Table 2. While the cost of Vinagreen and hand pulling were comparable in the first year, over the course of the project, Vinagreen emerged as the lowest cost management strategy. It became less expensive because the labor required to spray

decreased as the thistle plants weakened. The landscape fabric strategy cost us almost nothing in 2015 and 2016 because it completely controlled the Canada thistle, the high initial outlay to purchase it make it the most expensive option.

In the final year of the project, we also tried weed whipping as a management strategy. While we did not track labor cost for weed whipping, we did observe that it was as effective as acetic acid in weakening the thistle plants when we did it repeatedly and when the thistle plants were small. It seemed to take about half the time as applying acetic acid. In the future we will likely use a combination of weed whipping and acetic acid for thistle control in our blueberry rows.

Table 3. Canada Thistle Control Strategies, Cost per Acre, 2014-16

	Labor Hours	Labor Cost (\$15/hr)	Vinagreen Cost	Landscape Fabric Cost	Total Cost
Strategy #1 Vinagreen	78	\$1,170	\$600		\$1,770
Strategy #2 Landscape fabric	64	\$960		\$1,980	\$2,940
Strategy #3 Hand pulling	160	\$2,400			\$2,400

Management Tips

1. Controlling Canada thistle before you plant your blueberry field is much easier than after your blueberry field has been established. If possible, try to weaken or eradicate Canada thistle from your field with repeated cultivation and/or cover crops before planting your blueberry plants.
2. Vinagreen with an adjuvant seems to work much better than Vinagreen alone. We used CMR Organic Oil Adjuvant. Vinagreen is most effective when the temperature is 70°F or higher.
3. Canada thistle keeps growing into October in our area. It is not killed by light freezes. Don't neglect thistle control in September and October even if your crop is done. If you do, you will allow the thistle plant to recover. Keep treating it!

Cooperator

Thaddeus McCamant, Central Lakes College, Staples, MN

Project Location

From Northfield, take Hwy. 3 north 2 miles. Turn left on 320th St. W. and about a ¼ mile. We are located on the right (north side of the road).

Other Resources

Alger, Jess. 2012. Organic control of perennial weeds with vinegar and biologicals. Stanford, MT. Final report. SARE project number: FW11-024. mysare.sare.org/MySare/ProjectReport.aspx?do=viewRept&pn=FW11-024&y=2012&t=1

Forsburg, Fred. 2014. Vinegar as an organic herbicide in organic garlic production. Livonia, NY. Final report. SARE Project number FNE03-461. mysare.sare.org/MySare/ProjectReport.aspx?do=viewRept&pn=FNE03-461&y=2004&t=1

USDA Agricultural Research Service has conducted research on the use of concentrated vinegar for weed control. Visit www.ars.usda.gov and use the search word “vinegar.”

Principal Investigator

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 Learning Center
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Project Duration

2015-2017

Award Amount

\$19,583

Staff Contact

Meg Moynihan

Keywords

amendments, biochar,
 fertility, lime, pH, soil,
 soil health, wood ash

Raising Soil pH Effectively in Acid Soils

Project Summary

Soil health, productivity, climate change, and the need to sequester carbon are challenges to building food and farming systems that will be sustainable long into the future. We farm in northeast Minnesota, a region where acid soils are common and present agricultural production challenges. Our goal is to simultaneously raise soil pH and increase soil health on our farm using organic methods. We're specifically interested in comparing the labor, cost, and effectiveness of applying mined lime, wood ash, biochar, and combination applications.

Project Description

The Wolf Ridge Environmental Learning Center started an organic farm in 2009. Our goal is to provide all of the vegetables needed to serve 136,000 meals a year at our school cafeteria. We have built a processing facility for cleaning, cooling, and preparing the vegetables for the cafeteria, and we have kitchen gardens and an outdoor timber frame educational space for classes, workshops, and meals. This soil pH project we are undertaking is an essential part of our efforts for a productive, ongoing, price-stabilized local food source for the school children, teachers, and parents who attend Wolf Ridge each year.

Our soils here are very acidic—the typical pH is less than 5.0. Our need to find a cost effective and sustainable way to raise the soil pH and improve soil health motivated us to do this project. We are currently farming a small parcel of cleared land, and most of our production is in large commercial high tunnel greenhouses. We are in the process of clearing 3.25 acres of land, where we have begun growing potatoes, carrots, onions, beans, broccoli, and squash; this is where we are conducting our soil amendment demonstration. We surrounded this area with deer fence, which is essential for field production of vegetables in our area.

We are using five different amendment treatments (plus a “no treatment” control) on 50 x 50' plots. We are evaluating actual pH change and soil health (nutrient retention, organic matter, and biological health).

In the first year of our project, we established the field and conducted baseline soil testing. We cleared trees and brush, using a chain saw to cut the trees and a backhoe to dig out the stumps. We buried the logs and stumps below the future plow line. We removed large rocks and dug the entire area 3' deep, sifting the soil with the hoe.

In October, 2015, we marked out the six test plots and pulled four soil samples from each plot, combining them to make one composite sample for each plot. The results confirmed that our entire demonstration field was uniformly acidic, with soil pH between 4.3 and 4.7.

In 2016, I met with NRCS soil scientists to review the 2015 soil tests and determine the amount of each amendment we should add. We also made calls to several biochar experts. We decided to put 350 lb of lime on plots 1 and 4. We decided to apply 700 lb wood ash on plots 2 and 5. (Our original plan was to apply 1,000 lb, but considering the nutrient dense, high-valued wood pellets used in the Wolf Ridge furnaces, we decided 700 lb was enough.) Three of our plots also included biochar. One biochar expert recommended adding no more than 100 lb of biochar to the 2,500 ft² plots. All of the biochar experts we consulted

recommended that we inoculate the biochar with compost, but we did not. Instead, we added 100 lb dry biochar to plots 3, 4, and 5. Plot 6 was our control, with no amendments added.

In the spring and early summer 2016, we finished preparing the area that we had cleared the previous year. More than 100 students and dozens of workers dug out tree roots and rocks with shovels and pick-axes. Then we tilled the soil with a walking tractor, following behind to grab roots and rocks that the tractor turned up as it bounced along.



A student helps prepare the virgin land before we till the area and add soil amendments.



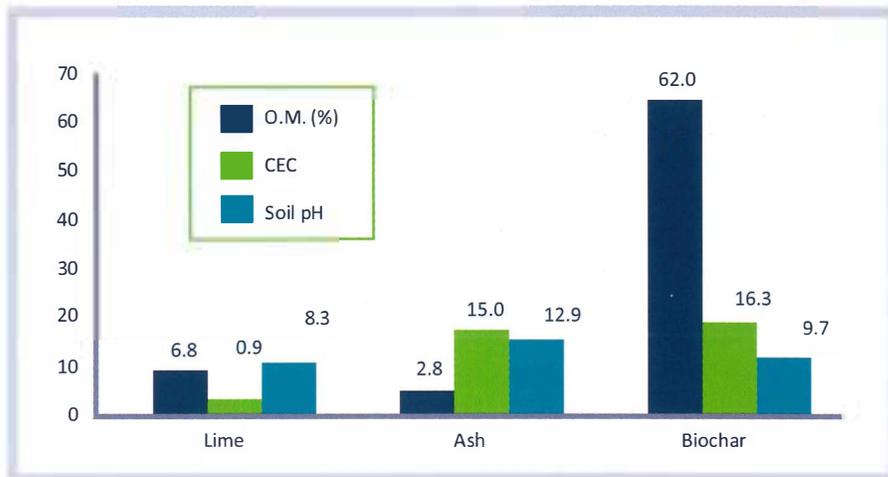
Summer Intern Julia Kloehn supervises as David measures biochar.

TABLE 1. Treatment: Inputs and Rates Applied

#1	#2	#3	#4	#5	#6
350 lb lime	700 lb wood ash	100 lb biochar	100 lb biochar + 350 lb lime	100 lb biochar + 700 lb wood ash	Control (nothing added)

On August 15, 2016 we added the amendments to the plots at the recommended rates (Table 1). We incorporated the amendments with the walking tractor. We then broadcast 8 lb of buckwheat seed and tilled it into each plot for our first cover crop. In October, we pulled more soil samples. We allowed the cover crop to grow through fall, and left the standing crop in the field to protect the soil. In spring 2017, we will do more soil testing.

Figure 1. OM%, CEC and pH of the Raw Soil Amendments Applied.



2016 Results

Results of the soil tests we took in October 2016 indicated that some of our treatments are already having more impact than others (Table 2).

	PLOT 1: Lime		PLOT 2: Wood Ash		PLOT 3: Biochar	
	2015	2016	2015	2016	2015	2016
% Organic Matter	10.5	6.6	10.3	5.8	11.1	3.9
CEC	8.5	6.4	7.1	9.5	7.7	4.1
pH	4.3	5.0	4.7	5.7	4.5	5.2
Mg (ppm)	6.4	54.0	9.2	92.0	7.3	52.0
Ca (ppm)	23.9	623.0	35.5	1281.0	29.7	420.0

	PLOT 4: Biochar + Lime		PLOT 5: Biochar + Ash		PLOT 6: control	
	2015	2016	2015	2016	2015	2016
% Organic Matter	10.8	4.2	11.1	1.8	12.9	2.7
CEC	6.9	10.1	6.5	18.5	6.1	10.8
pH	4.6	5.3	4.7	7.1	4.7	5.5
Mg (ppm)	9.4	162.0	9.7	391.0	10	219.0
Ca (ppm)	32	1,084.0	36.6	2,976.0	35.3	1,178.0

NOTE: all inputs were applied August 15, 2016

OM %

As we expected, the transforming previously largely anaerobic wooded land to aerobic cultivated fields produced significant reductions in soil O.M. This reduction should stabilize and, with careful conservation farming efforts using cover cropping, green manure and composts, we should begin to rebuild more stable O.M. levels.

pH

At this point, the clear short-term results show that ash (#2) and biochar + ash (#5) amendments produced a sizeable pH change (Figure 2). What is remarkable, is the difference between the ash amended field (rose from 4.7 to 5.7) and the biochar & ash amended field (rose from 4.7 to 7.1).

The lime (#1), biochar (#3), and biochar + lime (#4) treatments resulted in a short-term pH adjustment similar to what we saw in the control field (#6). Cultivation practices that promote oxidation also produce increased soil PH. We think that tillage accounts for the pH increase in the control plot.

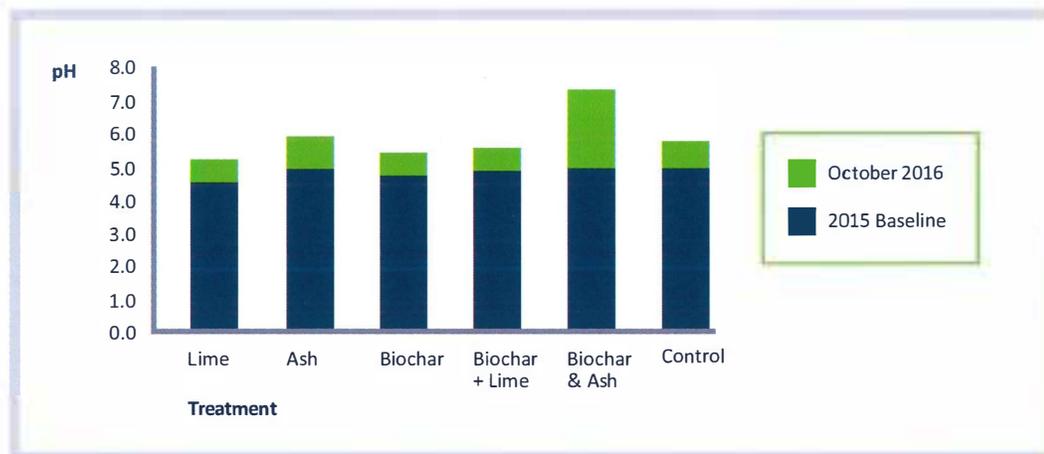
Mg

The short-term results show that Mg in the biochar + lime (#4) and biochar + ash (#5) treatments increased, compared to lime only (#1) and ash only (#2) treatments. The biochar only treatment (#3) had the lowest Mg value. The big anomaly we saw with Mg is that the level of this nutrient rose more in the control plot than in any of the treatments except biochar + ash.

Ca

One year after we applied the treatments, we saw the biggest Ca increases in the ash (#2) and the biochar & ash (#5) treatments, with increases of 1,246 ppm and 2,939 ppm, respectively. We think the increase in Ca is due to the high CEC levels of both the ash and the biochar. We did see a similar pattern in the lime (#1) and the biochar + lime (#4) treatments: that is, the lime +biochar treatment held more Ca than the lime alone. The biochar + ash treatment was the only one to vary substantially from the control.

Figure 2. Soil pH changes between baseline test November 2015 and subsequent test October 2016.



From the chemical analysis data, it was clear that treatment #5 (biochar + ash) produced more changes than any of the other plots, including treatment #2 (ash only). The ash-only plot had the second most significant change.

In addition to a higher pH level, the ash amendment has a small particle size with lots of surface area for quick assimilation into the soil, as compared to the lime amendment. Even though the pH of the biochar amendment itself was significantly higher than pH of the lime amendment, I do not think that is what determined the pH change in field plot 3 (biochar only) – since, due to its large particle size, the biochar assimilation rate is likely to be slower than either the lime or ash.

I think the extraordinary rise in pH and the higher Ca and Mg levels in plot 5 (biochar + ash) is due to the high CEC of both the ash and the biochar amendments.

We processed biological soil samples ourselves, using the Berlese funnel technique, which extracts living organisms, especially arthropods, from soil. We used a microscope to screen the samples to look for both the number and diversity of soil arthropod life. Unfortunately, we didn't find arthropods in any of the soil samples, and we only found a few worms. My confidence level of the Berlese funnel soil sampling technique is low.

Given the lack of biological data, I am going to change our data collection protocols next year. We will continue to take soil samples and do another series of Berlese funnel tests. However, I am also planning to add several new samples and analyses for comparison.

Adding the following two Berlese Funnel samples will let us know whether the method is sound:

- One sample from the soil of my own family farm, which I know has a mature biological soil community.
- One sample from the intact forest surrounding the test fields.

We are also going to diversify our biological tests beyond the Berlese Funnel:

- Another sampling technique we learned from several soil scientists who visited the Wolf Ridge Farm this summer – using hand lenses and a sorting table to look for arthropods in a designated time frame.
- The Solvita 1-day CO₂C test to assess the biological life on each field plot. NRCS has offered to help us perform these tests.

Quick Data Summary

- The biochar + ash (#5) treatment showed significant and superior results in regard to pH change and nutrient retention.
- We saw little difference in pH and nutrients between the control (#6) and any of the other treatments -- except ash only (#2) and biochar + ash (#5)
- Once tilled, organic matter was quickly consumed in all plots, especially in the biochar + ash (#5) and the control (#6).
- The biological data at this point showed no difference among any of the plots.

Management Tips

1. Use multiple biological soil sampling techniques to build confidence in assessing your soil.
2. Shipping costs will probably make biochar expensive, unless you have an on-farm or local source.
3. Use wood or other pure biomass ash to eliminate heavy metal contamination of your soil.

Cooperators

Mike Walczynski, USDA-NRCS, Duluth, MN 55811

Morgan Williams and John Lavine, Biochar Solutions Inc., Lafayette, CO.

Midwest Laboratories, Omaha, NE

Project Location

From Duluth MN, follow Highway 61 north for 66 mi. When you see a large sign marking the turn to Wolf Ridge, take a left on Cty. Rd. 6. Travel 4 mi to Cranberry Rd. Turn left and travel .7 mi; the farm will be on your right. Look for the sign!

Other Resources

Meyer, John. 2013. Kwik-Key to Soil-Dwelling Invertebrates. Raleigh: Vision Press.
www.cals.ncsu.edu/course/ent525/soil/ident.html

Lowenfels, Jeff and Wayne Lewis. 2010. Teaming with Microbes: The Organic Gardener's Guide to the Soil Food Web by Jeff Lowenfels & Wayne Lewis. Portland: Timber Press.

Smillie, Joe and Grace Gershuny. 1999. The Soul of Soil. 4th Ed. White River Junction, VT: Chelsea Green Publishing, Inc.

Soil Health Research in Southwest Minnesota

Principal Investigator

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Project Duration

2015 to 2017

Award Amount

\$16,814

Staff Contact

Jessica Del Fiacco

Keywords

cover crops, soil health, soil
nitrate

Project Summary

This project was designed to provide southwestern Minnesota farmers with soil health and fertility data to show how cover crops can bring value to their farm operations. This research focuses on four farms that have established 50 acre cover crop plots specifically for cover crop research. Soil samples collected and analyzed from the plots over three growing seasons will provide sufficient data points to statistically analyze the economic and environmental impacts of cover crop management. The Haney Soil Health Test (Haney Test) and the Nitrate Soil Test are being utilized to collect and measure baseline data as well as the changes in soil health and fertility that can be attributed to cover crop impacts. At the end of the project, the project partners will host a field day to present the research.



Figure 1. Fall strip till application on the Christoffer property.

Project Description

The project is located on four farm sites; two in Jackson County and two in Nobles County. The cooperators on this project consist of four farmers, the Heron Lake Watershed District, and Extended Ag Services, Inc., all of whom are working under an Environmental Protection Agency (EPA) 319 Grant. Through the EPA 319 project, each farmer established 50 acres of cover crops. Tillage transects, infiltration measurements, and soil samples are being taken to gauge cover crop success. The benefits of cover crops, which include reduced soil erosion and compaction, increased water infiltration to prevent runoff, nitrogen translocation back to the root zone, increased organic matter, and improved wildlife habitat are well documented. We are unaware, however, of any first-hand data about cover crop effects on soil fertility and soil health for southwest Minnesota. The need for first-hand data about cover crop effects is the main reason we applied for this grant.

Andy Nesselth, with Extended Ag Services, Inc., collected soil samples from each of the four cover crop sites. Three control samples were taken in order to develop baseline data. Soil samples were taken from the following sites on each farm:

- a non-agricultural site with perennial grass cover. This site should provide us with optimal soil health characteristics, which provides an indication of where we want our soil health characteristics to be;
- an agricultural site with no cover cropping history. This will provide soil characteristic data similar to our starting point;
- four agricultural sites with 4-5 years of cover crop history.

Samples from these sites will provide information on the long-term results of cover crop management. All soil samples were tested by the Haney Test and the Nitrate Soil Test. The Haney Test was developed to not only test for basic soil nutrient parameters, but also to determine the level of microbial activity in the soil. The different soil parameters tested in the Haney Test are analyzed mathematically to give a Soil Health Condition. The Soil Nitrate Test is an accepted Best Management Practice utilized to make accurate nitrogen fertilizer recommendations.

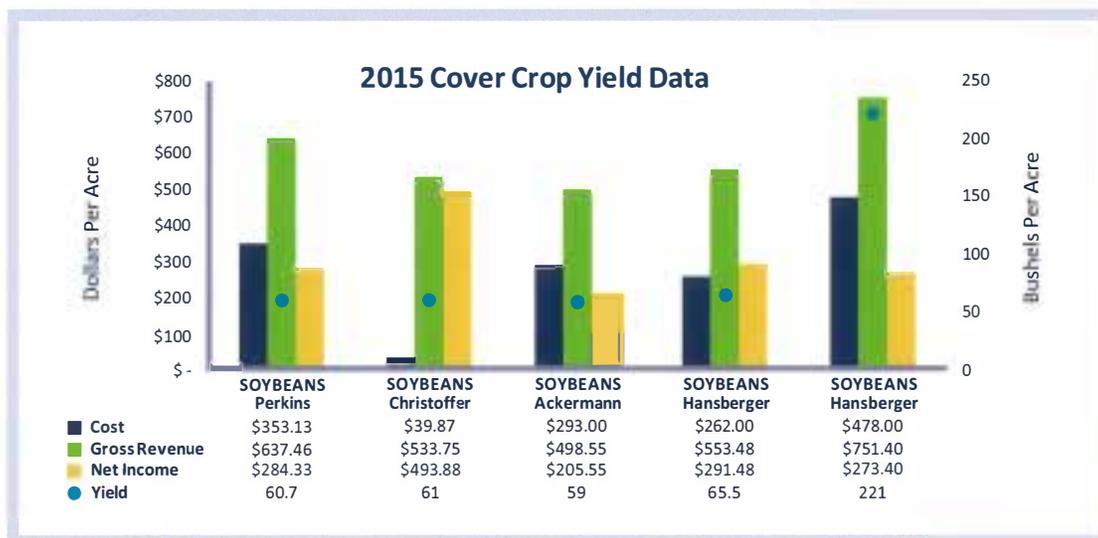
Our collaborators consist of the following farmers:

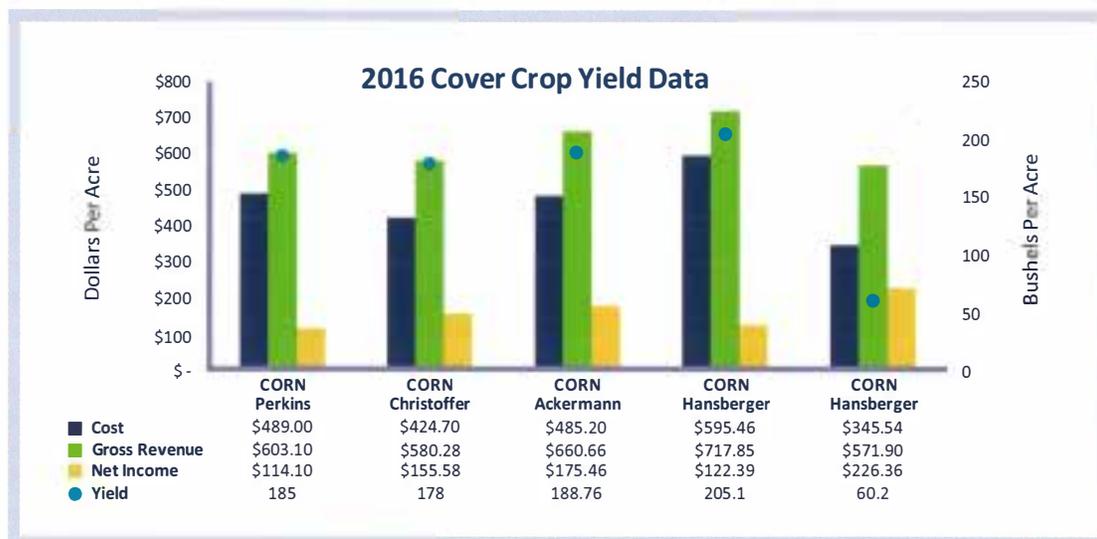
1. Principal investigators, Jerry and Nancy Ackermann, have been farming for 38 years and are active in pursuing on-farm research and test plot opportunities. Their crop rotation includes corn, soybeans, and alfalfa on 1,050 acres. For the past 11 years, the Ackermann's have incorporated 350 acres of no-till soybeans and 350 acres of strip-till corn in their rotation. They utilize the alfalfa as a cash crop and nutrient management tool in their alfalfa-corn rotation.
2. Dave Christoffer has been farming for 43 years. He farms 220 acres that he converted to strip-till production in 1992. He also rents 300 acres to two different individuals and works with them to incorporate conservation tillage and cover crops in their production systems.
3. Jerry and Terry Perkins have been farming for 40 years. Their farm consists of 627 acres of land. They rent 415 acres to a young farmer who utilizes no-till practices in his soybeans and strip-till practices in his corn crop.
4. Tim Hansberger has been farming for 10 years. His educational background includes a degree in Agronomy Production from the University of Minnesota. He farms 645 acres of no-till soybeans and strip-till corn.

Results

2015 Notes: We received 6" of rain in the 10 day period following harvest. There was no ponding of water on the fields where cover crops had been utilized, even on areas

heavily impacted by trucks and grain carts. Neighboring fields showed ponded water on areas that had been tilled to relieve compaction.





Soil Test Protocol

A minimum of six soil zones were sampled from the cover crop sites on all four farms. Three different control sites were sampled as well including a grass covered site, a site

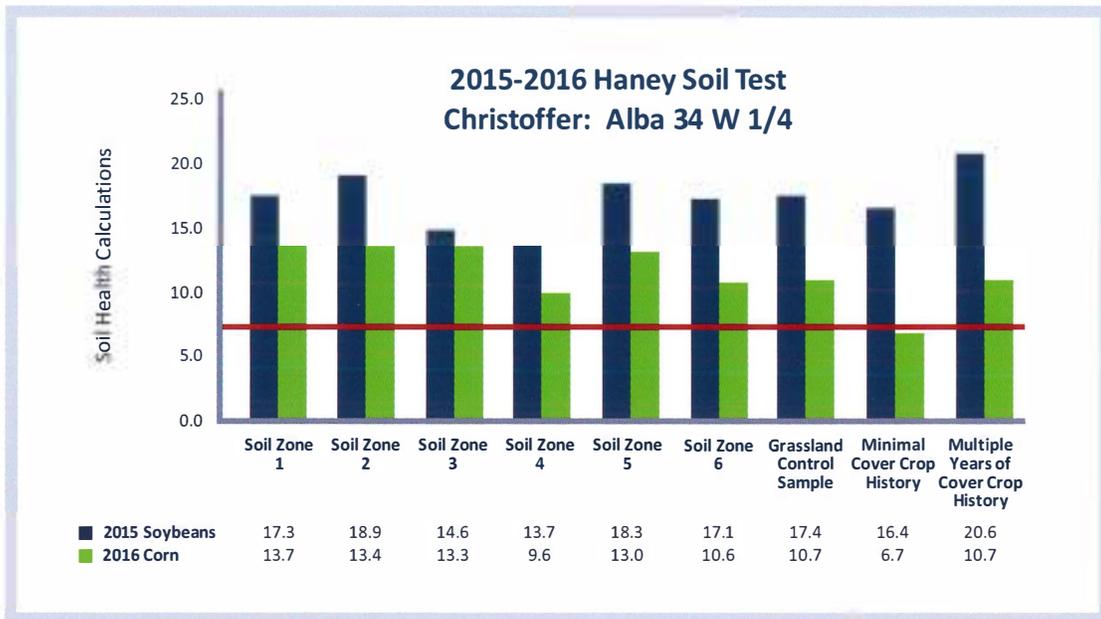
with less than one year of cover crop history, and a site with 2 to 5 years of cover crop history.

Haney Soil Test Results 2015-2016

Each field had six to ten soil zones and three control sample zones. These control sample zones included a grass covered site, a site with minimal history of cover crops, and a site with multiple years of cover crop history. In November 2015 and 2016, soil samples were collected by Andy Nesseth, Extended Ag Services from each site and submitted to Minnesota Valley Testing Lab.

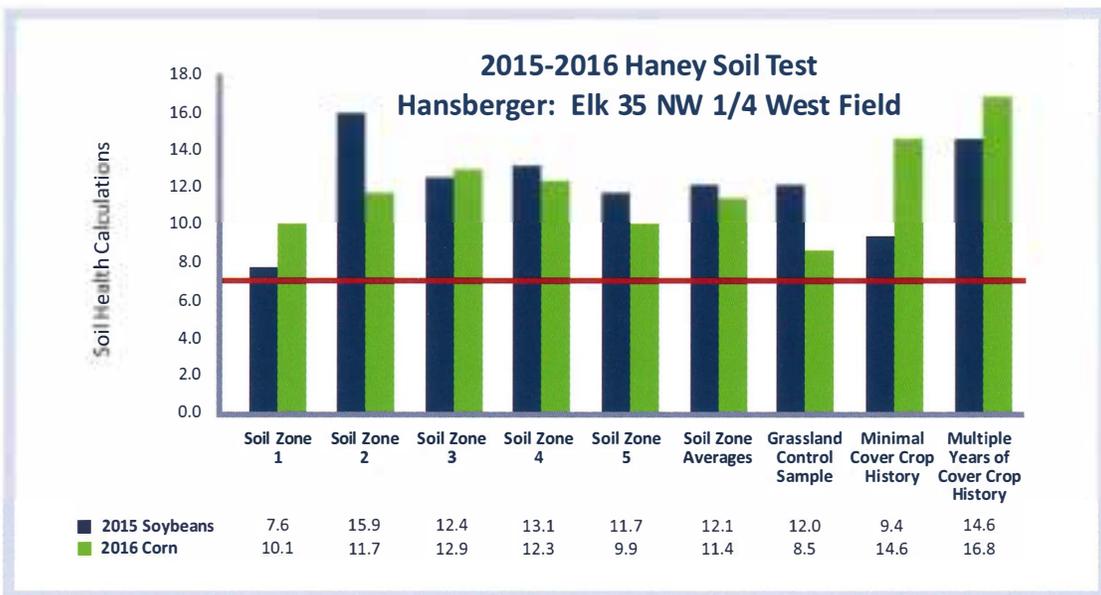
Several samples were analyzed and given an overall “Soil Health Calculation” to determine adequate soil health. A number greater than seven indicates adequate soil health. All sample sites in 2015 and 2016, except two,

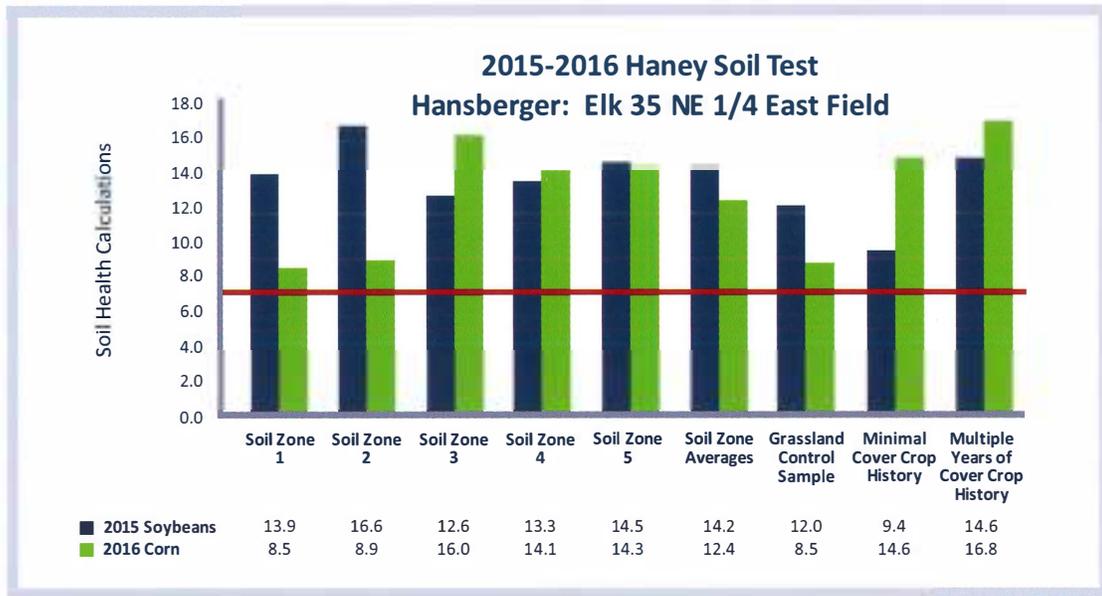
have had a soil health calculation over seven. The 2016 soil health calculations showed a slight decline from the 2015 data. The testing methods were not changed from year to year so a lower calculation could be the result of the following factors: increase in water within the soil profile can decrease microbial activity due to lack of nutrient availability and lack of gas exchange; colder soil temperatures; and/or an increase in residue amounts can increase microbial activity. The 2015-2016 results are as follows:



2015: All six soil zones had an average soil health calculation of 16.7. The control zones showed that the grassland area was at 17.4 and the highest soil calculation zone was 20.6 for the field with multiple years of cover crop history. The lowest calculation was 16.4 and was taken from the minimal cover crop history field.

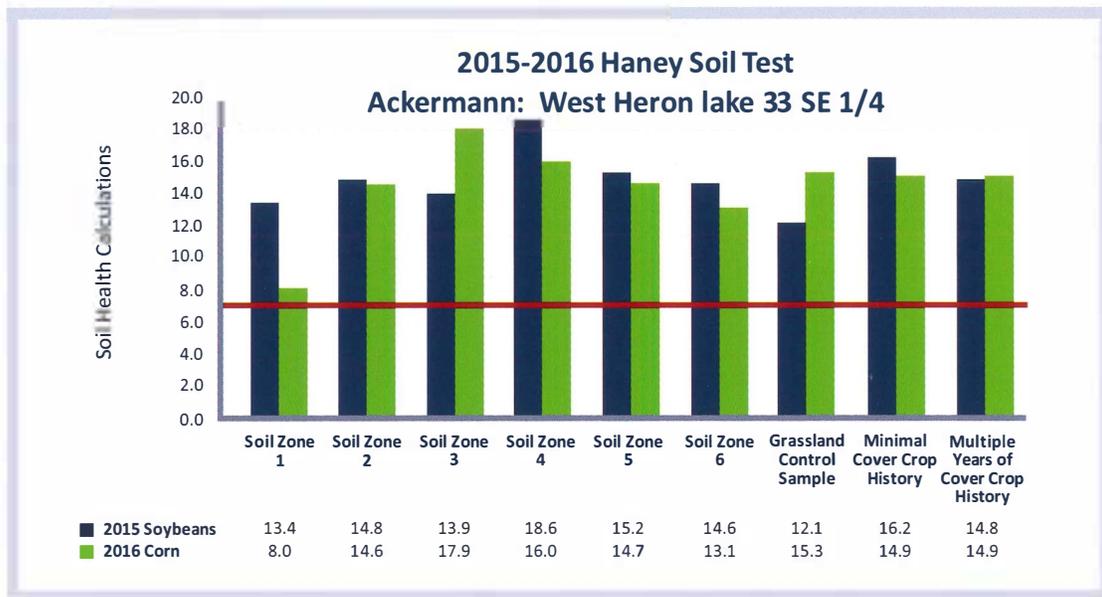
2016: All six soil zones had an average soil health reading of 12.3. The control zones showed that the grassland and the multiple years of cover crop history sample had a calculation of 10.7. The lowest calculation was 6.7 from the minimal cover crop history field.





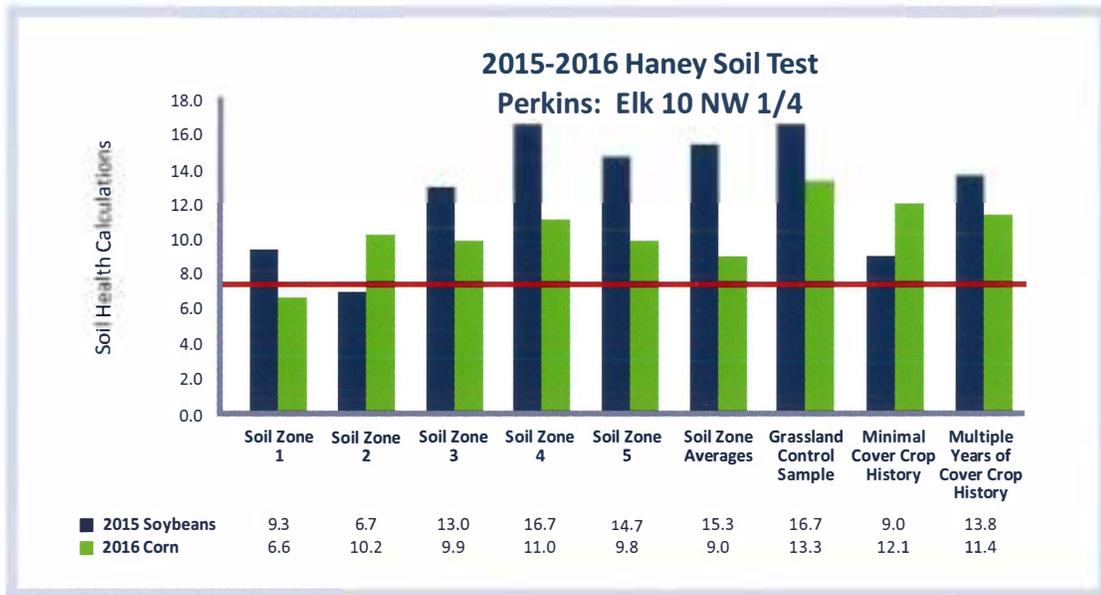
2015: All ten soil zones had an average calculation of 13.2. The control zones showed that the grassland area was at 14.6 and had the highest soil health calculation. The lowest control sample calculation was 9.35, from the minimal cover crop history site.

2016: All ten soil zones had an average soil health calculation of 11.9. The control zones showed that the grassland area was at 8.5 and had the lowest soil health calculation. The minimal cover crop history site showed a result of 14.6.



2015: All six soil zones had an average of 15.1. The control zones showed that the grassed covered area was at 12.1. The highest soil health calculation was on the field with the minimal years of cover crop history. The control sample calculation for the field that had multiple years of cover crop history was 14.7.

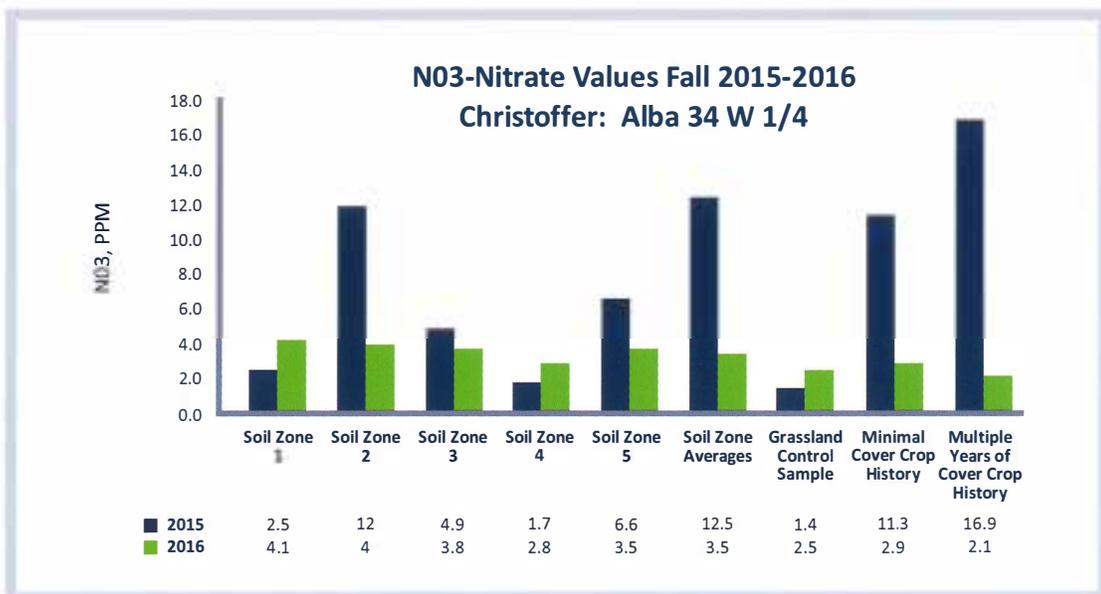
2016: All six soil zones had an average of 14.0. The control zones showed that the grassed covered area was at 15.3. This sample with the minimal cover crop history had a result of 14.9. The control sample calculation for the field that had multiple years of cover crop history, was 14.9.



2015: All six soil zones had an average of 12.6. The control zones showed that the grassland area was at 16.7 and the highest soil health calculation. The field that had multiple years of cover crop history had a calculation of 13.8. The field with minimal cover crop history was 8.98.

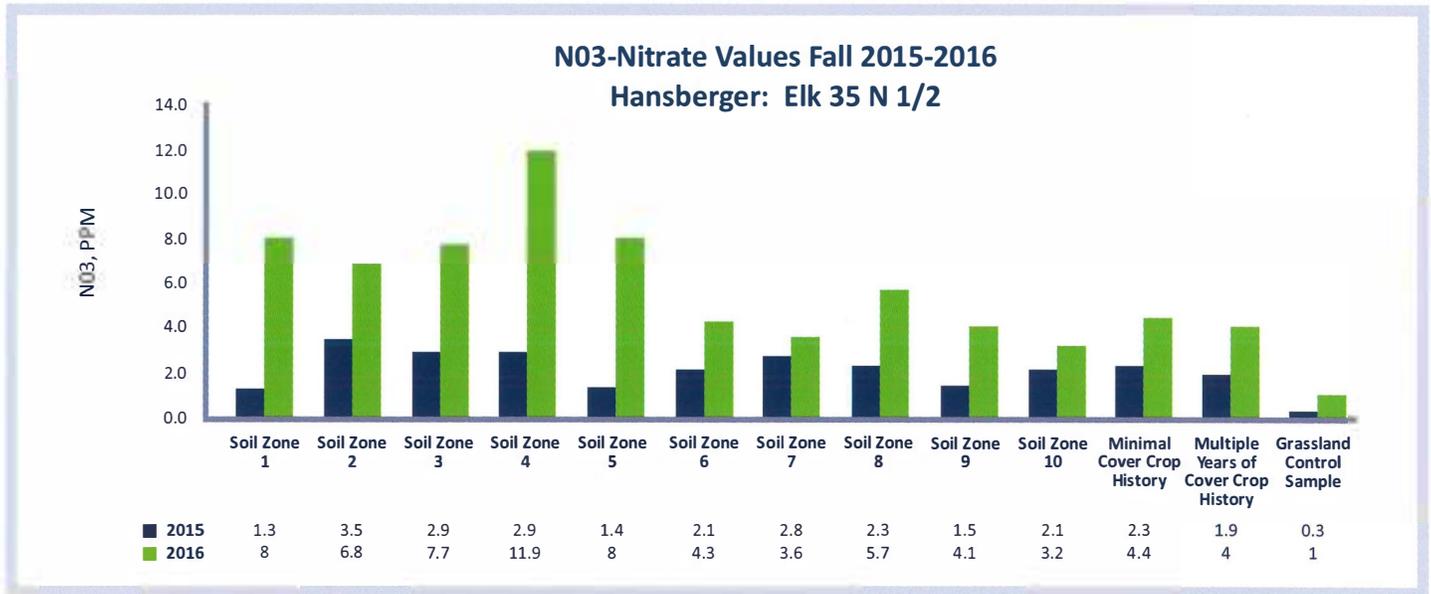
2016: All six soil zones had an average of 9.4 as a soil health calculation. The control zones showed that the grassland area had a reading of 13.3 and had the highest soil health calculation. The control samples showed 12.1 for the field with minimal cover crop history and 11.4 for the field with multiple years of cover crop history.

Soil Nitrate Results



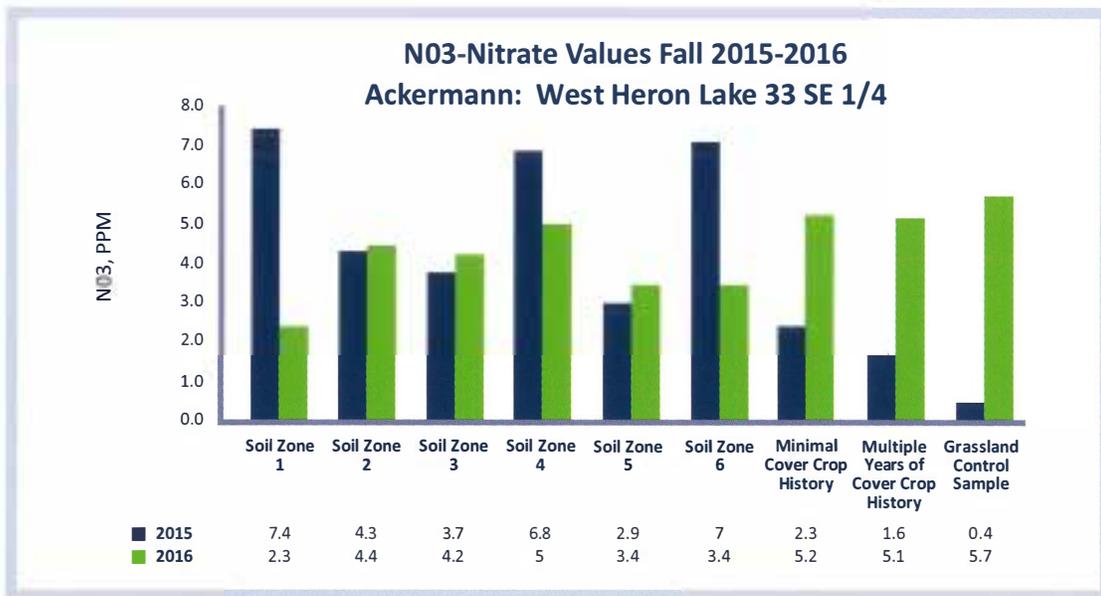
Nitrate values are expressed as parts per million (ppm) and were taken from 0-6". Values are extremely variable across the zones which is typical for nitrate sampling. Zones 1-6 all had a successful cover crop mix established in August 2015 and persisted with a favorable fall. Overall values are lower

than what was expected for fine-textured soils with high organic matter in a corn following soybean rotation. It was unclear if some nitrate was immobilized in the cover crop plant matter.



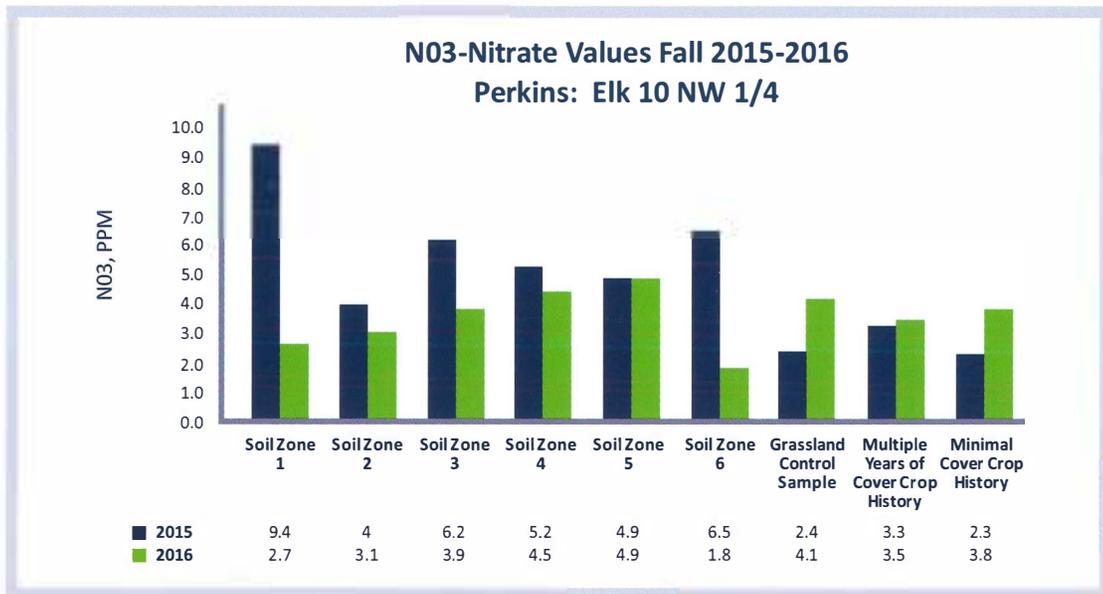
Nitrate values are expressed as ppm and were taken from 0-6". Values were fairly consistent across the zones. Zones 4-7 all had a successful cover crop mix established in August 2015 and persisted with a favorable fall.

Zones 1-3 and 8-10 did not have a cover crop planted in 2015. There does not appear to be a strong correlation with measured nitrate levels and cover crop establishment.



Nitrate values are expressed as ppm and were taken from 0-6". Values were variable across the zones. Zones 1-6 all had a successful cover crop mix established in August 2015

and persisted with a favorable fall. There does appear to be correlation with measured nitrate levels and cover crop establishment.



Nitrate values are expressed as ppm and were taken from 0-6". Values were fairly consistent across the zones. Zones 1-6 all had a successful cover crop mix established in August 2015 and persisted with a favorable fall. There appears

to be higher overall nitrate levels in the cover crop zones when compared to the control samples.

Management Tips

1. Plant multi-species blends to help ensure establishment and provide benefits to the soil biota.
2. Cover crops seem to establish best when planted in early maturing varieties of soybeans. The early leaf drop in these varieties helps in establishment.
3. Cover crop seeding should be done when the soybean leaves are yellowing or during the last week of August.
4. If a drill or ground rig isn't available to do early season seeding into corn, it may be better to wait until August for a high clearance seeder.

Cooperators

Dave Christoffer, Okabena, MN

Jerry and Terry Perkins, Worthington, MN

Tim Hansberger, Worthington, MN

Andy Nesselth, Extended Ag Services, Inc., Lakefield, MN

Jan Voit and Catherine Wegehaupt, Heron Lake Watershed District, Heron Lake, MN

Project Location

Jerry and Nancy Ackermann: From Lakefield, travel 5¼ miles west on Jackson Cty. Hwy. 14 (820th St.). Go ¼ mile north. Cover crop site is on the left.

Dave Christoffer: From Brewster, travel 2 miles south on Hwy. 264. Go east on Jackson Cty. Rd. 14 (820th St.) for 3 miles. Turn north on 340th Ave. The cover crop site is on the right, extending for a mile.

Jerry and Terry Perkins: From Worthington, go 8 miles north on US Hwy. 59. Then travel 1¾ miles west on 170th St. Cover crop site is on the left.

Tim Hansberger: From Worthington, at the intersection of Oxford St. and Hwy. 59, go 4 miles north on Hwy. 59. Go west for ½ mile. The cover crops are seeded on both sides of the tree line in the south half of the field.

Other Resources

No-Till Farmer. Website: www.no-tillfarmer.com

Farm Journal. The High Yield Conservation section. Website: www.agweb.com/farmjournal

Sustainable Agriculture Network. Managing

Cover Crops Profitably: Third Edition.

Beltsville, MD. 301-504-5236. Website: www.sare.org/publications/covercrops/covercrops.pdf

Principal Investigator

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Sherburne County

Project Duration

2014 to 2016

Award Amount

\$19,570

Staff Contact

Meg Moynihan

Keywords

cover crops, inter-seeding,
nitrogen

Nitrogen Capture using Cover Crops in a Cash Grain Rotation

Project Summary

The purpose of this project is to show how effectively cover crops can scavenge left over nitrogen fertilizer and reduce nitrate leaching on irrigated sandy soils. Bill Bronder worked with two farms to test several cover crops for their ability to take up residual nitrogen after removal of field corn, potatoes, and green beans.

Project Description

Planting cover crops to control wind erosion is a well-established conservation practice for irrigated cropland in Sherburne County. However, the potential for nitrogen to leach into the ground water is greatest when there is no living crop on the field – such as after fall harvest and before spring planting. The fall growing season, has typically limited farmers' cover crop choices to cereal rye or oats. The short growing season also limits the effectiveness of these two species to capture nitrogen and other nutrients in the soil.

This project tried to match cover crop mixes to different cash crops. For example, many farmers include a short season crop in their rotation, such as early harvest red potatoes or green beans. During these years, a diverse cover crop mix that included grasses, legumes, and brassicas could be planted after potato or bean harvest. Diverse mixes (sometimes called “cocktails”) can help farmers achieve other objectives, such as reducing field compaction, increasing soil organic matter, and improving soil health.

In the years when full season crops such as corn or soybeans are grown, this project focused on finding cover crops that can successfully be inter-seeded into the growing crop. These mixes had to be both shade and herbicide tolerant.

Bill Bronder, who is a district technician for the Sherburne County Soil & Water Conservation District partnered with two farms on this project: Triple J Farms near Becker, which is owned and operated by Steve Johnson and Diamond A Farms near St. Cloud, which is owned and operated by Lynn Ayers. Bill also had some plots at Olson Brothers Farm near Becker and used that data in this study.

The cover crop mixes and methods we used followed the Natural Resources Conservation Service's (NRCS) Cover Crop Standard 340. We also used the Midwest Cover Crop Council's selector tool for designing our cover crop mixes.

2014 Results

This year's demonstration project began in an irrigated corn field to be harvested for grain. On May 14, Steve Johnson of Triple J Farms no-tilled field corn into a spring rye cover crop that hadn't over-wintered. Due to a wet spring, planting was about 10 days later than normal. The plant population was 34,000 plants/A on 30" rows. A total of 187 lb of nitrogen fertilizer was added as ammonium sulfate starter and anhydrous ammonia.

We installed lysimeters (soil water samplers), at four different locations: the field, the planned cover crop plot, a windbreak along the field edge, and in a restored prairie. All lysimeters were placed at a depth of 48". Our theory was that any nitrogen found at that depth would be beyond the plant roots and lost to the ground water. We took water samples weekly and tested for nitrate nitrogen. The two lysimeters in the non-crop areas were to give us fertilizer-free background nitrate readings.

We broadcast a mix consisting of oats, berseem clover, and Tillage Radish® with a hand broadcast seeder on June 19, when the corn was at the 8-leaf stage. By this time, most

of the spring rye residue had decomposed, so the seed was falling on bare soil.

With the 30" row spacing and plant population, the corn canopy closed quickly. Little of the seed germinated, even though the field was irrigated shortly after planting. Meanwhile, we had trouble with the lysimeters, which either worked sporadically or not at all. And since the cover crop hardly germinated, we collected little useful data.

When it became apparent over-seeding into standing corn had been kind of a bust, we decided to change our tactics. We planted two fields with cover crops, putting in spring rye after green beans in late July and an oats/radish mix following potato harvest in early September. We sampled for soil nitrate-nitrogen right after the bean and potato harvests, and again on October 20.

Table 1 shows how diverse cover crop mixes scavenge leftover nitrogen fertilizer, which is then released as the cover crop decays. These results showed us that cover crops can scavenge nitrogen when they have time to grow.

Table 1. N Contributions of Different Cover Crop Treatments

Varieties in mix	Duration of growth	Soil Nitrate-Nitrogen (lb/A)
Baseline sample right after potato harvest	-	220
Oats, Radish, Winter Pea	6 wk	80
Oats, Radish, Turnip	6 wk	105
Oats, Winter Pea, Berseem Clover, Crimson Clover	6 wk	90
Oats, Radish, Canola, Spring Barley	6 wk	64
Oats, Buckwheat, Mustard, Phacelia	6 wk	104
Rye	6 wk	191
Baseline sample right after potato harvest	-	108
Oats, Radish	5 wk	128
Baseline sample right after green bean harvest	-	117
Rye	7 wk	118

2015 Results

On June 16, we inter-seeded a cover crop into corn at the 5-6 leaf stage. This time we used a hand seeder, which ensured good seed to soil contact. The cover crops we planted were: Roundup Ready® soybeans, spring barley,

Tillage Radish®, berseem clover, and lentils. All species germinated and started growing before the corn canopy closed. However, in November when we harvested the corn, only the Tillage Radish®, was still growing.



In November, radishes were still going strong in the corn understory.



What a difference light makes: the radish on the left was planted June 16 and grew under a corn canopy. The radish on the right was planted in mid-August after green bean harvest.

We planted an assortment of cover crops after green beans were harvested in mid-August. We measured aboveground biomass for each plot clipping and weighing all the

vegetation growing within a 1.92 ft² quadrant (Table 2). We estimated dry matter at 35% for all samples.

Table 2. Results of Aboveground Biomass Sampling, 2015

Cover crop	Plant date	Harvest/weigh date	Estimated dry weight lb/A
Spring rye	8/13/15	10/14/15	6,835
8 Species mix (barley, kale, lentil, crimson clover, phacelia, peas, radish, turnips)	8/26/15	10/14/15	8,575
6 Species mix (oats, radish, sunn hemp, kale, crimson clover, peas)	8/26/15	10/14/15	8,137
Kale	8/26/15	10/14/15	4,550
Lentil	8/26/15	10/14/15	1,050
Triple J Farms (spring rye, radish, lentil, turnip, sunn hemp, kale)	8/13/15	10/14/15	

These results indicate that early-harvested crops provide a substantial opportunity for cover crop species selection, building organic matter, and treating compaction.

We sent soil samples from the green bean fields for a Haney Soil Health Analysis both before planting the cover crop and after the cover crop was well established (Table 3).

Table 3. Soil Health Test Results, 2015

Sample	Date	Soil Health Calculation	Solvita Burst Test
Triple J Farms (before planting)	4/22/15	3.5	12.2
Triple J Farms (in cover, after green beans)	11/12/15	3.86	23.0
Diamond A Farms (after seed corn harvest)	9/21/15	6.30	22.1
Diamond A Farms (cover crop late fall)	11/12/15	3.27	16.1

The Solvita Burst test measures the amount of carbon dioxide produced over a 24 hour period; the higher the amount, the greater the biological activity. This number in combination with the organic carbon to organic nitrogen yields the Soil Health Calculation. If the cover crop treatment on these fields is successful, this number should increase over time.

The lysimeters worked better this year. Nitrate readings for the restored prairie (one of our baseline measurement spots) remained constant at .5 ppm for most of the growing

season. Nitrate readings in the cornfield started to peak shortly after we applied 230 lb/A N as anhydrous ammonia and again later in the season after we applied additional N through the irrigation system. Due to the poor growth of the inter-seeded cover crop, we think it's unlikely that it had any effect on N movement. Nitrate readings from the green bean field showed a similar pattern, but the samples had lower nitrate readings, probably due to less nitrogen fertilizer being applied.

2016 Results

For the last year of the project, we inter-seeded various cover crop mixes into standing corn (Table 4). We wanted to test the success of this type of seeding, try different cover

crop mixes, and to record soil water nitrates at 48" in order to monitor the occurrence of nitrogen leaching.

Table 4. 2016 Cover Crop Mixes

Annual Cereals	Compaction Mix	Legume Mix	Green Manure
oats, spring barley, spring wheat	oats, Tillage Radish®, turnips, beets	oats, crimson clover, cowpeas, lentils	oats, peas, oilseed radish

We planted irrigated corn for grain on April 30, followed by four different cover crop mixes inter-seeded in a 20' x 517' plot. The corn was at the 4-leaf stage and two different herbicide treatments were used: Acuron and Verdict. When we applied 180 lb N as anhydrous ammonia a week later, the applicator knives tore up the emerging cover crop. So we reseeded the cover crop plots on June 11, when the corn was at the 6-leaf stage. After three weeks, all four cover crop mixes were established and actively growing.



We used an 8' grain drill with four planting units to inter-seed the cover crops in 2016.

We installed lysimeters after planting and the data we collected indicated there was nitrogen loss from the anhydrous application. The data also showed that while the cover crops may have delayed the loss, they did not prevent it.

The annual cereal varieties and the oat components of the mixes germinated but then quickly died, possibly due to herbicide carryover. Lambsquarters, which we normally would have controlled with a post emergent application of glyphosate, was prevalent and competed with the cover crop, and we couldn't spray the lambsquarters, or we would have killed the cover crop.

The compaction and legume mixes performed well and survived through the summer.

The Tillage Radish® and the cowpeas continued to grow vigorously into the fall, with the cowpeas developing substantial nodules.

When we harvested corn on October 11, the yield monitor on the combine showed the differences between the yields recorded in the plots and the rest of the field; they were not significant.

From experiences during this project, Steve concluded that planting a diverse cover crop mix after early harvested crops seems to work best in his system. Using a grain drill to inter-seed the cover crop proved to be the most successful method; inter-seeding the cover crop by broadcasting over the top of the growing corn didn't work well at all.



Corn and cover crop prior to harvest on October 11.

Steve says he will continue to plant cover crop mixes when he can. He doesn't have time to inter-seed a cover crop, but he plans to continue experimenting with cover crops and may also try some plots using different nitrogen rates and sources.

Over the last 3 years, Steve has observed several of his neighbors planting cover crop mixes after green beans, potatoes, or kidney beans. Before, if they had planted a cover crop at all, it would have been just a single species, such as rye or oats.

Management Tips

1. If you have an early harvested crop in your rotation, plant a diverse cover crop mix for the most benefit.
2. Seed to soil contact is important for getting a cover crop to germinate and start growing.
3. Experiment with different cover crop species.
4. Cover crops can scavenge nitrogen when planted following the harvest of early crops such as green beans or potatoes.
5. Radishes and turnips can reduce compaction and improve water infiltration.

Cooperators

Lynn Ayers, Diamond A Farms, St. Cloud, MN

Olson Brothers Farm, Becker, MN

Steve Johnson, Triple J Farms, Becker, MN

Location

From Becker, go west on US Hwy. 10. Go 1 mile to MN State Hwy. 25. Then go north on Hwy. 25 for 5 miles to Sherburne Cty. Rd. 16. Go east on Cty. Rd. 16 for ¼ mile. The planting site is on the right.

Other Resources

United States Department of Agriculture
Agricultural Research Service. Cover Crop Chart.
www.ars.usda.gov/Main/docs.htm?docid=20323

<http://mccc.msu.edu/selector-tool>

Ward Laboratories, Inc. Biological Soil Analysis.
www.wardlab.com

Natural Resources Conservation Service. Conservation Practice Standard. Cover Crop Code 340. January 2014.
fotg.sc.egov.usda.gov/references/public/NE/NE340.pdf

Midwest Cover Crops Council. Cover Crop Decision Tools.

Principal Investigator

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 Happy Dancing Turtle
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 218-587-2001

Project Duration

2014 to 2016

Award Amount

\$20,385

Staff Contact

Cassie Dahl

Keywords

agroforestry, native plants,
 nurseries

Developing Low-cost Planting Materials and Establishment Methods to Accelerate Agroforestry Adoption for Function and Profit

Project Summary

This project is to demonstrate how to establish productive and profitable agroforestry land-use systems. Agroforestry focuses on proven ecological and environmental benefits. This project is to explore methods of establishing agroforestry systems using on-farm propagation to produce native plant species, productive cultivars, and hybrids of species suited to site specific ecological conditions and the succession patterns of native plant communities.

Project Description

Agroforestry combines agriculture and forestry to create integrated and sustainable land-use systems. Agroforestry takes advantage of the interactive benefits of trees and shrubs grown with crops and/or livestock. Considered agroforestry practices, riparian buffers and windbreaks' conservation benefits are well known. Other agroforestry practices such as silvopasture (integrating trees, forage and livestock together), alley cropping (rows of trees/shrubs with space between for agronomic crops), and forest farming (manipulating forest canopy to allow production of specialty crops such as medicinal herbs and mushrooms) are less known and researched, but have potential for similar conservation benefits and increased farm profitability. Species of both trees/shrubs and crops suitable for agroforestry systems in Minnesota are very limited. Similarly, there are few working examples of productive and profitable agroforestry systems in Minnesota. This project aims to determine species that are best suited to the specific site condition, are cost effective to establish, provide early return on investment, and provide long-term farm profitability. Targeted at marginal farmlands, these systems have the potential to provide the greatest conservation benefit. Programs like Reinvest in Minnesota (RIM) and Continuous Conservation Reserve Program (CCRP), though valuable for their conservation efforts, do little or nothing to provide for the growing societal needs for food, fuel, and fiber. Well-designed agroforestry land-use systems have the potential to provide these same conservation benefits and provide diversified products for local food security.

In order to reduce startup costs and have a supply of replacement stock, we will establish on farm plant propagation nurseries. We will use ecological classification and natural plant succession to determine possible multistory cropping systems. We want these systems to provide early marketable products and long-term income as they mature. Ecological classification models are not new and use soil, vegetation, and other landscape variables. For example, habitat types (Daubenmire, 1952) and plant community types (Hall, 1973) have been used in US Forest Service Regions.

The Minnesota Department of Natural Resources has practiced silviculture using an Ecological Classification System (ECS) on state managed lands since 2000. We are proposing to examine and determine the feasibility and practicality of using ECS in the establishment of agroforestry projects. The focus of this project will be on

mimicking ecological systems with similar cultivars and hybrids to increase productivity and producer income. We hope this design strategy will show that diverse plantings based on ECS can be used to establish agroforestry systems that conserve resources, are low maintenance, productive, and profitable.



Nursery on Early Boots Farm.



Newly planted hazelnut.

2014 Results

Forested areas adjacent to cooperators sites were surveyed using the *Minnesota Department of Natural Resources, Field Guide to the Native Plant Communities of Minnesota: The Eastern Broadleaf Province (2005)*.

Location	Soils	Forb	Overstory	Subcanopy	Notes
Early Boots Farm	Forest soils were sampled to 16". Loamy to 12" with light-colored clay to 16".	More mesic species at ground layer: Bloodroot abundant, sweet cicely common, jack-in-the pulpit scattered. Other common species: wild sarsaparilla, bedstraw, false Solomon seal, violets, large leaf aster.	Canopy is heavy to trembling aspen and green ash with large scattered bur oak.	Large ironwood, elm, green ash, boxelder. Shrub layer has juneberry, arrowwood and prickly ash. Some red oak regeneration at 1-2' level.	Overstory and shrub layers indicate MHC 2-6. Forbs and soils indicate MHC 3-6. Following up with John Almendinger on the site classification, he says that it is common for forested sites to become somewhat drier following disturbances – (whether those are from logging, wind, grazing etc). Hence the move from a 3-6 toward a 2-6 is not unusual, it may be preferable to use forbs and soils for NPC determination on these sites for this reason.
Camphill Village	Soils sampled to 16". Loamy first 8". Subsoil sandy to 16" with some fine particles. Rocks present.	Common forbs: columbine, sweet cicely, Canada mayflower, sedges.	Northern pin oak, bur oak, aspen common.	Shrub layer thick to prickly ash, grey dogwood.	Topography hilly with slope to west. Large bur oaks at top of hill have appearance of old savanna knoll. Small swale inclusion has black cherry and leatherwood= more mesic. General agreement that this site has all the earmarks of an FDs 3-7 site.
Happy Dancing Turtle	Soil map shows Menahga loamy sand. Soil probe was 5" of loamy material with brown sand beneath to the 16" soil probe depth.	Abundant forbs were bedstraw, blueberry, and Pennsylvania sedge. Other species were strawberry, starflower, wood fern, poison ivy, wild sarsaparilla, yarrow, violet, false lily with isolated red baneberry.	Common species were red pine, followed by pin oak and bur oak, some birch and scattered mountain ash. Jack pine scattered or absent.		The consensus was that the site was clearly FDC 3-4: likely subtype a. On the northern portion of the site inspection we encountered an area of ground pine, balsam fir and bracken fern, indicating that a portion of the site may tend toward FDN 3-3.

Propagation nurseries weren't established until late summer so little progress was made in propagating stock. Rooted cuttings from four different elderberry cultivars were planted at Early Boots Farm.

Happy Dancing Turtle planted hybrid hazelnuts and currents that were propagated over the winter of 2013/2014. These were planted in late fall as a living snowfence along the entrance to the Hunt Utilities Campus.

2015 Results

We had enthusiastic plans when going into this project. Our goal was to use propagations from the nurseries when planting in the field, however we did not realize how long it would take for the plants to become established, so additional planting stock has been purchased. Species were selected based on marketing potential. The stock consisted of hybrid hazelnuts, Ashworth oak, juneberry, Shagbark hickory, apple (Chestnut, Dolgo, Centennial), cherry (Carmine Jewel, Crimson Passion), plum, Northrop mulberry, blueberries, strawberries, elderberry, American plum, Aronia berry, false indigo, chokecherry (Black, Garrington), and honeyberry were split equally between the three sites, regardless of their suitability to the site. Camphill Village and Earlyboots Farm planted all varieties of stock in the nursery. The Camphill Village nursery was rooted up with hogs in the fall of 2014 and then tilled in the spring before planting. Then the stock was mulched with straw and weeded twice. The Earlyboots Farm site was planted into sod and mowed. At the Happy Dancing Turtle site, species suited to the site were planted together and those that were not were planted separately. A thin layer of composted leaf mulch was applied to both sites and they were mulched with a deep layer of wood chips and weeded once. All sites were irrigated only during extended dry periods.

The living snowfence at Happy Dancing Turtle was established along the main entrance road. In 2006, a garden was set up as a small alley cropping system. Some of the purchased stock was planted into the existing perennial rows within the alley cropping system. Plants put into this system included select cross hybrid hazelnuts, plums, and crab apples. These had good survival and growth, but this area has amended soil and is fenced.

New plantings were established on two sites with poor, sandy, and somewhat compacted soil. One site was planted to species suited to the NPC, including hybrid hazelnuts,

currents, bush cherries, bur oak (Ashworth cultivar), and blueberry cultivars. This planting was three rows, spaced 4' apart, and the plants were 6' apart within the rows. The hybrid hazelnuts were propagated from seed that was selected from established plantings on site and other sites in our region. The currents were propagated with cuttings sourced locally. Survival for all the species in this planting was good, but growth was poor and there was some predation over the winter. It is hard to say if the poor growth on the hazelnuts (compared to the select cross planted in the existing alley cropping system) was due to the genetics of the open pollinated propagation, the poor growing conditions, or a combination of the two. Propagation of the currents was easy and they had better growth.

The other site was planted primarily with species that are not found in the NPC database for our location. The plants included Aronia berry, nannyberry, black walnut, Shagbark hickory, and hybrid hazelnuts. They were planted in two rows 6' apart and the plants were 6' apart within the row. Tall trees were planted on the ends of the rows at 10' spacing. Survival was poor in this planting with all of the nannyberry dying as well as all but one black walnut. The Aronia berry fared better with only one plant dying.

The rest of the stock (juneberries and elderberries) were planted in the tree nursery for protection because they were small plants. None of the plants are producing fruit or nuts, although some of the select cross hazelnuts have set catkins.

Plans for spring of 2016 are to purchase additional planting stock to establish in field demonstrations at Early Boots Farm and Camphill Village of species that are suited to the site. They will be established as windbreaks, alley cropping systems, or incorporated into existing plantings. When practical we will be gathering materials and propagating plants on farm.

2016 Results

We faced several challenges over the growing season. The nursery at early Boots Farm was infested with gophers over the 2015-16 winter and they did major damage before they were discovered and could be controlled. Also, all three farms found little success propagating nursery stock. This further highlights that on-farm propagation of nursery stock is not feasible, except for a few species that are easily reproduced by rooted cutting or a similar vegetative method.

Additional planting stock was purchased in the spring of 2016, with species selection based on marketing potential, the 2014 assessments of the ecological classification of native plant communities for the cooperating farms, and the survival of stock planted in 2015. The purchased stock was planted at Early Boots Farm and Camphill Village. Early Boots Farm planted a multi-row windbreak consisting of honeyberry and bush cherry. Camphill Village planted the same species in an alley cropping system on contoured Hugelkultur berms. Happy Dancing Turtle added purchased blueberry plants and currents that were propagated in their nursery, to the windbreak that was established in 2014.

In the fall of 2016, planting stock that was established in the nurseries was measured to track performance and dead stock was documented. Measurements included the diameter 1" above ground and annual new growth. As in 2015, our 2016 data shows that the species that are not suited for the site have poorer survival rates. In 2015, survival of all the species not suited to the Happy Dancing Turtle site was less than 54%, while the plantings that are suited to the site had a survival rate of 94%. For all sites, mortality rates were 55%, 39% and 13% for not suitable, not common, and suitable species, respectfully. 2016 showed similar results with 33%, 22% and 11% for not suitable, not common, and suitable species, respectfully.



Honeyberry at Early Boots Farm.



Construction of a Hugelkultur berm.



Fruiting hybrid hazelnut bushes.

Management Tips

1. Land use history and previous disturbances can play a role in native plant community establishment.
2. Ecological Classification Systems and native plant communities can play a role in plant selection for agroforestry plantings.
3. Consistent site preparation, management, and record keeping is important for data collection.
4. On-farm propagation of woody plants requires skill and labor that may limit feasibility.

Cooperators

Tyler Carlson, Producer, Early Boots Farm

Stephen Briggs, Producer, Camphill Village

Diomy Zamora, U of M Extension Agroforester

Peter Bundy, Masconomo Forestry Inc.

John Almendinger, Minnesota Department of Natural Resources

Project Location

Happy Dancing Turtle is located on the Hunt Utilities Group Campus, 1/2 mile east of Pine River on Cass Cty. Rd. 2. Early Boots Farm is 6 miles north of Sauk Rapids on US 71,

1/2 mile west on Balsam Dr. Camphill Village is located 9 miles north of Sauk Center on US 71, 1 mile east on Cedar Lake Rd.

Other Resources

Field Guide to the Native Plant Communities of Minnesota: The Eastern Broadleaf Province. 2005.

Minnesota Department of Natural Resources. Website: www.dnr.state.mn.us/npc/index.html

Restoration Agriculture: Real-World Permaculture for Farmers. 2013. Mark Shepard. Website: www.newforestfarm.net

This Perennial Land: third crops, blue earth, and the road to a restorative agriculture. 2012. Lansing Shepard and Paula Westmoreland. Website: www.thisperennialland.com

Tree Crops: A Permanent Agriculture. 1950. J. Russel Smith

USDA National Agroforestry Center. Website: nac.unl.edu

Green Lands Blue Waters. Website: www.greenlandsbluewaters.net

Association for Temperate Agroforestry. Website: www.aftaweb.org

National Sustainable Agriculture Information Service. Website: www.attra.ncat.org/attra-pub/summaries/summary.php?pub=62

University of Missouri Center for Agroforestry. Website: www.centerforagroforestry.org/practices/ac.php

Principal Investigator

Caroline Devaney
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 locations)
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Project Duration

2016-2018

Award Amount

\$18,459

County

Hennepin

Staff Contact

Cassie Dahl

Keywords

compost, garden,
 produce, transplants,
 vermicomposting, worms

Demonstrating Vermicomposting for Soil Health in the Upper Midwest

Project Summary

Stone's Throw Urban Farm, is building a northern climate vermicompost system to demonstrate the production and incorporation of vermicompost into greenhouse transplant potting mixes. We are building the system with a view to maximize efficiency and savings, using free, locally available waste inputs. Our goal is to develop a system that can be adapted across scale and geography of organic growing to replace purchased inputs for transplant production.

Project Description

Stone's Throw is a 3 acre certified organic urban vegetable farm. We grow our crops on 16 formerly vacant lots in the Twin Cities. We use intensive growing methods and produce more than 50,000 lb of produce each season. We market through a regional producers' cooperative, sell to several dozen wholesale accounts, operate a 200-member CSA, and attend two weekly farmers markets. In addition to three farm owners, we have two seasonal employees.

On the urban lots we farm, the soil is generally low in organic matter, and lacks structure, biodiversity, and nutrient availability. Our limited space, and the fact that we don't own the land we farm, have kept us from investing in amending the soil enough to realize its production potential.

These challenges are not unique to our operation. Finding the most practical and economically viable way to build healthy, resilient soils is a challenge many growers in urban, peri-urban, and rural areas. Buying off-farm inputs to manage soils is a major expense, and we think it can be reduced by creating on-farm fertility building systems.

Our farm already uses a variety of soil building practices: building thermophilic compost from spent brewery waste in the city, applying generous amounts of compost and composted turkey manure to our fields, using a rotary hoe for less disruptive horizontal tillage, and using crop rotations and cover as possible in our limited growing space.



A neighbor's grandmother serenades us while we add brewery waste and wood chips to the compost pile.

Since 2014 we have been building 20-40 cubic yard compost piles, combining equal parts brewery waste from nearby breweries and wood chips from a local tree care service, and adding excess plant matter from the farm. We've been incorporating this compost in our transplant media and spreading it on our fields.

We first learned about vermicompost as a soil health strategy on an agricultural exchange in Cuba, where vermiculture is an integral piece of an agro-ecological farm system. We have since learned how it can be used in northern climates. For example, at Michigan State University, Horticulture Professor John Biernbaum has conducted research and developed a vermicompost system robust enough to process 100,000 lb of cafeteria waste each year.

Originally, we designed a system that involved both digging a tunnel and using windrows. After consulting Dr. Biernbaum as we started the project, however, we decided to simplify our approach to incorporate vermicomposting into our existing (thermophilic) composting practice. By keeping worms in these larger piles, we should need less maintenance to regulate major variables of temperature and moisture. Worms move around and through piles of this size to find their ideal climate, and using a large pile offers a much greater chance they will survive over winter. Anecdotally, we have found a large number of worms in our compost piles throughout the early spring, which suggests success in sustaining worms through the winter.

2016 Results

We inoculated one of our compost piles with 15 lb of worms and will monitor the compost pile through the winter. We are curious to see how worm population changes and how the addition of worms impacts pile metabolism. Throughout winter we will test activity and metabolism in the pile.

In the spring we will harvest vermicompost from the inoculated pile and incorporate into the potting mix we use for greenhouse transplants. We will create two transplant mixtures, one incorporating vermicompost, and the other incorporating inoculated thermophilic compost. We plan to measure chlorophyll, leaf nitrate, and above and below ground biomass of three different crops. We will also evaluate the nitrate content of water draining from flats.

Management Tips

1. Professors and farmers have different seasonal down times, so if you need advice, plan accordingly. It was a challenge for us to talk about vermicompost systems design with our advisors before things got busy for our farm in the spring.
2. In urban areas, getting neighbor buy-in to how compost piles look and smell can be a challenge. We like to engage neighbors, encouraging them to contribute plant based kitchen matter/non treated yard matter to the compost piles. We also keep plenty of wood chips on hand to cap any smells.
3. Rightsizing a compost/vermicompost system to fit your equipment and spatial constraints can be a challenge. To us, it was important to create a system that required the least possible upkeep through the growing season -- at least for the first year.

Cooperators

*John Biernbaum, Michigan State University,
East Lansing, MI*

Mark Quee Scattergood Farm, Brunswick, ME

Mary Rogers, U of M, St. Paul, MN

Karl Stoerzinger, Fabricator, Minneapolis, MN

Project Location

For directions to the vermicompost site, contact project leader Caroline Devaney.

Resources

Farmer to Farmer podcast featuring John Biernbaum
www.farmertofarmerpodcast.com/episodes/biernbaum

Biernbaum, John. Research and Guides on Vermicompost Systems

www.hrt.msu.edu/uploads/535/78622/PowerPoint-BasicBiologyEnvironment2014-47.pdf

www.hrt.msu.edu/uploads/535/78622/Vermicomposting-Systems-19pgs.pdf

www.hrt.msu.edu/uploads/535/78622/Vermicomposting-Bio-Enviro-Quality-13-pgs.pdf

Organic Agriculture Centre of Canada. Manual for Vermicomposting in Northern Climates.

http://oacc.info/DOCs/Vermiculture_FarmersManual_gm.pdf

Paul, Lindsay C. and James D. Metzger. 2005. Impact of Vermicompost on Vegetable Transplant Quality. HortScience. 40 (7): 2020-23.

Wisconsin Red Worms, Richland Center, WI. www.wisconsinredworms.com

Zaller, Johann. 2006. Vermicompost as a substitute for peat in potting media: Effects on germination, biomass allocation, yields and fruit quality of three tomato varieties. Scientia Horticulturae 112 (2): 191-199.

<https://doi.org/10.1016/j.scienta.2006.12.023>

Principal Investigator

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Project Duration

2015 to 2017

Award Amount

\$16,106

Staff Contact

Meg Moynihan

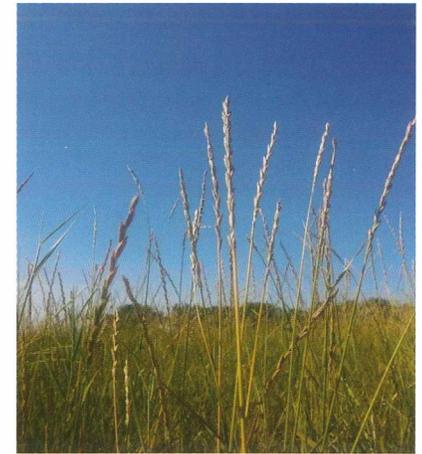
Keywords

intermediate wheatgrass,
 perennial grain, swath

Evaluating Harvest Methods for Intermediate Wheatgrass as a Perennial Edible Grain

Project Summary

The purpose of this project is to determine the optimum timing for intermediate wheatgrass grain harvest to maximize grain yield. Intermediate wheatgrass was mechanically harvested at three different stages of maturity and measured for grain yield, moisture content, harvest efficiency, and dehulling efficiency. Intermediate wheatgrass was also hand harvested to analyze grain yield potential.



Swathed intermediate wheatgrass.

Project Description

I operate a 350 acre certified organic crop farm and currently raise barley, oats, wheat, flax, corn, soybeans, and alfalfa in my rotation. In 2012, I became aware of the success that Lee DeHaan, geneticist at The Land Institute and endowed chair at the Minnesota Institute for Sustainable Agriculture, was having in breeding intermediate wheatgrass as a perennial grain crop. Perennial grains grown in a crop rotation have potential to provide economic benefits to the producer by helping minimize the annual costs of reseeding and fertilization. Perennial crops also require fewer tractor passes over the field than annual crops, which decreases fuel and energy input costs. Perennial grains provide benefits to the soil ecosystem including:

- providing perpetual cover for the soil surface, which minimizes soil loss from wind and water erosion;
- the fibrous root system effectively sequesters soil carbon and available soil nutrients; and
- the fibrous root system also feeds and protects the soil's microflora which acts to improve and maintain the soil's biological health.

During the first two years of growth, I noticed some interesting characteristics of intermediate wheatgrass. The grass sward grew rapidly in the early spring, which allowed the crop to compete successfully with the cool season weed species that are a major problem in annual small grain production. In 2014, I attempted my first grain harvest from the 2-acre test plot. While harvesting, I noticed that the maturity of the seed heads varied greatly across the field. The seeds developing on top of the seed head were dry and mature, while those at the base of the head were moist and soft. This observation complicated the decision as to when to harvest successfully. If I delay harvest to allow the soft seeds to mature, will I risk losing the early maturing seeds to shattering? If I harvest early, how much expected yield will I be giving up by losing the seeds, which are still maturing?

I brought these questions to other researchers working on intermediate wheatgrass and came to the realization that the question had not yet been answered. University of Minnesota researchers helped me design an experiment to answer the question: when is the optimum time to harvest intermediate wheatgrass to maximize grain yields?

My experimental design addressed the harvest issue and included the following treatments:

- early-season swath;
- mid-season swath; and
- late-season swath.

In 2015, I collected data on:

- grain yield potential based on yield estimates from hand harvested grain;
- actual grain yields taken from grain harvested by the combine;
- moisture content of the grain at swathing;
- moisture content of the grain at combining; and
- yield loss from shattering while drying in the windrow.

2015 Results

Yield data for all treatments are reported in Table 1. I swathed the early-season plot on August 5. The grain dried in the windrow until August 11, when I combined. I swathed the mid-season plot on August 11, but due to multiple rain events, did not harvest until August 24. I believe that there was significant shattering loss in the windrow.

I swathed the late-season plot on August 24 and combined on August 27. I attribute the low yields from that treatment to seed that shattered prior to swathing.

2015 Harvest Dates and Yield Data			
Treatment	Swath Date	Combine Date	Yield (lb)
Early-season	August 5	August 11	968
Mid-season	August 11	August 24	121
Late-season	August 24	August 27	403

2016 Results

2016 was the second year of my study but the fourth year of growth for my intermediate wheatgrass field. I had been warned that grain yield would start to decline after three years, and that's exactly what we observed. As the stand matured, I was seeing very few seed heads in the field. The plants were not dying, but they were not sending up seed heads, either. I was afraid that there would be no grain to harvest in 2016, especially if we tried to windrow and thresh with a combine. Instead, we estimated grain yields using hand-sampled quadrats. We found that the average grain yield was 75 lb/A, which is far too low to attempt to combine.

We decided to test a method to restore grain yields based on suggestions from researchers and on practices that other grass seed producers sometimes use. Instead of attempting to harvest grain I deep (8") strip-tilled sections of the field in fall 2016 using a chisel plow. It's possible that grain yields are declining because the stand is becoming too thick (sodbound). By breaking up the sod, we hope to restore grain yield. We left some areas untilled so that we can compare grain yields in tilled and untilled sections.

To estimate grain yields, we sampled 14 quadrats at random locations across the field. Grain yield was highly variable, and ranged from 3.56 to 220.72 lb/A. On average, grain yield was 75 lb/A. This is ten times less than a typical intermediate wheatgrass yield during of the first or second year of the stand.

The chisel plow treatments seemed to effectively kill strips of intermediate wheatgrass within the stand. We believe this will reduce stand density and result in more seedhead production and overall greater grain yields for 2017.

Management Tips

1. Based on my experiences with this study, I recommend early-season harvest. The immature seeds in the intermediate wheatgrass head at swathing dried adequately during the 6 days between swathing and combining.
2. Combine grain prior to forecasted rain events, even if the grain is not completely dry.
3. Try direct harvesting the late-season plots in order to avoid shattering losses in the windrow.
4. Stands planted in narrow rows decline substantially after 3 years, and may need additional management.

Cooperator

Jacob Jungers, U of M

Project Location

From Madison, go east on Hwy. 40. Continue for 1.5 miles.

2016 Grain Yields	
Plot	Yield (lb/acre)
1	42.72
2	24.92
3	65.86
4	117.48
5	3.56
6	220.72
7	49.84
8	26.70
9	142.4
10	140.62
11	69.42
12	80.10
13	24.92
14	48.06
Average	75.52



Chisel plow used to disturb sod-bound intermediate wheatgrass field in an effort to restore grain yield.

Principal Investigator

Keith Hartmann
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 com
 Nicollet and Sibley Counties

Project Duration

2016 to 2018

Award Amount

\$12,500

Staff Contact

Tori Hoepfner

Keywords

cover crops, soil health,
 corn, yield

Inter-seeding Cover Crops and In Season Nitrogen Application in One Pass



Keith pictured with inter-seeded rows.

Project Summary

Nitrogen management, soil erosion, and overall soil health are fast growing focal points in Minnesota agriculture. Inter-seeding is gaining more interest, but it comes with many questions and concerns. Herbicide use, lower grain yield, and nutrient competition are big concerns for farmers. My project addresses those concerns by inter-seeding cover crops into my corn fields.

Reducing tillage and maintaining a living root system in the soil is the driver for this project. My farm is located in south central Minnesota with heavy clay loam soils. Primary fall tillage is done on nearly all of the farm land in my area to break up compaction and to increase water infiltration through the tight soils and flat topography. With primary tillage comes winter wind erosion and black road ditches. Ever since I was a kid, seeing black snow banks and knowing that eroded soil would not return to the field piqued my interest in looking at different ways to increase water filtration and break up compaction without the use of tillage.

Project Description

I seeded a mixture of annual ryegrass, radish, crimson clover, turnips, and rapeseed into V6 stage corn on June 21, 2016 at a rate of 10 lb/A while applying a split nitrogen application of 80 lb/A. I chose those plant species because they each have a different root system with different jobs. The fibrous roots of annual ryegrass effectively absorb nutrients while radish, turnip clover and rapeseed have large taproots to break up compaction and recycle nutrients that are deep in the soil profile.

To seed these plants, I built an inter-seeder/nitrogen side-dress machine using a Great Plains NP4000 toolbar with fertilizer coulters, I added Yetter Strip Fresheners with firming wheels to incorporate the seed and a Gandy Orbit-Air seeder to meter the seed. Low seeding rates and high seed establishment was the key for this project. That is why I used the Yetter Strip Fresheners to lightly loosen the ground and throw 1/4"-1/2" of soil on top of the seed followed by a firming wheel for optimum seed to soil contact. My seed cost was \$15/A with 85% establishment in 2 weeks versus a typical aerial application seed cost of \$30-\$45/A and with stand establishment all dependent on rain to incorporate.

The cover crop grew 4" tall until the corn canopy shaded out the cover crop, making it dormant. In September, the corn started to mature and drop its leaves, allowing sunlight to again reach the established cover crop. The cover crop then took off and grew 12" until the first killing frost on November 18.

Along the way, I took measurements, samples and weights from my designated trial plot. The plot was 6 replicated strips of inter-seeded cover crop and no cover crop. Each strip was 1066' x 30'.

2016 Results

Warm temperatures and plenty of moisture made for fast cover crop growth and excellent establishment. These conditions made it an excellent year for testing the competitiveness of the cover crop with the primary corn crop.

On September 1, the cover crop stand was 25-28 plants/sq ft—an 85% stand establishment. The stand was primarily annual ryegrass, radishes, and rapeseed. The clover and turnips struggled under the shaded corn canopy. In 2017, I may remove those species from the mix to increase stand establishment and potentially lower the seed cost.

I took stalk nitrate samples from each of the six strips on October 6 when the corn reached physiological maturity (black layer). I compared the nitrogen content in the corn plants to see if the cover crop affected yield by taking excessive amounts of nitrogen away from the corn plant. The average of the three strips of cover cropped corn came to 1,211 mg/kg NO₃-N. The three strips of control corn was 1,595 mg/kg NO₃-N.



Close up of Yetter.

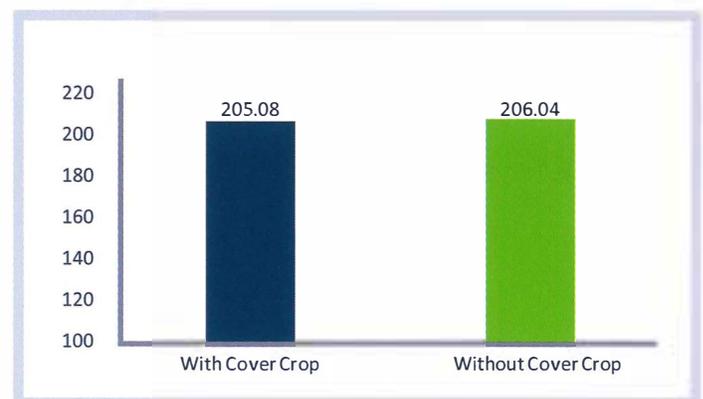
Herbicides applied to these strips are as follows:

- Pre-Plant: Dimethenamid-P + Saflufenacil; and
- Post-emerge applied 8 days prior to inter-seeding: Glyphosate and 3oz Tembotrione.

Although there is a difference of 384 mg/kg NO₃-N, both cover cropped and control fell within the optimal range of 700-2,000 mg/kg NO₃-N, so this would not be a yield factor.

In mid-November, I harvested each test strip and weighed with a weigh wagon. The average yields of the three strips are shown in Figure 1.

Figure 1. Corn Yield



A difference of .96 bu/A is not much in a trial of this size, and I do not think the inter-seeded cover crop had an effect on the corn grain yield. This is significant since the cover crop growth was so aggressive this year.

On November 20, I took 12" deep soil cores to measure the soil nitrate content in the cover crop strips versus control strips. I am comparing how much nitrogen the growing cover crops absorbed. Soil from the cover cropped strips had 5.63 ppm NO₃-N, while soil from strips without cover crops measured 5.33 ppm NO₃-N.

After reviewing the results, I don't feel this test was a true measure of the cover crops nitrate absorption. With the high amount of rain this field had in 2016 and being late in the growing season, most of the nitrate would be deeper than 12" in the soil profile. A soil core of 24-36" would likely portray the soil nitrate levels more accurately. I will take deeper soil cores in 2017 and 2018.

Management Tips:

1. **Equipment:** The Yetter Strip Fresheners were too long to fit in front of the lift assist wheels on the Great Plains NP4000. For those two rows, I dropped the seed behind the fertilizer coulter and the lift assist wheels firmed it. Other than that, the unit worked as planned with fast emergence and accurate depth control.
2. Use caution with residual herbicides. Most of the chemical labels do not include an inter-seeding cover
3. Seed depth is very important. Small seeded grasses, legumes, and brassicas require only 1/4"-1/2" of soil cover. Err on the shallow side, not deeper.

crop recommendation. How certain herbicides affect emergence will depend on soil types and trial and error of different types. Keep in mind that weed management and inter-seeding have to work together for this to be a sustainable practice.

Cooperators:

Spencer Herbert, Soil Scientist, Minnesota Department of Agriculture, North Mankato, MN

Chris Schmidt, Soil Conservationist, Natural Resource Conservation Service, Gaylord, MN

Project Site:

5 miles south of Gibbon, MN on Cty. Rd. 2.

Other Resources:

Penn State University

Rice County, MN Soil and Water Conservation District

Scott County, MN Soil and Water Conservation District

Principal Investigator

Alan Kraus
Cannon River Watershed
Partnership
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Rice and Goodhue Counties

Project Duration

2016 to 2018

Award Amount

\$24,400

Staff Contact

Tori Hoepfner

Keywords

cover crops, corn

Inter-seeding Cover Crop into Standing Corn in June

Project Summary

In order for cover crops to get established and grow successfully in the relatively cold climate of Minnesota, they need to be planted before the corn and soybean harvest.

This project explores broadcast seeding cover crops into standing corn in June (V5 to V7 stage). Eight farmers in Rice and Goodhue counties are testing this practice on their farms. Each farm has designed its own approach to the project (seed mix, equipment, etc.) and has unique field conditions. Four of the cooperating farmers used a small broadcast seeder developed by CRWP Ag Consultant Gene Kuntz. The seeder mounts on the back of a tractor (three-point hitch) with the spinner driven by a

hydraulic pump. It holds about 500 pounds of seed. Three farmers used area agricultural cooperatives to broadcast seed the cover crop. These machines are much larger and mounted on a high platform chassis. One farmer used a broadcast spreader wagon pulled by a tractor that is typically used for broadcast applying fertilizer.



Great Plains Drill Seeder.

Project Description

Cover crops can provide significant benefits to both the farming operation and the environment. According to the University of Minnesota, cover crops build organic matter, capture nitrogen, improve soil structure, reduce erosion, reduce soil compaction, increase water holding capacity of the soil, and can provide livestock forage. Environmental benefits include improving water quality by significantly reducing nitrogen leaching and reducing erosion.

The Cannon River Watershed Partnership has partnered with about 20 farmers in the Cannon River Watershed for the past three years to experiment with incorporating cover crops into their operations. Farmers are interested in exploring seeding cover crops in June to address the cost drawbacks of aerial seeding in August. The cost savings would make a significant difference in the economic sustainability of cover crops.

For this project, each farmer is designing the specifics of his experiment and implementing the experiment on their farm. Each farmer is choosing a cover crop species, planting method, and implementation of the cover crop (or arranging for custom planting). Five of the farms are in Rice County, which tends to be flatter terrain and three are in Goodhue County, which tends to have more rolling hills and deeper valleys. The study participants are using a variety of cropping systems, including conventional tillage, strip tilling, and no-till.

The Cannon River Watershed Partnership is providing technical expertise via our agriculture program consultants, experienced local agriculture educators. We will be gathering and summarizing the data generated and provide results to each farmer, and the group as a whole. We are gathering data on growth and establishment of the cover crops through stand counts, plant vigor, and height of the cover crops. We are also gathering data on corn yield to determine if yield drag occurs.

2016 Results

We developed two handouts for farmers interested in participating in the project and a one-page form to collect pertinent data and information related to the cover crop project on each farm and to make payments to participating farmers.

We worked with eight different farmers to plant cover crops in standing corn. All seeding occurred between June 7 and June 24. Five farmers were in Rice County and three were in Goodhue County. The cover crop plots ranged in size from 28 to 85 acres. A total of 368 acres were planted with a variety of species and different seeding methods into fields cultivated with varying tilling practices.

Table 1. Cover Crop Plot Review

Farmer name	Acres	Cover crop lb/A	Planting equipment type	Actual cost-application/acre	Planting methods
Lyle Dicke	46	annual ryegrass @ 11 + red clover @ 2	large broadcast seeder	\$17.12	broadcast with urea
Steve Lindstrom	85	annual rye @ 35	large broadcast seeder	\$5.75	broadcast with urea
Coty Hyllengren	28	cereal rye @ 56	large broadcast seeder	\$7.00	broadcast with 80 lb urea
Nathan Kuball	30	annual rye @ 15	CRWP broadcast seeder	\$6.00	
John Bonde	40	annual rye @ 15	CRWP broadcast seeder	\$2.25	
Jeremiah Franz	39	cereal rye @ 60	broadcast spreader wagon	\$6.00	broadcast with 28 lb urea
Mark Purfeerst	40	rye, winter cereal @ 40 + radish @ 2 + turnip @ 0.5	CRWP broadcast seeder	\$6.00	
Jim Purfeerst	60	rye, winter cereal @ 70 + radish @ 5 + turnip @ 0.6	drilled and CRWP broadcast seeder	\$6.00	

Each field was evaluated 1-3 times during the summer to determine the status of the cover crops. A large rain event occurred a few days after planting in some of the fields, washing seeds into pooled areas in a conventionally-farmed field. However, there appeared to be no soil erosion or seeds washed in a no-till field. One field had nearly no germination and growth, probably due to herbicide injury.

The drill-seeded plot exhibited good germination and growth and the rows of cover crop plants were discernible.

Overall, this project is going well. The farmers that we have been working with are looking forward to trying cover crops again next year. We learned a lot in the first year and will use this information to learn more from next year's implementation and results.

Management Tips

1. The earlier the cover crop is planted the better the results.
2. Cover crops were established better with drilling in the seeds. Broadcasting the seeds works fine, however, the following factors need to be considered: (1) crop residue helps keep seed in place to germinate; (2) rain events can really disrupt seed distribution prior to germination; and (3) wind can give you uneven results with ryegrass.
3. Annual ryegrass (recommended) worked much better than cereal rye (not recommended).
4. Herbicide injury will continue to be an issue.

Cooperators

Lyle Dicke, Goodhue, MN

Steve Lindstrom, Red Wing

Coty Hyllengren, Cannon Falls, MN

Nathan Kuball, Waterville, MN

John Bonde, Northfield, MN

Jeremiah Franz, Northfield, MN

Mark Purfeerst, Faribault, MN

Jim Purfeerst, Faribault, MN

Gene Kuntz, CRWP Agriculture Program Consultant

Lee Thompson, CRWP Agriculture Program Consultant

McKnight Foundation, Minneapolis, MN

Project Location

Contact Alan Kraus for project locations: 507-786-3913.

Other Resources

2016 Cover Crops Survey. Conservation Technology Information Center. www.ctic.org/Cover%20Crops/

Principal Investigator

Paul Kruger
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Wabasha, MN 55981
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Wabasha County

Project Duration

2014 to 2017

Award Amount

\$14,919

Staff Contact

Tori Hoepfner

Keywords

cover crops, legumes

Legume Cover Crops

Project Summary

Paul Kruger led a 3 year study to see whether cover crops can reduce the amount of Nitrogen (N) needed to produce corn.

Project Description

Paul farms 650 acres of corn and hay in the karst region of southeastern MN. The karst region was formed over layers of soluble bedrock, and sinkholes are common. Paul farms with his son and daughter. They milk 300 dairy cows and raise 150 steers each year.

Paul wanted to reduce, and ideally eliminate, the use of commercial nitrogen. Currently, he has to purchase commercial nitrogen for the acres he does not have enough manure for. He hoped that by planting cover crops, he could produce enough nitrogen for next year's crop and reduce or eliminate the nitrogen he has to buy. The cropping system he studied was corn for grain. Each plot was 1-2 acres, and all contained the same soil type.

Paul is monitoring:

- yield
- nitrogen credits and carryover (spring nitrate test)
- soil temperature
- erosion and weed pressure (visual)
- appearance (crop stress, yellowing or green leaves)

Results

In the first year of the project, Paul planted three different plots of legumes into corn that had been planted on May 30. On June 4, he drilled Roundup Ready® legumes into Plots 2 and 3, hoping that getting them in early would encourage nodule production. Since the seeding depth was only ½" for the cover crops and the corn was planted 2" deep, he was not worried about damaging any of the corn.

He sprayed the corn with herbicide on July 4, he broadcast seeded Plot 1, 5 days later, on July 29.

In addition, he had two control plots (#4 and 5), where he seeded no cover crops.

Twice each month, Paul hired the Wabasha Soil and Water Conservation District to inspect, document, and take pictures of each plot. Reviewing the notes, pictures, and his observations, he thought the plots would yield competitively with the control plot (Plot 4). On December 21 Paul harvested the corn.

Table 1. Cover Crop Treatments and Costs/A

Treatment	Legume	Seeding Rate lb/A	Cost/Bag	Total Cost/A
Plot 1 Broadcast	Austrian Winter Pea	50 each	\$28	\$250
	Lupine		\$63	
	Hairy Vetch		\$120	
	AC Greenfix		\$39	
Plot 2 Drilled	Roundup Ready® Soybeans	50	\$56	\$56
Plot 3 Drilled	Roundup Ready® Soybeans	50	\$56	\$105
	Roundup Ready® Alfalfa	14	\$49	

While harvesting the corn, Paul noticed spots where the corn was shorter and appeared poor, which may explain some of the variation in yields. He had been expecting a 170 bu average, which did not occur. Record rainfall was recorded in the 2014 growing season so a lack of rain was not the issue.

After looking at the results, Paul decided that there were no yield differences between the cover crop plots and the control plots. Overall, he was very impressed with the cover crop plots in 2014.

2015 Results

In 2015, Paul planted the same cover crop mixes he used in 2014. He planted corn on May 16. Rain delayed the cover crop planting; on May 27 he again drilled the cover crop mixes right into the corn in plots 2 and 3. Roughly 15% of the corn had sprouted and was less than 1" tall. On June 25, he broadcast seeded the cover crops onto plot 1, 5 days after spraying the corn with herbicide.

Paul fertilized the control plots with 170 lb of commercial nitrogen (N), 58 lb of phosphate (P), and 113 lb of potash (K). The cover crop plots received no nitrogen because he wanted to see whether the legumes he had planted last year would provide some nitrogen to the corn crop this year. He harvested the corn November 20. Yields are reported in Table 2.

Table 2. Corn Yields (bu/A)

Cover Crop Treatments	2014	2015	2016
1 - Austrian winter pea, lupine, hairy vetch, AC Greenfix	152	114	81
2 - Roundup Ready® soybeans	147	92	77
3 - Roundup Ready® soybeans & Roundup Ready® Alfalfa	135	81	74
4 - Control Plot	157	155	175
5 - Extra Control Plot	144	148	171

Paul was hoping legumes planted from the year before would produce enough nitrogen for this year's corn crop, but it was clear that yields on the cover crop plots suffered

compared to the control plot by almost 60 bu and Paul was sure the yield drag was due to the lack of nitrogen. He was disappointed with the cover crop plots.

2016 Results

The final year of this demonstration was 2016. Average corn yields from the cover crop plots underperformed the controls by nearly 100 bu (Table 2). Differences in the field where Paul did and did not apply anhydrous were evident, so Paul concluded the yield drag was due to the lack of nitrogen.

Overall Paul was disappointed with the cover crop demonstration. He had hoped the legumes would produce enough nitrogen so that he could reduce the commercial nitrogen required for corn production. He was expecting better corn yields, but concluded that the legumes had little to no carry over nitrogen – at least not enough to help the corn crop.

Management Tips

1. Seed cover crops before a rainfall, especially when broadcasting.
2. Don't assume cover crops can provide all the nitrogen a subsequent corn crop needs.
3. Keep in mind that experiments don't always go as planned.

Cooperators

*Wabasha Soil and Water Conservation District,
Wabasha, MN*

*Dan Nath, Soil Scientist, Natural Resources Conservation
Service (NRCS), Rochester, MN*

Location

From Wabasha, go N on Hwy. 61. Turn left onto Cty. Rd. 30. Turn right toward T-504. After 2 miles, destination will be on the left.

Other Resources

Sustainable Agriculture Network. 2007. Managing Cover Crops Profitably: Third Edition. Beltsville, MD. www.sare.org/publications/covercrops/covercrops.pdf

USDA Agricultural Research Service. Cover Crop Chart. www.ars.usda.gov/plains-area/mandan-nd/ngprl/docs/cover-crop-chart

Principal Investigator

Daniel Ley
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320-597-5065
Stearns County

Project Duration

2015 to 2018

Award Amount

\$5,089

Staff Contact

Cassie Dahl

Keywords

no-till, cover crops, soil
health

Evaluation of Winter Annual Small Grain Cover Crop for Forage Production

Project Summary

The focus of our project is to demonstrate the potential economic value of winter annual cereal grains planted as cover crops in the fall and harvested in the spring as silage, prior to planting that year's production crop. The differences in growth rate, silage yield, and forage value of cereal rye, winter wheat, winter triticale, and winter spelt will be measured and recorded. I hope to determine if it is economical, from a production standpoint, to add these cover crops to my rotation and which winter annual small grains are most practical. I am also assessing soil health including, physical, chemical, and biological change.

Project Description

For years I have been interested in building soil health. In 2006, my wife, Crystal and I took over full ownership of our family's Century Farm. The farm consists of 321 acres, 50 dairy cows with about 16 replacements, and 33 young stock and calves. We grow corn, small grains, alfalfa, and soybeans. In 2008, we began incorporating cover crops into our already no-till rotation.

In 2013 and 2014, we hosted a cover crop research and demonstration project on our farm funded by Minnesota Corn Research and Promotion Council and the Sustainable Agriculture Research and Education Program. We studied different ways of establishing cereal rye, and demonstrated the performance of a variety of fall planted cover crop mixes. The project was developed and managed by the Stearns County Soil and Water Conservation District (SWCD) and the University of Minnesota Extension. That project made me thirsty for more knowledge and answers. A recurring question that we heard from previous field day attendees was, "How do we make cover crops cost effective?" I was motivated to partner with Stearns County SWCD and others to continue to research cover crops. The purpose of this project is to evaluate the short-term economics of winter annual small grains that are planted in the fall as cover crops and harvested in the spring for silage. In addition, we want to achieve soil health benefits from these cover crops in a no-till system.

This project will hopefully show that cover crops provide resource protection without short-term economic hardship. The following are soil and water resource issues that I believe the winter annual cover crops will address on my farm and the surrounding area.

Nitrogen Immobilization - Much of my farm and the surrounding area is listed as having "very high" sensitivity to ground water pollution with bedrock within 50' of the land surface. I am very interested in using winter annual cover crops, with their fibrous root systems, to help immobilize nitrogen.

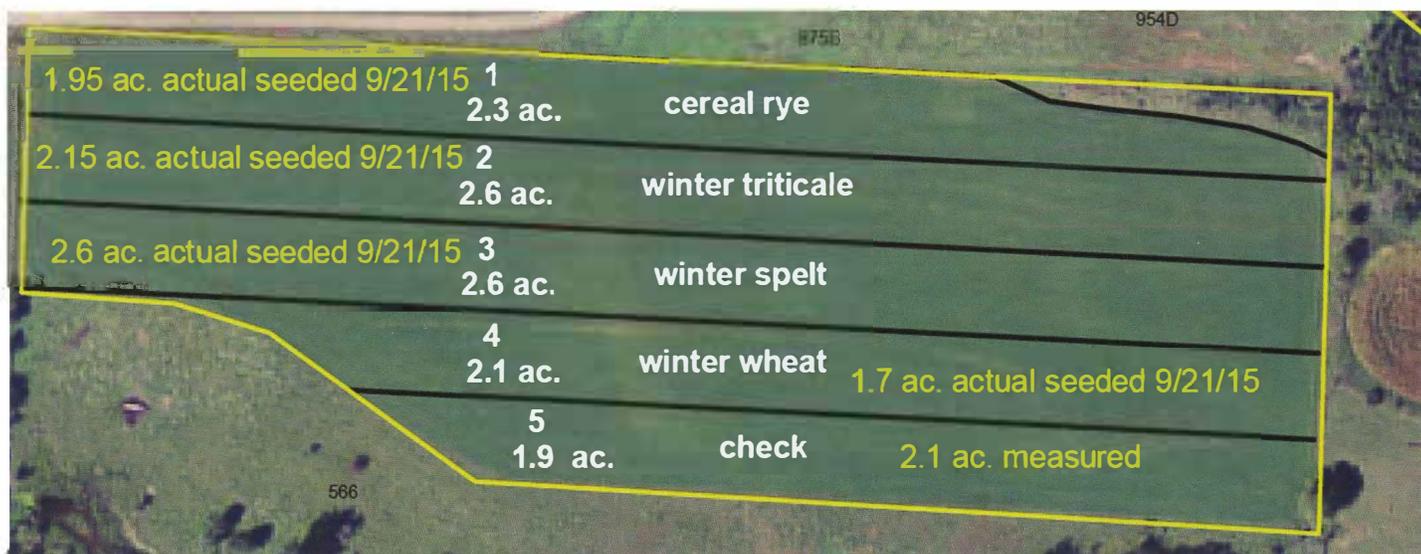
Increasing Soil Carbon - The winter annual grasses we are planting have a high potential to increase soil carbon. The sandy soils in our area are typically low in soil organic matter and increased organic matter will improve nutrient cycling, increase water holding capacity, and reduce wind and water erosion.

Erosion Control - The cover crops that we are planting will be actively growing in the spring. This is important because that is when we get our most erosive wind and rain events and having established plants will protect the soil during these periods. We will use no-till methods for minimal soil disturbance and to protect the residue cover.

The project is right on track, I have planted nearly equal sized strips of cereal rye, winter triticale, winter wheat, and winter spelt this fall after harvesting the production crop on a 12 acre field near my farmstead. In the spring, I will harvest the cover crop for silage at the appropriate time to maximize yield and quality. A check strip has been included in my project and does not have a cover crop.

We will monitor the yield and forage value of the cover crop silage in each strip and convert this data to monetary value. We will also monitor the yield and forage quality of the following production crop to determine if the cover crop affected these factors based on the check strip values.

Our partner, Ag Resource Consulting (ARC), has collected soil samples for standard soil series tests for phosphorus, potassium, soil organic matter, pH, and the Soil Health Tool (Haney test) for both inorganic and organic nutrient availability, and soil carbon for our baseline data. We will continue sampling throughout the project to monitor changes. We have also collected other soil factors, such as soil moisture, water infiltration rate, and compaction. In addition, we will also measure surface residue cover prior to planting the production crop. A crop consultant will monitor weed pressure in the production crop to see if the cover crop has any effect on weed species and abundance. The production crop following the cover crop will likely be corn harvested for silage.



Plot layout with cover crop locations.

2015 Results

This year soil samples were taken on June 4, 2015. Field monitoring for soil moisture was conducted throughout the growing season. Additional base data including, soil compaction, water infiltration rate, and soil temperature was also collected. It will be interesting to see how the data

changes as the project progresses. Corn silage was harvested on September 17, 2015 and manure was applied two days later at 5,895 gal/A. Spreader calibration was completed and cover crops were seeded on September 21, 2015.

2016 Results

On May 18, we harvested cereal rye and on May 24, we harvested winter triticale, spelt, and winter wheat. Field monitoring for soil moisture was conducted periodically throughout the growing season.

The main purpose of soil moisture testing was to determine the effect that our cover crops may be having on the production crops. Some say that dry conditions caused by cover crops can delay crop emergence and slow early growth. We decided to compare soil moisture in the cover crop strips to the check plot. Our focus was on moisture at production crop planting time and whether or not a moisture deficit recovered during the growing season.

We did see somewhat dryer conditions in the cover crop strips versus the check. This dryer condition seemed to continue into late August or early September. However, we cannot say that it affected yield significantly because all of the strips had higher soybean yields than the check.

The data on the east side was a little confusing. The check was dryer than the cover crop strips. However, both moisture levels appear to be fairly close on the east side, perhaps this was due to coarser soil.

Soybeans were harvested on September 23 and manure applied on September 29 at 5,895 gal/A. Spreader Calibration was completed the previous year and cover crops were seeded on September 30.

Management Tips

1. Keep an open mind when working with cover crops and no-till. I firmly believe the largest obstacle is having the right mindset.
2. Talk to your neighbors, consultants, and feed guys to find out what others are doing; that way you can build off of each other's ideas. Another way to be involved is to attend local field days.
3. Be prepared to change your herbicide program because your weed make up will change.

Cooperators

Stearns County SWCD, Waite Park, MN
Ag Resource Consulting, Inc., Albany, MN

John Dockendorf, Greenwald Elevator, Greenwald, MN

Project Location

The nearest town is Roscoe, MN. From the intersection of Cty. Rd. 10 and 1st St. (Cty. Rd. 114) in Roscoe head east on 1st St. for 1 mile, turn left onto 246th Ave. for .7 miles. Turn

right onto 222nd St. for .7 miles, the field is located at the end of the road on the south side of the mailbox.

Other Resources

Midwest Cover Crop Council (MCCC).
 Website: www.mccc.msu.edu

No-till Farmer Magazine.
 Website: www.no-tillfarmer.com

Principal Investigator

Russell V. Martie
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 Wright County

Project Duration

2015 to 2017

Award Amount

\$11,937

Staff Contact

Tori Hoepfner

Keywords

irrigation, soil moisture,
 water efficiency

Sub-surface Irrigation for Field Crop Profitability and Water and Fertilizer Efficiency

Project Summary

This project will compare three types of irrigation: 1) Subsurface Drip Irrigation (SDI), which was installed in an existing field in 2014, 2) a non-irrigated field, and 3) a center-pivot field. The objective of this project is to improve yields and profitability while utilizing irrigation water more efficiently and decreasing energy inputs.

Project Description

Russ has been farming for 42 years and grows several crops including corn, hay, and teff grass on about 400 acres. He is enrolled in the Natural Resources Conservation Service (NRCS) Conservation Stewardship Program (CSP), which includes the following activities: multi-species native perennials for biomass and wildlife habitat, wildlife friendly fencing, energy enhancement, water quality enhancement, and soil quality enhancement.

The idea for this project came from reading about SDI projects in Nebraska and other Great Plains states. Russ understands that rain is not guaranteed and knows he could do a better job with controlling the ground water he uses for irrigation. Russ's farm has sandy soil, making it difficult to use water efficiently. Water efficiency is important to Russ in terms of his long-term economic goals and his desire to make his farm more sustainable for the next generation. His goal is to grow 200 bu/A corn while being more efficient with water and electric use and ultimately, provide area farmers with a data set to help them improve resource conservation, increase profitability, and lessen ground water impact.

The following pieces of data are collected for this project:

- water used;
- electricity used;
- soil moisture (3 probes per field that are buried at 6", 12", and 18");
- yield rates per field;
- air temperature;
- rainfall per field (rain gauge);
- planting date/rate, and;
- fertilizer rate (same for all 3 fields).

This project runs from April through October. In April, the soil moisture sensors are installed when the soil temperature is suitable, which is around 45°F. In May, sensors in each field are checked for water balance prior to planting. This data is entered into the “ET Checkbook” to track daily information such as rainfall, irrigation, and

air temperature. This information gives other producers an idea of soil moisture levels and water needs based on the stage of their crop. In October, yield rates are collected, final water and electrical use rates are documented, and fields begin to be compared.

2015 Results

Russell believes the SDI style of irrigation was the most efficient in this past year. With SDI, the moisture level of the soil was better controlled so that it was saturated but not dry. Where SDI was used, the spikes in soil moisture levels over the season did not vary as greatly as the non-irrigated and center pivot systems.

The center pivot system created some soil moisture consistency, but was not as consistent as the SDI system. When a center pivot system was used between rainfalls, this field consistently had higher levels of soil moisture than the non-irrigated field. The moisture was substantially more variable in the center pivot system than in the SDI system, which leads Russell to believe it is not as effective as the SDI system.

The non-irrigated field had the lowest levels of soil moisture overall and the most variability in soil moisture levels, similar to the field with the center pivot system. When the last sample was taken, the non-irrigated field had higher levels of moisture at all depths than the center pivot system and similar levels to the SDI system. The SDI system had a higher level of moisture 12” below the soil surface, while the non-irrigated field had a higher level of moisture at 6”. This means that the SDI system penetrates water into the soil more efficiently, which is important to consider at different stages in the crop’s lifecycle.

2016 Results

The data Russell collected gave him a better understanding of how to efficiently use water so it directly waters the crop without evaporating, allowing him to reduce his ground water use and decrease the impact on his aquifer. Furthermore, Russell lives near the small town of Hasty that relies on individual wells for their drinking water. The SDI project will conserve more of their water supply than a normal center pivot.

Russell found the upfront costs for the SDI system to be much lower compared to the Center Pivot. However, over time he’ll have more insight into maintenance costs. Because farming is dependent on many variables (weather, commodity prices, fertilizer and fuel prices), maintaining some consistency with water and electrical use through the SDI system would increase income overall.

Next year, Russell will check the SDI system right away to confirm it is working correctly and will address any issues as soon as possible. In addition, he will update the ET Checkbook daily and check soil moisture sensors each month to confirm data recorded in the ET Checkbook. In order to maximize yield, he will need to have almost live soil conditions (balancing rain events and needed irrigation). Lastly, he will monitor plant development to ensure his crops receive the correct amount of water for their growth stage.

Table 1. Corn Yields



Table 2. Water Used

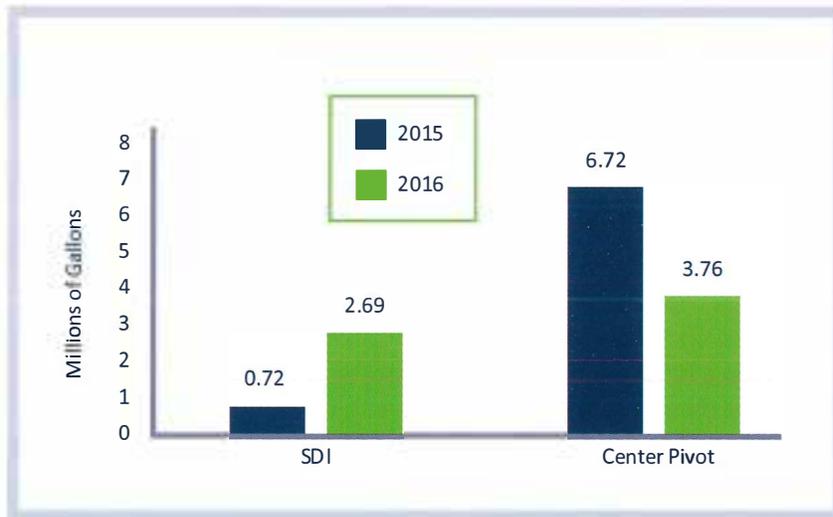
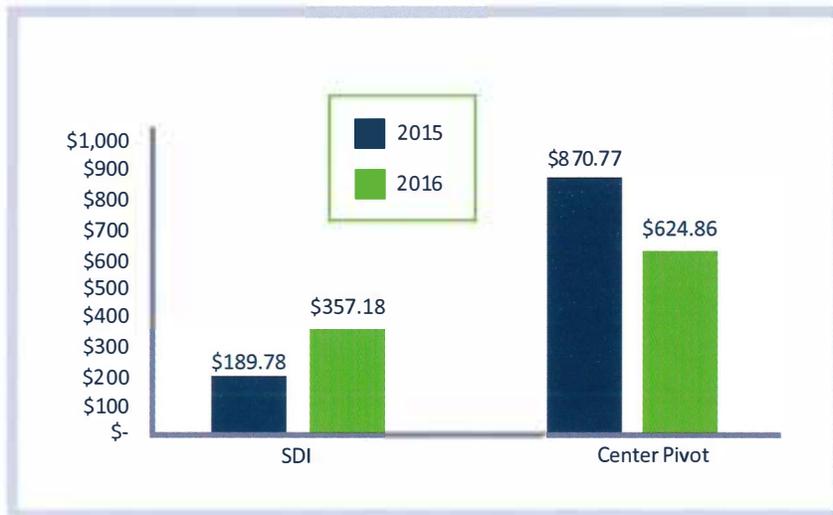


Table 3. Electricity Costs



Management Tips

1. Have background information (collect data – water/ electrical use) prior to investing so you understand where SDI can help.
2. Make sure flow of well stays constant, especially in sandy soils.
3. Install soil sensors as early as you can to get good base moisture information. This will help set-up the year and understand what your newly planted field will need if it doesn't rain.
4. If you plan to incorporate fertilizer through your SDI system, start early with your agronomist as there is a learning curve.

Cooperators

Scott Wicklund, MIDC Enterprises, Roseville, MN
Johan Oostenbrink, Netafim Irrigation, Fresno, CA
Rod Greder, U of M-Ext. Educator, Buffalo, MN

Josh Stamper, U of M Irrigation Specialist, St. Paul, MN
Dan Nadeau, Wright SWCD, Buffalo, MN
Julie Reberg & Katie Evans, Wright NRCS, Buffalo, MN

Project Location

From Minneapolis/St. Paul, go west on I-94. Exit onto Cty. Rd. 8. Turn right onto Cty. Rd. 8. Take the second right onto 150th St. Site is 1 mile down on the left.

Principal Investigator

John Mesko
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Mille Lacs County

Project Duration

2016 to 2017

Award Amount

\$9,829

Staff Contact

Meg Moynihan

Keywords

bale grazing, cattle, hay,
winter

How Much Can You Afford to Pay for Hay?

Project Summary

This study is investigating the impact of bale grazing on animal and pasture productivity. After taking all costs and benefits into consideration, what is the value of spent hay litter from purchased hay? How much can a farmer afford to pay for hay used for winter bale grazing?

We are monitoring changes in hay field and pasture productivity and quality to determine the true value of purchased bale-grazed hay. We expect to see the productivity of pastureland increase after we bale graze it. We are also measuring the true net cost and return on purchased hay—both from a forage perspective and a soil enhancement perspective.

Project Description

Soil health has become a hot topic in agriculture and has raised interest in pasture management and grazing. At grazing conferences and workshops in the upper Midwest, winter bale grazing (setting bales of hay out on a pasture and grazing them there) is often touted as a great way to add nutrients to the soil because of the spent hay litter left behind after the cattle are done grazing. I've heard statements like, "With what bale grazing can do for your soils, you can afford hay at almost any price!"

Is that true?

Bale grazing has been proven to be an effective way to increase productivity on grazing land. However, within a fixed acreage, there seems to be little advantage to just moving baled hay from one place on the farm to another. In order to boost productivity quickly, and to be able to produce enough beef to be economically viable, some form of purchased hay may be a producer's best option.

In our region, the cost of winter feed is often a grazier's biggest expense, and making hay is an essential component of producing grass-fed cattle. However, the need to make hay can often limit the amount of grazing land available (and thus the herd size) in a particular year, since some land needs to be hayed for winter feed instead of grazed during the growing season.

But what if hay could be affordably outsourced? If a producer bought all his or her hay, then grass-fed herds could grow larger, because most or all of a farm's land could be grazed. In an attempt to know the true cost and benefit of purchased hay in a bale grazing scenario, we must somehow measure the benefit of that hay litter on the pasture in subsequent years.

The site for this testing and demonstration is a 14 acre pasture at Lighthouse Farm near Milaca. The soil pH is about 6.0. The pasture was established in 1989 and is a mix of timothy, orchardgrass, and smooth brome grass. We hayed all 14 acres once in summer 2015 and grazed the regrowth in November of that year.

We split the site in half. On the “treatment” side, we set out purchased hay bales and grazed them during the winter of 2015-16. On the “control” side, we didn’t do any bale grazing at all. Otherwise, the two halves were managed identically. We recorded everything added to and harvested from the site. We conducted soil tests to monitor changes in soil nutrients and organic matter and forage tests to monitor forage quality.

In the spring, we dragged the treatment side to break up hay and manure clumps. We harvested hay off all 14 acres

in the summer, measuring yield and testing forage quality. We then grazed 14 yearling steers and heifers on the entire site from September 5-25, 2016 (20 days). We soil sampled again in fall 2016.

We bought 40 large round bales of hay weighing approximately 900 lb each at \$30 apiece and also fed our own hay. After weighing and forage testing the hay, we put them out, 7-10 bales at a time, about 25’ apart. We started bale grazing the same 14 animals in December.

Results

Baseline soil tests taken in the spring of 2016 showed average soil fertility and soil health. Table 1 shows forage quality in 2015 and 2016.

While forage quality improvements from 2015 to 2016 look impressive, it should be noted that the 2015 samples were

taken 9-10 months after the hay was baled, while the 2016 samples were taken only days after we made hay. We’ll be sampling the 2016 hay again in early 2017 in order to see how the quality changes over winter.

Table 1. Forage Quality of Hay Harvested from the Bale-grazed Half of the Study

Measure	2015	2016
Sampling Date	April 20, 2016	July 5, 2016
Crude Protein (Dry Matter)	7.7%	10.7%
Relative Feed Value	80	104
TDN (est,%)	55.2%	64.0%

Calves averaged 725 lb at turnout on September 5 and 755 lb on September 25, for an average daily rate of gain of 1.75 lb/day. This number is lower than what we normally achieve on our farm. We think regrowth may have been too short to really allow for efficient grazing. We also suspect that when we split the test group of 14 yearlings off from the rest of the herd, there was a day or two of stress on them from being separated, and they may not have gotten right down to grazing. Subsequent grazing in 2017 will help us determine the impact of these effects.

I suspect that at 25’, we put the bales too far apart. I expected the cattle to scatter the hay further than they did, but in the spring the hay litter was not evenly scattered and resulted in spotty regrowth. I plan to only allow 8-10’ between bales during our 2016-17 winter grazing season.

Management Tips

1. If you use small square bales, you will need some kind of feeder to keep cattle from wasting too much of it. We've actually used round bale feeders for feeding square bales and it works well.
2. We've put out as much as 3 weeks of feed at a time, with little "wastage."

Cooperator

Kent Solberg, Livestock and Grazing Consultant

Project Location

The study is located 6 miles south of Bock, MN on Mille Lacs Cty. Rd. 1.

Principal Investigator

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 Kandiyohi and Stevens
 Counties

Project Duration

2015 to 2017

Award Amount

\$22,578

Staff Contact

Meg Moynihan

Keywords

cover crops, soil health,
 tillage

Cover Crops to Replace Fall Tillage in the Shakopee Lake Bed

Project Summary

This project is analyzing effects of cover crops on soil compaction in the Shakopee Lake Bed area of west central Minnesota. We are exploring whether including tillage radish in a multi-species cover crop blend can alleviate root zone compaction and reduce the need for primary fall tillage. We are also tracking changes in soil biological activity using the Haney Test.

Project Description

Mark Erickson is one of the farmer cooperators in this project. He operates a grass-fed and finished beef operation with his son and rents a large portion of his land from neighbors. While the rent he pays is lower than the average for cropland in the area, it is higher than the typical rental rates for pasture. So Mark works very hard at achieving maximum production and quality feed on the acres he runs. The land is made up of gentle rolling hills, and soils are largely clay loam. Mark has put many acres of cropland surrounding his farm back into grass and is interested in ways to reinvigorate pastures without tillage because he knows tillage has a negative effect on soil biology. He'd also like to save money by reducing tillage and the use of Roundup®.

Mark's test field is an 8 acre "worn out" pasture that was seeded into perennials about 10 years ago. He wants to establish some new grasses but would like to do so without tilling the pasture. He is working to figure out a system in which he can rotate through his fields, refreshing pastures with deeper rooting and more diverse mixes. Cover crops like tillage radish not only provide late season forage, but start improving soil health and function in his pastures. Mark has discovered a hardpan layer on several of his rented acres from the years of tillage before he returned the land to grass and would like to start breaking through that barrier, giving pastures more access to nutrients, minerals, and moisture.

Mark hopes that using tillage radish will provide a combination of nutrient sequestration and cycling, increased micronutrient availability for the plants and animals, and increased water storage capacity in his pastures. He knows that tillage radish alone will not accomplish this, but he feels that if he can figure out how to establish the radish in weak pastures it can provide an important step toward improving his soil, grass, forage, and herd.

Jess Berge is the other farmer in the project. He is working with 40 rented acres that adjoin his farm. The soil is poor: very rocky, with a high clay content, and relatively low organic matter. Jess raises row crops, cattle and sheep. He primarily no-tills his soybeans, small grains, and cover crops. He wants to keep his equipment costs down and is not interested in purchasing a combine or major tillage equipment.

Jess has found that diversifying his farm has helped him make more out of few acres, giving him flexibility and some protection from fluctuating markets. He is interested in reducing the time and cost of tillage. Jess cuts a lot of his corn for silage and is able to plant late season cover crops after the corn comes off. He likes the fact that cover crops provide extra forage while also building his soil. For these reasons, he wants to learn as many ways to use them in his farm system as possible.

Like Mark, Jess suspects tillage radish could prove to be a tool with many uses – forage, nutrient sequestration, and soil preparation for the no-till application of corn. He would like to see if the radish can “earn its keep” by reducing tractor passes and/or providing late season forage in heavy soils.

Mark's Results

2015

Mark mowed and baled a poorly performing pasture 1 week before seeding. He drilled a mix of radish, clover and oats into the pasture on August 23. Then he turned the cattle into the field intending to keep weed competition down until the mix germinated. He kept the cattle there for a while and even fed some hay, but it was so dry that he had to move them. Mark had received 7/10” of rain on July 27 and 1” on August 7. It didn't rain again until September 20. The cover crop germination was poor. He was disappointed and planned to seed earlier and to irrigate if necessary.

2016

Mark hayed the pasture on August 1, then turned 150 head of cattle out to graze for a day on August 15. The cattle cropped the pasture low to the ground. On August 17, he drilled a mix containing 2.5 lb/A Buster tillage radish, 2.5 lb/A Brassica mix (rape, kale, collards, purple top turnips), and 15 lb/A Oats. He mowed the pasture on August 29 to reduce perennial weed pressure.

The cover crop did not establish well at all. The majority of the seed did not emerge. Where it did, it averaged around 4” of growth—not enough to offer any fall grazing.

Mark feels like the single most challenging issue of this project has been moisture. In the 20 days before he seeded, the farm got 2” rain. In the 20 days after seeding, he got only 0.8”. Mark thinks if he had seeded the cover crop pasture 10 days earlier immediately following rain, and had less perennial weed pressure, he would have seen better results.

Mark said the brassicas germinated right away, even with low moisture, but has observed that if they don't get enough moisture in the next 7-10 days, the little plants generally die. Weed pressure can also be a limiting factor. He planted another area of the farm with the same cover crop mix at the same time that he planted the pasture and had great success. The difference? Lack of perennial weed pressure in the second area.

Mark said that since at least one of the plantings turned out much better than he had hoped for, he is going to keep trying. He still plans to see whether irrigation will improve cover crop germination and establishment. He's also going to try using Roundup® to control weed competition.

Jess's Results

2015

The field that Jess used had been in alfalfa that suffered winterkill in 2014/15. In spring, he did some shallow tillage to set back the alfalfa crowns, then applied the herbicide Clarity®. He no-tilled silage corn directly into the weakened alfalfa. The corn and the alfalfa seemed to flourish and Jess said that yields in the demonstration field were comparable to those in other fields.

Jess chopped the corn on August 20 and drilled a cover crop mix that included tillage radish, oats, and forage turnips on August 20. It did not rain again until late September. When Jess and his project cooperators went to take soil samples, the ground was so hard that the soil probe would barely enter the soil, and the radishes were just starting to germinate. By December, there was only about 2" of growth, at best. On the other hand, another field that Jess had seeded with cover crops 2 weeks before this one looked fine. Jess concluded that lack of moisture was the limiting factor on his project demonstration field.

2016

Jess fed cattle on the demonstration field over the winter. He ripped the acres in early spring and followed with a shallow disturbance of the top inch or so of soil to break up clumps. He then no-tilled in a short season soybean in late May. His mix included the Millborn Classic Trio (40% tillage radish, 30% rape, 30% turnips) at 10 lb/A and oats at 32 lb/A.

Jess expected to harvest the beans early to mid-September, but with a cool wet fall, he did not take them out until October 3. He planted the cover crop October 4. Jess was skeptical that the cover crop would have any time to establish and in order to make sure that he didn't waste cover crop seed, time, and money, he only planted 15 acres of the most erodible hilltop acres in order to see what happened.

Despite the late seeding, the cover crop germinated and grew well, benefiting from a long fall and late freeze. Ultimately, the cover reached about 8" in height, with even, complete ground cover and uniform growth. He said the cover crop would have needed 4 more weeks of good growth to have achieved his expectation – which might have happened if he had been able to harvest soybeans at the usual time.

Considering the circumstances, Jess said it did a lot better than last year, crediting the winter feeding on the field, the spring ripping, and the better moisture in fall this year. Although the cover crop did not meet his expectations, he felt better knowing that his hilltops were protected with some living cover, and saving a pass of tillage and next year's first N application.

Even though he found the 2 years of this demonstration disappointing, Jess intends to keep using a multi-species late season mix in all of his fields where the crop comes off by mid-September. This includes silage corn, small grains, and any successful short season beans. He still believes they are a way to provide late season grazing and to reduce tillage and nitrogen inputs.

Management Tips

1. Knock back perennial competition. This seems to be one of the key impediments to a good cover crop stand.
2. Make sure there's plenty of moisture. There should be some subsoil moisture, plus .5" rainfall in 10 days prior to planting. Success or failure will happen within a week of seeding.
3. Always include oats in your mix. They are inexpensive, germinate quickly, and if you are grazing, they provide a good buffer for the "hot" brassicas.
4. Don't work the ground – it dries things out too much. If you drill the cover into undisturbed ground, you'll get better germination.
5. Pay attention to herbicide labels. You can really set back or completely kill your cover crop if you don't know what was put down and how long it can affect cover crop germination/survival.

Cooperators

*Jennifer Hoffman, Chippewa River Watershed Project,
Montevideo, MN*

*Sharon Weyers, Research Soil Scientist, North Central Soil
Conservation Research Lab, Morris, MN*

Project Location

Mark Erickson: Take Hwy. 74 East out of Donnelly for 2 miles, then go North on 500th Ave. for 2 miles. Turn left on 140th St. and it's the first farm site on this road: 50114 - 140th St.

Jess Berge: Take Hwy. 9 for 2 miles West of Sunburg, and then turn right (North) on 170th Ave. Go 1 mile, house is on west side of the road: 480 – 170th Ave. NE.

Principal Investigator

Daryl Patnode
 23301 Cty. Rd. 50
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 Hennepin

Project Duration

2015 to 2017

Award Amount

\$6,716

Staff Contact

Meg Moynihan

Keywords

cover crops, corn silage-
 soybean rotation, forage

Three-crops in Two Years for Farm Profit and Water Quality: Winter Rye after Corn Managed for Spring Forage

Project Summary

This demonstration project assessed the feasibility of including Winter Cereal Rye as a cover crop and managed as a forage in the spring as a one-cut system prior to seeding the subsequent soybean. Benefits, challenges, and costs were tracked to assess this system for use on MN livestock farms. Benefits of cover crops include improved soil quality, less soil erosion, less nitrogen leaching, related water quality impacts, and weed control benefits. The extra forage produced (two tons/acre or more) is a low cost source of high quality forage, especially by providing fresh green forage in the early spring when feed stocks were low. We used our existing equipment. The challenges of incorporating another crop into the rotation included timely planting of the Rye after corn harvest in addition to manure application and incorporation; timely harvest in the spring so as to not delay the planting of the subsequent crop, and the possibility of the Rye becoming too mature thus harder to prepare the ground for the next crop and quickly losing feed value as a forage.

Project Description

The land that we farm has been in our family for nearly 100 years. We live on this land and want to be good stewards not only to benefit our family, but also to provide environmental benefits for the neighbors surrounding us. The importance of improving and maintaining our land's soil health and productivity was magnified when my son joined my wife and me as the sixth generation to farm this land. Our operation consists of a 70 cow dairy herd raised on the 400 acre farm, which includes 30 acres of pasture. We utilize a corn-soybean-alfalfa rotation in our crop production system. We rely on soil testing data to develop our soil fertility program and to determine appropriate manure application rates.

The use of winter rye or other winter grains as cover crops is a proven but underutilized cropping system in beef and dairy operations. Winter grains planted as cover crops have the potential to bring added value to a livestock operation by providing a low cost, high quality feedstock for a dairy or beef herd. The use of cover crops allows farmers to significantly reduce sediment and nutrient runoff from their operations, which protects the surface waters that we enjoy in Minnesota. Cover crops also protect our valuable soils from wind erosion losses.



Silage Harvest on September 15, 2015. Photo Daryl Patnode.

Results 2015

Our project began on September 15, 2015 when we chopped our corn silage crop. Our average silage yield for 2015 was 27 tons/A. On September 20, manure was applied at a rate of 1,000 gal/A and incorporated using a field

cultivator. The next day, we seeded the winter rye cover crop at a rate of 120 lb/A. On December 7, the rye was 4" tall and looked good.



Winter Rye Cover Crop on December 7, 2015. Photo Karl Hakanson.

Results 2016

Once the frost left the ground, the rye took off and 4.5 to 5 tons of Rye were harvested per acre on May 7, 2016 (160' bag @ 1.2 ton/ft divided 38 acres of Winter Rye). On May 8, 2016 soybeans were planted. On June 1, 2016 the field was sprayed with Round-Up at 32 oz. rate to burn down volunteer Rye. The Rye forage was sampled on June 5, 2016 when we began feeding the Rye silage. The field needed to be sprayed on June 28, 2016 a second time with Flexstar GT at 3 oz. rate. Due to very good weather for the growing season the soybeans were harvested at 65 bu/A in the fall of 2016.

The cover crop provided a barrier to soil erosion during the winter months as keeping soil covered year-round is best for avoiding soil erosion. With more species of crops planted on the same ground the biology of the soil is improved, the roots of the plants are feeding different organisms in the soil, creating improved organic matter. Weed suppression and nutrient management were achieved while requiring less chemical use. The additional forage crop was an equally valuable benefit for our dairy operation and the cattle liked this additional forage as well. For us, the benefits heavily outweighed the extra time/work required. We repeated the Rye cover crop on a larger amount of land in the fall of 2016 and plan to keep doing so each year.

Management Tips

1. Winter Rye will remove a lot of water out of the soil in early spring; this is OK if you are on heavy ground, but not if planting on light soil.
2. The best window for planting Rye is August 15 - October 1 in our climate zone.
3. This project is best utilized by cattle/crop farmers because of the extra forage you can gain.
4. Know your goal: is it coverage crop for soil health or forage for nutritional value? Maybe plant a shorter term cash crop to maximize the nutritional value of the cover/forage crop (allowing a longer season for the forage crop).

Cooperators

Karl Hakanson, U of M Ext., Hennepin County

Kent Solberg, Dairy Farmer, Cover Crop Practitioner and Livestock and Grazing Specialist, Sustainable Farming Association of Minnesota, Verndale, MN

Dale Hanson, Agronomist/Seed Sales, Luxemburg Feed, St. Cloud, MN

Rod Gustafson, Agronomist, Federated Co-op, Albertville, MN

Project Location

From the intersection of Hwy. 55 and Cty. Rd. 19 in Loretto, drive north on Cty. Rd. 19 to the intersection with Cty. Rd. 50. Turn right and drive 1 block east. Our dairy farm is located on the southeast corner of the intersection of Cty.

Rds. 19 and 50. The project site is in the field on the east side of the farm.

Other Resources

1. Sustainable Agriculture Network. Managing Cover Crops Profitably: Third Edition. Beltsville, MD. 301-504-5236. Website: www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition
2. Midwest Cover Crops Council. Website: www.mccc.msu.edu
3. Minnesota Department of Agriculture. Cover Crops Research and Demonstration. Website: www.mda.state.mn.us/protecting/conservation/covercrops.aspx#soilhealth
4. USDA-NRCS. Cover Crops and Soil Health. Website: www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/crops/?cid=stelprdb1077238
5. USDA-NASS. 2015 State Agriculture Overview. Minnesota. Website: www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=MINNESOTA
6. Minnesota Pollution Control Agency. Nutrient Reduction Strategy. Website: www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/nutrient-reduction/nutrient-reduction-strategy.html
7. Minnesota Pollution Control Agency. Sediment Reduction Strategy for the Minnesota River Basin and South Metro Mississippi River. Website: www.pca.state.mn.us/index.php/view-document.html?gid=20703
8. University of Wisconsin-Madison Extension. Planting Winter Rye after Corn Silage: Managing for Forage. Website: http://ipcm.wisc.edu/download/pubsNM/Rye_090507_final.pdf
9. Journal of Soil and Water Conservation. Vol 47. No. 1. 14-16. Why farmers adopt production technology. Overcoming impediments to adoption of crop residue management techniques will be crucial to implementation of conservation compliance plans. Website: www.jswnonline.org/content/47/1/14.extract

Principal Investigator

Chad Rollofson
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Grant County

Project Duration

2014 to 2016

Award Amount

\$15,809

Staff Contact

Cassie Dahl

Keywords

no-till, corn, soybean, soil health

No-till Cover Crop Rotation vs. Intensive Tillage in Corn Soybean Rotation

Project Summary

My project is to compare the soil health and economics between cover cropped no-till plots with a wheat-corn-soybean rotation, and intensively tilled plots with a corn-soybean rotation. The corn-soybean rotation is the most common rotation used in west central Minnesota. Most of these rotations involve aggressive tillage to bury residues and make the fields “black”.

Project Description

My farming operation consists of 474 acres in Grant County of west central Minnesota. My soils are classified as loam and clay loam. These soils are fairly drought resistant. The last couple of years my plantings have consisted mostly of a tilled corn-soybean rotation. However, I was noticing a lot of soil erosion and wanted to try and slow that down, so I started using no-till production methods on some of my soybean fields. For the typical corn-soybean rotation I have always used a chisel plow after soybeans and a disk chisel after corn. For equipment, I have a John Deere 1590 no-till drill with 7.5 or 15” row spacing and a Great Plains Turbo Till vertical tillage tool for keeping residue on the soil surface. I found that I was getting good yields from the no-till soybeans and soil erosion was less on these fields compared to my tilled fields. From this research I want to determine if no-till production methods with cover cropping can be profitable, improve soil health, and slow erosion off my fields.

For the experiment, I set-up ten plots each slightly over an acre in size within a field that was planted with soybeans the year before. Four of the plots will be in a tilled corn-soybean rotation. The other six plots will be in a no-till wheat-corn-soy rotation with cover cropping. This year two of the tilled plots were in corn and two were in soybeans. The no-till plots had two in spring wheat, two in corn, and two in soybean. I am continuing with this rotation for the second year of the experiment.



Winter wheat plot that was seeded with cover crop mix in early November.

I have three objectives for the project. The first is to improve soil health. The second is to show that the economics of a wheat-corn-soybean rotation utilizing no-till and cover cropping is as profitable as or more so than the tilled corn-soybean rotation. Lastly, I would like to successfully demonstrate that we as farmers can reduce the erosion of our soils from winter winds and summer rainstorms by protecting it with cover cropping and no-till management.

This project is important to me because I see soil as one of the most overlooked resources. I hate to see our most valuable resource end up as black snow in road ditches and waterways, or carried off our fields by heavy rains and flow into our lakes and rivers. Keeping the soil in our fields is important to all of society and my children because it can help with sustainable food production and clean water. If I can show that no-till cover cropped fields in

wheat-corn-soybean rotations, not only benefit the environment and society, but is also economically viable for Minnesota farmers, it would be a win-win situation.

After laying out the plots this spring, Paul Groneberg took soil samples from all ten plots. We wanted to create a baseline of soil health and nutrient levels for each plot. We sent soil from each plot to Cornell Labs, Ward Labs, and Agvise Labs. Agvise did a general soil test for nutrients, pH, salts, and organic matter. Ward and Cornell labs each had a different soil health test. Paul also took residue counts after planting. During the summer Paul took tissue tests to monitor crop health. Then this fall I kept track of yields from all ten plots, measured above ground biomass from the cover crop plots, and again Paul took soil samples from all ten plots and then sent them this time only to Agvise for the general nutrient test. I also kept track of inputs and field work activities.

2014 Results

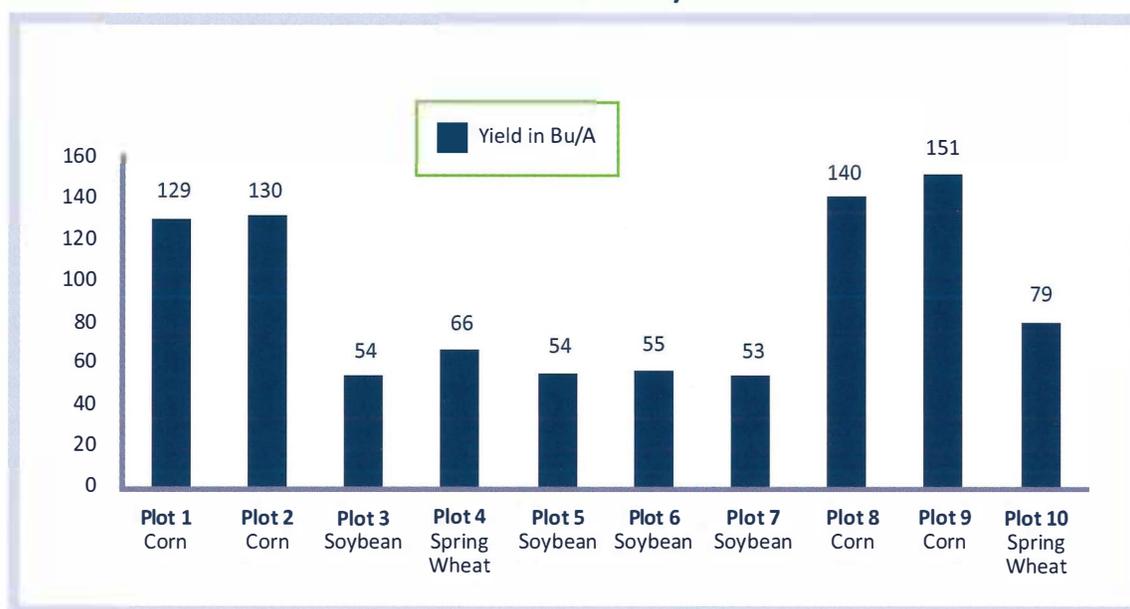
The focus of the first year of this project was to gather baseline data. This data will serve as a reference point in a long-term study beyond this grant period. The soil in the plots is a Barnes-Svea loam soil. The ten plots have 25-39% sand, 41-49% silt, and 20-26% clay. The baseline overall quality scores from Cornell were all in the medium range with the most limiting factors coming from available water capacity, aggregate stability, ACE soil protein index, and respiration. Tillage can negatively impact these factors. The Ward Labs results for soil health showed that four of the plots scored below seven while the other six plots scored above seven. Also from Ward Labs, the Microbial Biomass test showed that seven plots fell into the average category, one plot fell into the slightly above average category, and the other two plots were in the good category. Agvise was used for both spring and fall soil sampling to measure nitrogen, phosphorus, potassium, zinc, salts, organic matter, and pH. The pH averaged 7.5 across all ten plots while the organic matter averaged 4.4% across the ten plots. Phosphorus and potassium increased from west to east or from plot 1 to 10. This is because the farm had cattle who contributed manure to the farm more than 10 years ago.

The plots averaged 31% residue cover after one pass with a field cultivator, a pass with a Great Plains Turbo Till, and the planting pass. This will be the last time six of the plots will be tilled for the duration of this study. The economic results

are being tracked and will be summarized after the third year. See the graph below for yields in year one. Corn yields were below average and suffered from nitrogen being lost due to excessive spring rainfall. Cool summer temperatures also lowered corn yields as did the late planting date due to spring's cold wet conditions. Soybean yields were very good in the mid 50 bushel range for a 0.5 maturity soybean. An early soybean was chosen for early harvest to give time to plant winter wheat into plots 3 and 7 after the harvest. Wheat yields were quite good, although the late May planting date was a month behind normal.

The no-till cover cropping system had costs for cover crop seed that was \$23/A for plots 1 and 8 and \$22/A for plots 4 and 10 along with the costs associated with running the tractor and no-till drill on plots 4 and 10. The four tillage plots had costs that are associated with the two passes with a sunflower disk chisel this fall. All spring tillage costs were the same for each plot. Above ground cover crop growth was less than normal this year, after the spring wheat harvest, in plots 4 and 10 due to the late harvest of the wheat on September 5, 2014. The cover crop seed mix was from Millborn Seeds and contained 30% cover crop radish, 20% annual ryegrass, 15% common vetch, 15% crimson clover, 15% lentil, and 5% sunn hemp. Cover crop growth in corn plots 1 and 8 was small but emergence was very good, due to really nice rains that occurred after I hand spread the seed into the corn. Hand seeding was used to simulate

2014 Yield in Bu/A



aerial application. The mix was from Millborn Seeds and contained 30% annual ryegrass, 20% crimson clover, 20% cover crop radish, 20% turnip, and 10% dwarf essex rape. The two winter wheat plots had good emergence although growth was limited due to the late planting on September 26, 2014. Time will tell if this affects winter survival. The

one thing I did not count on for the first year of this study was the late wet spring and the cool growing conditions. I am excited to go into year two of this study with the no-till cover crop plots in place.

2015 Results

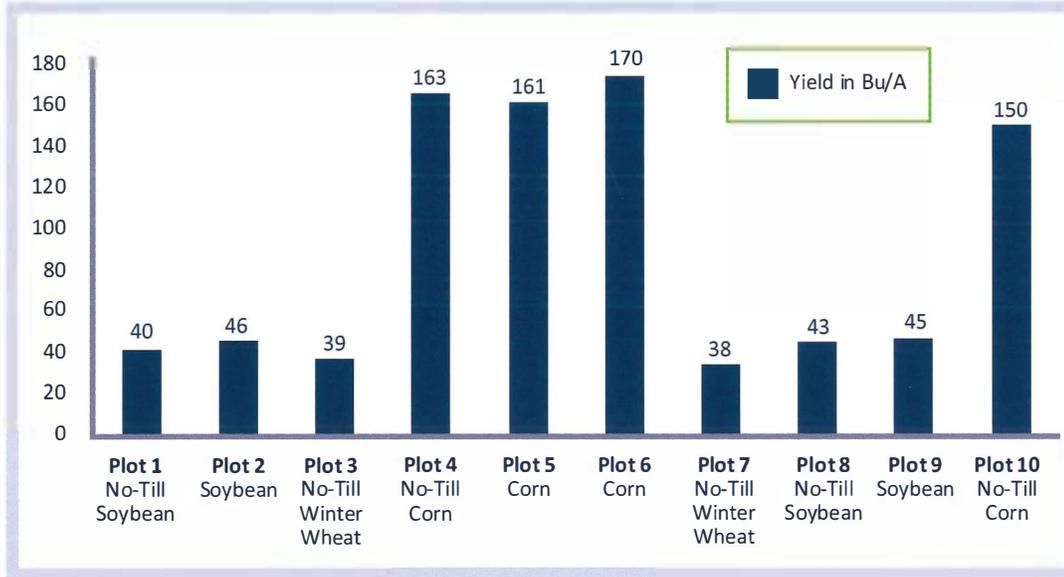
Year two of this study got off to a great start with an early spring. Winter wheat survival was good but not great as we had an open cold winter season. As it was though, the stand was adequate and was soon top dressed with 100 pounds of nitrogen. Corn planting in all the plots took place in the last days of April and the soybeans soon followed in the first days of May. All planting conditions were good. Crop growth was good with only one of the no-till corn plots a little “slow” due to a lot of wheat residue.

There was a severe hail storm on all of the plots on July 12th along with 3.5” of rain. Estimates were 20 bushels of wheat were lost to shelling and broken stems and 20-30 bushels of corn were lost due to plant damage. The soybeans had some yield taken also although they compensated the most of the three crops. You can see in the yield results that the no-till soybeans yielded slightly less than the conventional

tillage soybeans, the winter wheat plots yielded similar to each other, and in the corn the lowest yielding plot was the plot with the most wheat residue while the other three corn plots all yielded similarly.

With the early harvest of wheat, I had excellent cover crop growth on those plots. The cover crop mix was from Millborn Seeds and contained 30% cover crop radish, 20% annual ryegrass, 15% common vetch, 15% crimson clover, 15% lentil, and 5% sunn hemp. The late fall also allowed the cover crop growth in the corn plots to grow more than last year. That mix was also from Millborn Seeds and contained 30% annual ryegrass, 20% crimson clover, 20% cover crop radish, 20% turnip, and 10% dwarf essex rape. Winter wheat establishment was also excellent with better fall growth than last year. Plenty of rain fell with a total of 21.3” falling from planting to freeze up.

2015 Yield in Bu/A

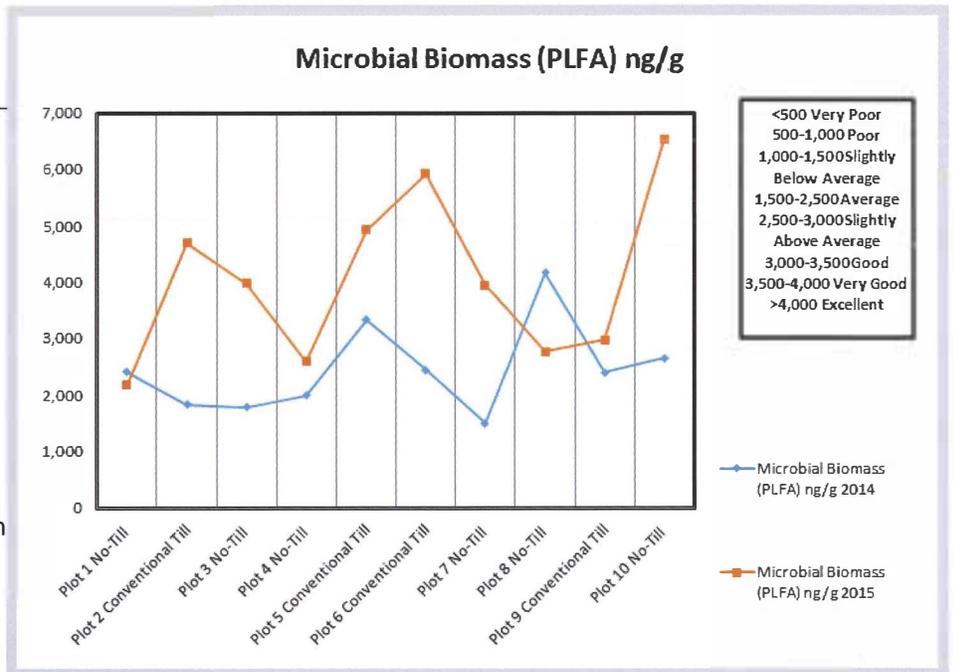


I did notice some trends in regards to the soil health parameters. In general, the Haney soil health measurements were lower in 2015 than in 2014, and in general the Microbial Biomass and Cornell Quality scores were higher in 2015 than in 2014. I cannot say that I see any big differences yet between the no-till cover crop plots and the conventional tillage plots, but I suspect these differences will appear slowly and even beyond the 3 years of this study.

However, one difference in year two was the greater amount of residue remaining on the no-till plots with significantly less appearing on the conventional tillage plots. The soil is being protected in the no-till plots.

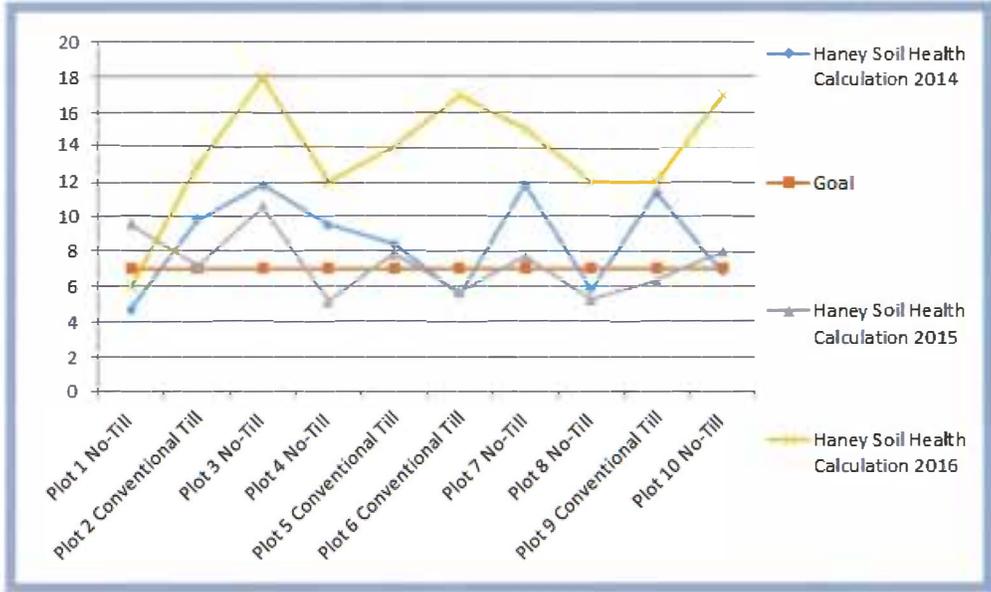
2016 Results

The final year of this study got off to another great start with an early and fairly dry spring. Winter wheat survival was excellent and top dressed with 100 pounds of nitrogen. However, the winter wheat developed a leaf disease during the growing season, which suppressed yields. My future plan is to spray fungicides on the wheat. Corn and soybean planting in all the plots took place in a timely manner and planting conditions were good. Overall crop growth was good, but the two no-till corn plots were slow and showed nutrient stress. The hail the previous season resulted in thick volunteer winter wheat growth that tied up the 100 pounds of nitrogen I broadcasted as urea before planting. I am tying up too much nitrogen by using urea in the no-till corn plots so I am going to apply nitrogen differently going forward. I will most likely use 28% liquid nitrogen applied with the coulter inject.



You can see in the yield results that the no-till soybeans yielded slightly less than the conventional tillage soybeans. Yields for the winter wheat plots were 50 and 65 bushels. For the corn the lowest yielding plots were the two no-till plots that had the winter wheat re-growth, while the two conventionally tilled corn plots yielded similarly. My lower

Haney Soil Health Test Results



soil penetrometer during the field day and readings were much more favorable. Soil erosion has been substantially reduced in the no-till cover crop system.

Unfortunately, the economics of my no-till system didn't quite meet or exceed that of the standard corn-soybean conventional tillage system. The corn-soybean conventional system yielded \$400 more over the 4 years than the no-till systems. I included tillage costs in the tillage system and cover crop seed and side-dressing cost in the no-till system. However, I did not put a dollar figure on the reduced soil erosion and increased

yielding no-till plots suffered from nitrogen deficiency. Although I sidedressed the no-till corn plots with 45 units of 28% liquid nitrogen, it was applied too late for the plants to fully recover maximum yields.

With the early harvest of wheat, I had excellent cover crop growth on those plots. The mix was from Millborn seeds and contained 30% cover crop radish, 20% annual ryegrass, 15% common vetch, 15% crimson clover, 15% lentil, and 5% sunhemp. Another late fall allowed for excellent cover crop growth. The no-till corn plots received a cover crop mix from Millborn seeds that contained 30% annual ryegrass, 20% crimson clover, 20% cover crop radish, 20% turnip, and 10% dwarf essex rape, which was planted around August 1. Winter wheat establishment was again excellent with good fall growth although there was some rust present on the leaves of the 2017 winter wheat crop.

The soil health results seem to be somewhat random so far, possibly dependent on the year, and previous crop. I suspect trends will develop in the long-term and not in a 3 year time span. Where we have seen soil health success is in aggregate stability and water infiltration rates. NRCS did an infiltration demonstration during my field day that showed much better aggregate stability and infiltration in my no-till plots. We also checked soil compaction with a

soil penetrometer during the field day and readings were much more favorable. Soil erosion has been substantially reduced in the no-till cover crop system. Unfortunately, the economics of my no-till system didn't quite meet or exceed that of the standard corn-soybean conventional tillage system. The corn-soybean conventional system yielded \$400 more over the 4 years than the no-till systems. I included tillage costs in the tillage system and cover crop seed and side-dressing cost in the no-till system. However, I did not put a dollar figure on the reduced soil erosion and increased



Winter wheat plot that was seeded with cover crop mix in early November.

Management Tips

1. Nitrogen management is crucial in no-till corn plots.
2. In no-till plots broadcasted nitrogen gets tied up in the wheat residue and side-dressing seems more effective.
3. I found that winter wheat needs fungicides to keep the leaves and plants healthy.

Cooperators

Paul Groneberg, Crop Consultant, Hoffman, MN

*Jodi DeJong-Hughes, Regional Extension Educator,
Wilmar, MN*

Project Location

The plots are located on the north side of Cty. Rd. 2 approximately 3 miles east of Barrett in Grant Cty. MN.

They are in Elk Lake Township, section 16. Visitors are welcome.

Other Resources

Jill Sackett's Minnesota Cover Crops email list, email:
mn-cover-crops@lists.umn.edu

Principal Investigator

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Fillmore and Winona
Counties

Project Duration

2015 to 2016

Award Amount

\$20,977

Staff Contact

Meg Moynihan

Keywords

corn, cover crops, forage,
soil health, water quality

Planting Short Season Corn for Cover Crop Success

Project Summary

This project tested whether early-maturing corn can help make cover cropping work for farmers in southeast Minnesota. There is increasing interest in cover crops and their ability to provide forage, enrich depleted soils, improve profitability, prevent runoff, and address other environmental concerns. However, many farmers find it a challenge to establish cover crops after corn comes off in September.

Our project objectives included field testing early maturing corn under typical cultural conditions for timely cover crop establishment; improving soil health; and stimulating local interest in cover cropping.

Project Description



This cover crop mix on Stan's farm is emerging under standing corn.

Three farmers participated in this project: Marty Malin (Peterson), Olaf Haugen (Harmony), and Stan Smith (Lewiston). All farm in Fillmore and Winona Counties in Southeast Minnesota. Olaf operates a grass-based dairy and wanted to extend his grazing season. Marty grazes polled Herefords and grows crops on rented ground; he is interested in reducing fertilizer and tillage. Stan raises beef cows, feed, and certified organic seed corn. His goals were to build soil and reduce tillage. Caroline van Schaik from the Land Stewardship Project coordinated the project: sourcing seed, collecting data, taking photographs, and organizing project and public meetings.

All three farmers planted short day corn in small plots, and then either inter-seeded cover crop mixes in July, or seeded them after chopping or combining corn in mid-September (Table 1). Olaf planted cover crops by aerial seeding before chopping, Stan used an adapted inter-seeder when the corn was at V5, and Marty drilled the cover crop in after he harvested corn. Good rains in the fall and late -arriving winters benefitted the cover crops, although one year Olaf wasn't able to fall graze because the ground was so wet.

Three farmers participated in this project: Marty Malin (Peterson), Olaf Haugen (Harmony), and Stan Smith (Lewiston). All farm in Fillmore and Winona Counties in Southeast Minnesota. Olaf operates a grass-based dairy and wanted to extend his grazing season. Marty grazes polled Herefords and grows crops on rented ground; he is interested in reducing fertilizer and tillage. Stan raises beef cows, feed, and certified organic seed corn. His goals were to build soil and reduce

All three farmers used the Haney soil health test to monitor the soils in treatment and control plots. They all helped with soil sampling and project planning, attended field events and participated in meetings to share their experiences with others interested in learning about cover crops.

Farmer	Haugen		Malin		Smith	
Acres	37		3.5		8	
Establishment method	Flown on before chopping		Drilled after corn harvest		Inter-seeded when corn at V5 and/or after corn harvest	
Year	2015	2016	2015	2016	2015	2016
Cover crop mix	winter rye annual rye medium red clover hairy vetch turnip tillage radish spring wheat meadow fescue	winter rye annual rye medium red clover winter pea turnip winter wheat	oats pea radish rye	triticale pea radish	sunhemp radish winter rye	Aroostook rye
Cover crop seeding rate (lb/A)	26	49	28	43	19	60
Cover crop seeding date	9/2	9/20	9/27	9/20	7/5, 10/18 (July seeding did not catch)	10/18
Cover crop seed \$/A	\$41	\$42	\$54.40	\$94.60	NA	\$18.60

Results

Corn yields ranged from 100 to 175 bu/A in 2015 and 75 to 208 bu/A in 2016 (Table 2). Significant yield losses on

two of the farm sites in 2015 were blamed on blight and weed pressure.

Farmer	Haugen		Malin		Smith	
Year	2015	2016	2015	2016	2015	2016
Corn maturity	96d		85d		83d, 88d	
Corn planting date	5/10		4/26		5/20	
Corn harvest date	10/15	11/5	9/24	9/18	10/11	10/13
Corn yield, (bu/A)	175	208	108	102	142, 100	75

Erosion control is a driving goal for Marty, and getting his corn out in September had a positive impact on the establishment of his soil-holding cover crops. His 85d variety was dry (18.5%) and ready to harvest in mid-September, and he planted his cover crop mix within 2 days of taking the corn off. In 2016, he noted a better cover crop stand going into winter than the previous year. Because his crop was so early, Marty had to locate storage before anyone was ready, and he took a yield hit compared to his control plot. But he was less concerned with yield than with being able to get his soil covered.

We may have pushed the envelope a bit by planting short season corn at the regular start of corn growing time rather than planting it later in the season – which is what it was bred for. But our goal was to try getting the corn off and the cover crops in and growing as early as possible. Although Marty's early season corn yielded less than his regular varieties, it matured quickly, as it is designed to do. It was ready for harvest as grain by mid-September, which allowed

him to establish the cover crops much more successfully than if he'd harvested at the usual time, 4-6 weeks later.

The short-season corn varieties did not impact the other two farmers in a significant way. In a separate experiment, a farmer was able to take 85-day corn off as high moisture (23%) corn in late September, allowing the clovers in an inter-seeded cover crop mix to flourish.

In both years, we took soil samples in early summer and late fall, froze them, and shipped them to Ward Labs in Nebraska for analysis. In 2015, all samples had Haney Soil Health Calculations above the desired level of 7, indicating good soil health. As we expected, we saw an increase in the Solvita 24-hour Burst Test, which represents microbial populations and indicates the potential for nutrient cycling in the soil (Table 3). These increases result from warmer soils, active roots, growing plants, and higher microbial populations.

Table 3. Solvita Burst Test Results (*Average of 2 tests)

	Spring 2015	Fall 2015	Spring 2016	Fall 2016
Haugen CC	78.4	128.9	128	118
Haugen Control	62.7	102.8	118	86.3
Malin CC	102.8	128.9	123	86.3
Malin Control	113.2	118.5	108	74.6
Smith CC	102.8	113.2	148	86.3*
Smith Control	78.4	134.1	128	113

All the soil samples showed desirable C:N ratios of below 20 (Table 4). The C:N ratio determines the ability of the soil bacteria to decompose organic matter, which also affects nutrient cycling. According to Lance Gunderson of Ward Labs, the active roots during the growing season typically

add to the microbial population, increasing carbon dioxide and lowering the level of organic nitrogen. We did see reduced C:N ratios in the fall compared to spring, likely because of plant use.

Table 4. C:N Ratios (*Average of 2 tests)

	Spring 2015	Fall 2015	Spring 2016	Fall 2016
Haugen CC	11.2	12.6	5.7	10.3
Haugen Control				
Malin CC	8.3	11.6	5.7	9.9
Malin Control	7.2	11.7	6.3	14.3
Smith CC	10.3	13.7	9.3	8.9*
Smith Control	10.2	12.8	7.1	8.6

Since soil temperature is an important variable, we tried to sample soils at temperatures comparable to those we took in 2015. Comparing Haney test results between spring and fall 2016 again showed the increase we expected in the Solvita 24-hr Burst test values and C:N ratios, both critical values in determining the overall Soil Health Calculation.

All 2016 samples had a Haney Soil Health calculation well above the desired 7, but some fields had a lower number this year than last. All samples also had the desired C:N ratio of less than 20 in both spring and fall, but fall values were lower in 2016 than in 2015. The tests indicated that all sites had more available N than a conventional soil analysis would indicate. If farmers credited this difference, their fertilizer bills would drop. This is a goal for some conventional farmers who are using cover crops for soil and financial health.

Solvita data from most, but not all, sites showed less biological activity in the control plots than in the treatments. The same is true for the overall Haney Soil Health Calculation. We would expect to see better scores in the cover crop treated plots compared to the controls, although seeing this after only 2 years is perhaps a little surprising. There are early indications that the cover crops are boosting soil fertility. However, there appeared less range between treatment and control results on Stan's organic farm.

After the participating farmers received their soil test results, we discussed them at a public meeting in early December. Caroline organized other meetings with NRCS soil scientist Dan Nath, and Jim Paulson, who worked for University of Minnesota Extension in Southeast MN at that time.



Area farmers met to discuss cover cropping and soil health.

Getting corn harvested and a cover crop planted in September definitely gave a welcome boost to cover crop establishment. Broadcast methods for seeding cover crops into standing corn present many of the same seed-soil challenge as aerial seeding. Everyone pretty much agreed that aerial seeding with its questionable seed-soil contact is a less reliable establishment method. On the other hand, if it rains after aerial application, the germination rate improves. Aerial seeding can also be done into wet soil -- unlike ground-based seeding methods.

Selecting cover crop species for shade tolerance is vital because, they have to germinate and then hang out under an increasingly dense canopy before corn harvest opens them up to daylight. Even in just the past 2 years there has

been growing interest in modifying equipment in order to improve the effectiveness of inter-seeding. With a growing desire to minimize or do away with soil disturbance, a dawning understanding of weed-cover crop interactions, and a continued commitment to corn and beans, farmers will continue to innovate.

As the project ended, the farmers were enthusiastic about the benefits of cover crops, but hadn't yet decided about the merits of planting a single cover crop species vs. a mix (sometimes called a cover crop cocktail). All three plan to continue using cover crops in 2017 and beyond.

"For 'seeding' ideas and a mindset to strive for cover and roots, the grant was a welcome boon in our region," said principal investigator Caroline van Schaik.

Management Tips

1. Try cover crops for more than 1 year.
2. Cover crops can interrupt weed seed germination – even if you just plant a mix in early spring and rotary hoe it into the ground prior to planting a cash crop.
3. Don't wait for an "expert" to tell you what to do. Be brave and imaginative, start small, and use the equipment you already have. For example, if you don't have a roller crimper to terminate a cover crop, try a Brillion seeder, flail mower, or sickle mower.
4. Talk to other farmers and attend field days so you can see things in practice.
5. Research your cover crops for such traits as shade tolerance, termination, timing of anthesis, and effect on following crop. Mix them up; they work better in tandem with one another than any one species by itself.

Cooperators

Olaf Haugen, Farmer, Harmony, MN

Martin Malin, Farmer, Peterson, MN

Dan Nath, Area Resource Soil Scientist, Natural Resources Conservation Service, Rochester MN

Jim Paulson, formerly Forage/Cover Crops Specialist, University of Minnesota Extension, Rochester, MN

Stan Smith, Farmer, Lewiston, MN

Project Location

Martin Malin's farm is located 11 miles south of Peterson, MN on Cty. Rd. 25. Olaf Haugen's farm is located 15 miles

south of Rushford, MN on Hwy. 43. Stan Smith's farm is located 8 miles south of Lewiston, MN on Hwy. 29.

Other Resources

Burleigh County Conservation District. Soil health website. www.bcsd.com/store/pc/Soil-Health-d3.htm

eXtension.org. Cover cropping in Organic Farming Systems. www.extension.org/pages/59454/cover-cropping-in-organic-farming-systems

Green Cover Seed. www.greencoverseed.com

Managing Cover Crops Profitably. 2007. Sustainable Agriculture Research & Education (SARE). www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition.

Moncada, Christine and Craig Sheaffer. 2010. Winter Cover Crops. In Risk Management Guide for Organic Producers. Regents of the University of Minnesota. Saint Paul, MN. https://organicriskmanagement.umn.edu/sites/organicriskmanagement.umn.edu/files/winter_cover_crops.pdf

USDA cover crops tool with information for 58 species on growth cycle, relative water use, plant architecture, seeding depth, forage quality, pollination characteristics, and nutrient cycling. Updated February 2017. <https://www.ars.usda.gov/plains-area/mandan-nd/ngprl/docs/cover-crop-chart/>

Principal Investigator

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Project Duration

2016 to 2017

Award Amount

\$24,946

Staff Contact

Meg Moynihan

Keywords

corn, hybrid, methionine,
 open pollinated, poultry

Breeding, Assessing, and Selecting Nutrient Dense Corn for Poultry Production

Project Summary

While poultry can get methionine, an essential amino acid, from pasture, growers typically have to supplement with synthetic methionine. The goal of our project is to breed a nutrient dense, locally adapted organic corn that is palatable to poultry. We are growing, evaluating, and selecting 20 varieties of nutrient dense corn for high nutrient levels of carotenoids, amino acids, yield, and earliness. By increasing the ratio of the limited amino acids in layer feed through classical organic breeding methods, we should be able to provide poultry with the amount of protein they require without the use of synthetic methionine. We are also conducting a palatability test to find out whether laying hens prefer high nutrient organic corn or standard organic corn.

Project Description

We are Sue Wika and Zachary Paige. Sue farms with partner Tom Prieve near Ashby, MN. They raise vegetables and pasture raise heritage breeds of goats, sheep, water fowl, cattle and horses. Zach produces hardneck garlic, potatoes, native corn varieties and squash as well as a few pastured butcher chickens and laying hens on his farm near Ponsford.

Zach is currently working on a Master's degree in plant breeding; Sue is interested in growing a corn that is high in nutrition, palatable for poultry, and that could be beneficial for people as well. A corn rich in beta carotene, fiber, protein and other nutrients could be good for individuals with sensitive stomachs and/or diabetes.

We want to find a high-nutrient corn that has an ample amount of methionine (a limited amino acid in corn) so that poultry producers do not have to feed synthetic methionine. Organic farmers are currently allowed to use synthetic methionine, but its use is restricted now and may be phased out in coming years. We are also interested in lysine and carotenoids, which can produce ultra-bright, nutrient dense yolks during winter when birds do not have access to pasture.

We'd like to find a corn that generally produces and yields well in a northern Minnesota climate. We also want to know if a high nutrient corn is preferred by chickens (there have been some problems with chicken palatability of organic corn in our area).

In the summer of 2015, we grew out several varieties of high nutrient corn obtained from the United States Department of Agriculture Genetic Resources Information Network seed bank and organic corn breeders. Many of the varieties were particularly high in beta carotene, which gave the corn an orange color. One experiment that looked promising was a hybrid we made from two high-nutrient corn varieties that grew well in western Minnesota. We took a high-carotenoid, open-pollinated flint corn called 'Dziekujie' from Argentina (from North Dakota corn breeder Frank Kutka) and a high



Picture of hybrid *Dziekujie x Dave 12*. 2015 Harvest.



Sue and Zack with their 2015 *Dziekujie x Dave 12* hybrid.

protein, experimental open-pollinated dent corn called ‘Dave 12’ (from Montana corn breeder Dave Christensen) and crossed the two. The outcome was very exciting because it appeared to have the desirable traits from both the parent varieties and it yielded well. (Figure 1)

We also obtained some varieties from plant breeder Walter Goldstein, who has been breeding high nutrient corn in southeast Wisconsin for more than 20 years. Walter is mainly producing hybrids and has a strong commitment to

producing a high-yielding and high-nutrient corn. According to Walter, some of his varieties have 40% more lysine and methionine amino acid protein than conventional hybrids. We are the first people to trial six of Walter’s most promising hybrids in a northern climate, although a lot of the genetics he used to create these varieties have been adapted to a Canadian climate for some time.

In 2016, Our experiment included 20 varieties of corn. (Table 1)

Table 1. Experimental Varieties, 2016

Entry	Varieties	Type	Source
1	Blue River 14A91	Hybrid	Blue River Seed
2	Blue River 06B21	Hybrid	Blue River Seed
3	Masters Choice MC4050	Hybrid	Masters Choice
4	Viking .90-.91N	Hybrid	Albert Lea Seed
5	Viking.85-90N	Hybrid	Albert Lea Seed
6	Viking 87-80N	Hybrid	Albert Lea Seed
7	CG Wigor 2009 x Wigor BC1	Hybrid	Walter Goldstein
8	PHK05.Ngor.. X LH119..15-2-7-3-6-1	Hybrid	Walter Goldstein
9	CG SS x LH119.LH132..15-2-7-3-3-1	Hybrid	Walter Goldstein
10	PHK05.Ngor X BS33 B.E. 2006 191-4-2	Hybrid	Walter Goldstein
11	PHK05.Ngor X LH119.LH123..15-2-7-3-3-3	Hybrid	Walter Goldstein
12	PHK05.Ngor X LH119.LH123..11-2-2-4-2-1	Hybrid	Walter Goldstein
13	Bejm	Hybrid (orange flint)	Commercial variety that has been grown in Poland
14	Dziekujie	Open pollinated	Frank Kutka
15	Pete Seeger	Open pollinated	Frank Kutka
16	Dave F12	Open pollinated	Dave Christensen
17	VK RX 2300 Flint	Open pollinated	Green Haven
18	Wapsie Valley	Open pollinated	Green Haven
19	Dublin	Open pollinated	Green Haven
20	MN13	Open pollinated	Victor Kucyk

In 2016, we planted our experiments as planned at Ashby, MN and Ponsford, MN. We added two locations to our project -- one at Lake Geneva, WI, overseen by Dr. Walter Goldstein from the Mandaamin Institute, and one at Iowa State University in Ames, overseen by Dr. Paul Scott. In variety trials, it is useful to have a large number of locations if possible. Adding the two extra locations was beneficial because we minimized the effects of environmental variation and added more data to our findings.

At each location, we planted two 17.5' rows by hand for each entry, spacing the seeds 7" apart. We replicated the experiment twice at each location. We planted all locations during the third week of May. During the growing season, we collected data on seedling vigor, pest and disease resistance, maturity, root and stalk lodging, and animal damage. At harvest, we recorded yield by weighing the seed (Table 2.)

Entry	Varieties	Total combined yield for all 4 locations (lb)
1	Blue River 14A91	88.3
2	Blue River 06B21	81.1
3	Masters Choice 4050	103.4
4	Viking .90-.91N	94.1
5	Viking.85-90N	93.7
6	Viking 87-80N	82.1
7	CG Wigor 2009 x Wigor BC1	41.1
8	PHK05.Ngor.. X LH119..15-2-7-3-6-1	79.8
9	CG SS x LH119.LH132..15-2-7-3-3-1	92.5
10	PHK05.Ngor X BS33 B.E. 2006 191-4-2	71.7
11	PHK05.Ngor X LH119.LH123..15-2-7-3-3-3	68.0
12	PHK05.Ngor X LH119.LH123..11-2-2-4-2-1	118.6
13	Bejm	74.3
14	Dziekuje	57.8
15	Pete Seeger	49.4
16	Dave F12	42.5
17	VK RX 2300	56.7
18	Wapsie Valley	72.1
19	Dublin	68.5
20	MN13	69.3

We expected the check hybrids (entries 1-6) to be high yielding, and they were; the Masters Choice entry was the highest. However, entry #12 (one of Walter's) surprised us by being the highest yielding out of all the varieties. Nearly all of the open pollinated varieties had a lower yield than any of the hybrids. Wapsie Valley was the highest yielding of the open-pollinated varieties.

Zach performed protein and carotenoid tests using Near Infrared Spectroscopy at Iowa State University. He will also analyze protein and methionine (those tests had not been done when we reported on our 2016 progress).

The highest protein varieties were (from highest to lowest):

- Dave 12
- CG Wigor 2009 x Wigor BC1
- PHK05.Ngor X LH119.LH123..15-2-7-3-3-3
- Pete Seeger
- Dublin
- Dziekuje
- MN13
- Masters Choice 4050
- Wapsie Valley
- CG Wigor 2009 x Wigor BC1

Generally, most of Walter’s corns were high in protein, compared to the other varieties in our trial.

Protein content is known to have a counter effect to yield, which was proven true in our experiment: the varieties highest in protein content yielded relatively low. Most of the open pollinated varieties were high in protein content. Dave 12 had the highest protein content, but did poorly on yield and had small cobs.

Sherry Tanumihardjo's lab at the University of Wisconsin in Madison performed carotenoid analyses. Most of the top carotenoid varieties were from either the open pollinated group or the check hybrid group. From highest to lowest, they were:

- Dziekuje (the highest total beta carotene by a long shot)
- Viking Check hybrid .90-.91N
- Bejm

After reviewing all of our data, we decided to make two hybrid crosses of the open pollinated of Dave F12 x Dziekuje and Dublin x Dziekuje.

We chose Dziekuje because it was top for carotenoids and not bad for protein. Dave F12 was the highest for protein and was fast maturing, but was the lowest in carotenoids and yielded poorly. We want to see whether this cross will make Dziekuje earlier and boost its protein. (This was that cross Sue and Zach made back in 2015, and it produced well then.)

Dublin was the second highest yielding open pollinated variety, but we chose it over Wapsie because Dublin had less lodging and more protein (third best for protein content overall). We want to see if the Dublin x Dzieukje cross will boost yield while keeping nutrient content high.

During 2017, Zach is going to make these crosses using hand pollination and will include some of the seed they produce in the poultry palatability trials, along with the 20 original varieties. In 2017, they'll limit their field trials to Ashby and Ponsford.



Dr. Walter Goldstein and his team harvest and weigh corn at the Mandaamin Institute plot in Lake Geneva, WI.



Sue eyes our 2016 harvest at Ashby, MN.

Management Tips

1. Start planning plots out starting in late March, especially if you are planting in multiple locations.
2. In cool weather, corn may not dry down fast enough by simply leaving it out in a shed with fans blowing on it. When we added a little heat and used a dehydrator, we got much. At Sue's place, we had access to her deep winter greenhouse.
3. Label all of the bags two times and throw a label into each bag as well when harvesting. Putting the label inside each bag is important insurance to prevent mixups when there are a lot of numbers involved.

Cooperators

*Walter Goldstein, Ph.D, Mandaamin Institute,
Lake Geneva, WI.*

Frank Kutka, Corn Breeder, Dickinson, ND.

Paul Scott, Ph.D, Iowa State University, Ames, IA

*Sherry Tanumihardjo, Ph.D, Chris Davis, and Michael Grahn,
University of Wisconsin, Madison, WI.*

Project Location

Ponsford Farm is located off Hwy. 78 on the west side of the road, about 8 miles South of Battle Lake, MN. Paradox Farm is located at 11643 State Hwy. 78 Ashby, MN 56309.

Other Resources

Breeding Non-commodity Corn for Organic Production Systems: eorganic.info/cornbreeding

Dave Christensen's webpage:
www.northfrontierfoods.com/Dave_Christensen.php

Mandaamin Institute:
www.mandaamin.org/research-results

USDA Germplasm Research Information Network:
www.ars-grin.gov

Principal Investigator

John Beckwith
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Project Duration

2016 to 2018

Award Amount

\$24,981

Staff Contact

Cassie Dahl

Keywords

goats, grazing, invasive
 species

Goat Grazing During Winter in Minnesota: Ways to Control Vegetation on a Larger Scale While Saving on Supplemental Feed Costs

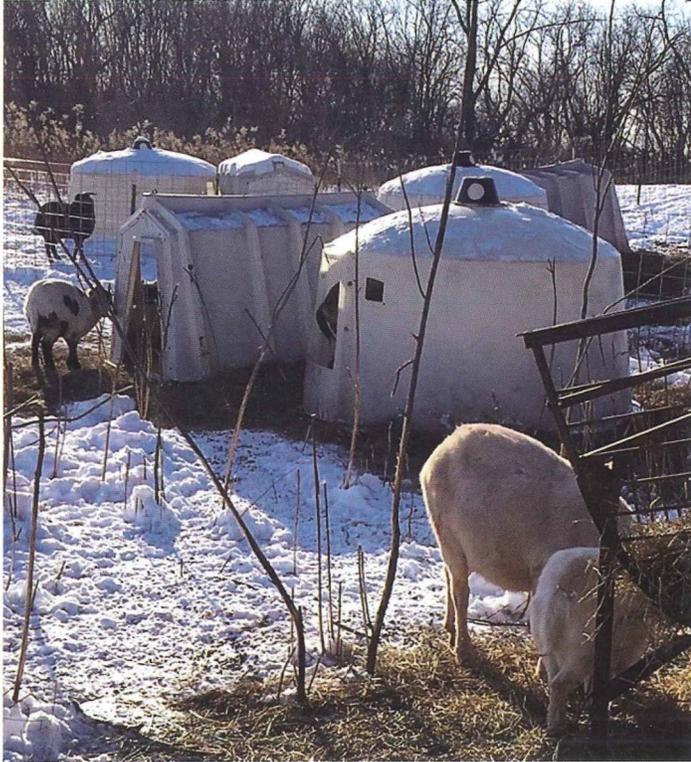
Project Summary

This project will evaluate winter grazing systems that maintain a healthy goat herd and provide control of invasive and undesirable plants during harsh Minnesota winters. Our overall goal is to find that this is a profitable service and meat goat enterprise. The project will assess winter husbandry challenges, including: effective electric mesh fencing, sheltering, watering, and meeting nutritional requirements. The project is also designed to determine if the season's limited browse and forage plants will lessen girdling, so the goats will need to graze a larger land area of invasive and undesirable woody vegetation to get enough to eat. Information gained from this project will benefit farmers with service and meat operations by providing additional income through the extension of the grazing season, and also by reducing costs required when wintering goats in a yard or building. In addition, having the goats graze on frozen soil that is normally wet, fragile, or steep will help protect fragile ecosystems.

Project Description

Jake and Amanda Langeslag, own a ten-acre parcel that serves as the home base for their goat service and meat enterprise. The service component refers to the contracting of the herd to control invasive and undesirable plants. This provides income as well as additional lands for grazing. During the past year, the operation has contract grazed in Rice, Dakota, and Olmsted counties on both public and private properties. The enterprise also includes a meat goat component. However, this opportunity has been limited during the early years of the operation due to the desire to grow the herd size. They have increased the herd size from 25 goats in 2013, to over 80 goats now. The Langeslag's have provided support for new graziers and hope what is learned can be of benefit to new farmers.

Winter is a costly time of year for a service and meat goat enterprise due to feed and supplemental nutrition costs, housing costs, and increased time demands of the herdsman. In addition, it's a time when weight gains are slow and income from service grazing has been limited. While addressing these concerns, this project has three overarching goals: 1) Explore the benefits and limitations of grazing goats during winter in order to increase our knowledge of electric mesh fence effectiveness, water supply maintenance, movable winter shelters, and also to quantify the economic benefit of winter grazing. 2) Assess winter grazing system potential for protection and release of native plant species while controlling invasive and undesirable plants by attempting to influence the goats' preference for undesirable woody vegetation. 3) Monitor indicators of livestock comfort and health.



This cover crop mix on Stan's farm is emerging under standing corn.

There are also ecological considerations we feel need be explored. We have found that certain sites such as prairies, grasslands, wetlands and lowlands can be difficult to graze during the growing season. These sites often contain many lush forbs and grasses, which the goats eat along with the brush. This “bogs” the goats down and they are not as able to go after the woodier vegetation. We hope the goats can be directed to undesirable woody vegetation in the winter due to limited availability of other plants. We also want to focus their attention to undesirable plants by applying several deterrents to preferred native species. If these experiments work out, profitability will increase and a greater land area can be serviced to reduce undesirable woody plants.

Key elements to be addressed in project evaluation: 1) Explore the benefits and limitations of grazing goats during winter; weight change, mortality, fence effectiveness, and temporary containment options. 2) Assess winter grazing system for protection and release of native plant species while controlling invasive and undesirable plants. 3) Monitor indicators of livestock comfort and health by noting their preference for certain shelters and the inside temperatures.

Results

Our project is a winter grazing project and 2016 has been used to prepare for the grazing season. There are a few items needed to fully implement the project, but most of

the equipment and facilities are in place and ready to go. So far the fence is maintaining excellent voltage.

Management Tips

1. The teepee style housing does not hold up in extreme cold and windy conditions.
2. Teepee style housing does not stand up to crowded conditions and move too easily.
3. Humidity and moisture control are just as important as temperature.

Cooperators

Jake Langeslag, Goat Dispatch, Faribault, MN

John Beckwith, Hiawatha Valley Resource Conservation & Development, Janesville, MN

Cheryl Culbreath, Landscape Restoration, Inc.

Project Location

From Faribault take Glynview Tr. SE., turn left on 227th St. E., right at “T”, left on 230th St. SE. to site at 4640 230th St. SE.

Principal Investigator

Hoch Orchard and Gardens
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La Crescent, MN 55947
507-643-6329
Winona County

Project Duration

2016 to 2018

Award Amount

\$15,000

Staff Contact

Cassie Dahl

Keywords

livestock, perennial fruit,
silvopasture

Integrating Silvopasture Practices into Perennial Fruit Production

Project Summary

The purpose of this project is to test the economic potential of grazing animals in perennial fruit systems. We will install permanent pasture fences and watering systems in the orchards. The farm is currently set up with blocks of fruit trees ranging from 2 to 4.5 acres. The fences will allow each block to act as a paddock for rotational grazing. Although silvopasture systems are being tested globally, there are few projects testing the potential of grazing in fruit production.

To evaluate production and economic potential, we will record the costs of installation and management of plots over two years. Further, we will record the number of animals produced and the corresponding income potential.

Project Description

Hoch Orchard and Gardens is a vertically integrated diversified food production company. Our primary crop is apples, but we have diversified into other fruit, meat, and vegetable production, and value-added products. We grow, pack, store, market, and distribute our products. Our farm is certified organic and certified biodynamic. Our goal is to continually strive to make our farm an independent organism that requires few off-farm inputs.

The purpose of this project is more of a 'proof of concept' than an evaluation of a single practice. By implementing this grazing system on our farm and recording the actual costs and the production of meat we will be able to show the potential of the system. Other farmers will be able to see how the system worked on our farm and adapt it to their own operation.

There are many permaculture and silvopasture systems being tested around the world, but there are few projects testing the potential of grazing in perennial fruit production systems. There is strong interest in this practice. At Hoch Orchard we currently rotate sheep, poultry, and hogs through our fruit plots using portable shelters and energized movable fencing. The number of animals we can manage in this system is limited due to the time required to move and maintain this fencing. We can increase production and reduce costs with better infrastructure. Using animals to control the ground cover can reduce energy costs, improve soil quality by increasing the biodiversity, and produce meat without diverting grains for human food production to feed animals.

Our initial interest in the integration was from a soil health perspective. Natural systems have both plants and animals contributing to nutrient cycling. Natural ecosystems require an animal component. Wild fruit trees grow in either low density forests or wooded meadow environments. These systems are conducive to grazing animals. Permaculture systems are often designed for a 60% shade cover at maturity because of the high forage production potential in the partial shade environment. A modern orchard creates similar environment conditions. In conventional orchard systems the ground covers are mowed regularly. This practice requires large amounts of fuel. We feel there is very high animal production potential and energy savings in the system we are proposing.

Results

We had a project kick-off meeting in April to review the project and allow our cooperators an opportunity to review the plan and provide input. The attendees were Jake Overgaard and Wayne Martin from University of Minnesota Extension, Jennifer Nelson of MOSES, and Ken Meter of Crossroads Resource Center. At the meeting, how to collect the data for the most effective gathering of information was discussed.

From April to December, we began recording the time involved with feeding and watering the pigs. This year, the pigs were rotated around the orchard using the existing

Each day, hours spent caring for the pigs are recorded. Time is split among four categories, including: the construction/deconstruction of temporary fences, feeding and watering, moving animals from one temporary paddock to the next, and time spent catching pigs that have escaped from temporary fencing. The data from this year will be compared to the next two years when animals will be moved inside permanent fencing. We also recorded the amount of money and time spent constructing permanent fences.

pastures that ring the orchard and temporary fences within the orchard. Temporary fences were constructed with ribbon wire or portable electric mesh.

In November, we started building permanent fences. We nailed 42" multi-species wire mesh fence to the windbreaks around the orchard. In addition, we built two fences that were not attached to windbreaks: one six-strand high-tensile fence and one t-post wire mesh fence. In total, we constructed 5,500' of permanent fence this year.



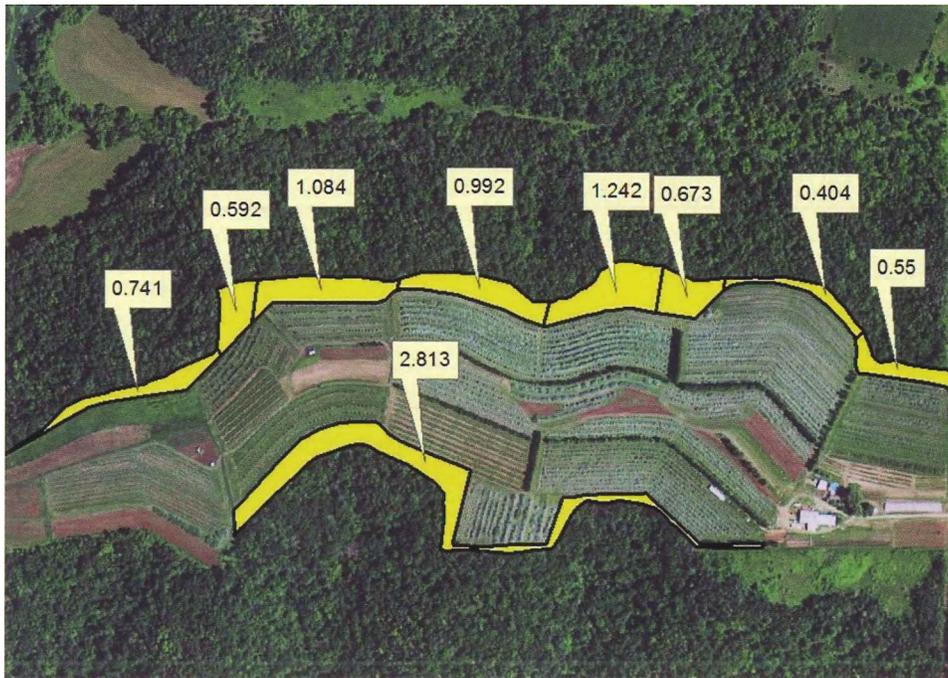
Woven wire fence dividing two orchard blocks.



Woven wire fence on one of the windbreaks.

At the end of the year, we had a meeting to discuss the year's data. Some questions we need to think about for data collection are: how to account for piglets-when do they count as pigs vs piglets, how to separate time feeding and watering for pigs in shed vs. pigs on pasture.

In addition, we used a GPS unit to map the pastures that ring the orchard. We now have accurate area measurements for each of our grazing paddocks. The total acres in the ring pastures are just over 9 acres with an average size of 1 A/paddock.



Since this is the first year of a three-year project, we haven't seen the full benefits of our project, either in environmental benefits or improvements in quality of life. Over the three years, we are hoping to be able to flash graze the animals more effectively. This should lead to healthier pastures that sequester more carbon and provide more habitat for native insects and birds while supplying high quality forage for our animals. We believe the orchard could support larger animal herds than we are currently running. By building the permanent fencing and optimizing our flash grazing system, we should be able to raise more animals with less time input; increasing our income from the land without increasing our use of nonrenewable resources.

In addition, we are hoping the permanent fencing will increase our quality of life by greatly reducing the amount of time we spend rounding up animals that have escaped from the temporary paddocks. Every time a pig gets out, we have to stop whatever other projects we are working on to put the pig back where it belongs and then walk the temporary paddock to determine and eliminate its escape route. Hopefully, we are able to do this before the rest of the herd also escapes and before any pigs discover the vegetable production fields. Having less pig escapes will decrease the stress on the farm and allow us to raise more vegetables for local markets.

Management Tips

1. Don't attempt to stretch a piece of fence at dusk. Since, there wasn't sufficient light and when stretching two sections of fence a horizontal wire in the mesh got caught and then shifted, making larger holes in the fence and the fence was not pulled as tight as it should have been.
2. Schedule time regularly to maintain electric fences. A few times this summer, we had a large number of pigs escape from the temporary fence because the power was very low. Then we would have to scramble to make time to look for dead shorts. However, if the weather didn't allow us to fix the fence, we would close the pigs in permanent pens and provide their food rather than letting them forage.
3. Evaluate your data collection categories periodically. We will have clearer categories next year. One change will be keeping a count of how many sows, feeders, and less than two month old piglets there are. In addition, we will differentiate between feeding and watering time for pigs in the shed and on pasture.

Cooperators

Ken Meter, Crossroads Resource Center, Minneapolis, MN

Jake Overgaard U of M Extension, Winona, MN

Wayne Martin, U of M Extension, St. Paul, MN

Jennifer Nelson, Midwest Organic & Sustainable Education Service, Spring Valley, WI

Project Location

Come into La Crescent on Hwy. 14, at the traffic lights turn west onto South 3rd St. (CTH 6). Turn left (south) onto Elm St. and follow to South 7th St. Turn right (west) onto 7th and follow it out of town where it becomes CTH 6. Follow

CTH 6 about 5 miles west of La Crescent and turn right (north) onto CTH 16. Take CTH 16 through the valley and up the hill to the top of the ridge and then turn left onto Forster Rd.

Principal Investigator

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Project Duration

2016 to 2018

Award Amount

\$8,918

Staff Contact

Cassie Dahl

Keywords

bees, brood, honeybees,
 nucleus (nuc) colonies,
 queens, Varroa

Trials to Overwinter Nucleus Colonies with a Pause in Brood Rearing

Project Summary

This project aims to evaluate the practice of overwintering smaller honeybee hives, commonly referred to as nucleus or “nuc” hives, to produce new honeybee colonies in our region. I am evaluating two methods of creating nucleus colonies and comparing their effect on Varroa mite populations within a hive. One method interrupts brood rearing long enough to create a period of time when no brood (eggs, larvae, or pupae) are present in the colony. The other method reflects a more traditional approach, with brood always present throughout the summer.

Project Description

Varroa mites are a major contributor to the nationwide decline in honeybee populations. This parasitic mite transfers viruses and bacteria with its bite and weakens the host bee as it feeds.

Current mite management techniques are not sustainable. Since I started keeping honeybee colonies in 2001, the beekeeping industry has cycled through multiple chemical Varroa mite treatments. The mites have adapted and developed resistance to most of them. Three years ago, I founded a business producing queens from bee colonies overwintered in Minnesota and started searching for alternative management techniques that may offer a more sustainable beekeeping model.

Around that time, I met Wisconsin beekeeper Adrian Quiney. He had been successfully implementing many experimental bee management techniques. The techniques Adrian uses to overwinter nucleus colonies and force a break in brood rearing may be the reason he has not had significant losses due to Varroa mites—despite not using any chemical treatments in his hives. In fact, Adrian has been selling surplus colonies for several years.

Few other people have been able to recreate Adrian’s success, and he does not monitor mite levels in his colonies. While I think Adrian’s principles could prove promising for beekeepers in our area, his methods are a significant departure from conventional wisdom. I undertook this project to see whether I can replicate Adrian’s results, and to generate the information needed to encourage other beekeepers to make the jump.

I am conducting my project in two locations; each has two test groups of honeybee colonies, A and B. In May 2016, I set up 30 purchased nucleus colonies—15 in each location—and grew them until they were big enough to split. In early July I split 23 colonies into 58 nucleus colonies. (Seven had signs of disease or queen issues and did not produce the brood necessary for the experiment.)

I left all 58 of the nucleus colonies without a queen for 8 days. Then, I introduced a mated queen (who could start laying eggs immediately) into half of them (group A). I introduced a queen cell (a pupa that would emerge within a few days, mate, and start laying eggs) into the other half of the colonies (group B). Since it takes about 13 days for a virgin queen to mate and start laying eggs, group B had a period of about 7 days when no capped brood would be present. Mites reproduce in capped brood and therefore evade grooming behaviors of the adult bees.

I took samples containing approximately 300 bees from each colony before I split them, and then once a month from each test colony until fall. I counted the Varroa mite population in each sample after dislodging the mites with an alcohol wash. I plan to compare treatments A and B using Varroa mite count data and winter survival rates.

2016 Results

At the time I wrote my 2016 report, I had counted Varroa mites from all the bee samples but had not yet statistically analyzed them, so I can't report the data in this article. In spring 2017, I will record colony survival rates and sample all the colonies that are still alive.

While I expected some failure among the nucs that I started with queen cells, I did not expect how high the failure rate would be in one of the locations. I expected 90% of queen cells to result in a laying queen. One location had all 16 out of 16 cells succeed (100%). However, in the other, only 8 out of 14 colonies developed a laying queen (57%). In 5 of those 6 colonies where the introduced queen cells failed to produce a laying queen, worker bees started laying infertile eggs. (This happened more quickly than normal since the colonies were without brood.) Once workers begin to lay, the situation is difficult to correct.

In addition, after the split about a dozen colonies became too weak for me to take bee samples. Right from the start, colonies in group B (the ones started with a queen cell) seemed to be weaker than the colonies in group A

(which got a mated queen). I believe this was because workers from the group B colonies began to drift to the ones nearby that already had a queen. This is a problem I plan to address in 2017. I was also unable to take samples from all hives in the fall because my inspections instigated a honey robbing frenzy among the test colonies. Robbing creates excessive stress in an already stressful time of year for hives.

Going into winter, my experiment had 52 colonies, which I wrapped with foil bubble insulation in groups of four. Despite some winter losses, I should have plenty of hives to repeat the experiment as planned in 2017 and improve upon the methods for more consistent sampling of all 64 hives. I am going to place group A colonies approximately 50 yards from those in group B in order to prevent forager bees from drifting to the test colonies that have queens. I will also be making splits a little sooner when more capped brood is present.

Management Tips

1. When you establish nucleus colonies with a brood break, make colonies strong using capped brood and enough young nurse bees to cover it. A large population of older bees may fly to a nearby hive instead of waiting for the new queen to start laying.
2. In the fall, keep hive entrances small, and your inspection time to an absolute minimum.
3. Use 5-frame boxes instead of dividing standard 10-frame equipment. The smaller boxes are lighter and more maneuverable.

Cooperators

Chris Kulhanek, Minneapolis, MN

Marla Spivak, Professor, U of M

Adrian Quiney, Beekeeper, Hudson, WI

Project Location

One apiary is on the north side of Diamond Lake in Dayton, MN.

The other is just east of Wolsfeld Lake near Long Lake, MN.

Other Resources

OTS Queen Rearing (and other related information).

Mel Disselkoen, International Mating Nuc, Inc.

<http://www.mdasplitter.com/>

Quiney Honey and Bee. <https://www.youtube.com/channel/UCn6RmZ0om1dMRSBPgBoCSmQ>

Michael Palmer, French Hill Apiaries, St. Albans, VT. Many presentations posted on YouTube at www.youtube.com.

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Project Duration

2015 to 2016

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\$24,565

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Keywords

acclimation, behavior, cows,
 dairy, handling, heifer,
 pressure zone, stress

Acclimating Heifers to Improve Cow Flow on Dairy Farms

Project Summary

Milking heifers for the first time can be stressful to both animal and human worker alike. However, familiarizing pre-fresh heifers with the milking parlor and handling by humans is rarely feasible on dairy farms. In the beef industry, a handling strategy called “acclimating” is commonly used to de-stress newly arrived animals in their pen. We designed this study to evaluate whether acclimating pre-fresh heifers to being handled will decrease stress levels and improve cow flow and behavior during the first times those heifers are milked.

Project Description

A common area of frustration and high injury risk on dairy farms is milking fresh heifers, those “teenage” animals that have just had their first calf. On most farms, heifers are not handled much prior to calving. Yet then they are asked to go into the milking parlor, where they have never been. New sights, smells and sounds bombard them and they are suddenly handled in close proximity and touched in places they have never been touched before.

This experience can be overwhelming, and stressed heifers commonly react by balking at the parlor entry or kicking and defecating during milking. We speculated that reducing the number of new stimuli and making the parlor visit a pleasant experience would reduce stress on these animals. Ideally pre-fresh heifers should be moved through the parlor to prepare them to its sights, sounds and smells without the pressure of a milking schedule. Unfortunately, only very few farms can afford to do this, so other training approaches are needed.

Since not all farms, including our farm partner for this project, can easily acclimate heifers by sending them through the parlor prior to calving, we decided to work with heifers in their home pen when they arrive from the heifer raiser to reduce the number of new stimuli once milking comes around. The approach we used was based on something called “acclimating” in the beef industry, where cattle from the range are made to walk the perimeter of the pen to get accustomed to be in close proximity to handlers. It is said to result in calm animals during subsequent handling and to reduce the occurrence of sickness as well.

Our objectives for this study were to:

- assess whether acclimating improves flow of heifers into parlor and their behavior during the first 3 days of milking; and
- assess whether acclimating decreases stress (measured as serum cortisol, haptoglobin, serum amyloid A and substance P) and improves lying time in transported heifers.

We are doing this study at Wolf Creek Dairy in Dundas, MN. Wolf Creek Dairy milks approximately 400 dairy cows and calves year round. Heifers are raised off-site until they come back roughly 2 mo prior to calving. We assigned each returning group to be acclimated (treatment) or not acclimated (control). Our goal was to have 4 groups of 9 heifers each.

For this study, we needed 32 heifers per group. The heifers came from the heifer raiser in groups of 9 every 2 to 4 weeks, so we aimed to have 4 heifer groups (36 animals)/ study group, 72 heifers total). We randomly assigned each group to either being the control or the acclimated group. We worked with the acclimated groups of heifers on days 0 (arrival), 1, 4, 7, and 11.

To assess whether there was any difference in activity between the acclimated and control heifers, we fitted each animal with an activity monitor (IceTag, IceRobotics, Scotland) when she arrived. This monitor measured her steps and how long she spent lying and standing for a month. We also collected blood samples, measuring stress parameters in the blood and hair upon arrival and on days 1 and 7. We looked for cortisol, substance-P, haptoglobin, and serum amyloid A.

We assessed each animal's "avoidance distance" on days 0, 1 and 7. The handler approached each heifer slowly from the side (at approximately the last rib) and measured how close to the heifer the handler was when the heifer started to move away. As cows acclimate, the handler should be able to get closer to them before they move away.

The acclimating procedure was as follows: we brought the acclimation group of heifers from the exercise lot onto a concrete platform where there were two pens with a chute between them (Figure 1). The handler stood in the middle of one pen (A) and used body movement, stepping toward and away from the cattle, to encourage heifers to move around the perimeter of the pen circle and then single file past the handler through a narrow chute or short alleyway into another pen (B). The heifers then walked around the perimeter of pen B and back through to the chute to the gate (dashed line) into pen A. Since the handler stood in the middle of the pen with the heifers walking around her, the animals could always see where she was. We moved the heifers through the figure 8 pen and chute system 2 to 3 times per session, then they were free to go back into the exercise lot. This entire exercise took on average 20 min.

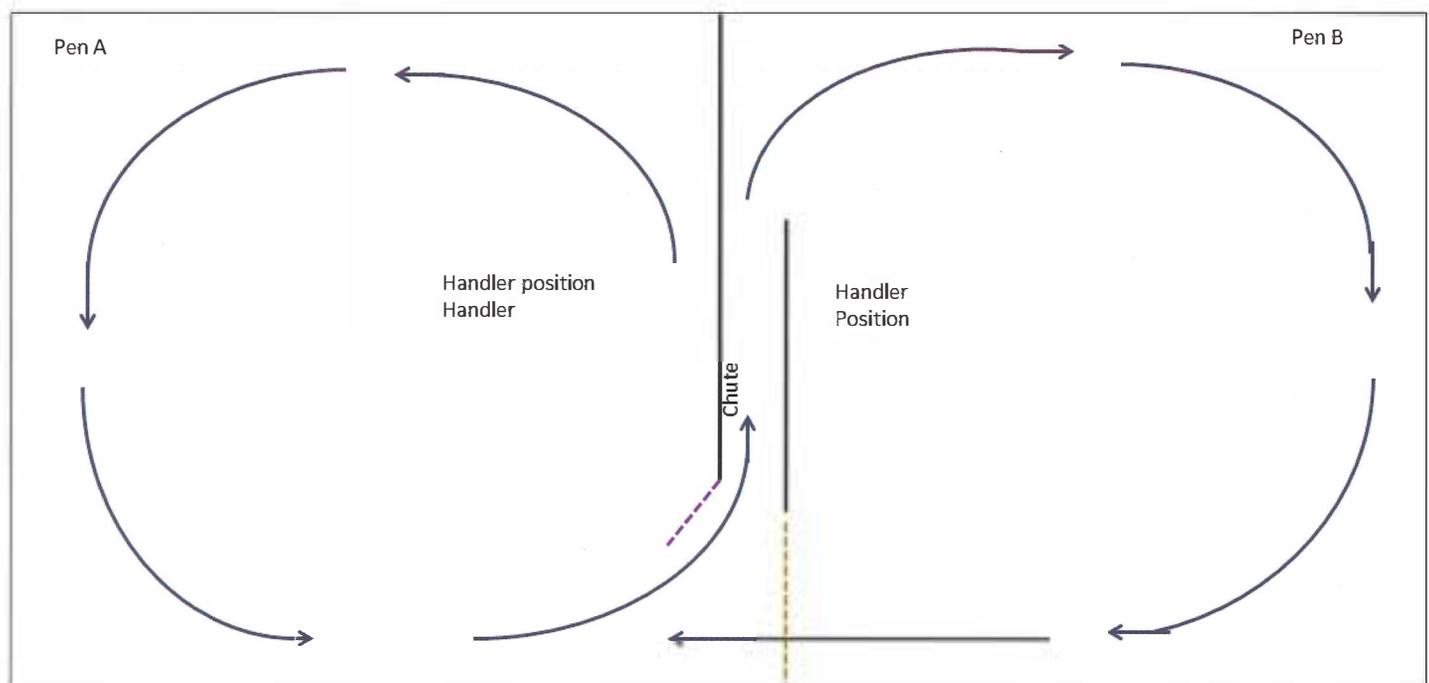


Figure 1. Layout of the acclimating pens.

We installed cameras over the acclimating pen, over the holding pen, and in the parlor to document behavior during morning milking for three days after calving. At calving, we marked each animal's back with large numbers using a liquid cattle marker, hoping this would make it easy for us to identify them on camera. We also attached a yellow leg band with the cow number to one hind leg. We found it was harder than we thought to identify the heifers going into the milking parlor. It seemed to work best for workers in the parlor to face the camera and use their fingers to signal each heifer's number.

Result

The heifers in both acclimated groups were slightly flightier than those in the control groups. On day 0 (at arrival) they moved away earlier (when handler was 10.5' away) compared to the control animals (7.8'). However, on the second day, the handler could get closer to the animals in the acclimated group (6.6') than to the control animals (10'). At day 7, the avoidance distance for groups distance was similar ($P > 0.05$).

The serum cortisol concentrations followed a similar trend. Data from the IceCube loggers told us that heifers in the acclimated groups did not walk more steps, and were less likely to lie down and stand up again. Their lying times were comparable to the controls. Over the following weeks the acclimated heifers had, on average, 300 steps per day more, but still had fewer lying bouts. The fewer lying bouts indicate that the acclimated animals were less restless than their not-handled counter parts.

When it came to the first few days of milking, the behavior of all heifers was better than expected and the differences between the groups were therefore not as large as we had anticipated. This reduced our statistical power. Many results were not statistically significant, but we observed numerical trends in the observations.

In the holding pen we recorded time from set-up to enter (heifer faces parlor entry and is within about 6'), entering and the frequency of balking, stopping, turning, escaping, and slips. In the parlor, we focused on the frequency of steps, kicks, defecation, and kicking off the milking unit. We also collected data on her milk yield for the morning milking.

In the holding pen, fewer acclimated heifers slipped (6% vs. 13% control) and fewer heifers balked when they were asked to go into the parlor (5% vs. 10% control). Similarly, fewer acclimated heifers kicked during milking (48% vs. 58%) but the total number of kicks did not differ between the groups. Furthermore, the acclimated heifers were calmer and had significantly fewer steps during the entire milking routine. Their cumulative milk yield over three morning milkings was higher (52.6 lb) than control heifers (48.5 lb).

Overall, the differences between the acclimated and control groups were less pronounced than we expected. We think that herding animals might teach the heifers to walk away from the handler – as seen in a slight increase of the flight zone on day 7 compared to day 1 for the acclimated group. But overall, the results are very promising and working with the heifers prior to calving seems to calm the animals down.

Steve recorded when the ewes were marked by the ram in the fall and had his vet ultrasound the ewes so he could pen them up at the right time. This eliminated the need to check multiple times during the night and day for lambs, a time consuming and exhausting process for a part time farmer.

At lambing time, he put the first six ewes in pens and monitored time-labor-feeding during lambing using the pen system. Batch lambing should promise enough time between batches so that the ewes to be in pens 4-6 days to acclimate them to their lambs.

Results

Steve insulated the building and poured a cement floor in order to increase heating and cleaning efficiency. He also set up the hog nursery with gates and feeders.

Steve observed the ewes appeared less stressed than when they lambed in open pens and were moved to a lambing jug after. This 5'x5' pen size worked well. The ewes had plenty of room and did not lay on their lambs. The ewes accepted all their lambs—even when they had triplets and one set of quads. A 175% lambing rate was the best Steve has ever had.

In addition to the pen setup, Steve made some other improvements to feed and bedding. Instead of bedding pens with straw and feeding ewes grain and hay, he switched to a feed consisting of 80% soy hulls and 20% distillers' grain. This method eliminated much of the hay that was previously wasted, although he used more straw, since the new feed made the sheep manure loose. He noticed lambs were self-feeding earlier and grew faster than before, allowing him to wean after around 45 days

verses the 60-70 days he was used to. Ultimately, this saved Steve \$300 in feed for all 16 ewes.

After 5-7 days, he took the pens down and the ewes and lambs mingled together until they were weaned and moved outside. To prepare the building for swine, he just had to fold the pens against the wall and clean out the building with a skidsteer, which took about 30 minutes. The building was divided in 1/2 and pigs adjusted well during the 60 days they remained there. They performed very well and weighed 70 lb. when he moved them out. He cleaned the pen and put in another group of pigs. His customers were very happy with the pigs and how they looked and adjusted to their straw based systems.

Steve was really pleased at animal performance in his remodeled building and figures the insulation saved him 50% on propane. In addition to saving on energy costs, he figured he spent 25-30% less time checking pens.

Management Tips

1. Insulation and high efficiency lighting reduce your energy bills right away.
2. Lambing in pens is less stressful for ewes, lambs, and the farmer.

Cooperators

Wayne Martin, Extension Educator, Alternative Livestock Systems, U of M Extension

Project Location

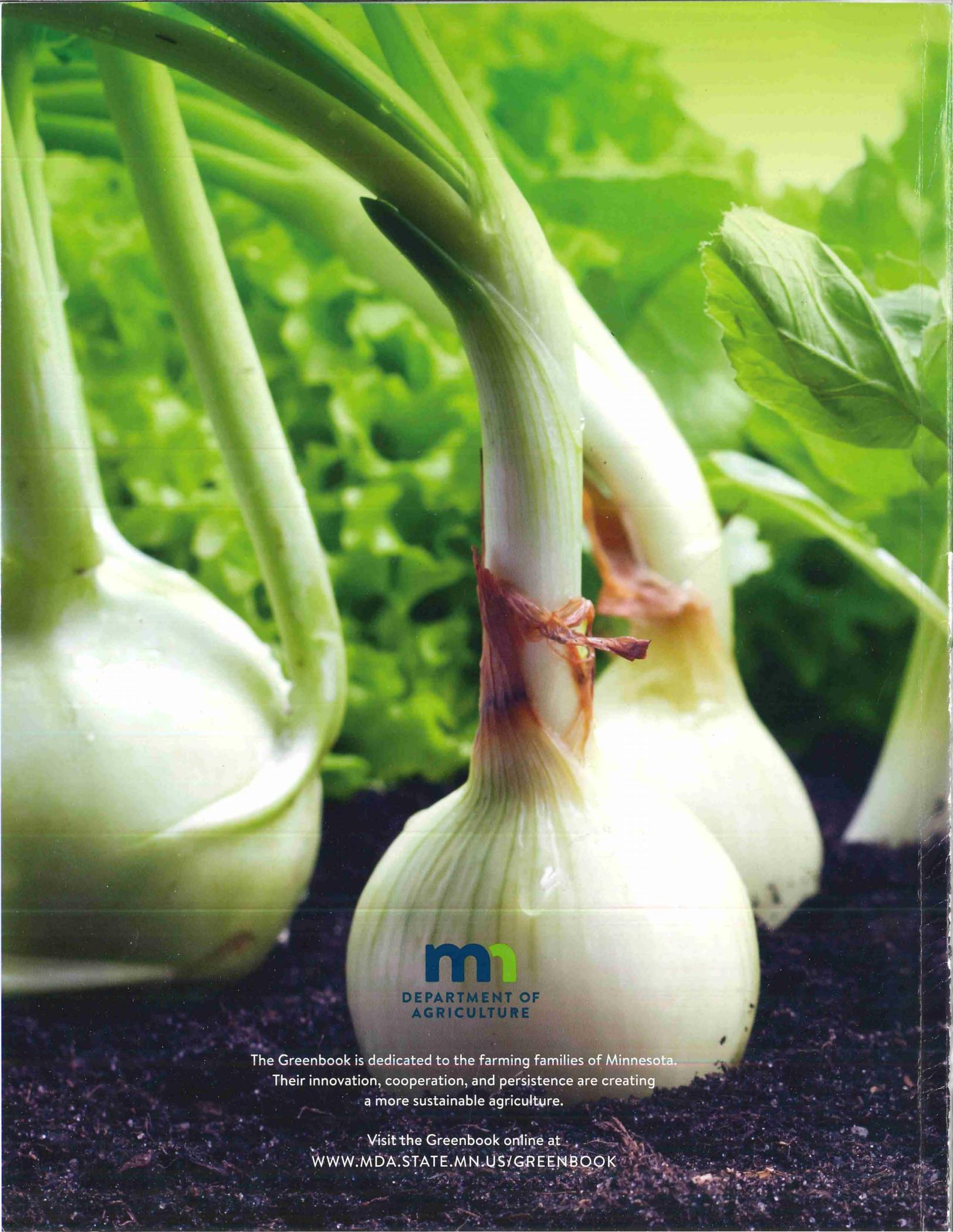
From Minneapolis/St. Paul, go west on I-94. Take the I-394 W exit. Continue onto US-12 W. In Kerkhoven, take

the second left onto Cty. Rd. 35. Continue for 1 1/2 miles. Project site will be on the left.

Other Resources

Premier 1 Supplies Newsletter. www.premier1supplies.com/pages/newsletter.php?mode=archive

University of Minnesota Extension. Alternative and Small-Scale Livestock Systems Program. www.extension.umn.edu/food/small-farms/livestock/



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