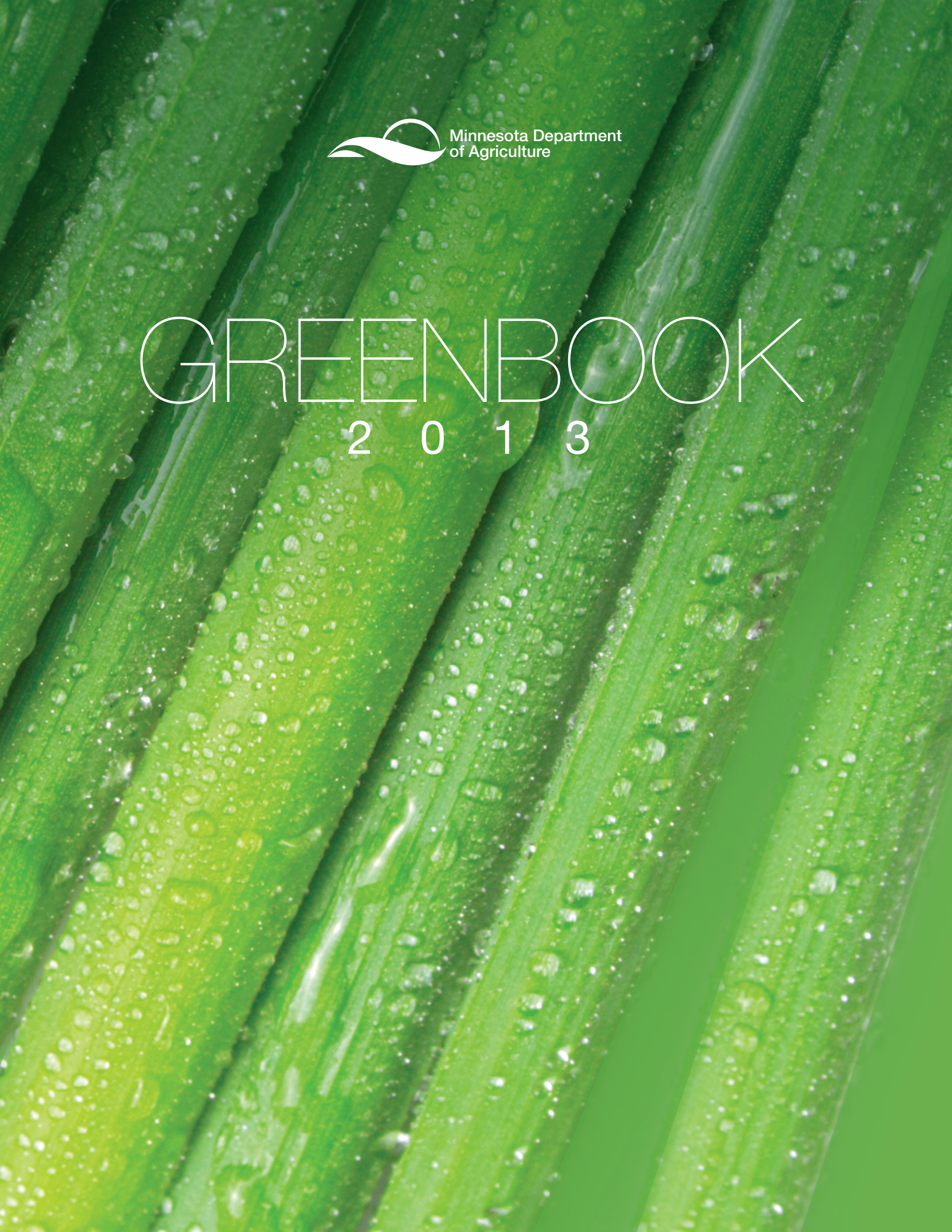

Minnesota Department
of Agriculture
GREENBOOK
2013

Greenbook 2013

Program Vision Statement

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

Program Mission Statement

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

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

MINNESOTA DEPARTMENT OF AGRICULTURE

June 2013

Thank you to the MDA's Agricultural Marketing and Development Division Staff who helped to make Greenbook 2013 a reality. They include: Jean Ciborowski, Alison Fish, Wayne Monsen, Stephen Moser, Meg Moynihan, and Mark Zumwinkle

Minnesota Department of Agriculture
625 Robert Street North, St. Paul, MN 55155
651-201-6012

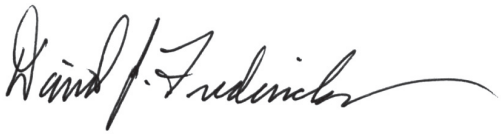
Introduction to the *Greenbook 2013*

I am pleased to present the annual edition of the *Greenbook*, a publication of the Minnesota Department of Agriculture's Agricultural Marketing and Development Division. This is the 24th edition of the *Greenbook* highlighting the Sustainable Agriculture Demonstration Grant projects of Minnesota farmers, ranchers, and researchers. These grants have provided an incentive for people to pursue research and innovations that they might otherwise not have done.

The annual *Greenbook* features the results of on-farm demonstration and research projects that test new approaches to raising crops and livestock as well as marketing agricultural products. These farmers have brought a multitude of ideas and hard work to help make Minnesota agriculture more environmentally friendly and profitable.

Over the past twenty-four years, the *Greenbook* has showcased hundreds of innovative and creative grant projects that have contributed to important advances in Minnesota agriculture. From the state's small specialty crop farmers to the large commodity crop farmers, all are working to make Minnesota's agricultural sector a success.

Greenbook 2013 contains articles on each project with observations and management tips from the participants. They have also shared practical and technical information. I think you will find *Greenbook* 2013 interesting and please feel free to call any of the grantees about their projects. They are eager to discuss their projects, the successes and the challenges, with you.



Dave Frederickson, Commissioner

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Sustainable Agriculture Grant Program

Program Purpose

The Grant Program has provided a unique opportunity for farmers, nonprofit groups, agricultural researchers, and educators across the state to work together to explore ways of enhancing the sustainability of a wide range of farming systems.

Program Description

The Department received over 1,100 grant applications and approved over $3 million in funding for 287 projects since the program began in 1989. Project categories include: Alternative Markets and Specialty Crops, Cropping Systems and Soil Fertility, Energy, Fruits and Vegetables, and Livestock. The grant projects, located throughout the state of Minnesota, are described in Greenbook 2013.

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

Grant Summaries

The project summaries that follow are descriptions of objectives, methods, and findings of individual grant projects funded in 2013. To find out more details about these projects, contact the principal investigators directly through the listed telephone numbers, addresses, and email addresses.

Summary of Grant Funding (1989-2013)

Year	Number of Grants Funded	Total Funding	Average Grant Size	Ranges
1989	17	$280,000	$16,500	$3,000-25,000
1990	14	189,000	13,500	4,000-25,000
1991	4	46,000	11,500	4,000-23,000
1992	16	177,000	11,000	2,000-25,000
1993	13	85,000	6,000	2,000-11,000
1994	14	60,825	4,000	2,000-10,000
1995	19	205,600	11,000	2,000-25,000
1996	16	205,500	12,900	4,000-25,000
1997	20	221,591	11,700	1,000-25,000
1998	19	210,000	11,100	1,000-24,560
1999	23	234,500	10,200	3,000-21,000
2000	17	150,000	8,800	4,600-15,000
2001	16	190,000	11,875	5,000-25,000
2002	18	200,000	11,000	4,300-20,000
2003*/2004*	---	---	---	---
2005	10	70,000	7,000	2,000-11,600
2006	8	70,000	8,750	4,600-12,000
2007	9	70,000	7,777	2,700-12,000
2008	10	148,400	14,800	4,500-25,000
2009	7	103,000	14,700	5,000-20,000
2010	11	77,000	7,000	3,600-10,000
2011*/2012*	---	---	---	---
2013	6	66,000	11,000	5,300-20,300
Total Funded	281	$2,993,416		

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

Fertilizing with Alfalfa Mulches in Field Crops

Principal Investigator

Carmen Fernholz
2484 Hwy. 40
Madison, MN 56256
320-598-3010
Lac Qui Parle County

Project Duration

2010 to 2012

Award Amount

$9,056

Staff Contact

Mark Zumwinkle
651-201-6240

Keywords

mulch, nitrogen, organic farming

Project Summary

Providing the nutrient needs for corn and small grain on an organic farm without livestock is a challenge due to a lack of on-farm forage and manure cycling. My project is an attempt to determine if on-farm produced alfalfa hay mulch can supply an adequate and reliable source of nitrogen and other plant nutrients to corn and small grain. In the spring, alfalfa hay is green chopped, analyzed for nutrients, and spread on the row crop ground. A secondary goal is to determine the efficiency of recycling farm produced nutrients through the mulch process.

If the project is successful, it will go a long way in alleviating the growing issue of low fertility on my farm. The alfalfa mulch should also improve weed management and enhance soil structure. On-farm production of fertility should reduce input costs and increase income by allowing me to maintain my certified organic status.

Project Description

In our current agricultural climate, many organic and conventional producers have operations without livestock. Alfalfa is grown for its soil building attributes. However, when the alfalfa is harvested as hay and sold off the farm, nutrients essential to plant growth are also exported in the hay.

I lost my livestock enterprise several years ago and have since been without a reliable source of hog manure. I previously used the manure to replenish soil nutrients needed for corn and small grain production.

Alfalfa is an ongoing component of my crop rotation. This demonstration is using a portion of my alfalfa hay crop to enrich the soil for grain crops.

Alfalfa round bales spread as mulch using a side delivery hay processor.

Table 1. Plot Layout for Alfalfa Mulch Demonstration (individual plots are 30' x 200')

CONTROL	FULL RATE MULCH	CONTROL	HALF RATE MULCH	CONTROL	HALF RATE MULCH	CONTROL	FULL RATE MULCH

On August 23, 2010, following the harvest of winter wheat, alfalfa hay was spread as mulch in preparation for a crop of barley which was planted in the spring of 2011. A side delivery hay processor was used to shred 1 ton round bales of alfalfa and distribute the mulch (see photo). The hay processor is normally used to feed cattle in feed bunks or on open range. The distribution of the mulch was reasonably uniform. The mulch was worked into the soil using a chisel plow.

Field corn followed the barley in 2012. Fertility for the corn crop was supplied by a second application of alfalfa hay mulch after the barley harvest in August of 2011.

In order to determine the value of the alfalfa mulch to the following crops and soil, replicated strips were applied to the field (Table 1). The treatments included:

- full rate application of mulch;
- half rate application of mulch; and
- no mulch control.

Results

A forage analysis revealed the alfalfa hay contained approximately 20% protein or 7.5% nitrogen (% crude protein/2.65 = % nitrogen). This means the full rate mulch treatment received 465 lb N/A. Due to the slow release nature of the mulch fertility, only a portion of this was available to the barley crop.

Selected plots were sampled in late fall for soil analysis. This provided a baseline for future reference of soil attributes expected to change slowly over time such as organic matter, pH, and micronutrients. Positive trends in nitrogen and potassium levels have been detected due to the addition of the alfalfa mulch (Table 2). The same was not true, however for phosphorus.

Due to a narrow window for harvest, no yield data were collected from the barley plots in 2011. However, visual differences in the plots were easily observed prior to harvest. The full rate mulch plots were darker green, had fuller grain heads, and plants were fully 6" taller than the control plots. The half rate mulch plots were visibly different from both the full rate plots and the controls in both height and density.

In August of 2011, alfalfa mulch was again applied to the plots using the same plot configuration and the same rates of application as in the initial year of the project. The analysis of the hay applied was similar to the first year's analysis.

In the spring of 2012, corn was then planted in the plots at a rate of 30,000 plants/A. Weed control was achieved by cultivating twice and tine weeding once.

In October, the corn was harvested for grain. In spite of the unusually dry growing season, the ambient field (including the control) yielded a respectable 141 bu/A. Yields were significantly higher where the mulch had been applied. The half rate and full rate mulch yielded 149 and 153 bu/A, respectively.

This project has initiated interest in more detailed scientific study of alfalfa as a nitrogen source for corn. The University of Minnesota has established replicated plots at Becker and Rosemount for this purpose.

Conclusions

Overall, the system shows great promise. I have found that alfalfa mulch is a legitimate alternative source of crop nutrients. However, several challenges must be overcome before the practice is used on a regular basis on my farm. Specifically, I feel I must:

- achieve a more uniform spread of the mulch;
- reduce the time invested in harvesting and spreading; and
- address the cost of the mulch material.

Although the mulch spread was fairly even, I would like to try an even finer chop for a more even spread. An additional application method might include the

Table 2. Available Major Plant Nutrients in 6" Soil Sample After Application of Alfalfa Mulch, Fall, 2010.

	NO3 Nitrogen (ppm)	Bray Phosphorus (ppm)	Potassium (ppm)
Control	4	13	182
Full Rate Mulch	15	10	308
Half Rate Mulch	17	17	276

stockpiling of chopped mulch using a tub grinder and then applying the mulch using a side slinger manure spreader. I will investigate methods used by the Minnesota Department of Transportation for applying mulch to soil needing protection in new highway construction. There may be efficiencies to be found here.

I am considering using green chop alfalfa as an alternative to dry hay. I plan to use high protein (high nitrogen) alfalfa for mulch and low protein alfalfa for hay.

Currently, we are facing a significant shortage of dry hay in Minnesota. Consequently, alfalfa hay prices are very high. High corn prices have exacerbated the high hay prices by driving hay ground into corn production. When these high prices moderate, the use of alfalfa mulch should become more economical.

The University of Minnesota has expanded this research. Currently a student is pursuing her Master's degree on the use of alfalfa as a surface mulch in corn. Preliminary results look favorable for alfalfa as a good source of nitrogen (please refer to "Other Resources" at the end of this article for reference to the University of Minnesota work).

In the near-term, I do not plan to continue this practice on a large scale on my farm. Instead, I will continue to work on better methods of applying the alfalfa material to the land. If I can work this out, I definitely will incorporate the idea into my mainstream farming operations. I continue to collaborate with the University of Minnesota on their work in this area.

Management Tips

1. A hay processor can deliver an even spread of alfalfa mulch.

2. Fine chop the alfalfa for the most even coverage.

3. An alfalfa forage sample analysis determines protein and, therefore, nitrogen in the mulch.

Cooperator

Glen Borgerding, Ag Resource Consulting, Inc., Albany, MN

Project Location

From Madison, go east on MN Hwy 40 1.5 miles and look for the A-frame house on the left.

Other Resources

Fernholz tests hay as alternative fertilizer, mulch. Agrinews, 9-15-2011. *www.agrinews.com/fernholz/tests/hay/as/alternative/fertilizer/mulch/story-3898.html*

Alfalfa Mulch As a Nitrogen Source for Corn Production. Presenting Author: Laura Fernandez, University of Minnesota. *https://dl.sciencesocieties.org/publications/meetings/2012am/9807/75492*

For more information on the University of Minnesota project contact Laura Fernandez. *Ferna125@umn.edu*

McNamara Filter Strip Demonstration

Principal Investigator

Goodhue County SWCD
Beau Kennedy
104 - 3rd Ave. E.
PO Box 355
Goodhue, MN 55027
651-923-5286

Project Duration

2010 to 2012

Award Amount

$7,094

Staff Contact

Mark Zumwinkle
651-201-6240

Keywords

feed quality, grass buffers, grass waterways, native grasses, soil and water conservation

Project Summary

In southeastern Minnesota, grass waterways and grass buffers provide a stable, cost-effective way to convey and filter storm water before entering perennial streams. Some landowners use these waterways as a hay source for livestock, while others neglect these areas and see them as an annoyance. A well maintained grass waterway can provide large amounts of forage for livestock, as well as reduce erosion in an agricultural setting.

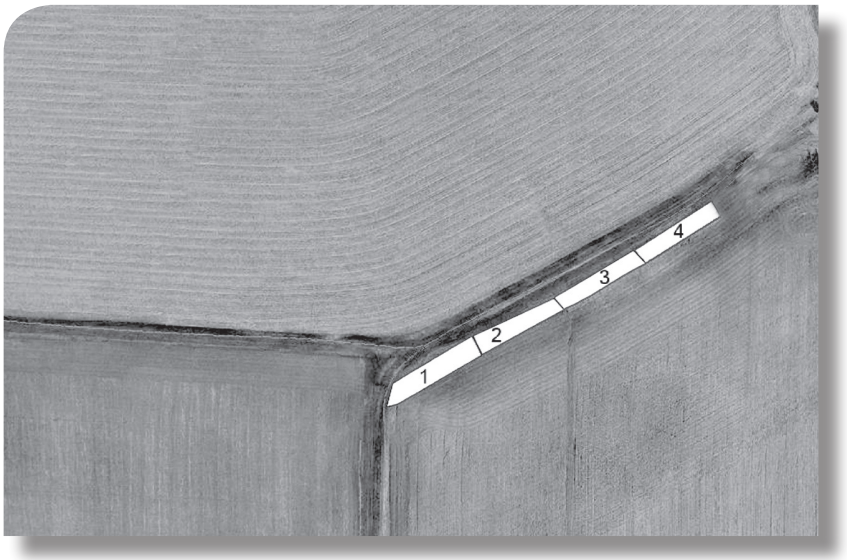
The intent of this demonstration is to compare the amount of forage and feed value produced in four buffers using different seed mixes. Test plots in a waterway and buffer setting have been established for this purpose.

The erosion control, soil filtering, and flood reduction capacities of grass waterways and buffers are extremely important. To test the water quality performance of the seed mixes, we will use a rain simulator to measure water runoff and sedimentation rates exiting in each test plot. The seed mixture producing the greatest forage value while still retaining soil stability may be marketed locally.

Project Description

This project is located in Goodhue County, roughly 4 miles west of the town of Goodhue. The four test plots are located in an existing grass waterway on Ed McNamara's farm. Ed is interested in improving the overall performance of the grass on his farm. He would like to explore ways to make his waterways and buffer areas produce harvestable forage while still protecting the soil.

The aerial photo shows how the four test plots are situated on the landscape. The seeding was done in corn stubble. We offset the test plots adjacent to an existing grass waterway. They are all approximately one tenth of an acre in size.



Aerial view of four buffer mix test plots adjacent to grass waterway on McNamara farm.

Table 1. Seed Mixes Planted in Buffer Test Plots on July 13, 2010 on McNamara Farm.

PLOT 1 Ed's Mix 1 (drilled)		**PLOT 2** SWCD Mix (drilled)		**PLOT 3** BC-17 Native Mix (drilled)		**PLOT 4** CP 21 CRP Mix (broadcast)	
	lb/A		lb/A		lb/A		lb/A
Alfalfa	8	Timothy	2	Big Bluestem	3	Indian Grass	1.5
Orchardgrass/Brome	15	Perennial Ryegrass	3	Canada Wild Rye	3	Big Bluestem	2.5
Winter Wheat cover	30	Kentucky Bluegrass	2	Switchgrass	4	Little Bluestem	1
Total	**53**	Smooth Bromegrass	10	Western Wheatgrass	4	Sideoats Gram	1
		Winter Wheat cover	36	Perennial Ryegrass	4	Canada Wild Rye	1
		Total	**53**	Red Fescue (late)	3	Blue Grama	0.5
				Winter Wheat cover	32	Switchgrass	0.5
				Total	**53**	Oat cover	25
						Total 33	

The dimensions of each plot are roughly 150' x 30'. For the most part, the entire length of the test plots receive the same amount of sheet and rill erosion. We selected this site because the soil characteristics of the cropland are similar to the waterway. These soils have the same productivity indices and similar drainage characteristics. The grass waterways leading to the plot sites are hayed throughout the growing season, allowing easy access during the summer months for data collection and maintenance. Waterways are used throughout the county to help convey runoff in a safe manner. In most cases they flow into an intermittent or perennial stream.

Results

On July 13, 2010, four test plots were seeded using various seed mixes (Table 1).

Three of the four test plots were seeded with a John Deere no-till drill operated by the Goodhue County SWCD. Plot 4 was seeded using a Truax broadcast spreader.

- **Plot 1** is Ed's mix, a typical pasture mixture found in Goodhue County that includes alfalfa, orchardgrass/brome, and winter wheat cover.

- **Plot 2** is the SWCD grass waterway seed mixture we sell in our drill. Plot 1 and Plot 2 are acting as controls during this project since they are the most prevalent buffer mixes used in our landscape.

- **Plot 3** is a BC-17 native mix that was created by SWCD staff with direction from other various state agencies. The SWCD wanted to test a grass mixture that had a native component with deep root systems and would hopefully still be fast growing and provide a respectable forage quantity in the establishment phase. We included big bluestem and switchgrass for the deep rooted, warm season grass component. Canadian wild rye, perennial rye, and fescue were chosen for early spring growth and persistence throughout the growing season. This mixture, if viable, may be marketed in our seed drill for waterways and buffers. We hope it will also provide winter cover for wildlife.

- **Plot 4** is a CP-21 CRP mixture. This is a typical native mixture (consisting of Indian grass, big bluestem, little bluestem, sideoats grama, Canada wild rye, blue grama, and switchgrass) used in most CRP buffer acres.

The photographs below show the vegetated stands in the four test plots on June 29, 2011 just before harvest. Labeled below each picture is the list of plants that were identified. The plant species are listed in order of dominance.

Plot 1 - Alfalfa, Brome, Orchard

Plot 2 - Perennial Rye, Timothy, Brome, Winter Wheat

Plot 3 - Winter Wheat, Western Wheat, Perennial Rye, Red Fescue, Switchgrass, Big Bluestem

Plot 4 – Oats, Clover, Switchgrass, Big Bluestem, Indian grass

Table 2. Forage yield and quality of four buffers (average of 2011 and 2012 harvests).

Test Plot	Biomass (lb/A)	Adjusted Crude Protein (%)	Acid Detergent Fiber (%)
Plot 1 Ed's Mix	4,669	11.76	96.2
Plot 2 SWCD Mix	3,793	7.92	98.2
Plot 3 Native Mix	4,231	7.74	92.0
Plot 4 CRP Mix	2,143	8.00	110.1

As of the fall of 2010, all plots were well established. In 2011 and 2012, we harvested and measured each test plot for biomass production and relative forage value in order to determine the cost-effectiveness of these traditional, native, and alternative buffer and waterway mixes. The height and variety of plant species was recorded. Then, the first cut of each plot was harvested with a round baler. Bales were weighed and sampled for forage quality.

The photographs below show the vegetated stands in the four test plots on June 29, 2011 just before harvest. Labeled below each picture is the list of plants that were identified. The plant species are listed in order of dominance.

Forage yield and quality

After two full growing seasons of forage testing, we were able to calculate an average forage yield and quality for each of the four test plots (Table 2). Plot 1 (Ed's Mix) showed the greatest yield and typically the highest adjusted crude protein. Plot 2 (SWCD mix) had a high relative feed quality rating while producing a moderate forage yield. Tall fescue became the dominate bunch grass, while perennial ryegrass and Kentucky bluegrass became prevalent as the plot's sod mat. The forage quality was moderate, while the weight of the stand was high, averaging 4,000 lb/A. Plot 4 (CRP mixture) was lacking in total biomass, but had a high relative feed quality. This was mainly due to the young, green plant species that were abundant in the plot.

Runoff water quantity and quality

A primary goal of this project was to investigate the water quality aspect of these different seed mixes. We set up a rain simulation on each of the four test plots (Table 3). An average of 3.69" of rain was delivered to each test plot over a 1 hour time period. All

Table 3. Runoff water quantity and quality comparison of four buffers after one hour, 3.7"/hr simulated rainfall event. September 6, 2012.

Test Plot	Ronoff Volume (gal)	Sediment Loss (lb/A)
Plot 1 Ed's Mix	12.8	11.29
Plot 2 SWCD Mix	19.1	3.47
Plot 3 Native Mix	15.8	8.16
Plot 4 CRP Mix	34.7	132.9

runoff was captured and sent to a lab and tested for total suspended solids. By combining the runoff volume with the total suspended solids concentration, we derived a weighted average of sediment loss on each plot during the simulated rain event.

Plot 1 (Ed's mix) proved to have the highest infiltration rate (lowest runoff) out of all the plots. Just 12.8 gal of the 91 gal applied to the plot was collected as runoff. We believe the roots of the alfalfa plant in Plot 1 created a soil structure and porosity which allowed oxygen and water to infiltrate easily. The lowest rate of sediment loss was found in Plot 2 (SWCD mixture).

The Goodhue SWCD uses this mixture for seeding grassed waterways and critical areas. We calculated that just 3.47 lb/A of sediment was lost during the rain event, which was much lower than the 132.9 lb/A of Plot 4 (CRP mix). Plot 4 also showed the highest rate of runoff, with 34.7 gal, but it was not yet a mature stand of native grasses which may have affected the results of the water quality test.

We will be repeating these rain simulation testing procedures in 2 years. It will be interesting to analyze the difference between the mature native warm season grasses found in Plots 3 and 4, and the mature cool season grasses found in Plots 1 and 2.

Management Tips

1. The 2011 spring was an extremely wet and cool season. This may have stunted some of the warm season native plant growth in Plot 3. An active spring located up gradient from the test plot sites became more active this year. Wet conditions will affect plant species not tolerant of hydric soil conditions.

2. The test plots were only cut and harvested once during the 2011 growing season. I would recommend a minimum of three cuttings to suppress weeds, warm the ground, and stimulate low plant growth.

3. Mixes with a strong native component should be clipped at 6"-10" in height to assure that the native component of the seed mix is not negatively affected.

4. Limit tractor/truck traffic to avoid compaction for at least one growing season (except for cutting/harvesting).

Cooperators

Ed McNamara, Farmer, Goodhue, MN

Mark Zumwinkle, Minnesota Department of Agriculture, St. Paul, MN

Location

From St. Paul, take Hwy. 52 through Cannon Falls. Go 5 miles south of Cannon Falls, turn left on Goodhue Cty. 9. Go 7 miles and turn left on Twp. 171. The McNamara farm is second on the left.

Other Resources

Iowa State University Extension. Stewards of the Stream, Buffer Strip Design, Establishment, and Maintenance. Website (PDF): *www.extension.iastate.edu/Publications/PM1626b.pdf*

Minnesota Department of Agriculture. Conservation Funding Guide. Grass Waterway. Website: *www.mda.state.mn.us/protecting/conservation/practices/waterway.aspx*

Optimizing Alfalfa Fertilization for Sustainable Production

Principal Investigator

Doug Holen
University of Minnesota Extension
WCROC
46352 State Hwy. 329
Morris, MN 56267
320-589-1711
holen009@umn.edu
Project Location: Otter Tail County

Project Duration

2010 to 2012

Award Amount

$7,926

Staff Contact

Meg Moynihan
651-201-6616

Keywords

alfalfa, boron, forage, persistence, potassium, sulfur, yield

Project Summary

Alfalfa is a key component of sustainable cropping systems in Minnesota. It is a perennial crop that fixes its own nitrogen, improves soil health, reduces soil erosion, and provides high-quality forage for ruminant livestock. Economic analyses have consistently shown alfalfa to be a profitable crop for haying and grazing. In many years, it has been more profitable than subsidy-supported corn or soybean production. We were interested in identifying fertilization strategies that economically optimize alfalfa production. We are confident that this information could help maintain alfalfa in crop rotations on Minnesota farms, enhancing overall farm profitability and sustainability.

Project Description and Results

Good soil fertility is known to be important to productive and persistent alfalfa. Potassium has generally been the nutrient recommended in greatest quantities due to the large amount of potassium removed when alfalfa is harvested as hay or haylage. Boron and sulfur have been recommended when alfalfa is grown on sandy soils, but there is increasing evidence that these nutrients may benefit alfalfa and other crops more than previously thought. Our specific objectives were to test alfalfa's response to various levels of:

1. Potassium fertilization
2. Boron fertilization
3. Sulfur fertilization
4. The interactions of these three nutrients, observed with timing of application

2010

In the first year, we set up the study, prepared the site, applied treatments, and documented existing soil fertility. On May 17, we planted a replicated small plot experiment on the Paul Beckman farm in Otter Tail County. We used a split-split plot restriction of a factorial arrangement of treatments to evaluate fall and spring applications of potassium, sulfur, and boron at different rates (Table 1). The total of all timings, fertilizers, and rates combined made for 48 different treatments, and replicating them three times required 144 plots. We seeded 'Rebound 5.0' alfalfa in 3' x 20' plots with a special small plot research planter, choosing this variety because it has performed well in recent University of Minnesota alfalfa variety testing. The seeding rate was 16 lb/A.

In June, we sprayed Raptor® herbicide because of heavy weed pressure from lambsquarters and redroot pigweed. We harvested twice: on July 13 and again on August 16 but did not collect yield data. Soil samples taken in June and August demonstrated slight increases in organic matter and pH, with gradual decreases in fertility levels for potassium, boron, calcium, magnesium, and phosphorus. In September, we applied lime at 1,140 lb/A effective neutralizing power in order to increase the soil pH from 5.8.

Table 1. Timing, Fertilizer, and Rate Treatments

Main Plot	Subplot	Sub-subplot	Sub-sub-subplot
Spring	Potassium at 0, 150, 300, 450 lb/A	Boron at 0 or 4 lb/A	Sulfur at 0, 30, 60 lb/A
Fall	Potassium at 0, 150, 300, 450 lb/A	Boron at 0 or 4 lb/A	Sulfur at 0, 30, 60 lb/A

2011 and 2012

In spring and fall 2011 we took soil samples from all 48 treatment combinations conducted to determine costs, returns, and profitability potential of the various fertility treatments. We soil sampled again in Fall 2012. We will continue our sampling program and intend to analyze and report on the data at the end of the project (check back for a follow-up article in Greenbook 2014). In the meantime, it is important for producers to know that soil tests are not a reliable way to determine sulfur needs. Traditionally, soil type has been the best predictor of sulfur need. Researchers like us are currently trying to learn more about different crops' sulfur requirements.

In our experiment, we applied the fertilizer treatments on July 6 and October 4 in 2011 and on July 3 and October 29 in 2012. In both years, we harvested the alfalfa four times using a small plot research flail harvester and documenting maturity, height, and weed content data at all harvests. The 2011 cutting dates were June 3, June 30, August 4, and October 4. The 2012 cutting dates were May 31, July 3, August 3, and October 8. We took representative forage samples to determine dry matter content. Fresh weights of harvested material were measured on site, and then adjusted to a dry matter basis based on content of the representative samples (Table 2).

Results

Yields for the four treatments are summarized in tables 2-5. In both 2011 and 2012 we saw significant yield increases with higher sulfur applications and we found significant differences for Timing x Sulfur. In 2012 only, we also found significant interaction for Potassium x Boron.

Our preliminary conclusion is that applying sulfur to alfalfa results in yield increases. We are going to continue this study for one more year, as the typical practice in our part of Minnesota is to keep alfalfa in production for 3 years after establishment. We expect treatment differences to become more marked as time goes on, and feel confident that we will be able to make fertilizer recommendations that will maximize forage production for biomass while also considering the cost of purchased fertilizer. At the end of the project, we expect to have better potassium, boron, and sulfur fertilization guidelines producers can use, as well as information about the economics of applying these nutrients – does increased yield offset their cost?

Once we have a complete 3-year data set, we will feel more confident about holding field days and sharing the results with farmers through Extension publications.

In the meantime, we published the results of our work to date in the 2012 edition of On-Farm Cropping Trials Northwest and West Central Minnesota, a University of Minnesota publication. Although we had planned to do it in 2012, we will hold a forage field day at the Beckman farm next year to feature this study and an alfalfa variety evaluation test.

Management Tips

1. If alfalfa isn't producing the way you think it should, start by taking soil samples. Nutrient availability and/or pH are often factors that limit production.

This is our research site just after its 144 individual plots were freshly harvested.

Table 2. Dry matter yield (T/A) by fertilizer application timing.

Timing	2011 Forage Yield	2012 Forage Yield
Fall	6.4	7.2
Spring	6.3	
LSD 0.05=	NS	NS

Table 3. Dry matter yield (T/A) for four Potassium (K) rates.

K (lb/A)	2011 Forage Yield	2012 Forage Yield
0	6.3	6.9
150	6.1	7.0
300	6.5	7.4
450	6.6	7.5
LSD 0.05=	NS	NS

Table 4. Dry matter yields (T/A) for two Boron (B) rates.

B (lb/A)	2011 Forage Yield	2012 Forage Yield
0	6.4	7.5
4	6.4	7.2
LSD 0.05=	NS	NS

Table 5. Dry matter yields (T/A) for three Sulfur (S) rates.

S (lb/A)	2011 Forage Yield	2012 Forage Yield
0	6.2	6.7
30	6.4	7.3
60	6.5	7.6
LSD 0.05=	NS	NS

2. Continually monitor alfalfa and forage fields for insect and disease pests. Properly identifying pests allows for timely management decisions if problems warrant action.

3. Matching the nutrient needs to the expected tonnage harvested is important. Deficiencies lead to underproduction, while excess fertility means lost money and risk to environmental quality.

4. Pound for pound, not all agricultural lime is created equal. Check the label for "effective neutralizing power (ENP)" to figure out the correct application rate.

Cooperators

Paul Beckman, Crop Farmer/Retired Dairy Producer, Underwood, MN

Paul Peterson, University of Minnesota Extension Forage Specialist, St. Paul, MN

Project Location

From Underwood, go north on Cty. Rd. 35 for ¾ mile. Turn right on 230th. Continue for ¼ mile. Site is on the south side of the road.

Other Resources

Minnesota Agricultural Experiment Station. 2012. Alfalfa variety trials and resources. *www.maes.umn.edu/Research/Crop_Variety_Trials*

Extended Season Marketing of Asian and Latino Ethnic Vegetables Grown in Quick Hoops and a Moveable Greenhouse

Principal Investigator

Judy and Steve Harder
1310 Mountain Lake Rd.
Mountain Lake, MN 56159
507-427-3200
jubilee@mtlake.org
Cottonwood County

Project Duration

2010 to 2012

Award Amount

$6,000

Staff Contact

Meg Moynihan
651-201-6616
Additional contributor:
Cassie Boadway

Keywords

Asian, high tunnel, Latino, season extension, quick hoops, vegetables

Project Summary

Our project investigated the profitability of growing ethnic vegetables and season extension. A population shift over the last generation has brought change to our southwest Minnesota community. More than 30% of Mountain Lake's population consists of families of Asian and Latino origin. Community gardening has shown that Lao and Latino families want to raise traditional ethnic vegetables. Since first frost brings an end to most gardens, we have explored ways to increase and extend the availability of fresh produce to our ethnically diverse community. In developing this market, we have networked with CSA share members, community gardeners, and local retail businesses.

Project Description

Our 20 acre farm is located in southwest Minnesota, within the city limits of Mountain Lake. It includes 1 acre of fruit and vegetable production nestled in a restored prairie. In June 2010 we started a business called Jubilee Fruits and Vegetables. We use two movable high tunnels, traditional outdoor gardens, and rows of quick hoops (sometimes also called "low tunnels"). We market a large variety of fruits and vegetables from May through December to CSA members, local schools, a hospital, a nursing home, and in our farm market.

The overall goal of our project is to discover which ethnic vegetables do best using season extension strategies such as quick hoops and moveable high tunnels. We are specifically testing how several varieties of Asian greens grow in three different systems: 1) a traditional garden setting in early spring and late fall under quick hoops and row covers to extend the season; 2) in a traditional outdoor garden; 3) under quick hoops and a row cover to protect plants from flea beetles; 4) in a high tunnel for fall and winter harvest.

The high tunnels are on tracks, so we can move them to cover different plots.

Table 1. 2010 Performance of Asian Greens

Variety	Observations
"Black Summer" and "Joi Choi" (large pac choi)	These are not a "cut and come again" crop like the other greens. We left one "Black Summer" to observe its cold tolerance. When this report was submitted in December 2010, it had no signs of cold damage yet.
"Green Lance" (Asian kale)	Grew to be a large plant with its head about 1' above the ground and had a 1" diameter stem at ground level. The leaves were huge and tasty.
"Tokyo Bekana" (like Chinese cabbage)	Midrib separates from the outside layer but is still usable. It does not brown or decompose. The taste remains crisp and sweet.
Hon Tsai Tai (Asian green related to mustard)	Produced the largest harvest of leaves. The base of the plant is at ground level and seems to tolerate the cold. Later in the season, new sprouts of leaves and flowers started to show.
"Kyona" Mizuna (Asian green related to mustard)	Seems to toughen as the season lengthens. Many leaves decomposed and had to be removed. It would not be marketable in winter.

Our high tunnels are 30' x 48' and are on V-tracks, which rotate among seven plots. We plant in 30" raised rows, with eight rows per plot. The setup in our outdoor garden was identical.

2010 Results

It was challenging to find seeds for the plants that ethnic grocers and local community members recommended. We purchased seeds from a variety of sources but found that the best germination rates came from well-known companies such as Johnny's Selected Seeds. Descriptions of all the varieties we planted are provided in Table 1.

In June, we direct seeded two varieties of pac choi (Black Summer and Joi Choi) and one variety of Asian kale (Green Lance) outdoors. We placed quick hoops over the rows of greens and covered them with a floating row cover, anchoring it down to prevent flea beetle damage. We had a run of very hot and dry days and decided that a soil moisture monitoring system would have been helpful. We also started Poblano and Serrano peppers in June, but they did not germinate.

At the end of July, we started more Black Summer, Joi Choi, and Green Lance, along with Hon Tsai Tai and Kyona Mizuna, in soil blocks indoors. In August, we transplanted them into one row of a high tunnel plot. Since we did not observe any flea beetle damage, we didn't use a row cover. At the end of August, we also direct seeded the greens into a high tunnel plot. We used quick hoops for protection from cold temperatures and wind.

In September, we had heavy rains. We moved the high tunnel over the plantings the first week of October. In November, before temperatures dropped into the 20s, we placed square wire wickets over each row in the tunnel and draped a large sheet of row cover over them. In order to have a good harvest through December 1 for our CSA boxes, we used supplemental heat for 3 days at the end of November. The heat allowed us to maintain an inside temperature of 20°F when outside temperatures were in the single digits.

The transplanted pac choi plants grown in the high tunnels grew 2-3 times larger than those in the summer garden and were much tastier. The flavor may have improved due to cooler weather and adequate soil moisture provided by the drip irrigation in this area of the high tunnel. We were able to harvest the other tunnel greens many times. They, too, were twice the size of the outdoor plantings and much sweeter in flavor. The Asian greens were a new treat and well received by our CSA members, who enjoyed their fresh flavor in salads and cooked in stir-fries.

These greens all proved to be fairly cold tolerant. During November the plants froze and thawed many times. We were still able to harvest the greens after the sun warmed up the high tunnel – removing the row covers for harvesting, and replacing them afterwards. Some observations about these greens are offered in Table 1. Our final harvest occurred on December 6.

Mizuna (top) and Tokyo Bekana (bottom).

2011 Results

Asian Greens

In spring and late fall, we planted outdoors under quick hoops and in the tunnel. We started much earlier than in 2010, seeding into soil blocks the third week of March and using a mixture of 20 qt compost, 30 qt peat moss, 20 qt perlite, 10 qt soil, and 3 C green sand/blood meal. We added water to make the correct consistency. We seeded 36 blocks each of Black Summer, Joi Choi, Tokyo Bekana, Kyona Mizuna, Tatsoi, and Hon Tsai Tai. Half of the plants were transplanted into the high tunnel the third week of April and intercropped with tomatoes. The remaining plants were transplanted into the outdoor beds in late May.

The high tunnel Asian greens really took off. In fact, we suspect they took nutrients away from the tomatoes, since these had a difficult start. We harvested greens for the first CSA pickup June 1, and they were a bit past their prime. We harvested the outdoor greens during the second and third weeks of June.

Peppers

We made our first attempt to start Serrano and Poblano peppers in tiny soil blocks in late February. It failed when their heating mat overheated. We purchased a thermostat and reseeded the peppers the second week of March. About a dozen Serranos and half a dozen Poblanos germinated. We transplanted half into the high tunnel the last week of April and the remaining half outside the first week of June.

Inside the tunnel, we clipped the axial suckers of the peppers after they formed two main branches and anchored them to overhead twine for support. Those high tunnel Serranos grew to 4' and the Poblanos to 5'! We waited to harvest the peppers until they were red. Those in the high tunnel were a month earlier than those outdoors. Both varieties yielded well, although we had a bad case of aphids inside the high tunnel. (We used a pyrethrin spray at too weak of a dose and the aphids got ahead of us.) The outdoor plants were stubby, with small fruits and small harvests.

We did a second planting of Asian greens in late summer. We planted one tray each of Black Summer pac choi, Joi Choi, Tokyo Bekana and Kyona Mizuna beginning the first of August through the second week of September. We chose these four varieties for their storage quality, customer acceptance, and visual appeal. Each of these trays was transplanted into four beds a month later. Three of the beds were outside under quick hoops for insect control and protection from the cold. The fourth bed was in the high tunnel for comparison. We had excellent harvests from all the beds.

After our difficult experience the first year, we moved our quick hoops to a site that was more protected from the wind, thereby preventing the stress of having to anchor loose plastic over and over again. We found it takes advance planning in order to have bed space available for transplanting Asian greens in August, keeping in mind rotation principles and efficient irrigation options.

In October, about 30 people attended a field day, which the University of Minnesota Extension and Rural Advantage helped promote. Since we hadn't had a killing frost yet, the plants looked great and provided us a wonderful opportunity to talk about season extension. It was a great way to build community.

We harvested the greens on November 21 after two single-digit hard freezes and found a surprise waiting for us. While we knew the greens in the high tunnel would be twice as vigorous as their counterparts outdoors, we did not expect to find any marketable plants under the quick hoops, but we did! There were overflowing market boxes for all the CSA members at our season finale.

2012 Results

Our focus this year was to improve the efficiency of our spring intercrop planting in the high tunnel in order to optimize the timing of harvest for the May CSA. Growing Asian greens in high tunnels in the spring allows us to plant an early crop that is cold tolerant and therefore needs minimal inputs in terms of added heat. When intercropped with tomatoes, we harvest the greens before the tomatoes really start to grow, and the greens provide an added source of income for producers who use high tunnels.

Because of heavy snow in 2012, we did not plant the Asian greens outside; we started Black Summer and Joi Choi varieties of pak choi as well as Kyona Mizuna and Tokyo Bekana in soil blocks in March, and transplanted them to the high tunnel on April 5. Staggered plantings made it possible for us to harvest these over the course of 6 weeks—from May 16 to June 20—adding special interest to the market boxes each week. Since the Asian greens were interplanted with tomatoes in the high tunnel, we could not use row covers to protect them from flea beetles. In spite of this limitation, we saw minimal leaf damage; the greens were very attractive and marketable. There was poor demand for the peppers we tried last year, so we did not grow them again in 2012.

We experienced above normal temperatures throughout the summer and fall, and these created challenging soil conditions. In the fall, we faced severe drought conditions, which required frequent irrigation. The high tunnel plantings had less insect pressure but more intense heat, which was not well tolerated by the greens. Production was fair.

We started the fall crop under fluorescent lights in our basement on August 24 and transplanted them to the field on September 7. We covered the Asian greens with Agribon row cover to prevent damage from flea beetles. There was a severe infestation of cucumber beetles in mid-September, however. We used one application of Pyganic in order to prevent loss of the entire Asian green crop. We believe the Pyganic allowed for an abundant harvest of greens from October 10 through November 28.

Market Day! Our farm market is set up and ready for customers.

Conclusions

The addition of Asian greens has been an important component of our CSA program. Intercropping and using field spaces that are otherwise idle during the early spring or late summer and early fall are management strategies that have increased our production. Once in the field, Asian greens require minimal care (except for insect control) and are easy to harvest. Although there have been challenges, our overall experience with Asian greens has been positive, and we will continue to include them as an integral component of our CSA and farm market offerings.

In our experience, the intercropped high tunnel plantings in spring and fall have worked the best. They matured better than the ones planted outdoors under quick hoops. Since we have a movable high tunnel system, we can shift the high tunnel over the Asian greens once it is cooler in the fall. Tokyo Bekana and the pac chois (both green and white) were peoples' favorites; we also found them to be more attractive and marketable than some of the other greens we tried. We recommend choosing early and late planting dates that favor the production of these cool season greens. In addition, careful rotation of crops and fastidious use of row covers will decrease flea beetle damage.

We also have a new hypothesis we want to test next year: Would interplanting Asian greens with brassicas such as cauliflower and broccoli provide a protective canopy that would shield the soil from driving rain or the drying effects of the sun? We think we could harvest Asian greens early, perhaps in 6-8 weeks, allowing the brassicas to continue growing to maturity. If we let a few of the greens to grow until they flowered, they should attract beneficial parasitoid wasps, syrphid flies, and ladybugs to deter other insect invaders.

We have found that our CSA members have been more receptive each year to having Asian greens included in their weekly market share. Some even bought extra greens each week, since their families enjoyed them so much. We used paid ads on a local radio station to promote the greens and know that several community members came to our farm market specifically to purchase the Asian greens we grow. We don't know of any other farmers in the area who are interested in growing Asian greens, so for right now, we've cornered that market!

Management Tips

1. Test seed germination rates and always use a heat mat thermostat, especially if you are growing peppers.

2. Monitor soil fertility closely when intercropping.

3. Learn languages of the community to build relationships.

4. Test new recipes to share with customers so they have a multitude of options.

Cooperators

Dave Birky, Ag Resource Inc., Detroit Lakes, MN

Lee Erickson, Bluestem Farm Supply, LLC, Mountain Lake, MN

Project Location

Our farm is located in the town of Mountain Lake, between Mountain Lake Rd. and Hwy. 60, and to the west of Cty. Rd. #1. The address is 1310 Mountain Lake Rd.

Other Resources

Coleman, Eliot. 1999. Four-Season Harvest. Chelsea Green Publishing.

Coleman, Eliot. 1995. The New Organic Grower. Chelsea Green Publishing.

Minnesota Department of Agriculture. *Greenbook* 2009 - 2011. *www.mda.state.mn.us/protecting/sustainable/greenbook.aspx*

Comparison of Strawberries Grown in a High Tunnel and Outside for Quality and Profitability

Principal Investigator

Debbie Ornquist
39995 St. Hwy. 32 NE
Middle River, MN 56737
218-222-3540
mornqst@wiktel.com
Marshall County

Project Duration

2010 to 2012

Award Amount

$5,000

Staff Contact

Jean Ciborowski
651-201-6217

Keywords

day-neutral strawberries, grow bags, high tunnel, hydroponic, Verti-Gro

Project Summary

For three years, we have been experimenting with different ways to grow day-neutral strawberries at our farm in northwest Minnesota. Half of the strawberries are grown in a high tunnel and half are grown outside. A third of the strawberries are grown hydroponically in towers, a third on a table with a peat mixture, and a third were planted directly into our alkaline soil. 2011 and 2012 were warm, dry years, and plants grown in the high tunnel produced about the same amount of fruit as plants grown outside. We were unable to successfully grow strawberries in the towers due to several different nutrient deficiencies and uneven watering. Even if we could grow strawberries in the towers, the high cost of acidifying the water with vinegar would have made the hydroponic system uneconomical. In 2012, we planted some strawberries using the Dutch bucket system, where the plants grow hydroponically in a container placed in water. The plants in the Dutch buckets grew much better than those in the tower. Growing strawberries in grow bags on the table appears to be the best system for our operation.

Project Description

Several years ago, we started raising and selling vegetables and bedding plants at our dairy farm. In 2011, we sold our dairy herd, and began growing fruits and vegetables for selling at our farm and the local farmers' markets.

The market demand for fresh strawberries in our area is quite high. Strawberries are difficult to grow in our area because much of the soil is clay and has a pH too high for strawberries. Strawberries start showing symptoms of iron chlorosis when the pH rises above 7.4. Since strawberries are difficult to grow in the soil here, we wanted to see if they could be grown hydroponically. The hydroponic system would allow us to plant day-neutral strawberries. We wanted to try day-neutral varieties because their harvest peaks at the same time as our vegetables.

We compared three different growing systems, both inside and outside a high tunnel: hydroponics, a peat mixture on a table, and beds in the soil. The hydroponic growing system consists of four vertical towers from the Verti-Gro company (www.vertigro.com). Each tower has four Styrofoam containers stacked on a metal pole. Growing strawberries in the vertical system allows more plants to be grown in a small space and we can avoid problems with alkaline soil. We never succeeded in growing plants in the towers. In 2010, we used coir (a natural fiber extracted from the husk of coconut) as a substrate, and the plants in the top containers grew quite well, while the plants in the lower containers were progressively smaller, because the coir trapped the nutrients. In 2011, we used a mixture consisting of half perlite and half vermiculite. The plants did not grow due to a severe sulfur deficiency. We used Miracle-Gro® as

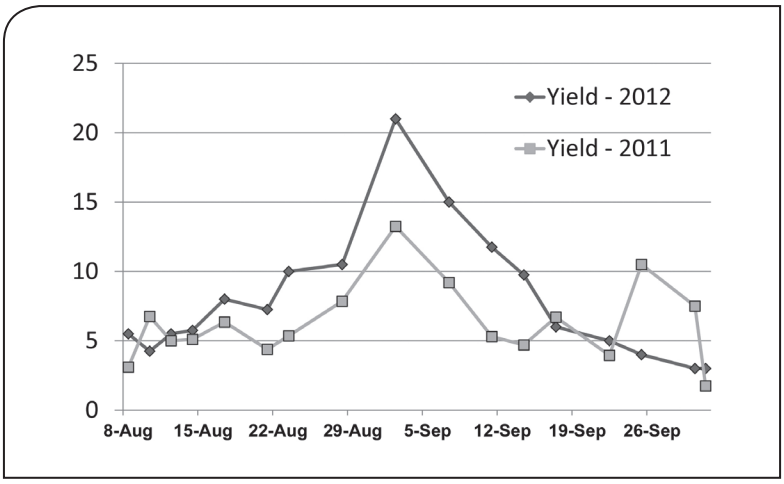


Figure 1. Yield for all treatments in 2011 and 2012 over the growing season.

a nutrient source, and Miracle-Gro® contains no sulfur. In 2012, we tried the towers a third time, using perlite as a substrate and Miracle-Gro® with sulfuric acid to acidify our water. We hoped the sulfuric acid would solve the sulfur deficiency.

In 2012, we also tried a different hydroponic system called the Dutch bucket. As with the towers, an emitter puts a nutrient solution in the top of the plant container, but the bottom of the container lies in the water and nutrient solution. We used perlite as a growth medium in both the towers and the Dutch buckets this year.

On the tables, we mixed local peat, compost and garden soil and placed the soil in landscape fabric on a table 4" x 12". The grow bag was setup on a table supported by pallets and irrigated with trickle tape. In 2010 and 2011, we planted using 6" x 6" spacing for 80 plants on each table. In 2011, we used the same soil from the previous year. In 2012, we mixed a new batch of soil and we increased the spacing to 8" between plants, which reduced the number of plants on each table to 64. Runner plants on the table were unable to root due to the bag on top of the soil. In 2010 and 2011, we used drip tape, but in 2012 we skipped the drip tape and decided to water the tables by hand.

On May 21, 2012, we planted strawberries directly into the soil. We used the varieties Seascape, Albion, and Evie 2. Half our plants were in a high tunnel and half were planted outside. The plants were spaced 10" apart and were free to runner and root. We sprayed the plants with malathion every 2-3 weeks to control tarnished plant bugs, and we sprayed neem oil to reduce damage from spider mites.

Results

We had problems with the towers each year of the project. In 2010, we used the nutrient solution supplied by the manufacturer of the towers. Shortly after planting, the plants had severe nutrient deficiencies. It turns out that our water supply has a pH of 7.5, and we had to reduce the pH to 6.0 in order for the nutrients to be available. In 2010 and 2011, we acidified the water using commercial vinegar. In 2010, the nutrient deficiency was corrected, but the nutrients were all caught in the top container, and plants in the lower containers continued to be deficient. In 2011, we changed the substrate from cocoa hulls to vermiculite, but we still had a sulfur deficiency from the Miracle-Gro plant food. In 2012, we started using sulfuric acid to acidify the water, because it contains sulfur, but the plants still looked poor. The cost of acidifying the water was quite high, and we spent far more in vinegar than we got in strawberries. We took the pots down and set each pot in a tray with water in the bottom, which is like the Dutch bucket system. The plants quickly recovered, and we were able to harvest 8 pints out of the Dutch bucket system.

Growing strawberries in the towers was not economical for our operation. The towers are expensive to buy, and there was a high cost to acidify the water. To maintain eight towers with four pots each, we spent $80 for plants and $115 for vinegar, which means we needed to sell more than 65 pints of strawberries ($3/pint) just to cover input costs. In the future, we will use the towers to grow another crop and we will continue to experiment with the Dutch buckets.

We started harvesting strawberries on August 8 and continued picking every 2 or 3 days until September 18

Strawberry plants on the outside table.

Table 1. Total yield in pints for each growing system by season.

Growing Unit	2010	2011	2012
Outside tower	31.5	2	0
Outside table	47.5	25.2	28.5
Outside soil	17.4	30.75	27
Inside tower	41.75	3	0
Inside table	34	36.35	23.25
Inside soil	30.5	30.9	35.75

(Figure 1). We did not notice a difference in yield or quality between the varieties. We started harvesting later this year than last year, because wasps were eating our fruit in July. In August, we put a row cover over the berries to keep the wasps out, and we were able to start harvesting fruit. The harvest peaked in early September. Over the season, we harvested 135 pints of strawberries, which was a considerable improvement over last year. The yield peaked much higher this year, giving us more to sell during the late August markets. The higher yields were due to a combination of hand watering and new soil for the table. We preferred watering by hand, because we could judge the amount of water the plants needed. With the drip system, there was always the possibility of some plants receiving too much water and other plants receiving too little.

This year, the plants grown in the soil did quite well, producing as much or more than the plants grown on the table (Table 1). With the dry summer, we did not have any problems with rain splitting or the disease anthracnose, and the plants grown in the tunnel produced about the same as those grown outside (see photo). We preferred growing plants in the high tunnel, because we were able to pick longer in the fall.

Growing day-neutral strawberries on the table and in the soil were commercially viable. By using recycled material to set up the table and local peat and manure for the soil, we spent almost no cash. The main cost for growing plants on the table is for new plants each year. In 2012, we planted 64 plants on each table at a cost of $22, so we did cover our yearly costs, even when selling at the local price of $2/pint. We liked the table, because we could weed and pick the strawberries without bending over.

In conclusion, we will not be using the hydroponic methods as it takes more water and nutrients and is difficult to manage. We will grow strawberries in raised beds in the ground. We feel this method yielded the best results based on the input costs. As far as growing in or outside the high tunnel, the inside crop seemed to be the best and bore fruit longer into the season.

Management Tips

1. Make sure the pH of the soil is correct when planting strawberries.

2. Hand watering often produces better results than drip irrigation. Make sure the pH of the water is around 6.0.

3. For plants grown in the soil or in grow bags; 8" between plants is a better spacing than 6".

Cooperator

Thaddeus McCamant, Central Lakes College, Staples, MN

Project Location

We are exactly 1 mile north of Middle River on the west side of MN 32. We are the first house on the left going north out of Middle River. You can see the dairy barn and silo. Turn left and cross the railroad track into our driveway.

Other Resources

Verti-Gro Company, Summerfield, FL. *vertigro.com*

Solar Energy Storage and Heated Raised Beds

Principal Investigator

Diane and Charles Webb
23750 State Hwy. 29
Henning, MN 56551
218-640-3276
diane@gardensgourmet.com

Project Duration

2010 to 2012

Award Amount

$8,000

Staff Contact

Jean Ciborowski
651-201-6217

Keywords

community supported agriculture (CSA), season extension, solar-heated water, vegetables

Project Summary

We designed and installed a system for growing vegetables in heated soil without using a high tunnel. Water is heated in a wood boiler, stored in a 10,000 gal insulated underground steel barrel, and pumped through plastic tubing in the vegetable beds. Half of our vegetable beds are on tables with heated soil called X-beds and half are in traditional raised beds in the ground. In April 2012, we started warming the soil with the heated water. The water did an excellent job of warming the soil, but plants in the raised beds and in the X-beds grew poorly. The soil in the X-beds may have been too hot, as the temperature reached 90°F. Both beds had fertility problems because the high organic matter soil we hauled in for the project was extremely low in potassium and boron.

Project Description

We designed a system of growing plants that will allow us to plant and harvest vegetables earlier in the spring, and help Chuck work more efficiently. We operate a market garden/CSA called Gardens Gourmet in East Otter Tail County in central Minnesota. We would like to start selling vegetables earlier in the season, and we need to find ways of making our labor in the vegetable production more efficient.

The average last date of frost in our area is May 12, and the soil is often not warm enough to plant warm season crops like peppers and melons until Memorial Day. We often cannot start harvesting these profitable crops until late August or early September, which is past the peak selling season. If we could warm the soil, then we would be able to plant vegetables earlier and get a jump on the market. Low soil temperatures in the spring delay seed germination, cause nutrient deficiencies, and stunt plants. Even cool season crops like lettuce and spinach will respond to warm soil early in the spring.

In order to plant and harvest earlier, we heated the soil with hot water that runs through tubes in raised beds. We built beds for raising vegetables on tables that are placed outside.

We heated the water in a wood boiler and pumped the water into a 10,000 gal steel tank that is buried in the ground. We insulated the tank with 2" of Styrofoam (r = 15) on the sides and top of the tank and 1" of Styrofoam insulation on the bottom. We backfilled the insulated tank with 3' of sand. Sand has an r value of 2 per inch. The tank stores 1,760,000 BTU's when the water temperature is 22°F above the ambient air temperature. The wood boiler and tank are a closed system.

For a second system, a pump moves heated water from the tank through ½" Pex-Al-Pex tubing into the outdoor raised beds and X-beds. We have 500' of coiled Pex-Al-Pex tubing inside the tanks that acts as a heat exchanger, which creates a second closed system.

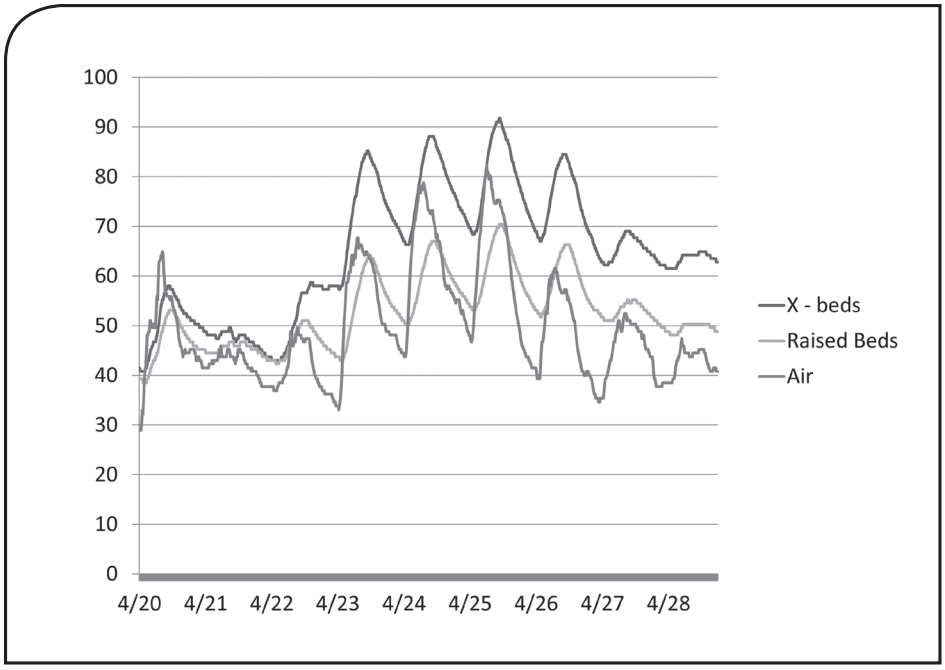


Figure 1. Temperature in the raised bed, the X-beds, and in the air before and after we started pumping heated water through the Pex-Al-Pex tubing. We started pumping warm water on April 22.

The X-beds are about 3' off the ground. The sides of the beds are made from pallets and are supported with 2' x 4' framing. We placed 1½" Styrofoam insulation at the bottom and sides of the beds and installed four lines of Pex-Al-Pex tubing on the insulation. We then covered the insulation with 9" of dark, high organic matter soil that we dug next to a nearby swamp. We placed two lines of drip tubing on top of the soil and covered the soil with plastic. There are two X-beds that are 3' x 100'.

On the east side of the X-beds, we built two traditional raised beds in the soil. The traditional raised beds are 10" high, and we used the same high organic matter soil as we used on the X-beds. One raised bed has four heating tubes with no Styrofoam insulation. The other raised bed has no heating tubes. The traditional raised beds are irrigated with drip tape and covered with plastic.

Results

We started pumping warm water through the beds on April 22, and the soil temperature warmed up immediately (Figure 1). During cool days, the soil temperature in the X-beds was nearly 20°F warmer than the air temperature, which give a number of benefits to starting vegetables. When the daytime high surpassed 70°F, the soil temperature in the X-beds surpassed 90°F during the day and cooled down to 65°F at night. Our system of heating the soil did an effective job of raising the temperature in the traditional raised beds in the soil. When the temperature dropped below 40°F at night, the soil temperature in the raised beds stayed near 50°F.

In April, we planted strawberries, arugula, green beans, parsley mesclun (salad greens) mix, peppers, and zucchinis in the X-beds. We chose crops that require bending over a lot during harvest, and the crops that respond to warm soils. We planted cantaloupe, zucchinis, and garlic in the heated traditional raised bed.

All crops grew poorly in both the X-beds and in the heated raised beds, and we were not able to harvest any produce from either the X-beds or the raised beds. The most likely reason why the plants did not grow was low nutrient levels in the soil we dug out of the nearby low ground in pasture. We applied several different fertilizers during the growing season, but the crops did not respond. After the end of the growing season we did a soil test. The potassium levels were 59 ppm, which is considered very low, and the boron levels were 0.4 ppm. The levels of both nutrients were too low to support plant growth.

Another problem we had was that the temperature in the X-beds may have been too warm. The soil temperature in the raised beds varied between 50°F and 70°F, which is ideal for both warm and cool season crops. The X-bed had much less soil to heat, (9" of dirt which is insulated with 1.5" of Styrofoam, bottom and sides) and when we started running warm water through the X-beds, the soil temperature rose to 90°F during the day. Such high temperatures can dry the soil out in a very short period, and the high temperatures themselves may hurt the roots. Since we can heat a larger area with our current heat storage system, we are thinking of buying more Pex-Al-Pex tubing to increase the area of heated soil so that we can continue to pump heated water through the raised beds.

2012 was an excellent year for raising vegetables, and all of our crops in the field and in the high tunnel had good yields. The same seeds that were planted in the field grew normally and produced a good crop. We put most of our time and energy into the vegetables in the field which are critical to keeping our sales going.

Management Tips

1. High organic matter soil can often be deficient in nutrients. Always do a soil test!

2. Start new technologies such as this with one crop.

3. Make sure you have the additional time to dedicate to the project and expect delays in perfecting the complete working system.

Cooperators

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

Keith Olander, Central Lakes College, Staples, MN

Project Location

Gardens Gourmet is located on State Hwy. 29, one mile south of the intersection of Hwy. 29 and State Hwy. 210. We are on the east side of the highway.

Other Resources

Information is available at the following websites for:
Wood boilers: *www.centralboiler.com*
Pex Superstore: *www.pexsupplier.com*
Heat exchangers:
www.stsscoinc.com/Products_HeatExchangerCoil.aspx
Spectrum Technologies: *www.specmeters.com*
Ag Resource. Detroit Lakes, MN. 218-847-9351

Raising Pastured Pork Using an Alternative Production System

Principal Investigator

Lori Brinkman
18980 – 102nd St.
Young America, MN
55397
952-467-3157
elmbrink@earthlink.net
Carver County

Project Duration

2010 to 2012

Award Amount

$8,000

Staff Contact

Wayne Monsen
651-201-6260

Keywords

acorns, grazing, heritage pig breeds, marketing, meat flavor

Project Summary

I raise heritage breeds of pigs, including Red Wattles and Large Black Hogs on pasture. I had two project objectives. My first objective was to implement an intensive grazing plan for the pigs. I compared the grazing characteristics of all of the pigs in the project. Red Wattles and Large Black Hogs, which are the main focus of the project, are described as efficient grazers by many who raise them. I also raise Hampshire and Berkshire pigs and used them as a control group as they do not have the reputation as grazers.

In addition to raising the pigs on pasture, I also finished them on an acorn diet, to determine if a varied diet affects meat flavor. It is my hope that a varied diet will enhance the quality and flavor of the pork and open markets for the product. Through my success, I hope to increase awareness of alternative production systems in Carver County and the potential economic, environmental, and social benefits they offer.

Project Description

Our previous farming operation was typical of many small dairies in Minnesota. We sold our 70 head herd of Holsteins in December 2010. We rented out our cropland in 2011 with the exception of 1.5 acres of alfalfa ground which was converted to hog pasture. In 2012, we converted an additional 3 acres of cropland back into pasture. Our soils are very fertile. The topography is flat to gently rolling.

Our project is a demonstration of a transition from commodity based marketing to local and niche marketing. We believe a local food system provides environmental and social benefits to local communities.

My goal was to produce a high quality pork product while demonstrating a successful grazing plan using Red Wattle pigs and Large Black Hogs. I integrated a small group of Hampshire and Berkshire pigs into the herd to use as a control group of pigs not noted for their grazing habits. I tested the feasibility of incorporating alternative feeds including acorns into the pigs' diets to determine the effect diet has on the flavor of the meat.

Results

Pasture Renovation:
In 2012, we converted three additional acres of cropland areas back into pasture. Unfortunately, it has not been integrated into the grazing rotation yet. Droughty late summer conditions slowed establishment of the grasses and legumes and we did not want to further stress the stand by placing animals on it too soon. It will be utilized in 2013 after we assess the stand quality in the spring. After researching the nutritional value of brassica crops including turnips and

Feeder pigs grazing alfalfa pasture.

radishes, and guidance from my cooperator, I decided against integrating turnips and radishes into our pasture rotation. It was determined that there would be minimal nutritional benefit in the crop for the finishing of swine.

Half of our existing pasture drowned out due to excessive spring rains. It was submerged for several days following three different rainstorms. We never experienced drowned out conditions on that ground in the past so we were quite disappointed. Because of this we were left with half of the available grazing area and it was not able to support the hog density, especially once drought conditions developed during the end of the summer. We will need to reseed this pasture in 2013.

Pigs:

In 2011, our stocking density was only 60 pigs to 2 acres, so we did not attempt rotational grazing. Instead, we allowed the hogs to roam freely throughout the alfalfa pastures. We learned that pigs are extremely efficient grazers. They often grazed in groups, selecting one area to graze and moving forward as a group. While the heritage breeds are thought to be more efficient grazers than conventional breeds, I did not note a difference in grazing behavior. We did not have any rooting in the alfalfa pasture. This could be due to the fact that the pigs also had access to a wooded lot and they displayed their rooting behaviors in the woods. There was always an ample supply of fresh alfalfa for them to graze. I had a central mud hole much like a dry lot and the pigs had the freedom to go back to that location as they were rotated through the paddocks.

In 2012, we increased our total number of feeder pigs to 100 head in 2012 in anticipation of a market outlet for pastured hogs. Unfortunately, the development of this market was held up due to production issues, so we were left with more hogs than we had markets for. While it was a catalyst for us to seek retail markets for our product, it was a detriment in that much more time was consumed in seeking markets for our pork rather than concentrating on developing a market for pork raised on an alternative diet. We have reduced our breeding stock numbers and plan to re-concentrate on an alternative diet in 2013.

Farrowing:

We continue to pen farrow with great success. Each gilt farrowed in a pen by herself. A heat lamp was used to lure the piglets away from their mother to reduce the risk of crushing. We also experimented with farrowing on pasture during the summer. Our experience was that the sows farrowed outside shelters at times and that created some worrisome nights for us. We plan to research pasture farrowing huts to determine if it is due to shelter preference of the sows. We used calf dome hutches as shelter for our sows on pasture.

Acorns in the Hog Diet:

The harvest of acorns from a neighborhood backyard was simple, fruitful, and well accepted. While acorns are a great food source, many people view them as a nuisance. Getting permission to remove the acorns from backyards was not a problem. We simply raked the acorns together in piles, scooped them with shovels, and

One of the Red Waddle gilts.

placed them in 5 gal pails to transport. Within 2 hours, we had collected 260 lb of acorns. The acorns were stored in gunny sacks in our granary until they were fed to the selected hogs.

Acorns were added to the diet of three Red Wattle-Large Black Hog crosses. Each hog received 3 lb of acorns/day along with 2 lb of our grain mix. We wanted to see how the pigs would handle the acorns since cupules were included in the acorn mix and we had heard that they can be harmful to the digestive system of the animals. We did not witness any problems with digestion. The hogs continued to gain at their previous rate. The meat was included in a tasting event our farm held.

As a side note: I researched purchasing dry whey from our local creamery and since they only sell it in one ton totes it was not a feasible option. Storage of the whey was a concern as well as keeping the product pest free. I tried windfall apples as part of the diet in 2010 but removed them in 2011 because I did not want to segregate just a couple of hogs from the alfalfa pasture during the growing season.

Basic boneless loin and pork belly from six different breeds or crosses were sampled during the event. Water was the only beverage offered to keep the palate of the participants clean. Berkshire, Red Wattle, Red Wattle x Berkshire, Tamworth/Large Black Hog x Berkshire, Tamworth/Large Black Hog x Red Wattle (acorn finished), and Large Black Hog x Berkshire were the choices, and the breed source was not disclosed. Each participant sampled each item and provided comments regarding flavor, texture, and preference. Comments and preferences were varied among the participants and no unanimous consensus was reached regarding the preferred pork. All of the comments were complimentary however. Participants were asked to guess the pork which was finished on a varied diet including acorns and 5 of 7 participants were able to determine the correct sample. The individuals that selected a different sample both believed the Red Wattle sample was finished on the varied diet.

Marketing:

We focused a great deal of time on marketing. MN Grown, our website, social networking, and word of mouth continue to be effective methods of reaching new clientele. We have expanded our contacts within the local food community and that has helped us reach new consumers. We also participated in the MN Cooks program which offered local advertising of our product through news articles in the Waconia, Norwood Young America, Chaska, and Chanhassen newspapers.

We became a seller at the Chanhassen Farmers' Market and also began selling through Twin Cities Local Foods, an online local foods option for residents of the Twin Cities metro area. We continued to provide pork to three different restaurants. We also sold our pork at two stores in Victoria.

Management Tips

1. When pen farrowing, allow access from outside of the pen so you can safely assist with farrowing. Mother pigs are very protective.

2. Allow hogs free access to pasture at all times as long as your pastures can support the stocking density. I believe that part of our success is that our hogs live stress free and feel comfortable in their surroundings.

3. Have enough pasture established in the event that acreage is lost due to excessive rain and/or drought.

4. Consumer outreach is constant and always evolving. Take advantage of every opportunity.

5. Guarantee that you have adequate direct markets in place prior to expanding pig numbers. The potential for lost income is high if you have to sell excess livestock through cattle sales barns.

6. When retailing your product, take the opportunity to hold tasting events at the stores. There is much education needed in promoting heritage pork. Marbling within the meat is what gives the pork its flavor and moistness. Pork has most recently been promoted as a lean product. Consumers need to understand what makes heritage pork great.

Cooperator

Dr. Yuzhi Li, Assistant Professor, Alternative Swine Production, University of MN, St. Paul, MN

Project Location

From Young America go west on MN Hwy. 212 approximately 2 miles to Cty. Rd. 135. Turn right onto Cty. Rd. 135 and go 1.5 miles to Cty. Rd. 34. Turn left on Cty. Rd. 34 for .5 miles and turn right on Yale Ave. Take Yale Ave. north for 1.5 miles to 102nd Street. Turn left, west, on 102nd and go to 18980 - 102nd Street.

Other Resources

Alternative Swine Production Systems Program, University of Minnesota Extension, 385 Animal Science Building, 1988 Fitch Ave., St. Paul, MN 55108, 612-625-6224.

MN Grown. Website: *www3.mda.state.mn.us/mngrown*

University of Minnesota Extension Service. 2001. Hogs Your Way: Choosing a Hog Production System in the Upper Midwest. Publication No. BU-7641-S. University of Minnesota

Determining the Pasture Restoration Potential and Financial Viability of Cornish Cross vs. Red Broilers for a Small Pastured Poultry Operation in Northeast Minnesota

Principal Investigator

Cindy Hale and Jeff Hall
Clover Valley Farms
6534 Homestead Rd.
Duluth, MN 55804
218-525-0094
cmhale@d.umn.edu
St. Louis County

Project Duration

2010 to 2012

Award Amount

$4,000

Staff Contact

Wayne Monsen
651-201-6260

Keywords

broilers, Cornish Cross, pasture poultry, pasture renovation, Red Broilers, Salatin pens

Project Summary

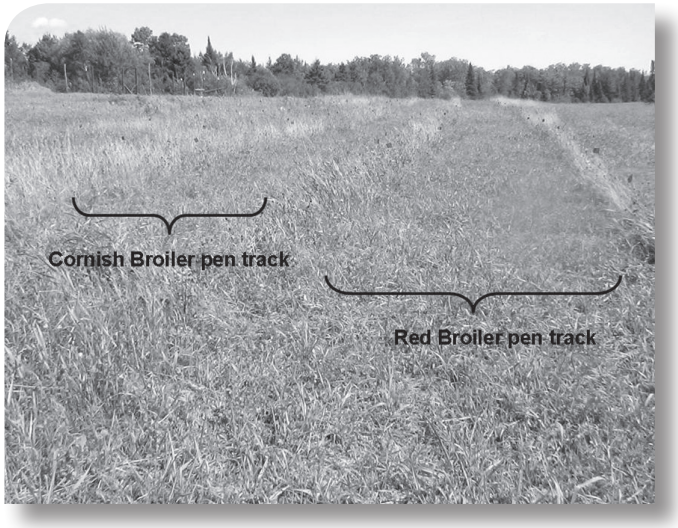
The goal of this project was to measure the ability of two chicken breeds (Cornish Cross and Red Broiler/Freedom Rangers) to improve the quality of an unproductive hay field, as demonstrated by the relative changes in plant composition and productivity after grazing alone and by a combination of grazing and seeding.

Overall, we are very pleased with the pasture rejuvenation results achieved through grazing of chickens using the Salatin pens. Within 3 years we saw substantial increases in the quality and quantity of forage available and improvement in the key soil measures of percent organic matter, phosphorus (P), and potassium (K). We have made good progress on maintaining or increasing the profit we make on our birds despite approximately 30% increases in feed costs. Through a combination of improved grazing, and buying feed in bulk we managed to keep our production costs about the same for the Cornish Cross and substantially decreased costs of the Red Broiler/Freedom Ranger as the study progressed. As a result, profitability on the Cornish Cross ranged between 6-9% through the study. In the first year of the study we had a 56% loss on the Red Broilers. However, by the end of the study we decreased that to a 4% loss and anticipate seeing a profit with those birds in 2013.

Additionally, the habitat quality of our pasture improved. Our pasture is used extensively by native grassland breeding bird species and 2012 was a high water mark in that we were able to document breeding by sedge wrens, dicksissels, and bobolinks for the first time. Local birders made our field a regular stopping place to view these rare species that used to be common. We also continued to see high levels of nesting success in 4-5 sparrow species and bluebirds.

We have learned a great deal about how to improve our management

Cindy collecting plant samples.



Grazing strips. The right path grazed by Red Broilers, the path on the left by Cornish Cross.

system through this grant, and expect our results to be widely applicable to small-scale, diversified pastured poultry operations in the western Great Lakes region.

Project Description

In 2005, we began a non-certified organic, direct to consumer, pastured poultry operation using 10' x 12' Salatin-style pasture pens which house 50 birds. We have grown from 50 Cornish Cross birds in our first year to 300 birds (mix of Cornish Cross and Red Broilers) in 2009. We move the pens 1 or 2 times/day to give new grass and ground for the chickens. We pre-sell all birds in the spring and do on-farm processing for fall delivery. We currently serve approximately 60 customers, but have much more demand. We also sell pastured eggs, ducks, turkeys, and hogs; and have a year-round solar greenhouse, vegetable gardens, and a fruit orchard enterprise.

The purposes of this study were to test the effectiveness of pasture rejuvenation using four different chicken breed-seeding combinations (Cornish Cross-clover mix, Cornish Cross-no seed, Red Broiler-clover mix, Red Broiler-no seed) compared to seeding alone, or no treatment (no chickens/no seed); and to test the break-even point and profitability of production for each breed, over 3 years, under different pasture conditions.

We used a 5 acre hay field for the study. This field has had no fertilizer applied for many years. In 2010, the first year of the study, half of the area grazed was seeded with a 50-50 mix of red and white clover immediately after the chicken moved over a given plot. The seeding was done after the chickens moved over the test plots so they would not eat the seed applied. The other half of the grazed area was left as a "no seed control." A section of the field remained ungrazed by chickens, half of which was seeded with the clover mix so we can compare the effects of seeding alone to seeding in combination with the different chickens.

Each year, we compared the cost efficiency of each chicken breed based on the forage available and the impacts each breed had on forage quality and abundance. In 2010, all chickens were grazing on unimproved pasture, half of which was seeded with clover after the chickens passed over it. In 2011 and 2012, chickens were grazed on the same area as in 2010, so half of the birds were grazed on clover-seeded areas and half on the no-seed control areas.

Table 1. The average proportion of vegetation from 2009 to 2012.

Year of Study	Narrow Leaved Grasses	Broad Leaved Grasses	Sedges & Rushes	Forbs	Legumes
2009*	42%	6%	28%	21%	3%
2010#	Not measured	Not measured	Not measured	Not measured	Not measured
2011	34%	27%	13%	19%	7%
2012*	47% (all grasses combined)		19%	32%	3%

**Values based on visual estimates of percent cover.*
#Values based on measure biomass.

Table 2. Plant biomass sampled in 2011.

Original Treatment Categories	Average Total Plant Biomass (grams of dry weight)	Merged Treatment Categories	Average Total Plant Biomass (grams of dry weight)
Cornish Cross - clover mix	43.6 g	Cornish	43.5 g (51% increase)
Cornish Cross - no seed	43.2 g		
Red Broiler - clover mix	40.9 g	Red Broiler	38.9 g (35% increase)
Red Broiler - no seed	37.5 g		
No grazing - clover mix	28.6 g	No grazing	28.8 g*
No grazing - no seed	29.1 g		

**Statistical analysis showed this value to be significantly lower than that for the Cornish or Red Broilers.*

Table 3. Soil analysis results prior to the study and at the end of the study in the no grazing control plots, and plots that had been grazed by either Cornish Cross or Red Broilers for 3 years (2010-2012).

Year/Treatment	Soil Texture	Organic Matter	pH	Buffer Index	P (ppm)	K (ppm)
2009 - control	Medium	5.0%	5.6	6.1	1	93
2012 - Cornish	Medium	6.8%	5.1	6.1	9	131
2012 - Red Broiler	Medium	6.7%	5.2	6.0	8	152
2012 - control	Medium	6.0%	5.2	6.0	7	152

Plant sampling was conducted in June of 2009 and 2012 to measure the relative abundance of different plant species/plants in each treatment area. In 2011, plants were sampled to measure the biomass of different species/plant groups in each treatment area. A 4" x 4' strip of vegetation was clipped down the center of each 10' x 10' sample plot and collected in a large flat. A total of 64 plots were sampled, between 8 and 13 samples were collected from each of the chicken and seed combinations. The samples from each plot were placed in labeled paper bags and oven dried at 60°C for 48 hours. The samples were weighed to determine the dried plant weights for each species/plant group in each plot. For each of the 64 plots sampled in 2011, visual estimates of percent cover (0-100%) were made for each species/plant group in each plot.

Results

Overall, we are very pleased with the pasture rejuvenation results achieved through grazing of chickens using the Salatin pens. Within 3 years we saw substantial increases in the quality and quantity of forage available and improvement in the key soil measures of percent organic matter, P, and K. Additionally, the habitat quality of our pasture remained high or perhaps improved. Our pasture is used extensively by native grassland breeding bird species and 2012 was a high water mark in that we were able to document breeding by sedge wrens, dicksissels and bobolinks for the first time. Local birders made our field a regular stopping place to view these rare species that used to be common.

Table 4. Comparison of weight, age, costs, and profits of broilers.

	Year: Breed	Average Market Weight (lb)	Age at Market	Average Cost/Bird	Average Sale Price/ Bird	Average Profit/Bird
2010	Cornish Cross – straight run	4.1	8 weeks	$11.35	$12.30	8%
	Red Broilers – straight run	3.8	14 weeks	$17.80	$11.40	(-56%)
2011	Cornish Cross – pullets	4.3	8-9 weeks	$14.97	$16.58	9%
	Cornish Cross – cocks	3.8	7-8 weeks	$12.33	$14.82	17%
	Freedom Ranger – cocks	3.8	9-10 weeks	$16.37	$14.82	(-11%)
2012	Cornish Cross – straight run	3.8	8-9 weeks	$14.05	$14.92	6%
	Freedom Ranger – straight run	3.4	9 weeks	$13.78	$13.26	(-4%)

The average number of plant species and the specific species present in plots did not change throughout the study. However, the relative proportions of different plant groups changed as the study progressed (Table 1). A preliminary survey of the plant community in 2009 prior to the study showed that narrow-leaved grass and grass-like species (e.g. Poa spp., Carex spp., Juncus spp.) dominated the plant population. Broad-leaved grasses composed only a small proportion including Timothy (Phleum pretense), native Canarygrass (Calamagrostis canadensis) [note: commonly referred to as "Reed Canarygrass" but not the exotic species Phalaris arundinacea]. A diverse mix of forb species composed just under ¼ of the plant community including hawkweed, buttercup, ox-eye daisy, yarrow, asters, plantain, wild strawberry and chickweed. Legumes (e.g. white & red clovers and field pea) made up the smallest component.

As the study progressed, the grass community shifted from being dominated by smaller, narrow-leaved species toward larger, broad-leaved species. The proportion of sedges and rushes decreased as the larger grass species expanded (Table 1). The relative proportions of forbs and legumes did not significantly change throughout the study. Though the averages reported here look substantial, there was a great deal of variability (i.e. some plots had a lot and some very

Two week old Cornish Cross chicks on pasture.

Red Ranger day-old chicks in the brooder.

little) so the averages are not significantly different. One example of this variability resulted from obvious patches of increased vegetative growth around the feeders and watering fonts where the chickens manured the most. Also, overall plant biomass responses to grazing by chickens appear to increase as they age and produce more manure each day.

Plant sampling in 2011 compared the average total biomass of forage available in each treatment (Table 2). There was no difference in total biomass among the seeded vs. not-seeded treatments so they were combined when analyzing for the impacts of each chicken breed compared to the no grazing control. The plots grazed by chickens for one season (2010) had significantly more total forage available than plots that had not been grazed (35-51% increase). The breed of chicken did not matter. Although the Cornish had a higher average biomass value than did the Red Broilers, the range of values was such that there was no statistical difference between the two breeds.

Soil sampling and analysis was conducted for the unaltered field conditions prior to the study in 2009 and in each of the six treatments at the completion of the study in 2012 (Table 3). All soil samples were collected in October; at the end of the growing season. Each sample was a composite of ten soil cores collected in the field and then homogenized for a single sample sent for analysis to the University of Minnesota soil testing lab. Each sample was analyzed for soil texture, percent organic matter, pH, buffer index, P, and K.

There was no difference in soil results between the seeded and not-seeded treatments so they were combined in the results reported here. The grazed plots have a notable increase in percent organic matter, P, and, K compared to the pre-study 2009 results.

I'm not sure how to interpret the fact that the 2012 control data also shows increases in these characteristics. The control plots were not hayed during the study which may have contributed to a moderate increase in percent organic matter since hay was not being removed. Leaving the uncut vegetation may have also contributed to the increases in P and K. However, we would not recommend leaving a hay field or pasture ungrazed since there was substantial establishment of undesirable shrub and tree saplings (willow, alder, Scotch pine) in the uncut plots. By grazing with chickens, undesirable trees are kept out of the pasture, P and K increase, and percent organic matter increases more than the uncut control plots. Remember, the chickens grazed on any given plot for only 1 day! So, the plots were able to re-vegetate and incorporate the manure the chickens had left behind.

Financial Break-Even Point for Each Breed

Overall, we have made good progress on maintaining or increasing the profit we make on our birds despite an approximately 30% increase in feed costs. Through a combination of improved grazing, which decreases the total amount of feed needed, and buying feed in bulk we managed to keep our production costs about the same for the Cornish Cross and substantially decreased costs of the Red Broiler/Freedom Ranger as the study progressed (Table 4). The production costs provided

are comprehensive and include the cost of the chicks, feed, field & processing labor, transportation and miscellaneous supplies.

In the second year of this study, 2011, we used the same hatchery for Cornish Cross, but raised pullets only on the experimental section of the pasture. This change was in response to high mortality with cocks near weeks 6-7 in 2010. Due to generally poor growth rates in 2010 with the "Red Broiler", in 2011 we switched to the "Freedom Ranger" breed which has been reported to perform better on pasture and so we could shorten their time to finish from 14 weeks to 9-10 weeks. For comparison, in 2011 we also raised Cornish Cross cocks on an adjacent pasture which was not part of the seeding/grazing trial. In the final year of the study we raised straight run of both the Cornish Cross and Freedom Rangers.

We raised 50 Cornish Cross or Freedom Rangers in each pen. There were substantial differences in both the costs and finished weights between the Cornish Cross cocks, pullets and Red Broilers/Freedom Rangers. The Cornish Cross outperformed the Red Broilers in the average cost/bird, finished weights, the time to get to finished weight, and in profitability. While each season varies, and the summer of 2012 was very hot and dry, we feel we could have had better overall profitability if we had raised only cocks for both breeds. We anticipate doing so in 2013.

Cornish Cross chicks were put on pasture at 3 weeks of age in 2011 and at 2 weeks of age in 2012. The cocks were processed at 7-8 weeks of age while the pullets and straight run birds were processed at 8-9 weeks of age. The Freedom Ranger cocks were put on pasture after 4 weeks in the brooder in 2011 while in 2012 the straight run chicks were put on pasture at 3 weeks of age and they were processed at 9-10 weeks of age.

The average feed cost/bird was the same for both breeds in 2011 at $0.06/day while in the brooder and $0.12/day while on pasture, which was comparable to what the hatchery and the feed producer estimated. In 2012, the feed costs were substantially lower for both breeds. The feed cost for the Cornish was $0.02/day while in brooder and $0.11/day while on pasture. The feed cost for the Freedom Ranger was $0.02/day while in brooder and $0.09/day while on pasture.

Customer Preference

A large proportion of our customers purchased both Cornish Cross and Red Ranger broilers. In the 2011 winter, prior to ordering birds and sending out customer order forms, we surveyed approximately 120 customers. We received responses from 78 customers. One question asked them if we should keep offering both Cornish Cross and Red Ranger broilers. The majority responded "yes" and a large proportion of them ordered both breeds. Only one customer ordered the Red Rangers exclusively.

Informal questioning of customers when they picked up their birds in the summer indicated that they liked both breeds, but that there were definite differences in flavor, the color of the meat, and the shape of the carcasses. Those who purchased both reported using them in different ways and for different dishes (i.e. Cornish Crosses for traditional roasting, Red Rangers for ethnic dishes).

In response to 30% or more increases in organic feed costs we also asked our customers if they would be willing to pay 30% more, or if we should shift to a non-organic feed. They overwhelmingly said to continue using organic or transitional organic feed and they would be willing to pay the higher price. In 2012, we sold out early so our customers clearly value the quality of the birds we produce.

Management Tips

1. Ask hatcheries about the breeding of chicks they offer and only buy those that the hatchery breeds themselves. It is important that they know the genetics of the chicks.

2. Depending on the breed and your management goals, you may want to raise pullets only, cocks only, or straight run. Cocks and pullets mature at different rates. Also, cocks can have a higher mortality rate during the last 2 weeks before processing.

3. Provide fresh pasture during the day and feed rations in the evening only for best performance. When birds eat feed, their metabolism ramps up, generating a lot of body heat which can stress the birds during the day leading to poor growth and increased mortality.

4. Select the poultry management, processing, and marketing strategies that work for you (i.e. day range, Salatin pens, etc.). Keep the focus on bird health, maximizing high quality forage, reducing feed costs and minimizing labor costs.

5. Ask your customers what they want and invite them to field days or special events that you will be attending. This allows you to make better decisions and gives customers a stake in your operation.

Cooperators

Cree Bradley, Lake Superior Sustainable Farming Association, Lake Superior Farm Beginnings Program Coordinator, Two Harbors, MN

Ryan Cox, University of Minnesota, Department of Animal Science, St. Paul, MN

Wayne Martin, University of Minnesota, Integrated Livestock Production Systems Program, St. Paul, MN

Craig Sheaffer, Professor, University of Minnesota, Department of Agronomy and Plant Genetics, St. Paul, MN

Project Location

Drive 14 miles NE of Duluth on Hwy. 61 to Homestead Rd., turn left and travel 4.2 miles to Clover Valley Farms.

Other Resources

Alternative Broiler Breeds in Three Pastured Poultry Systems. Kim Cassano. 2009. Sustainable Agriculture Research and Education (SARE) at: *www.sare.org*.

APPPA grit. Newsletter of the American Pastured Poultry Producers Association at: *www.apppa.org*

Raising Poultry on Pasture: 10 years of success. Published by the American Pastured Poultry Producers Association at: *www.apppa.org*

Perfecting the day-range pastured-poultry system through on-farm replicated feeding trials. Melissa Fischbach. 2009. Project Number: FNC08-729. Sustainable Agriculture Research and Education (SARE) at: *www.sare.org*.

Fall Forage Mixture for Grass Finishing Livestock Late in the Fall

Principal Investigator

Troy Salzer
3457 Sandy Lake Rd.
Barnum, MN 55707
218-384-3511
salze003@umn.edu
Carlton County

Project Duration

2010 to 2012

Award Amount

$10,000

Staff Contact

Wayne Monsen
651-201-6260
Article prepared by
Jean Ciborowski

Keywords

annual cover crops, finishing beef on grass, grazing corn

Project Summary

With the short growing season in NE MN, it is challenging to grow enough pasture forage to finish beef on grass. Adding annual forage crops into the pasture rotation may help by providing more available forage at the beginning of the grazing season and extending the grazing season into the fall and winter. By growing winter rye for early grazing and grazing corn in late summer followed by a planting of oats and turnips you may be able to graze late into the fall and winter. If the system allows us to graze longer on our land than in the past, it will provide extra carrying capacity and allow us to finish animals without having to use supplemental feeds.

The goal of this project was to demonstrate an economically efficient way to grass finish beef in late fall by grazing non-typical crops such as corn, oats, and turnips and reduce soil erosion and potentially reduce nutrient leaching. This was done by grazing immature corn from mid-August through mid-September, after the cattle were out of the perennial pasture rotations. After the corn was grazed, a fall forage mixture of oats and turnips and a seeding of annual ryegrass was sown then grazed later in the fall. We wanted to demonstrate that planting late forage mixtures would take up nitrogen and other nutrients that might be lost to runoff and leaching.

We worked on getting an early start to the grazing season by planting winter rye in the fall. Winter rye greens up early in the spring and can be grazed earlier than other forages. We compared the planting costs and the amount of gain for early and late season cover crops and grazing corn. By increasing the length of the grazing season we hoped to reduce feed costs which would allow us to be more profitable in the future. The project provided information we will need to increase our marketing window of grass finished beef by extending the grazing season earlier in the spring by grazing winter rye and later into fall by grazing corn, annual ryegrass, oats, and turnips.

Project Description

The project was conducted on the Troy Salzer and Abe Mach farms. Both operations keep a portion of the calves and grass feed them to market weight. Grass production is the focus of both operations and they use the livestock to convert it to marketable products. They also incorporate winter rye and annual ryegrass cover crops in crop rotation with the pastures to keep the pastures in prime growing condition. The Salzer site has very sandy soils and the Mach site has a loam soil.

The two cooperators were interested in adding corn for grazing followed by a fall seeding of oats and turnips to increase the yield of dry matter per acre. The annual crops in the rotation help breakdown the sod which improves the seedbed for the new pasture. The corn is grazed from mid-August through September.

Table 1. Seeding rates and costs of cover crops at both the Salzer and Mach farms.

Treatment	Seeding Rate (2010-12)	Seed Cost/A	Total Seeding Cost/A	Seed Cost/A	Total Seeding Cost/A	Seed Cost/A	Total Seeding Cost/A
		2012		2011		2010	
Winter Rye	2 bu/A	$27.50	$35.00	$20.00	$27.50	$19.00	$26.50
Corn	31,000 seeds/A*	$72.00	$245.00	$35 .00	$208.00	$35.00	$205.00
Annual ryegrass	20 lb/A	$17.00	$24.50	$14.40	$21.90	$12.40	$19.90
Oats	1.5 bu/A	$9.38	$23.12	$8.78	$22.18	$8.78	$21.68
Turnips	3lb/A	$6.24	$23.12	$5.90	$22.18	$5.40	$21.68

**Corn seeding rate in 2010 = 29,000 seeds/A*

After the old pastures are tilled to prepare for planting, a conventional planter is used to seed the corn. Once the corn is grazed, we used a no-till drill to plant the oats and turnips directly into the corn stubble. The drill has a cutting coulter to cut up any remaining corn stalks.

The project monitored the cattle weight gain and various management practices on each of the treatment areas. Each farm grazed about 20 head of finishing cattle on the plots. From the data and the costs of each of the treatments we calculated the cost of gain for each of the treatments.

2010 Results

The weather during the 2010 growing season in NE MN consisted of a very dry spring followed by a very wet summer and fall. The temperatures were above normal for the growing season.

The grazing corn was planted on May 17 at the Salzer farm and May 28 at the Mach farm. The seeding rate was 29,000 seeds/A (Table 1). Manure and starter fertilizer were added for nutrient needs. The corn yielded better at the Mach farm with 21.6 tons/A at 19% dry matter. The yield at the Salzer farm was 16.35 tons/A with 18% dry matter. There was more soil moisture early in the season and warmer conditions throughout the growing season at the Mach farm.

These are very good corn yields for this part of the state. Because of the large yields it took longer for the 20 cattle to graze the corn than planned. This longer grazing period affected the timing of grazing on the other cover crops in this project. The cattle grazed the corn at the Salzer farm until September 3 for an equivalent of 202 grazing days, and until September 9 at the Mach farm for an equivalent of 262 days (Tables 2 and 3). We found that it is important to take into account the amount of time it will take to graze the corn. With such large yields we could have easily grazed more animals.

The cover crops were seeded on September 3 at the Salzer farm and September 9 at the Mach farm after the corn was grazed. These dates worked well this year because of the good moisture levels this fall, but may be too late in northern MN during a typical fall. The delay in grazing the cover was due to incorrectly calculating the amount of time it would take to graze an acre of corn.

Cattle grazing corn on the Salzer farm.

We were pleasantly surprised with the low costs of gain on each of the treatments, with oats – turnips the lowest and annual ryegrass the highest (Tables 2 and 3). We had assumed the costs would be higher on the cover crops due to the high seed cost. But, the investment in the tillage was already accounted for in the corn crop so the cover crop was planted with one pass of a no-till drill, saving a lot of costs. Seed costs were high on this project because of the small plot sizes of the plantings. If planting larger acreages, prices should get lower due to buying in volume.

This extra grazing should help in reducing feed cost. The current average feed cost of production for finishing cattle today is around $.86/lb of gain. In our case the treatments ranged in cost from $.31 -.77/lb of gain. So the added value to our farms is $2.34/A with annual ryegrass up to $43.45/A with oats - turnips. These calculations are only based on cost of gain and do not consider the environmental or grazing season extension benefits.

Production per acre varied among the cover crops. The annual ryegrass was the lowest yielding based on the lb of gain/A, average daily gain, and the number of grazing days. This suggests that even though the cost for the seed is less, it is not your best choice, as it takes longer to establish than the other crops.

The use of the cover crop treatments seems to reduce the amount of nitrate nitrogen in the soil due the plant growth occurring later in the season. The soil tests taken on both farms in the summer and fall show a significant reduction of nitrate nitrogen in the fall (Table 4). This suggests that a cover crop reduces the risk of nitrogen being transported by rain into lakes and rivers as well as the drinking water.

2011 Results

The project was carried out in the same manner as 2010 other than both cooperators started grazing the corn in the first week of August. We tried to keep the plants younger, allowing the animals to do a better job cleaning up the corn as well as giving more time for the cover crop plants to grow. We did not think the cover crop plants had adequate time to produce forage in 2010.

The 2011 growing season was nearly opposite of 2010. The summer of 2011 was very wet to begin with, but about the time we started grazing the corn, the rain stopped and we did not get any more rain until it snowed. This caused poor germination and growth on the cover crops, especially for the annual ryegrass. This was more evident on the sandier Salzer site as compared to the loamy soil Mach site.

The grazing corn was planted May 21 at Salzer's and May 26 at Mach's. Grazing started the first week of August on both farms. The corn yielded 18 tons/A at Mach's and 16.6 tons/A at Salzer's. The corn was grazed until September 2 at the Salzer farm and September 9 at the Mach farm.

The largest hurdle that was encountered this year was the lack of rain late in the summer. This caused poor germination and poorer growth on the cover than expected. Annual ryegrass was the crop most affected by the lack of moisture by having the fewest grazing days and the highest cost of gain/day of all of the cover crops (Tables 2 and 3).

All of these cover crops are considered cool season crops and therefore the reason that we selected them for our planting was in hopes that they would keep growing late into fall. We didn't think much about the need for moisture to germinate them as NE MN typically will have enough rainfall, especially in fall, and the cool nights allow for heavy dews which often is enough to keep the plants growing.

Even with the dry conditions and the 2% to 4% increase in costs of seed we still were able to feed the cattle cheaper on the cover crops than if we fed stored feed. It cost between $.32 and $1.10/head/day to feed on the cover crops. Whereas, it costs $1.15 to $1.30/head/day to feed stored feed (Table 1).

The data from the two years of nitrogen tests suggests that planting a cover crop of any sort will help with reducing the nitrogen levels in the soil (Table 4). As the data suggests, the grazing corn had higher nitrogen levels due to being grazed early and not having any plants growing to take up the nitrogen as the soil organisms continued to release them.

The data also suggests that the levels in general were high in all treatments in 2011 due to perhaps less plant growth and no rain. This also suggests that with less rain there is less chance of Nitrogen loss due to leeching which we know from previous research to be the case.

Table 2. Comparisons of grazing annual forages on the Mach farm.

Crop Type	Year	Cost/A	Avg Daily Gain (lb)	Lb Gain/A	Grazing days/A*	Cost of Gain
Corn**	2012	$245.00	1.8	430	239	$0.57
	2011	$208.00	1.9	428	225	$0.486
	2010	$205.00	1.8	472	262	$0.43
Winter Rye	2011	$27.50	1.7	59	35	$0.466
	2010	$26.50	1.8	64	36	$0.41
Annual Rye Grass	2011	$21.90	1.5	29	19	$0.76
	2010	$19.90	1.5	26	17	$0.77
Oats - Tumips	2011	$22.18	1.7	55	32	$0.403
	2010	$21.68	1.8	58	32	$0.37

**Grazing days is a calculated number described to help readers use the number for planning purposes on their farm.*

***In 2012, winter rye, annual ryegrass and oats-turnips did not germinate on the Mach farm.*

Table 3. Comparisons of grazing annual forages on the Salzer farm.*

Crop Type	Year	Cost/A	Avg Daily Gain (lb)	Lb Gain/A	Grazing days/A*	Cost of Gain
Corn**	2012	$245.00	1.8	335	186	$.073
	2011	$208.00	2.0	394	197	$0.53
	2010	$205.00	2.0	405	202	$0.51
Winter Rye	2011	$27.50	1.6	58	36	$0.474
	2010	$26.50	1.7	66	38	$0.40
Annual Rye Grass	2011	$21.90	1.3	20	15	$1.10
	2010	$19.90	1.5	28	20	$0.71
Oats - Tumips	2011	$22.18	1.8	69	38	$0.32
	2010	$21.68	1.7	79	46	$0.31

**Grazing days is a calculated number described to help readers use the number for planning purposes on their farm.*

***In 2012, winter rye, annual ryegrass and oats-turnips did not germinate on the Salzer farm.*

Table 4. Summer and fall soil test results for nitrate nitrogen.

Salzer Farm	2010 Nitrogen	2011 Nitrogen	2012 Nitrogen	Mach Farm	2010 Nitrogen	2011 Nitrogen	2012 Nitrogen
Summer	88	78	81	Summer	64	70	71
Fall				Fall			
Corn	60	73	69	Corn	41	62	61
Winter Rye	52	54	63	Winter Rye	38	44	52
Annual Rye Grass	50	66	66	Annual Rye Grass	37	50	61
Oats - Tumips	49	53	71	Oats - Tumips	34	46	58

2012 Results

The corn was planted on May 26 at both farms. The corn yield on the Mach farm was 16.1 tons/A. The corn yield on the Salzer farm was 13.3 tons/acre. We started to graze the sites August 12 and 17 respectively. The yield data on the late planted corn was collected September 3 because the corn was needed for grazing. Both farms had more than adequate rain to begin the season. This changed at the end of June at which time the rain stopped for the remainder of the growing season. The impact was not as much as expected on the corn production but we think that the corn utilized all the moisture in the soil.

Once the crop was grazed, we inter-seeded the fields with the respective cover crop treatments. Unfortunately, lack of rain during late summer caused us to have little to no germination of the cover crop seeds. This prevented us from grazing in the fall of 2012. Overall the project did not turn out as we anticipated in 2012 compared with our experiences in 2010 and 2011. In mid-October there was minimal rainfall however it was too late to get much cover crop growth due to shorter, cooler days. Little rainfall coupled with high temperatures during the growing season shorted the soils enough to significantly decrease germination and growth of the cover crops which eliminated any potential for fall grazing.

The data from the 2010 and 2011 nitrogen tests (Table 4) suggests that by planting a cover crop, the nitrogen levels in the soil will be reduced to an acceptable level. The control and corn plot data harvested by the cows had higher nitrogen levels due to not having any plants growing to take up the nitrogen as the soil organisms continued to release them. The 2012 data (Table 4) was not conclusive due to the lack of plant growth.

This project allowed Troy and Abe to add more weight to the grazing animals with reduced use of harvested forages. It cost $26/planting for conventional 2x disking, cultivating, and planting vs. $10/planting with no-till planting of the cover crops. In addition, they were able to graze their cattle for a longer period of time. We kept the animals fed on a high quality of forage that did not have to be harvested. In 2010 and 2011, the project showed the benefits gained from feeding field forages vs. harvested forages. It was less expensive than feeding stored forages. ($.32-$1.10/head/day vs. $1.15-$1.30/head/day on stored feed). Unfortunately, 2012 was different due to the lack of growth of these crops.

It was hard for us to believe that the water could be a bigger issue than in 2011. Yet, once again it was the one variable that made the project very difficult to carry out. One option would be to install irrigation, yet this doesn't seem very practical. The other option would be utilizing our livestock to help build the soils.

Overall, we believe that the system worked very well for both our operations and could be used by other producers with some tweaking. Planting a cover crop after small grain and corn grazing is a good way to extend the grazing season, assist the farmer in capturing nitrogen and providing ground cover to control erosion.

Project Locations

Troy Salzer's farm is located east of Barnum, MN. From Barnum go 6 miles on Cty. Rd. 6. Then take Sandy Lake Dr. north for .3 miles. The field site is located on the west side.

Abe Mach's farm is located east of Sturgeon Lake, MN. From Sturgeon Lake go east on Hwy. 46 to the T. Turn right to stay on Hwy. 46 and go 3/4 of a mile. The site is on the left side.

Other Resources

Farm and Ranch Guide. 2401 - 46th Ave. SE, Mandan, ND 58554, 701-255-4904, email: *office@farmandranchguide.com* Website: *www.farmandranchguide.com* Farm news and information published every other Friday.

Graze. PO Box 48, Beltsville, WI 53508, 608-455-3311, email: *graze@mhtc.net*. Newspaper devoted to grazing. Published ten times per year.

Jung, G.A., A.J.P. Van Wijk, W.F. Hunt, and C.E. Watson. Ryegrasses. Pp. 605-641. In L.E. Moser et al. (ed.). Cool season forage grasses. Agron. Mongr. 34. ASA, CSSA, SSSA, Madison, WI.

Late Grazing Cover Crops. John Dhuyvetter, 2011. NDSU North Central Research Extension Center. Website: *www.ag.ndsu.edu/northcentralrec/livestock-extention/articles/late-grazing-cover-crops*

Mandan USDA Cover Crops Chart. Northern Great Plains Research Laboratory. Website: *www.ars.usda.gov/main/docs.htm?docid=20323*

Minnesota Cover Crop Decision Making Tool. Midwest Cover Crops Council. Website: *www.mccc.msu.edu*

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

The Stockman Grass Farmer. PO Box 2300, Ridgeland, MS 39158-2300, 800-748-9808. Monthly publication devoted to grazing.

New Demonstration Grant Projects - 2013

Alternative Markets and Specialty Crops

Reducing Chemical Use and Input Costs in Cold Climate Grape Harvest by Creating New Uses Other Than Wine

Grantee: Locust Lane Vineyards (Contact: Chad Stoltenberg)
Project duration: 3 years
Award amount: $10,950
County: Pipestone

Project objectives:

1. Grow grapes using less inputs and chemical applications while maintaining overall vine health and yield.

2. Identify grape cultivars that respond best to the reduced inputs.

3. Create new, quality food products from grapes that are grown with reduced inputs.

4. Improve farm profits by educating and supplying retail markets and chefs with the new food products created.

Cropping Systems & Soil Fertility

A Demonstration of Biological Primers on Drought Prone Soils

Grantee: Sustainable Farming Association of MN (Contact: Kent Solberg)
Project duration: 3 years
Award amount: $20,300
County: Wadena

Project objectives:

1. Demonstrate the efficacy of biological primers on drought prone soils.

2. Demonstrate versatility of biological primers in integrated livestock and crop operations.

3. Demonstrate the positive economic and environmental potential of biological primers in central MN.

4. Develop a core group of farmer/mentors experienced in biological primers.

Correcting Soil Structure to Reduce Erosion by Using a Cover Crop Mix with Diverse Root Systems

Grantee: Bois de Sioux Watershed District (Contact: Beth Markhart)
Project duration: 3 years
Award amount: $9,277
County: Traverse

Project objective:

Establish a 10 acre demonstration plot and evaluate the effect on soil physical characteristics of a diverse cover crop mix and associated system changes.

Weed Control in Soybeans

Grantee: Floyd Hardy
Project duration: 3 years
Award amount: $5,331
County: Crow Wing

Project objectives:

1. Suppress weeds in drilled soybeans.

2. Use low tillage.

Energy

Increasing Dairy Farm Profitability through an Energy Efficiency Implementation Model

Grantee: The Minnesota Project (Contact: Fritz Ebinger)
Project duration: 3 years
Award amount: $9,998
Counties: Multiple

Project objectives:

1. Design a comprehensive process to enhance energy efficiency services (the service model).

2. Test and refine the service model with dairy farmer.

3. Assess the model's impact and gauge whether it increases implementation of energy efficiency measures.

Fruits and Vegetables

Comparing the Production and Profitability of Heat-loving Crops in High Tunnel and Quick Hoop Systems

Grantee: Stone's Throw Urban Farm LLP (Contact: Robin Major)
Project duration: 2 years
Award amount: $10,092
County: Hennepin

Project objectives:

1. Compare the profitability and production in high tunnel and quick hoop season extension systems.

2. Evaluate the effectiveness of a cheap and portable season extension system in the Upper Midwest.

3. Increase yield and lengthen season extension on the farm with low-input systems.

4. Compare season extension lengths of heat-loving crops grown in a high tunnel and under quick hoops.

Completed Grant Projects...

Final Greenbook Article	Title of Project	Grantee
Alternative Markets and Specialty Crops		
2011	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
2009	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
2008	Dream of Wild Health Farm Indigenous Corn Propagation Project	Peta Wakan Tipi (Sally Auger)
2007	Developing a Saskatoon Berry Market in the Upper Midwest	Patricia Altrichter & Judy Heiling
2005	Creating Public Recognition of and Demand for "Grass-Fed" Dairy Products through the Development of Brand Standards and Promotion of These Standards to the Public	Dan French
2004	Collaborative Character Wood Production and Marketing Project	Cooperative Development Services, Isaac Nadeau
	Creating Consumer Demand for Sustainable Squash with Labels and Education	Gary Pahl
	Integrated Demonstration of Native Forb Seed Production Systems and Prairie Land Restoration	Michael Reese
	Pride of the Prairie: Charting the Course from Sustainable Farms to Local Dinner Plates	Kathleen Fernholz
2003	Demonstrating the Market Potential for Sustainable Pork	Prairie Farmers Co-op Dennis Timmerman
	Evaluating the Benefits of Compost Teas to the Small Market Grower	Pat Bailey
	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

Final Greenbook Article	Title of Project	Grantee
1998	Establishing and Maintaining Warm Season Grasses (Native Grasses)	Pope County SWCD
	On-farm Forest Utilization and Processing Demonstrations	Hiawatha Valley RC&D
1995	Cash Crop Windbreak Demonstration/Development	Phil Rutter
	Cutter Bee Propagation Under Humid Conditions	Theodore L. Rolling
	Red Deer Farming as an Alternative Income	Peter Bingham
	Wildflower Seeds as a Low-input Perennial Crop	Grace Tinderholt & Frank Kutka
1992	Alternative Mulch Systems for Intensive Specialty Crop Production	Ron Roller/Lindentree Farm
	Benefits of Crop Rotation in Reducing Chemical Inputs and Increasing Profits in Wild Rice Production	George Shetka
	Benefits of Weeder Geese and Composted Manures in Commercial Strawberry Production	Joan Weyandt-Fulton
	Common Harvest Community Farm	Dan Guenthner
	Mechanical Mulching of Tree Seedlings	Timothy & Susan Gossman
	Minnesota Integrated Pest Management Apple Project	John Jacobson
Cropping Systems and Soil Fertility		
2012	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
2009	Environmentally and Economically Sound Ways to Improve Low Phosphorus Levels in Various Cropping Systems Including Organic with or without Livestock Enterprises	Carmen Fernholz
2008	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)
2007	Field Windbreak/Living Snow Fence Yield Assessment	Gary Wyatt
2006	Gardening with the Three Sisters: Sustainable Production of Traditional Foods	Winona LaDuke
2005	Chickling Vetch-A New Green Manure Crop and Organic Control of Canada Thistle in NW MN	Dan Juneau
	Feasibility of Winter Wheat Following Soybeans in NW MN	Jochum Wiersma
	Treating Field Runoff through Storage and Gravity-fed Drip Irrigation System for Grape and Hardwood Production	Tim Gieseke
	Use of Rye as a Cover Crop Prior to Soybean	Paul Porter
2004	Development of Eastern Gamagrass Production	Nathan Converse
	In-field Winter Drying and Storage of Corn: An Economic Analysis of Costs and Returns	Marvin Jensen
	Mechanical Tillage to Promote Aeration, Improve Water Infiltration, and Rejuvenate Pasture and Hay Land	Robert Schelhaas
	Native Perennial Grass - Illinois Bundleflower Mixtures for Forage and Biofuel	Craig Sheaffer
	Northwest Minnesota Compost Demonstration	John Schmidt & Russ Severson

Final Greenbook Article	Title of Project	Grantee
2004	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
	Dairy Manure Application Methods and Nutrient Loss from Alfalfa	Neil C. Hansen
	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	Shane Johnson
	Using Liquid Hog Manure as Starter Fertilizer and Maximizing Nutrients from Heavily Bedded Swine Manure	Andy Hart
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
	Evaluation of Dairy Manure Application Methods and Nutrient Loss from Alfalfa	Stearns County SWCD
	Increased Forage Production through Control of Water Runoff and Nutrient Recycling	James Sovell
	Land Application of Mortality Compost to Improve Soil and Water Quality	Neil C. Hansen
	Turkey Litter: More is Not Always Better	Meierhofer Farms
2001	Applying Manure to Corn at Agronomic Rates	Tim Becket & Jeremy Geske Dakota County Extension & SWCD
	Cereal Rye for Reduced Input Pasture Establishment and Early Grazing	Greg Cuomo
	Establishing a Rotational Grazing System in a Semi-wooded Ecosystem: Frost Seeding vs. Impaction Seeding on CRP Land and Wooded Hillsides Using Sheep	James Scaife
	Living Snow Fences for Improved Pasture Production	Mike Hansen
	Managing Dairy Manure Nutrients in a Recycling Compost Program	Norman & Sallie Volkmann
	Reducing Chemical Usage by Using Soy Oil on Corn and Soybean	Donald Wheeler
	Techniques for More Efficient Utilization of a Vetch Cover Crop for Corn Production	Carmen Fernholz
	Using Nutrient Balances to Benefit Farmers and the Environment	Mark Muller/IATP
2000	Forage Mixture Performance	Itasca County SWCD
	Inter-seeding Hairy Vetch in Sunflower and Corn	Red Lake County Extension
	Growing Corn with Companion Crop Legumes for High Protein Silage	Stanley Smith
	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

Final Greenbook Article	Title of Project	Grantee
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	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
	Living Mulches in West Central MN Wheat Production	Dave Birong
	Making the Transition to Certified Organic Production	Craig Murphy
	No-till Barley and Field Peas into Corn Stalks, Developing Pastures on These Bare Acres	Jerry Wiebusch
	Weed Control and Fertility Benefits of Several Mulches and Winter Rye Cover Crop	Gary & Maureen Vosejpka
1995	Annual Medics: Cover Crops for Nitrogen Sources	Craig Sheaffer
	Integration of Nutrient Management Strategies with Conservation Tillage Systems for Protection of Highly Eroded Land and Lakes in West Otter Tail County	Harold Stanislawski
	Manure Management/Utilization Demonstration	Timothy Arlt
	Reducing Soil Insecticide Use on Corn through Integrated Pest Management	Ken Ostlie
	Taconite as a Soil Amendment	Donald E. Anderson
1994	Biological Weed Control in Field Windbreaks	Tim Finseth
	Energy Conserving Strip Cropping Systems	Gyles Randall
	Fine-tuning Low-input Weed Control	David Baird
	Flame Weeding of Corn to Reduce Herbicide Reliance	Mille Lacs County Extension
1993	Chemical Free Double-cropping	Jeff Mueller
	Cooperative Manure Composting Demonstration and Experiment	Rich Vander Ziel
	Early Tall Oat and Soybean Double Crop	Charles D. Weber
	NITRO Alfalfa, Hog Manure, and Urea as Nitrogen Sources in a Small Grain, Corn, Soybean Crop Rotation	Carmen M. Fernholz
	Nitrogen Utilization from Legume Residue in Western MN	Arvid Johnson
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

Final Greenbook Article	Title of Project	Grantee
1992	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		
2009	Evaluation of the Potential of Hybrid Willow as a Sustainable Biomass Energy Alternative in West Central Minnesota	Diomides Zamora
2008	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		
2012	Extended Season Marketing of Asian and Latino Ethnic Vegetables Grown in Quick Hoops and a Moveable Greenhouse	Judy & Steve Harder
2011	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
	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	Vang, Ly (American Association for Hmong Women in Minnesota)
2010	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
2009	Intercropping within a High Tunnel to Achieve Maximum Production	Mark Boen
2008	Chokecherry (Prunus virginiana) Production in Western Minnesota	Todd & Michelle Andresen
	Insect and Disease Pressure in Unsprayed Apple Orchards in Central and Northern Minnesota	Thaddeus McCamant
2007	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
2003	Research and Demonstration Gardens for New Immigrant Farmers	Nigatu Tadesse
	Root Cellaring and Computer-controlled Ventilation for Efficient Storage of Organic Vegetables in a Northern Market	John Fisher-Merritt
	Viability of Wine Quality Grapes as an Alternative Crop for the Family Farm	Donald Reding
2002	Development and Continuation of a Community Based Sustainable Organic Grower's Cooperative and Marketing System	Patty Dease

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2002	Flame Burning for Weed Control and Renovation with Strawberries	David Wildung
	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		
2012	Determining the Cost of Raising Pastured Pork on a Diet Including Whey and Finishing on a Diet Including Acorns	Lori Brinkman
	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
2010	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
2009	A Comparison between Cornstalk and Soybean Straw for Bedding Used for Hogs and Their Relative Nutrient Value for Fertilizer	John Dieball
2008	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
2007	Comparing Alternative Laying Hen Breeds	Suzanne Peterson
2006	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

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2004	High Value Pork Production for Niman Ranch Using a Modified Swedish System	David & Diane Serfling
	Low Cost Fall Grazing and Wintering Systems for Cattle	Ralph Lentz
2003	Can New Perennial Grasses Extend Minnesota's Grazing Season	Paul Peterson
	Enhancement of On-farm Alfalfa Grazing for Beef and Dairy Heifer Production	Dennis Johnson
	Farrowing Crates vs. Pens vs. Nest Boxes	Steve Stassen
	Forage Production to Maintain One Mature Animal Per Acre for 12 Months	Ralph Stelling
	High Quality – Low Input Forages for Winter Feeding Lactating Dairy Cows	Mark Simon
	Pasture Aeration and its Effects on Productivity Using a Variety of Inputs	Carlton County Extension
	Potential of Medicinal Plants for Rotational Grazing	Management Intensive Grazing Groups, Dave Minar
	Programmatic Approach to Pasture Renovation for Cell Grazing	Daniel Persons
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
	Reviving and Enhancing Soils for Maximizing Performance of Pastures and Livestock	Doug Rathke & Connie Karstens
	Whole System Management vs. Enterprise Management	Dennis Rabe
	Working Prairie – Roots of the Past Sustaining the Future	John & Leila Arndt
2000	Converting a Whole Farm Cash System to Sustainable Livestock Production with Intensive Rotational Grazing	Edgar Persons
	Dairy Steers and Replacement Heifers Raised on Pastures	Melissa Nelson
	Establishing Pasture Forages by Feeding Seed to Cattle	Art Thicke
	Grass-and Forage-based Finishing of Beef, with Consumer Testing	Lake Superior Meats Cooperative
	Learning Advanced Management Intensive Grazing through Mentoring	West Otter Tail SWCD
	Low Cost Sow Gestation in Hoop Structure	Steve Stassen
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

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1999	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
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
	Rotational Grazing Improves Pastures	MISA Monitoring Team
	Seasonal Dairying and Value-added Enterprises in SW MN	Robert & Sherril Van Maasdam
	Swedish Style Swine Facility	Nolan & Susan Jungclaus
1996	Dairy Waste Management through Intensive Cell Grazing of Dairy Cattle	Scott Gaudette
	Establishing Trees in Paddocks	Dave & Diane Serfling
	Evaluating Pasture Quality and Quantity to Improve Management Skills	Land Stewardship Project
	Expanding into Outdoor Hog Production	James Van Der Pol
	Grazing Limits: Season Length and Productivity	Doug & Ann Balow
1995	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
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
	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
1992	Intensive Rotational Grazing in Sheep Production	James M. Robertson
	Using Sheep and Goats for Brush Control in a Pasture	Alan & Janice Ringer

About the Staff…

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

Jean Ciborowski, Quarantine Officer and Sustainable Agriculture. Jean provides oversight to the Plant Containment Facility operated by the U of MN/MDA on the U of MN St. Paul campus. In addition, Jean coordinates the Sustainable Agriculture Demonstration Grant program and is the Greenbook editor. She has worked in sustainable agriculture and integrated pest management at the MDA since 1997.

Alison Fish and Stephen Moser, Administrative Support. Alison and Stephen provide administrative support to the staff and the program.

Wayne Monsen, Grazing Specialist. Wayne provides rotational grazing planning services for livestock producers. He is assisting the MN DNR by designing grazing plans that help identify ways of improving wildlife habitat on conservation lands. He began working for the MDA in 1992 after farming for 12 years near St. James, MN.

Meg Moynihan, Principal Administrator, Organic/ Diversification. Meg helps farmers and rural communities learn about crop, livestock, management, and marketing options, including organic. She has worked professionally as an educator and evaluator and as a community development extension specialist with the U.S. Peace Corps in northern Thailand. She is also a certified organic dairy farmer. She joined the Minnesota Department of Agriculture in 2002.

Mark Zumwinkle, Sustainable Agriculture Specialist. Mark provides hands-on experience to farmers working on soil quality and acts as a liaison with university researchers and farmers coordinating the use of the rainfall simulator. Mark uses soil and cropping system health as focal points for farmers exploring management options and provides the non-farm community with access to soil health information. Mark is a vegetable grower from North Central MN with research experience in living mulches and plant nutrition. Mark joined the MDA staff in 1993.

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