DEPARTMENT OF AGRICULTURE

GREENBOOK 2019

Sustainable Agriculture Demonstration Grant project descriptions and results

GREENBOOK 2019

It's my honor to be able to introduce the Minnesota Department of Agriculture's (MDA) 2019 edition of the annual *Greenbook*. As Minnesota's new Commissioner of Agriculture, I'm proud to support these 22 projects funded through the Sustainable Agriculture Demonstration Grant Program, a component of the Agricultural Growth, Research, and Innovation (AGRI) Program. I've been a long-time supporter of these programs and believe the projects presented here are great examples of the innovative ideas Minnesota farmers and researchers are exploring and testing to make farming in Minnesota more productive and sustainable.

Recipients were awarded up to $25,000 for forward-thinking agricultural initiatives. I can't highlight every project here in my introduction, but I'd like to! From finding peony varieties that can grow and flourish in the north, to determining the most effective pasture types for bringing lambs to market weight in one growing season, to determining the effects of cover crops on soil temperature and soil moisture in the southwest, these projects are fundamental to the future of agriculture. The Sustainable Agriculture Demonstration Grant Program is dedicated to improving and shaping the future; many of the previous grant projects have focused on practices that have become widely adopted, such as integrated pest management and cover cropping.

In *Greenbook 2019*, you'll meet an enthusiastic group of grantees who are focusing on ways to increase energy and labor efficiency, reduce purchased inputs, and improve both the environment and their bottom line. And, they're willing to share their successes and challenges with you. 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.

If there's a sustainable farming idea you'd like to try, please keep this opportunity in mind. To apply, please submit all application materials via the AGRI Sustainable Agriculture Demonstration Grant webpage at www.mda.state.mn.us/sustagdemogrant.

Thom Petersen, Commissioner

Minnesota Department of Agriculture | 625 Robert Street North | Saint Paul, Minnesota 55155

Agricultural, Growth, Research, and Innovation (AGRI) Program

MISSION STATEMENT

The Minnesota Department of Agriculture's mission is to enhance Minnesotans' quality of life by ensuring the integrity of our food supply, the health of our environment, and the strength of our agricultural economy.

Our Sustainable Agriculture Demonstration Grants support innovative on-farm research and demonstrations. They fund projects that explore sustainable agriculture practices and systems that are likely to make farming more profitable, resource efficient, and personally satisfying. In the *Greenbook*, grantees share their observations and experiences so that other citizens can benefit from them.

ABOUT AGRI

The Minnesota Legislature created the Agricultural Growth, Research, and Innovation (AGRI) Program in 2013 to advance the state's agricultural and renewable energy industries.

The AGRI Program awards grants and other types of financial assistance to create agricultural jobs and profitable businesses. Farmers, agricultural businesses, schools, researchers, and county fairs can apply to several different AGRI grant programs.

AGRI grants focus on areas of greatest opportunity and potential economic impact. These investments have resulted in increased production, employment, market expansion, and improved production and processing efficiencies since the program launched in 2013.

Table of Contents

Fruits and Vegetables

Livestock

Sustainable Agriculture Grant Program

PROGRAM PURPOSE

The Grant Program is designed to demonstrate and publicize the energy efficiency, environmental benefit, and profitability of sustainable agriculture techniques or systems from production through marketing. Grants fund research or demonstrations on Minnesota farms. Funding is from the Agricultural Growth, Research, and Innovation Program (AGRI).

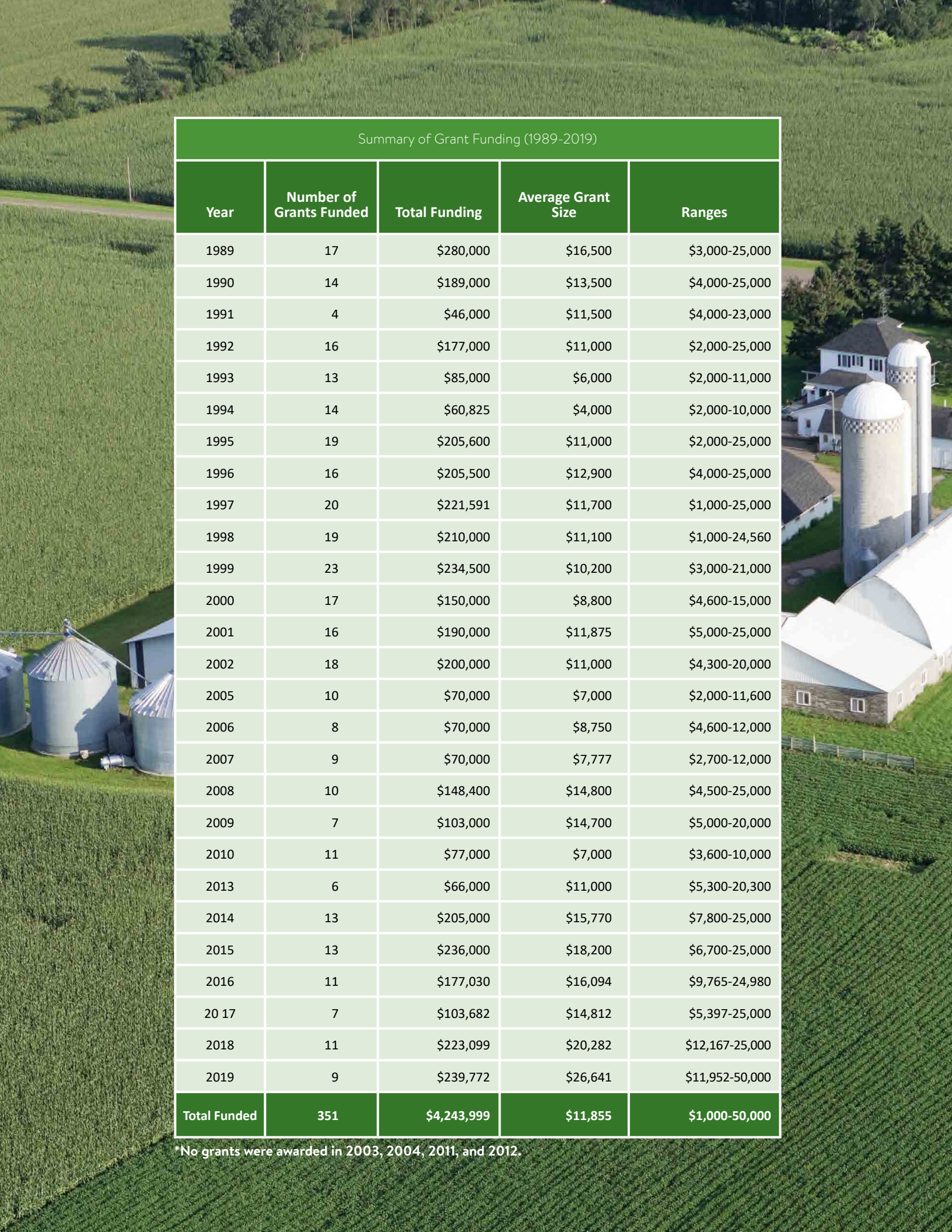
PROGRAM DESCRIPTION

The Department has received over 1,187 grant applications and approved over $4.2 million in funding for 358 projects since the program began in 1989. Project categories include: Alternative Markets, Specialty Crops, Cropping Systems, Soil Fertility, Energy, and Livestock. The active grant projects, being conducted throughout the state of Minnesota in 2018, are described in *Greenbook 2019.*

Grants provide a maximum of $25,000 for two or three year on-farm research or demonstration projects. Starting in 2019, the maximum grant can be $50,000 when the grantee provides a dollar for dollar match on the amount above $25,000. These projects by Minnesota farmers, educational institutions, individuals at educational institutions, or nonprofit organizations demonstrate farming methods or systems that increase energy efficiency or production, reduce adverse effects on the environment, and show economic benefits for a farm by reducing costs or improving marketing opportunities. 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 soil scientists, agronomists, postsecondary educators, ag marketing specialists, sustainable and organic farmers, and other agricultural experts.

GRANT SUMMARIES

The following project summaries are descriptions of project objectives and methods with activities and results obtained each year of the grant. 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 (1989-2019)				
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
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
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
20 17	7	$103,682	$14,812	$5,397-25,000
2018	11	$223,099	$20,282	$12,167-25,000
2019	9	$239,772	$26,641	$11,952-50,000
Total Funded	**351**	**$4,243,999**	**$11,855**	**$1,000-50,000**

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

2019 New Demonstration Grant Projects

CROPPING SYSTEMS

Regenerative Agriculture: A Pathway for Greater Farm Profitability and Practice Adoption

Grantee: Alan Kraus, Cannon River Watershed Partnership
Duration: 3 years
Award Amount: $41,534.30
Matching Funds: $16,534.30
Counties: Rice and Goodhue

Project Objectives:

Cover crops improve water quality by keeping nutrients in the soil and by keeping the soil in the field. The key to growing cover crops profitably is to use the biomass as forage for livestock. Cover crops interseeded into corn provides a source of forage for livestock after corn harvest. Determining if the width of the corn row affects the production of cover crop biomass and corn grain will provide information about how to improve profit. This project will test the effect of corn row width on cover crop biomass and corn grain yields. Four Southeast Minnesota farmers will each plant 20 acres of corn in five replicated plots using three different row widths and a control and then interseed a cover crop mix into the corn in late June for the 2019, 2020, and 2021 planting seasons.

1. Quantify total system outputs including cover crop forage yield and quality, grain yields, and compare with estimated beef gains.
2. Characterize ecosystem services to soil biological activities, water infiltration, and nutrient retention.
3. Develop enterprise budgets to evaluate the total value of the forage from cover crop biomass and corn grain between treatments and control.

Headwaters Agriculture Sustainability Partnership

Grantee: Sacha Seymour, Environmental Initiative
Duration: 2 years
Award Amount: $50,000.00
Matching Funds: $25,000.00
Counties: Stearns, Todd, Morrison, Benton, Wright, Meeker, Kandiyohi, Pope, and Douglas

Project Objectives:

This project will investigate and create case studies for farming practices that benefit both cost of production for farmers and natural resource conservation (particularly water quality), demonstrate the benefits of these practices to Central Minnesota dairy and row crop farmers through peer-to-peer learning, and engage and support motivated farmers in making practice changes through a unique public-private-nonprofit collaboration.

Project partners will assist participating dairy and crop farmers in quantifying the economic and environmental benefits of farming practices such as conservation tillage, crop rotations, improved nutrient management, etc. Project partners will help farmers package their data and stories for communication and demonstration to other farmers, with an emphasis on existing audiences and gatherings.

1. Demonstrate, through peer-to-peer farmer education, the alignment between profitable agronomic practices and improved environmental outcomes.
2. Conduct case study assessments of local farmer leaders that quantify the relationship between environmental outcomes and the economics of farming practices.

SOIL FERTILITY

Using sheep and cover crops in a strawberry rotation

Grantee: Sarah Brouwer, Brouwer Berries
Duration: 3 years
Award Amount: $11,952.48
County: Kandiyohi

Project Objectives:

Test the effectiveness of sheep grazing on grass cover crops as a method of improving soil health, reducing weed pressure, and increasing strawberry poundage per acre.

1. Strawberry soil improvement: Currently, each strawberry acre is harvested for two years, then allowed to rest in cover crops a full year before replanting strawberries. The plan is to graze sheep on the cover crops, and document soil health through soil and sap tests over a period of three years. Sales per acre will also be documented. Maximizing soil health through cover crops and grazing will have a positive environmental benefit and potentially be profitable.
2. Marketing opportunity: We have joined the Pipestone Lamb and Wool Project. They have successfully demonstrated for over 30 years that sheep can be raised for profit. We will be using their guidance and support to keep our flock healthy and productive. This will reduce our risk as farmers, because we'll have two potential income streams, from strawberries and sheep.
3. Education: Sarah is a licensed educator, and already uses social media and paid speaking engagements for agriculture education. The plan is to invite the public and schools to our farm during the lambing season for education and agritourism. Many of our customers have shown interest in our cattle and cover crop system, and they are eager to learn more. I believe we have a unique platform in Minnesota to be able to educate students, farmers, and the general public about our practices.

FRUITS & VEGETABLES

Rotational Grazing in an Orchard to Improve Pasture Health, Reduce Energy Input, and Increase Profit

Grantee: Robert Blair, Canosia Grove
Duration: 3 years
Award Amount: $15,212.00
County: Saint Louis

Project Objectives:

Establish an approximately 10 acre agro-forestry enterprise by implementing an intensive rotational grazing program within an apple orchard using a woven wire perimeter fence, with portable electric interior fencing. The fencing will improve our forage and the grazing will improve soil health, and decrease energy and manpower inputs.

1. Increase flock size:
   A perimeter fence will enable us to manage and protect our flock better. Improved forage quality from rotational grazing will improve our sheep's health. This will allow us to increase our flock size and earn more profit from the subsequent sales. This system should increase the total number of acres grazed per season.

2. Decrease manpower and energy inputs:
   Currently we spend 2 hours per week moving our sheep from paddock to paddock, and 3 hours per week mowing the grass in the orchard. We hope to reduce this time to 0.5 hours twice per week to rotate the sheep while substituting mowing for sheep.

3. Improve soil, pasture, and orchard health:
   Rotational grazing will reduce unwanted forage crops such as raspberry thistle and canary grass, while promoting a higher quality of forage such as trefoil clover and orchardgrass. These crops will help to fix nitrogen, and the sheep will naturally fertilize the pasture. We expect that removal of the large quantities of wild raspberries will help to control unwanted orchard pests. We also expect to see increased nutrient content of the orchard soils.

ALTERNATIVE MARKETS OR SPECIALTY CROPS

Integrated Hemp and Heritage Farm

Grantee: Nicolette Slagle, Anishinaabe Agriculture Institute
Duration: 2 years
Award Amount: $23,763.20
County: Becker

Project Objectives:

Create an integrated hemp and traditional foods working farm, utilizing rotational planting, natural fertilizers, and greenhouses. The site will serve as a demonstration farm, allowing others interested in sustainable industrial hemp cultivation to learn and work on the farm.

1. Hemp is traditionally grown as a monoculture crop. We would like to develop both a rotational plan for hemp and also companion planting plans. End uses of the hemp will define whether it can be grown with other crops, or if it needs to be grown alone.
2. We have been hosting the Tribal Hemp Conference for the past two years. We would like our farm to serve as a demonstration site where tribal members, governments, and other organizations can come and learn. To achieve this, we will document our processes and successes as measured by yields and profits. We will compile this information into a curriculum that can be used at tribal colleges.
3. Continue our tribal internship program by hosting three tribal members at our farm.

Exploring North Star Farm Tour as A Sustainable Agri-Tourism Model for Small Producers

Grantee: Melodee Smith, North Star Farm Tour
Duration: 3 years
Award Amount: $25,000.00
Counties: Dakota, Faribault, Fillmore, Goodhue, Olmstead, Ramsey, Rice, Scott, and Wright

Project Objectives:

North Star Farm Tour is a learning community of family-owned farms with a shared mission: "Connecting people, farms, and fiber." Member farms produce a variety of quality raw, processed and finished artisan products. North Star Farm Tour farmers also produce quality educational experiences for all ages on and off our farms. This project will document the story of North Star Farm Tour and each farm's quest for profitability.

1. Engage farmers in a 501c3 learning community to test whether involvement in the organization and an annual agri-tourism activity improves on-farm profitability and satisfaction. This grant will incentivize cooperator farmers to participate in: one committee, three tour cycles of farm program planning, tour marketing in each region, compliance with regulations, evaluation, and optional engagement with North Star Farm Tour-sponsored activities.

2. No models exist for meaningful evaluation of farm-based agri-tourism events. North Star Farm Tour and MN Tourism Center will create a tool that defines what can be counted as well as what counts. Farmers will develop skills to set goals for farm agri-tourism, contribute annual farm goals to the North Star Farm Tour grant project, participate in surveys as requested, report annual results, and participate in an annual Strengths-Weaknesses-Opportunities-Threats exercise that analyzes the annual evaluation.

3. Is agri-tourism a sustainable farm product? This "toolkit" of case studies will hopefully help others short cut the agri-tourism learning curve, and improve their experiences and profitability. We will include results of three years of research conducted with our collaborating experts along with field-tested ideas. We plan to make results available during the 3-year grant cycle, and present final findings at select conferences and online for cost-effective availability to other producers.

LIVESTOCK

Toward Forever Green Poultry Rations

Grantee: Jane Jewett, WillowSedge Farm
Duration: 2 years
Award Amount: $23,773.28
Counties: Aitkin, Ramsey, and Rice

Project Objectives:

Use three small-flock, seasonal chicken production systems already operating in Minnesota to compare a Forever Green poultry ration to a standard conventional or standard organic poultry ration. The Forever Green ration will be built on small grains and perennials (alfalfa), some of which could eventually be replaced by Forever Green crops currently under development. Forever Green is a U of MN initiative that seeks to maximize continuous living cover of agricultural production fields through crop rotations and perennial cropping systems.

1. Determine the viability of a Forever Green poultry ration built on small grains and perennial crops for production of small-flock meat chickens. Viability means comparable performance of chickens on the Forever Green ration to an identical batch of chickens raised on a standard ration.

   This will be done by doing paired comparisons of bird batches in each of three production systems. Data will be collected on carcass weights, ration disappearance, and meat eating quality. We will conduct an economic analysis of the Forever Green vs. standard rations in order to determine whether a Forever Green ration is economically viable and produces a good bird.

Testing two pasture types to finish lambs on pasture and an evaluation of meat quality from each

Grantee: Anna Johnson, Keith and Anna Johnson Farm
Duration: 2 years
Award Amount: $24,368.46
County: Sibley

Project Objectives:

In our rotational grazing system, average daily gains have usually decreased to economically unfeasible levels after August 20th, which we theorize may be because of decreasing sunshine and daylight. We will test two pasture mixes that can “store sunlight”: 1) A feed mix containing turnips and sugar beets, and, 2) A feed mix containing peas and small grains.

1. Test two different pasture types designed with the hope of achieving good finishing gains in lambs on pasture from August 20th until finished weight and compare that to lambs on a feedlot ration.

2. Analyze the lambs for fat and muscle depth using ultrasound and evaluate meat characteristics of tenderness, Omega-3 to Omega-6 ratio, Conjugated Linoleic Acid content, and vitamin and mineral content to further determine advantages and disadvantages of each finishing program.

3. Evaluate the economics and overall advantages, disadvantages, and considerations for each finishing system, taking into account the number of acres used, average daily gains, costs, machinery and supplies involved, and labor for each finishing system.

   This data will be analyzed to present a discussion of advantages and disadvantages of each system, including overall farm profitability and discussions of ecosystem services, energy and equipment use, health benefits, and marketing opportunities for pasture-raised lamb.

Evaluating Hazelnuts as a Soy-Protein Replacement in Free-Range Poultry Systems

Grantee: Wyatt Parks, Main Street Project
Duration: 2 years
Award Amount: $24,168.76
Counties: Dakota, and Rice

Project Objectives:

There is a growing demand for soy-free poultry feeds as consumer demand shifts away from traditionally raised and fed poultry products. Hazelnuts, as perennial and deep rooted plants, offer a sustainable and regenerative solution that build soil while producing a high-value product. Hazelnuts ability to grow in marginal land with limited support makes them ideal for large swaths of Midwestern farmland. They can also be grown in conjunction with poultry to convert animal waste back into a feed source. Research has already been completed in this realm though none has been performed regarding free-range chickens. This project will determine the economic and nutritional viability of hazelnuts as a soy alternative in free-range poultry flocks.

1. The objective of this project is to determine whether hazelnuts and their processing by-products can be used as a palatable replacement to soy in free-range poultry feed. The project will examine the feasibility of hazelnuts in relation to feed quality and nutrition as well as palatability. The project also will evaluate cost advantages to hazelnuts as an alternative feed source that can be produced locally on marginal land.

The following project summaries are descriptions of project objectives and methods with activities and results obtained each year of the grant. To find out more details about these projects, contact the principal investigators directly through the listed telephone numbers, addresses, and email addresses.

Sustainable Effects of Drip Irrigation on the Yields of Native Seed Production Plots

PRINCIPAL INVESTIGATOR
Dustin Demmer
Blazing Star Gardens LLC
28175 740th Avenue
Clarks Grove, MN 56016
507-402-8337
dustindemmer@gmail.com

PROJECT DURATION
2018 to 2020

AWARD AMOUNT
$12,983.92

STAFF CONTACT
Michael Greene

KEYWORDS
drip irrigation,
native prairie seed

PROJECT SUMMARY

Our project goal is to determine whether drip irrigation increases native seed production of four species of native plants and, if it does, whether the increased revenue is more than the added expenses. The supply of certain types of native seed for habitat restoration projects is struggling to meet demand due to long-term investment returns and lack of grower knowledge. Drip irrigation may help address this problem as it has the potential to increase yields, hasten returns, and reduce grower risk while using significantly less water and energy than conventional sprinkler irrigation.

PROJECT DESCRIPTION

While touring a friend's 2 acre vegetable farm, we noticed their extensive use of drip tape irrigation to water their crops. Drip tape irrigation is commonly used in vegetable production to boost yields by providing weekly water for plants. It delivers water directly to the base of plants through emitters in thin plastic tubing, resulting in less water use and evaporation than traditional sprinklers. Drip irrigation hasn't been significantly used or studied for native seed production in Minnesota. Our seed production fields are planted with several species of perennial prairie flowers, many that are wet-meadow species that require moderate moisture throughout the year, and we wondered if drip irrigation could similarly benefit our seed yields and reduce water waste.

Plot of Prairie Phlox (Phlox pilosa) being irrigated by drip tape underneath plastic ground cover. The darker areas on the left and center of the photo show the uniform wetting pattern compared to the lighter dry ground cover on the right.

Our project objectives are:

1. Determine whether regular irrigation via drip tape will increase seed production in test plots of four native perennial plant species compared to control plots that are only irrigated during establishment and droughts with traditional sprinkler irrigation.

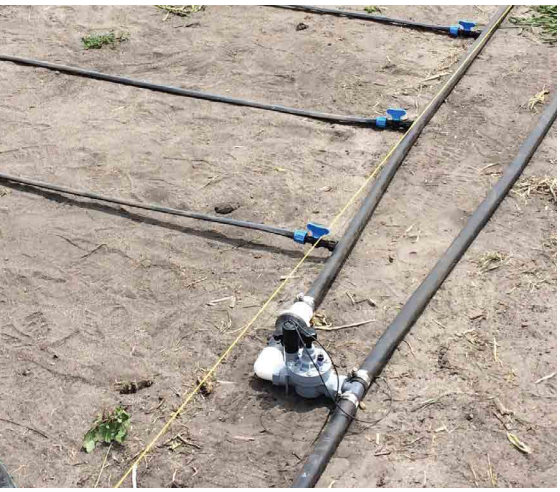
2. Determine if potential increased seed production will cover added expenses of installing and managing the drip tape irrigation system.

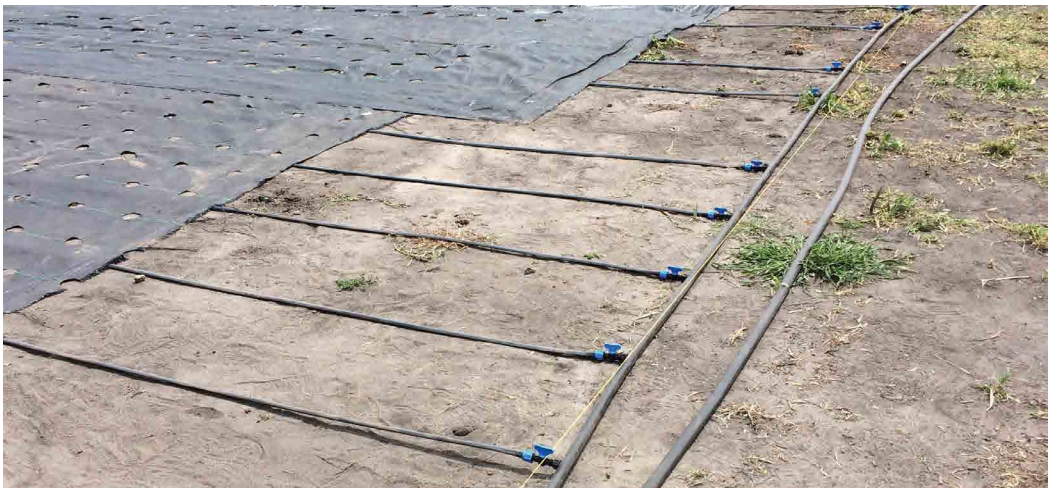
Our seed production plots are installed in 12 foot by 150 foot sheets of long-term plastic ground cover that is planted with plant plugs grown in a greenhouse, approximately 1,500 plants per sheet. Immediately after planting, plants are watered with sprinklers to settle the soil around the plants. Typically, we have needed rain or sprinkler watering every 2 to 3 days for 4 weeks until their roots have established. After that, sprinklers are used only during times of drought. To accomplish these irrigations, the sprinklers are moved by hand every few hours during irrigation cycles. Sprinkler irrigation is very labor intensive and wastes a lot of water on non-plant areas. It also limits watering to daytime when evaporation is the highest. For this project, we are using the previous sprinkler irrigation method on control plots and comparing the yields to test plots that are irrigated with drip tape on a regular basis.

For this project, we planted four different species of native perennial plants: Phlox pilosa, Liatris ligulistylis, Lilium philadelphicum, and Lilium michiganense. Each species was planted with one drip irrigated plot and one control plot that received only initial irrigation. There were a total of eight plots. We kept our seed production plots in the same layout as our previous plots but laid down drip tape before setting the plastic ground cover on top. We laid it underneath the plastic instead of on top because brand new ground cover isn't permeable enough to allow the irrigation water to pass through quickly or evenly based on some of our tests. One of our plant species, L. michiganense, spreads by underground rhizomes so we covered it with 3 inches of wood chip mulch instead of plastic ground cover and laid the drip tape on top with staples to hold it in place.

We used 0.34 gallons per minute (0.34 GPM for every 100 feet of tape), 10 millimeter thick drip tape and 0.22 GPM, 15 millimeter thick drip tape. We used the thicker 10 and 15 millimeter drip tape instead of the standard 3 millimeter annually-disposable tape in the hope that it will last as long as the plastic ground cover (about 10

years). The drip tape was placed down the middle of every two rows of plants, approximately 4 to 6 inches away from each plant. We measured out the row spacing we needed, put the drip tape on a homemade moveable spool holder, and laid out the tape. Then, we put the ground cover on top, stapled it down, and adjusted the drip tape so that it was in the middle of the rows. At the top of each plot, the drip tape was connected to 1 inch polyethylene header hose. The connections are made by using a hole punch tool to make holes in the tubing, then screwing a valve with a barb onto the drip tape by hand, which is then pushed into the header hose. The ends of the drip tape are folded three to four times and a sleeve is placed on the folds to cap them. The drip tape emitters are pointed up.





Drip tape lines are connected to the sub-header hose with barbed valves. The sub-header hose is connected to the main header hose with an electronically controlled solenoid valve.

The main header hose is connected to sub-header hose zones based on the maximum amount of water that can be provided by the water supply—about 5.5 GPM from our well. For example, if our drip tape uses 0.22 GPM for every 100 feet of tape, then (5.5 GPM ÷ 0.22 GPM) x 100 feet = 2,500 feet of drip tape can be supplied by our well at a time. If the plant rows are 150 feet long, then 2,500 feet ÷ 150 feet = 16 rows of drip tape can be hooked up to a sub-header hose. The sub-header hose is connected to an electric solenoid or ball valve, then to the main header hose. The main header hose is connected to all of the sub-header hoses and then to the main water supply. Then, the zones are turned on one-at-a-time, for about 3 to 4 hours each cycle during the initial root establishment phase, until all the zones are watered. We used electric solenoid valves and an automatic Wi-Fi controlled timer so that the zones could be turned on and off automatically and remotely through a smartphone app. This was possible because we had an existing electrical source and Wi-Fi connection near the fields. The solenoid valves can also be turned on and off by hand.

One concern we have is rodent damage to the drip tape. Burying the drip tape is a way to prevent rodent damage, but we didn't think it would water new plugs as effectively and also might be punctured by our ground cover staples. Any damage and repairs will be recorded and published in the final report.

RESULTS

We had a positive experience with drip tape irrigation during the first year of our 2 year project. Although the initial supplies and installation cost more than our previous system of moving around hoses and sprinklers, the more uniform irrigation and reduced management costs through automation have benefited our operation. Regardless of whether or not it increases seed yields in year two, we might continue to install drip tape in our future plots to provide irrigation during the critical root establishment period after planting.

Comparisons of the drip irrigation and sprinkler irrigation systems are reported in Table 1. Drip irrigation required approximately 24 hours for planning and ordering supplies and installation of header hose and drip tape (about 4 hours per 1,000 sq. ft.). The drip tape supplies cost $1,101. Our previous method of moving three sprinklers took about 1 hour to connect hoses and sprinklers. The sprinkler supplies cost $156. However, once the drip irrigation was installed, it required only two total hours for six irrigation cycles during the initial root establishment period. Our control method of sprinklers required 16 total hours to move sprinklers throughout the plots for six irrigation cycles during the same period.

Our yield results will be published in the final report because none of the perennial species we grew in our trial produce seed in their first year of growth.

TABLE 1. Labor hours and costs of drip and sprinkler irrigation systems, 2018.

Irrigation system	Cost of supplies*	Installation labor hours*	Management labor hours (6 irrigation cycles)
Drip tape	$1,101	24	2
Moveable sprinklers	$156	1	16
*For 6,000 sq. ft.			

MANAGEMENT TIPS

1. An irrigation supplier is essential for determining and supplying the specific parts to a drip irrigation system.
2. Although electronic valves and wiring have a much higher up-front cost than manual ball valves, they are a valuable tool that prevents overwatering and allows the user to manage the irrigation system automatically, making it possible to cycle through irrigation zones overnight and when away from the fields.
3. The hole punch tool dulls quickly but can be sharpened in the field with a sharpening stone.

COOPERATORS

Laura Mortimore, Orange Cat Community Farm, Lyndon Station, WI

PROJECT LOCATION

From Clarks Grove, go west on 283rd Street for 3 miles and turn south at the stop sign. We are located about 750 feet south on 740th Avenue on the west side of the road.

OTHER RESOURCES

All about Sprinklers and Drip Systems. Ortho Books, 2006.

Berry Hill Irrigation, Inc., has a helpful Frequently Asked Questions to help understand design basics: www.berryhilldrip.com/FAQ

Nolt's Midwest Produce Supplies is one of the nearest suppliers of agricultural drip irrigation components for Minnesota: 3160 140th St., Charles City, IA 50616, 641-228-4496

Minnesota Hops Terroir Identification and Promotion

PRINCIPAL INVESTIGATOR
Eric Sannerud
Mighty Axe Hops
8505 95th Street NE
Foley, MN 56329
952-201-4227
eric@mightyaxehops.com
Benton County

PROJECT DURATION
2018 to 2020

AWARD AMOUNT
$25,000

STAFF CONTACT
Michael Greene

KEYWORDS
hops, marketing, sensory, terroir

PROJECT SUMMARY

Terroir is a distinguishing, marketable feature in wine grapes that refers to the characteristic taste and flavor imparted by the environment in which a plant is grown. A valuable opportunity exists to treat the hops used in craft beer with the same care and appreciation that wine grapes have long experienced. With the assistance of sensory experts from the University of Minnesota (U of M) and St. Croix Sensory, we have set out to identify the terroir of Minnesota grown hops by scientifically comparing their aroma and flavor characteristics to the same variety of hops grown in the Pacific Northwest.

PROJECT DESCRIPTION

Mighty Axe Hops is Minnesota's largest hop farm, growing 82 acres of hops on medium-heavy soil in Benton County. We do all harvesting, drying, pelleting, and packaging on-site. We believe in the future of MN grown hops and see the biggest opportunity for long-term success of MN hops through distinguishing what makes MN hops different from the rest. One way we can successfully differentiate MN hops from others is by defining the terroir of MN hops. Terroir is the idea that where something is grown affects its characteristics. The concept of terroir is most common in wine and cheese. For example, a French grown pinot noir (red wine) will taste different compared to a California grown pinot noir.

Accurately defining terroir is not as simple as smelling MN hops and non-MN grown hops. We knew we did not know enough to define MN hop terroir on our own. Our collaborators at the U of M and St. Croix Sensory bring world-class sensory science and methods to our research process.

Hops impart distinct flavor to beer is based upon the variety used and the environment in which it was grown.

For terroir to be trusted and marketable, it is essential to define the sensory profile objectively. The methods we are using to evaluate the aroma and flavor of our hop samples are a hybridization of cutting-edge sensory science and best practices for beer sensory analysis developed by the beer industry.

Communicating the terroir of MN grown hops with both accuracy and precision is key to our farm's marketability in Minnesota and beyond. MN hop terroir will be a critical differentiator for MN grown hops. Terroir takes MN grown hops from a locally sourced ingredient for regional brewers to a desirable ingredient for any brewer who is interested in rare aromas, unique flavors, experimentation, or innovation. We expect this to add significant value to hops grown within the State of Minnesota.

RESULTS

Through consultation with our collaborators, we identified the best methods for hop aroma and flavor evaluation. Cascade, a popular MN hops variety, was selected for terroir evaluation. In 2018, samples were obtained from Washington growers and our fields in Minnesota. Dried hop samples will be left whole cone for analysis. The whole cone hops will be placed into a blender to be broken up and mixed. The pulverized hops samples will be introduced into a beer using a hop rocket or randall device. The beer is a national beer brand selected for its consistency and lack of hop character, which makes it a blank canvas for the addition of hop flavor. Next, two panels will convene to evaluate the flavors and aromas of the beers. One panel will be comprised of brewers and professionals in the beer industry. Trained sensory specialists will make up the other panel. Initial data will be available following this round of evaluation. A second evaluation round will be run following the 2019 hop harvest. At the end of the grant period, we will have two seasons worth of sensory data. We expect to present the data using spider graphs. Finally, our farm will host a field day in the summer of 2020 to provide our results to customers and other growers.

MANAGEMENT TIPS

1. Coordinating collaborators can be time consuming. Do not underestimate how much of your time on a project will be dedicated to organization and coordination.
2. Academics are invaluable partners when seeking validated methods of inquiry.
3. Involve your customers in your project. They will approach your project with a different set of values that could be very valuable.

COOPERATORS

This first year of the grant was heavy on discovery and design. The U of M team led the initial stages of inquiry into best methods and research design. Then, the three of us gathered to translate their recommendations into a process that St. Croix Sensory and Mighty Axe Hops could run. Mighty Axe Hops will coordinate with St. Croix Sensory to perform the actual research.

Kirsten Weiss, Saint Croix Sensory

Chris Vandongen and Zata Vickers, University of Minnesota

PROJECT LOCATION

Our farm is located just north of Foley, MN off MN-25. Take MN-25 north from the MN-25/MN-23 intersection in Foley. Head west on Little Rock Road. After roughly a mile, you will see our fields on the south side of the road. To reach our main entrance from Little Rock Road, head south on Goldenspike. Then, turn east on 95th Street NE. We are the first driveway on the north side of the road.

Terroir evaluation of hop varieties.

Peonies for Profitable Cut Flower Production in Northeastern Minnesota

PRINCIPAL INVESTIGATOR
Kate Paul, Owl Forest Farm
3442 Mobraten Drive
Iron, MN 55751
218-290-6630
Saint Louis County

PROJECT DURATION
2018 to 2021

AWARD AMOUNT
$23,860

STAFF CONTACT
Michael Greene

KEYWORDS
blossoms, cold hardy, cut flowers, peonies

PROJECT SUMMARY

Peonies (*Paeonia spp.*) are a highly sought-after cut flower around the world. The number of peony stems sold in the international cut flower market has been increasing in recent years. Peonies are winter hardy and incredibly long-lived plants, often living for over a century. Grown in USDA Zones 2 - 8, they need an extended period of cold during the winter in order to go dormant and bloom the next year.

The goal of this project is to grow and evaluate 32 varieties of peonies for cut flower production in USDA Zone 3 in Northeastern Minnesota. This study will seek to identify those cultivars that produce the most blooms per plant and identify cultivars that would extend the production period, allowing Minnesota growers to meet the demand for peonies after production ends in many other states. This project has the potential to serve as a benchmark for kick-starting a new commercial enterprise in Minnesota that would support small farms and promote USA grown peonies.

PROJECT DESCRIPTION

Owl Forest Farm is a small farm in Iron, MN that supports vegetable, herb, and cut flower production on over 5 acres. Sales of wholesale cut flowers to local flower shops began in 2017. Both annual and perennial flowers are grown on the farm. Perennial species include hydrangeas, lilies, lupin, and peonies. Although it is not certified organic, the farm follows organic practices. The farm's owner, Kate Paul, has an M.S. degree in Biology.

In warmer zones in the United States, as well as in Denmark, peonies bloom mainly in May and June. New Zealand's peony market is in November and December. In Chile, peonies are ready for market in January and February. In northern Minnesota (Zone 3), there is potential to grow vigorous peony plants that produce a bounty of blooms during late spring to late summer. This seasonal advantage would help fill a niche in the market when supplies are low or non-existent elsewhere. While this advantage is similar to Alaska's peony market, northern Minnesota grown peonies would have an edge over Alaska due to the proximity of shipments within the lower 48 states, which would likely keep costs lower. Peonies grown in northern Minnesota would fill local florist needs and be available for next day air shipments throughout the United States and around the world.

The purpose of the project is to grow and evaluate peony (Paeonia spp.) production in a location where there is great potential for a local, national, and international cut flower peony industry. The project will help identify those peony cultivars that perform well overall (measured by average budding/blooming stems per plant) as well as those cultivars that bloom the latest during the growing season, thus extending the marketing season.

Discing the ground at Southern planting area.

Peony bare roots were transplanted in the fall of 2018. General maintenance will be done on the young plants in 2019, including watering, fertilizing, and monitoring for Botrytis (gray mold). Once plants begin to bloom during the 2020 growing season, data collection will begin and will continue weekly throughout that season. Total mean blooms per cultivar will be recorded each week. Also, a chart will be made showing a timeline of the weeks during which each cultivar was blooming. An ANOVA (analysis of variance) test will be done to compare the mean blooms per cultivar during their peak weeks. If the ANOVA shows a statistically significant difference in group means, a Games Howell post hoc test (or other appropriate post hoc test) will be performed to determine which cultivars had significantly more blooms.

Through this study, we will determine the dates and duration of blooming for each cultivar. We will also determine which cultivars bloom the latest into the growing season. Extending the production period will allow Minnesota growers to meet the demand for peonies after production ends in many other states. Notes will also be made regarding general plant health in both 2019 and 2020. There may be cultivars that simply do not do well, and if so, notes will be made prior to any data collection on blooms. Perhaps not every variety will be well suited for the growing conditions in this study, and that is just as important to know as which varieties perform well.

RESULTS

Soil samples were gathered in the spring from the location where bare root peonies were proposed to be planted, plus one alternative location. Soil samples were sent to the University of Minnesota Soil Testing Laboratory and measurements were made of regular series phosphorus, potassium, pH, and percent organic matter. Sulfur, zinc, iron, copper, manganese, boron, calcium, and magnesium in the soil were also measured. The alternative location and two additional locations where soil composition was already known were substituted due to the presence of deer that trampled on the previous year's peony plantings. The deer frequently travel across the proposed location and they caused several bare roots to dislodge from the soil. Except for one small area, the locations that were chosen for the 2018 plantings were already protected by deer fencing. The smaller, non-fenced area will be monitored for deer damage in 2019 and fencing will be installed if needed.

Bare root peony divisions were ordered in the early spring from four reputable wholesale companies in order to secure the varieties needed for fall shipment. Thirty-two different peony cultivars (Table 1) were ordered, all of which had 30 - 50 roots each with 3 - 5 eye roots, for a total of 1,385 bare roots. An equivalent number of early, mid, and late season cultivars were selected. A wide range of colors within each season were chosen, including white, light pink, dark pink, red, coral, and yellow.

The field after planting beds have been made.

Landscape fabric covers the planting beds to prevent weeds and to retain soil moisture.

Table 1. List of peony varieties planted and their characteristics.				
Name of Variety	Peak Bloom Season	Flower Color	Flower Form*	Number of Bare Roots Planted
Duchess de Nemours	early	white	double	40
Charles White	early	white	double	50
Festiva Maxima	early	white with crimson flecks	double	50
Premevere	early	white	Japanese	45
Madam Calot	early	cream white/blush pink	double	45
Paula Fay	early	dark pink	semi-double	50
Coral Charm	early	coral	semi-double	50
Allan Rogers	early/mid	pure white	double	50
Pecher	early/mid	light pink fade to white	double	30
Bowl of Beauty	early/mid	pink	Japanese	50
Rachel	early/mid	bright crimson red	double	40
Coral Sunset	early/mid	coral fade to ivory	double	45
Shirley Temple	mid	white	double	45
Lady Alexandra Duff	mid	light pink	semi-double	50
Edulus Superba	mid	pink	double	50
Alexander Fleming	mid	rose pink	double	30
FD Roosevelt	mid	crimson red	double	30
Flame	mid	crimson red	single	50
Kansas	mid	watermelon red	double	40
Adolphe Rousseau	mid	deep maroon	double	50
Henry Sass	mid/late	pure white	double	30
Nick Shaylor	mid/late	white/blush, salmon	double	40
Mme. Emile Debatene	mid/late	salmon pink	double	30
Felix Crousse	mid/late	raspberry red	double	50
Inspector Lavergne	mid/late	dark crimson	double	40
Dr. F.G. Brethour	late	pure white	double	50
Auten's White	late	white	double	50
Auten's Pride	late	blush pink	double	40
Sarah Bernhardt	late	light pink	double	45
Red Sarah Bernhardt	late	dark red/pink	double	30
Best Man	late	red maroon	double	45
Marie Lemoine	late	cream white	double	45

*Description of flower forms:

Single: Similar to the wild form of the peony with five or more guard petals arranged around the carpels and pollen-bearing stamens of the flower. This is the fundamental peony flower form.

Semi-double: Five or more outer guard petals with a center of smaller inner petals often decreasing in size as they near the center of the flower. Pollen-bearing stamens may be intermixed with petals or be present in the center of the flower. Occasional transformation of stamens to petal-like structures.

Double: Five or more outer guard petals with a center of stamens and carpels that have been more or less transformed into petals - creating the full body of the flower. Occasional stamens may be interspersed throughout the flower.

Single: Similar to the wild form of the peony with five or more guard petals arranged around the carpels and pollen-bearing stamens of the flower. This is the fundamental peony flower form.

Semi-double: Five or more outer guard petals with a center of smaller inner petals often decreasing in size as they near the center of the flower. Pollen-bearing stamens may be intermixed with petals or be present in the center of the flower. Occasional transformation of stamens to petal-like structures.

Double: Five or more outer guard petals with a center of stamens and carpels that have been more or less transformed into petals - creating the full body of the flower. Occasional stamens may be interspersed throughout the flower.

During the summer of 2018, the ground was prepped for planting by disking, tilling, and applying compost and granulated lime where it was needed prior to planting oats as a cover crop. During the last half of September, additional disking and tilling were done to work the cover crop into the soil. Rows 4 feet wide on 9 foot centers were made by using the disc hiller attachment on the tractor to make a trench on both sides of the beds. In all but two beds, hand raking was done to smooth off the bed surface and remove loose soil from the trenches. Six foot wide landscape fabric was laid down on the beds and the sides were secured in the trenches using landscape staples and covered with soil. For each bed, holes were marked 2 feet apart to create a double row for bare root peonies. Using a Bernzomatic torch and the top portion of a metal bucket, 11 inch holes were then burned in the fabric.

We used a stick to measure hole spacing in the landscape fabric.

The first shipment of peony roots arrived during the first week of October and the last shipment arrived near the end of the third week of October. The later shipment was overdue by two weeks due to wet soil conditions at the wholesaler's location which caused difficulties in harvesting the bare roots. All bare roots arrived in good condition with the approximate number that were ordered, except for one variety in which 50 were ordered, but only 25 were received. A total of 1,371 peony bare roots were transplanted and amended at Owl Forest Farm with an appropriate amount of composted manure, granular fertilizer (8-16-16), bone meal, and pelleted lime where needed. Each variety was marked in the field using bamboo markers with labeled flagging. In addition, a diagram was made showing the location and exact number of each variety in the field. Permanent markers will be installed in the spring of 2019.

MANAGEMENT TIPS

1. Prior to ordering bare roots, inquire with other growers about suppliers of bare root peonies to find the best quality and ease of handling. For example, the bare roots from one company were very long compared to another company that cut the roots more compactly. The number of eyes was the same, but it was much easier and quicker to transplant the more compact roots. Shipping costs can also be drastically different between companies, so inquire prior to placing your bare root orders.
2. Although deer do not tend to browse on peonies, we discovered from a previous year's plantings that they can trample on the fresh transplants in the fall and again in the early spring, causing some of the bare roots to dislodge from the soil. Because of this, we changed the location of most of the plantings to an area that was already fenced in to keep deer out immediately after transplanting.
3. In preparing beds for the landscape fabric, the side trenches were made with the disc hiller attachment on the tractor, but the best results were obtained when the beds were also hand-raked to smooth the bed top and to clean loose soil out of the trenches. It takes more time and is more labor intensive, but the fabric ultimately lays better with a smoother base underneath.

COOPERATORS

Kendall Dykhuis, Agriculturalist and Agronomist,
St. Louis County Extension Service.

In 2018, Kendall assisted with interpreting the soil test results and made recommendations for amendments.

PROJECT LOCATION

From the center of Forbes, at the junction of County Roads 7 and 16 (which is 9 miles south of Eveleth), take County Road 16 two miles west. Turn left on Mobraten Drive and travel ½ mile south to the site at 3442 Mobraten Dr.

OTHER RESOURCES

The Alaska Peony Growers Association is an example of a cooperative with a long list of supported farms. They also host the annual Alaska Peony Conference.
www.alaskapeonies.org
www.alaskapeonyconference.com

Perennial Farming and Carbon Sequestration, Ecosystem Services and Innovative Entrepreneurship

PRINCIPAL INVESTIGATOR
Michele Manske
Mashkiikii Gitigan/Pillsbury United Communities
2323 11th Avenue South
Minneapolis, MN 55404
651-356-9320
michelem@pillsbury united.org
Hennepin County

PROJECT DURATION
2018 to 2020

AWARD AMOUNT
$24,606.29

STAFF CONTACT
Michael Greene

KEYWORDS
perennial fruit and vegetable systems, urban farming

PROJECT SUMMARY

What once was a vacant, un-managed lot has been transformed into a food producing green space within the city of Minneapolis. Sheet mulched, bio-charred raised beds produce annual vegetables for the Minneapolis Lead Free housing project and the Waite House's food shelf. Fruit trees, flowers, and medicinal herbs support medicine -making classes and our community cafe. Neighbors stop by to relax under the honey locust tree or to watch the University of Minnesota (U of M) students gather data and admire the abundance around them. In this multi-tiered growing environment, we will evaluate the perennial system's ability to sequester carbon, affect soil contaminant levels, and provide entrepreneurial opportunities.

PROJECT DESCRIPTION

The purpose of this project is to establish and evaluate a multi-tiered perennial cropping system to determine if it has the potential to provide increased economic prosperity and environmental quality when integrated into urban agricultural practices in South Minneapolis. Our farm site is part of the Mashkiikii Gitigan (Ojibwe for "Medicine Garden") urban farm. This farm is comprised of layers containing differing crop functional types - including mushrooms, herbs/native flowers, and fruit-bearing shrubs and trees. Collectively, these plant products command higher profit margins than vegetables at market, and a perennial system has the potential to generate sustained, lasting benefits to soil and environmental quality.

Entrance to farm site.

I've wanted to start this project for many years because I believe that accessible agriculture is an important strategy for public health and improving the urban environment, serving as a tool for community engagement and as a direct way to address food security. The economic intentions of growing in this specific location are to train interested community members from the neighborhood who could make a profit selling the produce once we've addressed the most significant barriers.

This project has three objectives:

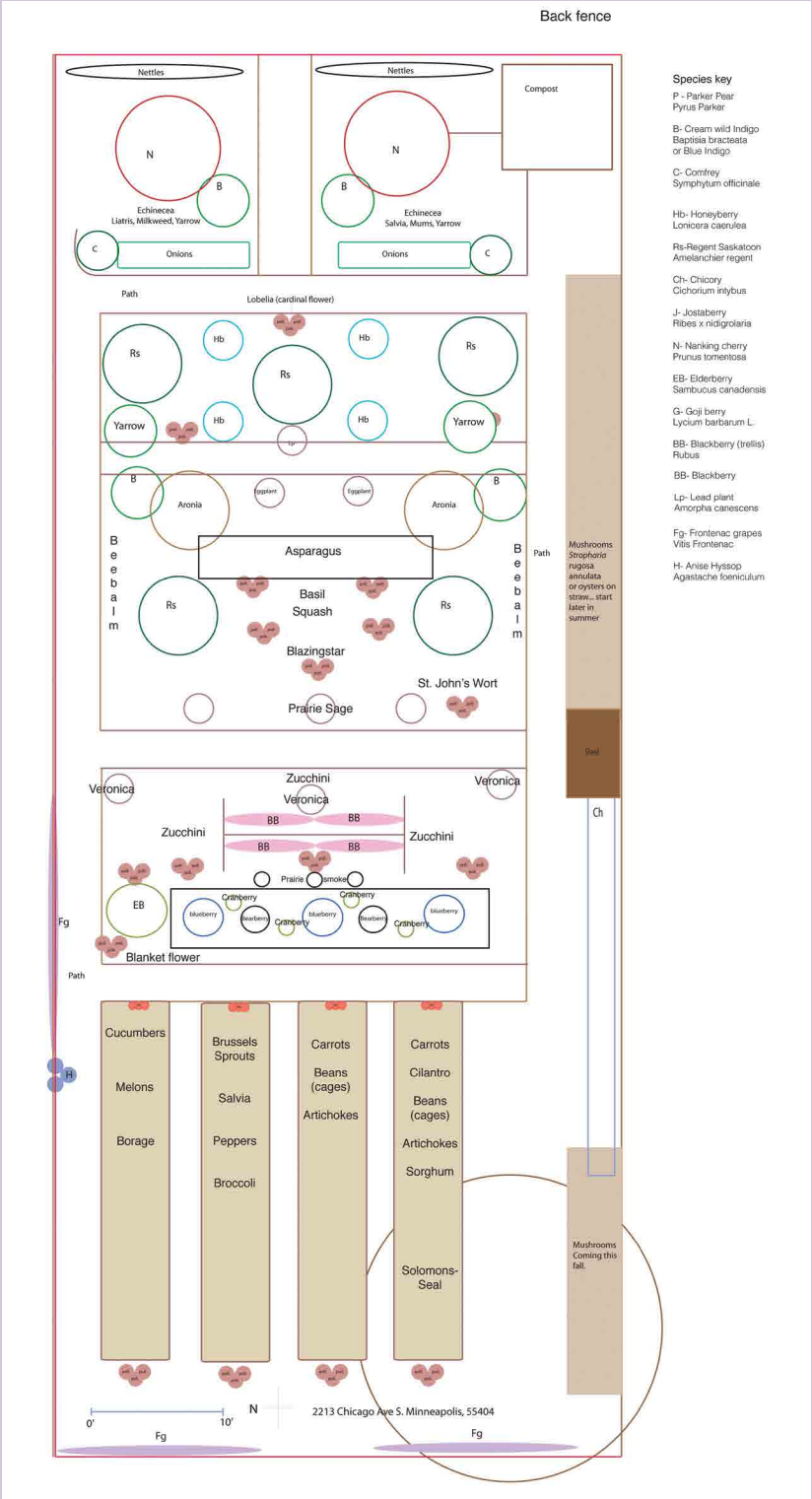
1. Evaluate the effectiveness of a perennial system to sequester carbon.
2. Investigate the impact of production oriented perennial systems on soil contaminants/heavy metals.
3. Assess the biodiversity on this site and its potential to provide innovative, entrepreneurial opportunities for urban farmers and populations who face disproportionate toxic exposure in the urban environments.

I started farming for Pillsbury United Communities (PUC) in February 2018 because of their long- standing commitment to food justice. Pillsbury's community cafes and food shelves have operated for decades, providing healthy food access to communities within the city of Minneapolis that have been historically excluded from traditional food systems. These services are particularly vital among many of the marginalized communities we serve, for whom the culturally informed practices of PUC centers provide a critical lifeline to not only nutrition, but a broader sense of community connection.

We currently farm on six city-leased lots, varying in size but none larger than ¼ of an acre. Our sites have been exposed to arsenic contamination and are in one of the most polluted neighborhoods in the Twin Cities. For this reason, all of our beds are raised and have imported soil. Most of our water is metered and purchased from neighbors or the city.

Fall transition of city lots to vegetable beds.

Many people walk through our farm sites, providing an assortment of challenges; drug use, theft, damage, and human contaminants. However, sometimes these are positive interactions; clients from Our Savior's (our neighbors) love to help in the garden because they say it gives them something positive to do during the day. I've encountered many people who were trying to sneak produce and used the opportunity to teach them how to harvest without damaging the plants. Several times people join me in the garden because they just need someone to talk to; the garden is a therapeutic, healing space. The benefits of nature are the driving forces of this project.



The garden leasing program is a considerably new program for the City of Minneapolis. At first the city only allowed for 1 year leases. Staff from PUC and others worked hard to change that duration to its current 3 year status. This change in policy has encouraged the growth of community gardens and urban farms. Our Chicago Avenue farm aims to modify the policy even further. We are advocating for permanency. Our collaboration with the U of M will drive the importance of allocating for green space in future urban planning. At the end of the study, we will be able to describe the unique ecosystem services and food production metrics that a small urban plot of land can provide with responsible management and stewardship.

The Chicago Avenue farm, the site selected for this study, is part of the Medicine Garden urban farm which has a 5 year lease from the city. This site has been under raised bed annual vegetable production for one growing season and was previously a vacant lot. The perennials will be planted so that they are mutually supportive, but not in direct competition. The design of the space is meant to mimic a woodland ecosystem by including edible trees, shrubs,

herbs, and native pollinator species. Each plant has its own niche; for example, Fragaria x ananassa (strawberry) was planted around the fruit trees as an edible ground cover and weed suppressor. Nitrogen fixing species are included in the system and meant to be cut two to three times throughout the growing season and placed around fruiting species as green manure or mulch to enhance nitrogen availability to surrounding plants. To encourage mycorrhizal symbiosis and enhanced nitrogen fixation, Baptisia species will be inoculated with Rhizobia. Fungal species to be incorporated into the system include the edible Red Wine cap (Stropharia rugosa-annulata), which requires inoculation on a layered bed of hardwood mulch and straw.

The first season will rely heavily on fast maturing fruit crops (Rubus sp.) and mushrooms. We will begin harvesting the other crops in 2019, plants chosen for their quick maturity rates (1-3 years). By the third season, we plan to have reliable produce to bring to market.

Trellising to support vining plants.

The project will be evaluated in several ways. The U of M team is collecting data on soil, carbon, water quality, leachates, earthworm, and pollinator populations. They are comparing this data across the metro at several other collaborator sites. To track farm economics, we will use QuickBooks™ and an accountant. Everything that happens on the site will be recorded and a harvest record will include: time spent on harvest (includes setup and cleanup), what was harvested and how, washing, packing, and where produce was sold. To evaluate the goals that align best with the values of PUC, we are surveying the overall social impact and growing capacity. Compared to previous years, we can confidently say that our program is providing more families with a diverse, fresh, and healthy diet.

2018 RESULTS

This year we transitioned most of the site from annual vegetables to perennials and fruit trees. We removed the back half of the row crops to create poly-cultured perennial beds. We built and installed trellis supports for blackberries, a separate blueberry and bearberry bed, and purchased drip line irrigation for precision watering. Results were affected by a late snow storm (April 13-16, 2019). Although we still produced food, I considered this to be a transition year to establish a new system.

Creating perennial beds.

The benefits that the farm brought to the community were many. We had one of the most diverse bee populations (data collected from our community partners), a weekly box of fresh produce to help families who were in transitional housing while their homes were being treated for lead, a very successful plant medicine class using plants from the garden, new research being conducted on the benefits of bio-char, and co-hosted a weekly garden based class with a registered dietician.

This project has reduced the use of non-renewable resources and inputs in the following ways.

1. Drip irrigation improved water management.
2. A higher percentage of perennials will eventually reduce the labor for this site and therefore reduce costs, making it more economical to manage.
3. Small farm size reduced use of fossil fuels for equipment. Ninety-five percent of the site was sheet mulched and heavily wood chipped without the use of fossil fuels.
4. Sale of produce in local markets and nearby restaurants reduce transportation costs and fetch higher prices.

MANAGEMENT TIPS

1. Educate everyone on how you would like things planted, even if they say that they understand, still show them the steps. I found that although people told me they had experience, some plants were planted way too low and others too high.
2. Lay all potted plants out in the design that you want them when working with a large group of volunteers for planting.
3. Do a weekly walk through of the site without tools in your hand. This helped me to notice things that weren't working, catch pests or diseases at the start, and time to enjoy my work.
4. Purchase a scale for each site, so volunteers can weigh and record everything immediately, so no data gets lost.
5. Have fun garden signage to educate and list garden hours for safety.
6. Encourage volunteer help by posting when you'll be there and letting people know they can take home fresh produce after.
7. I know this won't pertain to everyone, but I like to give gifts of gratitude to the people who help me. It doesn't have to be expensive. It could be a simple thank you card, some flowers, a little chocolate treat (this is a favorite), or a cold lemonade on a hot day. It goes a long way.

COOPERATORS

Dr. Nic Jelinski, University of Minnesota, St. Paul, MN

Kat LaBine, University of Minnesota, St. Paul, MN

Jennifer Nicklay, University of Minnesota, St. Paul, MN

Jim Doten, Environmental Services, City of Minneapolis, Minneapolis, MN

Eliza Schell, Minneapolis Health Department, Minneapolis, MN

A box of CSA produce.

PROJECT LOCATION

Chicago Avenue runs north to south from the downtown area. This site is about 2 miles south from the heart of downtown Minneapolis. It is 0.4 miles from the Waite House, our main community center.

OTHER RESOURCES

Bradley, Fern Marshall. Find it fast: Answers for your vegetable garden.

Farmer to farmer podcast.com: Interviews of farmers and their processes.

Jacke, Dave, and Eric Toensmeier. Edible forest gardens. Volumes 1 and 2.

Kimmerer, Robin Wall. Braiding sweetgrass.

Kujawski, Jennifer. The Week-by-week vegetable gardener's handbook: make the most of your growing season.

Minnesota Horticultural Society. Roseville, MN.

Permaculture Institute. https://permaculture.org.

Urbanfarm.org: podcasts from all types of farmers.

Economic Feasibility of Spray Foam Insulation in a Hog Finishing Barn

PRINCIPAL INVESTIGATOR

Jordan Vandeputte
J_vandeputte_06@hotmail.com
507-829-0130

Vande Ag Enterprises
Ryan Vandendriessche
rv.channel@gmail.com
507-530-7601
2355 County Road 9
Marshall, MN 56258
Lyon County

PROJECT DURATION

2017 to 2019

AWARD AMOUNT

$7,909

STAFF CONTACT

Kevin Hennessy

KEYWORDS

energy, insulation, hog finishing barn, spray foam

PROJECT SUMMARY

When we, Vande Ag Enterprises, decided to build a 4,800 head tunnel ventilated custom hog finishing barn, we wanted to incorporate the latest technology and add features that would make feeding pigs and the barn itself as efficient as possible. We looked at this building as a long-term way to transition our farms back into livestock production after many years of being out due to facility obsolescence and weak prices. As part of this determination for maximum efficiency, we started looking at ways to minimize the energy required to operate the barn. We knew propane usage would be a large portion of the energy and could potentially be one of our highest operating costs, especially during times of propane shortages and when the pigs are small and unable to generate enough body heat to keep the barn at a stable temperature. This is where we got the idea to insulate the barn with closed cell spray foam insulation instead of the traditional batt style insulation that is typically used in hog barns. We compared costs between the two types and naturally the spray foam insulation was substantially higher priced. From this, the question arose, “with the potential propane savings, will the added cost of the spray foam insulation pay for itself over the life of the barn?” We talked to barn contractors and searched the internet for research already done by other producers. We were unable to find much of anything so we decided to go for it and insulate with spray foam. We thought other hog producers and contractors may have some of the same questions we did, so we decided to make a project out of it and share our results.

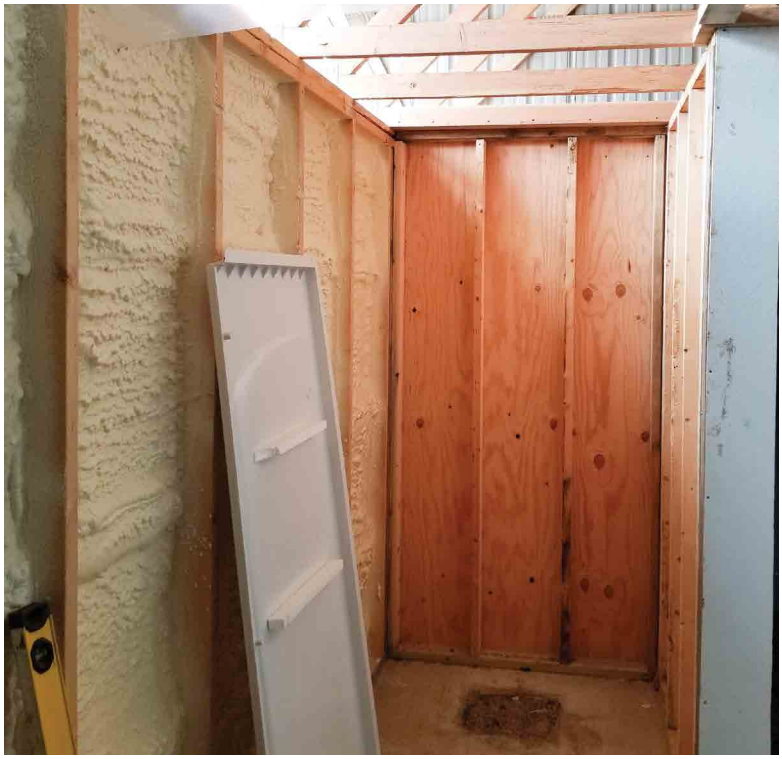
Hog finishing barn this past winter.

PROJECT DESCRIPTION

Vande Ag Enterprises consists of three young farmers from two families who grew up on livestock and crop production farms. Both farm families decided to abandon livestock production about 15 years ago because of low prices and facilities that required too much labor. Currently, the members of Vande Ag came back to their family farms after completing school and looked for ways to make their operations sustainable and diversified. Having grown up with livestock, and attractive rates for custom finishing hogs, the idea for a large hog finishing barn continually resurfaced. Also, all three members of the company currently have part-time off the farm jobs and would like to make agricultural production their sole source of income.

Construction of the 4,800 head facility began in early summer 2017 and was completed in late fall 2017.

This project compares the cost effectiveness of different materials used to insulate hog finishing barns. We chose to install closed cell spray foam insulation rather than the traditional batt style insulation. To do this, we will be comparing the propane usage of our spray foam insulated barn with two others similar to it insulated with batt style insulation. We will compare the propane usage of our spray foam insulated barn with two others similar to it but insulated with batt style insulation. The comparison barns are 2,400 head barns where ours is two 2,400 head barns put together, so the square footage of the actual pig space can easily be used as a comparison. The office and load out space is also the same. The ceiling and roof heights are the same. There will be very similar sized pigs in all barns during the same time period. This is important for the accuracy of the comparison since pigs give off a lot of body heat and, as they mature, less supplemental heat is needed to maintain the required temperature. Also, all the barns are using the same temperature curve, meaning that as the pigs get bigger and provide more body heat, the target temperature in the barn decreases. The barns are all located within a ten mile radius of each other, so it is presumed the ambient outside air temperature will be the same at each of the sites. Wind breaks are another factor to consider that could affect the results of the test. Each of the barns being tested is in the open with minimal trees or cover from the weather elements. Results of this will be calculated annually for three years to obtain the most accurate data possible. The final results will be divided by the added cost of the spray foam and multiplied over the expected useful life of the barn which we hope will be at least 40 years. Two questions to be answered are (a) is spray foam insulation a better product based on how it improves savings on propane, and (b) how many years will it take to pay back the investment with these savings?



Spray foam insulation in barn after installation.

The stud walls as well as the concrete stem walls were insulated with spray foam insulation. The batt insulation has an R-value of 19, while the spray foam insulation has an R-value of 21 so it is fairly obvious the spray foam will insulate better, but the question remains, "will it yield enough propane savings to recoup the added cost?" The cost to insulate the barn with batt insulation is $6,076 and the cost to insulate the barn with spray foam is $12,023.

Besides the potential energy cost savings, other benefits of an efficient barn include a smaller environmental footprint from fewer nonrenewable resources being consumed, and a contribution to a more positive overall outlook on the agriculture industry by showing the public our eco-friendly efforts. Some other benefits of spray foam insulation are that is has better longevity in that it won't settle over time or absorb moisture. It also creates an airtight seal over the building and provides superior coverage over batt style insulation. These factors also contribute to the performance of the insulation. Insulation is extremely important in winter months, but it is also beneficial in the summer. Insulation keeps the hot steel exterior of the building from radiating through to the inside air keeping the temperature lower.

2017 AND 2018 RESULTS

In the summer of 2017, the finishing barn was built and was completed in late fall 2017. We started recording propane use the day the pigs arrived on November 29, 2017. As can be seen in the charts below, Vande Ag's barn insulated with spray foam did use less propane per pig space than the two comparison barns which have batt insulation. (Pig space is simply the number of pigs the barn can hold when they are at market weight. Industry experts have done extensive research to determine the optimal balance of economic and productive space each pig needs to live. Today, barns with multiples of 2,400 pig spaces are very common. In the case of our barn and the comparison barns, no pigs were added or removed until reaching market weight). So far, the investment of spray foam insulation is proving to be worthwhile. If these trends continue, the added cost of the spray foam will pay for itself over time. Another year of collecting data will be needed to further confirm this theory. For our barn, using the spray foam, cost was about $6,000 more than the batt insulation would have been. Based on first-year results, the additional cost of the spray foam would be paid off in less than 7 years.

MANAGEMENT TIPS

1. We learned that by spray foaming the above ground concrete stem walls, they do not transfer the outside temperature to the inside. For example, on a very cold, winter day, one would expect the temperature of the inside of the concrete wall to be very cold to the touch because of concrete's heat transfer properties. Because of the spray foam on the outside, this is not the case. The inside of the wall nearly matches the inside air temperature when felt. This strengthened our confidence in our insulation choice.

TABLE 1. Annual propane usage.

	2017 - 2018 Gallons
Vande Ag Barn (spray foam)	5,124
Comparison Barn #1	2,680
Comparison Barn #2	2,873

TABLE 2. 2017-2018 propane costs per barn.

	Avg. Propane Price	Propane Used (Gallons)	Barn Capacity (Head)	Propane Cost/ Pig Space	Cost Difference/ Pig Space
Vande Ag Barn	$1.37	5,124	4,800	$1.46	
Comparison Barn #1	$1.37	2,680	2,400	$1.53	+$0.07
Comparison Barn #2	$1.37	2,873	2,400	$1.64	+$0.18

The spray foam can continue expanding for a period of time after it is applied so caution should be used when insulating around window and door openings. Also a day or more should be allowed between the foam application and covering the foam with plywood so warping doesn't occur.

2. Hog producers need to consider the expected useful life of today's barns. Most of the materials being used in barn construction are aluminum, stainless steel, and plastic vs. mostly steel in older barns, which would rust quickly. The contractors and barn equipment suppliers we talked to guess barns built today should last in excess of 40 years, as compared to 25 to 30 years for barns built years ago. This gives an extended period of time for extra investments such as spray foam insulation and the latest technology to pay for themselves. This was a major driving factor in many of our decisions.

COOPERATORS

Mike Boerboom, Boerboom Ag Resources, Marshall, MN

PROJECT LOCATION

From Marshall, MN: Go south on Highway 59, 1 mile to County Road 6, turn east (left) and go 3 miles to County Road 9, turn south (right), and go 1.5 miles. The barn is on the west side of the road.

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

PRINCIPAL INVESTIGATOR
Keith Hartmann
34333 641st Avenue
Gibbon, MN 55335
507-276-0573
Keith.hartmann88@gmail.com
Nicollet and Sibley Counties

PROJECT DURATION
2016 to 2018

AWARD AMOUNT
$12,500

STAFF CONTACT
Michael Greene

KEYWORDS
corn, cover crops, in-season nitrogen application, soil health, yield

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. My project addresses those concerns by inter-seeding cover crops into my corn fields.

Keith Hartmann pictured with inter-seeded rows.

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 the farmland 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 to break up compaction without the use of tillage.

PROJECT DESCRIPTION

I have a diverse farm that includes pasture finishing organic hogs; growing organic corn, field peas, and barley for feed followed by cover crops; and growing conventional corn and soybeans on the 320 acres

View of the back of the inter-seeder.

that I operate. In my part of the state, primary fall tillage is done on nearly 100 percent of the farmland to break up compaction and to increase water peculation. I want to use roots instead of iron.

Another driver leading me to extending root life in the soil was my experience growing up on an organic dairy farm. We grew corn, soybeans, wheat, and alfalfa in rotation. We always had roots growing in the soil with alfalfa and a plow-down seeded after wheat. When I returned home after college, I rented a farm right across the road from our home farm that had been conventionally farmed for many years. I immediately noticed a difference in the soil. It took much more horsepower to pull through that soil than it did the organic fields. The "ah-ha!" moment was when I realized the importance of keeping a living root in the soil longer and the affect living roots have on the soil properties. Looking back at the native prairies of Minnesota, there was always a living root growing. Cool season grasses, warm season grasses, legumes, brassicas, annuals, and perennials -- all flourished at different times of the year. We have lost the beneficial properties of the prairie soil with a corn and soybean rotation where we have only five months of living roots in the soil in a year. To reestablish those properties, I came up with seeding a mixture of plant types into my growing corn crop.

To accomplish this, in 2017, I seeded a mixture of annual ryegrass and radish into V6 stage corn on July 4 at a rate of 15 pounds per acre while applying a split nitrogen application of 60 pounds per acre. 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 have large taproots to break up compaction and recycle nutrients that are deep in the soil profile. I removed crimson clover, turnips and rapeseed that I had in my 2016 mix because they didn't perform well under the corn canopy or handle the residual herbicide. Removing those ineffective species lowered the seed cost per acre, allowing me to increase the seeding rate from 10 pounds per acre to 15 pounds per acre to maintain a seed cost of $15 per acre.

In 2018, I seeded a mixture of 13 pounds per acre annual ryegrass and 2 pounds per acre kale into V6 stage corn (June 30, 2018) for a total rate of 15 pounds per acre while applying a planned 60 pounds per acre split nitrogen application of Urea Ammonium Nitrate 28%. I chose those plant species because they each have a different root system with a different job. The annual ryegrass root system is fibrous to absorb nutrients and build soil structure. Kale has a medium taproot to penetrate compaction and recycle nutrients that are deep in the soil

profile. Kale will also live until 14°F so it offers more late-season growth potential. I removed the oilseed radish that I had in my 2017 mix because it didn't provide much root growth after corn harvest.

In 2016, I built an inter-seeder/nitrogen side-dress applicator using a Great Plains NP4000 toolbar with fertilizer coulters, 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 ¼ - ½ inch of soil on top of the seed followed by a firming wheel for optimum seed to soil contact. The machine worked well injecting a consistent nitrogen band and incorporated the cover crop seed to proper depth achieving an 85 percent cover crop establishment.

Yetter Magnum 10,000 fertilizer unit.

However, machine assembly offered some challenges which led me to the newly released in 2017 Yetter Magnum 10,000 fertilizer unit. It has a smooth blade and fertilizer tube that places the nitrogen 4 inches deep in the soil, trailed by a single shark tooth closing wheel, and finished with an 8 inch wide firming wheel to seal the nitrogen trench. This single unit achieved all of the goals that I was trying to accomplish with 2 units; nitrogen placement, soil incorporation, and firming. I was confident that I could achieve the same inter-seeding success with the Yetter Magnum 10,000 and simplify the assembly process increasing farmer adaptability. In 2017, I replaced the original injector fertilizer coulters and the Yetter Strip Fresheners with the Yetter Magnum 10,000 units. I positioned the seed tube to distribute the seed at the base of the firming wheel to ensure that the seed was only covered by ¼ - ½ inch of soil. I was able to achieve better depth control through varying soil conditions with the Magnum vs. the Strip Freshener. The Magnum also distributes a 12 inch wide band of cover crop seed. I continued to use this same set-up in 2018.

Through the season, I took measurements, samples and weights from my designated trial plot. The plot was three replicated strips of inter-seeded cover crop and three of no cover crop. Each strip was 1,080 feet long and 30 feet wide.

Herbicides applied to these strips are as follows:

- Pre-plant: Dimethenamid-P + Saflufenacil; and
- Post-emerge applied 11 days prior to inter-seeding: Glyphosate and 3 ounces Tembotrione.

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 per feet^2—an 85 percent stand establishment. The stand was primarily annual ryegrass, radishes, and rapeseed. The clover and turnips struggled under the shaded corn canopy.

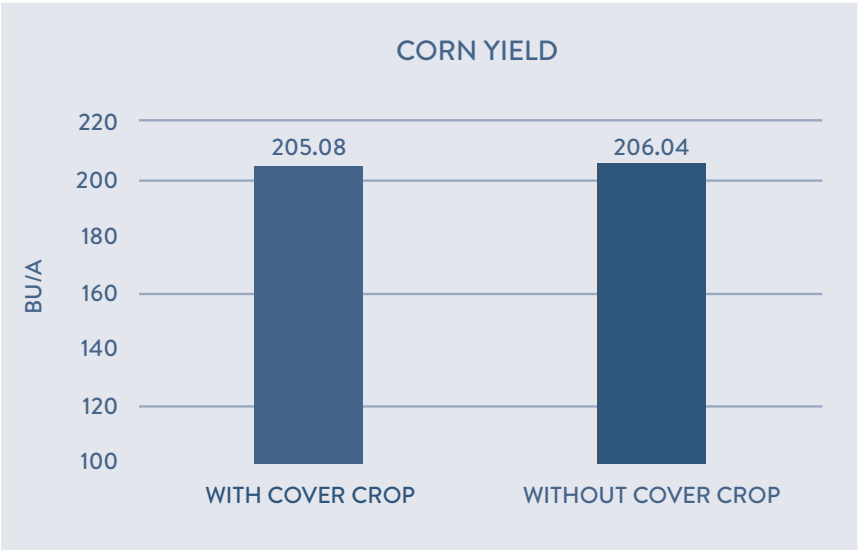
I took stalk nitrate samples from each of the six strips on October 6 when the corn reached physiological maturity (black layer). I compared the nitrogen content in the corn plants to see if the cover crop affected

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 milligrams per kilogram NO3-N. The three strips of control corn was 1,595 milligrams per kilogram NO3-N.

Although there is a difference of 384 milligrams per kilogram NO3-N, both cover cropped and control fell within the optimal range of 700-2,000 milligrams per kilogram NO3-N. I don't think this would 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 Table 1.

TABLE 1. 2016 corn yields by treatment type.



A difference of 0.96 bushels per acre 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 inches 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 parts per million NO3-N, while soil from strips without cover crops measured 5.33 parts per million 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 inches in the soil profile. A soil core of 24-36 inches would likely portray the soil nitrate levels more accurately. I will take deeper soil cores in 2017 and 2018.

2017 RESULTS

After seeding, there was no rain for 14 days causing slow, varied inter-seeding growth. At the same time, high temperatures accelerated the corn growth closing up the canopy when the partially emerged cover crop was only 2 inches tall. I was concerned that the stand would be thin. To my surprise, following the next rain, most of the remaining seed emerged under the canopy. This showed the resilience of annual ryegrass. The radish stand was reduced because of the fast corn canopy, but plants were still present.

On September 7, the cover crop stand was 42-46 plants per foot^2—an 85 percent stand establishment. The ratio of annual ryegrass to radish at the end was 90 to 10, respectively.

I took stalk nitrate samples on October 10 when the corn reached physiological maturity (black layer). I compared 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, ultimately affecting yield. A 15 stalk sample was taken from each of the six test strips. The average of the three strips of cover cropped corn came to 795 milligrams per kilogram NO3-N. The average of the three control strips was 414 milligrams per kilogram NO3-N.

Comparison of inter-seeded rows in 2016 and 2017.

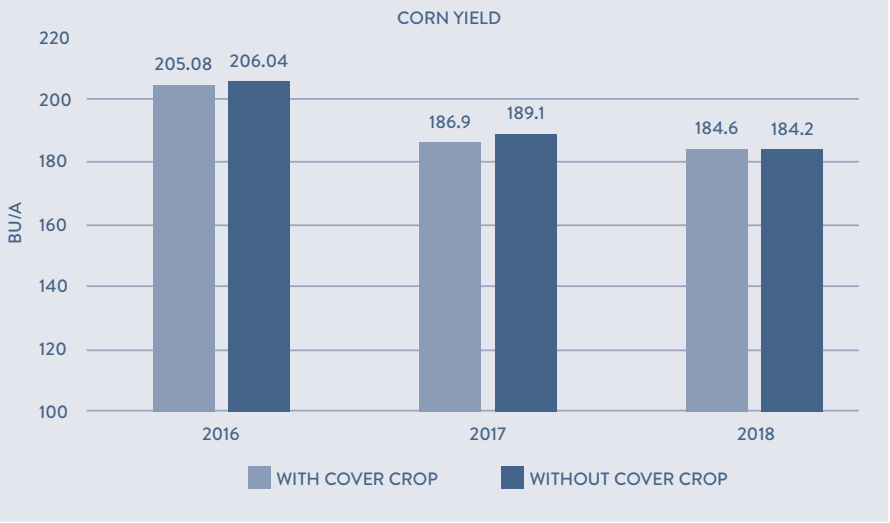
The range on the six test strips was extremely wide and variable. The variations didn't correlate with the different management practices. Other environmental and weather factors contributed to these varying results as sufficient nitrogen was applied to the corn crop. I do not believe that cover crop increased nitrogen availability to the corn as the results indicate.

On November 1, I harvested each test strip and weighed using a weigh wagon. The average yields of the three strips with cover crops and the three control strips from 2017 are compared to 2016's yields in Table 2.

Removing the clover, rapeseed, and turnips from the mix and increasing the seeding rate from 10 pounds per acre to 15 pounds per acre for even cost ($15 per acre) demonstrated a higher return on investment by increasing plant establishment, especially in less than ideal conditions. The cover crop remained 2-4 inches tall in a dormant state, as planned, until September when 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 8 inches until the first killing frost, after the corn was harvested on November 5. The cover crop growth was less in 2017 than 2016 due to the slow emergence and less vegetative growth of the cover crop prior to corn row closure.

A difference of 2.2 bushels per acre in 2017 is not statistically different in a trial of this size. The inter-seeded cover crop did not have an effect on corn grain yield. This is the second year that the inter-seeded cover crop has not been shown to compete with the corn crop. That is great to see and positive in advancing this practice.

TABLE 2. Corn yield results from all years by treatment type.



On November 21, I took 30 inch deep soil cores to measure soil nitrate content in the cover crop strips versus control strips to compare how much nitrogen the growing cover crops absorbed with their living roots. Soil from the cover cropped strips had 37.5 pounds nitrate, while soil from control strips measure 38.5 pounds nitrate. A difference of 1 pound is not statistically different.

2018 RESULTS

The experimental design was six replicated strips of both inter-seeded cover crop and no cover crop. Each strip was 1,285 feet long and 30 feet wide. Herbicides applied to these strips are as follows: Dimethenamid-P + Saflufenacil applied pre-plant; post-emerge Glyphosate and 3 ounces Tembotrione applied 10 days prior to inter-seeding.

With the persistent and heavy rains in June 2018, timely seeding was a challenge. My goal was to seed and to apply nitrogen around V4 corn growth stage; however, by the time an opportunity to get in the field arose, the corn was at V6. This meant less exposure to sunlight for the cover crop to achieve some growth before full corn canopy. On a positive note, soil moisture was abundant, allowing the inter-seeded cover crop to germinate in 3 days. The cover crop was able to achieve 6 inches of top growth before full canopy was reached. The cover crop remained 6 inches tall in a dormant state as planned until September when 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 inches until the first killing frost on November 8. The cover crop growth in 2018 was surprisingly greater than 2017 and 2016. I believe this was due to the abundance of moisture throughout the growing season as well as a fine-tuned seed mix that performed well under the corn's canopy.

In mid-September, the cover crop stand was 55-60 plants per feet^2, around 85 percent stand establishment. I took stalk nitrate samples to see if the presence of a cover crop affected the nitrogen content in the corn plant which could affect yield. The average of the three strips of cover cropped corn came to 348 milligrams per kilogram NO3-N. The average of the three control strips was 428 milligrams per kilogram NO3-N. Due to the high amount of moisture during the growing season, most of the stalk samples had a significant amount of stalk rot, making the samples extremely variable. According to the results, both the inter-seeded cover crop and no cover crop strips tested "marginal" in their nitrogen content. This test has been widely variable during the 3 year trial and hasn't had a strong correlation to yield for determining the effect of the inter-seeded cover crop.

Corn was harvested on October 7. The average of the three strips of cover cropped corn was 184.6 bushels per acre. The average of the three control strips was 184.2 bushels per acre. A difference of 0.4 bushels per acre is not statically different in a trial of this size. The average yields each year are shown in Table 2. The inter-seeded cover crop did not influence the corn grain yield. In all three years of this replicated research, the inter-seeded cover crop has not appeared to compete with the corn crop. That is great to see and positive in advancing this practice.

Inter-seeded cover crop after 2018 corn harvest.

Inter-seeded rows in 2018.

On November 8, I took 24 inch deep soil cores to measure soil nitrate content in the cover crop strips versus control strips to compare how much nitrogen the growing cover crops absorbed with their living roots. Soil from the cover cropped strips had 29 pounds nitrate, while soil from control strips measure 45.9 pounds nitrate. This year's test showed the most consistent and exciting results due in part to the excellent fall growth of the cover crop. A difference of 16.9 pounds per acre shows that the cover crop had absorbed that excess nitrogen and was holding it in plant form.

On November 14, I took a cover crop biomass sample in 1 square foot to measure pounds of dry matter produced per acre. I estimated biomass production of 3,296 pounds per acre. This was the most biomass produced through the three years of the project. It correlates well with the amount of nitrate absorbed by the cover crop.

MANAGEMENT TIPS

1. Seed earlier rather than later. Target V4-V5 corn to inter-seed. This allows the cover crop time to establish and put on some vegetative growth before row closure. This will directly impact the fall growth. From past experiences, I don't think the earlier seeding will increase the cover crop competition with the corn. The lack of sunlight after row closure will still slow the more advanced cover crop growth.
2. Use caution with residual herbicides. Most of the chemical labels do not include an inter-seeding cover crop recommendation. How certain herbicides affect emergence will be dependent 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!
3. Seed depth is very important. Small seeded grasses, legumes, and brassicas recommend only ¼ - ½ inch of soil cover. Err on the shallow side, not deeper.

COOPERATORS

Nate Firle, Certified Crop Advisor, AgRevival, Gibbon, MN

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

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

PROJECT LOCATION

5 miles south of Gibbon, MN on County Road 2.

OTHER RESOURCES

Dr. Scott Wells, University of Minnesota, Department of Agronomy and Plant Genetics. Inter-seeding research. agronomy.cfans.umn.edu

Dr. Abbey Wick, North Dakota State University, Soil Science Department. Soil health and cover crop research. www.ndsu.edu

Penn State University. Cover crop inter-seeding research. extension.psu.edu

Saddle Butte Ag. saddlebutte.com

Using Precision Ag Data to Maximize Economic and Environmental Benefits

PRINCIPAL INVESTIGATOR

Tanner Bruse – Ag and Conservation Programs Manager (MN)
Pheasants Forever
605 W Railroad Street
Lynd, MN 56157
507-865-1163
tbruse@pheasantsforever.org

PROJECT DURATION

2017 to 2019

AWARD AMOUNT

$25,000

STAFF CONTACT

Michael Greene

KEYWORDS

conservation practices, management zones, precision ag, working lands

PROJECT SUMMARY

Recent advancements in ag technology provide new opportunities for farmers to evaluate the performance and profitability of individual acres and examine alternative land use options on underperforming acres to increase both economic and conservation benefits. This project will work with a group of farmers, using Profit Zone Manager™, to identify revenue negative zones and to evaluate financial impacts of changes in practices before implementing them. In addition to considering existing USDA conservation programs, we will provide alternatives to farmers who may be interested in doing something but are not interested in a 10 to 15 year CRP contract.

PROJECT DESCRIPTION

Recent advancements in ag technology, including precision ag practices and software, have created new opportunities for farmers to examine ways to provide environmental benefits while maintaining or increasing profitability on their farms. This new level of data collection has revealed that 3 to 15 percent of cropped acres do not return a profit, that is, revenue negative acres. There is huge potential in examining opportunities to adopt alternative practices for these revenue negative acres that combine conservation and increased profitability. In the past, there has been little consideration of the economic performance of conservation practices when working with farmers to enroll these acres in federal or state programs or examples of how conservation and production agriculture can complement one another and generate income.

BJ Werk, Precision Ag and Conservation Specialist, presents to a group of farmers, ag professionals and conservation professionals on the benefits of acre by acre analysis and implementing voluntary conservation on revenue negative acres.

To demonstrate the power of this new technology and its potential, this project will use a precision platform, Profit Zone Manager™, to incorporate farm technology with business planning principles with up to 12 farmers. A focus on profitability, as return on investment, will provide these farmers with economic outcomes, acre by acre, to identify revenue negative management zones and alternative practices that combine conservation and more profitable production.

The objectives of this project are:

1. Using precision business planning, identify revenue negative acres at the subfield area to provide farmers with alternative land use options to increase their return on investment.
2. Build scenarios where farmers can evaluate the financial impact of alternative practices before implementing them.
3. Provide farmers with a working lands alternative, beyond existing conservation programs, that are less restrictive with shorter contracts. This new program would increase both economic performance and natural resource benefits.

Farmer partners will be identified and receive a subscription to Profit Zone Manager™. Pheasants Forever precision ag and conservation specialists will work with the farmer and their trusted advisors to find out the goals for their operations and gather detailed information on their current practices and historic yields. Farmers will choose an operation budget template (established from University of Minnesota data) or create a personal custom budget from actual operational expenses. For each farm, our Pheasants Forever's precision ag specialist will identify the typical three zones found on all farms:

- the revenue zone which is generally 60 to 90 percent of the operation, usually with the best soils, where it makes sense to intensify management and direct working capital (highest yielding acres);
- the expense limited zone which is generally 10 to 30 percent of the operation where yield fluctuates dramatically year to year; and
- the no cost zone which is generally 3 to 15 percent of the operation, also referred to as the revenue negative zone, where uncontrollable variability leads to a negative return year after year.

Scenarios incorporating alternative working lands management and practices such as existing federal, state, and local programs, planting small grain or forage, establishing or renovating pasture, and introducing cover crops with income potential will be developed for possible implementation on the expense limited and no cost zones of each farm. In addition, on the expense limited zones, opportunities exist to work with the farmer's trusted ag advisor to identify agronomic practices to increase profitability. The scenarios will be evaluated for each management zone for economic return on investment.

The working lands program under development will provide each farmer with a seed mix of quick establishing species and offer 3 to 5 year contracts with an upfront rental payment of half the current CRP enrollment rate for their county. Farmers can hay or graze the site after primary nesting season and drive through these areas while planting and harvesting.

After precision ag and conservation analysis, the farmer diversified their rotation of these 17 acres (with negative revenue) by planting wheat instead of corn to increase return on investment and profitability.

2017 RESULTS

The first year of this project included hiring a precision ag and conservation specialist, spreading the word about the project, and building relationships with farmers, ag retailers, consultants, agronomists, and conservation organizations. We enrolled seven farmers in the program and they are analyzing their 2017 harvest data (in addition to previous years harvest data), beginning the business planning process, and developing management scenarios for implementation in 2018.

We built alternative management scenarios (conservation practices, increased crop rotation, and forage production) for each management zone focused on increasing profitability and environmental benefits. We've analyzed some of the data from farmer partners' revenue negative acres and estimated the potential of alternative management scenarios to increase profitability (Table 1). Of the farms analyzed, the average percent of acres that are revenue negative is just above 30 percent. The profit increase from implementation of the recommended scenarios was projected at $41.48 per acre. Farmers are considering the options recommended for their farms and will make decisions on implementation for the 2018 growing season.

TABLE 1. Program summary for 2017 including data from the seven initial farmer cooperators.

Category	Average Value
Number of negative revenue fields	9
Total acres with negative revenue	844
Percent unprofitable acres	31.20%
Current return on investment	$70,109.34
Estimated return on investment (after change in management practices)	$86,295.84
Estimated increase in return on investment per acre	$41.48

2018 RESULTS

Pheasants Forever hired a new Precision Ag & Conservation Specialist, B. J. Werk, to be the second specialist in Minnesota. The goal was to have two specialists, but the original specialist departed late in 2018. The biggest highlight for the project in 2018 was entering into an agreement with the agriculture consulting company, CENTROL Crop Consulting, to work with their clients to run a Veris Sensor Cart across five farmers' fields (total of 1,000 acres) to collect electrical conductivity soil data. This will include involvement from five consultants as well as coordination with our specialist and farmers. The agreement allows us to take soil characteristics, historical yield data, and profitability into consideration when making management and conservation options. After data analysis, the specialist can meet with farmers and make recommendations regarding conservation and farm profitability that match the farmers' objectives.

The number of farmers and acres involved in this project has increased substantially in the project's second year (Table 2). Farmers implemented conservation practices including, but not limited to, Environmental Quality Incentives Program (EQIP) contracts, Conservation Reserve Program contracts, and alfalfa and cover crop plantings. To date, Veris has been run over 1,000 acres, data has been collected and is currently being analyzed with historical yield. From this, profitability on separate zones will help guide farmer agronomic and conservation decisions. Meetings with consultants, our specialist, and farmers are planned for February 2019. So far, the biggest hurdle to putting conservation plans in place is the availability of Farm Bill programs. That should change as the new Farm Bill takes effect.

TABLE 2. Program summary for 2018.	
Category	Value
Number of farmers involved	42
Number of Profit Zone Manager™ subscriptions	15
Number of MN counties	16
Number of financial partnerships	8
Total number of partners	51
Acres analyzed using Profit Zone Manager™	21,651
Of analyzed acres, number of revenue negative acres	4,565
Acres offered for submission into a conservation program	212
Acres waiting acceptance into a conservation program	131
Acres implemented into conservation by farmer	418.8

MANAGEMENT TIPS

1. Because of the intense labor, preparation, and weather dependence in farming, there are short windows of opportunity to work one-on-one with farmers and their trusted advisors.
2. Change doesn't happen overnight. A discussion regarding management decisions or alternative options may not be implemented immediately and may take several growing seasons before implementation.

COOPERATORS

We currently have 42 farmer cooperators located in 16 Minnesota counties.

EFC Systems (Brentwood, TN) Previously AgSolver with an office still open in Ames, IA

CENTROL Crop Consulting, Marshall, MN

PROJECT LOCATION

Contact Tanner Bruse for location information.

OTHER RESOURCES

pheasantsforever.org/Newsroom/2017-December/Harvest-More-Buck$-and-Birds-Precision-Ag-Workshop.aspx

todaysfarmermagazine.com/mag/1498-borders-in-order

www.efcsystems.com/index.php/agronomicplanningandsustainability/

www.farmprogress.com/crops/turning-red-acres-green-pheasants-forever

www.farmprogress.com/data/cull-unprofitable-land

Agrophenology Project

PRINCIPAL INVESTIGATOR

David Abazs
Wolf Ridge Environmental Learning Center
6282 Cranberry Road
Finland, MN 55603
218-353-7414
abazs@round-river.com
Lake County

PROJECT DURATION

2018 to 2020

AWARD AMOUNT

$15,525.20

STAFF CONTACT

Michael Greene

KEYWORDS

nature-based planting calendar, phenology, wild indicator plant species

PROJECT SUMMARY

Using a standard calendar to determine when we plant our crops has become less reliable due to more variable and extreme weather patterns. Choosing planting times has always been difficult, but in today's climate the risks are greater. Instead of using the standard calendar to determine the best times to plant our crops, we are combining agriculture with phenology (the scientific study of the timing of nature) to create a more useful planting guide. We are identifying the best wild indicator species that could provide us with a natural assessment of the growing conditions. We are experimenting with crop plantings as they relate to wild indicator species timing to create a nature-based planting calendar that can be more reliable than the standard calendar we use today and possibly provide increased crop productivity. This research project is called Agrophenology.

PROJECT DESCRIPTION

This project's research objectives are:

- to identify and evaluate plant, insect, mammal, and migratory animal species to determine their reliability in providing a planting calendar for domestic crops. We are assessing whether this natural timing can provide a better gauge for when to plant crops for maximum plant health and growth in both field and greenhouse settings;

Planting the test plots.

- to develop an agrophenological calendar for our region that will serve as a more reliable planting guide for growers; and
- to develop an agrophenology methodology, with downloadable phenology observation sheets and crop record-keeping documents that growers can use to assess their unique conditions and individualize their own nature-based planting calendar. We will address this objective in our final year.

For our first year, we established the research protocols for identifying and choosing phenological indicators and their appropriate phenophase (the observable start and end point of a plant or animal life cycle). For example, one indicator could be the period over which open flowers are present on a plant. In looking at the different phenological indicators, we determined the 22 best indicator species to use in this calendar. We initially proposed choosing 10 standard Minnesota species of insects, plants, and animals that could be used throughout the state, but realized that we needed to broaden our diversity and numbers to provide for a more comprehensive timeline to better determine crop planting dates. We chose mostly domestic and wild plants indicators but also included a frog, some birds, and an insect (Table 1). The list will change slightly as we learn more from our research.

We chose these indicators because:

- they cover most of the typical planting time period in our northern summers;
- they are more likely to be seen or heard on or near our farms;
- they do not mimic the calendar, i.e. some species arrive the same day every year regardless of environmental conditions; and
- they do not exhibit radical time swings and inconsistences, i.e. the American Crow was removed from consideration because it returns to our region over a three-month period with no connections at all to the environmental conditions.

TABLE 1. Twenty-two indicator species, 2018.		
Month	Date	Phenological Indicator
March	13-Mar-18	Sugar Maple - first sap flow
	19-Mar-18	Robin - first sighting
April	8-Apr-18	Speckled Alder - first catkins fully expanded
	11-Apr-18	Beaked Hazelnut - first pollen or red stigma
	12-Apr-18	Rhubarb - first leaves emerge
	21-Apr-18	Trembling Aspen - first catkins fully expanded
	23-Apr-18	White Throated Sparrow - first song
	26-Apr-18	Dandelion - first flower
May	1-May-18	Chorus Frog - first song
	9-May-18	Common Strawberry - first flower
	10-May-18	Oven Bird
	19-May-18	June Berry - first flower
June	1-Jun-18	Common Lilac - first flower
	12-Jun-18	Orange Hawkweed - first flower
	14-Jun-18	Spittle Bug - first larva
	21-Jun-18	Raspberry - first flower
July	15-Jul-18	Fire Weed - first flower
	16-Jul-18	Black Eyed Susan - first flower
September	24-Sep-18	Snow Bunting - first fall migration flock seen
October	3-Oct-18	Temp - first max temp <32°F
	8-Oct-18	Paper Birch - first tree bare from leaves
	13-Oct-18	Snowshoe Hare - feet all white

This year we also collected physical observations and data on indicator species including timing, minimum and maximum temperatures, light, precipitation, and soil temperature at 7 inch and 17 inch depths. We also looked at GDD/50 (Growing Degree Day above 50 degrees Farhenheit) and GDD/32 (Growing Degree Day above 32 degrees Farhenheit) since a significant portion of our northern growing season is below the GDD/50 and many of our crops respond to conditions below 50 degrees Farhenheit.

We also identified the crop-specific weekly assessment parameters including soil temperature, percent plant survival, average length growth, percent flowering, percent fruiting, percent mature fruit, percent pest or disease damage, and production. Due to the variation and nature of the crops, not all these parameters will be used. For example, some crops are vegetative in nature (basil), roots (carrots), tubers (potatoes), or fruit (tomatoes). Each will have different observational consideration. We will observe a variety of crop species in the field and greenhouse this season to determine a final list of crops to study.

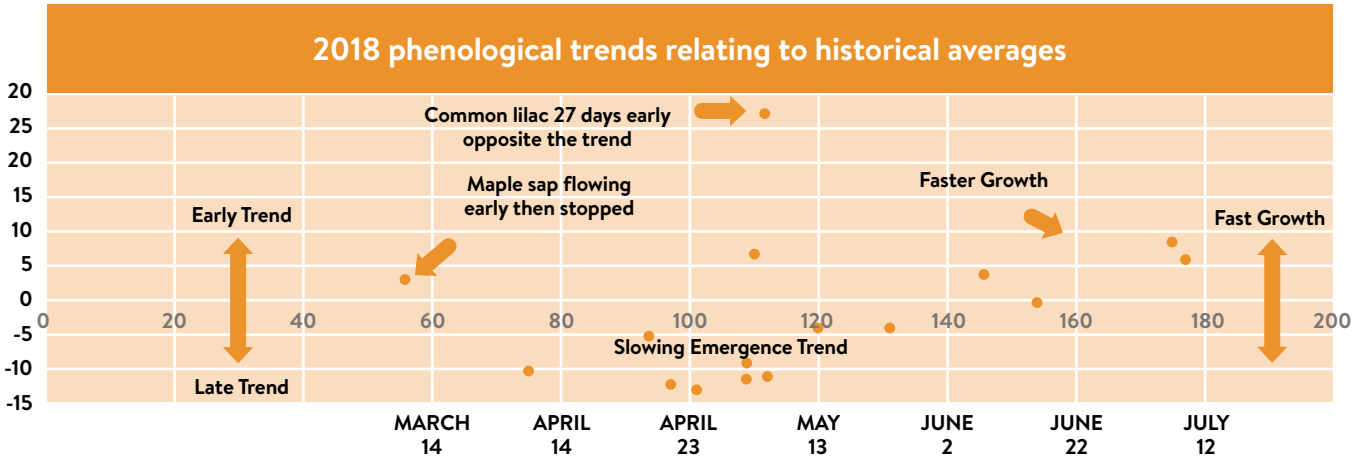
By looking for correlations between our agrophenological observations with crop health and production, we should be able to develop a reliable planting calendar. For now, our farming operations will plant exactly what we always plant, but the timing of the plantings will be adjusted as we connect the planting schedule to phenological indicators.

During the 2019 planting season, we will do a sequence of plantings in the hoop houses and high tunnel greenhouses including peas, cucumbers, carrots, tomatoes, and basil. We will also plant peas, beans, summer squash, pumpkins, carrots, and potatoes in outside fields. In 2019, we will complete the garlic sequenced planting which we will evaluate after the 2020 harvest. Typically, the sequenced plantings will mean that we will do three plantings, each two weeks apart to assess plant health, growth, and production of the different plantings. This information will be used to best match that crop to the related phenological indicator(s).

RESULTS

As we observed and studied the possible phenological indicator species to determine which ones we should use in our study, we realized that many of the migratory birds would not be useful indicators, since their "first sightings" in our location were either drastically variable or too precise. For example, the American Crow may show up in January one year and the end of March another year, regardless of any measurable change in seasonal conditions. At the other extreme, hummingbirds are known to arrive in our area on the exact same day every year, basing their migration on day length or star patterns and providing no better insight than using the current calendar.

We ran multiple graphing assessments trying to connect indicators to the physical data points of light, temperature, GDD/50, and GDD/32 but we found no scientifically significant correlations. The lack of correlation is disconcerting but holds promise that the phenological variability may be beyond the understanding and scope of the physical parameters, making the indicator species truly unique. For example, if the indicator species mimicked the temperatures then we might as well just use temperatures to determine planting times. The fact that they do not match the temperature trends may actually reveal the hidden secrets that indicator plants "use" to determine when to emerge, send out flowers or leaves. This "uniqueness" aspect may be the way the agrophenological planting calendar can help us in this time of changing climate. The 22 chosen indicators provide us with broad enough diversity and timing to produce significant and reliable data for the study goals and provide a better chance to see clear results as our research progresses.



In this graph, the phenological indicator of maple sap flow started three days earlier than average but stopped due to subsequent changing conditions. During the next few weeks, the indicators emerged later than normal with the delays in the first sighting of robins, rhubarb first leaves, speckled alder first catkins fully expanding, beaked hazelnut first pollen, the first song of the white throated sparrow, and chorus frog first songs, and the later than normal first flowers of the dandelion, common strawberry, and Juneberry. This overwhelming slowing of spring was countered by the faster than normal emergence of the first oven bird song and an incredible 27 day early emergence of the common lilac. What's going on there? As the growing season moved into June and July, we saw a shift to earlier than normal arrivals of the first flowers of the orange hawkweed, black-eyed Susan and fire weed. The spittle bug's first larva emerged exactly on the same day as the historical average.

Lise planting the final garlic in the test plots.

Garlic test plots planted in sequence.

This graph will be reevaluated and compared to the next two years of observations to see which indicators might help inform our planting cycles. The work, data collection and observations that we accomplished this year will provide the baseline for comparison in the years to come.

Based on the results of this season's greenhouse and field observations on both farms, we finalized which crops to study and which parameters we plan to use to assess that crop relative to the timing of its planting. These include five crops that are direct seeded – beans, carrots, garlic (cloves), peas, and potatoes (tubers) – and five crops that are transplanted – basil, cucumbers, pumpkins, summer squash and tomatoes. For the next two seasons, each of these crops will have multiple plantings, one when we typically would plant them and other plantings before and after. We will then compare each planting with the phenological indicator data to determine the best time to plant them in the future for the optimal results.

We started the experiment with garlic this fall. Our assumption going into this crop assessment is that we should plant garlic when the feet of the snowshoe hare turn white in the fall. To assess this, we planted identical plots of German and Krasnodar garlic at three different intervals. One set of plots was planted September 20, 2018, a month earlier than typical, another set around the "normal" time of October 18, 2018, and the final set right before the ground froze on November 4, 2018. We will observe the differences in crop performance during the 2019 growing season.

We had technical challenges with the temperature capturing buttons and computer interface this year. I am thinking we should go "old school" and use min/max temperature gauges so that, once a week, we can have these correlating numbers to compare the two farms' locations with the main data collection site to recognize site specific differences between the locations.

MANAGEMENT TIPS

1. Use the appropriate technology for gathering your research observations and data. Sometimes you can over-engineer and sometimes you can under-engineer your collection process.
2. Develop reasonable routines, daily and/or weekly, that afford you the time to walk your land to observe what is going on around you and allow you to take the time to record and assess your data.
3. Be patient. Try not to jump to conclusions based on initial observations and perceived trends. Use the gift of time in the winter hours for data assessment to reveal the real trends, (or no trends) that provide you with a greater understanding of what is really happening. You may have been correct with your initial thoughts, but as our work this past year showed, sometimes what looks significant is not actually statistically meaningful. This patience can be helpful over several years to further reveal or confirm your findings.

COOPERATORS

Lise Abazs, Farmer, Round River Farm, Finland, MN

Peter Harris, Science Instructor, Wolf Ridge ELC, Finland, MN

Rod Kuehn, Prairie Track, Ramsey, MN

Sam Anderson and Samantha Krueger, Antioch University/Wolf Ridge ELC, Finland, MN

Tori Dahl, Wolf Ridge Organic Farm, Finland, MN

Rebecca Montgomery, University of Minnesota, Department of Forest Resources, St. Paul, MN

Diane Booth, Minnesota Extension - Cook County, MN

PROJECT LOCATION

Drive North from Duluth on Highway 61. In Illgen City, turn left and take Highway 1 to Finland, MN. In Finland, take County Road 6 (Little Marais Road) 2.5 miles and you will see the sign on the right to Wolf Ridge. To visit the Wolf Ridge Organic Farm, turn right by the sign and take Cranberry Road 0.7 miles and turn into the farm driveway. To get to Round River Farm, stay on County Road 6 (Little Marais Road) and travel another 0.3 miles and bear right onto Nikolai Road. Take Nikolai Road 0.7 miles and you have reached the farm.

OTHER RESOURCES

Minnesota Phenology Network. Available at: https://mnpn.usanpn.org/

Phenology Resources on Wolf Ridge phenology webpage. Available at:
https://wolf-ridge.org/fall-phenology-setting-the-stage/

Cover Crop Effects on Soil Temperature and Soil Moisture

PRINCIPAL INVESTIGATOR

Jerry and Nancy Ackermann
39750 820th Street
Lakefield, MN 56150
507-662-5584
ackermann.jn@gmail.com
Jackson and Nobles Counties

PROJECT DURATION

2018 to 2020

AWARD AMOUNT

$19,078

STAFF CONTACT

Michael Greene

KEYWORDS

cover crops, soil moisture, soil temperature

PROJECT SUMMARY

Previous research has shown that cover crops can reduce erosion, decrease soil compaction, increase water infiltration to prevent runoff, bring leached nitrogen back to the root zone for the following year's crop, and increase organic matter. However, project partners are unaware of any first-hand data about cover crops effects on soil temperature and soil moisture for southwest Minnesota. Soil temperatures and soil moisture are very important for nutrient uptake for plants and plant growth. It is common for farmers to see flooding and drought conditions in the same growing season. This project will help determine if cover crops can improve infiltration during wet conditions and water holding capacity during drought conditions. Soil and tissue samples will also be collected to observe if cover crops can be a tool to help cash crops become more effective at nutrient uptake. With the cost of inputs increasing and water quality declining, this type of project will assist southwest Minnesota farmers in their farming operations and also help improve water quality in local streams.

Over the duration of this project, soil temperatures and soil moisture will be measured using soil probes. Weather stations will be placed on each plot to measure rainfall, humidity, and air temperatures. Infiltration tests, tissue samples, and soil samples will also be collected. The data collected will be used to provide a dataset with which to analyze the impact of cover crops on current farm management. In addition, project partners will work together to host a field day at the end of the grant period. This field day and project will create an educational opportunity for farmers interested in implementing cover crops in their farming operations and will provide first hand, measurable results in southwest Minnesota.

PROJECT DESCRIPTION

Jerry and Nancy Ackermann have been farming for 45 years and both are extremely active in on-farm research and test plots. The farm is 1,050 acres dedicated to a crop rotation of corn, soybeans, and alfalfa. For the past fifteen years, the landowners have incorporated 350 acres of no-till soybeans and 350 acres of strip till corn in the crop rotation. The alfalfa crop is a cash crop and is used in nutrient management for alfalfa-corn rotations.

Jerry and Nancy have partnered with multiple landowners, the Heron Lake Watershed District, Extended Ag Services, Inc., and University of Minnesota on research efforts. They have hosted numerous field days in the past five years. Project partners will continue to work together on this grant effort.

Kevin and Dana Schmid are fourth generation farmers and are currently in their 23rd year of farming. They have a corn and soybean rotation on 1,680 acres of cropland. Historically, they have used conventional tillage and have no-tilled soybeans from time to time. They also have a wean-to-finish swine operation consisting of three 1,100 head tunnel barns. These were built in 2005 and have allowed them to utilize manure as a fertilizer source in their operation. They are in their third year of studying cover crops on 20 acres at home and have added 54 more acres in the last two years.

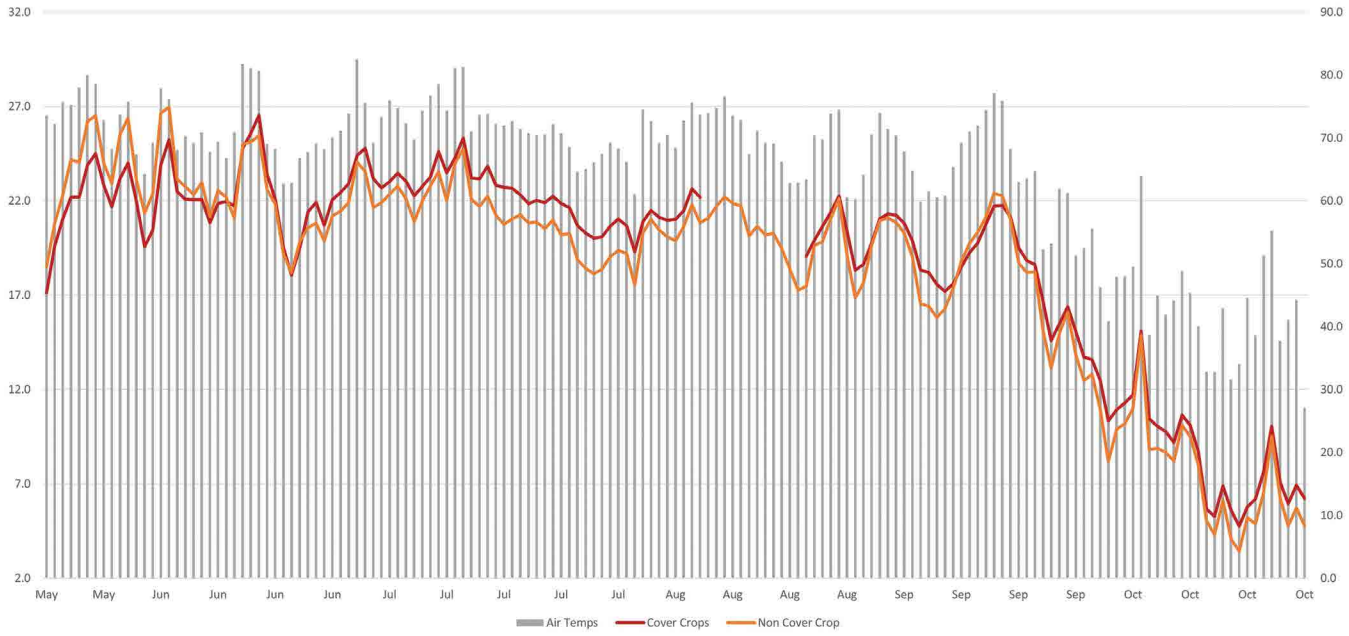
Bruce Leinen started farming with his father in 1987 and he now farms with his sons. One son farms with him full-time and the oldest son part-time. He currently farms 1,600 acres and grows corn, soybeans, and has started to incorporate some wheat. He has 150 head of cattle and nearly 400 ewes. He also sells feeder lambs and finished lambs.

All project cooperators and partners are looking for research data that shows how cover crops can affect soil moisture and soil temperature. Project partners are not aware of research regarding soil moisture and soil temperature in southwest Minnesota. The farmers in this area are looking for a way to better utilize their costly nutrient inputs and also protect our water resources. Weather variations are becoming more intense and southwest Minnesota farmers are looking for a way to protect their crops during flooding and drought conditions within the same growing season. The project will provide hands on data for southwest Minnesota. It will also provide a way to reach other farmers and share data with them through a field day.

RESULTS

Extended Ag Services, Inc. collected spring soil samples on May 30, 2018. The samples were sent to Minnesota Valley Testing Labs to be analyzed for pH, Organic Matter, Phosphorus, Zinc, and Potassium. Multiple soil samples were collected in each field plot to accurately demonstrate soil characteristics in each plot. These samples will be used to show any significant changes in the soil over the grant duration between cover crop versus a non-cover crop management.

Figure 1. Soil Temperatures in 4" Soil Depth in Cover Crop Strip Till (tilled row) versus Non-cover Crop Conventional Till Jackson County, MN



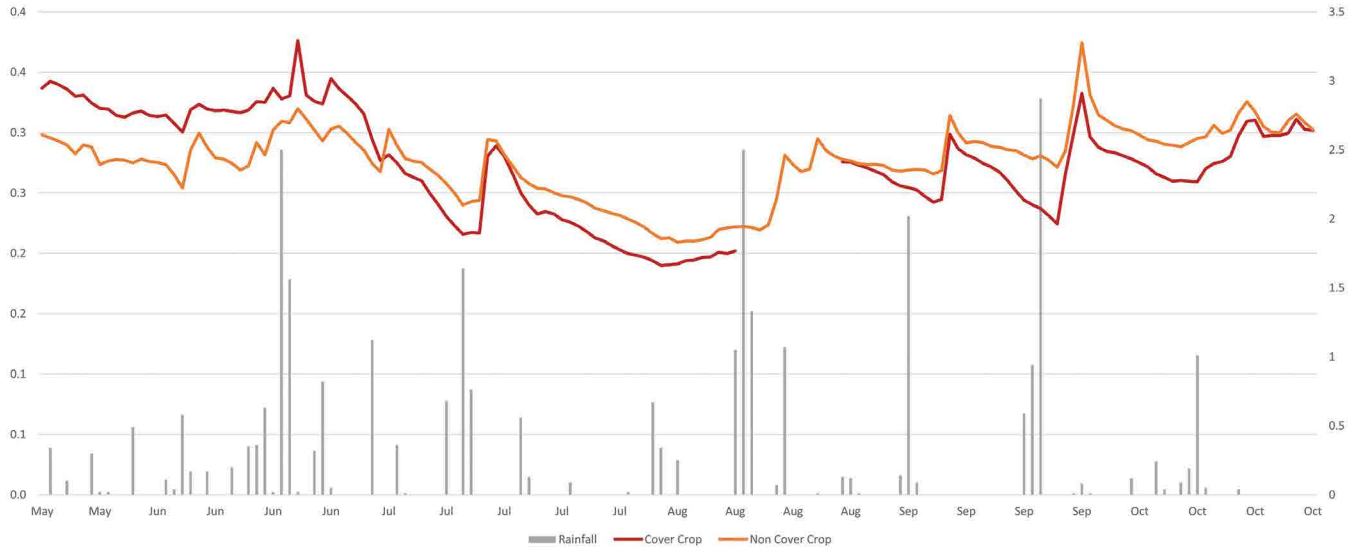
The Heron Lake Watershed District conducted infiltration tests following harvest. Since the Nobles County field was frozen following harvest, an infiltration test was only done on the Jackson County field plots. The cover crop field had three inches per hour and the non-cover crop field had less than one inch per hour. The results demonstrate that infiltration is better in the management system using a cover crop and strip till.

Soil temperatures and soil moisture were collected at all four test plots starting in late May 2018, following planting. Soil probes were placed in the ground at 4 inch and 8 inch depths. All soil readings were collected at 15 minute intervals. Rainfall and air temperature were also recorded at each test plot.

The 2018 Jackson County soil temperatures, on average, were cooler in the control field than the cover crop/ strip till field throughout the entire growing season (Figure 1). Over the entire growing season, there was more soil moisture in the conventional till/non-cover crop field versus the cover crop/strip till field. It was a very wet year for southwest Minnesota in 2018 and having a cover crop with strip till management showed to be a benefit throughout the wet growing season (Figure 2).

In the Nobles County test plots, tillage management is the same. The only difference is cover crop versus non-cover crop. The 2018 data showed the same amount of moisture early in the growing season and slightly more moisture in the cover crop field throughout the entire season (Figure 3). Temperatures were very similar in May and June, but the cover crop field showed a slightly cooler reading early in the growing season. Throughout the whole growing season, the non-cover crop field had warmer temperatures on average (Figure 4).

Figure 2. Soil Moisture in 4" Soil Depth in Cover Crop Strip Till (tilled row) versus Non-cover Crop Conventional Till Management Jackson County, MN



To conclude the first year, the data showed there were bigger differences associated with the tillage system when it came to soil moisture and soil temperatures than between cover crop and non-cover crop under the same tillage management. In the early growing season, readings showed that conventional tilled soils were warmer and drier. It was a very wet year in 2018, and this year's project showed that cover crops had less moisture, due to better infiltration throughout the entire growing season. For example, after a 1 ¾ inch rain, our moisture levels at 4 inch and 8 inch depths were the same. The comparison on the tilled field was the same at the 4 inch level, but at 8 inches it was significantly higher. This would indicate a hard pan just below tillage depth. Our soils from previous 1 hour water infiltration tests had shown we could handle 11 inches of rain in an hour without water standing on the surface. The cover crops have appeared to break up any hard pan from previous tillage. The non-cover crop/ conventional tilled field held on to rainfall and moisture longer and kept soil temperatures cooler than in the cover crop/strip till fields. All data will be used to compare the coming years. More data will show a clearer picture of what is happening in the soil profile.

Figure 3. Soil Moisture in Cover Crops versus Non-cover Crops
4" Soil Depth, Strip Till, Tilled Row
Nobles County, MN

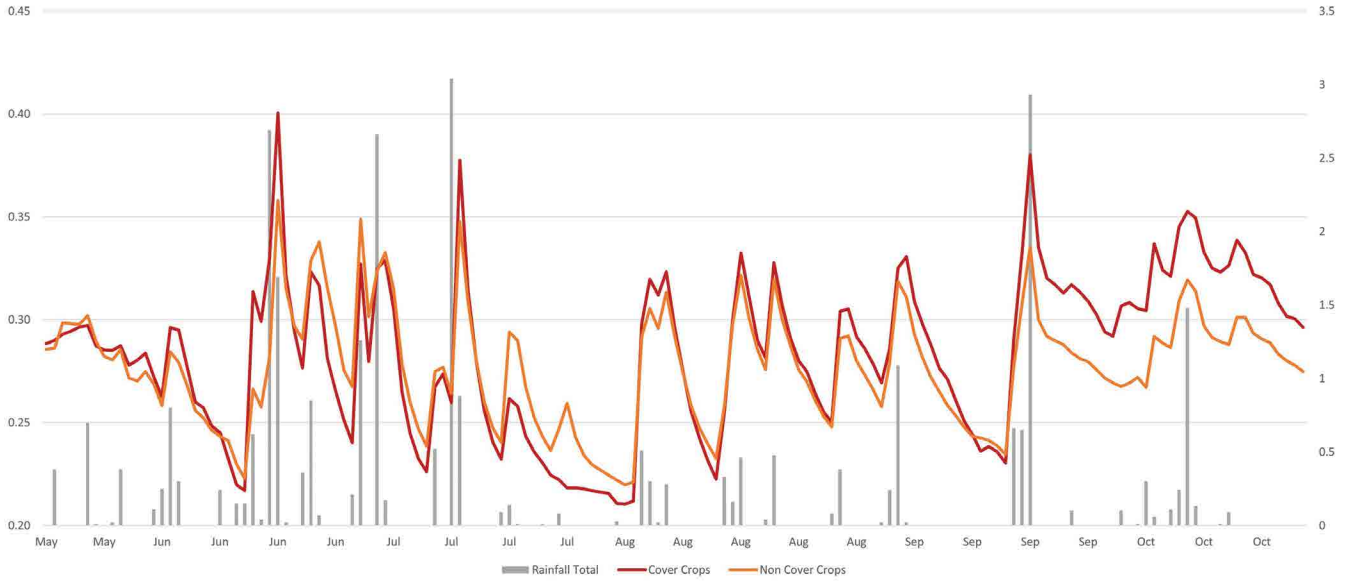
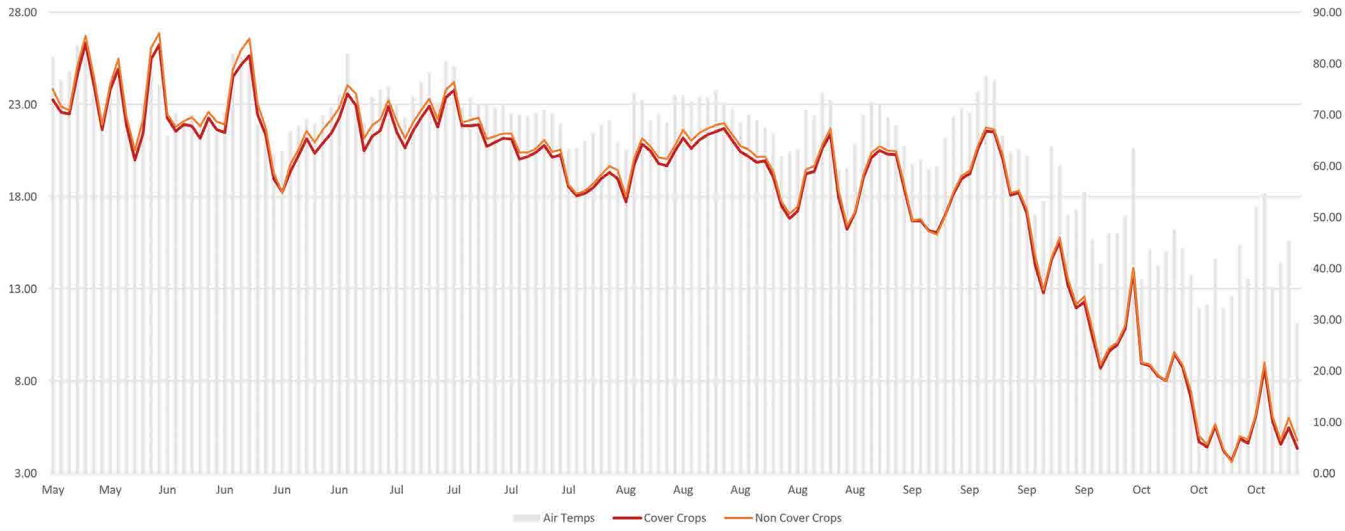


Figure 4. Soil Temperatures in Cover Crop versus Non-cover Crop
4" Soil Depth, Strip Till, Tilled Row
Nobles County, MN



MANAGEMENT TIPS

1. It would have been helpful to have a third moisture probe, at approximately the 24 inch level, to compare how much moisture is getting into deeper levels to be stored when conditions turn dry for the following crop to use.

2. The goal is to have people do as little tillage as possible. If strip till is implemented, in the farmer's mind, he is still doing tillage, even though it is just a small strip. Benefits can be seen within a year or two.

3. When seeding over the crops, it doesn't seem to matter if it is done aerially or by high clearance equipment as far as germination. Incorporation is better, but that has to be done with a drill or other seeding device after harvest. There generally isn't enough time after harvest for proper germination. Unless there is a cover crop that will overwinter, it would do very little to change anything in the soil.

4. Farmers can do their own infiltration tests. Place a 6 inch diameter ring (any metal or plastic pipe will work) in the soil about 3 inches deep. Place a piece of plastic wrap evenly over the top of the ring. Slowly pour 16 ounces of clean water into the ring on top of the plastic wrap. This will prevent the soil surface from being disturbed. Slowly remove the plastic and measure the time it takes for all the water to infiltrate. Repeat these steps for 1 hour. This will be the infiltration rate in inches per hour. The test should be done on a cover crop and a non-cover crop field for comparison. The infiltration tests are very eye-opening. In our experience, the infiltration rate in cover crop fields is much greater than in non-cover crop fields.

COOPERATORS

Kevin Schmid, Worthington, MN

Bruce Leinen, Fulda, MN

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

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

PROJECT LOCATION

Ackermann Farm: 5 ¼ miles west of Lakefield, Minnesota on Jackson County Highway 14 (820th Street) and ¼ mile north on the west side of the road.

Schmid Farm: 5 ¼ miles west of Lakefield, Minnesota on Jackson County Highway 14 (820th Street) and ¼ mile south on the west side of the road.

Leinen Farm: 3 miles south of Fulda, Minnesota on Highway 59, 1 ¼ miles west on Nobles County Highway 18 (120th Street), south side of road.

OTHER RESOURCES

Farmer Journal. The High Yield Conservation section. www.agweb.com/farmjournal

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

Sustainable Farming Network. Managing Cover Crops Profitably: Third Edition. Beltsville, MD 301-504-5236. www.sare.org/publications/covercrops/covercrops.pdf

Grazing Intermediate Wheatgrass (Kernza®) as a Dual-Use Crop for Forage and Grain Production

PRINCIPAL INVESTIGATOR

Alan Kraus
Conservation Program Manager
Cannon River Watershed Partnership
710 Division Street
Northfield, MN 55057
Rice County

PROJECT DURATION

2018 to 2021

AWARD AMOUNT

$24,965

STAFF CONTACT

Michael Greene

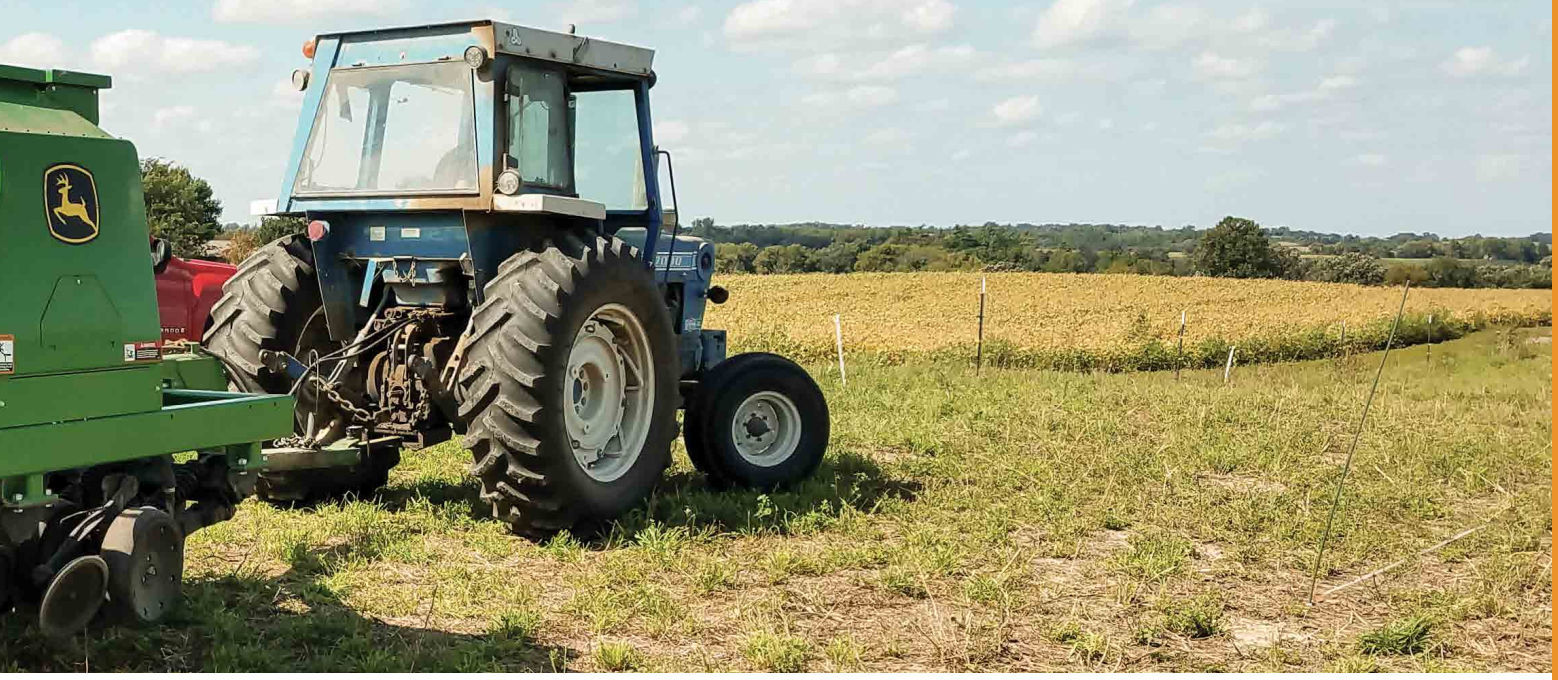
KEYWORDS

grazing, Kernza®, perennial, profitability

PROJECT SUMMARY

Many producers in the Cannon River Watershed have an interest in grazing Kernza® on their farms for biomass production and crop diversification. Through our research, we aim to provide information about forage biomass production and quality. Growers can use this information to make decisions regarding grazing on their fields. Ultimately, we would like to identify if grazing is beneficial or detrimental for subsequent grain yield of Kernza®. Growers need to understand the consequences of introducing grazing to the management of the crop before broadly adopting it.

By making data sets and enterprise budgets publicly available on the web, we give livestock managers and farmers information to use as they determine if they should integrate Kernza® into their operations. We will also help current growers to optimize their management strategies. The market for Kernza® is expected to grow with new end users like General Mills committing to incorporating Kernza® into their products. Dual-use of Kernza® for both grain and forage production could further increase the financial returns for Kernza® growers, encouraging adoption of a crop with potential to increase the productivity and sustainability of Minnesota cropping systems.



Planting Kernza with a no-till drill at Kaleb Anderson's farm, Goodhue County, September 2018.

Kernza seed provided by the University of Minnesota. Planted at Dan Honken's farm, Rice County, September 2018.

PROJECT DESCRIPTION

Minnesota crop and livestock growers are recognizing the need to adopt crops that provide ground cover year-round to mitigate soil erosion, nutrient losses, and water pollution. Further, livestock managers in Minnesota have expressed the need for alternative forages that provide biomass production in the fall to offset the cost of winter feeding and extend the grazing season. While still in the early stages of development, Kernza® has been grown for the past five years by several early adopters in the state of Minnesota, some of whom are managing over 50 acres for grain production.

This project will explore the viability of Kernza®'s dual-use for grain and forage production on two Minnesota farms. We will evaluate viability by measuring grain and forage yields and calculating returns using an enterprise budget. An enterprise budget is an estimate of the costs and returns to produce a product (enterprise). In addition, we will evaluate the effect of grazing on grain production and total returns by comparing results from the grazed and ungrazed portions of the fields. Altogether, on-farm estimates of grain yield, biomass yield, biomass forage quality, and estimates of financial return will serve as verified data to inform decisions of Minnesota growers considering Kernza® as an alternative crop.

2018 RESULTS

Kernza® was established in early September 2018 on 15 acres at two farms using a grain drill in a field with good residual soil fertility. Soil samples were collected throughout the fields to a depth of 24 inches and analyzed for nitrogen, phosphorus, and potassium content to track soil fertility status throughout the course of the study. U of M researcher, Dr. Mitchell Hunter, and CRWP Conservation Program Manager, Alan Kraus, assisted the growers at the time of planting. Grain drills were optimized to maximize establishment success by calibrating for proper depth and seed-to-soil contact. Kernza® emerged and accumulated biomass this fall. The crop will overwinter and begin to regrow during the spring of 2019. Stand counts were performed in October 2018, and they will be performed in the spring to evaluate establishment success on each field.

MANAGEMENT TIPS

1. Getting a good density of plants is important to getting the highest yields.
2. With Kernza® being so new to the area, it takes consultation with experts to ensure you are making the best management decisions.

COOPERATORS

The two farmer cooperators each provided land: Dan Honken, 9 acres; and Kaleb Anderson, 6 acres.

PROJECT LOCATION

Dan Honken Farm is located at 5680 - 120th Street West, Faribault, MN 55021. From Dundas, go west on Millersburg Boulevard, then south on Echo Avenue. Next, go west on 120th Street West, then South on Elmore Avenue. Field is on the west side of road.

Kaleb Anderson Farm at 12535 - 335th Street, Goodhue, MN 55027. From Cannon Falls, go south on Highway 52. Then, go east on County 1 Boulevard, then north on 335th Street. The field is on the east side of road.

OTHER RESOURCES

The University of Minnesota has been working with Kernza® for several years and is an excellent source for information about the crop. UMN contacts: Dr. Jake Jungers and Dr. Mitchell Hunter.

The Land Institute is the organization that brought Kernza® to market potential and is an excellent source for information. landinstitute.org

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

PRINCIPAL INVESTIGATOR
Melissa Geiszler
and Lauren Proulx
Minnesota Wheat Research and Promotion Council
2600 Wheat Drive
Red Lake Falls, MN 56750
218-253-4311 Ext 1
Polk County

PROJECT DURATION
2017 to 2020

AWARD AMOUNT
$17,536

STAFF CONTACT
Michael Greene

KEYWORDS
conservation tillage, hard red spring wheat, soil health, soybeans, vertical tillage

PROJECT SUMMARY

For the past 100 years, tillage in Northwest Minnesota has involved turning over the soil to create a black seedbed. This research will look at the difference between the conservation tillage method called vertical tillage and the more conventional chisel plow and cultivation as the primary fall tillage systems. The two tillage systems in a soybean and hard red spring wheat rotation will be compared for soil temperature, soil moisture, compaction, yield, and protein or oil content.

PROJECT DESCRIPTION

The predominant tillage system in Northwest Minnesota is turning over the soil using a chisel plow and cultivation to create a black seedbed. Conservation tillage systems such as vertical tillage reduce compaction, leave more residue over the winter, reduce erosion, and retain more moisture in the soil profile. However, because Northwest Minnesota has a shorter growing season, fewer frost-free periods, and cooler springs and falls, farmers are hesitant to adopt conservation tillage practices which can cause cooler soil conditions in the spring.

Vertical tillage is an option that is not as intensive as strip or no-till yet can still reduce erosion and improve soil health. It is a good practice to cut crop residue to manageable sizes, lightly incorporate residue, and break up any shallow compaction layers. A vertical tillage implement is pulled behind a tractor. It consists of straight, fluted discs set about 10-12 inches apart. The discs are followed by a section of harrows, then a set of rolling

Vertical tillage tool in action.

baskets. The implement cuts the residue, spreading it across the width of the machine. Then the rolling baskets crimp and cover the residue. The tool works from 1-5 inches below the soil, resulting in little soil disturbance.

Our two objectives for this research are:

1. To determine if vertical tillage for a soybean/hard red spring wheat rotation is economically viable compared with the conventional tillage practice in the region. We will measure tractor passes (fuel and time), yield, and protein/oil.

2. To quantify soil health factors for the two tillage systems including soil temperature, moisture, and compaction, as well as visible signs of erosion and water runoff.

This research is being conducted on 155 acres at Tim Dufault's farm near Gentilly, MN on the beach ridge of the Red River Valley. Wheat was planted and harvested in 2016. The field was divided into four plots. We worked the wheat stubble in two plots with a vertical tillage implement in September and October 2016. The other two plots were worked with a chisel plow twice in September and again in October. All four plots were cultivated and then seeded with soybeans in Spring 2017. Data on crop yield, grain test weight and percent moisture, soil temperature and moisture in the spring, and plant population were collected.

2017 RESULTS

The first year's soybean yield results showed little difference between the vertical tillage and conventional tillage plots (Table 1). Stand counts taken at the V3 growth stage showed an average of 10,000 fewer plants per acre in the vertical tillage plots. Soil temperature was an average of 0.5 degrees Farhenheit cooler in the vertical tillage plots than in the conventional tillage plots. There were only slight differences in soil moisture between the two treatments (Table 2). The average grain test weights were 0.366 pounds per bushel higher in the vertical tillage plots and the average grain moisture was even at 10.16 percent.

TABLE 1. Soybean yield in vertical tillage and conventional tillage plots, 2017.	
Tillage Practice	Yield* (bu/A)
Vertical Tillage	42.34
Chisel Plow	43.29
*Average of two plots.	

TABLE 2. Soil temperature and moisture in vertical tillage and conventional tillage plots, 2017.				
Date	Temperature (°F)*		Moisture (m3/m3)*	
	Chisel Plow	Vertical Tillage	Chisel Plow	Vertical Tillage
04/11/17	34.4	34.6	-	-
05/04/17	47.0	46.1	0.391	0.395
05/10/17	47.8	47.6	0.422	0.444
05/17/17	51.1	50.0	0.356	0.353
Average	45.1	44.6	0.390	0.400
*Average of two plots.				

Anecdotally, there was less mud on the roads and less visual evidence of soil erosion from the vertical tillage plots. Tim believes that vertical tillage could be the better option for his farm even though he hasn't seen many differences between the two tillage systems. He is starting to feel that vertical tillage will come out with the higher return on investment.

Following soybean harvest, the two vertical tillage plots were vertical tilled and the conventional plots were chisel plowed. Urea was applied to all plots and the plots were cultivated to incorporate the urea.

2018 RESULTS

Wheat was planted in early May in 2018 for the second year of the two-year rotation with soybeans. Planting was not delayed in the vertical tillage plots from wetter soil in the spring; the vertical tillage plots were ready to plant at the same time as the conventionally chisel-plowed plots.

A t-test was used to compare measurements from the two treatments at the 90 percent confidence level. There were no significant differences in yield, protein, and test weight, or soil moisture and temperature between the two treatments in 2018. There were also no significant differences between treatments when comparing relative combined crop yields for 2017 and 2018 (Tables 3 and 4). So far, there seems to be no negative impact on crop yield with vertical tillage. Additionally, the vertical tillage system required fewer tillage passes and less soil disturbance.

TABLE 3. Wheat yield in vertical tillage and conventional tillage plots, 2018.				
Tillage Practice	Stand* (plants/A)	Test Weight: (lb/bu)	Protein* (%)	Yield* (bu/A)
Vertical Tillage	1,260,723	60.5	13.8	78.0
Chisel Plow	1,335,065	61.1	13.5	75.5
LSD (.10)	NS	NS	NS	NS
*Average of two plots.				

TABLE 4. Soil temperature and moisture in vertical tillage and conventional tillage plots, 2018.				
	Temperature (°F)*		Moisture (%vol/vol)*	
	Chisel Plow	Vertical Tillage	Chisel Plow	Vertical Tillage
Pre-planting	43.9	43.4	31	31
At planting	51.4	51.9	34	41
Post-planting	42.2	42.4	31	31
*Average of two plots.				

Again this year, anecdotal observations from the grower include less blowing soil and increased snow cover during the winter on the vertical tillage plots.

MANAGEMENT TIPS

1. Changing equipment takes time and money, but vertical tillage will use less fuel and time as well as reduce soil erosion in the long run.
2. Going with less tillage had little impact on yield, soil moisture, or temperature. Tim did not run into any soil condition problems in 2017 or 2018. He is starting to feel that vertical tillage will come out with a higher return on investment.

COOPERATORS

Katie Kainz – Research Assistant, MN Wheat Research & Promotion Council, Red Lake Falls, MN

Tim Dufault – Farmer, Crookston, MN

PROJECT LOCATION

From Crookston, go east on County Road 11 for 8 miles, then north 3.5 miles. The farm is in the northwest quarter of section 3, Gentilly Township, Polk County.

Cover Crop and Intercropping Alternatives during the Establishment Period of Perennial Fruit Crops

PRINCIPAL INVESTIGATOR

Richard Traugott
13265 Jonquil Road
Foley, MN 56329
320-333-4203
trau0103@umn.edu
Benton County

PROJECT DURATION

2018 to 2020

AWARD AMOUNT

$16,356

STAFF CONTACT

Michael Greene

KEYWORDS

cover crops, intercropping with vegetables, mulching, perennial fruit establishment, secondary crops

PROJECT SUMMARY

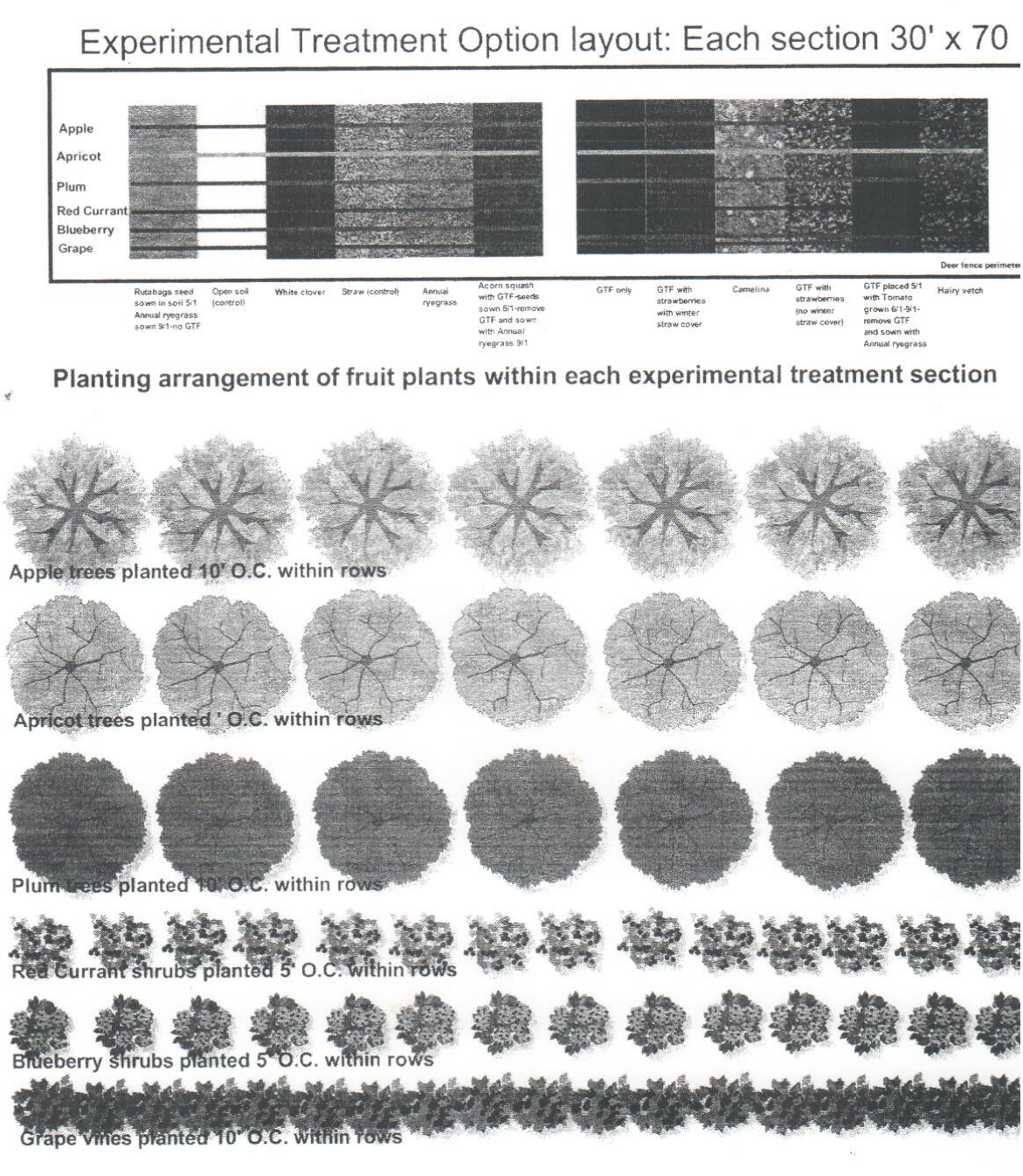
Perennial fruits are among the most sustainable and profitable crops for Minnesota farmers but require a significant initial investment. This three-year study will determine whether the establishment of the primary perennial fruit crops (apple, blueberry, currants, grapes, and plums) are affected by the simultaneous production (intercropping) of a secondary crop. Twelve intercropping options will be compared to current production practices during the first three years of establishment.

Evaluating the anticipated value of these secondary crops (rutabagas, squash, strawberries, and tomatoes) with the potential delay of establishment or losses of the primary fruit crop during the first three establishment years may help farmers consider whether this intercropping technique is preferable to current production practices in generating profits.

PROJECT DESCRIPTION

Like many small farms providing Community Supported Agriculture and other offerings, our farm is designed to offer a diverse product mix under sustainable production practices. In the next few years, we anticipate that perennial fruits will become a significant portion of our farm's offerings. Over many years, perennial fruit production can be highly profitable. However, under the current production methods practiced in Minnesota for establishing perennial fruits, a significant investment in resources plus the loss of annual revenue from that land can make adding perennial fruits financially prohibitive. As we considered production alternatives for adding perennial fruits, the idea of intercropping perennial fruits with horticultural crops that could generate revenue during the establishment years seemed to be an advantage, but only if the health and yields of the primary fruit plants would not be significantly decreased.

With our other production designs, we have tried to integrate ideas used by other area farmers or learned from past research projects. We have successfully integrated rotational cropping, vertical production, and intercropping with great success in vegetable and herb production. In addition, we extensively use red clover between rows, on our driving paths, as a cover crop, and frequently cut and collect clover to supplement animal feed for our 4-H animals. We use geotextile fabric and other mulches to reduce labor and increase yields. Each of these ideas seems to offer an advantage over the current production system used during the establishment of perennial fruits in our area. As current practice, perennial fruits are planted in open soil (Plot 2 on field map), in a cover crop such as white clover (Plot 3) or annual ryegrass (Plot 5), or in a non-living mulch such as straw (Plot 5). For small fruits such as blueberries and currants, geotextile fabric (Plot 7) is commonly used.



We designed this study to see how horticultural crops (rutabagas, squash, strawberries, and tomatoes) could be intercropped with five commonly produced perennial fruits (apple, blueberry, currants, grapes, and plums). We will compare 12 intercropping options with current production practices. We will also compare red clover, already used as a cover crop and living mulch on our farm, with rye and hairy vetch because other farmers have had great success with these alternatives. We will evaluate the new system for added value from the intercrops and cover crops as well as for soil health effects.

In 2017 in preparation for this project, an acre of fallow land was used in rotation with pastured pigs until about 80 percent of vegetation had been cleared. The pigs were sent through the field twice (May and September). Each time, they were moved after about 30 days. To provide a long-term acidic soil for the blueberry row, oak leaf/pine needles were composted (40 yd^3 finished volume) to be incorporated in 2018.

The 1 acre field for the study measures 105 feet (north to south) by 415 feet (east to west). For easier access, a 15 foot road surrounds the area and an additional road divides the plot north to south. A deer fence was installed to protect the experiment.

The five perennial fruit species were planted in individual rows with an east to west orientation. Trees (apple and plum), bushes (currant and blueberry) and vines (grape) were planted 10 feet on center within rows and shrubs (currant and blueberry) were planted 5 feet on center, the spacing recommended at maturity. Each of the twelve experimental treatments is 30 feet wide running north to south. Six shrubs and three fruit trees or vines of each species were planted within each of the experimental treatment sections. The plot map included in this article outlines the placement of the perennial fruit plants and the twelve experimental treatment options to be compared.

Strawberries were planted on 1 foot on center, tomatoes on 3 foot on center, squash on 5 foot on center. Rutabaga seed was broadcast as were the cover crop species: white clover, ryegrass, and vetch. These secondary crops were planted as if the fruit trees were not there. As shown in the plot map, except for planting within 24 inches of the fruit plants, secondary plants were planted perpendicular to the perennial plants.

Compost was added in July around the fruit plants to increase fertility and reduce weeds. The secondary crops (rutabagas, squash, strawberries, and tomatoes) were raised without supplemental fertilizer or composting.

To evaluate our project, we will measure growth of each fruit and horticultural plant species and survival rates. The value of each treatment section will be calculated. The horticultural crops will include a percent of salable and cull items harvested. Cull items will not be given a value in the table, but their weight will be included. For the harvest of salable vegetables/strawberries, their value will be calculated as pounds multiplied by potential dollars produced. The squash/rutabaga will be valued at $1 per pound, Roma tomatoes at $2 per pound, and strawberries at $4 per pound.

We will track the volume of harvested cover crops, the crop analysis and the value of forages based on $40 per ton (wet). From this data, we will report the relative cost per square foot for each cover crop treatment.

RESULTS

The beneficial effect of the pigs' "fertility" on the 2018 season greatly reduced the need to add nitrogen throughout the season. There was a significant reduction in rocks, thistle, and saplings in the area formerly occupied by the pigs.

Higher than normal temperatures in the first weeks after planting required nearly daily supplemental watering the first month. High winds required changes to staking design of the apple and plum trees as well as the geotextile fabric. Until growth of the secondary crops provided a micro-climate and helped secure the fabric, keeping narrow widths of fabric in place became an issue.

The effect of the secondary crop on fruit plant growth will be evaluated in spring 2019. Size differences between the experimental plants and the control are not expected the first two years. We are optimistic that any losses over the winter will be low. The greatest concern is winter kill with the small fruit plants. The purchased currant and blueberry plants were disproportional with top growth two to three times the size of roots and were available later than we would have preferred. Excessive early leaf development in May began within days of planting before new rooting had begun. As a result, the secondary crops received more irrigation than would normally be required. In late summer, when the secondary crops did not need irrigation, but the small fruit plants were showing signs of stress, we hand watered the fruit plants to encourage greater root growth for fruit development and to prevent cultural issues with the secondary crop. Managing the moisture requirements with the two crops could have been more easily accomplished with individual drip emitters for fruit plants, which

were not included in this project's design. The early high temperatures and required frequent irrigation may present a challenge going into this first winter as roots may not be deep enough.

For the secondary crops, rutabagas did not perform well, likely due to excess nitrogen and weed pressure. However, the yields of the other crops closely matched production in areas without perennial fruits, even though these were produced without receiving any supplemental fertilizer. Squash yielded 0.31 pounds per foot^2 with over 90 percent salable produce and a total of 550 pounds valued at $550. The control squash yielded 0.38 pounds per foot^2. The Roma tomatoes yield in intercropped plots was 7.2 pounds per plant (30 percent cull rate) compared to 9.4 pounds per plant in the control (20 percent) cull rate. The 120 tomato plants in the 1,800 ft^2 project area yielded 609 pounds valued at $1,218. Weed pressure in future years should decline so comparison of yields in the two systems will be more useful.

High weed pressure in the cover crops eliminated the chance to harvest and estimate yields this year. The cover crops made up less than one-third of the cut foliage. We anticipate better forage in the next 2 years of the project.

MANAGEMENT TIPS

1. Until growth of the secondary crops provides a micro-climate and helps secure geo-textile fabric, keeping narrow widths of fabric in place will be an issue.
2. Managing the moisture requirements with the two crops could be more easily accomplished with individual drip emitters for fruit plants.

COOPERATORS

Daniel Martens, U of M, Extension

Beth Berlin, U of M, Extension

PROJECT LOCATION

The project is being conducted about 2 miles northeast of Foley. From the intersection of Highways 25 and 23 (Foley), drive 2 miles northeast on Highway 23, turn left onto 135th Avenue Northeast. Drive 1.25 miles, then turn left into farm.

OTHER RESOURCES

Cornell University Fruit Resources: www.fruit.cornell.edu

Minnesota Extension: www.extension.umn.edu

National Sustainable Agriculture Coalition: www.sustainableagriculture.net

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

PRINCIPAL INVESTIGATOR
Andy Cotter
York Farm LLC
21161 York Road
Hutchinson, MN 55350
612-968-3565
Andy@YorkFarmMN.com
McLeod County

PROJECT DURATION
2017 to 2019

AWARD AMOUNT
$6,728

STAFF CONTACT
Michael Greene

KEYWORDS
consumer preferences, fruit, gooseberries, trellis systems, varieties

PROJECT SUMMARY

This project is testing eight varieties of gooseberries on three different training systems to determine what works best in Central Minnesota. We will find out which varieties are most disease resistant, most vigorous, easiest to harvest, and most acceptable to consumers.

PROJECT DESCRIPTION

York Farms is a certified organic farm started in 2010 as a vegetable CSA but now we've shifted to organic fruit production. We have apples, pie cherries, table grapes, apricots, seaberries, strawberries, raspberries, and currants which we market through restaurants and as a fruit share CSA. We planted Hinnomaki Red and Pixwell gooseberries in 2014. In 2015, we installed a deer fence around 20 acres of our property.

Of all the cold hardy fruits we have tried, we believe gooseberries show the greatest potential. The fruit is nutritious with a unique flavor and is in demand. There are many varieties but Pixwell, the only variety most people know, has a bad reputation because it develops a bitter flavor when ripe. Varieties more acceptable to consumers are needed. Also, gooseberries are very difficult to harvest and susceptible to leaf diseases. Fruit is produced very close to thorns on the canes. Different trellis and pruning systems could make picking easier.

Gooseberry trellis systems from left to right: double post, single post with multiple wires, and cordon trellis.

This project will compare eight varieties of gooseberries on three different trellis systems. We will collect information on flavor, ease of picking, yield, leaf disease resistance, fruit size, and plant vigor (number of canes and cane heights). In the third year of the project, we will assess consumer variety preference.

2017 RESULTS

We planted 24 plants each of eight varieties this spring (Table 1). We chose the varieties to include both large, dessert quality gooseberries for fresh eating, and smaller, more intensely flavored varieties that are best used in baking and cooking.

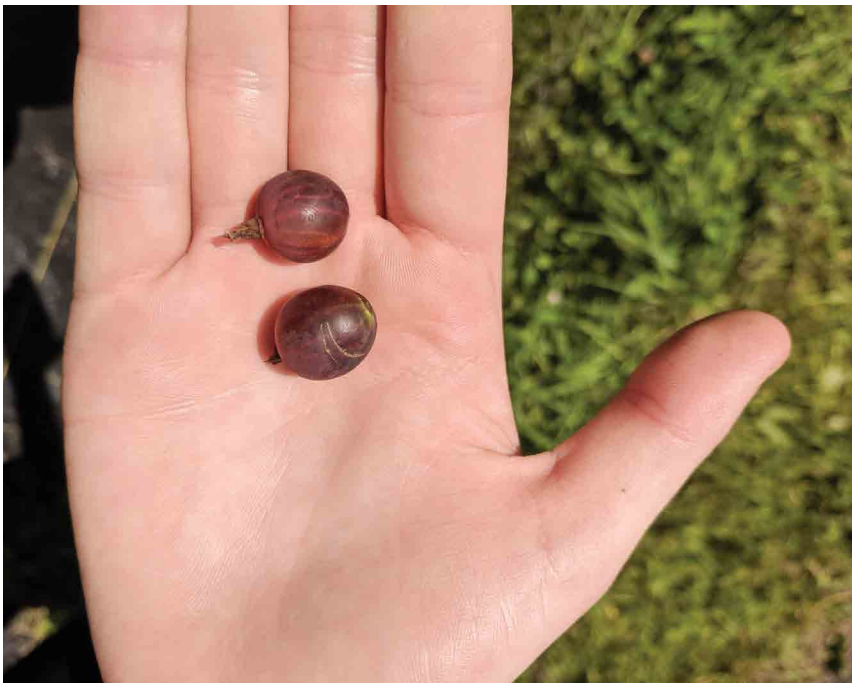
Canes were planted 3 feet apart on rows that are 8 feet apart on center on April 8, 2017. Cane size and root systems varied greatly among the varieties which will likely affect short-term growth. Tixia and Jahn's Prairie were little more than sticks. After planting, we spread a layer of wood chips followed by drip irrigation. Then, we covered with the planting rows with 4 foot wide landscape cloth. While this was extra labor and cost, the mulch and fabric will help with water retention and weed control. A clover cover crop was planted between the rows.

Two different trellis systems were installed in mid-summer, one row of each type with 64 plants per row – eight plants of each variety. Discarded 8 foot metal highway posts for wire attachment were pounded 3 feet into the ground. One row will be trained to wires run down the center of the row at 12 and 24 inches above the ground. Another row will be trained to two wires attached 14 inches above the ground and set 1 foot apart on each side of the plants. The third system, to be installed in spring 2018, is an intensive cordon system that is typically used in Europe. Only one cane is allowed to grow and is headed the first season. Two branches that run parallel to the ground are formed. This delays production one year but has been shown to make picking easier.

Nearly all the plants survived transplanting and most varieties grew quite well. Black Velvet did best, growing 12 inches or more. All the other varieties grew 3 to 6 inches. Hinnomaki Red produced some berries. We expect to have a crop in 2018 and will begin data collection.

2018 RESULTS

This spring we put in the posts for the cordon trellis using 3/8-inch rebar that was 6 feet long. To make sure the posts didn't move we strung one wire the length of the row and tied the posts to the wire. We also heavily pruned and tied up canes. No pruning was done on the two rows with the cordon trellis as there wasn't enough to prune. We noticed flowers on most varieties and a few dead plants (mainly Jahn's Prairie), possibly from winter injury. Liquid fish fertilizer was applied as a foliar spray and will be applied again in 2019 along with slow release Sustane fertilizer.



Customer favorite - Black Velvet.

There was fruit to harvest in all the varieties except Tixia which allowed us to do some initial taste testing. The start and end harvesting dates were tracked (Table 1) along with taste quality and plant vigor. As many of these varieties are new to us, we wanted to keep some of the fruit on the vine as long as possible to see if the flavor improved.

We currently like the single post trellis system with multiple wires. It is the least costly, keeps the canes off the ground, makes it easier to pick, and is a reasonable compromise for training canes when compared to the other trellis systems. We may have not made the posts tall enough for some vigorous varieties (Black Velvet and Captivator) which are growing past the top wire. Some other gooseberry varieties (Hinnomaki Yellow) didn't even make it to the first wire. The biggest drawback to the single wire trellis is having to walk all the way around to get to the other side of the plant!

TABLE 1. Gooseberry variety descriptions.

Plant	Berry Color	Vigor*	Plants w/ Berries	Taste	Start Harvesting	End Harvesting	Planted	Died
Black Velvet	Red	Strong	16	Excellent	07/07/2018	07/15/2018	24	0
Captivator	Red	Strong	18	Good	07/07/2018	07/15/2018	24	0
Hinnomaki Red	Red	Average	14	Amazing	07/06/2018	07/14/2018	24	0
Hinnomaki Yellow	Yellow	Weak	10	Ok	07/09/2018	07/15/2018	24	0
Invicta	Green	Average	6	Ok	07/07/2018	07/14/2018	24	0
Jahn's Prairie	Red	Average	3	Good	07/17/2018	07/20/2018	24	6
Tixia	Red	Weak	0	NA			24	1
Jeanne	Red	Average	1	Ok	07/17/2018	07/20/2018	24	0

*Plant growth compared to other varieties.

MANAGEMENT TIPS

1. Using wood chips covered with landscape cloth helps with water retention and weed management. We only had to minimally weed (right around the plant) and didn't have to water at all in 2018. Without the weed fabric, it would have been cost prohibitive to keep up on the weeding.
2. Using a ripper (Yoeman plow) to create 16-inch-deep furrows reduces shovel work for planting.
3. At this point in the project, we would go with the single post with multiple wire trellis. It was the least expensive of the trellises and offered the most benefit.
4. We experimented with gloves during harvesting to see what would work best as gooseberries can have long painful thorns. What worked best for us was to have one hand in a cut resistant glove to move the cane around while the other hand doing the harvesting did not have a glove. This test was done on an established gooseberry row that didn't have any type of trellising. The trellising should make harvesting easier and may eliminate the need for any type of glove. The gloves that we found that worked the best are Ansell Cut Protection Gloves and Turtle Skin CPR-500.

COOPERATORS

Thaddeus McCamant, Northland Community and Technical College, Detroit Lakes, MN

PROJECT LOCATION

From downtown Hutchinson, take Highway 15 (Main St.) south to the roundabout then go right (west) on Airport Road/County Road 115. In a mile, this becomes York Road. Go another 1.5 miles and the farm is on the left.

Using Juneberries as a Cold Hardy Rootstock for Minnesota Pears

PRINCIPAL INVESTIGATOR
Thaddeus McCamant
Central Lakes College
1830 Airport Rd.
Staples, MN 56479
tmccamant@clcmn.edu

PROJECT DURATION
2016 to 2018

AWARD AMOUNT
$14,120

STAFF CONTACT
Cassie Dahl

KEYWORDS
juneberry, pear, rootstock

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 2 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 2 years after planting.

Photo 1. Trees ready to be planted.

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 inch 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 gallon 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 2. Planted trees with trellis system

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 of the 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 were between 2 and 3 feet 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 used seedling A. alnifolia rootstocks, and some rootstocks were nearly ¾ inch in diameter while others were close to ¼ inch 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 gallon 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.

2017 RESULTS

Staples was the coldest site and had the most winter injury with 61 percent of the trees dying during the winter of 2016-17 (Table 2). In spite of reaching a temperature of -30 degrees Fahrenheit, the site near Hutchinson had the highest survival rate, with over 80 percent of the trees surviving. At Taylor's Falls, 26 percent of the trees died. The winter injury in Staples was not surprising since the trees were planted in a site that was exposed to wind and the site was exposed to three cold snaps. High rainfall at Taylor's Falls in November, April, and May could have lowered the survival rate at that site.

TABLE 2. Survival rates and coldest temperatures of all pears at each site.

Site	Total trees planted	Percent of trees that died	Lowest temperature and date temperature occurred
Staples	56	61%	-35°F, Dec. 18, Jan 6, Jan 13
Taylor's Falls	142	26%	-25°F, Dec. 18
Hutchinson	127	19%	-30°F, Dec. 18

There were large differences in survival rates: between cultivars, between rootstocks, and between the different variety x rootstock combinations. Gourmet had the highest survival rate of the seven cultivars, with Gourmet on Old Home x Farmingdale 87 having a 100% survival rate at all sites (Table 3). In addition to having a high survival rate, the Gourmet trees on OH x F 87 were vigorous and the only trees that grew substantially at the Staples site. The cultivar with the lowest survival rate was Luscious at 61 percent, but the low survival rate was because only 30 and 40 percent of the trees grafted onto the two juneberry rootstocks survived. Luscious planted onto OH x F 87 had a survival rate of 83%. Honey Sweet appears to be the most suitable for juneberry rootstocks, with a survival rate of 100 percent when grafted onto A. alnifolia. The lowest survival rate of any rootstock x cultivar combination was Ewart on A. alnifolia, with a survival rate of 13 percent.

Survival rates of pears grafted to both pear rootstocks were higher than those grafted onto either juneberry species. The survival rate on both juneberry rootstocks was slightly over 50%, whereas the survival rates of trees grafted onto pear rootstocks was over 75 percent. In addition to having a higher survival rate, there were more trees after the first summer on OH x F 87. When the trees were planted in the field in November 2017, there were 109 trees on OH x F 87, 84 trees on OH x F 97, 76 trees on A. x grandiflora, and 58 trees on A. alnifolia.

TABLE 3. Survival rate of each cultivar and each cultivar x rootstock combination at all three test sites.

	All Rootstocks		% Alive	A. alnifolia	A.x grandiflora	OH x F 87	OH x F 97
	Alive	Original		Percent of trees that survived 1 year			
Clara Frijs	32	47	68%	63%	50%	79%	71%
Ewart	34	53	64%	13%	67%	76%	75%
Gourmet	47	62	76%	67%	47%	100%	81%
Harrow Sweet	26	36	72%	57%	63%	73%	90%
Honeysweet*	21	32	66%	100%	60%	67%	50%
Luscious	30	49	61%	30%	40%	83%	73%
Summercrisp	35	48	73%	38%	62%	88%	90%
Average			69%	52%	55%	81%	76%

Pears on juneberry rootstocks differed from pears on pear rootstocks in both growth rates and the production of floral buds. Many trees on both pear rootstocks had excellent growth. At the Hutchinson site most of the trees on pear rootstocks grew between 2 and 3 feet during the summer of 2017 (Photo 3). The trees on juneberry rootstocks grew at most 4 to 6 inches during the same time period. Leaves on trees with juneberry rootstocks tended to be smaller than those on pear rootstocks (Photo 4). Most of the growth occurred in the summer of 2016, and leaves are smaller and less healthy than trees grafted on OH x F 87 in neighboring row.

Juneberries appear to be extremely precocious rootstocks when grafted with pears. One pear tree on Amelanchier x grandiflora had two flowers 1 year after grafting. In the fall of 2017, many of the pear trees on both juneberry rootstocks appeared to have floral buds. As expected, some cultivars appear to be more suitable for juneberry rootstocks than others. Honeysweet, Clara Frijs, and Gourmet all had very good survival on juneberry rootstocks.

After 2 years, we do not know if juneberries will be a viable rootstock for hardy pears. Survival rates were low, but acceptable. The low survival rate could have been aggravated by planting the trees directly in the ground in the fall. In the future, we will overwinter the plants in a high tunnel and then plant in the spring. A bigger problem with the trees grafted onto juneberry rootstocks was extremely slow growth rates at each site. The slow growth rates were a surprise, because there was no difference in growth rates between trees the year of grafting. Some pear varieties on A. alnifolia and A. x grandiflora grew 2 feet the summer after they were grafted, but had almost no growth in 2017. We will be carefully monitoring growth rates on the different rootstocks during 2018.

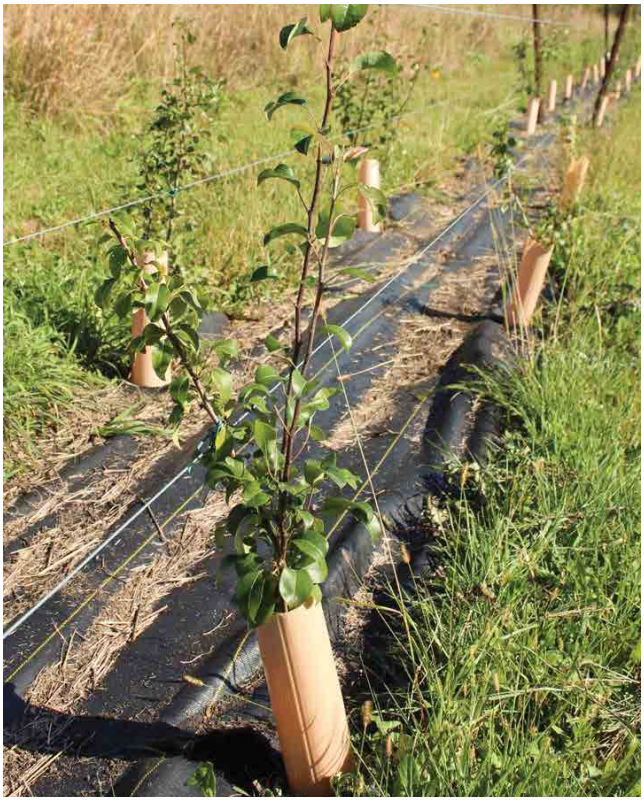


Photo 3. Pears on OH x F 87 at York Farm showing 3' of growth, with healthy leaves 1 year after planting.

Photo 4. Pear on A. x grandiflora at York Farm.

2018 RESULTS

In 2018, growth rates on juneberry rootstocks became normal on some cultivars, including Summercrisp (Photo 5). Both pear rootstocks had excellent growth rates in 2017 and 2018, but OH x F 87 looked better than OH x F 97. In particular, OH x F 87 grew the most at a rate of 3 feet each year in Hutchinson.

However, with inconsistent results in two growing seasons, we don't know if slow growth rates are going to be a major problem for pears grafted onto juneberries. We would like a dwarfing rootstock for pears, but we also don't want a rootstock that causes stunted trees. Since the extremely slow growth rates coincided with winter injury, there is a chance that the problem was aggravated by winter injury.

Even with some issues, juneberries appear to be a viable rootstock for hardy pears and all three participants will continue to experiment with juneberry rootstocks. To use Amelanchier rootstocks we are trying to find ways to get more vigor into the scions. Some pear varieties grafted onto juneberry rootstocks produced blossoms and fruit within 2 years, but growth rates were unacceptably slow the second year. It does appear that letting the juneberry rootstocks leaf out and grow after grafting will increase vigor in the scions.

Of the two species of juneberries we tested, the apple serviceberry was more vigorous and possibly more suitable than saskatoon. With our continuation of the project we will also try a Siberian species and Cotoneaster (a dwarf pome fruit) for rootstocks. Moving forward we will overwinter grafted plants in a high tunnel and then plant outdoors in the spring. In addition, we will allow the rootstocks to leaf out.

Photo 5. Summercrisp on Amelanchier grandifolia in summer 2018.

MANAGEMENT TIPS

1. Juneberries show promise as dwarfing and precocious rootstock for hardy pears, but they may be too dwarfing. Allowing the juneberry rootstock to leaf out and grow may mitigate some of the excess dwarfing.
2. In the meantime, growers should look at using OH x F 87 as a hardy pear rootstock. It is more precocious than OH x F 97 and appears to have better tree form than pear rootstocks commonly planted around the state.
3. Some pear cultivars are more suitable for juneberries than others. Gourmet, Harrow Sweet, and Summercrisp all appear to be compatible.
4. If grafting in the spring, leave the plants in a protected nursery bed or high tunnel the first year instead of planting into the field.

COOPERATORS

Dan Sheild, Stone Creek Farms, Taylors 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 Road to County Highway 2. Take a left on Highway 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 Road, Hutchinson, MN. From Hwy 15, take Airport Road West to York Road. Farm is on the south side of the road.

Stone Creek Farm is located between Taylors Falls and Shafer. From Shafer, take Redwing Avenue NE to 310th Street. Take a right (east) on 310th Street. Farm is on the north side of the road next to the solar farm.

OTHER RESOURCES

Cummins Nursery. Website: www.cumminsnursery.com

North American Fruit Explorers. www.nafex.org

Organic Fruit Growers Association. www.organicfruitgrowers.org

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

Using Essential Oils to Repel Spotted Wing Drosophila in Blueberries

PRINCIPAL INVESTIGATOR

Bev O'Connor
Blueberry Fields of Stillwater
9450 Mendel Road North
Stillwater, MN 55082
bev@blueberryfieldsofstillwater.com

PROJECT DURATION

2017 to 2019

AWARD AMOUNT

$5,397

STAFF CONTACT

Cassie Dahl

KEYWORDS

blueberry, essential oils, spotted wing Drosophila

PROJECT SUMMARY

We are trying to control spotted wing Drosophila (SWD) on our blueberry farm by using repellents made from botanical essential oils instead of insecticides. We grow 1 3/4 acres of blueberries just north of Stillwater. We primarily market our blueberries as pick-your-own, which draws customers from the Twin Cities metro area. Our customers have requested we follow organic practices. Currently, we use more expensive organic fertilizers and pay for extra mulch and labor for weed control. In 2013, our goal of certifying organic was stopped by the arrival of spotted wing Drosophila. In order to protect our crop we used conventional insecticides during the 2014 and 2015 growing seasons. Wanting to use organic practices, in 2015 we tested lavender oil as a repellant on about 10 bushes outside of our field and had encouraging results. In 2016, we started using lavender oil to repel SWD in our entire field and the results were good enough that we wanted to scientifically test the efficacy of essential oils as a repellant for SWD.

PROJECT DESCRIPTION

Several studies have looked at essential oils as a way to repel or kill SWD adults (Renkema et al., 2016, Jang et al., 2017), and shown that peppermint oils were the most effective. The first studies were conducted in laboratories and only a few people have tried essential oils to control SWD on commercial fruit farms. We decided to test the

Photo 1. Northblue blueberry patch where we conducted the experiment.

efficacy of different essential oils to see if they could keep SWD populations low enough so we would not have to use conventional insecticides. Initially, we were going to compare essential oils to Jet Ag, which is a hydrogen peroxide product that kills the yeast that attracts SWD, but it also contains acetic acid or vinegar, which could attract flies. Therefore, we decided to compare lavender and peppermint oils, both with two differing concentrations.

We tested the essential oils on a block of Northblue blueberries which is separate from the other three fields that are used for pick-your-own (Photo 1). SWD tend to be worse in Northblue, partly because the variety produces many small berries at the end of the season that are rarely picked. One concern with conducting on-farm pest control research is the possibility of creating a breeding ground that could increase the number of SWD's, and they could spread to the surrounding fields. As a precaution, we monitored 15 plants that were in another section of our property as our control. All three fields of pick-your-own blueberries were sprayed with lavender oil.

The small block of Northblue bushes is divided into a north and south section, each with two rows of 20 to 23 plants/row. The north and south areas were each divided into four sections, and each section received a different spray treatment (Table 1). The order of treatments was alternated on the north and south sections. Each area was sprayed with 1/2 gallon spray solution on a weekly basis, but altered as needed if it rained. For the control, we monitored 15 plants that were in another section of our property, also away from the commercial field.

We monitored for SWD adults using traps baited with yeast and sugar, but we were afraid to place traps in the blueberry field, because in past years the mixture appeared to attract insects. We finally decided to place the traps in a forested area that had wild red elderberries. Traps were checked each week and the adult flies were counted. Males were most present, but are easier to identify due to the distinct spots on their wings. Females lack the wing spot and are difficult to distinguish from common fruit flies without using a hand lens.

TABLE 1. Different spray treatments for each section of the blueberry patch.	
Section	Ingredients
1	1/4 tsp Lavender in 1/2 gal water; 1/2 Tbsp soda; 1/4 tsp NuFilm P[1]
2	1/2 tsp Lavender in 1/2 gal water; 1/2 Tbsp soda; 1/4 tsp NuFilm P
3	1/4 tsp Peppermint in 1/2 gal water; 1/2 Tbsp soda; 1/4 tsp NuFilm P
4	1/2 tsp Peppermint in 1/2 gal water; 1/2 Tbsp soda; 1/4 tsp NuFilm P
5	Not Sprayed
[1]NuFilm P is a sticking agent that helps hold pesticides on plant foliage.	

We began spraying the oils as the first berries started to turn blue. Weather permitting, we continued to spray once a week until we stopped picking for the season. To test for the presence of SWD larvae in berries, we picked 1/2 cup of blueberries from each block. The berries were crushed and added to a solution of 1 cup salt to 1 gallon of water. We placed the crushed berries in the salt solution in plastic bags. After allowing this mixture to sit for 1/2 hour, the number of larvae that floated to the top was counted (Photo 2).

Photo 2. Blueberries in solution to float SWD larvae out for counting.

To determine if any of the spray treatments were either helping or hurting the fertility of the plants we sent in tissue for testing before and after the picking season. We also sent in a soil sample, which will be compared to a 2018 sample to see if there were changes. In addition, to see if the oils were affecting the taste, we invited guests to do a taste testing of berries from all five plots.

2017 RESULTS

Blueberries started to turn blue in late June, so we started applying essential oils on June 23 and planned to spray weekly. At the time, there were reports of SWD in strawberries in our part of the State. We caught our first SWD on July 6, when our traps had five SWD males. On July 11, our trap had 24 males. On July 24 and 31, the sticky card in the trap had too many SWD flies to count.

The pick-your-own patch opened to customers on July 6 and, thankfully, we did not find any larvae in either the test areas or the commercial blueberries. On July 11, we found one larva in our samples from the unsprayed control and the main field.

The sections sprayed with 1/2 teaspoon of lavender per 1/2 gallon had the lowest numbers of SWD larvae, while sections sprayed with peppermint had about the same numbers as the unsprayed control (Table 2). Also, the south section appeared to have more larvae. Looking closely at the bushes, the bushes in the south section that were sprayed with peppermint oil were denser with a tighter canopy. In the future, we will prune these bushes to become more open in order to improve SWD control.

Our plan to spray the commercial block and the test block once a week was complicated by the weather. We sprayed the test plots on June 23 and June 25, after it rained. We sprayed on July 1, 8, and again on July 12 after the rain stopped. It rained on and off from July 17 through July 21, so we had to wait to spray. We were finally able to spray again in the evening on July 21 and then again on July 26.

By July 21, SWD numbers were starting to increase rapidly. On July 28, SWD numbers in the commercial patch were too high to continue picking, so we closed for the season. Fortunately, most of our crop had been sold by then.

At this point, the lavender does appear to reduce SWD pressure. The test blocks sprayed with lavender had less SWD larvae than other treatments and the control, and we were able to harvest most of our commercial fields before the SWD numbers became too high. With SWD, the goal is often to try to keep the problem from getting out of hand rather than to eliminate the pest. In 2017, the lavender appeared to give us at least one extra week of picking.

After reviewing the 2017 data, the 2018 research will be adapted. Bushes will be pruned as evenly as possible. Lavender will be tested, but peppermint will be omitted. A review of the latest research will be done to see about testing any new products. So far, we have seen new research on an organic insecticide named Grandevo, which may be an effective option against SWD.

We were pleasantly surprised with the positive response from our guests. Many of them wanted to hear all about the study and had numerous questions. On the taste testing days, they were willing to take a few minutes to complete the survey (Photo 3). They were very encouraging of us as we try to use oils as repellents so we can be certified organic. According to our taste tests, consumers could not detect any difference between berries sprayed with an essential oil and berries that were not sprayed.

TABLE 2. Counts of SWD larvae in 1 cup of blueberries from each treatment.

Sampling Date	1/4 tsp Lavender	1/2 tsp Lavender	1/4 tsp Peppermint	1/2 tsp Peppermint	Unsprayed Control
July 6, 2017	0	0	0	0	0
July 11, 2017	0	0	0	0	2
July 18, 2017	0	0	6	0	0
July 25, 2017	13	4	31	30	NA
August 1, 2017	18	16	21	29	40

The essential oils are cost effective when compared with other Organic Materials Review Institute approved sprays (Table 3), and they have no pre-harvest interval. The most commonly used insecticide is Spinosad (Entrust), but with current recommendations, should only be sprayed two times during the growing season. However, two times is not enough to prevent SWD numbers from exploding. Spinosad also has a 3 day pre-harvest interval, which can be inconvenient during the picking season. Growers who want to use essential oils should do some comparison shopping to find a source that is economically viable.

Photo 3. Taste testing in progress.

TABLE 3. Cost of different products used for SWD control in 1 acre of blueberries.

Product	Total cost for package, includes shipping	Amount needed for each spray	Cost per spray	Estimated sprays per year	Annual Cost	Restricted-entry Interval	PHI
Grandevo	$450/20 lb	3 lb/A	$67.50	6	$405.00	4 hr	None
Lavender	$481.40/64 oz	4 oz/24 gal water	$30.09	8	$240.701	None	None
Nu Film P	$75/128 oz	4 oz/24 gal water	$ 2.34	8	$ 18.75	None	None
Entrust	$500/32 oz[2]	6 oz/A	$93.75	23	$187.50	4 hours	3 Days
2 Entrust with 6 Grandevo				2 Entrust with 6 Grandevo	$592.50[4]		

2018 RESULTS

In 2018, we tested lavender oil, Grandevo, and two Ecotrol® PLUS formulations (the company provided two sample formulations). One other change was with picking; we had the control area picked by the owner and family, while guests picked the test plots. We found that guests left some ripe berries on the bushes and on the ground. The control bushes were picked completely clean with little to no berries left on the bushes or on the ground. The berries in the control had less larvae than the berries in the treated areas. Picking cleanly provided better control than any type of spray.

We began spraying the oils once we saw the berries starting to turn blue and planned to spray every 5 days. We sprayed on June 26, July 1, 5, 10, 13, 21, and 26. There were multiple rain events from July 13-21, which made spraying impossible. Blueberries were unprotected during this time and testing revealed more SWD infestation after this period.

TABLE 4. Spray treatments for each section of the blueberry patch in 2018.

Section	Ingredients
1	1/2 tsp Lavender in 1/2 Gallon water; 1/2 Tbsp soda; 1/4 tsp NuFilm P
2	3 Tablespoons Grandevo in 1/2 Gallon water; 1/4 tsp NuFilm P
3	2 teaspoons Ecotrol® PLUS A in 1/2 Gallon water; 1/4 tsp NuFilm P
4	2 Teaspoons Ecotrol® PLUS B in 1/2 Gallon water; 1/4 tsp NuFilm P
5	Not Sprayed

Once again we had yeast traps placed in a forested area near wild red elderberries. There were no SWD on June 20, 1 male on June 27, then numbers began to climb. On July 3, there were at least 13 males on sticky card and lots in the liquid. On July 10, there were 22 males on the sticky card and lots in the liquid. On July 17, there were at least 12 males on the sticky card and lots in the liquid. On July 25, there were too many to count on the card and lots in the liquid (Photo 4).

Pick your own blueberries opened on July 5 and closed on July 26, when the number of larvae in the blueberries increased. Most of our blueberries had been picked by then and we had a successful season. The last picking of the berries was done by family, friends, and employees.

Photo 4. Late season photo of SWD yeast trap.

TABLE 5. Counts of SWD larvae in one cup of blueberries with different treatments.

Sampling Date	Lavender	Grandevo	Ecotrol® PLUS A	Ecotrol® PLUS B	Unsprayed Control
July 15, 2018	0	0	1	1	0
July 24, 2018	10	13	9	8	0
July 29, 2018	12	17	10	11	3

Berries with all sprays had roughly the same number of SWD larvae, meaning that all four sprays showed about the same effectiveness. The berries in the control had less larvae than the berries in the treated areas but this may be due to the difference in picking.

As a side benefit, we noticed the sprays appeared to repel birds in blueberries. Only a few birds were in the bushes 1 to 4 days after spraying, but on day 5 more would be in the field. There were many rain events in July, which washed the products off the berries and many birds would then enter the field.

Ecotrol® PLUS was the least expensive of the Organic Materials Review Institute approved sprays with prices for lavender oil, Nu Film, and Entrust with Grandevo similar to 2017. Ecotrol® PLUS had a total annual cost of $118.80 for one acre, we used 16 ounces per gallon and sprayed eight times. In addition, there is not a restricted-entry interval or pre-harvest interval with this product.

This research has changed our business. For a few years, our customers have encouraged us to grow blueberries organically. In 2019, we will use lavender oil and Ecotrol® PLUS on all of the blueberries on our farm. We are grateful for a cost-effective organic option for controlling SWD and we will pursue organic certification in 2019.

MANAGEMENT TIPS

1. Prune bushes evenly to maintain an open canopy, which will allow air movement and spray penetration.
2. Plan on more time than expected for spraying bushes, testing berries for larvae, and documentation.
3. Order all products before the growing season begins for the year.
4. Lavender oil does appear to reduce SWD pressure.
5. Pick all the bushes clean for best control of SWD.

COOPERATOR

Thaddeus McCamant, Central Lakes College, Staples, MN

PROJECT LOCATION

At I-694 and Highway 36 go east towards Stillwater on Highway 36. After about 5 miles turn left (north) on Manning Avenue/Highway 15. Go north 3.5 miles until you get to a roundabout at Highway 96/Dellwood Road. Turn right (east) on Highway 96/Dellwood Road and go 1 mile. Take a left (north) onto Mendel Road North (by the ponds) and our field is about a ½ mile up the road on your left. You will see our sign there.

OTHER RESOURCES

Jang, M., Kim, J., Yoon, K. A., Lee, S. H., & Park, C. G. 2017. Biological activity of Myrtaceae plant essential oils and their major components against Drosophila suzukii (Diptera: Drosophilidae). Pest Management Science, Vol. 73(2), pp. 404-409.

Renkema, J.M. 2016. Plant essential oils and potassium metabisulfite as repellents for Drosophila suzukii (Diptera: Drosophilidae). https://www.nature.com/articles/srep21432

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

PRINCIPAL INVESTIGATOR

Steven Poppe
U of M West Central Research and Outreach Center
46352 State Highway 329
Morris, MN 56267
320-589-1711 ext. 2121
Stevens, McLeod, Hennepin, and Otter Tail Counties

PROJECT DURATION

2017 to 2018

AWARD AMOUNT

$23,212.50

STAFF CONTACT

Erin Connell

KEYWORDS

biodegradable mulch, low tunnel day-neutral strawberries, winter rye cover crop

PROJECT SUMMARY

Minnesota farmers need an environmentally acceptable system for producing annual strawberries to increase the supply of this high-value specialty crop. Despite growing consumer interest in local foods, the supply of Minnesota-grown strawberries is extremely limited due to the short growing season and perishability of traditional varieties. We have developed a low tunnel production system for strawberries yielding high quality berries that extends the strawberry season into October. Plastic mulch and landscape fabric were integral to our initial system for weed control, a challenge in strawberry production.

In our recent survey of 200 regional farmers, 73 percent want to learn to grow annual strawberries, and 64 percent want to learn about low tunnels for season extension. However, 57 percent of farmers surveyed expressed concerns about our system's use of plastic mulch and landscape fabric, including negative environmental effects and lack of recycling options. Therefore, to increase local strawberry production and meet the needs of farmers, exploring the performance of biodegradable mulches in the row and in-between the row was the next step.

PROJECT DESCRIPTION

Strawberry research has been ongoing at the University of Minnesota West Central Research and Outreach Center (WCROC) in collaboration with the Department of Horticultural Science both with perennial June-bearing varieties and day-neutral varieties (grown as annuals). While the traditional June-bearing varieties produce fruit from early June through early July, our day-neutral low tunnel system offers high quality fruit

Aaron Wills, Little Hill Berry Farm, Northfield.

from late July to October, a non-traditional time of year in Minnesota. This system for growing strawberries offers great potential for farmers.

Since 2013, we have done research with this day-neutral low tunnel strawberry system to determine suitability for Minnesota farmers. We have adapted the system to withstand wind, rain, and heat, as well as to establish irrigation and nitrogen best practices. We have also learned that growing a single day-neutral variety can lead to pest problems.

The low tunnel system requires hoop-like structures that go over the rows of strawberry plants. In addition, the strawberry plants must be planted into some type of mulch for adequate weed control and to maximize plant growth. In initial studies we used white-on-black plastic mulch in the row, which is a very effective weed control strategy. However, farmers expressed concern over the amount of plastic used, considering that the plastic mulch is not reusable. This concern led us to our current project of evaluating the effectiveness of biodegradable mulch in the low tunnel system. Our experimental objective was to determine if there is a more environmentally sustainable alternative to plastic mulch. To further reduce plastic in the system, we evaluated the use of cover crops in place of landscape fabric for weed suppression between the rows of strawberry plants.

Our project consisted of the following objectives:

1. Determine the performance of biodegradable mulches in an extended season annual strawberry production system as compared to our standard white-on-black plastic mulch.
2. Improve understanding of the effectiveness of sustainable mulches between crop rows in an extended season annual strawberry system as compared to landscape fabric used between crop rows.
3. Increase the awareness of the benefits of the extended season annual strawberry system.
4. Increase awareness among farmers to help them establish extended season annual strawberry systems on their farms.

In our original proposal, we listed three treatments:

Treatment 1: White-on-black plastic mulch (this is the mulch used in past experiments and will be the control);

Treatment 2: White-on-black biodegradable plastic mulch (this will be one of the comparisons); and

Treatment 3: Paper mulch approved for certified organic production (this will be another comparison).

Treatments 1 and 2 were installed, but we didn't install treatment 3, the paper mulch. Based on our original research, we were confident that this paper mulch would work when installed with a plastic mulch machine. We tried to install this product with the machine in the spring of 2017 but failed. During the installation process, the product continually ripped. We made numerous mechanical adjustments to the mulch machine but with no success. We abandoned this paper mulch treatment and continued to install the other two treatments.

Bio360 biodegradable compostable black plastic mulch being installed on a 6 inch raised bed.

One of the objectives of this project was to compare biodegradable plastic mulch with standard white-on-black plastic mulch. The plastic mulch is installed over the raised bed prior to planting dormant strawberry transplants. During the 2017 and 2018 growing season, we compared Bio360 biodegradable compostable black mulch film with our standard white-on-black plastic mulch. As stated from the manufacturer's website, Bio360 is made of Mater-Bi®, a plastic that is completely biodegradable and compostable and used in the manufacturing of products having a low impact on the environment. Temperature, humidity, and microorganisms in the ground transform Bio360 into water, carbon dioxide, and biomass. There is no toxic residue left. At the WCROC, the Bio360 biodegradable mulch had the same mechanical and physical characteristics as the white-on-black plastic mulch. In 2017 and 2018 we installed the Bio360 on a 6 inch raised bed with a plastic mulch machine. Visibly, the Bio360 didn't have quite as tight a fit on the raised bed as the standard white-on-black plastic mulch. Without a tight fit, strawberry transplants initially appeared to have a more difficult time growing through the slit/opening in the Bio360.

Slight breakdown around mid-season of biodegradable, compostable black mulch.

In 2017, the Bio360 mulch started to break-down near the end of the growing season, which is what it's supposed to do, however, in 2018, the break-down happened much earlier in the season. We suspect this is due to the excessive heat in 2018. Despite the early break-down, this product does provide sufficient weed suppression in the plant row. The product breaks down along the edge, exposing the soil bed. This creates a problem – as rain or water hits the exposed soil, it splashes onto the plants and fruit. We are not seeing this issue on the comparison white-on-black plastic mulch.

Mid to late season winter rye cover crop in-between strawberry rows. Area sprayed with an organic herbicide to control weeds.

The WCROC horticulture department has extensive experience in planning, managing and coordinating research protocol for numerous plant research projects. For this project, we partnered with three grower-collaborators to replicate plantings: Little Hill Berry Farm in Northfield, MN; Tangletown Gardens Farm in Plato, MN; and Fairhaven Farm in South Haven, MN.

2017 AND 2018 RESULTS

In 2017, our yields in pounds per acre were lower compared to recorded yields since 2013. The spring planting date of these day-neutral strawberries was average and the plants appeared healthy. Plant loss might have been from dormant strawberry plants being stored at temperatures that encouraged growth before planting.

The strawberry harvest was 2 weeks shorter in 2017 when compared to cumulative data from 2013 to 2016. This factor could reduce cumulative yield. Although the strawberry yield was lower than we anticipated, berry quality and size were rated good to excellent (Table 1).

TABLE 1. Comparison of two within-row mulching treatments two day-neutral strawberry varieties in 2017 and 2018.

Cultivar	Yield (lb/plant)		Cumulative Yield (lb/A)		Berry Weight (g)	
	White-on-black Plastic	Biode-gradable	White-on-black Plastic	Biode-gradable	White-on-black Plastic	Biode-gradable
Portola 2017	0.69	0.42	12,628	7,580	18.1	14.6
Albion 2017	0.41	0.37	7,502	6,829	16.1	15.7
Portola 2018	0.96	0.76	17,518	13,832	14.7	14.2
Albion 2018	0.73	0.60	13,241	10,875	13.1	13.2

On average in 2017, white-on-black plastic mulch produced higher yields of larger fruit regardless of variety, but this difference was especially prominent in Portola. When examining within mulch treatments, Portola showed significantly higher yields and larger fruit than Albion in traditional plastic mulch, but these differences did not appear in biodegradable mulch.

In 2018, the data suggests a significant difference between varieties and a barely significant difference between mulches. In general, white-on-black plastic mulch yielded more strawberries over the course of the season when compared with biodegradable plastic mulches. Portola produced significantly more than Albion, even when using the biodegradable plastic mulch (Table 1).

In summary, in 2017 and 2018 the white-on-black plastic mulch had higher strawberry yields in pounds per acre than the biodegradable mulch. In 2017 the white-on-black plastic treatment had 2,860 more pounds per acre and, in 2018, had 3,027 more pounds per acre than the biodegradable mulch treatment.

Hourly temperature was recorded at the WCROC site in 2017 and 2018 using WatchDog A-Series data loggers in the low tunnel beds. The data loggers were suspended 12 inches above both beds and recorded temperatures from early June until early October in 2017 and 2018. We wanted to know if there were any differences in the low tunnel with either the black biodegradable plastic or the white-on-black plastic mulch. There were no significant differences in temperatures either year between the biodegradable and the white-on-black plastic mulch.

We were cooperating with three farmer-cooperators on this project. At each site, we installed and planted two 100 foot rows of low tunnel day-neutral strawberries. One row was covered with standard white-on-black plastic mulch, while the other was covered with Bio360 biodegradable mulch. Through these partnerships we were able to expand our outreach not only to a broader range of producers, but to their customers as well.

Harvested Albion day-neutral strawberries.

Little Hill Berry Farm

Little Hill Berry Farm in Northfield, MN offers certified organic, pick-your-own blueberries. Their first year growing strawberries was in 2017. In addition to the installation of two 100 foot rows of low tunnel day-neutral strawberries, they also installed an additional eight rows of strawberries for their pick-your-own operation. Based on their experience with this growing system, they offered their own successes and challenges.


White on black plastic mulch treatment during strawberry harvest.

2017

Successes: "We've received positive feedback from customers on the taste and size of the strawberries. During picking, customers found it easy to see the berries. In a typical June-bearing system, there is abundant foliage which can make finding the berries a bit more challenging. Day-neutral strawberries tend to have less foliage, making it easier to find the berries. The plastic that went over the hoop structure of the low tunnels held up well in rain and wind. One of the in-row mulch treatments had biodegradable black plastic mulch (Bio360), which held up well. We did not notice any differences in yield or vigor of the plants compared to the standard white-on-black plastic, which was the second treatment. Overall, we really like the system and plan on growing more day neutral strawberries next year."

Challenges: "We did experience disease and insect pressures. Portola had some leaf disease issues, and we did have spotted wing drosophila under the tunnels. On our farm, we had more spotted wing drosophila in the tunnels than in the rows without the tunnels. The winter rye cover crop, which was planted in between the rows for weed suppression, grew well until the end of July. After that, the rye died out and the weeds took over. This didn't affect our strawberry quality, but made for unsightly walk-ways."

2018

Successes: From the positive relationship and feedback we received from Little Hill Berry Farm in 2017, they moved forward with numerous additional rows of day-neutral strawberries on their farm in 2018.

Challenges: "The two demonstration rows of day-neutral low tunnel strawberries we installed and planted together for some reason did not do well in 2018. Excessive amounts of rain more than likely led to poor production this growing season." Note: With Dr. Poppe's permission they removed those rows in mid-September.

Tangletown Gardens Farm

Tangletown Gardens Farm is an integrated biological farm that incorporates plants and animals in a symbiotic environment that allows each to thrive in Plato, MN. They have a 70 member CSA program as well as Tangletown Gardens and Wise Acre Eatery in Minneapolis.

2017

Successes: "The low tunnel system was the most productive method for growing strawberries at Tangletown, as compared to three other methods. In both quantity and quality, the low tunnel day-neutral strawberries out-performed berries from the other growing methods. The white-on-black plastic mulch produced significantly more strawberries than the black biodegradable plastic (Bio360). We had very little insect damage and, as of mid-August, had not applied any pesticide."

Challenges: "We did experience some minor damage to the plastic that goes over the hoops of the low tunnel. Most of this was due to the fact that we had not rolled up the sides properly at installation, which caused pooling of water. From a timing standpoint, we did not mow the cover crop early enough which may have prevented the strawberry plants from getting full sun for part of the summer. It also meant that we had to go through later and hand pull the weeds that were growing up against the plastic mulch, which is quite labor intensive."

2018

Successes: "We found that the Strawberry Low Tunnel Growing System had many benefits over our field grown strawberries. The system offered better weed and moisture control, while also extending the harvest period. We are enthusiastic about what this system has to offer growers in Minnesota!"

Challenges: "The low tunnel system required more hands-on management throughout the season."

Fairhaven Farm

Marsha Anklam and David Macgregor own and manage Fairhaven Farm, South Haven, MN. They sell their fruit at local farmer's markets and use the berries for jam production. They made the complete switch from growing June-bearing varieties to day-neutral varieties based on their success with the low tunnel system. 2018 marks the fourth year we've partnered with them on the low tunnel system.

2017

Successes: “Charged $6.00 per quart for u-pick customers with no complaints about price. Sold out every time at farmers market. Day-neutrals worked well for jam.

Challenges: “Leaf disease was prevalent on Portola strawberry variety and had to be sprayed with fungicide in early to mid-August. Portola strawberry variety was productive, but had poor flavor. Albion variety had excellent flavor. Spotted wing drosophila and tarnished plant bug were not bad but required five applications of insecticide including Spinosad, Malathion and Assail.

2018

Successes: “Noticed more fruit on the white-on-black plastic mulch treatment early in the season and more noticeable fruit on the biodegradable plastic mulch towards the end of the season. Removed strawberry runners and flowers - up until July 1. Strawberry picking started about the last week in July. Selling at the Annandale farmers market for $4.00 per pound. Good customer comments, repeat customers, and always sold out. Makes just as good a jam as June-bearing strawberries. Much more reliable production with this day-neutral system than June-bearers. Timing of the sales in August and September work great. The low tunnel sides were always left down to prevent deer browsing damage.”

Challenges: “Winter rye planted in-between strawberry rows didn’t germinate well and had numerous weeds. Had botrytis/grey mold fungal issues on fruit. Production was about the same as 2017 but not as productive at the end of the season.”

MANAGEMENT TIPS

1. In 2017 and 2018 the spring planting date of these day-neutral strawberries was around mid-May and the plants appeared healthy. Initially, there was some plant loss. These losses were replaced with new dormant strawberry plants. We have learned that after plants are received from the strawberry plant nursery, storage temperatures should be at 28 degrees Fahrenheit for optimum storage conditions.

2. In 2017 and 2018 with the cooler fall weather, we kept the sides of the tunnel down to increase temperatures under the low tunnels and to provide a more desirable environment for strawberry productivity. Between 75-85 degrees Fahrenheit is optimum temperature for growth and productivity. There are ventilation holes on the sides of the low tunnel plastic which allow adequate ventilation of warm air.

3. If the temperatures under the tunnels start to rise above 85-90 degrees Fahrenheit, you need to manually lift the sides of the tunnel. In the past, this process has been quite labor intensive because we lifted the plastic at every hoop. However, in 2018, we tried a new method of raising the sides where we only lifted the plastic every 6th or 7th hoop, or at approximately 30 feet (per 100 foot row). This method worked really well and the plastic stayed up, offering adequate ventilation. This method takes about 10 minutes for our 1,000 feet of tunnels.

4. The winter rye, which was planted in May 2017 and 2018 as a cover crop in between the strawberry rows, failed to provide adequate cover to suppress weeds for the entire growing season. By mid-August, the winter rye had died off, which allowed weeds to take over between the rows. Our best guess is that the winter rye had met its reasonable life expectancy and died off naturally. Even though fruit quality and quantity were not affected by the weeds between the rows, we are reevaluating the use of winter rye as a weed suppressant.

COOPERATORS

Emily Hoover, U of M, Department of Horticultural Science, St. Paul, MN

Nathan Hecht, U of M, Department of Horticultural Science, St. Paul, MN

Rachel Brockamp, U of M, West Central Research and Outreach Center, Morris, MN

Alexandra Carroll, U of M, West Central Research and Outreach Center, Morris, MN

Aaron Wills and Molly McGovern Wills, Little Hill Berry Farm, Northfield, MN

David Macgregor and Marsha Anklam, Fairhaven Farm, South Haven, MN

Dean Englemann Tangletown Gardens Farm, Plato, MN

PROJECT LOCATION

University of Minnesota West Central Research and Outreach Center: From Morris, go 1 mile east on State Highway 329.

Tangletown Gardens Farm: From Norwood Young America, go 6 miles west on State Highway 212. Turn right onto County Road 9. The farm is on the left.

Little Hill Berry Farm: From Northfield, go north on MN Highway 3 for 2.5 miles. Turn left on 320th Street West. The farm is ½ mile on the left.

Fairhaven Farm: From Saint Cloud, take County Road 136. Turn right on County Road 7 in Fairhaven Township. Turn left on 51st Avenue.

OTHER RESOURCES

Burst, G. 2013. Tarnished Plant Bug (Lygus) Management in Strawberries. University of Maryland Extension. extension.umd.edu/TarnishedPlantBug_LygusInStrawberries

Dubois Agrinovation. 2013. What is Mater-Bi? www.duboisag.com/en/biodegradable-and-compostable-black-mulch-film-bioplus.html

Relationship of Strawberry Yield with Microclimate Factors in Open and Covered Raised-Bed Production. 2017. Vol. 60(5): 1511-1525. American Society of Agricultural and Biological Engineers ISSN 2151-0032. doi.org/10.13031/trans.12371

University of Minnesota Fruit Research. fruit.umn.edu/

Updates on strawberry research and other fruit production research are posted regularly. Includes links to additional information on the University of Minnesota Extension. extension.umn.edu/

University of Minnesota West Central Research and Outreach Center. wcroc.cfans.umn.edu/

Tomato Productivity in High Tunnels

PRINCIPAL INVESTIGATOR
Andrew Bernhardt
The Good Acre
1790 Larpenteur Avenue West
Falcon Heights, MN 55113
andrew@thegoodacre.org

PROJECT DURATION
2018 to 2020

AWARD AMOUNT
$23,558

STAFF CONTACT
Cassie Dahl

KEYWORDS
grafting, high tunnel, tomato

PROJECT SUMMARY

The goal of this project is to increase yield and quality in high tunnel tomatoes. We are looking at three factors used in production and will assess their benefits. First, we are using sap analysis to monitor fertility needs throughout the season, so we can apply a custom fertility regimen based on the sap results. Second, we are going to compare grafted and non-grafted tomato plants for yield differences. Lastly, we will grow two varieties, Arbason and Caiman, and look at the differences in fruit quality and yield. We will be growing tomatoes at The Good Acre and on Sogn Valley Farm.

PROJECT DESCRIPTION

As the Grower Support Specialist for The Good Acre, I spend a lot of time on farms. Many farmers have taken advantage of the funding from the Natural Resources Conservation Service's Environmental Quality Incentives Program for high tunnels and have been using them for several years. Tomatoes are the most common crop that farmers are growing in their high tunnels, but the fertility, varieties, and growing methods vary widely. Many tunnels could be more productive than they are. Improving growing practices and maintenance of the tomatoes could potentially double yields.

One factor that seemed to be affecting everyone's yields was having adequate fertility throughout the growing season. Most farmers rely on a pre-plant application of fertilizer and/or compost to get them through the season. When growing in an expensive structure and expecting maximum production, it is difficult to apply enough fertility prior to

Caiman tomatoes grown in a high tunnel at The Good Acre.

planting, while preventing unnecessary vegetative growth from applying too much. Excessive fertility can also create insect pest problems such as aphids. A few farmers will do a later fertilizer application, but in a structure where it never rains it can be a challenge to get it to the roots.

Some farmers are taking advantage of a new technique called sap analysis. It provides detailed plant sample information throughout the season, and the farmers can adjust their drip-line fertigation based on that. Since our tunnels and those of Sogn Valley Farm are both managed organically, it presented some special challenges, in particular, how to get liquid nutrients through our drip lines. But recent developments in the quality of the National Organic Program-compliant macro and micro nutrients suspended in liquids are just starting to show up on the market.

I also wanted to look more closely at grafted tomato plants in the high tunnel, having heard from numerous growers on the East Coast that they have seen improved yields of 20-30% with grafted plants. Sogn Valley Farm grew grafted plants exclusively in their tunnel. There were two varieties grafted to Estamino rootstocks: Arbason and Caiman. At The Good Acre we grew grafted and non-grafted versions of two different varieties. Arbason and Caiman were grafted to Estamino rootstocks, and we grew Arbason and Caiman normally.

For spacing we had all plants in rows that were 18” apart with 24” between plants at The Good Acre and we pruned them to one leader. For Sogn Valley, we pruned to two leaders and had plants in 18” rows with plants 48” apart.

Dosatron assembly for fertigation at The Good Acre.

During the 2018 growing season we sampled plant leaves every two weeks and sent them in for sap analysis. Fertility applications were adjusted based on the results we received, and we recorded harvest quantity and weight data for all of the plants in our trial. Only number 1 quality fruit was recorded, since that is where it's most important to see results.

RESULTS

The results from the first year of this demonstration were mixed. In The Good Acre tunnel, we grew Arbason and Caiman plants and looked at differences in fertility and grafted versus non-grafted plants. The grafted versus non-grafted plants had some clear results. For the variety Arbason, the grafted plants yielded 50 percent higher than the non-grafted. However, there was variation in fertility where the non-grafted Arbason were planted, so I don't think the benefit of the grafted plants was as significant as the data showed. The variety Caiman saw over a 16 percent yield increase for the grafted plants, which seems more accurate. A 16 percent yield increase could generate $2,000 of additional income in a 30' x 96' tunnel; more than paying for the additional cost of grafting the tomato plants.

The fertility treatment results were less conclusive. We used the sap analysis to determine our fertility treatments. At The Good Acre we saw a 17 percent yield increase for the Caiman grafted plants, but saw an 18 percent yield decrease for the Arbason grafted plants.

At Sogn Valley Farm where all plants were grafted, the Arbason showed some benefit to fertigation. With the routine fertigation of 3-2-3 N-P-K, we saw a 22 percent yield increase over no fertigation. However, the custom treatment based on the sap analysis had a yield increase of 12 percent over no fertigation. The Caiman, however, showed no measurable difference between the three treatments. This may suggest that some varieties are more responsive to fertigation, but as we saw in The Good Acre tunnels, Caiman showed more responsiveness to fertigation, not less.

We also found that it would be wise to start fertigating much earlier in the season than you think you need to. Some of the benefit from fertigating with 3-2-3 resulted from beginning that fertigation regimen earlier in the season than the custom fertigation. Because, in order to use the custom blend we had to wait for the sap analysis results to determine what it would be. For the second year of the project we will start earlier with the custom blend.

If you are going to use grafted plants, use a two-leader pruning system in order to need half as many plants. Costs for grafted plants are high and grafting them yourself is challenging. Sogn Valley used a two-leader system, which is why their per-plant yield was more than twice as The Good Acre. Overall yield on a square footage basis was similar, but with half as many expensive rootstock seeds to purchase and graft. It seems like the best choice.

MANAGEMENT TIPS

1. Have fertigation protocols start at the same time. It might be wise to start fertigation earlier in the season than you think you need to.
2. Prune plants to have two leaders to increase yields. You'll need fewer expensive rootstock seeds and yields per square foot remains the same with half the plants.
3. Use a barrel and sump pump for fertigation.

COOPERATORS

Sogn Valley Farm, Cannon Falls, MN

PROJECT LOCATIONS

The Good Acre, Falcon Heights, MN. From the corner of Snelling Avenue and Larpenteur Avenue head west 0.4 miles to the site on the south side of Larpenteur. The high tunnels are located at the back of the property.

Sogn Valley Farm, Cannon Falls, MN. From the intersection of US Highway 52 and County 24 Boulevard, take County 24 West (South) for 5.6 miles to County 57 Boulevard. Take a left on County 57 for 0.6 miles to 360th Street. Go left on 360th Street for 0.5 miles to the farm at 4830 360th Street.

OTHER RESOURCES

Advancing Eco Agriculture. Sap Analysis. www.advancingecoag.com/plant-sap-analysis

Cornell University. High Tunnel Tomato Spacing. rvpadmin.cce.cornell.edu/uploads/doc_360.pdf

Cornell University. How to Graft Tomatoes. rvpadmin.cce.cornell.edu/pdf/submission/pdf155_pdf.pdf

The Dosatron assembly we used for fertigation works well, but it is expensive. A lower cost option for a high tunnel is to do your fertigating with a barrel and a sump pump, mixing up each feeding in the barrel and pumping it into the lines with just the sump pump, filter, and a pressure regulator. We chose to use the barrel and sump pump as the source of our water for the Dosatron, because, by law in Minnesota, you cannot hook a fertigation unit directly to the water supply without hiring a professional plumber and putting in expensive backflow preventers. But it turned out to be easier to mix some of the custom fertigation directly in the barrel and bypass the Dosatron altogether.

Testing of a Non-traditional Process for Cleaning and Sorting Minnesota Wine Grape Varietals

PRINCIPAL INVESTIGATOR

Arlyn Wall
KISS LLC dba Brookview Winery
6772 90th Street
Milaca, MN 56353
320-420-4794
Mille Lacs and Stearns Counties

PROJECT DURATION

2018 to 2020

AWARD AMOUNT

$25,000

STAFF CONTACT

Erin Connell

KEYWORDS

fruit processing, harvest capacity, multicolored Asian beetle, wine grapes

PROJECT SUMMARY

Due to the invasive multicolored Asian beetles and early growing season frosts, a more advanced sorting and cleaning method is required to insure harvest can be completed quickly. The traditional method of picking and preparing wine grapes requires a high degree of manual cleaning and pest control with and without pesticides prior to the grapes entering the wine making process.

Modern methods used in other wine regions on non-cold hardy varieties have not been fully explored in Minnesota. These modern methods employ technology and equipment designed to maximize wine grape quality, separate unwanted waste, and potentially elevate a marginal B-rated bin of grapes into an A-rated bin. The process involves changing the order grapes are handled at the crush pad with equipment that separates traditionally combined tasks and reduces labor to sort the grapes using technology.

PROJECT DESCRIPTION

In 2017, approximately 550 grape vines consisting of 10 cold hardy varieties in 32 rows were harvested on a little over an acre of land near Milaca, MN, yielding just over 2.67 tons of wine grapes. The harvest was successful, but took 15 days to accomplish. Similar to past harvests, issues arose with pests, weather, labor, and available time around other business activities. We recognized that future winery and vineyard expansion would depend on escalating harvest and processing capacity to cost effectively increase harvest while maintaining our high quality standards.

Sorting for quality in the field and on the crush pad was a major factor to the labor needed at harvest. Proving that a better sorting method exists will allow us to expand our operation to more acres of vineyard as well as allow us to purchase grapes from outside growers and sort them at our winery to insure the quality of our wine.

A non-traditional method of cleaning and sorting the grape harvest can speed the field work component of grape harvest to reduce labor and allow us to pick the crop at the peak of ripeness. As field work is weather dependent and picking grapes off the vine in most Minnesota vineyards is a manual process, speeding up this component of the harvest is of critical importance.

Foreign material or material other than grapes can be removed at the crush pad more effectively than in the field. As we experience increasingly marginal quality loads of fruit with multicolored Asian beetles and stunted berry growth mixed with sound fruit, increasing our sorting and cleaning efficiency using technology will leave only high quality fruit for the wine maker.

Harvest input.

Minnesota cold hardy wine grape varieties can benefit from the reorganization of the cleaning and sorting process and the use of modern equipment. This could then pave the way to mechanical harvesting while also elevating wine quality with a proven cleaning and sorting method. This non-traditional method of sorting grapes is used in other wine making regions, but needs to be tested with the physical size, shape, and characteristics of the cold hardy varieties.

For the 2018 harvest, we assembled a harvest sorting line and changed the harvest process to begin testing. Originally, we were looking at a de-stemmer that used a conveyor belt and rubber fingers to gently remove grapes

Destemmer in feed and table 1 in operation.

Sorting in process on table 2.

from their stems. After talking to a few winemakers in other parts of the United States, we found that they were unhappy with the cleaning process required by these units. Some winemakers had already replaced their units with de-stemmers that use a tumbling cage with rubber finger design. These de-stemmers also boast gentle de-stemming but use their different design to accomplish the same goal. We decided to use a tumbling cage de-stemmer for our harvest process.

For other winemakers this is good news as this tumbling cage design is most available in the market place; however, the in-feed design of our de-stemmer employs no auger for gentler handling of clusters.

Our selected de-stemmer does not have an onboard crusher, a key factor in the sorting next steps. Instead of crushing the output of grape berries at this point, they drop onto the first sorting table that shakes the grapes over a wedge wire screen that eliminates underdeveloped fruit, multicolored Asian beetles, and other small debris. This first table then feeds onto a second sorting table that uses a variable speed blower to further clean the fruit as it passes through the sorting line. Ripe grape berries fall into collection lugs and the last of the underdeveloped fruit and any remaining debris get blown away by the blower. Finally, the sorted and cleaned grapes are collected for crushing.

Traditionally, underdeveloped grapes and other small debris are manually sorted or allowed to go into the winemaking process in the hopes that only a slight acidity and small amount of tannin is added to the finished wine. Cold hardy grapes already have a high acidity so eliminating these underdeveloped grapes is a benefit. Eliminating other debris helps avoid off-flavors and helps with the consistency of the product.

RESULTS

In 2017, we averaged one row of grapes harvested in nine man-hours with manual sorting in the vineyard. In 2018, we harvested an average of one row of grapes in 4.7 man-hours with sorting done on the crush pad. This is close to a 50 percent time saving. Crush pad time was also reduced as the new sorting machine and process was a step up in sizing and automation from past equipment.

In 2018, our crop yield was 3.55 tons of grapes. This was up from 2.67 tons of grapes in 2017. This is a 33 percent increase on the same number of vines. In 2018, we made some trellising changes to promote growth and stop wild turkeys from eating the low hanging grapes. We were able to harvest the rows nearly 50 percent faster, even with increased grape yields.

The vineyards include ten varieties of cold hardy grapes harvested for wine making. We found that not all of these varieties sort well. Three factors were observed in 2018 that come into play as to why these varieties don't sort well. Factors one and two were fragile fruit/thin skin and over ripeness. The Sabrevois variety is an example of

fragile fruit/thin skin that we may process differently next year instead of using the sorting line. An example of over ripeness is the King of the North variety whose harvest was delayed this season due to poor weather. Factor three is fruit size. The Louis Swenson variety has a large berry which did not allow for typical machine sorting.

Some cold hardy grapes "danced through the machine like marbles" leaving only the cleaned fruit behind. Some examples of grape varieties that sorted well are LaCresent, Marquette, Frontenac, Frontenac Gris and Prairie Star.

MANAGEMENT TIPS

1. In 2018, we switched to unvented harvest lugs for field use and transport instead of buckets and barrels/totes. For the farm's size and the number of varieties we harvest, these worked very well to gently handle the fruit. Minimal handling and re-handling the clusters was an objective and these harvest lugs worked well for this.
2. Careful attention to equipment power requirements and matching this to crush pad/site power is critical. Power requirements for mid-size to large-size wine making and harvest equipment is generally all three-phase power. We used a phase converter to change the 240v single-phase to 240v three-phase. Refitting machines motors and controls can be expensive so knowing these things up front when selecting equipment is important.
3. During harvest we purchased a digital scale and upgraded from our balance beam scale for accuracy and to speed up our readings. Having a good scale that can output a reading quickly and accurately is essential. Our new digital scale is more portable than our manual balance beam scale and provides a fast reading.

COOPERATOR

Jill Herchenhahn, Brookview Winery, Saint Cloud, MN

PROJECT LOCATION

Vineyard #1: From Princeton, go north on State Highway 1. Turn right on 90th Street. The vineyard is on the left.

Vineyard #2: From Cold Spring, go southeast.

OTHER RESOURCES

"Grapes." Minnesota Hardy, 15 Oct. 2015: www.mnhardy.umn.edu/varieties/fruit/grapes

Horton, Drew, Enology Specialist, U of M, dhorton@umn.edu

Klodd, Annie, Extension Educator, U of M Extension, kloddann@umn.edu

Minnesota Grape Growers Association: www.mngrapes.org/

White, Mike, Viticulture Specialist, Iowa State University Extension, mlwhite@iastate.edu

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

PRINCIPAL INVESTIGATOR

Anna Johnson
Keith and Anna Johnson Farm
63326 300th Street
Gibbon, MN 55335
507-240-5004
Anna.Seidl@blc.edu
Sibley County

PROJECT DURATION

2017 to 2019

AWARD AMOUNT

$17,898.50

STAFF CONTACT

Michael Greene

KEYWORDS

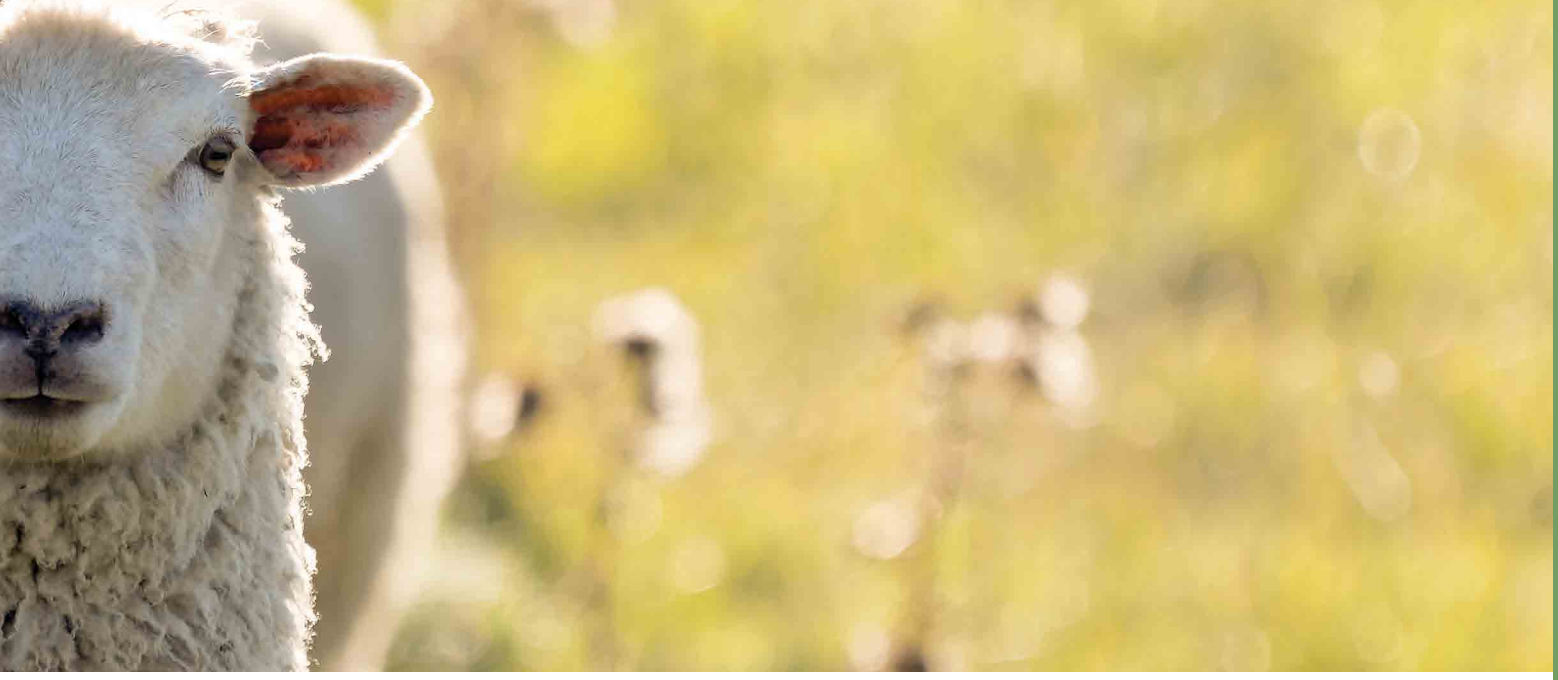
average daily gains, grazing, grazing lambs, pasture establishment costs, sheep

PROJECT SUMMARY

In the United States, ewes are often grazed, but lambs are almost always raised in feedlots from weaning to market weight. We are trying to determine the most effective pasture types for bringing lambs to market weight within the growing season. There is some research on finishing steers on pasture, but sheep have different forage preferences than steers. In the summer heat, most typical perennial pasture plants lignify, reducing digestibility which results in slower lamb growth and, ultimately, reduced profitability. Energy is also considered one of the most limiting factors to weight gain on pasture. With these factors in mind, along with our observations of what sheep prefer to eat, we designed three different pasture mixes that were grazed during July and August. Lambs were weighed to determine which mixes maximized average daily gains.

PROJECT DESCRIPTION

While we have rotationally grazed a few sheep for a number of years, 2018 marked the sixth lambing year where we have become more serious about growing our flock and raising sheep profitably. Well-managed, rotationally grazed pasture can have excellent water infiltration, leading to less runoff and more even manure distribution across the land. This results in better utilization of nutrients. In addition, well-managed pastures can act as a net carbon sink. We have achieved average daily gains, similar to those seen in feedlots, in our lambs rotationally grazed on our improved pastures. However, this primarily only occurs through mid-July at the latest. Looking at the numbers, if the lambs were born in mid-April and they maintained the 0.75 pounds



per day average daily gain that we see in June, they could reach the market weight of 120 pounds by the first part of September. Bringing the lambs all the way to finished market weight has the potential to maximize income, as opposed to selling them as feeder lambs. Additionally, lambs finished on pasture could potentially be sold for a premium at specialty markets, as they would be 100% grass-fed, with all the associated health benefits of grass-fed meat.

If lamb weight gain on pasture can be improved so they reach finished weight in September when pasture growth slows, most or all the lambs (potentially 2/3 of the animals) could be removed from the pasture and the remaining ewe flock could graze longer into the fall and early winter. This would reduce ewe feeding costs by decreasing hay usage. Raising lambs on pasture is also potentially more family-friendly, as feeding time is spent out in the pasture and even young children can tag along and help while parents are moving polywire. This reduces the use of tractors and feed mixers, and later manure spreaders, to feed and care for the animals. The annual pasture in particular can also add a different "crop" in the rotation if the farm also raises row crops, which can help break up disease cycles and increase profitability in those enterprises.

Sheep grazing in the non-lignifying pasture.

Our thought was that the decrease in weight gain starting in mid-July may be due to lignification and decreased digestibility of most pasture plants. This study aims to test different pasture types to determine if there is some forage combination that will maintain high average daily gains on pasture through the growing season. We designed three different pasture types to try to maximize average daily gain and profitability. The first pasture type was a diverse annual pasture, heavy on peas and oats, but including a total of 21 different species (Table 1). The thought behind this mix was that both the diversity of plants and the selection of particularly sheep-palatable plants would encourage maximum dry matter intake, leading to high average daily gains. The second mix

had a heavy component of chicory and white clover (Table 2), plants that are known to not lignify even in summer heat. The third pasture (self-harvested grain pasture) was planted in two distinct strips that were meant to be rotationally grazed together: one wide strip of alfalfa and one narrower strip of oats that was allowed to mature to grain (Table 3). As the fence was moved forward every two days, the sheep would get a new portion of oats to self-harvest balanced with the protein in the alfalfa, ideally making a nicely balanced ration. The flock was divided into four groups, one in each pasture type with the fourth group used as a control, rotationally grazed on our regular perennial pasture and weighed like the other groups.

We gathered data to, in the end, determine the profitability of the different pasture types. One of the expenses that affects profit per acre is the cost of pasture establishment. The establishment costs used in Tables 5 through 8 assume that the annual pasture has a lifespan of one year, the non-lignifying pasture 4 years, the self-harvested grain pasture 4 years for the alfalfa portion and 1 year for the oats portion, and the perennial pasture 10 years.

The diverse annual pasture, the non-lignifying pasture, and the grain finishing pastures were planted on May 8, May 10, and May 7, 2017, respectively. In 2018 the diverse annual pasture was planted on May 8. A grain drill was used to plant the oats and the larger seeds, and a Brillion seeder was used for the smaller seeds. Seeding details and prices for the three mixes are in Tables 1, 2, and 3. Due to a large amount of competition from green and yellow foxtail grass in half of the non-lignifying pasture, this half was mowed at a height of 3 to 5 inches on June

TABLE 1. Seeding details for the diverse annual pasture.

Species	Cultivar	Lb/A	Cost/lb	Cost/A	Total Cost
Peas	4010	50	$0.38	$19.00	$104.50
Forage Oats	Everleaf 126 Forage	32	$0.39	$12.50	$68.75
Hairy Vetch	VNS*	3	$1.60	$4.80	$26.40
Lentils	VNS*	2	$0.90	$1.80	$9.90
Common Vetch	VNS*	2	$1.00	$2.00	$11.00
Sunflowers	Peredovik Black Oil	0.75	$0.60	$0.45	$2.48
Cowpeas	Iron and Clay	2	$0.88	$1.76	$9.68
Grazing Corn	Blue Open Pollinated	4	$2.00	$8.00	$44.00
White Sweet Lupin	VNS*	2	$1.62	$3.24	$17.82
Red Clover	Medium	1.75	$2.80	$4.90	$26.95
Italian Ryegrass	Tetilia	10	$0.90	$9.00	$49.50
Turnips	Purple Top	0.5	$1.60	$0.80	$4.40
Turnip/Kale	Winfred Hybrid	0.25	$4.68	$1.17	$6.44
Rape	Dwarf Essex	0.25	$1.10	$0.28	$1.51
Kale	VNS*	0.25	$4.60	$1.15	$6.33
Sweet Clover	VNS*	0.25	$1.50	$0.38	$2.06
Balanza Clover	Fixation	0.75	$2.50	$1.88	$10.31
Crimson Clover	VNS*	2	$1.28	$2.56	$14.08
Sorghum-sudan	Viking 200 BMR	4	$0.96	$3.84	$21.12
Sugar Beets	VNS*	0.75	$6.50	$4.88	$26.81
Radishes	Tillage	0.5	$1.60	$0.80	$4.40
			TOTALS	$85.17	$468.44

*VNS = Variety not stated.

TABLE 2. Seeding details for the non-lignifying pasture.					
Species	Cultivar	Lb/A	Cost/lb	Cost/A	Total Cost
Chicory	VNS*	3	$7.20	$21.60	$118.80
Plantain	Tonic	2.3	$5.85	$13.46	$74.00
White Clover	Alice Grazing/ Ladino	4.6	$5.84	$26.95	$148.25
Alfalfa Coated 66% Pure	Foregrazer	3.3	$4.40	$14.67	$80.67
Red Clover	Medium	1	$2.80	$2.80	$15.40
Meadow Fescue	HDR**	7	$2.60	$18.20	$100.10
Festulolium	Spring Green	5	$1.94	$9.70	$53.35
Orchardgrass	High Leaf Ratio	1	$3.88	$3.88	$21.34
Timothy	Barpenta	2	$2.86	$5.72	$31.46
			TOTALS	$116.98	$643.37
*VNS = Variety not stated. *HDR = High yielding, digestible, and disease resistant.					

21, 2017. We hoped this would encourage growth of the desired species. Canada thistles in all the plots were spot sprayed as necessary to avoid flower and seed production.

For the 2017 season, there were 81 lambs and 56 ewes that were part of the experiment. Lambs were weighed on June 29, 2017 at an average of 73 days old. For the 2018 season, 111 lambs and 67 ewes were part of the experiment. In both years, average daily gain was calculated for each lamb. Because the lambs would be left with their mothers and to avoid splitting up families, the average daily gains of the lambs were assigned to each mother, averaging between twins as necessary. The mothers were arranged in order of average daily gain of their lambs and randomly assigned to four groups. Groups were adjusted as necessary to have a similar number of lambs, ewes, and average daily gains.

In 2017, grazing was initiated on the diverse annual pasture on July 12 and on the non-lignifying pasture and the grain finishing pasture on July 22. In 2018, grazing was initiated on the diverse annual pasture and the non-lignifying pasture on June 27, with lambs at an average of 55 days old. Grazing was initiated on the self-harvested grain pasture on July 21, with lambs at an average of 79 days old. In both years, each group was moved every 2 to 3 days throughout the study period, depending exactly on forage consumption. Every attempt was made to keep all the groups on the choicest forage available in their respective pastures and not to force them to eat too much course/undesirable forage.

In 2017, all lambs were weighed before beginning the treatments and again at the end, on approximately August 16. Additionally, the lambs on the diverse annual pasture and the non-lignifying pasture were weighed partway through to distinguish potential differences in gains as the forage composition changed. In the diverse annual pasture, the oats and the peas matured to grain partway through, so the lambs ended up eating a significant portion of grain in their diet instead of just forage. In the non-lignifying pasture, due to previous cropping history, approximately half of the plot was very thick with green and yellow foxtail grass, while the other half had less foxtail, but instead was thick with lamb's quarters, water-hemp, and giant ragweed. The third pasture planted, the grain-finishing pasture, was not ready to graze in the same time frame as the annual and non-lignifying pastures, so the group that should have grazed that pasture were combined with those grazing the non-lignifying pasture.

TABLE 3. Seeding details for the self-harvested grain pasture					
Species	Cultivar	Lb/A	Cost/lb	Cost/A	Total Cost
Alfalfa Coated 66% Pure	Foregrazer	13.6	$4.40	$60.00	$270.00
Ladino	VNS*	1.5	$4.00	$6.00	$27.00
Red Clover	Ruby Red	0.5	$2.80	$1.40	$6.30
Alsike Clover	VNS*	0.5	$3.80	$1.90	$8.55
Meadow Fescue	VNS*	8	$2.60	$20.80	$93.60
Orchardgrass	High Leaf Ratio	2	$3.88	$7.76	$34.92
Timothy	Barpenta	0.75	$2.86	$2.15	$9.65
Hakari Brome	Hakari	3	$3.40	$10.20	$45.90
Oats for Nurse Crop**	BetaGene	1.5	$6.50	$9.75	$43.88
Oats for Grain Portion**	BetaGene	3	$6.50	$19.50	$19.50
			TOTALS	$139.46	$559.30
*VNS = Variety not stated. **Measurements and dollars for oats are by the bushel instead of pounds.					

For 2018, data were collected similarly, with all lambs weighed before the treatment, partway through, and again at the end, on approximately August 15. The exception was the lambs in the self-harvested grain pasture, which were weighed only at the beginning and end due to the speed that they ate through the pasture and the timing when grazing was initiated.

2017 AND 2018 RESULTS

Lamb weight gain data in 2017 and 2018 is summarized in Table 4. In 2017, the final weights of the lambs at the end of the study period were greatest in the diverse annual pasture (93 pounds), followed closely by the non-lignifying pasture (90 pounds), with the perennial pasture lambs being the smallest (89 pounds) by a slim margin. This trend mostly repeated itself in 2018, except there was only a 1-pound difference between the diverse annual lambs (79 pounds) and the non-lignifying lambs (80 pounds). Additionally, the lambs in the self-harvested grain pasture were similar at 81 pounds. With the high average daily gains of the lambs in the self-harvested grain pasture, these lambs should be significantly heavier than those in either of the other pasture types, however, because of the shorter grazing window of these lambs on this pasture, the difference in final weight was not magnified as much as it should have been. Ultimately, more data is needed to conclude that the trends we saw are repeatable.

The lambs in the late perennial pasture were an average of 5 pounds lighter than those in the non-lignifying pasture group in 2018. This would become significant to the producer if there were, for example, 100 lambs or more to sell, as the total sale weight would be much lower and therefore less profitable. The greater difference between the perennial pasture and the other pasture types was likely partly due to the warmer temperatures in 2018. Higher temperatures affected average daily gains in two ways: heat reduced forage consumption, animals were simply too hot and uncomfortable to get up and eat; and many plants lignified when the temperatures are too hot, making them less digestible.

TABLE 4. Summary of 2017 and 2018 lamb weight gains.					
Pasture	Avg. lamb age (days)	Avg. weight of lambs end of period normalized*	Cost/lb	Cost/A	Total Cost
2017 Control - Early Perennial	73	67	0.72	10	153
2018 Control - Early Perennial	55	49	0.69	12	169
2017 Control - Late Perennial	118	89	0.66	6	74
2018 Control - Late Perennial	102	75	0.56	7	79
2017 Diverse Annual	122	93	0.73	8	118
2018 Diverse Annual	94	79	0.65	10	129
2017 Non-lignifying	124	90	0.72	11	157
2018 Non-lignifying	104	80	0.65	10	127
2017 Self-harvested Grain	No data collected in 2017				
2018 Self-harvested Grain	94	81	0.80	8	125

*The different pasture types ran out at different times, so the final weights were collected at different dates and lamb ages. To correct for that and better allow comparison between the different pasture types, the final lamb weights in 2017 were extrapolated to a lamb age of 122 days (using their respective average daily gains) and those in 2018 were similarly extrapolated using a lamb age of 102 days. These extrapolations were not performed on the early perennial pasture, as that is a separate comparison.

**Because the groups were slightly different sizes, this was normalized for 20 lambs with their mothers to allow comparison between the pasture types.

Across all pasture types, average daily gains were greater in 2017 than in 2018. However, the differences seen between the pasture types in 2017 were seen again in 2018. In both years, the diverse annual pasture produced average daily gains that were almost identical to the average daily gains achieved on the non-lignifying pasture. These average daily gains were very similar to the average daily gains achieved on the early perennial pasture in their respective years. The lambs in the late perennial pasture had average daily gains that were less than those lambs in the diverse annual and the non-lignifying pastures. The data collected on the self-harvested grain pasture suggests that high average daily gains are attainable on this particular mix; however, more data should be collected before this is concluded.

The total pounds gained per acre is a good way to assess the yield per acre of the different pasture types and to assess profitability (Table 4). In 2018, with all the pastures fully established, lamb pounds gained per acre were very similar between the diverse annual (129 pounds), the non-lignifying (127 pounds), and the self-harvested grain (125 pounds) pastures. None of the pasture types matched the higher pounds gained on the lambs in the early perennial pasture. The early perennial pasture data reflects the spring flush, when both yield and quality are high. Curiously, the non-lignifying pasture in the establishment year was the only one to match the spring flush pastures in pounds gained on the lambs. By casual observation, this pasture almost appeared to be a failed seeding in 2017, as the weed pressure was so high, and these weed species made up a considerable portion of the lambs' diet. While additional data would be necessary to conclude that this is a real phenomenon, our data suggest that these annual species, with some chicory, plantain, and alfalfa mixed in, make quite good lamb gains and yield per acre.

The overall profitability of the various pasture types must be considered. This is as complex as the farm system that exists on each individual farm. For example, the diverse annual pasture had the highest average daily gains

on the lambs and some of the heaviest lambs to sell, but the profit per acre from the lambs was only $78 and $95 (Table 5), mostly because the lambs grazed the pasture once per season and seeding costs are high because it needs to be planted every year. In contrast, the perennial pasture had the lowest average daily gains for July through August, but the season-long profitability from the lambs was $744.30 and $784.20 per acre for 2017 and 2018, respectively (Table 6). This is likely due to the fact that perennial pasture can be grazed four to five times each year, and with a life-span of 10 years, seed and planting costs are minimal. However, it must be considered that it will ultimately take more days and, therefore, more acres for the lambs to achieve finished weight at an average daily gain of 0.66 pounds per day versus 0.73 pounds per day. (This is mostly due to the maintenance requirements of the animals. Most of the forage consumed each day goes to maintaining the animal and only a small percentage goes towards gaining weight). So, if a 120 pound lamb is the producer's goal, it may be more profitable over the life of the lambs to use an annual pasture that uses the fewest acres to feed the lambs and achieves higher average daily gains during key parts of the year. This strategy can also optimize profitability per acre. If the goal of the producer is to sell feeder lambs off of the pasture from mid-August to September, the perennial pasture can be fairly profitable with minimal pasture establishment hassle.

It is also important to consider how something such as the annual pasture may lead to increased profitability for the farm as a whole. If the sheep producer also raises corn and soybeans, this annual pasture can add a third "crop" to the rotation. With its diverse mix of species, including nitrogen-fixing legumes, it could increase soil health and fertility to the extent that fewer purchased inputs would be needed for the following corn crop, increasing profitability in that crop.

TABLE 5. Diverse annual pasture profitability – 2017 and 2018.

	July Actual 2017 1st grazing	Aug-Sept Actual 2017 2nd grazing	July Actual 2018 1st grazing	Aug-Sept Approximate 2018 2nd grazing
Lamb weight gain (lb/A)	118		129	
Value of lamb (lb x $1.50/lb)	$177.00		$193.50	
Seed cost ($/A)	$85.17			
Seed cost ($/A/Yr)	$85.17	$85.17	$85.17	
Planting + disking cost ($/A/Yr)	$13.00		$13.00	
Total cost of pasture ($/Yr)	$98.17		$98.17	
Profit ($/A)	$78.83		$95.33	
Dollars not spent on ewe feed per acre*	$31.32	$70.00	$36.10	$70.00
Total dollars not spent on ewe feed*		$101.32		$106.10
Total value of the pasture minus expense		$180.15		$201.43

* Ewe feed was valued at $9 per month per ewe, determined from our winter-feeding experience, for all of the pastures.

The non-lignifying pasture has the unique advantage of high average daily gains in the lambs and minimal planting costs, as the stand should last at least 4 years, adding to its profitability (Table 7). We also observed that parasite pressure from barber pole worms was less in the lambs that grazed the non-lignifying pasture (as assessed using FAMACHA, a system of determining anemia, and therefore parasite pressure, by observation of the color of the inner eyelids). Other research suggests that the condensed tannins in chicory can inhibit barber pole worms and this is perhaps the effect that we saw in our lambs in 2018. As a perennial pasture, it can also increase soil health beyond what any annual pasture can because fungal soil communities can establish and flourish as annual tillage is unnecessary. We feel that this pasture offers a great balance between maximizing average daily gains and soil health, while minimizing planting labor.

The self-harvested grain pasture shows promise for maximizing average daily gains and overall profitability (Table 8); however, data collection was limited due to various weather circumstances and we don't feel confident drawing any conclusions. In the seeding year (2017), establishment was slow due to dry conditions in the early spring and, in 2018, excessive snow in April delayed first cutting and made it difficult to time grazing

TABLE 6. Perennial pasture profitability – 2017 and 2018.

	May Actual 1st Grazing	June Actual 2nd Grazing	July Actual 3rd Grazing	Aug-Sept Approximate 2018 2nd Grazing	Sept Approximate 5th Grazing
2017 Lamb weight gain (lb/A)	153	153	86.7	86.7	25
2018 Lamb weight gain (lb/A)	169	169	103	65	25
2017 Value of lamb (lb x $1.50/lb)	$229.50	$229.50	$130.05	$130.05	$37.50
2018 Value of lamb (lb x $1.50/lb)	$253.50	$253.50	$154.50	$97.50	$37.50
Seed cost ($/A)	$110				
Seed cost ($/A/Yr)	$11				
Planting + disking cost ($/A/Yr)	$1.30				
Total cost of pasture ($/Yr)	$12.30				
2017 Profit ($/A)	$217.20	$229.50	$130.05	$130.05	$37.50
2018 Profit ($/A)	$241.20	$253.50	$154.50	$97.50	$37.50
2017 Total profit ($/A)					$744.30
2018 Total profit ($/A)					$784.20
2017 Dollars not spent on ewe feed ($/A)*	$42.29	$42.29	$30.00	$29.00	$20.00
2018 Dollars not spent on ewe feed ($/A)*	$45.00	$45.00	$32.00	$25.00	$20.00
2017 Total dollars not spent on ewe feed*					$159.58
2018 Total dollars not spent on ewe feed*					$167.00
2017 Total value of pasture minus expense ($)					$903.88
2018 Total value of pasture minus expense ($)					$951.20

* Ewe feed was valued at $9 per month per ewe, determined from our winter-feeding experience, for all of the pastures.

when the oats were ready. Timing the cuttings of alfalfa to allow enough regrowth to coincide with grazing mostly mature oats may always be difficult and may be the biggest challenge with this pasture. However, if a producer can see where this fits in his/her system, it may be worthwhile to experiment and perfect the timing.

Because our winter-feeding goal is to simply maintain the ewe and the ewes gained body condition on all pasture types, while feeding their lambs, the ewe feed values would probably be greater than presented in the tables (Tables 5 through 8). Our valuation of ewe feed is based on our winter-feeding costs (feed only, not including yardage or other expenses). In particular, the ewes on the diverse annual pasture seemed to gain the most body condition. Any time the ewes can self-harvest feed and gain body condition during the growing season increases profitability. This saves the cost of making hay and nicely fat ewes at breeding time can increase the chances of twins and triplets and maximize the lamb crop for the following year. Additionally, fat ewes going into winter do fine on lower quality feed during second trimester because they can utilize some of their back fat.

Overall, each individual producer should study our results, weigh the pros and cons of each pasture type, decide on individual overall farm goals, and evaluate where each type of pasture might fit into the larger farm system and how they might influence overall profitability. This study provides data for many different puzzle pieces that each producer can evaluate and place appropriately in his/her own system.

TABLE 7. Non-lignifying pasture profitability – 2017 and 2018.

	July-Aug Actual 2017 1st Grazing	October Actual 3rd Grazing	May-June Theoretical 2018 1st Grazing	May-June Actual 2018 1st Grazing	June-July Actual 2018 1st Grazing	Aug-Sept Approx. 2018 1st Grazing
Lamb weight gain (lb/A)	157			148	117	60
Value of lamb (lb x $1.50/lb)	$235.50			$214.50	$175.22	$90
Seed cost ($/A)	$116.98			$116.98		
Seed cost ($/A/Yr)	$38.99			$38.99		
Planting + disking cost ($/A/Yr)	$13.00			$13.00		
Total cost of pasture ($/Yr)	$51.99			$51.99		
Profit ($/A)	$183.51			$170.01	$175.50	
Total profit per acre from lamb gains	$183.51					$435.51
Dollars not spent on ewe feed per acre*	41.24	80	40	44.93	45	35
Total dollars not spent on ewe feed*		121.24				164.93
Total value of the pasture minus expense		$304.74				$552.44

* Ewe feed was valued at $9 per month per ewe, determined from our winter-feeding experience, for all of the pastures

TABLE 8. Self-harvested grain pasture profitability – 2018.*			
	June Actual 2018 1st Grazing	July-August Actual 2018 2nd Grazing	October Approximate 2018 3rd Grazing
Lamb weight gain (lb/A)		126	
Value of lamb (lb x $1.50/lb)		$189	
Seed cost ($/A)		$119.96	
Seed cost ($/A/Yr)		$49.49	
Planting + disking cost ($/A/Yr)		$3.25	
Total cost of pasture ($/Yr)		$52.74	
Profit ($/A)		$136.26	
Dollars not spent on ewe feed per acre**	$200	$28.65	$30
Total dollars not spent on ewe feed**			$258.65
Total value of the pasture minus expense:			$394.91
*No data collected in 2017.			
** Ewe feed was valued at $9 per month per ewe, determined from our winter-feeding experience, for all of the pastures.			

MANAGEMENT TIPS

1. Rotational grazing is key to success with any animals on pasture, resulting in better pasture utilization, a more balanced ration, and it allows the rest of the pasture to recover and grow. This maximizes pasture yield and carrying capacity. Tall, fully recovered plants result in deep roots leading to increased carbon sequestration, water infiltration, and drought resistance. Additionally, there is then habitat and food for birds and pollinators.

2. The barber pole worm parasite must be managed to obtain acceptable average daily gains on pasture. Chemical de-wormers cannot be fully relied upon due to decreasing sensitivity on the part of the parasite. We assess anemia in the lambs using the FAMACHA system and are then able to deworm only the lambs that need it. For lambs in particular, rotational grazing where the animals are not left in any one paddock longer than three days can help avoid parasites, particularly the barber pole worm. Barber pole worm eggs are shed by the ewes and can hatch in as little as four days if the weather is conducive, which it often seems to be in Minnesota. If the lambs are rotated out of the paddock, they cannot ingest the worm larvae. Anyone is welcome to contact us for more details on our parasite management strategies.

3. Despite what some people will say, we feel that it is important nutritionally for the lambs to remain with their mothers on pasture. Many people say that the ewes produce so little milk after 40 days or so that it is nutritionally insignificant for the lambs. However, those of our lambs that have been weaned even as late as 60 days old have done significantly worse than their peers. There is also a small body of research that suggests that the small amount of milk that is produced is high enough in fat to lead to a significant difference in average daily gain in the lambs. Our ewes gain body condition but do not become obese on our pastures mid-season, so our thought is that they must still be working hard for their lambs.

4. It was difficult to set up temporary fences through the diverse annual pasture for rotational grazing. The pea component is so viney that it is hard to walk through, much less set up a fence. Extra labor needs to be factored in when considering using this pasture type on a larger scale.

5. We used a 3-line polywire fence for all our rotational grazing. For this to work with sheep who do not feel the shock through their wool, it is essential to spend some time in the early spring training the lambs to the fence. We find that 3 millimeter black and white polywire provides great visibility, which adds to the psychological aspect of the fence. Even with all the different groups of sheep on our farm for this research, no one ended up mixing.

6. Many recommendations for grazing chicory stress the importance of not allowing the plant to bolt. In our experience, this is not important when grazing sheep. All the chicory had bolted when we grazed in 2018 and average daily gains were still quite good. Unlike cows, who must wrap their tongues around large mouthfuls of forage and pull off and consume the whole mouthful, sheep have small mouths and top teeth, and can effectively pick all the leaves and flowers off the stalk and selectively choose any choice grasses or alfalfa that are growing up between the stalks. Grazing cows is likely where the "don't let it bolt" recommendation came from.

COOPERATOR

Dr. Craig Sheaffer, University of Minnesota, St. Paul, MN

PROJECT LOCATION

From Gibbon, travel south out of town on County Road 2. Turn west on County Road 25 or 300th Street, which is the first intersection out of town. We are the first place on the north side of the road.

OTHER RESOURCES

Flack, Sarah. 2016. The Art and Science of Grazing, How Grass Farmers Can Create Sustainable Systems for Healthy Animals and Farm Ecosystems. Chelsea Green Publishing.

Gerrish, Jim. 2010. Kick the Hay Habit, a Practical Guide to Year-around Grazing. Green Park Press.

Gerrish, Jim. 2004. Management-intensive Grazing, the Grassroots of Grass Farming. Green Park Press.

Graze, PO Box 48 Belleville, WI 53508, 608-455-3311. Publication devoted to management-intensive rotational grazing and family-scale livestock farms.

Lane, Woody. 2014. From the Feed Trough, Essays and Insights on Livestock Nutrition in a Complex World. Lane Livestock Services.

Nation, Allan. 2005. Grassfed to Finish, a Production Guide to Gourmet Grass-finished Beef. Green Park Press.

Schroedter, Peter. 1997. More Sheep, More Grass, More Money. Ramshead Publishing Ltd.

The Stockman Grass Farmer. PO Box 2300 Ridgeland, MS 39158. 800-748-9808. Grazing publication devoted to the art and science of making profit from grassland agriculture.

Turner, Newman. 1955. Fertility Pastures, Herbal Leys as the Basis of Soil Fertility and Animal Health. Acres USA.

Voisin, Andre. 1959. Grass Productivity. Island Press.

Zimmer, Gary F., and Leilani Zimmer-Durand. 2017. The Biological Farmer, a Complete Guide to the Sustainable and Profitable Biological System of Farming, 2nd edition. Acres USA.

Goat Grazing During Winter in Minnesota: Ways to Control Vegetation on a Larger Scale While Saving on Supplemental Feed Costs

PRINCIPAL INVESTIGATOR

John Beckwith
Hiawatha Valley Resource Conservation and Development
63005 - 172nd Lane
Janesville, MN 56048
612-599-5864

PROJECT DURATION

$24,981

AWARD AMOUNT

$17,898.50

STAFF CONTACT

Cassie Dahl

KEYWORDS

goats, grazing, invasive species

PROJECT SUMMARY

This project evaluated winter grazing systems that maintain a healthy goat herd and provide control of invasive and undesirable plants during harsh Minnesota winters. Our overall goal was to find that this is a profitable service and meat goat enterprise. The project assessed winter husbandry challenges, including: effective electric mesh fencing, sheltering, watering, and meeting nutritional requirements. The project was 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, plus reduce the 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 10-acre parcel that serves as home base for their goat grazing 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 meat enterprise 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 Langeslags have provided support for new graziers and hope what is learned here can benefit 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 is limited. While addressing these concerns, this project has three overarching goals:

Farmer Jake Langeslag.

1. Explore the benefits and limitations of grazing goats during winter by increasing our knowledge of electric mesh fence effectiveness, water supply maintenance, and movable winter shelters. We also wanted 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 by noting their preference for certain shelters and the inside temperatures. In addition, weight change and mortality of goats were monitored.

There are also ecological considerations that need be explored. 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 willing 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 feeding on preferred native species. If these experiments work out, profitability of the grazing service will increase and a greater land area can be serviced to reduce undesirable woody plants.

2016 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.

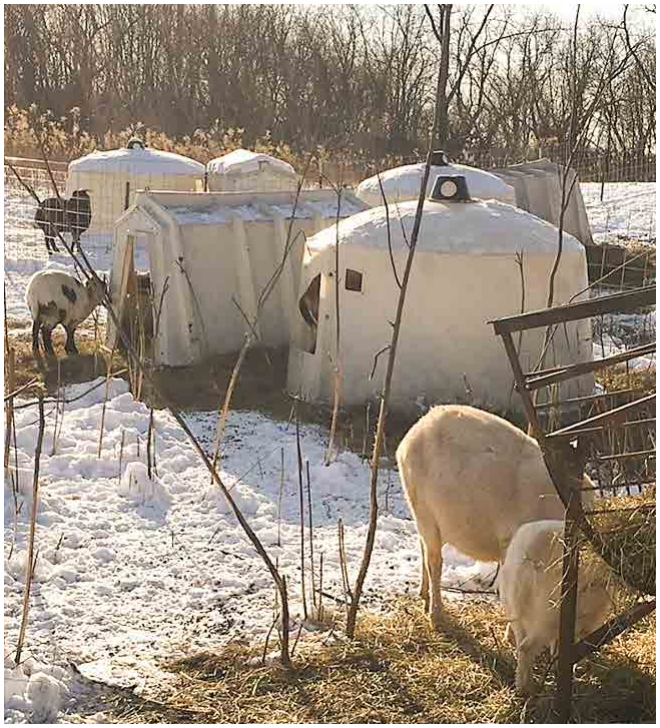
2017 RESULTS

Grazing commenced in November 2016 and continued through mid-March 2017. The goats focused on woody vegetation during this time, aggressively stripping the bark from many undesirable species, such as buckthorn. Our anecdotal observation is that 60-70% of the brush/woody plants up to 6" diameter were girdled and will not regrow above the girdled level. The Langeslag's have not seen this aggressive girdling of woody species during summer grazing. The project resulted in less supplemental feed and a shorter period when they needed to provide supplements.

The electro-net fencing contained the goats effectively, with no escapes during the entire winter. The voltage measurements did show increases and decreases with weather and flooding. We think a major factor in the lack of escaping goats is that they were exposed to the fence prior to the winter months and respected the fence.

The round poly-dome huts have benefits for animal comfort as well as ease of moving to new locations, since they are easy to slide or roll. They also maintain a comfortable and healthy temperature and humidity level. Herd health on this site was very good this year. These huts effectively protected the animals to -29°F this past winter with heat from solar gain, as well as heat from the animals.

Game cameras provided evidence of grazing and herd behavior. We intended to also show wildlife damage to the fence with the cameras, however, during this grazing cycle this was not a problem.



Goat staging area.

Cheryl Culbreath recording species within grazing area.

Winter grazing increased available food in wetter sites during frozen winter months. These sites are often avoided in other seasons. Frequent use of these sites in other seasons can also lead to health and hoof problems that do not occur with winter grazing.

Physical deterrents were used to protect some native desirable plants as well as some buckthorn, which we know are desirable foods. Steel reinforcing mesh and galvanized wire mesh, both with rebar stakes, were used; a plastic tube system was also used to protect the trunks of vegetation. Both mesh systems were effective. The lighter weight galvanized wire would be more difficult to re-use due to its flimsiness. These methods were the most costly. The plastic tubing, while less costly, was less effective, especially when placed on more palatable plants. Goats use their horns to scrape and loosen bark when eating and likewise scraped the plastic tubes off some trees.

2018 RESULTS

Upon completion of the winter grazing project we believe goats will aggressively graze the woody vegetation during winter months. We can manage that grazing to remove plants such as buckthorn or honeysuckle, while protecting desirable woody vegetation such as Nannyberry, oak, and hickory. Differences between grazed and un-grazed areas just across the fence were apparent. The goats seemed to enjoy having access to the larger landscape rather than being housed in smaller lots throughout the winter and the farmer believes this management system creates a healthier environment for the goats.

What happened this year? November and December were fairly mild with periods of no snow in December. The lack of snow allowed the goats to graze the entire 30 acre study area. Then, in January, we were very cold, the coldest in our area in 20 years. Temperatures were -32°F on the farm with a -65°F wind chill. Then we had record breaking snow fall amounts - 3 feet of snow fell at the study site in February alone.

Goats eating from a round bale of hay.

We provided the goats extra sustenance this year with approximately 350 Christmas trees and hay. The goats ate all the needles, tender branches, and some of the bark from the trees. In addition, we changed how we fed hay in the study site. When weather was favorable, we put round bales into areas of the field that were not seeing as much goat browsing. At first, we used the metal round bale feeders, but we were having problems with goats bedding down on the waste hay and not going into their calf hut shelters. And some goats were getting smothered under the feeder. Next, we tried putting the hay bale out without a feeder - just on the ground - and the goats would cluster and often bed down in the hay instead of going in the shelters. Finally, we found it was best to roll the bales out with the skid loader into open areas and then the goats would bed down in the shelters.

We had very few escapes from the site because the goats were trained or used to the electro-net fencing. This year, fencing was less necessary with deep snow, because the goats are not inclined to venture out into it. For that reason, the fence was not always powered up. In previous years we realized our electro-net fencing was a bit close to the gravel road, so we moved it further back each year. Even with moving the fence away from the road, there were 5 foot deep snow drifts over the top of the fence, due to the heavy snow fall and plows throwing a lot of snow from the road. However, we found that if you feed and bed the goats down in the center

of the pen, they didn't have a good reason to try plowing through deep snow to challenge the fence. As things started to melt, we added additional fence near the areas that were buried in the deep snow.

The round poly-dome huts are important for herd health and we discovered better ways to set them up this year. We found that, in extreme cold, it was best to double the shelters with the doors not aligned during the night. This kept the warmth in the shelter and goats could not evacuate to other huts where they might "pile on" or leave others without the benefit of shared heat. How did we try placing shelters? At first, we tried placing the calf hut shelters in an area approximately 20 to 30 feet from each other. We found that the herd would often pick a favorite hut and all try to cram in. Next, we clustered them together with doors facing different directions so different prevailing winds wouldn't go into all of them. This arrangement worked better but still not ideal. Finally, we discovered the ideal set up was a circle pattern with all the doors facing into the center. That way when one hut was full, it was easy for the displaced goats to move into the next hut. We left enough room to walk in between the huts, so we could check on the goats.

MANAGEMENT TIPS

1. Moving shelters and supplemental feed dispersed the goats away from the pens or huts, which increased the size of the grazed area.
2. If you think the grazing area will flood, consider using a stronger fence system along with raising the wires to keep them out of the water.
3. In case of flooding or fencing problems, we set up holding pens. The goats were able to move freely from the pens to the work area.
4. Use caution around goats while using a chain saw. We noticed they aggressively swarm around when we were cutting larger trees and shrubs because it gives them access to berries and tender tree tips.

COOPERATORS

Jake Langeslag, Goat Dispatch, Faribault, MN

Cheryl Culbreath, Landscape Restoration, Inc., Webster, MN

PROJECT LOCATION

From southeast Faribault take Glynview Trail SE, then turn left on 227th Street East, right at the "T", left on 230th Street SE to the site at 4640 230th Street SE.

Integrating Silvopasture Practices into Perennial Fruit Production

PRINCIPAL INVESTIGATOR
Hoch Orchard and Gardens
32553 Forster Road
La Crescent, MN 55947
507-643-6329
Winona County

PROJECT DURATION
2016 to 2018

AWARD AMOUNT
$15,000

STAFF CONTACT
Michael Greene

KEYWORDS
livestock, perennial fruit, silvopasture

PROJECT SUMMARY

The purpose of this project is to evaluate the economic potential of grazing animals in perennial fruit systems. We are installing 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 are recording the costs of installation and management of plots over 2 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 and diversified food production company. Our primary crop is apples, but we have diversified into other fruit, meat, vegetables, 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.

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

Sheep grazing in the non-lignifying pasture.

with better infrastructure. Using animals to control the ground cover can reduce energy costs and improve soil quality by increasing biodiversity.

Our initial interest in this integrated system came 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 percent shade cover at maturity due to the high forage production potential in a partial shade environment. A modern orchard creates similar environment conditions. In conventional orchard systems, the ground cover is mowed regularly, and this practice requires large amounts of fuel. We aim to achieve very high animal production potential and energy savings using this system.

The purpose of this project is more of a proof of concept rather than an evaluation of a single practice. By implementing this grazing system on our farm and recording the costs to set up, number of hours invested in care activities, and production of meat, we will be able to show the potential of the system. Other farmers will be able to see how this system worked on our farm and be able to adapt it to their own farms.

Our three objectives for this grant are:

1. Establish infrastructure;
2. Record establishment and production costs; and
3. Review the data collected about rotation with a final report on time spent and cost to raise the hogs in this system.

PROJECT RESULTS

From April to December in 2016, we recorded the time involved with feeding and watering the pigs. The pigs were rotated around the orchard using the existing 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 inch multi-species wire mesh fence to the windbreaks around

Before pigs.

After pigs.

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.

In 2017 we continued to document the time required to care for the pigs. Time was split between moving temporary fences, moving animals between paddocks, feeding/watering animals, and catching escaped animals. We started to review the data that was being collected.

We experienced two major issues in 2018 that affected the progress of our project. Our employee who was managing the animals left in March. In order to reduce our workload, we sold several of our feeder pigs and reduced the herd to 1 boar, 2 sows, 5 feeders, and 5 piglets. We put this group on pasture several times but nowhere near as much as years one and two of the project. Even though all the paddocks were not completely enclosed and the gates were not yet installed, the moving of animals was much faster than when we used portable electric fencing.

The other major issue was the fall weather. October had very heavy rainfall and made the orchards too wet to put the hogs in. The cool wet fall delayed apple harvest giving us less time to work on fencing when harvest was complete. Also, the ground was too wet to auger holes, install fence, and install gates. We completed one run of fence in Block 1 and installed gates in that block and the adjoining block giving us two completed paddocks in time for our fall field day.

The following paragraphs are a summary of what we did and what we learned about fencing and pasturing livestock over our 3 year project.

FENCING

We already had a perimeter fence in place and we nailed our woven wire to windbreak trees so our cost was quite a bit lower than having to buy all the posts and fencing the farm perimeter. We spent $3,118.81 on materials and utilized 119.5 hours of labor. If you are considering installing permanent woven wire fence, we have some base costs for you to work from when estimating your own fence expenses. The cost of a straight run of fence is not very high; however, adding corners and gates increases the price considerably.

For our project, woven wire was $0.45 per foot and the posts were $9.00 each. Including the costs of post and gates, a total of 1,000 feet of fence is only $1,350 or $1.35 per foot. One corner requires three posts in the ground and two posts for the top of the H-brace. There will also be about $10.00 of hardware. One corner adds $55. A gate requires an H-brace on each side of the gate. That is another six posts, hardware, and about $150 for the gate (depending on size) and its hardware. One gate adds $214. A site that is not square and requires many extra corners is going to be more expensive. In fact, sometimes it is cheaper to run a longer fence than putting in three corners to go around an obstacle. There are also many ways for a farmer's ingenuity to reduce costs. Using an oak tree as a corner or running up to an existing barbwire or electric fence can always save some money. From our experience, we highly recommend using a moderately priced, high-tensile, woven wire designed for multiple species. I can't emphasize enough the value of knotted, woven wire over old fashioned low tensile, welded wire. High tensile wire can be stretched tight like piano wire and will still have some give. A tree falling on the fence or a tractor driver misjudging how the width of a wagon can break posts and knock down long stretches of fence. Woven wire will often lay down but can be pulled back up when the broken posts are replaced. Old-style, welded-wire fencing kinks and breaks. It requires much more time to replace and repair. The wire we used has 8 horizontal wires that are spaced closer near the ground and wider higher up. The vertical wires are 1 foot apart. The height is only 42 inches, but we figured we could add a single wire on top if we want more height. That top wire could be hung with insulators and be energized if you have plans of splitting paddocks with temporary energized wire.

One problem with the wire was that small feeder pigs under about 50 pounds can hop up to the wider horizontal wire and squeeze through. We have found that pastured pigs that are getting most of their nutrition from the pasture are hungry most of the time. They have to eat a lot of high-fiber, low-calorie food. They will pressure the fence a lot more than a grain-fed, "pastured" hog. We should have spent a little more money on fencing and gone with either 8-42-6 fencing, which has twice as many verticals and costs $.60 per foot, or 13-48-12 fencing, which has horizontal wires much closer together and costs $.68 per foot. We recommend using 5 inch diameter, 7-foot-long treated posts for making pasture fence. This size can be pounded in without shattering or can be augered in. This is a very common size that is often on sale at farm stores and lumber yards. Metal T-posts can also make good line posts. An advantage of T-posts is that they are cheaper than the wood posts, and you can often find used ones at farm auctions for a low price. T-posts can be put in fairly quickly with just a post pounder. However, stretching and attaching woven wire to metal T-posts can be trickier. Posts should be anchored at one end then stretched using a tractor to pull the fencing taut. This process involves sliding the wire along the post which works well on a smooth round post. Sliding the wire against a T-post can snag and require a few more sets of hands. Attaching the wire to the T-post also requires a special clip or cutting thousands of pieces of malleable wire that can be twisted tight on the post. Attaching the wire to wooden posts just requires pounding a few simple U-nails.

Spacing of posts is a decision made based upon the type of livestock. High-tensile, woven-wire fence can be stretched tight and will not break with cattle or other heavy animals leaning on it or pushing into it. You can space your line posts as far apart as 24 feet for most grazing animals. Hogs are a different story. I put my line posts 10 feet apart because, if I have more space, then there is some degree of flex in the wire mesh. A mid-size feeder pig or adult hog can get his snout under the wire and then push it up enough to slip under. With a spacing of 10 feet, there is not enough slack for the pig to get under.

Organic farms can run into trouble with treated posts. Each certifying agency can have its own interpretation of what is allowed for a fence holding certified organic livestock. Technically, there are no treated posts that are allowed according to the National Organic Program. A certifying agency may require a 24-inch buffer between your treated post and the organic livestock. I have been told that I have to fence off my fence posts so the animals cannot contact the treated posts! We have been using metal T-posts for line posts and cedar for the end posts and H-braces. In some cases, the certifying agency may allow treated posts for paddocks that are used for flash grazing. A farm that is transitioning to organic production will most likely have the existing field fences grandfathered in, but you may not be allowed to add fences or replace broken posts with treated wood.

LIVESTOCK

In years one and two of this grant project, we raised three groups of feeders on pasture. The pigs were pastured using a combination of permanent high tensile, energized fence on the perimeter and energized mesh or ribbon to complete the paddocks. There were three groups of pigs consisting of 4 sows and 27 feeders. One group of 7 was born in August the year before, the second group of 16 was born in March, and the third group of 11 was born in June. The pigs were on pasture for 240 days and received little or no supplemental feed. The groups were moved 46 times. Each group was moved about 15 times. On our pasture system, we raise old breed hogs for 1 year with little or no supplemental feed while on pasture.

Windbreak fence.

In 2018, we had one small group of pigs. We only moved them about five times. No time was spent catching loose pigs. Less than 10 hours was spent putting up temporary fencing to complete the perimeter of partially fenced blocks or to act as gates. Moving animals into paddocks was less than a half hour per move. There is a huge savings of time when utilizing permanent fencing. After all the fences are complete with gates, we should be able to get the average time spent per animal down to under an hour each over the season giving a tenfold reduction in hours.

In 2018, we slaughtered when they weighed between 140 and 160 pounds. We spent an average of 11.5 hours tending to each hog over their lives. We sold our hogs either for custom slaughter or had all the meat processed and sold it retail from our farm or at farmers markets. The meat was certified organic giving us a premium price. The chart below is the actual number of cuts recovered from processing three hogs that weighed 140 pounds on average. Our profit excluding production costs by sale type is shown in Table 2. We hope this information will help producers decide if these practices will work for their operation.

MANAGEMENT TIPS

1. We used a multispecies 42 inch fence with the horizontal wire spacing at 5, 5, 6, 6, 6, 7, and 7 and the vertical wires at 12 inches. This spacing is too wide for young feeder pigs. Curious young pigs up to almost 50 pounds will hop up to the third wire and wriggle through. A tighter mesh is needed for young small breed pigs.
2. If you are going to raise animals and do not have the time to do the maintenance yourself, make sure you have a backup plan if your farmhand leaves or cannot work for some reason. Pastured animals need constant attention.
3. Check fences before each move. Temporary fencing needs to be set up and double checked before animals are moved. Permanent fencing is better but a tree limb across a section or an accidental bump into the fence with a mower or wagon can snag a wire and open a section big enough for a curious pig to crawl through. A few minutes walking the perimeter can save hours of catching loose pigs.
4. Check each group daily. Flash grazing requires a lot of management. Old breed hogs moved promptly can get all their nutrition from the pasture with minimal damage, but hungry hogs can do a lot of damage to any type of plant including small trees.

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

Hugh Kraemer, K Fence Company, Zumbro Falls, MN

PROJECT LOCATION

Our farm is approximately 5 miles south of Nodine, MN. Take Winona County Highway 16 south out of Nodine until you intersect with Forster Road. Go south on Forster Road for two miles. Hoch Orchard is on the west side of Forster Road.

OTHER RESOURCES

Butterfield, Jody; Sam Bingham; and Allen Savory. 2006. Holistic Management Handbook: Healthy Land, Healthy Profits. Island Press, Washington, DC.

Klober, Kelly. 2007. Dirt Hog: A Hands-On Guide to Raising Pigs Outdoors...Naturally. Acres U.S.A., Austin, TX.

Looby, George B.; and Steven Thomas. 2017. Backyard Livestock: Raising Good, Natural Food for your Family, Fourth Edition. The Countryman Press, New York, NY.

Midwest Organic and Sustainable Education Services: https://mosesorganic.org/silvopasture

The Savanna Institute: www.savannainstitute.org/events.html

The USDA National Agroforestry Center (NAC): https://www.fs.usda.gov/nac/practices/silvopasture.shtml

Comparision of Mobile Confinement and Day-range Production Systems for Pastured Broiler Chickens

PRINCIPAL INVESTIGATOR

Randy Kleinman
Seelye Brook Farms
22390 Rum River Boulevard
Oak Grove, MN 55303
612-567-7826
info@seelyebrookfarms.com
Anoka County

PROJECT DURATION

2018 to 2020

AWARD AMOUNT

$12,166

STAFF CONTACT

Michael Greene

KEYWORDS

broiler chickens, chicken tractors, day-ranging, mobile confinement system, pastured poultry

PROJECT SUMMARY

In this project, we will compare the profitability, labor, and marketability of two mobile pasturing systems for two chicken breeds. In the first method, we will use a mobile chicken pen method, known as a chicken tractor, to raise broiler chicks to typical processing weight. The second method, termed day-ranging, is similar to the chicken tractor method but provides chickens with access to larger pasture area and reduces the frequency of movement of pens to new pasture.

PROJECT DESCRIPTION

Day-ranging is a method for growing broiler chickens which allows birds on pasture to forage on greens and insects within a paddock. Recently, poultry farmers have reported more desirable animal conditions and feed reduction using day-ranging instead of the more typical full-time confinement in a bottomless mobile chicken pen (also known as a chicken tractor). This study compares the labor requirements, feed usage, mortality rates, nutrient composition, and profitability of day-range systems versus a full-time mobile confinement system (called chicken tractor for the rest of this article) in side-by-side trials of fast-growth (Cornish Cross) and slow-growth (Freedom Ranger) broiler chickens. Two batches will be raised each year to obtain data in both early and late season climate and pasture growth. The Freedom Ranger was chosen to compare the pasturing systems with a breed that has a slower growth rate but is known to forage more than the standard Cornish Cross. In total, 320 chickens will be raised over the two years.

The objectives of this project are:

Day-ranging poultry production system.

1. Compare profitability. We will compare total production cost and profitability of each pastured broiler chicken system including feed consumption and infrastructure costs. We will also track total output of the system by weight of the finished broilers to determine if there is significant difference in feed conversion. Loss to predation and mortality will also be tracked.

2. Compare labor requirements. We will track total labor requirements of each pastured broiler chicken system. This is particularly important for beginning farmers who may be working full- or part-time off-farm jobs, and/or leasing pasture away from their residence. The considerable time and transportation costs of tending birds away from the residence may make pastured poultry a non-viable or less profitable option.

3. Compare product marketability. We will conduct a nutritional analysis of the chicken meat to see if the different pasture access model is complementary to consumer nutritional demands. Any increase in one of many favorable nutrients (or vice versa, for unfavorable nutrients) would potentially be a desirable marketplace advantage.

The chicken tractor follows the methods described in Joel Salatin's book, Pastured Poultry, but with a different tractor design. In this system:

- Chicks are raised in a brooder for 21 days;
- Chickens are relocated to mobile chicken tractors on pasture until 56 days (70 days for a second slow-growth breed);
- Chickens are confined to the tractor to provide protection from weather and predators;
- Tractor stocking rate is 1.2-1.7 birds per square foot;
- The tractor is moved once a day to fresh pasture for 14 days, then twice a day for 21 days;
- Chickens always have access to broiler feed and water; and
- Ruminants graze ahead of the tractor to keep the pasture height to 1-3 inches.

The day-ranging method is much like the chicken tractor method but provides chickens with access to a larger pasture area and reduces the frequency of movement of pens to new pasture. The differences between the two methods are:

- Chickens are confined to a chicken tractor only at night. They have access to more pasture around the tractor during the day which may reduce consumption of supplemental feed. Birds will have access to 7 times as much space per day in the first 14 days and 3.5 times as much per day in the last 21 days as the full-time confined chicken pen method;
- An energized, portable netting defines the available pasture area (420 ft^2) and serves as predator protection; and
- Fence and tractor are moved less frequently, typically once a week for the first 14 days and twice a week for the last 21 days, which may reduce labor.

The total amount of pasture available to birds in each system will be the same – 3,360 ft^2 for Cornish Cross birds in year one and 5,040 ft^2 for Freedom Rangers in the second year.

The mobile tractors used by both systems were built according to Stress-free Chicken Tractor Plans published by John Suscovich. The pens are 60 ft^2 and hold 40 birds (1.5 birds per ft^2). We are using them instead of the Salatin-style chicken tractor because the Suscovich design has fewer concerns about chicken overheating and can be used by farmers for other purposes in the broiler "off season" (egg layers, sheep winter shelters, farrowing huts, greenhouse, etc).

In the chicken tractor system, the tractor is the sole predator protection. When uneven ground is present as the tractor is moved, "plugs" of lumber fill the voids under the tractor to stop ground predator access. No livestock guardian animal or electric fencing will be in use. For the day-range system, the tractor (and plugs) protect from ground predators at night and provide limited aerial predator protection. The perimeter is double-fenced with a roll of energized, portable, electric poultry netting and contains the birds and tractor at all times.

Both Spring and Fall groups of Cornish Cross broiler chickens were fed the same diet of transitional organic no-corn, no-soy broiler starter and grower feeds. All groups ate only starter (19 percent protein) feed in the brooder. When it was time to move the birds out on pasture, they were weighed and separated into groups with similar total live weights to start the chicken tractor and day-range groups with roughly equal live weights. Remaining starter feed was equally distributed to the two systems and consumed before moving to broiler grower (17 percent protein) feed. When it was time to process the birds, the total amount of feed consumed was recorded for each tractor assuming an equal amount of feed was consumed at the brooder stage. All groups were processed at 61 days and were on pasture for 39 days and 36 days for the Spring and Fall groups, respectively.

RESULTS

Labor

Since it was expected that brooder time, time moving birds from brooder to pasture, travel time to pastures, and time to gather birds to take to the processor would be equivalent among batches, these activities were not tracked.

For the chicken tractor groups, we recorded time spent moving the tractor and resupplying the feed and water once per day for the first 14 days on pasture and twice per day for the next 21 days. For the day-range system, we recorded all the chicken tractor group tasks plus the time required to move the fencing and energizer to create

new paddocks. Originally, we expected to move the day-range tractor within the enclosure only when it was being placed into a new paddock, however, excessive manure build up from the first few days in a paddock resulted in an unsanitary environment for the birds around the tractor. We changed the location of the tractor within the enclosure every day for all 35 days on pasture. Neither the size of the paddocks nor the frequency of their movement needed to be modified as a result of this management change.

The total time to manage birds on pasture was nearly double for the Spring groups compared to the Fall groups. This was partly due to farmers getting used to the system and working out a routine. The largest factor, however, was water access in the pasture; the Spring groups were located further away from the tractor setups than the Fall groups. In the spring, the time to manage the day-range system was 20 percent higher than the chicken tractor system. In the fall, the day-range system was 39 percent higher. In general, moving the portable electric fencing and energizer for the day-range system was the largest contributing factor, requiring anywhere between 5 and 25 extra minutes in the pasture once every 7 days. Also, getting the day-ranging birds back into the tractor in the evening took additional time.

Mortality

Mortality was tracked to determine if predation might be a factor in the day-range system since it was more amenable to aerial predators as well as predators that may be able to get past a portable electric fence.

In the Spring batch, 92 birds were received from the hatchery and two died in the brooder from unknown causes. Forty-five birds were placed in each chicken tractor setup on pasture on day 22. Eighty-nine birds were harvested with one bird dying on pasture from the chicken tractor group due to an unknown cause.

In the Fall batch, 92 birds were received from the hatchery and two died while in the brooder from unknown causes. Forty-five birds were placed in each chicken tractor setup on pasture on day 25. Forty-three birds were harvested from the chicken tractor batch since two died in transit to the processor (there were signs of cannibalism with these birds). Forty-two birds were harvested from the day-range batch. Two birds were killed from birds piling on each other during an unseasonably cool September night and one was accidentally run over by the chicken tractor during a pasture move.

So far, predation has not been a factor in mortality. The only bird that died from an unknown cause on pasture did not have any signs of predation.

Feed Conversion

All groups grew well and provided carcass weights in line with both farmer and customer expectations. Overall feed conversion ratio (that is pounds of feed required to produce 1 pound of live weight) was 36-49 percent higher than the roughly 2:1 ratio reported by Salatin. This could be caused by several differentiating factors (feed, genetics, climate, forage base, etc.), but was not a focus of this study.

Feed conversion ratio was higher in the day-range system in the spring, but lower than the tractor system in the fall (Table 1). Fall chickens consumed less feed presumably because they were on pasture during the optimal forage growth and peak insect populations. The Fall day-range chickens used the least amount of feed and ended up with the highest live weight and therefore the lowest feed conversion ratio of all four groups. Conversely, the Spring day-range group performed the poorest. We hypothesize that the additional movement of the birds within their paddock resulted in the need for more calories in lower spring air temperatures. Since insect populations had not peaked, additional feed was required for the chickens to grow and to counter their increased activity.

TABLE 1. Feed utilization and growth results for the Cornish Cross groups.				
System and season	Total feed consumed (lb)	Avg. feed/bird (lb)	Avg. finished wt. (lb)	Total feed conversion ratio
Spring day-range	789	17.5	5.86	2.99
Spring tractor	766	17.0	6.05	2.88
Fall day-range	724	16.1	6.29*	2.73
Fall tractor	733	16.3	6.12**	2.78
*Does not include the birds that died on pasture. **Includes the birds that died in transit to processor.				

Farmers observed that the day-range groups actively preyed on ants, beetles, moths, flies, and especially grasshoppers. However, the decrease of 1.8 percent in the feed conversion ratio between the Fall birds and the Spring birds suggests that the additional access to pasture wasn't an especially strong effect compared to the time of year the birds were on pasture.

Meat Nutrient Composition

A random sample of meat was collected from each batch after processing and sent to a food laboratory for nutritional analysis. We selected a few whole birds from each batch and sent in a sample comprised of breast, thigh, and leg. Meat was analyzed for fat-soluble vitamins (A, E), cholesterol, saturated, and unsaturated fats as well as omega 3 to omega 6 ratio.

TABLE 2. Nutritional analyses of meat from chicken tractor (CTS) and day-ranging systems (DRS).					
Nutrient*	Spring CTS	Spring DRS	Fall CTS	Fall DRS	USDA Standard Reference
Cholesterol (mg)	76	68	83	82	75
Vitamin E (mg/100g	1.4	1.0	1.3	1.1	0.3
Omega-6:Omega-3	6.6:1	5.5:1	4.7:1	4.7:1	14.8:1
EPA**	0.015	0.008	0.009	0.014	0.01
DHA***	0.015	0.020	0.021	0.024	0.030
ALA****	0.180	0.082	0.049	0.089	0.14
Fat (total)	7.52	4.09	3.06	4.70	15.06
Monounsaturated fat	3.03	1.73	1.33	2.18	6.24
Polyunsaturated fat	1.68	0.79	0.51	0.80	3.32
Saturated fat	2.44	1.37	1.07	1.5	4.30
*All values are grams/100 gram sample unless otherwise noted. **Type of omega-3 fatty acid - eicosapentaenoic acid. *** Type of omega-3 fatty acid - docosahexaenoic acid. **** Type of omega-3 - alpha-linolenic acid.					

Both systems showed desirable nutrient composition for human consumption compared to USDA reference values for Vitamin E, total fat, and fatty acid composition (Table 2). The difference between day-range and the chicken tractor systems was minimal, suggesting seasonal differences in pasture forages and insect population were determining factors.

Profitability

Profitability was determined using total feed consumption, infrastructure costs, and labor. Based on first year data with Cornish Cross birds, given the additional labor and infrastructure costs, it is not likely that day-range poultry systems could be more profitable under the current setup. Over ten years, the amortized cost of the day-range system's infrastructure is $76 per year (assuming $200 for a quality plugin-style fence energizer), whereas the chicken tractor infrastructure is only $37 per year. Over 10 years, assuming the farmer has become proficient with the paddock moves, the results here show that each batch of broilers will still require two extra hours of labor. Depending on the cost of labor, this means that the day-range system will have to net an additional $1 per bird of profit plus the cost of the extra labor to break even with the tractor system.

There are some ways to close this gap, but they are highly dependent on context. For instance, the chicken tractor in the day-range system could be replaced by a simple, much cheaper shade shelter if predator pressure is at a level where the farmer would feel comfortable not locking the chickens in at night. The farmer may also experiment with higher stocking rates since the paddocks sizes are larger than the chicken tractor. Lastly, if farmers can market their birds at a higher price point because of the greater "free range" nature of the day-ranging system, they may make up for the additional time and labor as well.

We will see how the two systems compare when we switch to the low-growth Freedom Ranger breed next growing season.

MANAGEMENT TIPS

1. Based on the results from the first year, day-ranging only has benefits for reducing feed costs when chickens have enough calories from forage to offset their increased activity.
2. Day-ranging systems with mobile pens still must account for manure accumulation. Cornish Cross chickens cannot be confined to the same section of pasture for more than a day except when they are very young. While they do range throughout the pen, most manure is deposited near the feeders.
3. Day-ranging is not likely to be more profitable than the traditional system. The main tradeoff is the cost of managing the electric netting and energizer versus the cost of labor and materials for constructing and maintaining only the chicken tractors. You could significantly reduce labor if no chicken tractor was needed and larger paddocks were used so the birds wouldn't need to be moved so often. Salatin warns against such shortcuts; they remove the positive effect of daily "fresh greens" for the birds.
4. The day-range system does not provide a consistent distribution of manure like the traditional system if fertilization is a reason for pasturing.
5. The farmer's specific situation (for example, access to electricity or access to markets that will pay a premium for "free range" birds) is a major factor in determining potential profitability of changing to a day-ranging system.

COOPERATOR

Kent Solberg, Sustainable Farming Association of Minnesota, Minneapolis, MN

RESOURCES

Agricultural Marketing Resource Center. 2018. Pastured Poultry Profile. Web Page. Retrieved January 1, 2019 from: www.agmrc.org/commodities-products/livestock/poultry/pastured-poultry-profile

Badger, Mike. 2015. Pasture and Feed Affect Broiler Carcass Nutrition. Technical Report. American Pastured Poultry Producers Association, Hughesville, PA, USA.

Burns, Greg. 2017. Day Range Chickens, Turkeys and Sheep. Video. Retrieved December 27, 2018 from: youtu.be/sZ--8rZIyrc

Footer, Diego. 2017. The BEST Pastured Poultry System Out There – Truly Free Range. Video. Retrieved December 27, 2018 from: youtu.be/0IGTQx5yExM

Salatin, Joel. 1999. Pastured Poultry Profit$ (3rd ed.). Polyface Farms, Swoope, VA. www.polyfacefarms.com/product/pastured-poultry-profits

Suscovich, John. 2016. Stress-Free Chicken Tractor Plans: An Easy to Follow, Step-by-Step Guide to Building Your Own Chicken Tractors. (2nd ed.). Emerald Lake Books. www.farmmarketingsolutions.com/stress-free-chicken-tractor-plans/

Completed Grant Projects

Final Year	Title of Greenbook Article	Grantee
Alternative Markets and Specialty Crops		
2018	Developing a Network for Environment and Weather Applications	Minnesota Apple Growers Association, JP Jacobson
	Evaluation of Hybrid Hazel (Corylus) Woodchips as Mushroom Substrate	Wholesome Harvest, Sue Weigrefe
2017	Using Compost Tea in Organic Farming	Seeds Farm, Becca Carlson
	Creating Beneficial Habitat for Weed Management & Wildlife Enhancement on Farm Waste Land	Melissa Nelson
	Preserving and Attracting Native Bees while Providing a Habitat that Adds Value to Small Acreage	Noreen Thomas
2016	Reducing Chemical Use and Inputs in a Cold Climate Grape Harvest by Creating New Uses Other than Wine	Locust Lane Vineyards Chad Stoltenberg
	Evaluating Different Depths and Types of Mulches in Blueberry Production	Redfern Gardens, Kathy Connell
2012	Growing Cherries in Central Minnesota	Pat Altrichter
	Organic Mushroom Cultivation and Marketing in a Northern Climate	Jill Jacoby
	Feasibility of Small Farm Commercial Hop Production in Central Minnesota	Robert Jones
2010	Hardwood Reforestation in a Creek Valley Dominated by Reed Canarygrass	Timothy Gossman
	Introducing Cold – hardy Kiwifruit to Minnesota	James Luby
	Growing the Goji Berry in Minnesota	Koua Vang & Cingie Kong
2009	Dream of Wild Health Farm Indigenous Corn Propagation Project	Peta Wakan Tipi, Sally Auger
2008	Developing a Saskatoon Berry Market in the Upper Midwest	Patricia Altrichter & Judy Heiling
2005	Creating Public Recognition of and Demand for "Grass-Fed" Dairy Products through the Development of Brand Standards and Promotion of These Standards to the Public	Dan French
2004	Collaborative Character Wood Production and Marketing Project	Cooperative Development Services, Isaac Nadeau
	Creating Consumer Demand for Sustainable Squash with Labels and Education	Gary Pahl
	Integrated Demonstration of Native Forb Seed Production Systems and Prairie Land Restoration	Michael Reese
	Pride of the Prairie: Charting the Course from Sustainable Farms to Local Dinner Plates	Kathleen Fernholz
2003	Demonstrating the Market Potential for Sustainable Pork	Prairie Farmers Co-op, Dennis Timmerman
	Flour Corn as an Alternative Crop	Lynda Converse

Final Year	Title of Greenbook Article	Grantee
2002	Increasing Red Clover Seed Production by Saturation of Pollinators	Leland Buchholz
	Propagation of Native Grasses and Wildflowers for Seed Production	Joshua Zeithamer
2001	Establishing Agroforestry Demonstration Sites in Minnesota	Erik Streed, CINRAM
	Managed Production of Woods-grown and Simulated Wild Ginseng	Willis Runck
	Midwest Food Connection: Children Monitor on Farms	Midwest Food Connection
	Phosphorus Mobilization and Weed Suppression by Buckwheat	Curt Petrich
2000	Converting a Whole Farm Cash Crop System to Keeping an Eye on Quality of Life and the Bottom Line in Sustainable Agriculture by Using Key Farm Economic Ratios to Aid in Decision-making	Red Cardinal Farm
	Dry Edible Beans as an Alternative Crop in a Direct Marketing Operation	Bruce & Diane Milan
	Native Minnesota Medicinal Plant Production	Renne Soberg
1999	An Alternative Management System in an Organic, Community Supported Market	Candace Mullen
	Cultural and Management Techniques for Buckwheat Production and Marketing	Tom Bilek
	Pond Production of Yellow Perch	John Reynolds
1998	Establishing and Maintaining Warm Season Grasses (Native Grasses)	Pope County SWCD
	On-farm Forest Utilization and Processing Demonstrations	Hiawatha Valley RC&D
1996	Permanent Raised Bed Cultivation for Specialty Crops	Terry & Jean Loomis
1995	Cash Crop Windbreak Demonstration/Development	Phil Rutter
	Cutter Bee Propagation Under Humid Conditions	Theodore L. Rolling
	Red Deer Farming as an Alternative Income	Peter Bingham
	Wildflower Seeds as a Low-input Perennial Crop	Grace Tinderholt & Frank Kutka
1992	Alternative Mulch Systems for Intensive Specialty Crop Production	Ron Roller, Lindentree Farm
	Benefits of Crop Rotation in Reducing Chemical Inputs and Increasing Profits in Wild Rice Production	George Shetka
	Benefits of Weeder Geese and Composted Manures in Commercial Strawberry Production	Joan Weyandt-Fulton
	Common Harvest Community Farm	Dan Guenthner
	Mechanical Mulching of Tree Seedlings	Timothy & Susan Gossman
	Minnesota Integrated Pest Management Apple Project	John Jacobson

Completed Grant Projects

Final Year	Title of Greenbook Article	Grantee
Cropping Systems and Soil Fertility		
2019	Interseeding Cover Crops and In Season Nitrogen Application in One Pass	Keith Hartmann
2018	Raising Soil pH Effectively in Acid Soil	David Abazs
	Soil Health Research in Southwest Minnesota	Jerry & Nancy Ackermann, & Jan Voit
	Maximizing Profitability in a Modular Moveable Cathedral Hoop House	Megan Henry
	Perennial wheatgrass and legumes for cropping, grazing, and soil health	Mike Jorgenson
	Inter-seeding Cover Crops into Standing Corn in June	Alan Kraus
	Evaluation of Winter Annual Small Grain Cover Crops for Forage Production	Daniel Ley
	Demonstrating Vermicomposting for Soil Health in the Upper Midwest	Robin Major & Caroline Devany, Stone's Throw Urban Farm
	Use Sub-Surface Irrigation to Increase Crop Profitability	Russell Martie, Dan Nadeau, Wright Co SWCD
	How Much Can You Afford to Pay for Hay?	John & Lisa Mesko, Lighthouse Farm
	Cover Crops to Replace Fall Tillage in Shakopee Lake Bed	Robin Moore
2017	Nitrogen Capture using Cover Crops in a Cash Grain Rotation	Sherburne County SWCD, William Bronder
	Developing Low-cost Planting Materials and Establishment Methods to Accelerate Agroforestry Adoption for Function and Profit	Happy Dancing Turtle, Jim Chamberlin
	Legume Cover Crops	Paul Kruger
	No-till Cover Crop Rotation vs. Intensive Tillage in Corn-Soybean Rotation	Chad Rollofson
	Planting Short Season Corn for Cover Crop Success	Caroline van Schaik
2016	The Effects of Cover Crops on Water and Soil Quality	Hmong American Farmers Association
	Correcting Soil Structure to Reduce Erosion by Using a Cover Crop Mix with Diverse Root Systems	Bios de Sioux Watershed District
	A Demonstration of Biological Primers on Drought Prone Soils	Sustainable Farming Association of Minnesota
2015	Weed Control in Soybeans	Floyd Hardy
	Comparing the Productivity & Profitability of Heat – Loving Crops in High Tunnel and Quick Hoops Systems	Stone's Throw Urban Farm
2013	Fertilizing with Alfalfa Mulches in Field Crops	Carmen Fernholz
	McNamara Filter Strip Demonstration	Goodhue SWCD, Beau Kennedy & Kelly Smith
	Optimizing Alfalfa Fertilization for Sustainable Production	Doug Holen

Final Year	Title of Greenbook Article	Grantee
2010	Environmentally and Economically Sound Ways to Improve Low Phosphorus Levels in Various Cropping Systems Including Organic with or without Livestock Enterprises	Carmen Fernholz
2009	Establishing Beneficial Bug Habitats in a Field Crop Setting	Noreen Thomas
	Keeping It Green and Growing: An Aerial Seeding Concept	Andy Hart
	Rotational Use of High-quality Land: A Three Year Rotation of Pastured Pigs, Vegetable Production, and Annual Forage	Gale Woods Farm – Three Rivers Park District, Tim Reese
2008	Field Windbreak/Living Snow Fence Yield Assessment	Gary Wyatt
2006	Gardening with the Three Sisters: Sustainable Production of Traditional Foods	Winona LaDuke
	Feasibility of Winter Wheat Following Soybeans in NW MN	Jochum Wiersma
2005	Chickling Vetch – A New Green Manure Crop and Organic Control of Canada Thistle in NW MN	Dan Juneau
	Treating Field Runoff through Storage and Gravity-fed Drip Irrigation System for Grape and Hardwood Production	Tim Gieseke
	Use of Rye as a Cover Crop Prior to Soybean	Paul Porter
2004	Development of Eastern Gamagrass Production	Nathan Converse
	In-field Winter Drying and Storage of Corn: An Economic Analysis of Costs and Returns	Marvin Jensen
	Mechanical Tillage to Promote Aeration, Improve Water Infiltration, and Rejuvenate Pasture and Hay Land	Robert Schelhaas
	Native Perennial Grass - Illinois Bundleflower Mixtures for Forage and Biofuel	Craig Sheaffer
	Northwest Minnesota Compost Demonstration	John Schmidt & Russ Severson
	Potassium Rate Trial on an Established Grass/Legume Pasture: Determining Economic Rates for Grazing/Haying Systems	Dan & Cara Miller
	Woolly Cupgrass Research	Leo Seykora
	Yield and Feeding Value of Annual Crops Planted for Emergency Forage	Marcia Endres
2003	Aerial Seeding of Winter Rye into No-till Corn and Soybeans	Ray Rauenhorst
	Manure Spreader Calibration Demonstration and Nutrient Management	Jim Straskowski
	Replacing Open Tile Intakes with Rock Inlets in Faribault County	Faribault County SWCD
	Soil Conservation of Canning Crop Fields	Andy Hart
	Using Liquid Hog Manure as Starter Fertilizer and Maximizing Nutrients from Heavily Bedded Swine Manure	Dakota County SWCD, Brad Becker & Johnson
2002	Agricultural Use of Rock Fines as a Sustainable Soil Amendment	Carl Rosen
	A Low-cost Mechanism for Inter-seeding Cover Crops in Corn	Tony Thompson
	Annual Medic as a Protein Source in Grazing Corn and Weed Suppressant in Soybeans	Joseph Rolling

Completed Grant Projects

Final Year	Title of Greenbook Article	Grantee
2002	Dairy Manure Application Methods and Nutrient Loss from Alfalfa	Neil C. Hansen
	Evaluation of Dairy Manure Application Methods and Nutrient Loss from Alfalfa	Stearns County SWCD
	Increased Forage Production through Control of Water Runoff and Nutrient Recycling	James Sovell
	Land Application of Mortality Compost to Improve Soil and Water Quality	Neil C. Hansen
	Turkey Litter: More is Not Always Better	Meierhofer Farms
2001	Applying Manure to Corn at Agronomic Rates	Tim Becket & Jeremy Geske, Dakota County Extension & SWCD
	Cereal Rye for Reduced Input Pasture Establishment and Early Grazing	Greg Cuomo
	Establishing a Rotational Grazing System in a Semi-wooded Ecosystem: Frost Seeding vs. Impaction Seeding on CRP Land and Wooded Hillsides Using Sheep	James Scaife
	Living Snow Fences for Improved Pasture Production	Mike Hansen
	Managing Dairy Manure Nutrients in a Recycling Compost Program	Norman & Sallie Volkmann
	Reducing Chemical Usage by Using Soy Oil on Corn and Soybean	Donald Wheeler
	Techniques for More Efficient Utilization of a Vetch Cover Crop for Corn Production	Carmen Fernholz
	Using Nutrient Balances to Benefit Farmers and the Environment	Mark Muller, IATP
2000	Forage Mixture Performance	Itasca County SWCD
	Growing Corn with Companion Crop Legumes for High Protein Silage	Stanley Smith
	Inter-seeding Hairy Vetch in Sunflower and Corn	Red Lake County Extension
	Legume Cover Crops Inter-seeded in Corn as a Source of Nitrogen	Alan Olness & Dian Lopez
	Surface Application of Liming Materials	Jane Grimsbo Jewett
	The Introduction of Feed Peas and Feed Barley into Whole Farm Planning	Ken Winsel
1999	CRP in a Crop Rotation Program	Jaime DeRosier
	Evaluating Kura Clover for Long-term Persistence	Bob & Patty Durovec
	The Winona Farm Compost Strategies	Richard J. Gallien
	Timing Cultivation to Reduce Herbicide Use in Ridge-till Soybeans	Ed Huseby
1998	An Evaluation of Variable Rate Fertility Use on Ridged Corn and Soybeans	Howard Kittleson
	Farming Practices for Improving Soil Quality	Sustainable Farming Association of SC MN
	Sustainable Agriculture in Schools	Toivola-Meadowland School, Jim Postance

Final Year	Title of Greenbook Article	Grantee
1997	Converting from a Corn-Soybean to a Corn-Soybean-Oat-Alfalfa Rotation	Eugene Bakko
	Manure Application on Ridge-till: Fall vs. Spring	Dwight Ault
1996	Base Saturation of Calcium	Randy Meyer
	Biological vs. Conventional Crop Systems Demonstration	Gary Wyatt
	Building Soil Humus without Animal Manures	Gerry Wass
	Controlled Microbial Composting to Improve Soil Fertility	Howard & Mable Brelje
	Legumes as a Protein Supplement in Fall Grazed Corn Stalks	Grant Herfindahl
	Living Mulches in West Central MN Wheat Production	Dave Birong
	Making the Transition to Certified Organic Production	Craig Murphy
	No-till Barley and Field Peas into Corn Stalks, Developing Pastures on These Bare Acres	Jerry Wiebusch
	Weed Control and Fertility Benefits of Several Mulches and Winter Rye Cover Crop	Gary & Maureen Vosejpka
1995	Annual Medics: Cover Crops for Nitrogen Sources	Craig Sheaffer
	Integration of Nutrient Management Strategies with Conservation Tillage Systems for Protection of Highly Eroded Land and Lakes in West Otter Tail County	Harold Stanislawski
	Manure Management/Utilization Demonstration	Timothy Arlt
	Reducing Soil Insecticide Use on Corn through Integrated Pest Management	Ken Ostlie
	Taconite as a Soil Amendment	Donald E. Anderson
1994	Biological Weed Control in Field Windbreaks	Tim Finseth
	Energy Conserving Strip Cropping Systems	Gyles Randall
	Fine-tuning Low-input Weed Control	David Baird
	Flame Weeding of Corn to Reduce Herbicide Reliance	Mille Lacs County Extension
1993	Chemical Free Double-cropping	Jeff Mueller
	Cooperative Manure Composting Demonstration and Experiment	Rich Vander Ziel
	Early Tall Oat and Soybean Double Crop	Charles D. Weber
	Nitro Alfalfa, Hog Manure, and Urea as Nitrogen Sources in a Small Grain, Corn, Soybean Crop Rotation	Carmen M. Fernholz
	Nitrogen Utilization from Legume Residue in Western MN	Arvid Johnson

Completed Grant Projects

Final Year	Title of Greenbook Article	Grantee
1992	Demonstration of Land Stewardship Techniques in the Red River Valley	Donald H. Ogaard
	Demonstration of Tillage Effects on Utilization of Dairy and Hog Manure in SE MN	John Moncrief
	Economically and Environmentally Sound Management of Livestock Waste	Fred G. Bergsrud
	Herbicide Ban? Could You Adapt on a Budget?	David Michaelson
	Improving Groundwater Quality and Agricultural Profitability in East Central MN	Steven Grosland & Kathy Zeman
	Modified Ridge-till System for Sugar Beet Production	Alan Brutlag
	Soil Building and Maintenance	Larry H. Olson
	Strip-cropping Legumes with Specialty Crops for Low-cost Mulching and Reduced Fertilizer/Herbicide Inputs	Mark Zumwinkle
	Using Nitro Alfalfa in a No-till Corn and Soybean Rotation	Jeff Johnson
1991	Alternative Methods of Weed Control in Corn	Sr. Esther Nickel
	Hairy Vetch and Winter Rye as Cover Crops	Mark Ackland
Energy		
2016	Increasing Dairy Farm Profitability Through an Energy Efficiency Implementation Model	Fritz Ebinger
	Solar-powered Rainwater Catchment & Distribution System Using Drip Irrigation	Hammers Green Acres, Sharon Utke
2010	Evaluation of the Potential of Hybrid Willow as a Sustainable Biomass Energy Alternative in West Central Minnesota	Diomides Zamora
2009	On-farm Biodiesel Production from Canola	Steve Dahl
2007	Testing the Potential of Hybrid Willow as a Sustainable Biomass Energy Alternative in Northern Minnesota	Dean Current
Fruits and Vegetables		
2019	Developing an annual day-neutral strawberry planting system with biodegradable mulches	Steve Poppe, University of Minnesota
	Using essential oils to repel spotted wing Drosophila in Blueberries	Blueberry Fields of Stillwater, Bev O'Connor
	Using Juneberries as a Cold Hardy Rootstock for Minnesota Pears	Thaddeus McCamant, Central Lakes College
2017	Developing Profitable Apple Production along Lake Superior's North Shore of Minnesota	Clover Valley Farms, Cindy Hale
	Evaluating Different Depths and Types of Mulches in Blueberry Production	Redfern Gardens, Kathleen Connell
	Controlling Canada Thistle in Organic Blueberry Production	Little Hill Berry Farm, Aaron Wills

Final Year	Title of Greenbook Article	Grantee
2013	Extended Season Marketing of Asian and Latino Ethnic Vegetables Grown in Quick Hoops and a Moveable Greenhouse	Judy & Steve Harder
	Comparison of Strawberries Grown in a High Tunnel and Outside for Quality and Profitability	Debbie Ornquist
	Solar Energy Storage and Heated Raised Beds	Diane & Charles Webb
2012	Growing Blackberries Organically under High Tunnels for Winter Protection and Increased Production	Erik Gundacker
	High Tunnel Primocane Blackberry Production in Minnesota	Terrance Nennich
	Minimizing the Environmental Impact and Extending the Season of Locally Grown Raspberries	Steve Poppe
	Growing Fresh Cabbage for Markets Using Integrated Pest Management Strategies	Ly Vang, American Association for Hmong Women in Minnesota
2011	Using Solar Energy to Heat the Soil and Extend the Growing Season in High Tunnel Vegetable Production	Dallas Flynn
	Extended Growing Season for Lettuce	Michael Hamp
	Organic Day-neutral Strawberry Production in Southeast Minnesota	Sam Kedem
	Winter Plant Protection of Blueberries in Northern Minnesota	Al Ringer
2010	Intercropping within a High Tunnel to Achieve Maximum Production	Mark Boen
2009	Chokecherry (*Prunus virginiana*) Production in Western Minnesota	Todd & Michelle Andresen
	Winter Harvest of Hardy Crops under Unheated Protection	Kelly Smith
	Insect and Disease Pressure in Unsprayed Apple Orchards in Central and Northern Minnesota	Thaddeus McCamant
2008	Apple Scab Control Project	Rick Kluzak
	Controlling Western Striped Cucumber Beetles Using Organic Methods: Perimeter Trap Crops and Baited Sticky Traps	Peter Hemberger
	Establishing Healthy Organic Asparagus While Utilizing Minimal Labor and Maintaining Proper Soil Nutrition	Patrick & Wendy Lynch
	Novel Preplant Strategies for Successful Strawberry Production	Steven Poppe
2005	Organic Strawberry Production in Minnesota	Brian Wilson & Laura Kangas
2004	Root Cellaring and Computer-controlled Ventilation for Efficient Storage of Organic Vegetables in a Northern Market	John Fisher-Merritt
2003	Evaluating the Benefits of Compost Teas to the Small Market Grower	Pat Bailey
	Research and Demonstration Gardens for New Immigrant Farmers	Nigatu Tadesse
	Viability of Wine Quality Grapes as an Alternative Crop for the Family Farm	Donald Reding

Completed Grant Projects

Final Year	Title of Greenbook Article	Grantee
2002	Development and Continuation of a Community Based Sustainable Organic Grower's Cooperative and Marketing System	Patty Dease
	Flame Burning for Weed Control and Renovation with Strawberries	David Wildung
	Good Eating with Little Healing: A Straw Bale Greenhouse	Linda Ward
	Integrating Livestock Profitably into a Fruit and Vegetable Operation	David & Lise Abazs
	Soil Ecology and Managed Soil Surfaces	Peter Seim & Bruce Bacon
	Value Adding to Small Farms through Processing Excess Production	Jeffrey & Mary Adelmann
2001	Bio-based Weed Control in Strawberries Using Sheep Wool Mulch, Canola Mulch and Canola Green Manure	Emily Hoover
	Biological Control of Alfalfa Blotch Leafminer	George Heimpel
	Cover Crops and Living Mulch for Strawberry Establishment	Joe Riehle
	Sustainable Weed Control in a Commercial Vineyard	Catherine Friend & Melissa Peteler
1999	Development of Mating Disruption and Mass Trapping Strategy for Apple Leafminer	Bernard & Rosanne Buehler
1998	Alternative Point Sources of Water	Joseph & Mary Routh
	Comparison of Alternative and Conventional Management of Carrot Aster Leafhoppers	MN Fruit & Vegetable Growers Association
	Jessenland Organic Fruits Project	MN New Country School
	Propane Flame Weeding Vegetable Crops	Jean Peterson & Al Sterner
	Soil Quality Factors Affecting Garlic Production	Tim King
	Wine Quality Grapes in Otter Tail County	Michael & Vicki Burke
1997	Community Shared Agriculture and Season Extension for Northern Minnesota	John Fisher-Merritt
	Living Mulch, Organic Mulch, Bare Ground Comparison	Dan & Gilda Gieske
Livestock		
2019	Goat Grazing During Winter in Minnesota: Controlling vegetation while saving on feed costs	John Beckwith, Hiawatha Valley Resource Conservation & Development
	Practices	
2018	Integrating Silvopasture Practices into Perennial Fruit Production	Jackie & Harry Hoch,
2017	Hoch Orchard	Ulrike Sorge
	Utilization of Building for Multiple Livestock Species	Steve Stassen

Final Year	Title of Greenbook Article	Grantee
2013	Determining the Cost of Raising Pastured Pork on a Diet Including Whey and Finishing on a Diet Including Acorns	Lori Brinkman
2011	Determining the Pasture Restoration Potential and Financial Viability of Cornish Cross vs. Red Broilers for a Small Pastured Poultry Operation in Northeast Minnesota	Cindy Hale & Jeff Hall
	Fall Forage Mixture for Grass Finishing Livestock Late in the Fall	Troy Salzer
	Increasing the Profitability of Raising Livestock: An Evaluation of Two Methods to Extend the Grazing Season	Dean Thomas
	Methods to Establish Grazing of Annual Forages for Beef Cows on Winter Feeding Areas	Walker & Mathison
2010	A Comparison between Cornstalk and Soybean Straw for Bedding Used for Hogs and Their Relative Nutrient Value for Fertilizer	John Dieball
2009	Demonstration of How Feeding In-line Wrapped High Moisture Alfalfa/Grass Bales Will Eliminate Our Fall and Winter "Flat Spot" in Grass-fed Beef Production	Donald Struxness
	Diversified Harvest of Integrated Species	Joe & Michelle Bowman
2008	Comparing Alternative Laying Hen Breeds	Suzanne Peterson
2007	Composting Bedded Pack Barns for Dairy Cows	Marcia Endres
	Managing Hoops and Bedding and Sorting without Extra Labor	Steve Stassen
2005	Performance Comparison of Hoop Barns vs. Slatted Barns	Kent Dornink
	Raising Cattle and Timber for Profit: Making Informed Decisions about Woodland Grazing	Michael Demchik
	Using a 24' x 48' Deep Bedded Hoop Barn for Nursery Age Pigs	Trent & Jennifer Nelson
2004	Comparing Performance of Hoop Buildings to an Older Conventional Building for Finishing Hogs	Kevin Connolly
	High Value Pork Production for Niman Ranch Using a Modified Swedish System	David & Diane Serfling
	Low Cost Fall Grazing and Wintering Systems for Cattle	Ralph Lentz
2003	Can New Perennial Grasses Extend Minnesota's Grazing Season	Paul Peterson
	Enhancement of On-farm Alfalfa Grazing for Beef and Dairy Heifer Production	Dennis Johnson
	Farrowing Crates vs. Pens vs. Nest Boxes	Steve Stassen
	Forage Production to Maintain One Mature Animal Per Acre for 12 Months	Ralph Stelling
	High Quality – Low Input Forages for Winter Feeding Lactating Dairy Cows	Mark Simon
	Pasture Aeration and its Effects on Productivity Using a Variety of Inputs	Carlton County Extension
	Potential of Medicinal Plants for Rotational Grazing	Management Intensive Grazing Groups, Dave Minar
	Programmatic Approach to Pasture Renovation for Cell Grazing	Daniel Persons

Completed Grant Projects

Final Year	Title of Greenbook Article	Grantee
2002	Adding Value for the Small Producers via Natural Production Methods and Direct Marketing	Peter Schilling
	Grazing Beef Cattle as a Sustainable Agriculture Product in Riparian Areas	Frank & Cathy Schiefelbein
	Improvement of Pastures for Horses through Management Practices	Wright County Extension
	Increasing Quality and Quantity of Pasture Forage with Management Intensive Grazing as an Alternative to the Grazing of Wooded Land	Michael Harmon
	Supplement Feeding Dairy Cattle on Pasture with Automated Concentrate Feeder	Northwest MN Grazing Group
	Viability of Strip Grazing Corn Inter-seeded with a Grass/Legume Mixture	Stephen & Patricia Dingels
2001	Annual Medic as a Protein Source in Grazing Corn	Joseph Rolling
	First and Second year Grazers in a Year Round Pasture Setting Served by a Frost Free Water System	Don & Dan Struxness
	Low Input Conversion of CRP Land to a High Profitability Management Intensive Grazing and Haying System	Dan & Cara Miller
	Whole System Management vs. Enterprise Management	Dennis Rabe
	Working Prairie – Roots of the Past Sustaining the Future	John & Leila Arndt
2000	Converting a Whole Farm Cash System to Sustainable Livestock Production with Intensive Rotational Grazing	Edgar Persons
	Dairy Steers and Replacement Heifers Raised on Pastures	Melissa Nelson
	Establishing Pasture Forages by Feeding Seed to Cattle	Art Thicke
	Five Steps to Better Pasture in Practice: How does it really work?	Sarah Mold
	Grass-and Forage-based Finishing of Beef, with Consumer Testing	Lake Superior Meats Cooperative
	Low Cost Sow Gestation in Hoop Structure	Steve Stassen
	Reviving and Enhancing Soils for Maximizing Performance of Pastures and Livestock	Doug Rathke & Connie Karstens
1999	Deep Straw Bedding Swine Finishing System Utilizing Hoop Buildings	Mark & Nancy Moulton
	Extending the Grazing Season with the use of Forage Brassicas, Grazing Corn and Silage Clamps	Jon Luhman
	Home on the Range Chicken Collaborative Project	Sustainable Farming Association of SE MN
	Hoop Houses and Pastures for Mainstream Hog Producers	Josh & Cindy Van Der Pol
	Learning Advanced Management Intensive Grazing through Mentoring	West Otter Tail SWCD
	Management Intensive Grazing Groups	Dave Stish
	Renovation of River Bottom Pasture	Jon Peterson
	The Value Added Graziers: Building Relationships, Community and Soil	Values Added Graziers

Final Year	Title of Greenbook Article	Grantee
1998	Buffalo: Animal from the Past, Key to the Future	Richard & Carolyn Brobjorg
	Marketing Development - Small Farm Strategies Project	Sustainable Farming Association of NE MN
	Pastured Poultry Production and Riparian Area Management	Todd Lein
1997	Butcher Hogs on Pasture	Michael & Linda Noble
	Developing Pastures Using Various Low-input Practices	Ralph Lentz
	Grass Based Farming in an Intensive Row Crop Community	Douglas Fuller
	Grazing Hogs on Standing Grain and Pasture	Michael & Jason Hartmann
	Grazing Sows on Pasture	Byron Bartz
	Low Input Systems for Feeding Beef Cattle or Sheep	Dennis Schentzel
	Raising Animals for Fiber	Patty Dease
	Seasonal Dairying and Value-added Enterprises in SW MN	Robert & Sherril Van Maasdam
	Swedish Style Swine Facility	Nolan & Susan Jungclaus
1996	Dairy Waste Management through Intensive Cell Grazing of Dairy Cattle	Scott Gaudette
	Establishing Trees in Paddocks	Dave & Diane Serfling
	Evaluating Pasture Quality and Quantity to Improve Management Skills	Land Stewardship Project
	Expanding into Outdoor Hog Production	James Van Der Pol
	Grazing Limits: Season Length and Productivity	Doug & Ann Balow
	Rotational Grazing Improves Pastures	MISA Monitoring Team, Dorsey
1995	Backgrounding Rotational Grazing	Frank Schroeder
	Evaluating Diatomaceous Earth as a Wormer for Sheep and Cattle	David Deutschlander
	Intensive Controlled Grazing and Pasture Rejuvenation on Fragile Land	Lyle & Nancy Gunderson
	Intensive Rotational Grazing on Warm Season Grasses	Jim Sherwood
	Rotational Top-grazing as a Method of Increasing Profitability with a High-producing Dairy Herd	Alton Hanson
1994	Economics of Rotational Grazing vs. Row Crops	Harold Tilstra
	Low Input Range Farrowing of Hogs	Larry Mumm
1993	A Comparison Study of Intensive Rotational Grazing vs. Dry-lot Feeding of Sheep	R & K Shepherds
	Controlled Grazing of Ewes on Improved Pastures and Lambing on Birdsfoot Trefoil	Leatrice McEvilly
	Farrowing and Raising Pigs on Pasture	Charles Cornillie
	Improving Permanent Pastures for Beef in SW MN	David Larsen

Completed Grant Projects

Final Year	Title of Greenbook Article	Grantee
1993	Intensive Rotational Grazing	Chad Hasbargen
	Research and Demonstration of Rotational Grazing Techniques for Dairy Farmers in Central Minnesota	Stearns County Extension
	Winter Grazing Study	Janet McNally & Brooke Rodgerson
1992	A Demonstration of an Intensive Rotational Grazing System for Dairy Cattle	Ken Tschumper
	Intensive Rotational Grazing in Sheep Production	James M. Robertson
	Using Sheep and Goats for Brush Control in a Pasture	Alan & Janice Ringer

The Greenbook is dedicated to
the farming families of Minnesota.
Their innovation, cooperation, and persistence
are creating a more sustainable agriculture.

Visit the Greenbook online at

WWW.MDA.STATE.MN.US/GREENBOOK

DEPARTMENT OF
AGRICULTURE