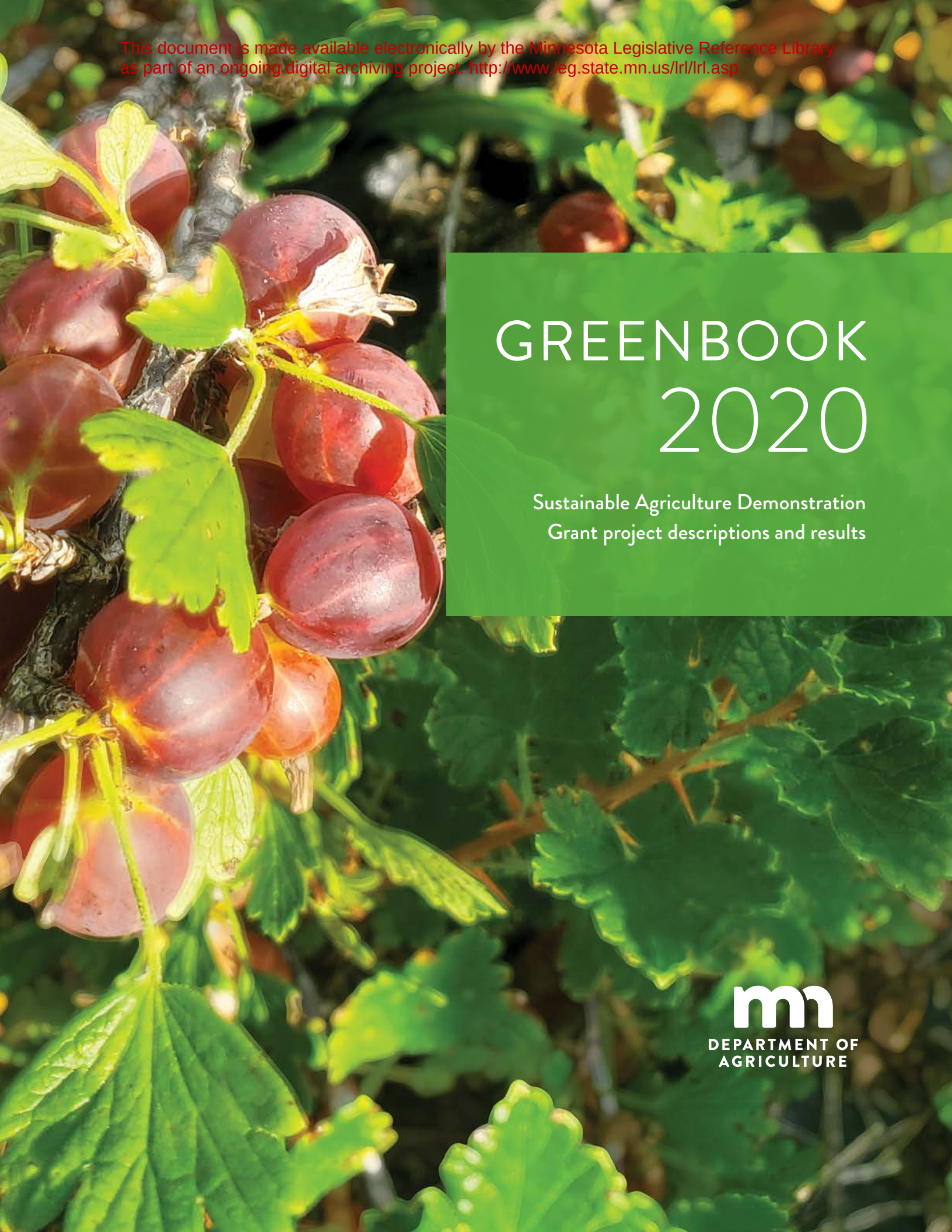

GREENBOOK 2020

Sustainable Agriculture Demonstration Grant project descriptions and results

DEPARTMENT OF AGRICULTURE

GREENBOOK
2020

On behalf of the Minnesota Department of Agriculture (MDA), it is my great pleasure to introduce the 2020 edition of the annual Greenbook. As Commissioner of Agriculture, I'm proud to highlight the important work of the Sustainable Agriculture Demonstration Grant Program, a component of the Agricultural Growth, Research, and Innovation (AGRI) Program. 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, and I've been a long-time supporter of them.

This year's recipients were awarded a total of over $160,000 for forward-thinking initiatives that promote sustainability in agriculture. Much as I would love to, I can't highlight every project here. But if you read further, you'll see that from exploring non-chemical methods for controlling pests in strawberry and potato crops, to examining the effects of sheep grazing for controlling wild parsnip or increasing plant diversity in native pollinator habitat, to exploring new specialty crops, these projects are fundamental to the future of agriculture. The Sustainable Agriculture Demonstration Grant Program is dedicated to improving and shaping the future; many previous grant projects have focused on practices that have become widely adopted, such as integrated pest management and cover cropping.

In *Greenbook 2020*, you'll learn about the successes and challenges an enthusiastic group of grantees have encountered while finding ways to increase energy and labor efficiency, reduce purchased inputs, and improve both the environment and farmers' profitability. In addition to descriptions of new projects, this year, the Greenbook will present final reports on 2017 and 2018 projects, as well as brief updates on the progress of ongoing projects. To learn more about any of them, 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

Thom Petersen, Commissioner
Minnesota Department of Agriculture

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

July 2020

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.

Our Crop Research Grants are intended to generate applied crop research that will improve agricultural product quality, quantity, or value. They fund projects led by professional scientists and researchers that respond to complex questions facing crop producers in Minnesota.

In the Greenbook, we share the recommendations, observations, and experiences collected by grantees so that the public can use this growing collection of information to improve their decision-making on their own farms. We welcome growers with research questions to apply for our grants so that we can address the emergent and on-going challenges facing local agriculture.

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.

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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 1,215 grant applications and approved over $4.4 million in funding for 359 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 2019, are described in Greenbook 2020.

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, methods, project activities, and results. To find out more details about these projects, contact the principal investigators directly through the listed telephone numbers, addresses, and email addresses.

Sustainable Agriculture Grant Program

SUMMARY OF GRANT FUNDING (1989-2020)

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
2017	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
2020	8	$160,145	$20,018	$11,158- 25,137
Total Funded	**359**	**$4,404,144**	**$12,640**	**$1,000-50,000**

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

2020 New Demonstration Grant Projects

CROPPING SYSTEMS

Non-chemical Methods for Managing Colorado Potato Beetle: Feasibility for Diversified Farms

Grantee: Natalie Hoidal, University of Minnesota
Duration: 2 years
Award Amount: $15,439.00
County: Chisago

PROJECT OBJECTIVES:

Participants in a 2019 needs assessment of 315 Minnesota fruit and vegetable growers selected "insect pest management" as their number one research priority. Colorado Potato Beetles (CPB) were listed as a top priority pest. Organic potato growers across Minnesota have relied on the insecticide Entrust (spinosad) for years. However, resistance has been documented in other states, and in 2019 Extension educators identified a population of Entrust-resistant beetles at Big River Farms. CPBs have a long history of developing insecticide resistance, notoriously developing resistance to DDT, arsenic, and neonicotinoids. A diversified approach that includes preventive control is critical for all potato farmers who wish to have long-term success with this insect, and for the overall reduction of pesticides used in potatoes. Growers are motivated to reduce insecticide use. Seventy-four of respondents to the 2019 fruit and vegetable needs assessment identified as either certified organic or organically focused; another 16 percent use Integrated Pest Management.

Potatoes are an important crop for diversified vegetable farms. While they are not a high-profit crop, customers expect to see potatoes in their Community Supported Agriculture (CSA) boxes, and they store well, which allows for inexpensive season extension and winter sales (another priority identified in the Klodd & Hoidal needs assessment). Low profit crops need low-cost management strategies to be financially viable. Current strategies include spraying insecticides (for organic growers this is usually spinosad, a relatively expensive product compared to other insecticides on the market), and manually removing beetles, which is time intensive.

According to the Minnesota Grown database, there are at least 228 potato growing CSA farms in the state. There are likely many more not registered in the database. Research on preventative management methods would benefit potentially hundreds of farms.

1. Assess five of the most promising cultural control methods for CPB from the perspectives of labor hours, cost, effectiveness in reducing beetle populations, and final plant damage effects.
2. Gather qualitative data on how to best implement these strategies, lessons learned, and how the timing of these strategies fit into the flow and workload of a diversified vegetable farm.

2020 New Demonstration Grant Projects

FRUITS & VEGETABLES

Trialing High Tunnel Raspberries to Increase Yield and Reduce Spotted Wing Drosophila Pressure

Grantee: Aaron Wills, Little Hill Berry Farm
Duration: 3 years
Award Amount: $17,535.00
County: Chisago

PROJECT OBJECTIVES:

Raspberries are a popular berry crop in Minnesota. Many farmers across the state offer pick-your-own raspberries and sell raspberries at farmers markets, roadside stands, and to wholesale customers. Recently due to the introduction of an invasive fruit fly, Spotted Wing Drosophila (SWD), raspberry production in Minnesota has become increasingly difficult. According to research released by the University of Minnesota, raspberry growers in Minnesota lost an estimated $2.3 million in sales to SWD in 2017. Raspberry growers reported the highest level of infestation among the state's berry growers with a median damage of 20 percent. Twenty-four percent of raspberry growers said they would 'probably' or 'definitely' reduce acreage the following season as a result of SWD infestation.

SWD infests undamaged, ripening, or ripe fruit where the common fruit fly only infests overripe or rotting fruit. SWD lays eggs in the fruit. The eggs hatch into larvae (small, white worms) which feed on the flesh of fruit, turning the fruit mushy and unmarketable. SWD populations build quickly in the summer months. It takes just over a week to develop from egg to adult, and there can be more than 10 generations in a single growing season.

High tunnels may reduce SWD pressure. According to University of Minnesota research, the tunnel environment might prevent SWD development due to higher air temperatures compared to open field plots and could be a viable management strategy for SWD. In my own experience growing day-neutral strawberries in high tunnels, I had zero pressure from SWD in my high tunnel strawberries, but moderate SWD pressure in my open field strawberries. We would like to test if this same reduced SWD pressure is found in raspberries in a high tunnel like we saw with our strawberries.

In addition to possible reduced SWD pressure, high tunnels offer the opportunity for significant increase in raspberry yields compared to open field production. In 2009, a variety trial was conducted in Grand Rapids by Carl Rosen from the University of Minnesota comparing high tunnel raspberry yields to open field yields. This study showed that raspberries grown in high tunnels will produce greater yields than raspberries in open field production. However, this study was done in Northern Minnesota (Grand Rapids, zone 3b) and my farm is in Southern Minnesota (Northfield, zone 4b), which are very different growing conditions. Also, many new raspberry varieties have been released in the last ten years which were specifically bred for high tunnel growing that we would like to trial. To date, these new varieties have not been compared in Minnesota. They must be trialed here before farmers can adopt them for high tunnel production. And finally, SWD was not present in the state when this study was conducted, so the growing conditions for raspberries have changed dramatically.

So, although there has been a study of high tunnel raspberries in Minnesota, there are quite a few changes over the past 10 years that make conducting a variety trial now worthwhile.

2020 New Demonstration Grant Projects

Finally, there is much discussion going on right now about how fruit and vegetable producers can become more resilient to climate change. Growing fruit in high tunnels is one of the main strategies that is being discussed. It is important to test the high tunnel growing method for raspberries as a way to maintain successful raspberry production in Minnesota in the face of climate change.

1. Trial four varieties of primocane fruiting raspberries (fall-bearing) in high tunnel and open field rows.
2. Collect data on yield and SWD impacts in order to make recommendations for best management practices for growers.

Growing and Evaluating Perry and Dessert Pears on a Tall Spindle System

Grantee: Gretchen Perbix, Sweetland Orchard
Duration: 3 years
Award Amount: $22,593.70
County: Rice

PROJECT OBJECTIVES:

The purpose of this project is to establish, grow, and evaluate a dessert and perry pear high-density planting. The project will be assessed in terms of hardiness, growth, disease, and precosity. Key findings will indicate if the rootstock/variety combination is hardy, how well the trees are suited for the tall spindle high-density system, and if the trees yield a crop in year three.

This project is important because pears are not usually planted on a high-density system, though there seems to be promise in these techniques. This project can provide a proof of concept and a feasibility study for Minnesota apple and pear growers. Since a number of pear varieties are hardy in Minnesota, including Parker and Summercrisp, the key takeaway points for growers will be in the hardiness of the semi dwarfing rootstock that many are unlikely to have yet worked with, how well the planting performed in the high-density system on trellis, and the hardiness of varieties not commonly grown in Minnesota with particular interest in the hardiness of the perry varieties.

Demonstrating rootstock hardiness is important and has been a key limiting factor to the expansion of pear growing. An eight-year project by Cornell University demonstrated the hardiness of the OHF87 rootstock in up-state New York (USDA hardiness zone 6a) being used in this project. Environmental and climatic conditions in up-state New York are significantly different than Minnesota; therefore, a trialing in Minnesota will help growers better understand their risks in using this rootstock.

Demonstrating the feasibility of the tall spindle planting system is important too. Tall spindle systems crop earlier and generate higher yields per acre than conventional, free-standing central leader systems. For example, the aforementioned New York project had an eight-year cumulative yield of 1,000-2,000 bushels of Bosc pears on a low density central leader system (242 trees per acre) contrasted to 3,000-3,800 bushels of Bosc pears on a high density tall spindle system (908 trees per acre).

The timing of the project is significant because the growing cider industry provides a new consumer for pear crops. Cidermakers and distillers are currently importing pears and pear juice from out-of-state. Since the Minnesota Farm Wineries Act (Minn. Stat. § 340A.315) specifies that cidermakers use a majority of Minnesota-grown produce to sell cider in a retail operation, Minnesota-grown pears will be a valuable crop to this industry.

Due to broad similarities between apples and pears, growers accustomed to operating an apple orchard should be easily able to add pears to their operations since growing principles, management practices, and equipment requirements are the same.

For those interested in permaculture in general and new to perennial fruit tree crops, pears are a relatively uncommon specialty crop with excellent marketing possibilities.

1. Establish, grow, and evaluate a dessert and perry pear high-density planting.
2. Evaluate trials in terms of hardiness, growth, disease, and precosity. Key findings will indicate if the rootstock/variety combination is hardy, how well the trees are suited for the tall spindle high-density system, and if the trees yield a crop in year three.

Expanding the Effectiveness of Non-Chemical Pest Control in Organic Strawberry Production

Grantee: Andrew Petran, Twin Cities Berry Company
Duration: 3 years
Award Amount: $23,236.00
County: Dakota

PROJECT OBJECTIVES:

Organic (and conventional) fruit production in the Upper Midwest is in peril. The onset of climate change combined with the encroachment of invasive species has generated a cocktail of pest, disease, and environmental pressures that traditional fruit management practices in this region are no longer able to properly control. Organic farmers often resort to spraying more frequently to deal with these pressures, but this option has limited efficacy while also increasing costs and damaging pollinator habitat. Indeed, my research and extension contacts at the University of Minnesota have estimated that approximately 25 percent of fruit production operations have closed in the past decade. The climate isn't just changing, it has changed. If farmers of especially perishable goods (like fruits) do not alter their practices to adapt to these changes, then their operations will likely be in peril as well.

Fortunately, there has been some success in non-chemical pest control for organic fruit production. Twin Cities Berry Company managed a portion (1/4 acre) of our extended-season strawberry fields under insect netting in 2019. This physical exclusion practice significantly increased total and marketable yields compared to an equal-sized open field control plot managed with sprays during our 2-month recording period. We believe this difference was mostly generated by the lack of tarnished plant bug and spotted wing drosophila presence under the net, even without the use of environmentally damaging sprays. The difference in revenue generated under the netting compared to open field is estimated to be enough to pay for the cost of the netting in two years. We believe that this practice is proving to be an important tool in a Midwestern fruit farmer's management against increasing environmental uncertainty.

However, the current physical exclusion system does little to protect the plants from environmental and disease pressures from wet field conditions. While the effect was delayed compared to the open field, much of the late season fruit under the net was infected with anthracnose and botrytis fruit rot which spread and thrived in our region's increasingly rainy field seasons and significantly decreased potential marketable yields. It became clear that a modified net structure that also maintained a dry environment could increase total and marketable yields even above the current system, especially later in the season.

Our proposed demonstration project will investigate if a modified hybrid exclusion environment (combining netting for pest control with plastic for environmental control) can maximize yields of organic, long-season strawberries compared to a traditional netting system while eliminating the need for potentially harmful sprays. The proposed exclusion environment can be constructed at considerably less overall cost compared to an equal-sized plot under high tunnels, which often do not provide complete pest exclusion either. If found to be economically viable, this system could be

applied to almost any type of small fruit or management style (organic/conventional), maximizing the breadth of impact to most all specialty-crop farmers. To protect the strength of our local fruit production, we need to protect the actual fruit. This system may help secure the future of Minnesota's produce in the face of ever-increasing pressure.

1. Evaluate strawberry yield and quality using a hybrid exclusion (netting and plastic) to manage pests and disease.
2. Assess the economic viability of hybrid exclusion techniques.

ALTERNATIVE MARKETS AND SPECIALTY CROPS

Exploring Hull-less Seed Pumpkins as a Specialty Crop

Grantee: Rachel Sannerud, Pluck Flower Farm
Duration: 2 years
Award Amount: $11,158.00
County: Mille Lacs

PROJECT OBJECTIVES:

This project aims to demonstrate the feasibility and viability of growing hull-less seed pumpkins and processing them for pepitas for local markets by small farmers. Small market farmers need more opportunities to generate income. Hull-less seed pumpkins are a novelty crop that can be harvested, processed, and marketed in October and through fall and winter, which is the typical slow or off season for vegetable growers. It is a valuable opportunity for small farmers to extend income into the slow season.

Hull-less seed pumpkins have not been explored as a specialty crop and product in Minnesota, though there have been publications from the University of Minnesota in the past. In order for small farms to begin growing these pumpkins on their farm, they need to know if it is worthwhile and have resources that lay out seed varieties, best practices, disease and pest pressure, and harvesting and processing methods.

Consumer trends favor health food products and specialty products made with ingredients that are sourced locally. Pepitas are a known health food and can be marketed directly to consumers, to specialty food product producers who are already using pepitas in their products such as granolas, and to restaurants with pepitas already on their winter menus. The interest is already there for pepitas, but the local option is not yet there.

This project will benefit other farm businesses because they can look to the project report and attend a field day to decide if hull-less seed pumpkins are a crop they would like to add to their farm. The decision can be made with significantly less risk than if they did a trial without prior knowledge. Farmers will be able to see growing practices, variety trials, pest and disease pressure, and markets explored without having to grow the pumpkins themselves to find out. If proven a viable crop, small farm businesses will have another crop to choose from for extending their season, their markets, and therefore their income.

1. Evaluate hull-less pumpkin varieties under two management strategies.
2. Explore the market viability of selling pepitas.

2020 New Demonstration Grant Projects

Diversity Agriculture and Its Feasibility in Minnesota: Sustainable Practices and Marketing

Grantee: Dr. Dean Current, University of Minnesota
Duration: 2 years
Award Amount: $25,000.00
County: Hennepin, Ramsey

PROJECT OBJECTIVES:

This project focuses on demonstrating the viability of diversifying sustainably produced agricultural products in Minnesota. Minnesota has a large immigrant population, many with agricultural backgrounds but limited opportunities to work in agriculture. The purpose of this proposal is to gather and share common information about the varieties of crops that are grown in Nepal and Bhutan and that may be grown in Minnesota. This may guide policies promoting better health, environment and social justice among every group of citizens. This way we may be able to develop a synergy to fight against increasing pressure on our natural resource base.

Our diverse immigrant population is not only an incredible human resource but also a reservoir of cultural knowledge, which, if valued, can provide information for better living. Many immigrants can recall their childhood memories of being engaged in organic agricultural production and consumption. That knowledge is often lost as immigrant populations are assimilated in a new cultural condition, losing knowledge that can contribute to the health of immigrant populations and our agricultural production.

We will work with Bhutanese and Nepali immigrant populations. Crops popular with immigrant populations are not always available. Minnesota immigrant communities bring important agricultural skills that are often not utilized due to the lack of opportunities for those communities to access land and resources needed to produce and market agricultural products. This project focuses on production and markets for lesser known Asian crops common from Bhutan and Nepal.

The outcome of the study is adding new agricultural products to local markets. The long-term benefit of the project is to introduce innovative crop varieties that contribute to the environment, human health and the local economy. We will use a change model embracing diversity knowledge to support community-based agricultural micro-enterprises.

We plan to demonstrate production of lesser known traditional agricultural products as a way to improve the diets of the immigrant communities, diversify Minnesota's sustainable agricultural base and create and strengthen community enterprises to support immigrant livelihoods and improved health outcomes.

1. Research Bhutanese and Nepali community knowledge of alternative crop varieties using qualitative methods.
2. Introduce innovative crop varieties in Minnesota by identifying seed sources and sustainable cropping methods to produce those crops in Minnesota.
3. Develop minority community capacity to engage in agricultural enterprise for economic development by exploring opportunities for immigrant students to attend the University of Minnesota and study agriculture and enterprise development.

2020 New Demonstration Grant Projects

LIVESTOCK

Determining Effects of Prescribed Sheep Grazing on Plant Diversity in Native Pollinator Habitat

Grantee: Jake Janski, Minnesota Native Landscapes
Duration: 3 years
Award Amount: $25,137.50
Counties: Wright, Chisago, Stearns, Carver, Washington (TBD), and Dakota (TBD)

PROJECT OBJECTIVES:

Restoration of native plant communities that require some form of vegetation management in perpetuity is common in Minnesota. Pollinator friendly solar production facilities have been a recent addition to that trend. As prescribed burning in such scenarios is impractical, the management of these facilities fall to the traditional chemical or mechanical methods.

Prescribed grazing of restored prairie using sheep has been implemented as an alternative option for the past three years. The effectiveness of this practice on short-term vegetation height and density reduction goals have been immediately deemed successful. Target weed management goals have been initially effective but will take time to achieve. What is largely unknown is precisely how this grazing is affecting the species diversity of the pollinator friendly plant community. As native plant communities are managed to improve habitat through increased species diversity, understanding these effects will enable us to better represent all the ecological benefits grazing can provide as a management tool, well beyond the obvious and immediate results.

1. Graze solar production facilities with practices consistent with the owner's and Ecologist's ongoing goals.
2. Evaluate grazed and control plots for plant species diversity using vegetation surveys twice during the growing season to capture data on warm and cool season plant species.

Control of Wild Parsnip through Rotational Sheep Grazing

Grantee: Heidi Eger, Radicle Heart Farm
Duration: 2 years
Award Amount: $20,045.00
County: Houston

PROJECT OBJECTIVES:

The purpose of this project is to measure the impact of a carefully managed sheep flock on a population of wild parsnip. Wild parsnip is listed as a noxious weed by the Minnesota Department of Agriculture. As a noxious weed, "efforts must be made to prevent the spread, maturation and dispersal of any propagating parts, thereby reducing established populations and preventing reproduction and spread as required by Minnesota Statutes, Section 18.78."

Wild parsnip is a growing problem across much of Minnesota, especially in the southeast. It outcompetes desirable species by being one of the first species to grow in the spring. When sap from the plant gets on skin, it causes large burn blisters. Mowing is expensive and only moderately effective. Spraying the plant with herbicide is expensive, can result in desirable nearby plants being accidentally killed, and is dangerous to grazing animals. Organic producers can't spray and can only mow accessible areas. If grazing by sheep provides good control of the plant, it would allow land managers an alternative that is beneficial to the environment and their bottom line.

2020 New Demonstration Grant Projects

There are areas in our pasture that are impossible to graze once the parsnip starts to grow tall and form flower heads. Our flock is rotated across the pasture using temporary fence. The parsnip is so prevalent that, once tall, it is hazardous for her to walk through the plants to set up fence for paddocks. These areas are either too hilly to be mowed or are inaccessible to the mower because of gullies. In 2019, we lost access to almost a sixth of the pasture because there was no path through the parsnip. The tall parsnip flower stalks also shade the grass, reducing pasture quality.

We have heard anecdotal evidence that goats reduce parsnip populations, but we have not found any data to support the claim. Goats prefer to eat high up, eating leaves off the flower stalk but not the first-year growth of leaves which are close to the ground.

Our sheep flock has shown a strong preference for parsnip leaves and frequently eats them before other plants in their paddock. The sheep do not eat the flower heads and will not stop well established plants from blooming. We want to test the hypothesis that sheep can kill some of the young plants through grazing and trampling and can weaken the plants that survive enough that the flowers will produce fewer, smaller, and thus lower quality seeds.

1. Test whether or not sheep can impact parsnip populations over two grazing seasons.
2. Evaluate grazed and control plots for plant species diversity using vegetation surveys twice during the growing season to capture data on warm and cool season plant species.

Sustainable Agriculture Demonstration Grant Project Updates 2019

The following 2019 project updates contain the purpose for conducting the project, project design, and activities conducted during the first year of the grant project. To find out more details about these projects, contact the principal investigators directly through the listed telephone numbers, addresses, and email addresses.

ALTERNATIVE MARKETS OR SPECIALTY CROPS

Integrated Hemp and Heritage Farm
Grantee: Bridget Guiza and Winona LaDuke, Anishinaabe Agriculture Institute

Exploring North Star Farm Tour as A Sustainable Agri-Tourism Model for Small Producers
Grantee: Melodee Smith and Wendy Wustenberg, North Star Farm Tour

CROPPING SYSTEMS

Regenerative Agriculture: A Pathway for Greater Farm Profitability and Practice Adoption
Grantee: Alan Kraus, Cannon River Watershed Partnership

Headwaters Agriculture Sustainability Partnership
Grantee: Sacha Seymour, Environmental Initiative

FRUITS & VEGETABLES

Rotational Grazing in an Orchard to Improve Pasture Health, Reduce Energy Input, and Increase Profit
Grantee: Robert Blair, Canosia Grove

LIVESTOCK

Toward Forever Green Poultry Rations
Grantee: Jane Jewett, WillowSedge Farm

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

Evaluating Hazelnuts as a Soy-Protein Replacement in Free-Range Poultry Systems
Grantee: Wyatt Parks, Main Street Project

SOIL FERTILITY

Using Sheep and Cover Crops in a Strawberry Rotation
Grantee: Sarah Brouwer, Brouwer Berries

Integrated Hemp and Heritage Farm

Grantee: Bridget Guiza and Winona LaDuke, Anishinaabe Agriculture Institute
Contact information: 218-280-1720, anishinaabeag@gmail.com, bridget@honorearth.org
Duration: 2 years
County: Becker

PROJECT SUMMARY

Create an integrated hemp and traditional foods working farm, utilizing rotational planting, natural fertilizers, and greenhouses. Hemp is traditionally grown as a monoculture crop. We would like to develop both a rotational plan for hemp and an intercropping and crop rotation of the hemp in the fields with corn, beans, squash, tobacco, and Jerusalem Artichokes as well as other varieties. We will create a farm or field plan with these crops and utilize traditional fertilizers from Red Lake fisheries, horse manure and a combination of options and continue to test these on our food and hemp crops. End uses of the hemp will define whether it can be grown with other crops, or if it needs to be grown alone.

The site will serve as a demonstration farm, allowing others interested in sustainable industrial hemp cultivation to learn and work on the farm. 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. We will also continue our tribal internship program by hosting three tribal members at our farm.

PROJECT DESCRIPTION

The hemp industry has been suppressed for about 70 years, and the technology we had in 1940 is of great interest to Anishinaabe Agriculture as possibly scaled and pre petroleum opportunities. We began extensive research into growing and production of hemp in 2018 and continue that research in both historic records, and in broad review of industry opportunities and standards. We were able to begin at the hemp farm, and to make a beautiful location, featuring murals by Teresa LaDuke and also open a small farm market.

- Start varieties for local agriculture (April) including tobacco, squash, tomatoes, hemp, and herbs). Secure additional hemp varietals (Czech, Polish, French, Ukrainian and Italian fiber varieties as well as four CBD varietals) (underway).
- Working with hemp industry people in Europe continue to secure additional seed varieties and review equipment options for the processing of hemp into fiber options (underway).
- Begin the process of seeking organic certification for our products.
- Tribal Demonstration/curriculum - Winona LaDuke and Tribal Interns.
- Host three community feasts with these foods.
- Utilizing integrated research and support including that from the University of Washington Jackson School for International Policy, develop an integrated tribal hemp curriculum which can be used in tribal and non-tribal colleges and programs.
- Hosted third Intertribal Hemp Conference February 2020, on the White Earth reservation in collaboration with the White Earth Indigenous Farming Conference. One hundred attendees came regionally and nationally.

*Began greater outreach and collaboration with tribal farmers in the region and nationally, providing technical assistance to Red Lake, Cheyenne River, Yankton, Navajo, and Oneida, and holding meetings with Sisseton, Oneida, Omaha, and Oglala Lakota nation on hemp varieties and opportunities.

Presented in 2019, at the Minnesota Hemp Conference, sponsored by the MDA, and at a number of Native American agriculture conferences regionally and nationally, as well as Flow Kana- Catalyst for Change, national gathering.

- Present first draft of Tribal Hemp Curriculum at the hemp Conference with plans for a fall release of the final curriculum which will include history, botany, uses, technology, economics, and futures in industrial hemp.

Continue Youth Agriculture Program - Winona LaDuke and Don Wedl:

- Recruit and train three tribal interns working with tribal programs. (underway: Jon Martin, Nick Boswell, and Gwekaanimad Gasco have been involved in planting, harvesting and decordicating).

2019 RESULTS

In 2018, we worked with the White Earth band and were able to harvest hemp from the 8 acres of the White Earth's reservations seed stock. We cut the hemp by hand and with a sickle mower and left about half of it to field rett in the Callaway Field. A good portion of the hemp we shocked and left to field rett, trying to understand the process. We had a hemp field education day in Callaway.

We brought the remainder off the field in the spring of 2019, and ran it through a decorticator, which we purchased from China. This was an educational experience for all of us as we had to determine the best technologies for production and for harvesting. We didn't plant that year, because the crop volunteered in the field and was growing with no additional fertilizers. We planted a small field in Osage in 2019, utilizing a new variety. We field retted this hemp for the most part, bringing in some of the hemp for artisan processing. Some of the hemp has been sent to Dine weavers in New Mexico on the Navajo reservation for a new initiative blending churro wool and hemp, and also with hemp for rugs.

At the Osage farm, we cultivated with our pony Orion, and were able to prepare the field with Orion in the smaller plots and the two work horses in the larger plots.

We continued to grow corn, particularly an Osage Red Corn variety, and a Painted Mountain variety, both Native varietals of flint corn for hominy. In 2019, we had little success with our corn due to excessive rain. We planted again for 2020. We used fish guts and emulsion on the corn varieties with great results. We used manure with the squash varieties which seemed to be best. We also found that the production of heirloom potatoes was best with the fish gut varieties, yielding potatoes with approximately one third higher yields with fish guts, both in terms of size of potato and number of tubers. Our potato varieties from two farms grew well in 2019, yielding over l,000 pounds of heritage potatoes. We decided to focus on these varieties for market and local consumption. Our bean varieties grew well with the manure on the farm, and we were able to grow Taos red beans, 40 pounds, 25 pounds of hidatsa shield beans, and 25 pounds of appaloosa beans. We maintained this production in 2019. In coordination with the University of Wisconsin at Madison we were able to grow out l0 varieties of heritage potatoes. The Dark Red Norland we got between five and six potatoes per hill. From the five pounds of seed potatoes we got over five gallons of nice potatoes.

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

Grantee: Melodee Smith and Wendy Wustenberg, North Star Farm Tour
Contact information: 651-212-8099 and 651-246-6332, northstarfarmtour@gmail.com
Duration: 3 years
Counties: Dakota, Faribault, Fillmore, Goodhue, Olmstead, Ramsey, Rice, Scott, and Wright

PROJECT SUMMARY

North Star Farm Tour is a 501c3 learning community of family-owned farms founded under the mission: "Connecting People, Farms & Fiber." Small-scale farmers and agritourism operators run on notoriously thin margins, yet face increasing pressures to improve facilities, ensure product quality, and professionalize their businesses in order to meet consumer demand and regulatory requirements. North Star Farm Tour is a clearinghouse to help members to prevent redundant investments or costly mistakes. The 15 members located in Minnesota and who joined as cooperators before the Dec. 12, 2018 application deadline can receive up to three years of unrestricted block grants to invest in projects beneficial to their farm. This grant project then uses longitudinal evaluation to track how members' investments and involvement with our nonprofit experiment influences their profitability and personal wellbeing associated with agritourism. In return, each recipient agrees to participate in North Star Farm Tour activities, serve on at least one North Star Farm Tour committee, attend the annual meeting, and participate in evaluations.

PROJECT DESCRIPTION

North Star Farm Tour is an all-volunteer, educational organization founded in 2017, funded by membership fees, donations, sponsorships, and grants. In 2019, our 20 members produced and independently sold a wide variety of quality raw, processed & finished fiber products, as well as food and artisan goods, livestock, forages and other income-producing goods. Members collaborated under the North Star Farm Tour banner to accomplish three special educational projects that were honored with funding and co-labeling from Minnesota Grown: "The Sock Project," "Farm2Fashion," and "Farm Safety & Health Project." The heightened 2019 publicity drew 5,000+ people from over 80 Minnesota cities, 5 states & 7 countries to our 16 tour sites, about double the 2018 attendance. Surveyed visitors wanted more: farm dinners; wedding venues; events; open-air concerts; farm stays; demonstrations; classes; youth camps; locally grown, sustainably raised products; spring birth experiences; and more. Adding more activities guarantees more work and risk, but not necessarily increased enjoyability or profitability. Measuring improvements on those two returns on investment are at the heart of agricultural sustainability.

PROJECT OBJECTIVES

1. Incentivize active participation in North Star Farm Tour as a cost-effective, replicable model. It's expensive, risky, and unnecessary for farmers to figure out everything the hard way by themselves. There is much to know about regulations, liability, marketing, effective community education for all ages, emergency preparation, multi-cultural outreach, and much more.
2. Encourage members to develop skills as entrepreneurs and agritourism hosts. As of October 2019, we are benefiting from higher-education partnerships with Vermont Law School's Center for Agriculture and Food Systems, University of Minnesota Tourism Center, and University of St. Thomas ENACTUS Club (a long-term partnership to accomplish entrepreneurial business plans for each farm and North Star Farm Tour). We are working closely with an increasing roster of state and regional agency staff, agricultural associations, insurance companies, and community-minded companies and cultural organizations to develop competencies necessary for hosting the public.
3. Share what we learn about agritourism as a sustainable product through a "toolkit" of field-tested ideas by the end of 2021. What we learn we will share to help others shortcut the agritourism learning curve, improve their experiences and profitability, and help define agritourism and professionalize the industry as a whole.

2019 RESULTS

In September and October, participating farms completed the baseline survey, which gathered information on farmers' activities, income, wellbeing, plans for the future, current challenges, and intentions for investing grant money in farm business operations. A short follow-up survey in November collected information on how farmers actually invested the first year's grant funds.

North Star Farm Tour members have diverse business structures and income sources. Farmers also express varying levels of commitment to commercializing their farm operations. Of 15 farms surveyed, four viewed their farms as primarily commercial, three as primarily personal, and eight as a combination.

Farms reported a wide distribution of farm incomes. On average, farm income contributed 4.45 percent of each household's total income, reflecting the heavy reliance of agritourism operations on off-farm income sources. However, reliance on off-farm income is not consistent across farms. Pooled across all farms, almost half (43 percent) of farm income came from on-farm product sales and 30 percent came from other sources of income including boarding of animals, hosting craft events, manure sales, and selling livestock for breeding and meat. When reviewing these kinds of results, it is important to keep in mind that increased success of agritourism operations is primarily reflected in increased on-farm product sales and not necessarily increased income directly from hosting agritourism events (via entry fees, etc.).

The 2019 farm survey identified key barriers to increasing farm profits. Four main barriers included: lack of time, lack of business development and marketing, financial constraints, and need for facilities improvement. Of 15 farms surveyed, 60 percent cited lack of time as a major barrier to increased profitability. Time constraints stemmed from commitments to off-farm work and family, dedication to farm operation rather than farm business development, and the need to close the farm to the public seasonally. Several farms noted a lack of entrepreneurial nature as a reason for an undeveloped

business plan; fundamentally, they run their farms and agritourism operations out of a sense of community rather than a desire to increase profits. A third of the farms cited a lack of marketing, publicity and exposure to markets as a major barrier to improving their business. Financial barriers included an inability to eliminate debt, high cost of fiber processing which results in high product cost, access to land, access to capital to develop and expand, and difficulty monetizing interactions for fear of seeming unwelcoming or reducing the customer base. The need to welcome new customers onto the farm and fulfill the mission of providing an agricultural education to all pushes against the ability of these farms to effectively monetize their interactions and turn a profit. Asset constraints included an inability to find reliable part-time labor, the need to establish professional studio spaces to host visiting artists for workshops, need to seasonally close the farm to the public, and lack of access to land and capital to develop and expand the farm enterprise.

Of the 12 farmers who responded to questions about wellbeing and meaning, all agreed that the work on their farm was meaningful to themselves, to their spouse/partner, and to their customers. Over half also agreed that work on their farm was meaningful to their family. All but two of the farmers reported feeling that their work was important to the environment. Most farmers were optimistic and feel positively about their well-being. All of them felt strongly connected to people who share similar interests and that their work was emotionally, professionally, and spiritually fulfilling. The greatest reported source of discontentment came from feeling unable to balance on-farm and off-farm work. North Star Farm Tour programming helped farmers feel, on average, 75 percent confident that they were prepared to host agritourism events at the time of the survey. Surveyed farmers report enjoying their farming experience despite perceiving low profitability from their work. Despite all of the challenges identified by the survey, our farmers are - on average - 90 percent certain that they will still be farming in 5 years, given what they know today.

CROPPING SYSTEMS

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

Grantee: Alan Kraus, Cannon River Watershed Partnership
Contact information: 507-786-3913, alan@crwp.net
Duration: 3 years
Counties: Rice and Goodhue

PROJECT SUMMARY

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, and when interseeded into corn, provide 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. Cover crop biomass quantity and quality along with corn grain yields compared between treatments will determine the corn row width that optimizes cover crop biomass production and corn grain yield and ultimately, profit.

PROJECT DESCRIPTION

These farm based experiments and demonstrations will be conducted in collaboration with farmers; Jim Purfeerst, Ed McNamara, Mark Comstock, and John Jaeger; Alan Kraus, Conservation Program Manager for the Cannon River Watershed Partnership; and Dr. Scott Wells, University of Minnesota Agronomy Department.

Beginning in 2019 and ending in 2021, the four collaborating farmers will each plant 16 - 20 acres of corn into strips (experimental unit) that are 60-feet wide and 725-feet long (1 acre), using on-farm scale equipment (e.g., 24-row planter), modifying their planters to accommodate a prescribed row spacing (treatment). Treatments include 30-inch (Best Management Practices), 30-inch with 2 skip rows every 4th row (i.e., balanced), and 60-inch row (i.e. wide) spacing in a randomized complete block design. A fourth 60-feet wide strip of corn planted in 30-inch rows will function

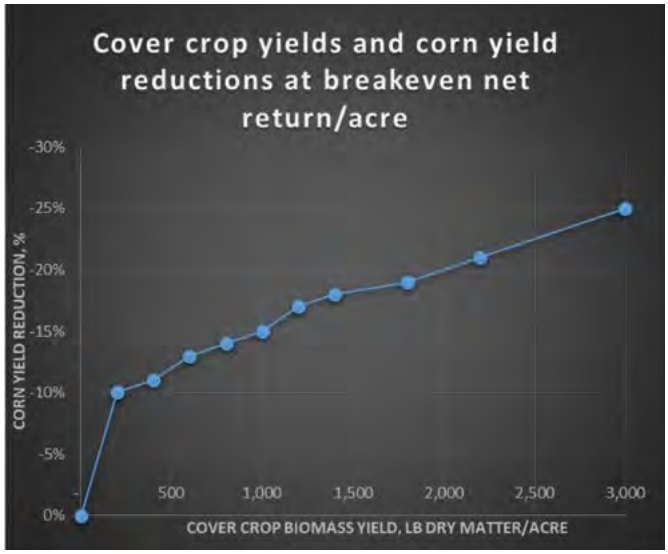
as the control and receive no cover crop. These planting patterns will be replicated four to five times across the test area. The corn seeding population, crop fertility, crop protection, and the cover crop mix and seeding rate will be constant between treatments. High biomass yielding cover crops of good forage quality (e.g., annual ryegrass, kale and intermediate red clover) will be encouraged. However, the farmers will base their corn hybrid and cover crop species selections on their own experiences and in consultation with cover crop and agronomy experts. Cover crops will be interseeded at corn growth stage V3 to V7.

Prior to corn planting in 2019 and after the final harvest of corn in 2021, soil samples will be collected on each experimental unit and analyzed for nitrogen, phosphorus and potassium content. Soil microbial activity and water infiltration between treatments and controls will also be measured. Cover crop biomass production (forage yield) will be assessed prior to corn grain harvest by obtaining a composite sub-sample from each experimental unit and the quantity (pounds of dry matter per acre) and quality analysis (crude protein, acid detergent fiber, neutral detergent fiber, and relative feed value) will be determined. Corn grain yield from each experimental unit will be measured using a weigh wagon at harvest. The corn grain and the cover crop forage will be valued at current market prices to estimate and compare maximum gross values of production between treatments and partial budget analysis will be used to make profitability comparisons.

2019 RESULTS

Corn grain yield was maximized under the treatment of 30-inch rows planted with cover crop, however there was no statistical difference between the grain yield for that treatment and the control (30-inch rows without cover crops). All farms experienced statistically significant corn grain yield reductions for row treatments that were wider than the Best Management Practices of 30 inches.

Cover crop biomass yield was maximized under the "balanced" treatment. This treatment utilized a pattern of planting four rows with 30 inch spacing and then skip 2 rows, resulting in a cover crop planting zone of 90 inches. The biomass yield advantage for this treatment was statistically significant from the 60 and 30-inch row treatments, offering just over 1,600 pounds of forage dry matter per acre available compared to 800 and 150 pounds, respectively. Cover crop biomass quality was evaluated using wet chemistry analysis and indicated very high-quality forage. Relative feed value ranged from 145 for the biomass in the 30-inch row treatment to 191 for the biomass in the 60-inch row treatment. Crude protein of the cover crop biomass was identical between treatments at 23 percent.



Analysis by Dr. Bill Lazarus University of Minnesota Agricultural Economist determined that high yielding cover crop forages can offset up to 10 percent corn grain reductions (without any value given to soil health or ecosystem benefits) and maintain profitability equal to the Best Management Practices (or the control) – see graph. The 20 percent average corn yield reduction from the wide and balanced treatments found in 2019 in this study would require significant cover crop biomass, soil health, ecosystem benefit payment, or other input costs reductions to achieve comparable profitability to the Best Management Practices (or the control). However, the two farmers who were able to allow their cattle to graze the cover crop biomass reported that the cattle completely consumed it and felt that wide-row corn, paired with cover crops that produce large quantities of high-quality forage can provide corn farmers an opportunity to improve profit, soil health, and the environment.

Headwaters Agriculture Sustainability Partnership

Grantee: Sacha Seymour, Environmental Initiative
Contact information: Haley Burns, 402-926-6512, hburns@en-in.org
Duration: 2 years
Counties: Stearns, Todd, Morrison, Benton, Wright, Meeker, Kandiyohi, Pope, and Douglas

PROJECT SUMMARY AND DESCRIPTION

Dairy farmers are struggling as milk prices are below their cost of production and low crop prices are making many row crop farms unprofitable. 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.

This project will create a cohort of farmers with varying operations, farming practices, and environmental outcomes—starting with integrated dairy and row crop operations and expanding to commodity corn and soybean farms. The purpose of this effort is to create case studies that are relevant and motivating for farmers in a similar geography. These operations should not be seen as outliers and farms will be chosen for their similarity to an "average" farm in Central Minnesota, though above average in the success they found in farming for both environmental outcomes and economic returns. This will help demonstrate the achievability of different farming practices.

The unique collaboration that has emerged to solve this problem includes Environmental Initiative, the Minnesota Milk Producers Association, the Stearns County Soil and Water Conservation District, Syngenta, Steve Schlangen (farmer and Chair of Associated Milk Producers Inc.), The Nature Conservancy, Compeer Financial, Steve Peterson (farmer and former Director of Sustainable Sourcing at General Mills), Integrated Crop Management Services, and Houston Engineering Incorporated (collectively, the "Partnership").

GOALS/INTENDED OUTCOMES:

- Motivate the adoption of farming practices that achieve:
  - Short-term cost savings and efficiencies for dairy and crop farmer and long-term regulatory certainty and productivity; and
  - Greater protection and improvement of water quality and soil fertility.
- Motivate practice changes that keep dairy and row crop farms profitable and in business, and protect natural resources that Central Minnesota communities rely on for growth, recreation, and long-term agricultural productivity.
- Engage crop advisors and agronomists as secondary audiences so they are more comfortable recommending sustainable farming practices to their clients.
- Create a replicable, scalable model for showcasing sustainable farming practices that can be used to enhance profitability and environmental sustainability for a range of geographies and farm operations.

2019 RESULTS

During the grant period in 2019, Environmental Initiative convened four in person partnership meetings in addition to many conference calls involving a subset of partners. Partners determined roles, developed plans for the project, identified core criteria for farmer participants, and refined the methodology for the collection of data.

Through their networks, the partnership recruited and contracted with three Stearns County dairy farmers for the case studies. The farms include Steve Schlangen, dairy farmer in Albany, MN and chair of the Associated Milk Producers; Kerfeld Hillview Farms, dairy farm in Melrose, MN; and Mill Creek Dairy, dairy farm in Kimball, MN. The partnership selected these farms for the following criteria: participation in the Minnesota Agricultural Water Quality Certification

Program, good financial record keeping, and because they represent varying sizes of dairy farms with different conservation practices.

The bulk of the case studies will take place in 2020. Each farm will undergo an economic assessment and an environmental assessment. The economic assessment will result from enrollment in the Farm Business Management Program at Central Lakes College. The data collected will be compatible with the FINBIN database and will be compared to the average farmer in Stearns County, other dairy farms, and other participants in the water Minnesota Agricultural Water Quality Certification Program. The Minnesota Milk Producers Association will be covering a portion of the tuition costs for this program. To date, Farm Business Management staff have completed initial interviews with all case study farmers.

The environmental assessment will be managed by Mark Lefebvre at the Stearns County Soil and Water District, who completed the initial Minnesota Agricultural Water Quality Certification assessment with all farmers. Therefore, Mark is familiar with their operations and the conservation practices adopted as part of their plan to achieve certification. Mark will use the FieldPrint calculator, a national assessment tool several partners have access to through Field to Market, to assess the farms. He has made initial contact with each farm and plans to complete the data collection in early 2020.

After the environmental and economic assessments have been completed, Houston Engineering will analyze the data, compare the farms to the average farm in Stearns County, and help to paint a more detailed picture of the return on investment for on-farm conservation practices.

Environmental Initiative developed a preliminary communications plan for the case studies. The communications plan outlines communications goals that will support project goals stated in the project summary, as well as identifies key audiences and key messages.

In December 2019, Environmental Initiative convened a day-long retreat for the partnership to identify group purpose and goals beyond the case study project. With the expertise and reach of the partners, the group has the potential to influence and support a wide network of sustainable agriculture projects in Central Minnesota. The group now aims to act as a sustainable agriculture project incubator in the Headwaters area.

FRUITS & VEGETABLES

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

Grantee: Robert Blair, Canosia Grove
Contact information: 218-341-0988, canosiagrove@gmail.com
County: Saint Louis

PROJECT SUMMARY

This project is demonstrating that intensive rotational grazing within an apple orchard can improve pasture, soil, and orchard health, while decreasing manpower and energy inputs in the orchard understory. The synergy between the sheep and the orchard understory is important because it may have the effect of increasing profitability while simultaneously improving the overall health of our farm.

PROJECT DESCRIPTION

Canosia Grove is a northern Minnesota permaculture orchard and cidery specializing in on-farm production of small batch, traditional dry sparkling hard ciders made from local apples. Our unique “North Shore” climate affords us with some of the fastest tree growth rates in Minnesota, and even our thirty-year-old apple trees have no apple scab, apple maggot or codling moth. We have a small quarter acre of old trees, 1.5 acres of new orchard, and we are planting an additional 5 acres of new apple trees. We are struggling to convert existing fields from reed canarygrass because it can choke out tree growth. We were trying to control the grass by mowing.

Mowing the orchard allows for increased light during establishment of the trees and allows air to circulate, which decreases fungal diseases. It also decreases pressure from rodents. Mowing, therefore, is a critical and valuable function

in our orchard. However, it is also the most time-consuming aspect of our farm labor and has a high opportunity cost. We hope that grazing sheep on the reed canarygrass will provide an economically viable farm enterprise and will cut our overall labor inputs dramatically while providing a new income stream for our farm through sales of wool and lamb. Grazing should add value to the pasture soil, by adding nutrients and organic matter from trampling. The increase in soil health should lead to healthier and faster apple tree growth.

The project involves installing traditional sheep fencing for rotation of our Icelandic sheep flock and establishing an additional 5 acres of pasture within an existing apple orchard. We will assess soil health and forage quality within several paddocks prior to and during subsequent years of rotational grazing, and track labor hours related to mowing, understory management, and tree protection over time. The results of monitoring forage quality and soil changes will help demonstrate the amount of time over which former pasture lands that have undergone succession are able to be re-established for rotational grazing. The improved forage quality will support an expansion of the flock, which will lead to additional capacity to build soil health over time.

2019 RESULTS

We started the year using temporary electric fence for the sheep and rotated the sheep over approximately 40 feet by 40 feet sized plots throughout the summer. The best control of reed canarygrass came when we grazed the sheep in early spring. Plant diversity increased dramatically in the first paddocks grazed in spring 2019, with an increase in plants like goldenrod and hawkweed. While not desirable forage, the new plants will be better understory plants in the apple orchard than the solid mat of reed canarygrass. Paddocks grazed in late summer are still over 95 percent reed canarygrass.

In 2019, we acquired the materials needed for full enclosure of our summer and winter paddocks with 4 feet high, woven wire sheep fencing. We installed 3,200 lineal feet of fenceposts, 44 H-braces, and eight gates in late September and then stretched 800 feet of fence for the winter paddock. The fence for the summer paddocks will be stretched in the spring of 2020.

In the summer and fall of 2019, we collected baseline data related to labor inputs, soil health, and forage quality. Approximately 4 hours per week (on average) were spent mowing the orchards.

Soil samples were collected in late October once the sheep were brought in from the pastures. We added the Haney test and the phospholipid fatty acid test. Samples were collected from the 0 to 6 inch interval using a soil auger; approximately 10-14 subsamples were collected from four different paddocks and composited into one sample representing each paddock. The subsample locations were recorded using a global positioning system. The baseline soil quality data indicate that we have generally excellent soil rating based on the phospholipid fatty acid test of total living microbial biomass, and slightly above average to good functional group diversity and a balanced bacterial community.

Our soils were generally found to have relatively low phosphorus and potassium. These nutrients are critical for orchards, which presents a paradox: why are we getting such good growth rates in these soils? Incidentally, sheep manure is an excellent source of both nutrients; distribution of manure within the orchard may help with these deficiencies.

We hosted a Soil Health summer field day in the summer of 2019 in collaboration with the Lake Superior Sustainable Farming Association; we will host an additional field day at the end of the project in 2021 to review the results of soil and forage analyses.

LIVESTOCK

Toward Forever Green Poultry Rations

Grantee: Jane Jewett, WillowSedge Farm
Contact information: Jane Jewett, 218-670-0066, jane@janesfarm.com
Duration: 3 years
Counties: Aitkin, Ramsey, and Rice

PROJECT SUMMARY

We are using 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. Forever Green is a University of Minnesota initiative that seeks to maximize continuous living cover of agricultural production fields through crop rotations and perennial cropping systems. The Forever Green ration will be built on small grains and perennials (alfalfa); some of which could eventually be replaced by Forever Green crops that are currently under development. We will do paired comparisons of bird batches in each of three production systems; collect data on carcass weights, ration disappearance, meat eating quality; and conduct 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. Success of a Forever Green poultry ration could help drive perennial cropping system adoption on Minnesota acreage.

PROJECT DESCRIPTION

The objective of this project is to 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.

The three participants have three different seasonal production systems and raise multiple batches of birds per summer:

- Jane Jewett – Cornish cross birds raised in a day-range model with conventional feed.
- Kathy Zeman – Cornish Cross birds raised in a hoop moved daily with organic feed.
- Wayne Martin – Kosher Kings raised in a chicken tractor model with conventional feed.

We hired Jeff Mattocks of Fertrell to assist in developing our shared ration recipes. For each farm we were able to match the farm's typical rations to their Forever Green ration for crude protein percentage and energy content and use at least 60 percent Forever Green ingredients in each ration.

Each farm selected two chicken batches during their season to split into a "typical feed" sub-batch and a "Forever Green Ration" sub-batch. We collected data on grow-out period, mortality rate, and ration disappearance in each sub-batch. Chickens were processed and we collected data on carcass weights. The intent was to have six paired comparisons.

We worked with Minnesota Institute for Sustainable Agriculture's Executive Director, Helene Murray, and chef Beth Dooley to conduct a taste test of standard ration and Forever Green ration chicken from each farm.

2019 RESULTS

Comparison of average weight per bird: The Forever Green ration birds did not perform as well as the Standard ration birds on either Jane Jewett's farm or the Student Organic farm. We think this was at least partly because the grind on the Forever Green ration was too coarse. On Kathy Zeman's farm, the Forever Green ration birds performed very similarly to the Standard ration birds in each of two batches. We are researching options to get a finer grind on the non-organic Forever Green feed for the next set of feeding trials.

Taste testing results were very mixed and difficult to interpret. Beth Dooley, a trained chef, said she could detect differences between the Forever Green ration birds and the Standard ration birds; but she thought they were subtle and not likely to be picked up by members of the general public. We chose to have the chicken for taste testing prepared with basic seasonings – salt, pepper, oil, lemon juice. Taste testing was done on three different days, one farm featured per day. The volunteer taste testers were not the same people from day to day. The Forever Green ration chicken was generally rated "Best" by fewer people than the store-bought chicken; although the Forever Green chicken was rated "Best" by more people on several sub-components like texture and juiciness.

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
Contact information: Anna.Seidl@blc.edu, 507-240-5004
Duration: 2 years
County: Sibley

PROJECT SUMMARY

This project will test two different pasture types to effectively maintain average daily gains in lambs on pasture from August 20th until finished weight. 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 daylength and sunny days. We will test two pasture mixes that can "store sunlight": 1) A mix containing turnips and sugar beets, and, 2) A mix containing peas and small grains. These pasture treatments will be compared to lambs on a standard feedlot ration. In addition, meat from the three treatments will be analyzed for human health attributes and eating quality. These data will be analyzed to present a discussion of advantages and disadvantages of each system, including discussions of ecosystem services, energy and equipment use, health benefits and marketing opportunities for pasture-raised lamb, and overall farm profitability.

PROJECT DESCRIPTION

This project will offer valuable data on the advantages and disadvantages of alternative lamb finishing options that can offer greater environmental benefits and potentially tap into additional markets and increase farm profitability.

Plan: One-hundred-five lambs will be divided equally into the three treatment groups in August. Group 1 will graze the turnip/sugar beet mix. Group 2 will graze the small grain mix. Group 3 will be given a standard feedlot ration of corn and purchased concentrate with adequate roughage. Group three will provide a control comparison of what our flock would gain in a feedlot. The lambs from group three will be removed from their mothers, as this is standard procedure for feedlot finished animals. The ewes will graze with their lambs in groups one and two for several reasons: 1) The ewes will teach the lambs how to harvest turnips and grain; 2) never weening the lambs is standard procedure for our system; 3) grazing pasture is generally agreed to be the most economical way to feed livestock, and excellent pasture will put more fat on the ewes backs and reduce winter feed costs later; and 4) High quality pasture this time of year will increase body condition of the ewes to increase breeding efficiency and likelihood of multiple births.

PROJECT OBJECTIVES

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.

These 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.

2019 RESULTS

Weather led to less than ideal growing conditions in 2019, and the two pasture mixes did not work exactly as planned, but we were able to gather some data. The meat analysis also revealed some differences in meat quality between the pasture-finished and feedlot ration-finished lambs.

The lambs were sorted into their groups for the experiment on September 26th 2019. This was slightly later that our original plan, but the growing season as it was, and with variations in our pastures it was beyond our control. Prior to this date, all of the lambs were rotationally grazed with their mothers on our various perennial and/or annual pastures. We had planned to have two pasture groups: one on a turnip/sugarbeet pasture and one on a small grain pasture. The feedlot group would receive a standard corn/concentrate/roughage diet and would serve as a comparison for the pasture treatments. However, the small grain pasture mostly failed so we were not able to collect the data from it as planned. We did, however, learn some things to modify for 2020 to hopefully make it workable.

The lambs and ewes in the turnip/sugarbeet treatment were rotated to fresh paddocks every 3 days. The lambs in the feedlot group were kept on pasture and corn/concentrate mix was gradually introduced to them. Once they were fully acclimated, the corn/concentrate mix was fed free-choice. Pasture quality was initially of moderate quality and gradually reduced in quality as they acclimated to the grain ration to encourage maximum corn/concentrate intake.

For both mixes (contact the grantee for specifics on the mixes and their observations), we feel that diversity is key to success, as this increases soil health, animal health, beneficial ecosystem services, and increases the likelihood of a successful planting (i.e. if one species fails, there are others to fill in. This theory ended up manifesting itself in the turnip/sugarbeet pasture).

The basic costs associated with feeding each group of lambs are presented in Tables 3 and 4. For each group, some costs are missing and each producer must figure these on his/her own. For the turnip/hairy vetch treatment, a cost for the acres grazed should be included. Depending on the producer, that could be land rent, property tax, or any fraction of these costs if the producer was able to use these acres for another purpose (other grazing/haymaking, cash crops such as small grains, etc.).

Table 3. Costs associated with feeding the turnip/hairy vetch lambs.

$42.89	Seed cost per acre
$25	Planting cost per acre
0.204	Acres eaten per day (34 lambs, 28 ewes)
69	Theoretical # of lambs if ewes were all lambs
$.20	Cost per day to feed one lamb (no labor)
$4.00	Labor dollars per day (40 minutes every 3 days, $18 per hour)
$.12	Labor cost per lamb per day (for the actual 34 grazed)
$.32	Total cost per day for the hairy vetch lambs

Table 4. Costs associated with feeding the feedlot ration lambs.

$.0625	Cost of a pound of corn ($3.50/bu)
0.27	Cost of a pound of concentrate
2.55	Average pounds of corn eaten per day per lamb
0.22	Average pounds of concentrate eaten per day per lamb
$.056	Value of roughage consumed per day per lamb
$.28	Cost per day to feed one lamb (no labor)
$6.00	labor dollars per day (20 minutes per day, $18 per hour)
$.17	labor cost per lamb per day
$.39	Total cost per day for the feedlot lambs

Overall, the lambs in the hairy vetch/turnip group had slightly higher average daily gains than the feedlot group (Table 5), but average daily gains in both groups could have been higher with ideas for improvement next year. We were impressed with the average daily gains from the turnip/hairy vetch group, as the average average daily gains was higher than any we had observed in previous years on pasture at this time of the year. Perhaps the greater amount of sunshine allowed the plants to produce more sugars that led to the higher gains. Additional data from 2020 should offer some insight.

For the meat analysis, we compared two samples: Meat from lambs the turnip/hairy vetch group compared to meat from lambs from the feedlot group. The turnip/hairy vetch sample had a higher percentage of saturated fat (53.45 percent) than the feedlot sample (50.49 percent), and twice as much Omega-3 fatty acids (Eicosapentaenoic Acid and Docasahexaenoic Acid). There was a lower overall amount of saturated fat in the turnip/hairy vetch sample (5.04) than the feedlot sample (7.16), but the total conjugated Linoleic Acid in the turnip/hairy vetch sample was higher. There was little difference between the two samples for most of the vitamins and minerals tested.

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

Grantee: Wyatt Parks, Main Street Project
Duration: 2 years
Contact Information: 425-760-2764, wparks@mainstreetproject.org
Counties: Dakota and Rice

PROJECT SUMMARY

We are testing the viability of feeding hazelnuts and hazelnut processing byproducts to chickens within our poultry production methods as a substitute for soy based protein. We want to know if the hazelnuts can provide usable protein in high enough density to maintain the growth and vigor of the birds. We also are exploring the economic potential of feeding waste hazelnuts (small/non-retail quality) to poultry and whether hazelnuts as feed can be price competitive with soy meal or if the chickens can command a higher retail price due to quality.

PROJECT DESCRIPTION

Alternative to soy-based poultry feeds are critical in the development of sustainable food systems in the Upper Midwest. Market conditions through consumer choice and feed cost variations have created conditions favorable to alternative protein sources in poultry feed. Hazelnuts offer a viable alternative in protein content, nutritional value, as well as the potential for value-added products created in the conjunction with poultry feed. Various studies have confirmed the general viability of replacing up to 50 percent of the protein feed in a confinement poultry operation with hazelnut meal but no research could be found that pertained to free range/paddock raised chickens. Trial groups need to be performed in Minnesota and in non-confinement conditions to validate existing research.

We will be using two trail groups, one that is fed whole hazelnuts that have been run through a hammer mill, and a second group that is fed just the meal leftover from the de-fatting or oil pressing process. The whole nuts will represent small or deformed nuts that would normally be waste products and the meal will represent a waste product from the production of hazelnut oil. To implement this research, we will be raising three flocks, one control and two trail flocks. All three flocks will receive the same starter feed for the first 4 weeks of life and will transition feed sources when they begin to roam in the paddocks. All three groups will also receive a blended mix of sprouted grains as a portion of their daily feed. The control group will receive the normal, corn and soy based non-GMO, feed that Main Street Project uses for all flocks. The trial groups will also receive the corn base of the feed with the soy removed. The hazelnuts, both the crushed nuts and the meal, will be mixed in with the normal feed to limit selection bias when the chickens feed.

The final evaluation will consider the economic results, comparing normal soy-based feed to hazelnut replaced feed. It will also include evaluations of the animal's health and vigor and if they reach target market weight on time. We are also considering the overall product quality and whether a premium product is being reached that consumers will want to buy.

RESULTS

This project did not start until March 2020 because a new site needed to be prepared for the research flocks and construction of new coops finished in the spring of 2020. Conducting this project on Main Street Project's Demonstration and Research Farm coops was preferred over rental for one year and then moving the flocks.

SOIL FERTILITY

Using sheep and cover crops in a strawberry rotation

Grantee: Sarah Brouwer, Brouwer Berries
Contact information: sarah@brouwerberries.com
Duration: 3 years
County: Kandiyohi

PROJECT SUMMARY

We are testing the effectiveness of sheep grazing on grass cover crops during fallow periods between strawberry rotations as a method of improving soil health, reducing weed pressure, and increasing strawberry poundage per acre.

We hope to increase the profitability of our farm by grazing sheep on cover crops between rotations of strawberries. Sheep, being smaller, will not compact the wet soil around the cover crops the way cattle have in past years, and that if we use strictly grass cover crops, we will be able to reduce weed pressure. We hope the sheep for meat will be profitable as an enterprise, and that the combination of sheep and a specialty crop will be useful for educational outreach.

PROJECT DESCRIPTION

We are a pick-your-own strawberry farm in west central Minnesota. In 2013, we started to expand and now have 15 acres in our rotation. Each year we plant about 3 acres with new strawberry plants, harvest about 8 acres off mature strawberry plants, and have about 4 acres that are in cover crop, resting before being planted again with strawberries.

Strawberry fields must be rotated on a regular basis to reduce weed pressure and to minimize the replant diseases called black root rot. We have our strawberries in the ground a little more than three years. The first year is the establishment year, and the second and third years are used for production. At the end of the third picking season (early July), the strawberry plants are plowed under and are planted into a series of cover crops for the end of summer and for the following growing season. We would like to show that grazing sheep on the cover crops will be a profitable use of the strawberry ground in the fallow years while reducing strawberry plant disease and improving the soil for our strawberry plants.

We, like all Minnesota farmers, have faced increasingly negative weather events over the past two decades, including drought, extreme rain events, deep winter kill, and powerful winds. Each weather event cost us thousands of dollars in lost revenue. About 5 years ago, we enrolled in classes with Thaddeus McCamant at Central Lakes College to learn how to grow stronger plants that could withstand extreme weather and remain productive. These classes led us to believe that healthy soil is the key to healthy plants, and that healthy plants can withstand adverse weather conditions. We have a silt loam soil with a pH above 7.2. In some areas of our strawberry field, the plants occasionally become chlorotic due to the high pH. Chlorosis is a major problem for strawberry growers in western Minnesota, where the soils are heavier and often have a pH above 7.0. A high pH is the cause, but other factors like soil compaction, soil health, and organic matter can either aggravate or minimize chlorosis.

The cattle grazing the cover crops caused compaction in the areas around the water troughs, leading to poor strawberry plant establishment. While compaction is a problem in all soils, it is worse for us, because soil compaction increases chlorosis. The cattle grazed selectively, leading to heavy weed pressure in new strawberry beds. In fall 2018, we sold the cattle and purchased a flock of sheep.

For our project, we are looking at the feasibility of grazing sheep in the cover crops that are planted between strawberry rotations. Immediately after plowing a strawberry field down, we are seeding the field to sorghum/sudan. sorghum/sudan is an ideal cover crop because it is a warm season grass that grows extremely fast, and it has shown to be one of the most effective cover crops for reducing replant diseases. Since sorghum grows so fast, it also crowds out many weeds. We intend to carefully steward this flock, in order that the sheep will be profitable as a separate enterprise, to balance out any losses we incur on our strawberries.

Farmers are looking for ways to increase production per acre while minimizing risk due to things like unpredictable weather. If the sheep improve soil, thus profits, while at the same time being profitable as a side business, they will 'flock' to us to learn our techniques.

EVALUATION:

- Track weeding labor hours per field block.
- Track grazing days and feed cost saving in sheep flock.
- Sap Testing: Using Sap tests to target nutrient deficiencies and increase poundage per acre.
- Soil Testing: Using soil tests to track changes caused by grazing and cover crops in soil nutrient levels, organic content, and pH.
- Track student education and social media metrics on the topics of this Sustainable Agriculture Demonstration Grant Project.

Plan for Summer 2020: Field 1: Plant 3 acres spring oats in April. Start grazing in June. Plant 3 acres sorghum sudan in July. Graze in September and October. This land was grazed by cattle in 2015 and 2016 and by sheep in 2019. Fields 4 and 5: Harvest strawberries in June. Plant 5 acres oats and rye. Graze in August and September. This land has never been grazed. Conduct soil and sap tests on all field blocks.

2019 RESULTS:

2019 Grazing days: We planted 3 acres of annual rye grass/oats on June 9 and started grazing the sheep 4 weeks later. It took our 56 mature ewes 98 days to graze 3 acres of annual rye grass and oats. At $0.25 per head for maintenance hay ration this grazing resulted in $1,372.00 saved in sheep feed cost.

2019 Weeding hours: fields that were planted to cover crops and grazed with cattle required 65 labor hours per acre for weeding during the summer. We anticipate fewer weeding hours/acre on sheep grazed fields.

2019 strawberry poundage: 3,378 pounds per acre. This is an all-time low, due to incessant rain during our harvest.

Online engagement in 2019:

- 567 views of Blog Entries about Sustainable Agriculture Demonstration Grant Project
- 19,700 views of Facebook Posts about Sustainable Agriculture Demonstration Grant Project

Sustainable Agriculture Demonstration Grant Project Updates 2018

The following 2018 project updates are descriptions of activities conducted to accomplish the project objectives, results obtained, and lessons learned during the two years of the grant project. These projects were summarized with more detailed project descriptions and 2018 results in the 2019 Greenbook. To find out more details about these projects, contact the principal investigators directly through the listed telephone numbers, addresses, and email addresses.

CROPPING SYSTEMS

Cover Crop Effects on Soil Temperature and Soil Moisture
Grantee: Jerry and Nancy Ackermann

Grazing Intermediate Wheatgrass (Kernza) as a Dual Purpose Crop for Forage and Grain Production
Grantee: Alan Kraus, Cannon River Watershed Partnership

Agrophenology Project
Grantee: David Abazs, Wolf Ridge Environmental Learning Center

FRUITS & VEGETABLES

Cover Crop and Intercropping Alternatives During the Establishment Period of Perennial Fruit Crops
Grantee: Richard Traugott

SOIL FERTILITY

Perennial Farming and Carbon Sequestration, Ecosystem Services and Innovative Entrepreneurship
Grantee: Michele Manske, Mashkiikii Gitigan 24th Street Coalition & Pillsbury United Communities

SPECIALTY CROPS

Peonies for Profitable Cut Flower Production in Northeastern Minnesota
Grantee: Kate Paul, Owl Forest Farm

Cover Crop Effects on Soil Temperature and Soil Moisture

Grantee: Jerry and Nancy Ackermann
Contact information: Catherine Wegehaupt, cwegehaupt@hlwdonline.org, Jan Voit, jvoit@hlwdonline.org, Jerry and Nancy Ackermann, Ackermann.jn@gmail.com
Counties: Jackson and Nobles (two plots each)
Final outreach event: Planning to conduct a field day in fall of 2020 or produce a guide on how they recorded their data and describe their findings.

PROJECT DESCRIPTION

Previous research has shown that cover crops 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 can increase organic matter. However, project partners are unaware of any first-hand data about cover crop 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 help southwest Minnesota farmers in their farming operations and also help improve water quality in local streams.

Jerry and Nancy Ackermann have been farming for 46 years and both are extremely active in on-the-farm research and test plots. The farm is a 1,050 acre crop rotation of corn, soybeans, and alfalfa. For the past 15 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.

They are partnering with Kevin and Dana Schmid and Bruce Leinen to conduct this project. Kevin and Dana Schmid are currently in their 24th 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. Bruce Leinen started farming with his father in 1987 and he now farms with his sons. He currently farms 1,600 acres and he grows corn, soybeans, and has started to incorporate some wheat.

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.

PROJECT OBJECTIVES

Summary of activities conducted and results through 2019:

1. Determine how cover crops and tillage method (Jackson County) affect soil temperatures and soil moisture. Soil temperature and moisture are important for nutrient uptake and plant growth. Soil volumetric water content and soil temperature were measured three times per month and the amount of precipitation was monitored throughout each entire year.

    - In 2018, soil probes were installed until after planting was completed in all field plots so early season data isn't available for 2018. On average, Jackson County soil temperatures, were slightly cooler in the non-cover crop, conventional tilled field versus the cover crop/strip-till field throughout the entire growing season. Soil moisture season averages were the same for both managements throughout the entire growing season.

- One type of tillage management was used for all the Nobles County test plots, so these plots were comparing 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. Temperatures were very similar in May and June, but the cover crop field showed a slightly cooler reading early in the growing season.
- Jackson County in 2019: the cover crop field warmed up sooner than the conventional tilled field. This showed that cover crops and strip-till management plots warmed the soil up without having to do conventional tillage.
- In Jackson County, the only significant differences in water volume between tilled and no-tilled fields occurred in April and May 2019. Unexpectedly, the tilled condition was significantly wetter in the 0 to 10 centimeter depth than the no-till. Data for the 10 to 20 centimeter depth showed that there was significantly more water stored in April and May under no-till than the tilled condition.

2. Determine if soil moisture and soil temperatures have an impact on plant growth or nutrient uptake.

- Microbial activity, pH, infiltration rate, bulk density (pore space in the soil structure), and soil Potassium, Zinc, and nitrate levels were measured.
- Water infiltration testing has always been higher in the cover crop strip-till field plots. In 2018, the Ackermanns stated, "We were somewhat disappointed in the one-hour water infiltration test as it showed 3.5 inches in one hour. However, the tilled field did not even take in 1 inch in an hour".
- In 2018 and 2019, Microbial activity was always higher in the field plots that had cover crops, strip-till management.
- Bulk density test results haven't shown patterns or relationships with any managements.

MANAGEMENT TIPS

1. The 2019 crop season appears to be a repeat of 2018 and may be a trend in the future of cool, wet springs with more prevent planting acres than in previous years.

2. Our test field was planted to soybeans this year. All acres were planted and harvested. We feel the cover crops helped warm the soil earlier, which was a benefit for germination. The cover crop roots and plants also helped carry the planting equipment to minimize compaction.

3. Extreme moisture for the year did take the top end off yields in the area. Even with excess moisture, we did not have any drowned-out spots in this field, while neighboring fields did. Harvest was completed on all acres without any deep ruts from equipment. We attributed this to having a living root in the soil to carry the equipment and minimize compaction.

Grazing Intermediate Wheatgrass (Kernza) as a Dual Purpose Crop for Forage and Grain Production

Grantee: Alan Kraus, Cannon River Watershed Partnership
Contact information: Alan Krause, 507-786-3913, alan@crwp.net
County: Rice
Final outreach event: Farm field day this year will be on July 29, 2020 because the project termination date will be June 30, 2021, which is before harvest of the Kernza crop.

PROJECT DESCRIPTION

Minnesota crop and livestock growers are recognizing the need for increasing the use of crops that provide ground cover year-round to mitigate soil erosion, nutrient losses, water pollution, and increased productivity. 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. Kernza, while still in the early stages of crop adoption, has been grown for the past 5 years by several early adopters in the state of Minnesota. One of these early adopters identified the potential to graze Kernza in the fall and expressed this interest to University of Minnesota researchers. Since then, many growers have expressed an interest in grazing Kernza in Minnesota and Wisconsin.

This project will demonstrate the viability of Kernza's dual use for grain and forage production on two Minnesota grain and livestock farms. The viability for a grower to receive feasible financial returns on the crop products, and the ability of the grower to fit grain harvesting and grazing operations into their larger workload, will be evaluated by measuring grain and forage yields and calculating returns via the construction of the enterprise budget. The effect of grazing, versus no grazing, on grain production and total returns will be evaluated by comparing yields and enterprise budgets among the grazed portion of the field and the exclosures, where grain yields are collected with no grazing treatment (control). On-farm estimates of grain and biomass yields and biomass forage quality, as well as estimates of financial return, will be generated and will serve as verified data to inform decisions of Minnesota growers considering Kernza dual use for grain and forage production in the future. Grower comments on labor and livestock performance, as well as the enterprise budgets for each treatment, will be disseminated to the grower community via the Cannon River Watershed Partnership website and at the pasture walk event. A brief questionnaire and comment sheet will be disseminated to Pasture Walk participants to elicit comments about the project's outcome, the grower's experience, and participants' perspectives on Kernza dual use and production.

Prior to Kernza swathing in August 2019, hand samples will be collected by clipping two 0.5-m2 quadrats in each exclosure, and six randomly placed 0.5-m2 quadrats in the grazed portion. Spikes will be separated from the straw in the clipped samples and threshed, and grain weighed to determine grain yields. Across the entire field, grain will be harvested by swathing and combining in August of each year, for 3 years.

After grain harvest, Kernza will be allowed to regrow until approximately 1 ton of biomass is present in the field, after which grazing will commence. Three exclosures of approximately 50-m2 will be placed randomly throughout the field and fenced off to prevent livestock access. Biomass production will be estimated in the grazed area and in the exclosures (non-grazed area; control treatment) by randomly placing 0.5-m2 quadrats throughout the field and collecting Kernza biomass to a stubble height of 2 inches. The biomass will be weighed wet to calculate forage yield, dried in an oven at 55 degrees Celsius, and weighed dry to calculate dry matter yields and moisture content. Dry biomass will be ground and analyzed for forage quality using near-infrared spectroscopy. Cannon River Watershed Partnership and University of Minnesota researchers will work with growers to calculate an appropriate stocking rate, depending on biomass production, livestock forage requirements, and the planned grazing duration. Livestock grazing will be managed to leave a short stubble height (<2 inches) by rotation throughout the field via planned paddocks. Livestock behavior while grazing will be observed and recorded by the grower and proper health management will be performed while grazing (water, nutrient block, etc. will be made available as necessary for livestock health). Livestock forage utilization will be estimated post-graze in the grazed area by randomly placing quadrats and collecting remaining biomass to 2 inches as described above. Post-graze biomass will be dried, weighed, and the proportion to pre-graze biomass calculated, to estimate the percent consumed by grazing livestock.

These grazing methods will be repeated each fall for three years on Dan Honken's farm. On Kaleb Anderson's farm, three plots will be managed separately for a spring grazing only, a spring and fall grazing, and finally a fall grazing only. Grain yields will be collected each year in the grazed and non-grazed areas (exclosures). Grain yields and biomass production will be compared between the grazed and non-grazed areas to investigate the effect of grazing on Kernza productivity over time. Cannon River Watershed Partnership and University of Minnesota researchers will work with growers to design enterprise budgets for the grazing and non-grazing scenarios, to evaluate the economics of grazing on a Kernza-growing enterprise.

PROJECT OBJECTIVES

Kernza was established on farms where the farmers are new adopters of the crop to:

1. Investigate the impact of fall grazing on subsequent Kernza grain yields in the first 3 years of production following fall planting of Kernza.

2. Investigate the quantity and quality of the fall regrowth of Kernza biomass.

    - 6 acre plot on Kaleb Anderson Farm: Average forage yield prior to grazing was 1,178 pounds of dry matter forage per acre. Average protein content prior to grazing was 21.2 percent, and the average relative feed value was 117. Average utilization rate was 64 percent.
    - Regrowth sufficient for food-grade end use Kernza did not occur on the 9 acre plot on Dan Honken's Farm. They planted a new 6 acre parcel in August 2019 nearby.

3. Develop enterprise budgets to evaluate the effect of grazing on Kernza production economics.

2020 RESULTS

Because the early spring growth of the Kernza biomass was good at the Kaleb Anderson Farm in Goodhue County and because a key goal of this project is to investigate the dual aspects of forage and grain production, the research team decided that spring grazing and fall grazing of this Kernza plot would be investigated. Pre and post grazing forage samples were collected from the treatment and the controls (no grazing) in May 2020. There was no statistically significant difference in forage dry matter amounts between previously grazed and un-grazed portions of the field. Averaged across the previously grazed portions and the controls (un-grazed portions), there was 0.8 tons of forage dry matter per acre available in each of these areas. In August 2020, grain yields from the treatment and controls will be determined, followed by a fall grazing (late October 2020).

The growth of the Kernza on Dan Honken's Farm (Rice County) looks good to date. A Kernza grain harvest is anticipated for mid-August, with a late October grazing planned.

MANAGEMENT TIPS

1. Work closely with consultants that have expertise growing intermediate wheatgrass and specifically Kernza or MN Clearwater.
2. Plant Kernza or MN Clearwater prior to September – preferably mid-August – following seeding rate recommendations and avoid choosing soils that tend to be wet or have poor subsoil drainage.
3. Direct combine, if the straw will be utilized on farm, in which case delay harvest until seed heads are brown and dry. Swath to maximize grain yields and provide flexibility in harvest timing but expect potentially lower straw yields. Graze or mechanically harvest vegetative regrowth late October.
4. There is potential for spring and fall (i.e. pre and post grain harvest) beginning in the second full production year of Kernza. Base this decision on stand establishment, vegetative growth, and soil moisture conditions. Graze in the spring before stem elongation to avoid cattle consumption of developing seed heads.

Agrophenology Project

Grantee: David Abazs, Wolf Ridge Environmental Learning Center
Contact information: abazs@round-river.com
County: Lake
Final outreach event: A webinar or online presentation in January 2020.

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. (Agriculture - the science or practice of farming, including cultivation of the soil for the growing of crops. 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 OBJECTIVES

Summary of activities conducted and results through 2019:

1. Identify and evaluate plant, insect, mammals, and migratory animal species to determine their reliability in providing a better planting "calendar" for our domestic crops. Using phenology, the scientific study of the timing of nature will provide a better gage as to when we should plant our crops for maximum plant health and growth.

- In 2019, at both locations we continued to observe the "finalized" list of 22 indicator species, observed other potential indicators and determined if or which ones should be removed and which ones should be added to our list for the upcoming 2020 season.

2. To determine the best phenological indicators for greenhouse/high tunnel production. We know that growing conditions vary greatly between and within greenhouses and high tunnels making it particularly difficult to determine the best planting times. We want to experiment between the phenological observations outside and within the season extension greenhouse/high tunnels by comparing specific indicator species both inside and outside the enclosures.
   - In 2018, we also determined and measured physical observations and data including timing, minimum and maximum temperature, light, precipitation, and soil temperature at 7 and 17 inch depths. We also looked at Growing Degree Days above 50 degrees Fahrenheit and Growing Degree Days above 32 degrees Fahrenheit since a significant portion of our northern growing season is below the Growing Degree Day of 50 and many of our crops respond to conditions below 50 degrees Fahrenheit. These physical parameters were used to cull the phenological indicators and helped us focus on the ones that might provide us with the most reliability for the new nature-based planting calendar.
   - In 2019, at both locations, we observed the 22 indicator species, noted other potential indicators and determined to remove some, add others, and questioned the reliability of other indicator species. The new "finalized" list of 23 indicator species will be the one used in the preliminary 2020 planting calendar.
3. Develop an agrophenological calendar for our region that will serve as a more reliable planting guide for farmers. Even more importantly, the research results will establish an agrophenological methodology with downloadable phenology observation sheets and crop record keeping documents to provide farmers the tools necessary to assess their own farms' conditions and individualize their own nature-based planting calendar.

MANAGEMENT TIPS

1. If you use an individual bush or plant phenological indicator, make sure to observe and note other phenological indicators that you could use in its place if something happens to your primary indicator species.
2. It is important to establish your own indicators on your land, in your growing conditions, since we have found significant differences between the two research locations in regard to the phenology of our indicators. Even though we are just miles apart and on our own land, the micro climate, soil type and local conditions are significant. We had a 4 day difference of dandelion flowers between our upper pasture and the area where we are growing our crops 150 feet away. Choose one patch (ideally closest to the area you are growing things) to observe the indicator and stick with that one for ongoing observations for consistency.
3. Trying to plant things earlier doesn't always save time and may actually cost you time and money with the reduced germination rate and the added time needed to weed the crop. For some crops, we are going to stop pushing them earlier and earlier as some of the negatives outweigh the positives.
4. The benefits we realized through the process of this research were many. On the farming level, we were better at noticing soil moisture levels and cover crop plant conditions, on another level, we were better in-tune to the natural conditions and trends by carefully observing the phenological trends.

FRUITS & VEGETABLES

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

Grantee: Richard Traugott
Contact information: 320-333-4203, trau0103@University of Minnesota.edu
County: Benton
Final outreach event: If COVID-19 prevents conducting the planned on-site field day, will use an alternative method to disseminate project results and lessons learned.

PROJECT DESCRIPTION

Over many years, perennial fruit production can be highly profitable. However, under 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.

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, and as a cover crop, and frequently cut and collect clover to supplement animal feed. 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, in a cover crop such as white clover, or annual ryegrass, or in a non-living mulch such as straw. For small fruits such as blueberries and currants, geotextile fabric 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 compared 12 intercropping options with current production practices. We will also compare red clover 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.

Upon conclusion of this project, farmers will understand which option best maximizes fruit plant growth during the first three seasons of plant establishment for several perennial fruits produced in Minnesota. Combined with the potential added value of the secondary crop, this project may encourage a new establishment paradigm.

PROJECT OBJECTIVES

Summary of activities conducted and results through 2019:

1. This study will be evaluating and demonstrating alternatives to current production practices used with perennial fruit plant establishment by comparing 12 options. The growth of the fruit plants will be evaluated in the spring of each year.
   - 2019: After most of the apple trees initially leafed out in the spring, by the end of June, 22 of the 36 apple trees had not survived the first winter. The roots on the surviving apple and plum trees appeared similar in size when they were first installed. Additional apple trees purchased separately and planted on the same date in other areas on the farm did not experience any losses the first winter. These trees did not receive the amended soil, so firm staking was not required. In addition, these trees did not receive supplemental irrigation from July-September.
   - Although the row of plum trees were planted next to the apple row, there were only five of 36 trees lost.
   - The grapes and currants had minimal losses but 37 of 144 blueberries were lost.
2. In addition to emphasizing rapid establishment of the primary fruit plant, this study will evaluate the potential added value of the secondary crop produced. Harvested amounts of the four horticultural crops will determine the relative added value of intercropping. The four cover crops will be cut each month and collected to determine yield.
   - In 2018 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.
   - As in the first season, the weeds within the cover crops (ryegrass and vetch) in 2019 remained but the mixture of intended crop and weeds provided good supplemental feed. The clover showed less issues with weeds and provided clean areas around the primary fruit plants.
   - 2019: Strawberries require high levels of both irrigation and fertility, and we determined that this crop is incompatible as an intercropping option when the primary fruit trees need a drier period to establish roots. The Roma tomatoes performed well despite receiving no supplemental irrigation.
3. Evaluating and demonstrating the effect of options on the condition of the soil. Soil samples will be recorded in the beginning and at the end of the project.

MANAGEMENT TIPS

1. Use clover as a ground cover in the initial year of establishment. Cut frequently to reduce weeds.
2. After this first year, squash (or other vine crops) or determinate tomato varieties may provide a suitable intercropping option if the irrigation to the primary fruit crops is considered. Using strawberries may be an option after year two and three.
3. Staking of fruit trees should be monitored. Once roots have developed, allow for some movement to stimulate roots.

SOIL FERTILITY

Perennial Farming and Carbon Sequestration, Ecosystem Services and Innovative Entrepreneurship

Grantee: Michele Manske, Mashkiikii Gitigan 24th Street Coalition & Pillsbury United Communities
Contact information: michele@savannainstitute.org
County: Hennepin
Final outreach event: Most likely a virtual book.

PROJECT DESCRIPTION

Urban vacant lots within chronically underserved communities are often characterized by low soil quality, limited ecosystem services, and lost opportunities for engagement and economic prosperity. This project will test the ability of a novel, multi-tiered, perennial cropping system to enhance economic and environmental prosperity, compared to unmanaged turf and intensive annual vegetable production. This perennial food system site is a part of the Mashkiikii Gitigan (Ojibwe Medicine Garden) and 24th Street Farming Coalition.

This demonstration farm was designed to mimic a multi-tiered natural eco-system containing differing crop functional types - including mushrooms, herbs/native flowers, perennial vegetables, and fruit-bearing shrubs/trees. Collectively, these items 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. This project will evaluate and demonstrate how this system could be replicated to address current operational and environmental issues within urban agriculture.

Switching from conventional to biodiverse/perennial agriculture has, in some cases, been shown to sequester significant amounts of carbon in the soil. Can urban perennial farming systems sequester carbon, improve soil health, and provide economic services for urban environments? This site has been under raised bed annual vegetable production for one growing season and was previously a vacant lot. Effectiveness will be evaluated by comparing carbon storage in production oriented perennial systems to turf and vegetable production and exploring the impacts on ecosystem services.

PROJECT OBJECTIVES

Summary of activities conducted and results through 2019:

1. Evaluate the effectiveness of this perennial system to sequester carbon due to perennial inputs and management practices that promote carbon storage.
    - Our University partners are collecting the following information on this demonstration site: Crop yield and quality, water quality, infiltration rates, nutrient cycling, biodiversity assessments, and cultural (education, aesthetics and discovery) services. They are collecting this data on triplicate plots (1 meter - square), each of three urban agricultural management practices, contrasted with existing turf grass: 1) No amendment, 2) Compost amendment, and 3) a “Growers Choice” practice.
    - Preliminary data provided by the University of Minnesota indicates that this project has increased water infiltration rates and sequestering more carbon from its historic state as turf grass. Includes counts of biodiversity by recording numbers of differing pollinator species and earthworms found at the site.

2. Investigate the impact of production-oriented perennial systems on soil contaminant accessibility. Research has shown changes to soil quality and health can decrease contaminant bioavailability and that perennial systems, with deep roots and deciduous leaf fall may increase aeration, microbial activity, and formation of organic matter.
    - This project will investigate whether perennial system changes to soil health decrease heavy metal contaminant exposure risk in urban gardens.
3. Evaluate the sustainability of this biodiverse perennial production system to provide innovative entrepreneurial opportunities for urban farmers and populations who face disproportionate contaminant exposures in this urban environment.
    - Through monthly hands-on classes and event photos of this site, this project will provide needed training and develop market access strategies.
    - In 2019, I drafted a brochure titled "Urban Agriculture, building resilient ecosystems" and an Urban Agriculture toolkit.

MANAGEMENT TIPS

1. Install drip irrigation on a timer if possible - know your water source well. If you are buying or sharing with neighbors, bring them fruits from the garden. It is important to have a strong relationship.
2. Invest in educational material - like signage and rules. People like to know what is going on, where the food will go, and it is beneficial to your project to set guidelines for the public.
3. Plan for pests that will increase labor inputs and costs and decrease yield. The first year of the project, the Japanese beetles were awful and an influx of bindweed in 2019 destroyed half of the plants.
4. Don't give people more than one weed to pull/identify at a time. Even if they say they have planting experience, chances are they'll pull things that aren't supposed to be pulled unless you are simple and explicit.
5. Invite community input! The more people who feel a connection to the space, the more eyes you have watching out for it (and the more help you have with labor!) In the urban environment, many eyes will be watching what you do. Therefore, aesthetics become important in the success of your site. Invite as many collaborators as you can.
6. If you have several sites spread out within the urban environment, invest in a good transport system (bike with trailer/ golf cart/small truck etc.).
7. Build a wash station in a secure location. The Leopold Center has Good Agricultural Practices certified free designs on their site.
8. Connect with your local urban "waste" distributors. For example, tree services have to pay to dump their wood chips and will happily deliver to you for free! Be creative- use old stop signs for trellising to save money.
9. Have a pet waste disposal plan - it is inevitable that this will happen in the city.

SPECIALTY CROPS

Peonies for Profitable Cut Flower Production in Northeastern Minnesota

Grantee: Kate Paul, Owl Forest Farm
Contact information: 218-290-6330; owlforestfarm@gmail.com
County: Saint Louis
Final outreach event: Plans to do a video that would piece together several clips as the season progresses with a narration of the project.

PROJECT DESCRIPTION

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.

Peony bare roots were transplanted in the fall of 2018. General maintenance was done on the young plants in 2019, including watering, weeding, 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.

PROJECT OBJECTIVES

1. The primary objective is to support the production of peonies for use in commercial cut flower production in an area of Minnesota where it has never been done before, but where growing conditions (in USDA zone 3) are potentially ideal.

2. To identify peony varieties, particularly late season cultivars, that will extend the season of their use for cut flowers beyond what is readily available in the industry, thus creating a niche for sales in later summer (July into September) when supplies are low or nonexistent elsewhere in the lower 48 states.
   - Permanent markers were installed during the spring of 2019 to identify each peony variety.

3. To identify particular peony cultivars that grow well and produce the most cutting stems per plant. In essence, to identify which peony cultivars are most suitable for commercial cut flower production in northern Minnesota.

MANAGEMENT TIPS

1. Regarding seeding between the peony rows, we decided against using white Dutch clover. The clover was used between rows of peonies that were planted prior to and separate from this study. We found that during seeding, the round clover seed easily bounced away from the intended areas and into the holes in the landscape fabric with the peonies. Once established, white Dutch clover is difficult to weed out. Also, it blooms prolifically and attracted so many bees that it became difficult to walk between the rows. A lawn seed mix of short grass varieties, in particular red fescue, that contains just a small amount of white Dutch clover was ultimately chosen to seed between the rows for this study.

2. The copper-based fungicide Nu-Cop 50 DF, when mixed and applied, leaves a turquoise-colored residue on foliage that remains through many rain events. For this reason, we choose to spray the Nu-Cop on emerging peony plants only and not on more mature foliage. The Actinovate fungicide does not leave a colored residue and is thus more suitable for spraying on plants when stems and foliage are to be harvested.

3. Hand weeding the peonies consumed much more time than expected and more than we would like to handle with off farm jobs. Looking ahead to planting and managing more peony plants in the future, it will be necessary to hire part-time, temporary helpers to keep up with weeding.

Articles >

The following articles are project summaries with descriptions of the project's purpose, activities conducted to achieve the objectives, and final evaluation results of the completed grant project. To find out more details about these projects, contact the principal investigators directly through the listed telephone numbers, addresses, and email addresses.

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

Liatris ligulistylis seed production plot with drip tape irrigation between every two rows.

PRINCIPAL INVESTIGATOR

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PROJECT DURATION

2018 to 2020

AWARD AMOUNT

$12,983.92

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.

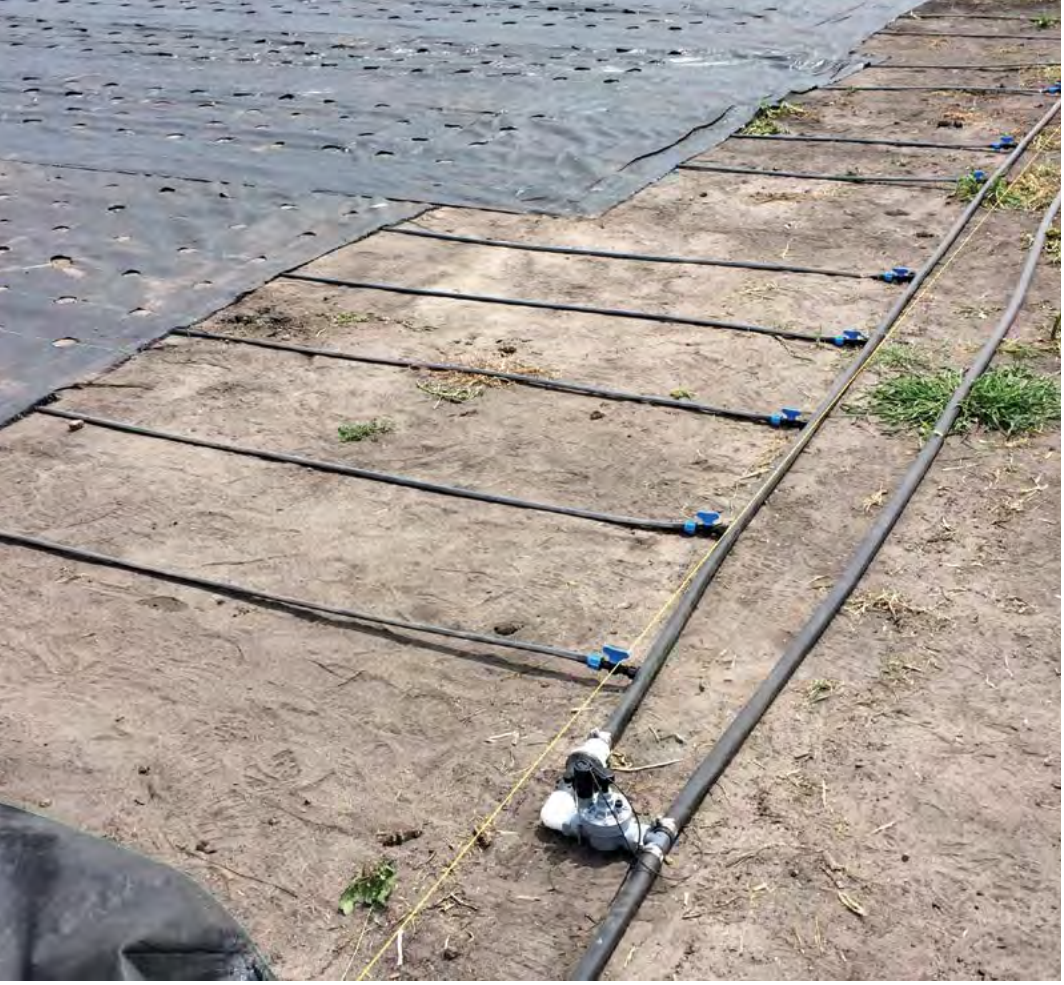
Our project objectives are:

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 to establish plants on control plots, but not irrigating further, 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 mm thick drip tape and 0.22 GPM, 15 mm thick drip tape. We used the thicker 10 and 15 mm drip tape instead of the standard 3 mm annually-



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.

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.

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.

2018 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.

Comparisons of the labor and costs 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 2 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.

2019 RESULTS

We evaluated two of the species, *Liatris ligulistylis* and *Phlox pilosa*, by harvesting, weighing, and selling the seed to compare revenue and profit from the irrigated test plots and non-irrigated control plots. The two other species did not produce seed so we harvested bulbs and either weighed or measured them to compare growth between the irrigated test plots and non-irrigated control plots.

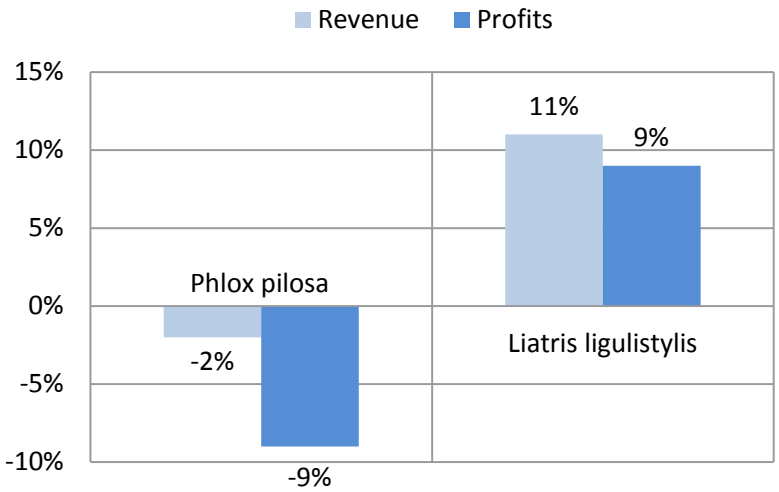
Our yield results in year 2 showed that drip irrigation can increase yield, profit, and plant survivability in some species while having little effect on others. These results were impacted by the weather, however, because 2019 was a consistently wet year in southern Minnesota and we only irrigated the drip irrigated plots 4 times at 4 hours each, and the control plots zero times. This is unlike other years where we likely would have irrigated more than 10 times. As a result of the consistently good rainfalls, we had similar plant growth and yields on both the drip irrigated test plots and non-irrigated control plots.

The *Phlox pilosa* (prairie phlox) seed yield and revenue with drip tape was 2 percent lower than without drip tape. This difference is insignificant and could be a result of slightly different planting or harvest dates. However, when factoring in higher expenses for the drip irrigated plots, this resulted in the drip irrigated plots having 9 percent less profit when averaging the expenses over a 5 year productive life span of the plot.

The *Liatris ligulistylis* (meadow blazing star) seed yield and revenue with drip tape was 11 percent higher than the control plot without drip tape. When factoring drip tape expenses over a 5 year productive life span of the plot, this resulted in 9 percent higher profit. This was a wet year and we expect the profit increase to be even greater in dry years.

The *Lilium philadelphicum* (prairie lily) did not bloom in 2019 but we harvested bare root bulbs to determine the survival rate and measured the diameter of the bulbs. The survival rate of the drip irrigated test plot was 10 percent higher than the non-irrigated control plot. However, the ratio of large bulbs (greater than 1 inch diameter) to small bulbs (less than 3/4 inch diameter) was higher in the non-irrigated control plot. In the non-drip irrigated plot, 36 percent of the bulbs were greater than 1 inch and 64 percent were less than 3/4 inch. In the drip irrigated plot, 26 percent of the bulbs were greater than 1 inch and 74 percent were less than 3/4 inch. We believe the increase in survival rate in irrigated plots was due to consistent irrigation, but the increase in bulb size in non-irrigated plots might be due to prairie lily being a drier prairie plant and not thriving as well in the consistently moist conditions of the irrigated plot.

Figure 1. Revenue and Profits on Drip Irrigated Test Plots in 2019



The *Lilium michiganense* did not bloom in 2019 but we harvested a portion of the bulbs and weighed them to compare growth. The bulbs from the non-irrigated control plot weighed 7 percent more than the bulbs in the drip irrigated test plot. Again, this could be due to the lilies not thriving in the moist soil of the irrigated plot, especially since this plot was in a more clayey area of the field.

One concern has been rodent damage to the drip tape. We had one drip irrigation line break in spring 2019 with what appeared to be rodent damage. This was much less than we had expected. Burying the drip tape, which we did not do, is a way to prevent rodent damage but we didn't think it would water new plugs as effectively and might be punctured by our ground cover staples. Everything else worked perfectly after the first winter even though two of the test plots were entirely covered in water and ice in late winter.

CONCLUSION

We will continue to install drip tape in our future plots to provide irrigation during the critical root establishment period after planting. Our research also showed that it can increase profits in certain crops. Drip tape has allowed us to irrigate our fields in less time, because with an automated system we can irrigate 24 hours per day with no overwatering or downtime between irrigation zones. This helps during hot, dry weeks when plants need water fast. Even with manual ball valves, drip irrigation zones only take minutes to turn on and off, allowing the producer to focus on other farm tasks.

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. Drip tape irrigation requires a lot of planning and details to work well. It's not as easy as just hooking it up to a faucet like sprinklers. Do plenty of research and utilize suppliers before purchasing and installing drip irrigation components. Since many of the components are not available locally, shipping times and costs can delay installation and cut into profits.
4. There are a few hands-on tips that will make installation a lot better: use a sharpening stone to sharpen the header hose hole punch, use white sealant tape on hose clamped fittings to reduce leaks, and, to get poly hose off fittings, use a small propane torch to soften the poly hose and make it much easier to slip off.

If you are planning on installing drip tape on more than a couple acres, it might be worthwhile to either dig a new well or expand your pumping or piping capacity from the well. This allows you to have larger irrigation zones, which means fewer valves and zones to manage.

COOPERATORS

Laura Mortimore, Orange Cat Community Farm, Lyndon Station, WI
Bill Souba, Souba Greenhouse, Owatonna, MN

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 Street, Charles City, IA 50616, 641-228-4496.

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.

Minnesota Hops Terroir Identification and Promotion

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

PRINCIPAL INVESTIGATOR

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Benton County

PROJECT DURATION

2018 to 2020

AWARD AMOUNT

$25,000

KEYWORDS

hops, marketing, sensory, terroir

PROJECT SUMMARY

Terroir is one of the most important distinguishing qualities in wine and cheese markets, why not beer? The influence of the ecology of the location that the grapes were grown, where the milking animals grazed imparts distinct characteristics in these farm goods. Our research sought to understand what role growing location plays in hop characteristics. Identifying terroir in hops could make for a large impact in beer. As craft brewers continue to multiply and hoppy beers continue to drive consumer purchasing, adding depth to growers' and brewers' knowledge and expectations of hops is like adding new colors of paint to a painter's palette. Additionally, if terroir were to become a known and important characteristic influencing hop purchasing decisions, new localized markets could form to supply hops with a region's distinctive terroir, boosting local farm economies and keeping local beer dollars more local. Terroir may be a part of the solution to making craft beer ingredients purchasing more local.

PROJECT DESCRIPTION

We started thinking about hop terroir early on. We were travelling to the USA Hops conference one year and visited a California vineyard as part of the trip. The importance of appellations (codified terroir) for wine grapes in Sonoma, Napa, etc. is paramount. We thought, why not in hops? What new understandings or appreciations might be hiding behind this idea

of hop terroir? Mighty Axe Hops grows 80 acres of hops for craft brewers across the country. We do all our own harvesting and post-harvest processing on the farm including pelleting, packaging, and shipping. We take pride in our personal approach with our brewer customers and actively look for ways to bring new ideas and innovations to craft hops. Terroir is one of the avenues which we believe is an opportunity to raise not just our profile but the profile of small hop farmers across the country. As we grew our farm, we became more and more interested in terroir. The hops we were raising did not have the same characteristics as the same varieties grown by the commodity growers in the Western U.S. We reached out to hop thought leaders and sensory scientists at the University of Minnesota, and the project was born. In cooperation with experts from the University of Minnesota's world class Sensory Lab and private sensory scientists at St. Croix Sensory, we developed a two-technique, descriptive analysis process for scientifically comparing the aromas and flavors of hops grown here and on the West Coast. We picked two varieties to look at: Chinook and Cascade. Chinook has gained a reputation as having some different flavors depending on where it was grown. Cascade is considered the workhorse and defining 'American' hop. Both varieties are widely grown on the West Coast and grown by us here in MN, so we knew we could access sample hop material. One technique we used is a published process by the American Society of Brewing Chemists for mechanically replicating a crushed hop flower analysis. Essentially taking the famous imagery of brewers crushing and rubbing hop cones in their hands and making it something which is consistent and replicable in a laboratory setting. The second technique we used was randalling, or hop rocketing, the technique goes by many names, but essentially it involves introducing a hop sample to a standard, base macro beer without much hop characteristic, and introduces the flavor of the hop sample to the beer.

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 were left whole cone for analysis. The whole cone hops were placed into a blender to be broken up and mixed. The pulverized hops samples were 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.

Two panels convened to evaluate the flavors and aromas of the beers. The first panel is made up of volunteer brewers or other brewery staff. They walked through a short version of the study and data was collected using the St. Croix Sensory software. This data was treated primarily as qualitative data due to the lack of training. The second panel is the Descriptive Analysis panel, this panel is made up of paid, trained, and screened St. Croix Sensory contract employees who gather quantitative data using St. Croix Sensory software.

At the time of this report, final data was not available due to delays and complications from COVID-19. When the final data is available it will be shared with the Minnesota Department of Agriculture and available to the public.

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. The right partners make all the difference. We could have never-ever-ever-ever ran such a scientific and professional study of hop terroir without the outstanding knowledge of our collaborators at the University of Minnesota or the brains, brawn, and physical laboratory assets of St. Croix Sensory.
3. Involve your customers in your project. They will approach your project with a different set of values that could be very valuable.

COOPERATORS

Kirsten Weiss is a Sensory Scientist at St. Croix Sensory located in Stillwater, MN. Kirsten and her team at St. Croix Sensory held panels, prepared samples, and collected data. Without Kirsten's deep knowledge of research design and lab management we could never have completed the project to such a high degree of professionalism or scientific value.

Christine Vandongen is a Fellow at the University of Minnesota's Sensory Center. Along with the Sensory Center's Director, Dr. Zeta Vickers, Christine selected and designed the descriptive analysis process which we followed.

Attendees of the Terroir Field Day viewed hops growing on trellises. They also rubbed hops, tasted various beers all brewed with MN hops, and participated in a mock-study of terroir by analyzing both MN grown and West Coast hops.

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

Vertical tillage tool in action.

PRINCIPAL INVESTIGATORS

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PROJECT DURATION

2017 to 2020

AWARD AMOUNT

$17,536

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 (VT) and the more conventional fall tillage practice of chisel plowing. The two tillage systems in a soybean and hard red spring wheat rotation were compared for soil temperature, soil moisture, soil erosion, compaction, soil health, yield, and protein or oil content. Ideally, we wanted to see if using the VT equipment could at least maintain the same yield or even improve yield over time compared to the conventional tillage treatment using fewer passes over the field with less soil disturbance.

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.

The flat landscape and high winds have created a large wind erosion problem in this region. Vertical tillage is one way of reducing tillage and leaving more crop residue on the soil surface in order to reduce soil erosion, without fully committing to a more complicated, management-intensive practice such as strip-till, no-till, or cover

cropping. 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 baskets. The fluted discs or coulters cut the residue, while the harrows help spread the residue evenly across the width of the machine, and the rolling baskets crimp and cover the residue with soil to speed up decomposition by soil microorganisms. The implement can be set to work from one to about 5 inches below the soil surface. Very little soil is disturbed when the implement is set to work at about 1-2 inches.

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.

Wheat was planted in early May in 2018 for the second year of the 2 year rotation with soybeans. In 2019, two tillage treatments were replicated three times using three tillage implements: the chisel plow, field cultivator, and the vertical tillage implement prior to planting soybeans. The 'Conventional' tillage treatment included two passes of a chisel plow with twisted shanks and one pass with the field cultivator in the fall. The vertical tillage treatment included two passes of a Salford 570 RTS vertical tillage tool in the fall of 2018.

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). While oil content was 0.2 percent higher in the conventional treatment, agronomically there is not much of a difference in oil content between treatments. 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 Fahrenheit 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	Stand** (plants/A)	Test Weight* (lb/bu)	Protein* (%)	Oil Content* (%)	Yield* (bu/A)
Vertical Tillage	142,000	59.7	34.9	17.6	42.3
Chisel Plow	132,000	59.4	35.0	17.8	43.3
LSD (.10)	NS	0.25	NS	0.1	NS

*Average of two plots.

Table 2. Soil temperature and moisture in vertical tillage and conventional tillage plots, 2017.

	Temperature (°F)*		Moisture (m3/m3)*	
Date	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

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 three 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 three 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.

2019 RESULTS

Soybeans were planted in the spring with an air seeder fitted with 11 inch sweeps at a 7.5 inch row spacing. Soil moisture and temperature were measured five times in each plot one week before planting, at planting, and one week after planting. Grain yield was measured using a weigh wagon and corrected for moisture content. Grain protein and oil were measured using a NIR analyzer at the University of Minnesota-Crookston.

As in the previous two years of the study, there were no differences in yield or grain quality between the two tillage treatments at harvest (Table 5). In the spring of 2019, we were unable to measure soil moisture and temperature one week before planting due to extremely wet soil conditions. At planting, the soil temperature in the vertical tillage treatment was 2.1 degrees Fahrenheit warmer than the conventional tillage treatment. Despite being such a wet year, Tim was able to plant and harvest the field without leaving ruts from the tractor in both treatments.

Table 5. Soybean yield in vertical tillage and conventional tillage plots, 2019.

Tillage Practice	Stand* (plants/A)	Test Weight* (lb/bu)	Protein* (%)	Oil Content* (%)	Yield* (bu/A)
Vertical Tillage	219,648	57.5	33.4	17.8	47.6
Chisel Plow	206,976	57.9	33.4	17.7	47.3
LSD (.10)	NS	0.4	NS	NS	NS

*Average of three plots.

Tim's anecdotal observations included less soil blowing on windy days and greater snow catch during the winter in the vertical tillage plots. He also noted smoother travel over the vertical tillage plots, although there was more resistance from the soil when planting into the vertical tillage plots compared to the conventional tillage plots.

Vertical tillage (left) and conventional tillage (right).

Other than the temperature difference at planting and small difference in test weight in 2019, there were no other differences between treatments for soil temperature, soil moisture, and grain yield and protein. This is great news!

CONCLUSIONS

The evidence from this study leads us to the conclusion that reducing soil disturbance by using vertical tillage instead of conventional tillage with a chisel-plow and cultivator can save time and fuel by using fewer passes through the field and reduce soil erosion and disturbance by leaving more residue on top of the soil without affecting planting conditions or final soybean or wheat yield, or quality at harvest. Based on the results from the three years of this study, there was no evidence to back the widely held belief that reducing tillage will cause delayed planting and yield loss from significantly colder and wetter soils in the springtime at planting.

Based on evidence from this project that reducing soil disturbance and using few tillage passes does not affect crop quality or yield, Tim Dufault, the farmer-cooperator, has transitioned his entire farm to reduced tillage with the vertical tillage implement to save time and money and improve soil health.

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. Using less tillage had little impact on yield, soil moisture, or temperature. Tim did not run into any soil condition problems in 2017, 2018, or 2019. He is starting to feel that vertical tillage will come out with a higher return on investment.
3. Reducing tillage from the conventional tillage practice of several chisel plow or field cultivator passes to one to two vertical tillage passes did not reduce yield or grain quality over the three years of the project, so we feel that we can confidently say that reducing tillage to vertical or surface tillage is not likely to reduce wheat or soybean yield.

COOPERATORS

Katie Kainz – Research Assistant, MN Wheat Research and Promotion Council, Red Lake Falls, MN
Lauren Proulx – Former On-Farm Research Coordinator, MN Wheat Research and Promotion Council, Red Lake Falls, MN

Economic Feasibility of Spray Foam Insulation in a Hog Finishing Barn

Hog finishing barn winter of 2018.

PRINCIPAL INVESTIGATORS

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PROJECT DURATION

2017 to 2020

AWARD AMOUNT

$7,909

KEYWORDS

spray foam insulation vs.
traditional batt insulation

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 investment as we transitioned our farms back into livestock production after many years of being out due to facility obsolescence and weak prices. To meet our goal of 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. We began to consider insulating 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 as expected the spray foam insulation was substantially higher priced. From this dilemma 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 to influence our decision one way or the other, so we decided to take the up-front financial risk and insulate the barn 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.

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 seeing 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 ag 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 consists of comparing the cost effectiveness of different materials used to insulate hog finishing barns. We chose to install closed cell spray foam insulation rather than traditional batt style insulation. For our project, we compare the propane usage of our spray foam insulated barn with two others similar to it 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 are also the same. The ceiling and the roof heights are the same. There are 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. The results of this will be calculated annually for three years to obtain the most accurate data possible. The 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 the savings?

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. Propane use recording was started 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 in fact use less propane per pig space than the two comparison barns using 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). For this winter, the investment of spray foam insulation proved to be worthwhile. If this trend continues, the added cost of the spray foam will pay for itself over time. For our barn, the spray foam insulation cost about $6,000 more than the batt insulation that would be used. Based on the first year results the additional cost of spray foam insulation would be paid off in less than 7 years.

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.

	Average 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

2019 RESULTS

The propane usage of 2018-2019 further proved the assumption that the spray foam barn uses less propane per pig space than the comparison barns insulated with batt insulation. In 2018-19 the average propane price was slightly lower than in 2017-18, but more gallons were used in all three barns. These numbers are subject to change each year based on fuel prices and weather conditions. The winter of 2018-19 was colder than the prior year as is reflected in the energy required for heating. According to the trend developed over the project timeframe, the colder the weather, the larger the difference in propane usage compared to the batt insulated barns, and with this the faster the added cost of the spray foam investment pays for itself. Each year, propane prices are largely affected by demand. The higher the demand, the higher the chances for a propane

Table 3. Annual propane usage.

	2018-2019 Gallons
Vande Ag Barn (spray foam)	5,764
Comparison Barn #1	3,337
Comparison Barn #2	3,590

shortage and the higher the prices could be. The savings the spray foam insulation provides are amplified in years of high propane prices. In 2018-19, the results indicate the $6,000 added cost of the spray foam will pay for itself in as little as 3 years. Averaging these results with the prior year of a 7-year payback gives a complete return on investment in 5 years. As stated earlier, many unforeseeable factors contribute to the results going into the future, but nonetheless, the trend so far is quite remarkable.

Table 4. 2018-2019 propane costs per barn.

	Average Propane Price	Propane Used (Gallons)	Barn Capacity (Head)	Propane Cost/ Pig Space	Cost Difference/ Pig Space
Vande Ag Barn	$1.23	5,764	4,800	$1.48	
Comparison Barn #1	$1.23	3,337	2,400	$1.71	+$0.23
Comparison Barn #2	$1.23	3,590	2,400	$1.84	+$0.36

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.
2. The spray foam can continue expanding for a period 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 foam application and covering the foam with plywood, so warping doesn't occur.
3. 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 25-30 years for barns constructed years ago. This gives an extended period 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.
4. After completion of the project, the results show spray foaming has a quick return on investment and is a worthwhile upgrade when building a new hog barn.

PROJECT PRACTICE CONTINUATION

Going into the future, we will absolutely continue to monitor propane usage and equate it to a per pig space basis as it is a major expense and an important aspect to monitor and document. It will be interesting to see if the developed trend continues and how the results compare year to year and with other barns of the similar type.

COOPERATOR

Mike Boerboom, Boerboom Ag Resources, Marshall, MN

OTHER RESOURCES

www.sprayfoammagazine.com

www.greenbuildingadvisor.com

www.thermosealusa.com

Evaluating Effectiveness of Sap Analysis to Increase High Tunnel Tomato Yield and Quality

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

PRINCIPAL INVESTIGATOR

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PROJECT DURATION

2018 to 2020

AWARD AMOUNT

$23, 558

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 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 percent 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.

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.

The Dosatron assembly we used for fertigation works well, but it is expensive. A lower cost option for a high tunnel is 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.

Dosatron assembly for fertigation at The Good Acre.

2018 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 feet by 96 feet 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.

2019 RESULTS

The trials at The Good Acre changed a bit for the 2019 season. We switched from trialing fresh market tomatoes to two organic hybrid paste tomato varieties, Pozzano and Granadero. We changed because we do not have a market outlet for fresh tomatoes and a variety better suited to processing is a better fit. Both of the paste varieties were grafted to Estamino rootstock. We also changed our spacing between plants from 24 inches on center to 48 inches to match Sogn Valley along with having two leaders.

For the 2019 season, we consulted with EnviroKure, the source of the 3-2-3 fertilizer for our scheduled fertigation treatment and they suggested a higher rate than what we had been using. Based on that we changed the amount from 100 ppm to 200 ppm. However, initially there was some miscommunication about the fertilizer product and for several weeks were using it undiluted, instead of at a 6:1 dilution we used last year. It's difficult to estimate how much additional fertility this added to the scheduled treatment. What we do know is there was a yield benefit due to the over application of fertilizer to the scheduled treatment. I suspect this is because the increased volume of fertilizer was significant enough to overcome the limitations of fertigating with very low nutrient concentrations, which are all that are available for National Organic Program-compliant production.

Yields and quality were exceptional, with the scheduled treatment yielding over 50 pounds of #1 fruit per plant (Table 1). Both varieties grew well, with Pozzano averaging a 12 percent higher yield than Granadero on a per plant basis across the three different fertility treatments.

Table 1. 2019 weekly harvest and season yields for the paste tomatoes at The Good Acre.

		Scheduled Treatment Bi-weekly 3-2-3 Applications at 200 ppm N			Custom Treatment Bi-weekly customized fertility based on sap analysis			Control Treatment, pre-plant fertilizer only		
	Variety	Pozzano	Granadero	Treatment Total Wt	Pozzano	Granadero	Treatment Total Wt	Pozzano	Granadero	Treatment Total Wt
	Plants per treatment	18	22		19	22		20	22	
Harvest Date										
7/15/2019	Pounds	5.3	7.1	12.4	2.5	4.5	7.0	7.4	7.2	14.6
7/22/2019	Pounds	9.8	10.2	20.0	6.7	10.2	16.9	12.2	12.9	25.1
7/29/2019	Pounds	31.7	32.7	64.3	31.7	36.6	68.3	40.4	31.2	71.6
8/2/2019	Pounds	24.8	17.6	42.4	13.3	13.6	27.0	32.4	29.0	61.4
8/6/2019	Pounds	22.4	30.8	53.2	22.5	17.2	39.8	30.5	24.9	55.3
8/12/2019	Pounds	55.7	43.6	99.3	54.6	45.1	99.6	74.9	50.8	125.6
8/19/2019	Pounds	127.5	134.8	262.2	108.9	104.7	213.6	116.5	79.1	195.6
8/26/2019	Pounds	79.9	54.3	134.2	51.3	67.5	118.8	91.2	74.7	165.9
9/2/2019	Pounds	71.4	81.8	153.2	77.9	89.2	167.1	92.3	89.0	181.3
9/12/2019	Pounds	113.5	144.0	257.5	110.2	139.2	249.4	117.0	138.0	255.0
9/19/2019	Pounds	89.6	86.7	176.2	72.8	89.0	161.8	71.6	102.2	173.8
9/25/2019	Pounds	174.1	164.8	338.9	121.4	130.7	252.1	156.2	135.5	291.7
10/3/2019	Pounds	68.5	125.6	194.1	61.5	70.0	131.5	57.2	69.7	126.9
10/10/2019	Pounds	41.4	51.3	92.7	34.9	24.0	58.9	20.1	22.6	42.7
	Totals	915.4	985.2	1900.6	770.2	841.5	1611.7	919.8	866.8	1786.6
Pounds per plant		50.86	44.78		40.54	38.25		45.99	39.40	
Pounds per leader		25.43	22.39		20.27	19.13		22.99	19.70	

This year I also looked to see if fertigation improved late season yield. The last four harvests showed more than a 30 percent increase for the scheduled fertigation over the custom and control treatments. This translated to roughly 5 pounds of additional fruit for those plants. Extrapolated to a 30 feet x 96 feet tunnel with a plant population of 200

plants, we could see an additional 1,000 pounds of fruit. At a conservative price of $1.50 per pound, we could gross another $1,500 in the tunnel. For the entire tunnel we would use about 50 gallons of 3-2-3 per season, which costs about $350.

One other anecdotal observation was that late season trusses of the tomato plants had similar numbers in both the custom and scheduled treatments as they did earlier in the season, but the number of viable fruit developing on the control treatment declined. We did not keep any data on this, but I expect that this would have led to further reduced yields in a longer season.

There were some growing problems at Sogn Valley Farm. Some of the plants in the trials had lifted out of the ground, reducing yields and causing drip irrigation lines to clog. Our confidence in the data is low. If we remove the control treatment because of outliers, we see that there was a 35 percent increase in yield only for the custom treatment over the control.

What is clear from the two years of data is that using sap analysis to analyze the crop's needs and adjust for it through custom fertigation was not worth the effort under our conditions. Cost is significant, averaging $550 annually for testing and fertigation materials. I think we could have significantly increased our fertigation concentrations to move the needle with the custom materials. The companies that we were working with primarily recommend the materials for foliar application and applying through drip lines does not have the same impact on the crop. Applying a foliar to high tunnel tomatoes was not a strategy we considered.

We did conclude, however, that fertigation can benefit the overall yield of the crop by increasing late-season harvest, and that doing so is economical. All the tunnels in our trials were unheated, so that transplanting didn't occur until mid-May. I would think that with some minimal heat to get an earlier start on the season, we would see greater late season yields due to fertigation.

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. Stay away from fertigation products that contain phosphorus because this will clog drip lines.
3. 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.
4. Grafted tomato plants are worth the investment in terms of increased yields, we recommend buying them from a professional nursery.
5. Make sure your tunnel can support the added weight of pruned, trellised tomatoes, which may be as much as several thousand pounds.
6. Use a barrel and sump pump for fertigation.

COOPERATOR

Sogn Valley Farm, Cannon Falls, MN

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

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

Hinnonmaki Red Gooseberries.

PRINCIPAL INVESTIGATOR*

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PROJECT DURATION

2017 to 2019

AWARD AMOUNT

$6,728

KEYWORDS

consumer preferences, fruit, gooseberries, trellis systems, varieties

*Original grantee and principal investigator for 2017 and 2018 was Andy Cotter, York Farm LLC.

PROJECT SUMMARY

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

PROJECT DESCRIPTION

Good Courage Farm is a certified organic fruit farm just southwest of Hutchinson. We purchased the farm in spring of 2019, taking over the various fruit crops planted by the prior owners (under the name York Farm), and adding a few more. The farm has focused on organic fruit production since approximately 2014 when the owners began planting fruit crops in earnest, including apples, pears, plums, apricots, currants, table grapes, seaberries, pie cherries, and raspberries. We market through restaurants, CSA fruit shares, and at two farmers markets. We have a deer fence around 18 tillable acres of the property.

Several years ago, the previous farmers saw that gooseberries were a cold hardy fruit crop that showed good potential. The fruit is nutritious with a unique flavor and is in demand. However, gooseberries have a reputation for being sour when ripe. Also, gooseberries are difficult to harvest and susceptible to leaf diseases. Fruit is produced very close to thorns on the canes. Research to address these issues was essential to making gooseberries profitable and to increasing production to reach profitable volumes. The previous owners started the research and we've continued it.

- The most common variety, Pixwell, has a sour flavor. What varieties taste best and have a pleasing appearance?
- We will want to find the most vigorous and productive varieties in our soils and climate. Gooseberries often have leaf diseases, which usually defoliate plants by the middle of August. Which varieties are the most disease-resistant, precocious, and productive?
- Different trellis and pruning systems could make picking easier. Is there a pruning and/or trellising system that can make picking easier?

This project compared eight varieties of gooseberries on three different trellis systems. We collected 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 assessed consumer variety preference.

2017 RESULTS

Three parallel rows with a total of 64 plants in each row were planted on April 8, 2017 (Table 1). Each row consisted of 8 plants each of 8 different varieties. Varieties chosen for this research included 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 in rows 8 feet apart on center. Cane size and root systems varied greatly among the varieties which likely affected short-term growth. Tixia and Jahn's Prairie were little more than sticks. A combination of landscape fabric and wood chip mulch was deposited in the rows for weed control. Wood chips were put down first, which helped keep the roots cool. Drip irrigation was installed on top of the mulch, followed by landscape fabric. A clover cover crop was planted between the rows.

Each of the three parallel rows has a different trellis system. One row is trained to three wires set at 1 foot, 2 feet, and 3 feet above the ground on single posts that run down the center of the row (Center Wire). The second row is trained to wire (14 inches high) strung on each side of the rows, 1 foot from center (Side Wires). The third row, installed in 2018, is dedicated to the intensive cordon training system commonly used in Europe (Cordon). For the cordon training system, only one cane is allowed to grow, and that one cane is headed during the first growing

season, forming two branches that run parallel to the ground. The cordon system delays production by at least 1 year but is often used in Europe 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. Hinnonmaki Red produced some berries.

2018 RESULTS

In spring 2018, posts for the Cordon trellis were installed using 3/8 inch rebar that was 6 feet long. To make sure the posts didn't move, they were tied to the wire strung the length of the row. No pruning was done on the cordon row as there wasn't enough to prune. In the Center Wire and Side Wire rows, canes were heavily pruned and tied up.

There were flowers on most varieties and a few dead plants (mainly Jahn's Prairie which lost 25 percent of the plants, possibly from winter injury). Liquid fish fertilizer was applied as a foliar spray.

There was fruit to harvest in all the varieties except Tixia which allowed some initial taste testing. Initial data on taste quality, plants with berries, and plant vigor were recorded. As many of these varieties are new to us, fruit was left on the vine as long as possible to see if the flavor improved.

The Center Wire trellis system with multiple wires was a favorite this year. It is the least costly, kept the canes off the ground, made 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 grew past the top wire. Some other gooseberry varieties (Hinnomaki Yellow) didn't even make it to the first wire. The biggest drawback to the Center Wire trellis is having to walk all the way around to get to the other side of the plant!

Gooseberry Cordon trellis at center.

2019 RESULTS

Plant Growth and Vigor

Plant growth and vigor was limited this year. Plants needed more nutritional support. Soil tests revealed several conditions including very high pH (7.8), low sulphur (14ppm), and low values for nearly all micronutrients. Leaf sap testing was also done and showed significant deficits of numerous nutrients, including sodium, chloride, sulphur, and several micronutrients. A leaf disease was diagnosed. We strongly hope that an improved nutrition program and an anti-fungal spray regime in 2020 will reduce the impact of disease, increase plant vigor, and improve flavor and berry size. Of note, gooseberries were able to produce even in alkaline soil.

Productivity and Taste

Hinnonmaki Red and Captivator produced large crops this year with heavy fruit set on relatively large bushes. Hinnonmaki Red flavor was excellent with nice sweet/tart balance. Fruit set was also good on Hinnonmaki Yellow, Jahn's Prairie, and Jeanne, but the plants were much smaller, so productivity was limited. Invicta set large, notably delicious fruit, but fruits were few and on small plants. Black Velvet plants were tall, and the fruit was delicious – the favorite of most people – but fruit set was light.

Flavors failed to develop in several varieties, especially Captivator. Captivator was defoliated by fungal leaf spot before the fruit matured. The poor flavor was probably related to too few leaves to supply sugar to the ripening fruit. Fruit set and harvest from Captivator was nearly as heavy as Hinnonmaki Red, but the berries did not sell due to the mild flavor.

We took gooseberries to a farmers market for the first time (Mill City FM in Minneapolis) this year. This was an opportunity to assess public reactions. Many people came by to taste gooseberries and said they had never had them before. Some said they had had them as children in their grandmothers' gardens. We had enough berries of four test varieties to take to market: large harvests of Hinnonmaki Red and Captivator, and smaller amounts of Jahn's Prairie and Jeanne. Hinnonmaki Red was the most successful variety, selling well to restaurants and market customers. Hinnonmaki Red is also good for cooking with a nice red color and spicy flavor. Pastries made with Hinnonmaki Red were well received.

Different varieties with different ripeness levels received very different responses.

- A few people tasted sour green pre-mature Pixwell berries before we had a chance to warn them and the reaction was negative. However, when we told people, "these are sour like lemons," they prepared themselves and most responded favorably, including many children who were entertained by the tart flavor. (Note: Pixwell variety was not part of this research, but it's a useful comparison.)
- Mature berries of Hinnonmaki Red were well-received and we sold out each market day. Mature Jahn's Prairie and Jeanne were similar.
- We had a large supply of Captivator berries that were slightly sweet but very mild, even bland tasting. They had not gained their full flavor, Brix, or tartness because of fungal leaf drop. We thought they might be popular with people who did not want a strong tart flavor. However, we sold almost none of the Capitivator berries despite having a good supply.
- A handful of market customers from England and Germany and some restaurants loved berries picked early (green and quite sour).
- In general, later varieties had more flavor and more favorable reactions from broader farmers market public.

Harvesting

As in 2018, we found the best way to pick berries was to hold one branch with a leather-gloved hand and pick with an un-gloved hand. Fruit set appeared heavier on more horizontal branches and lighter on vertical branches.

- Trellis systems were critical for vigorous varieties like Captivator and Black Velvet which are now over 3 feet tall. Hinnonmaki Red, Jahn's Prairie, and Jeanne also did better with a Side Wire trellis system because the wires kept some branches off the ground. Invicta, Tixia, and Hinnomaki Yellow did not grow more than 12 inches in 3 years and needed no trellising.
- The Cordon training method produced almost no fruit on any variety, except a few berries on Hinnonmaki Red. The plants appear to be one full year behind the others in their development. Eventually this trellising system may pay off in ease of harvest, but in Year 3, there was no harvest to speak of. There also seemed to be less fungal leaf spot in the cordon-trained plants.
- The top wire on the Center Wire training was 3 feet off the ground and worked well with the two tallest varieties, Captivator and Black Velvet. However, the Center Wire training system had no impact on most varieties as the plants were not tall enough to reach the wire.
- The Side Wires system did not keep all branches from hanging low with heavy fruit set; however, it did keep most of them from touching the ground, which is important for food safety. The Side Wire system was ideal for Hinnonmaki Red and Jahn's Prairie. It also helped keep them off the grass alleys between rows, which facilitated mowing. As of 2019, this seems the best overall trellising system for smaller plants.

Table 1. Summary of gooseberry variety descriptions over three growing seasons.

Plant	Berry Color/Size	Vigor*	First Year Plants w/ Berries**	Fruit	Taste
Black Velvet	Dark Red/Small	Strong	16	Moderate	Excellent
Captivator	Red (Pink/Green in 2019)	Strong	18	Heavy	Mild – flavor failed to develop in 2019
Hinnonmaki Red	Red	Average	14	Heavy	Very Good
Hinnomaki Yellow	Yellow	Weak	10	Moderate	Very Good
Invicta	Green/Large	Average	6	Light	Excellent
Jahn's Prairie	Red	Average	3 (7 plants died)	Moderate	Good
Tixia	Red	Weak	0	NA	NA
Jeanne	Red	Average	1	NA	NA

*Plant growth compared to other varieties.

**From 24 plants.

We will continue to grow gooseberries. We found a good market with several restaurants as well as with buyers at the farmers markets. We will likely remove Tixia and Jeanne bushes in 2021 and replace them with varieties that are more productive and tastier. We will give all of the varieties one or two more years before replacing them because we have heard some varieties can take up to 7 years to become productive, and we want to give them a chance to mature. We also want to improve our nutritional support for the plants and treat for fungal disease more effectively. We hope this will allow plants to retain robust leaf cover for a longer season and bring all the fruit to full flavor and color.

We will continue to assess the efficacy of the cordon training system, which appears to be one year behind the other plants in maturity but may end up being worth it if harvest is easier.

We like a Side Wire training system simply because it keeps branches a few inches off the ground for mowing. While the current system is great for weed control, we will consider trying a system that doesn't use woven plastic ground cover for more effective application of soil-based nutrients/amendments.

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. However, the use of weed fabric makes it difficult to apply nutrients. Fertigation is an option, but in a wet year like 2019, there was no need to irrigate.
2. Use the Side Wire trellis system, that is, a wire strung on each side of the rows, 1 foot from the center.
3. We found the best way to pick berries was to hold one branch with a leather-gloved hand and pick with an un-gloved hand. The gloves that we found that worked the best are Ansell Cut Protection Gloves and Turtle Skin CPR-500.
4. You need to treat for fungal disease. We had been told that "the plants always get those spots late in the season, but it doesn't seem to affect next year's growth." Now we know it does affect the berry flavor, and we will be treating for fungal spot early in the season to improve fruit growth and flavor.
5. Gooseberries need nutritional support through soil improvement and foliar sprays throughout the season. Soil test and do leaf sap analysis in early June for a snapshot of plant health in time to intervene with foliar nutrition.

COOPERATORS

Thaddeus McCamant, Central Lakes College, Staples, MN

OTHER RESOURCES

McCamant, T., and S. Schroeder. Perennial Fruit: New, Unusual and Unique Crops for Northern Climates. www.misa.umn.edu/publications/perennialfruit

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

Sorting in process.

PRINCIPAL INVESTIGATOR

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PROJECT DURATION

2018 to 2020

AWARD AMOUNT

$25,000

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 (MOG) 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.

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 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.

Harvest lug input.

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 Graphiccollected 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.

2018 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.

Crop yield for 2018 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. We changed our trellising system to single high wire (SHW) training to promote growth and stop wild turkeys from eating the low hanging grapes and decrease the harvesting time. When looking for trellising options, we found an article by Mike White with Iowa State University Extension that showed that cold hardy grape varieties did best with SHW training. (www.prairiefirewinery.com/Cellar/wp-content/uploads/2016/12/Vineyard-Trellis-Construction.pdf and www.extension.iastate.edu/wine/files/newsletter/files/wine_grower_news_401_pruning_edition_2-15-19.pdf). This system has been shown to be a mechanically harvestable way to trellis grapes. https://cdn.ymaws.com/www.mngrapes.org/resource/resmgr/Files/Training_Systems_for_Grape_V.pdf. 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 came 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.

In 2018 we didn’t use insecticides in the vineyard as pest pressure was light and we knew we wanted to test sorting lines capabilities. We maintained a light fungicide spray schedule.

2019 RESULTS

In 2019 we didn’t use insecticide in the vineyard for multicolored Asian lady beetles and proved the sorting systems capabilities to remove the beetles to get us the quality we wanted. We maintained a light fungicide spray schedule as we have in past years. In future years, depending on pest pressure, we may or may not need a light application of insecticides and will continue the fungicide spray schedule.

In 2019 the crop yield was 1.73 tons of grapes, down significantly from previous years due to the late January and early February 2019 polar vortex. This extreme cold caused the above ground trunks and arms of nearly 50 vines to die back. The surviving vines, although they maintained their developed trunks and arms, suffered some degree of minor injury. Additional complications due to the extremely wet year also negatively impacted the grape crop yield. The trellising changes made in 2018 were a benefit in 2019 with almost no loss due to turkeys. When harvesting the grapes in 2019 we maintained the same speed gains found in 2018, 50 percent faster than the 2017 harvest.

Sorting last year’s challenging varieties was more successful this year. We hand sorted and used our small manual destemmer on Sabrevois to minimize losses on this fragile/thin skinned grape after we learned in 2018 that this variety doesn’t sort well mechanically. We had success sorting the King of the North variety mechanically this year as the weather permitted harvesting at a more optimal time. King of the North was still a bit thin skinned but slowing the machines down helped maximize yield. The Louis Swenson, a variety with a large berry, remained a challenge this year as it did in 2018. Grape varieties that sorted well in 2018 also did well in 2019.

Losses at processing averaged about 7 percent for varieties that sorted well and about 17 percent for those that didn’t. Seven percent loss falls in line with what we would typically experience with hand sorting. In exchange for the reduction in sorting time in the vineyard for equal grape quality, even a 1 to 2 percent increase in losses compared to hand sorting is worth it.

We will give special processing attention to the hard to sort varieties already in the ground but do not plan to plant any additional plants in those varieties.

Destemmer and sorting line.

MANAGEMENT TIPS

1. 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. We tried repurposing a commercial upright dishwasher into a harvest tote washing machine with some minor initial success. In 2020 we will make further modifications to this washing system for improved performance, time, and water savings also.
3. 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.
4. 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.
5. We found that a materials wagon without sides was a great help for transporting harvest totes from the vineyard rows to the trucks for transport back to the winery. This further saved back strain and time for our picking team.
6. In 2018 and 2019 we had spotty rainy weather to contend with on the crush pad. In both years we used a small pop up canopy tent and rain gear so we could work more comfortably. The mechanical sorting process allowed us some freedom to work in accordance with the weather report.
7. Before harvest in 2019, we had the opportunity to tour a large vineyard and winery and saw that they used refrigerated storage after harvest until processing. We theorize that chilled grapes may process better so in 2020 or 2021 we may invest in a refrigerated trailer to store the grapes for the short time between harvest and sort. The results may be minor to yield but possibly significant to wine quality.

COOPERATOR

Jill Herchenhahn, Brookview Winery, Saint Cloud, MN

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

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

Day-ranging poultry production system.

PRINCIPAL INVESTIGATOR

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PROJECT DURATION

2018 to 2020

AWARD AMOUNT

$12,166

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 (DRS) 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 - CTS). 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) (2018) and slow-growth (Freedom Ranger) (2019) 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:

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 advantage in the marketplace.

The chicken tractor follows the methods described in Joel Salatin's book, Pastured Poultry Profits, 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 (Cornish Cross) or 70 days (Freedom Rangers).
- 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 until harvested.
- Chickens always have access to broiler feed and water.
- 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 in the paddock 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 and serves as predator protection.
- 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. No livestock guardian animal or electric fencing are used. For the day-range system, the tractor (and plugs) protect from ground predators at night and provide limited aerial predator protection. The perimeter is 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 (Cornish Cross) and 72 days (Freedom Rangers).

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 rest of the time on pasture. 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 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 in 2018 was nearly double for the Spring groups compared to the Fall groups (Table 1). 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. Similar additional labor was required in the 2019 batches with the Freedom Ranger chickens. Although the total labor amounts for each batch were less than their 2018 counterparts (presumably due to the increasing efficiency of the farmers in their daily routine), the relative labor time difference between the chicken tractor and day range systems remained roughly the same.

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 until the birds were trained to roost inside the tractor. Even when the birds were in the day range tractor at the end of the day, the farmers still needed to make an extra trip to close them up which was not necessary for the chicken tractor group which was always confined.

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 (2018 Cornish Cross batches) or 35 days (2019 Freedom Ranger batches that require 14 more days on pasture than the Cornish Cross) contributed substantially to labor requirements. Originally, the design of the experiment only expected to move the day-range tractor when it was being placed into a new paddock. However, excessive manure build up from just the first few days resulted in an unsanitary environment for the birds, so the tractor in the day-range batches was moved once per day within the energized net enclosure or paddock for all 35 days (2018 batches) or 49 days (2019 batches) while on pasture.

Mortality

Mortality was tracked to determine if predation might be a factor in the day-range system considering 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 2018 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 2018 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 among this group of birds).

Table 1.
Total labor time required for maintaining each system.

Year	Batch[1]	Time Spent	Percent Difference[2]
2018	Spring DRS	12 hr 17 min	+20
2018	Spring CTS	10 hr 13 min	-
2018	Fall DRS	6 hr 40 min	+39
2018	Fall CTS	4 hr 47 min	-
2019	Spring DRS	10 hr 12 min	+35
2019	Spring CTS	7 hr 33 min	-
2019	Fall DRS	7 hr 58 min	+19
2019	Fall CTS	6 hr 43 min	-

[1] DRS = Day-range system; CTS = Chicken tractor system
[2] The percent difference is reported as the difference from the CTS (control) batch from each season, respectively.

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 transition.

In the 2019 Spring batch, 96 birds were received from the hatchery and seven died while in the brooder of unknown causes. This 7 percent mortality in the brooder is not uncommon. Forty-five birds were placed in the chicken tractor setup and 44 in the day-range batch on day 24 (once again, weather prevented the move to pasture on day 21). All 89 birds on pasture were successfully harvested on day 72. In the 2019 Fall batch, 92 birds were received from the hatchery and only one died while in the brooder (from unknown causes). Forty-six birds were placed in the day-range setup and 45 in the chicken tractor setup. One bird died on pasture (from the day-range group, day 68) and this was from unknown causes (no signs of cannibalism or predation). Ninety birds were successfully harvested on day 70.

During the two seasons where the study was carried out, numerous aerial predators (Bald Eagles and Red-tailed Hawks) were seen observing the chickens on pasture. The farm also experienced several predator attacks from foxes during the daytime on other chickens present on the farm that were not a part of this study. However, for the time on pasture in this study, predation was not a mortality factor.

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 and not unexpected especially given the climate differences between Virginia (where Salatin is located) and Minnesota (the location of the present study). Incidentally, feed intakes were all within the expected range of the feed estimates given by the feed supplier, so it is reasonable to conclude the batches performed within expectations for the context.

Feed conversion ratio was higher in the spring compared to the fall (Table 2). Fall chickens consumed less feed presumably because they were on pasture during the optimal forage growth and peak insect populations. The Fall day-range groups used the least amount of feed and ended up with the highest live weight (for Cornish Cross) and therefore the lowest feed conversion ratio of all four groups. Cornish Cross were expected to be more efficient converters of feed to weight (i.e. lower FCR) than Freedom Rangers and that is affirmed with the data.

Conversely, the Spring day-range group performed the poorest for the Cornish Cross and was nearly identical (within 1 percent difference) for the Freedom Rangers with respect to FCR. 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. The average air temperature difference was 2.6°F lower in the spring than the fall in 2018, and 4.1°F lower in 2019, suggesting that the Freedom Rangers indeed performed better in lower air temperatures.

Table 2. Feed utilization and growth results for the Cornish Cross and Freedom Ranger groups for 2018 and 2019.

Year	System and season [1]	Breed [2]	Total feed consumed (lb)	Avg. feed/ bird (lb)	Avg. finished wt. (lb)	Total feed conversion ratio (FCR)	FCR Percent Difference[6]
2018	Spring DRS	CC	789	17.5	5.86	2.99	+3.8
2018	Spring CTS	CC	766	17.0	6.05	2.88	-
2018	Fall DRS	CC	724	16.1	6.29[3]	2.73	-1.8
2018	Fall CTS	CC	733	16.3	6.12[4]	2.78	-
2019	Spring DRS	FR	923	21.0	6.76	3.10	-0.9
2019	Spring CTS	FR	930	21.2	6.75	3.13	-
2019	Fall DRS	FR	901	19.6	6.42[5]	3.05	-5.0
2019	Fall CTS	FR	902	20.1	6.25	3.21	-

[1] DRS = Day-range system; CTS = Chicken tractor system
[2] CC = Cornish Cross; FR = Freedom Ranger
[3] Does not include the birds that died on pasture.
[4] Includes the birds that died in transit to processor.
[5] Includes the bird that died on pasture day 68.
[6] FCR percent difference is the difference between the CTS group and the DRS group in each individual season.

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 2018 birds and the Spring 2018 birds for the Cornish Cross 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.

For the Freedom Ranger batches in 2019, the relationship between forage availability is stronger in the Fall compared to the Cornish Cross (FCR difference of 5% in the DRS batch) but does not follow for the Spring. While the reason for

this is not known, it may be the result of the supposed better foraging characteristics of the Freedom Ranger breed compared to Cornish Cross being able to overcome the effects of the growing environment in the Spring.

Meat Nutrient Composition

One of the main motivations for growing pastured poultry besides providing a more natural environment for the animal is the possibility that the meat (in the case of broiler chickens) provides a superior human nutritional profile. From the pasture-based farmer's perspective, being able to objectively show positive nutritional variation from available commodity chicken meat is a considerable marketing advantage as well. For these reasons, this study included a comparison of several vitamins and nutrients commonly considered to be higher in pasture raised broiler chickens.

A random sample of meat was collected from each batch after processing and sent to a food laboratory for nutritional analysis. The sample was comprised of breast and thigh meat. Meat was analyzed for fat-soluble vitamins (A, E), cholesterol, saturated, and unsaturated fats as well as omega 3 to omega 6 ratio. Vitamin A results were below observable levels and are not reported.

Both systems showed nutrient composition for human consumption compared to USDA reference values for Vitamin E, total fat, and fatty acid composition (Table 3). The difference between day-range and the chicken tractor systems was minimal, suggesting seasonal differences in pasture forages and insect population were determining factors.

Table 3. Nutritional analyses of meat[1] from chicken tractor (CTS) and day-ranging systems (DRS).

	Cornish Cross Breed				Freedom Ranger Breed				
Nutrient[2]	2018 Spring CTS	2018 Spring DRS	2018 Fall CTS	2018 Fall DRS	2019 Spring CTS	2019 Spring DRS	2019 Fall CTS	2019 Fall DRS	USDA Standard Reference
Cholesterol (mg)	76	68	83	82	108.7	109.6	111.8	99.0	75
Vitamin E (mg/100g	1.4	1.0	1.3	1.1	1.2	1.8	1.2	1.1	0.3
Omega-6:Omega-3	6.6:1	5.5:1	4.7:1	4.7:1	3.34:1	3.08:1	4.91:1	4.81:1	14.8:1
Fat (total)	7.52	4.09	3.06	4.70	9.09	6.35	9.83	7.07	15.06
Monounsaturated fat	3.03	1.73	1.33	2.18	4.32	2.77	4.60	3.45	6.24
Polyunsaturated fat	1.68	0.79	0.51	0.80	1.25	1.03	1.26	0.92	3.32
Saturated fat	2.44	1.37	1.07	1.50	3.08	2.25	3.47	2.36	4.30

[1] Breast and thigh meat with skin from eight batches of chickens.
[2] All values are grams/100 gram sample unless otherwise noted.

Profitability

Profitability was determined using total feed consumption, infrastructure costs, and labor. Table 4 provides a real cost analysis of the eight batches of chickens grown for this project characterized as the cost to raise the final product per pound of carcass weight. The base cost is shown which includes the price of each day-old chick and the cost to bring the chick to butchered product, not accounting for brooder, housing, transportation or labor costs. The cost of the feed was $0.37 per pound and $4 per bird for processing. Cornish Cross day-old straight run chicks were $1.58 per bird and Freedom Rangers were $1.15 per bird at the 100-bird quantity. Mortality, feed consumption, breed differences, and FCR from Table 2 were used to calculate this "base" cost of poultry production.

When adding the additional labor on pasture and infrastructure costs required for the day-range system, the last column in Table 4 provides the cost difference on a per-pound basis. Regardless of the breed, season, and performance (FCR), the day range system in the bird quantities of this study is always more expensive to produce considering the cost factors tracked here. However, if labor costs are not considered, it may be possible to raise birds

in the day-range system at a lower production cost than the chicken tractor system. The foraging and/or feed efficiency can overcome the infrastructure costs if labor costs are omitted. Additionally, this analysis shows that the Freedom Ranger breed, which is generally expected to be not as cost effective to produce compared to the feed-efficient Cornish Cross, can be cheaper to produce in the early season. A possible reason for this is the Freedom Ranger is fully covered by feathers (the Cornish Cross typically has far less feather coverage) and may be able to conserve energy in cooler temperatures which occurred in the spring in this study's location.

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 paddock 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.

Table 4. Cost analysis for each pastured poultry system per pound assuming carcass weight equals 75% of live weight. All values are in 2018 USD.

Year	Batch[1]	Base Cost[2]	Base Cost + Infrastructure[3]	Addt'l Pasture Labor[4]	Addt'l Expense
2018	Spring DRS	$2.75	$2.88	$0.13	$0.32
2018	Spring CTS	$2.64	$2.69	-	-
2018	Fall DRS	$2.45	$2.58	$0.11	$0.09
2018	Fall CTS	$2.54	$2.60	-	-
2019	Spring DRS	$2.56	$2.67	$0.14	$0.18
2019	Spring CTS	$2.58	$2.63	-	-
2019	Fall DRS	$2.59	$2.71	$0.07	$0.03
2019	Fall CTS	$2.70	$2.75	-	-

[1] DRS = Day-range system; CTS = Chicken tractor system
[2] Base cost includes cost of the animal, feed, and $4 per bird processing costs.
[3] Infrastructure includes chicken tractor and electric fencing costs (for DR batches only), amortized over 10 years use, three batches per year.
[4] Labor cost is hourly rate of $12 per hour only counting the difference in pasture time from Table 1.

Summary of Research Findings

Day-ranging required 19-39 percent more labor in the field to move the animals in an electric fence surrounding the paddock each week. Increased probability of mortality due to predation was not observed in this study. Feed conversion ratio and total feed consumption were lower in the day-range system except for in the cooler season (Spring) for the fast-growth breed. Both management systems showed desirable nutrient composition for human consumption compared to USDA reference values for Vitamin E (266-500 percent higher), total fat (35-80 percent lower), and omega-6 to omega-3 ratio (55-79 percent lower) as expected for broilers raised on pasture. The difference between day-range and the control was indeterminate for the fast-growth breed, but day-ranging reduced total fat and the omega-6 to omega-3 ratio. Given the additional infrastructure cost and labor requirements, day-range systems have the potential to be more profitable than the control system if the farmer can command a premium price from consumers for the greater "free-range" nature of the day-range system or is willing to risk less protection from predators or reduce the frequency of paddock rotations. Reducing additional infrastructure and labor costs is essential to making the day-ranging system an economically viable pastured poultry management system for the farmer.

Seelye Brook Farms will continue to use the Freedom Ranger breed of chickens and, based on the findings of this study, will likely use the day-range setup for the early season chicken batches.

MANAGEMENT TIPS

1. Based on the results from this research, 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 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 creating sanitation issues. The day-range system does not provide a consistent distribution of manure like the traditional system if uniform fertilization is a reason for pasturing.
3. Day-ranging is not likely to be more profitable than the traditional system at smaller scales. The main trade off 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 as often. Salatin warns against such "shortcuts"; they remove the positive effect of daily "fresh greens" for the birds.
4. Farmers should evaluate their management style for pastured poultry in the context of their target market and predator pressure. Choosing to day-range poultry may be more expensive and riskier unless the farmer can earn more for their day-ranged poultry. Additionally, farmers' specific situations may also be a factor in determining whether this system is for them.
5. The Freedom Ranger breed is well known for not being as efficient at feed conversion as the Cornish Cross. However, day-ranging and seasonality are factors that may unseat this widely held belief in certain circumstances. Farmers who would like to try the Freedom Ranger breed should try them and keep records to see how the cost of producing this breed is different from the traditional Cornish Cross. They may be as surprised with the results as we were.
6. Farmers who are raising poultry on pasture should do their best to let their customers know the nutritional differences of their product compared to commodity chicken. It is not an apples-to-apples comparison. While the nutritional differences between chicken raised in day-ranging and full-time mobile confinement on pasture are small, the difference between pastured chicken and conventionally raised commodity chicken is quite striking.

COOPERATORS

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

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Using Precision Ag Data to Maximize Economic and Environmental Benefits

Booth at 2019 Farmfest.

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PROJECT DURATION

2017 to 2019

AWARD AMOUNT

$25,000

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 worked 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 provided 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.

To demonstrate the power of this new technology and its potential, this project used 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, provided 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 were:

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 were identified and received a subscription to Profit Zone Manager™. Pheasants Forever precision ag and conservation specialists worked 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 chose an operation budget template (established from University of Minnesota data) or created a personal custom budget from actual operational expenses. For each farm, our Pheasants Forever's precision ag specialist identified 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 were 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 were 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 could hay or graze the site after primary nesting season and drive through these areas while planting and harvesting.

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	19
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 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

2019 RESULTS

The number of farmers and acres involved in this project increased again in the project's third and final year (Table 3). The largest success in 2019 was working with CENTROL crop consulting and five of their clients to collect Electrical Conductivity (EC) soil data on about 1,000 acres. This was described in the 2018 results, but we now have some results from this work after meeting with the farmer/trusted advisors teams through CENTROL (Table 3).This collaboration and considerations of soil characteristics, historical yield data, conservation opportunity and profitability all combined led to changes made on every acre analyzed. Implemented changes included addition of cover crops, no-till, wildlife habitat, and conservation cover as well as reduced fertilizer use using variable rate technology. Pheasants Forever's role in this was the identification of recommendations on revenue negative acres as well as conservation opportunity (vegetative) over all acres. Implemented practices included 23 acres into wildlife habitat, 18 acres into a Conservation Stewardship Program (CSP) monarch butterfly Regional Conservation Partnership Program (RCPP) with an additional 20+ acres applied for Environmental Quality Incentive Program (EQIP) and CSP but not accepted this time around. Above and beyond, now that the Conservation Reserve Program (CRP) has opened, there are additional acres being considered for enrollment. At the writing of this report in the early stages of this sign up period, we can't report the number of acres offered for CRP, but we are confident that decisions on more acres will be impacted in the future.

Table 3. Program summary for 2019.

Category	Value
Number of farmers involved	55
Number of Profit Zone Manager™ subscriptions	20
Number of MN counties	19
Number of financial partnerships	8
Total number of partners	59
Number of outreach events	46
Number of people attending outreach events	2,410
Acres analyzed using Profit Zone Manager™	27,241
Of analyzed acres, number of acres of opportunity based on being revenue negative	4,896
Acres implemented by farmer into conservation	465.8

Outreach activities were very important in our effort to introduce our project to more farmers and ag advisors. We had a booth at Farmfest in 2019 and hosted a precision ag workshop titled "How to Make Precision Ag Pay". The event covered a broad range of topics covered and included Cody Nelson with Soil RX Inc. talking about profitable soil health practices, as well as several NRCS professionals and Pheasants Forever Farm Bill Biologists talking about Federal Farm Bill conservation opportunities. Landowners discussed on their perspectives and experiences with precision ag and working with data to identify conservation opportunities.

Pheasants Forever will continue our initiative of utilizing precision ag data for increased farmer profitability with conservation and habitat implementation. We have had success and great conversations with farmers, looking at the financial aspect, diving in acre by acre, and making more sense of replacing row crops on negative revenue and unprofitable acres with perennial vegetation or other management uses. This is bringing technology into conservation and creating win-win scenarios for farmers' bottom line while improving water quality, soil health and wildlife habitat.

MANAGEMENT TIPS

1. Because of the intense labor, preparation, and weather dependence in farming during planting and harvesting seasons, 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. Be patient and don't expect immediate results.
3. Know what technology is being used in your area. The ag tech and precision data industry is highly competitive. Being knowledgeable in the multiple platforms being used in a specific area is key to success. More often than not, the technology is already there, and you need to be able to use the technology already on the farm.

COOPERATORS

We currently have 55 farmer cooperators located in 19 Minnesota counties.

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

CENTROL Crop Consulting, Marshall, MN

OTHER RESOURCES

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

pheasantsforever.org/Newsroom/2018-October/New-MN-Precision-Ag-Conservation-Specialist-Helps.aspx

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

www.agriculture.com/technology/turning-red-acres-black

www.agriculture.com/video/applying-conservation-practices-on-the-farm

www.efcsystems.com/index.php/agronomicplanningandsustainability

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

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

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
Alternative Markets and Specialty Crops		
2020	Minnesota Hops Terroir Identification and Promotion	Mighty Axe Hops, Eric Sannerud
	Effects of Drip Irrigation on the Yields of Native Seed Production Plots	Blazing Star Gardens, Dustin Demmer
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

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
	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
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

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
	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
Cropping Systems and Soil Fertility		
2020	Using Precision Ag Data to Maximize Economic and Environmental Benefits	Pheasants Forever, Tanner Bruse
	Impact of Two Tillage Types on Yield, Economic Profitability, and Soil Health in Polk County, MN	Minnesota Wheat Research and Promotion Council, Melissa Geiszler
2019	Interseeding Cover Crops and In Season Nitrogen Application in One Pass	Keith Hartmann
2018	Raising Soil pH Effectively in Acid Soils	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
	Interseeding 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

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
	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	Bois 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
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

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
	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
	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
	Living Snow Fences for Improved Pasture Production	Mike Hansen
	Managing Dairy Manure Nutrients in a Recycling Compost Program	Norman & Sallie Volkmann

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
	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
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

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
	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
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

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
	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		
2020	Economic Feasibility of Spray Foam Insulation in a Hog Finishing Barn	Vande Ag Enterprises, Ryan Vandendriessche & Jordan Vandeputte
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		
2020	Testing of a Non-traditional Process for Cleaning and Sorting MN Wine Grape Varietals	KISS LLC dba Brookview Winery, Arlyn Wall
	Testing Different Training Systems and Varieties to Improve the Profitability of Gooseberries	Good Courage Farm, Jen Blecha
	Evaluating Effectiveness of Sap Analysis to Increase High Tunnel Tomato Yield and Quality	The Good Acre, Andrew Bernhardt & David Van Eeckhout
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

Completed Grant Projects

Final Greenbook Article	Title of Project	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 Greenbook Article	Title of Project	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 MN	John Fisher-Merritt
	Living Mulch, Organic Mulch, Bare Ground Comparison	Dan & Gilda Gieske
Livestock		
2020	Comparison of Mobile Confinement and Day-range Production Systems for Pastured Broiler Chickens	Seelye Brook Farms, Randy Kleinman
2019	Goat Grazing During Winter in Minnesota: Controlling Vegetation While Saving on Feed Costs	John Beckwith, Hiawatha Valley Resource Conservation & Development
	Integrating Silvopasture Practices into Perennial Fruit Production	Jackie & Harry Hoch, Hoch Orchard

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
	Testing Three Novel Sheep-specific Pasture Types to Maximize Average Daily Gains in Lambs on Pasture	Anna Johnson
2018	Breeding, Selecting and Assessing Organically Grown Nutrient Dense Corn for Poultry Production	Zachary Paige & Sue Wika, Paradox Farm
	Trials to Overwinter Nucleus Colonies with a Pause in Brood Rearing	Four Seasons Apiaries, LLC, Joseph Meyer
2017	Acclimating Heifers to Improve Cow Flow on Dairy Farms	Ulrike Sorge
	Utilization of Building for Multiple Livestock Species	Steve Stassen
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

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
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
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

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
	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
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

Completed Grant Projects

Final Greenbook Article	Title of Project	Grantee
	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
	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