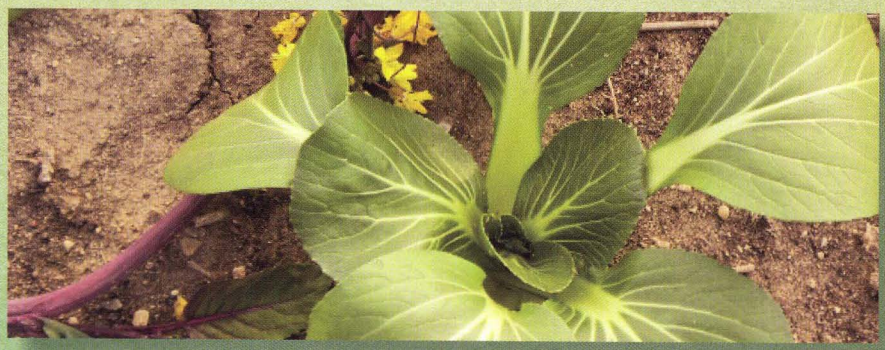
GREENBOOK 2011



MINNESOTA DEPARTMENT OF AGRICULTURE

Greenbook 2011

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
AGRICULTURAL MARKETING AND DEVELOPMENT

August 2011

Thank you to the MDA's Agricultural Development and Financial Assistance Staff who helped to make Greenbook 2011 a reality. They include: Cassie Boadway, Jean Ciborowski, Alison Fish, Mary Hanks, Wayne Monsen, Meg Moynihan, and Mark Zumwinkle. A special thanks to Stacy Gulden, Information Technology Division, for the layout and design of Greenbook 2011.

Minnesota Department of Agriculture
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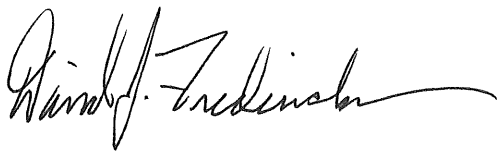
Introduction to the *Greenbook 2011*

I am pleased to present the 22nd edition of the *Greenbook* highlighting Sustainable Agriculture Demonstration Grant projects of Minnesota farmers, ranchers and researchers. These grants support on-farm practices that promote environmental stewardship and conservation of resources as well as improve profitability and quality of life in rural areas.

To date, the annual *Greenbook* has showcased 281 projects of innovative and creative grant recipients. Many of these projects have contributed to important advances in Minnesota agriculture.

I am proud of the diversification of our farming community – from the small specialty crop farmers to the large commodity crop farmers – they all work to make Minnesota's agricultural sector a success.

Greenbook 2011 contains articles on each project with personal observations and management tips from the participants as well as practical and technical information. The project results highlighted in this book are intended to be shared and these grantees are more than willing to talk with you about their experiences. Feel free to give them a call about their projects!



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 1,080 grant applications and approved over $2.9 million in funding for 270 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 2011*.

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 make 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. Funding has not been available since 2010. .

Grant Summaries

The project summaries that follow are descriptions of objectives, methods, and findings of individual grant projects funded in 2008-2010. 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 (1989-2010)

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*	---	---	---	---
Total Funded	**281**	**$2,993,416**		

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

Growing Cherries in Central Minnesota

Principal Investigator

Pat Altrichter
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Morrison County

Project Description

2009 to 2011

Award Amount

$5,000

Staff Contact

Meg Moynihan
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Keywords

cherries, 'Evans', fruit, sour cherry, zone 3

Project Summary

Overwhelming interest in a Saskatoon berry U-pick operation that we began several years ago encouraged us to try growing cherries. We want to expand our picking season, offer more variety, and increase our income. In comparison with traditional crops we hope cherries will be sustainable and require less physical labor. This project will involve family members and provide a healthy product for the community.

Project Description

I am Pat Altrichter and am working with my sister, Judy Heiling, on this project. I raise hay and 100 head of beef brood cows on a 226-acre beef farm near Randall in central Minnesota. Judy operates a 4 acre nursery about eight miles away, between Randall and Browerville. Judy grows and markets all her plants locally, both off the farm and at local farm and flea markets.

In the mid 2000s, we received demonstration grants from the Minnesota Department of Agriculture Sustainable Agriculture Demonstration Grant Program and the North Central SARE Producer Grant Program. Our project was to try establishing several varieties of commercially available Saskatoon berries developed in Canada (see the final article in Greenbook 2008). We found several cultivars we liked and that grew well. Our success enabled us to start a Saskatoon berry U-pick operation. We were interested in exploring other fruits, too. Fruit trees and berries may be expensive to establish but they are a good long-term investment. Saskatoons do not require much labor as compared to traditional crops that need annual tillage. Plus, we have a lot of rocks, so I really like the idea of not turning the soil over.

Sweet cherries do not survive the winters where we live. However, we learned about 'Evans,' a newer variety of sour cherry from Canada that is flavorful and not as tart as most sour cherries. 'Evans' is also reportedly very hardy and we expected it would survive in our area, which the USDA rates as hardiness zone 3. After trying a few plants in Judy's nursery with good results, we wondered if we could replicate our success with the Saskatoons and establish an 'Evans' cherry orchard.

Some plants were affected by the late frost (left), while others weren't damaged (right).

One of our little trees next to the lawn mower. We are impressed with these cherries!

'Evans' cherry trees have a life expectancy of 20-30 years. According to our research, it is possible to harvest 50 lb of cherries from one tree. We estimate that we can fit 150 trees on 1 acre. At $3.00/lb, the orchard would gross more than $20,000/A! Even after factoring in establishment costs, low production for the first few years, and a bad year now and then, we think the cherries have the potential to generate a lot more income than traditional crops. I (Pat) participate in farm business management (FBM) education through a local college. According to FBM data for the state (www.finbin.umn.edu), the average net income per acre for traditional field crops in our area for 2010 was $186 for alfalfa, $223 for corn, $158 for soybeans, and $16 for oats.

2009

We planted a total of the 115 'Evans' cherry trees in late April and early May in the fenced grass hayfield near the Saskatoon berry bushes. We used grant funds to plant 15 3' to 4' trees that were about 3 years old. The rest were assorted 2-5 year old trees that Judy propagated from trees she purchased from a nursery in Montana.

We prepared the ground by hauling well rotted cow manure and spreading it with beet lime (to provide calcium). We dug the holes with a post auger, spacing the trees 15' apart in 18' rows - wide enough to allow us to cut hay in between them. We mulched all the trees well with woodchips.

Before it snowed, in an effort to thwart nibbling mice and rabbits, we sprayed the trunks with an Irish Spring® soap solution we previously found effective for protecting Saskatoons (see Management Tips). We also put out some bait stations for mice.

Judy has been selling the trees for a few years already and is very impressed with their growth and hardiness, so it was interesting to see how they did in the orchard as compared to the potted ones in the nursery that get watered on a regular basis. Unfortunately, 2009 was another dry year. We watered our cherries a couple of times, noting that they seemed rather drought tolerant, like the Saskatoons. The cherries grew slowly because of the drought, but bushed out nicely and looked very healthy by fall. There was a lot of moisture in fall 2009, and we hope that helped get the trees well established.

We plan to record input costs and winter survival, and will keep growth records on the trees. Until the trees start bearing fruit, we won't be able to evaluate production.

2010

As for other pests and diseases, in late fall we mowed all the grass real short and close to the trees to discourage rodents from hiding there. Then we placed bait stations throughout the orchard to take care of mice and other nibblers. After there was no longer any chance of rain, we also sprayed the trunks with our trusty soap solution (see recipe in Management Tips) to keep rodents from chewing on them.

Every one of our cherry plants survived the winter! Then we had a late frost this spring that hurt the blossoms. We had temperatures hitting the 60's in late March and early April. As a result our fruit and berries bloomed 2 weeks earlier than previous years. Then, about a week into May, we had overnight temperatures hitting the mid 20's. A lot of the blossoms on most of our plants in the orchard froze.

This rocky start was followed by a good summer with plenty of rain. It was a great growing year. We observed some excellent growth on our cherry trees. At the beginning of spring, they were about 4' high, and by the end of the season they had grown more than a foot and had branched out a lot. A couple of trees had even suckered. 'Evans' grows on its own root so we'll leave the suckered ones in the row to see if productivity is greater in a hedge situation (as we observed with our Saskatoon berries), or if they do better as single trees.

We had good weed control and applied strategies we found to be successful with our Saskatoons –mowing between the rows and mulching the cherry trees. We did have some trunks split from sun scald but they seemed to heal up and do all right through the summer. In the past, we have had good luck painting the trunks on apple and plum trees with white paint to reflect the sun in spring. We plan on painting the cherry tree trunks next fall.

Birds were a problem – we had a lot of robins and cedar waxwings helping us eat what few berries and cherries we had this year. We are looking into different types of control

like noise makers, hawk calls, etc. We didn't have other insects and diseases to speak of. We had a few web worms this spring but nothing serious. While Saskatoons had some leaf spot fungus, the cherries didn't seem to have any disease problems.

Our local USDA Farm Service Agency and Natural Resources Conservation Service field staff are very involved in our project. With the frozen blossom problem and most of our cherry trees being young, the overall average yield was pretty minimal, but on your best tree, we picked almost two ice cream buckets full (12-18 lb). Plus, I know the birds also got a few. We have been noting weather effects and survival rates on our specialty crops. We're collecting yield information on the Saskatoons, and will be doing the same for the cherries. Some of this information could be used in the future for federal crop insurance, in the "non-insurable" program for specialty crops, for example.

We have also been enrolled in Farm Business Management (FBM) education through Central Lakes College for the past years and our instructor is helping us collect and monitor the financial information about specialty crops. Right now the Minnesota Department of Agriculture has scholarships to defray the cost of tuition for specialty crop growers; this scholarship has lowered our cost to participate in FBM.

We share information about what we are doing as informational bulletins we print up, newspaper articles that are written about us and speaking events like a fruit and vegetable forum in Perham where we taught two classes about our experience with specialty fruits. It surprises me to learn how people find out about us. Sometimes when searching for "Saskatoons" or "Minnesota cherries," they find prior Greenbook articles that contain our phone number.

Looking Ahead

We have enrolled in an intensive integrated pest management course for fruit growers. It is offered by universities in Wisconsin and Michigan. It focuses on apple, cherry and grape growers, and I think it will be very educational for us.

We are also beginning to think that investing in irrigation might be a good idea. We were fortunate to have ample rain this year, but after hauling water to hundreds of plants for the previous 5 years, I know we would get a very good return on investment in a dry year just in the yield increase. Also, studies have shown that water at fruit set time increases berry size and quality dramatically. We're also thinking about experimenting with foliar feeding; it is supposed to be one of the most efficient ways to fertilize.

Management Tips

1. Protect plants from wildlife, including deer, rabbits, mice, etc. We use fencing, sprays, poison, and the following soap solution: shave a couple of bars of Irish Spring® soap into a kettle of 1 to 2 quarts of hot water until you have slurry. Dilute 2 cups of the slurry with 4 gallons of water. Spray plants. Repeat as needed after rain events. This method seems to work well when applied to tree trunks in late fall and can really cut down on the mouse and rabbit chewing.

2. Mulch heavily. It not only helps control weeds, but will help hold moisture during dry periods.

3. Watch for insect and disease damage and treat accordingly.

4. Test the soil and/or leaves to know exactly what kind and how much fertilizer your trees need.

Cooperators

Nate Converse, Farm Business Management Program, Central Lakes College, Staples, MN
Morrison County Soil and Water Conservation District Staff, Little Falls, MN
USDA Farm Service Agency
USDA Natural Resources Conservation Service

Project Location

We are located 3 miles west of Randall or 18 miles east of Browerville on Cty. Rd. 14. We are on the north side of the road just east of the Cty. Rd. 14 and 11 intersection.

Other Resources

Edmonton Journal. 2006. Alberta's little cherry miracle. August 17. *www.canada.com/topics/lifestyle/gardenersguide/story.html?id=dca25d83-e932-4154-9a9d-898a17eeda44&k=21361*

FINBIN farm financial data. Minnesota State Colleges and Universities and University of Minnesota. *www.finbin.umn.edu*

Hardy plants for northern climates: *www.northscaping.com*

Information about 'Evans' cherries: *http://www.dnagardens.com/Articles/cherry_evans_tips.htm*
Video about 'Evans' cherries: www.youtube.com/watch?v=qvy4jHJou3o

Tree/Shrub Establishment by Direct Seeding on Red Clay Soils

Principal Investigators

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Project Duration

2010 to 2012

Award Amount

$3,704

Staff Contact

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651-201-6260

Keywords

direct seeding, conifer, hardwood, shrubs, timber reforestation, upland erosion control

Project Summary

This project will demonstrate direct seeding of trees and shrubs on red clay soils in the Lake Superior Watershed. The traditional tree establishment method of transplanting trees requires expensive, labor intensive deer damage control measures, as well as expensive weed control measures. Direct seeding with seedbed preparation is an established method in southern Minnesota, but is untried in northeastern Minnesota. On tillable soils direct seeding may be a less expensive and less labor intensive seeding method. It may also provide for more diversity, quicker establishing, and higher quality timber reforestation than transplanting trees. These have increased the wildlife benefits as well as current and future income on our farm. This project is a continuation of that process.

Project Description

The purpose of the project is to evaluate and demonstrate the potential for the direct seeding of a hardwood/conifer/shrub mixture in northeastern Minnesota. Reforestation can be challenging in this watershed due to the heavy soils, dense grass competition, and high deer damage potential. The conventional transplanting of trees has grown more expensive as increasing deer populations require expensive, labor intensive deer deterrents.

Water quality of streams in the area is largely a factor of sediment loading from bank erosion. Bank erosion amounts are strongly affected by runoff events. Runoff is generally modified and less erosive of streambanks when higher percentages of the contributing watershed are forested. Reforestation of fields no longer farmed is an ongoing conservation objective in this area for water quality protection purposes.

The 1.7 acre project site, owned by John Murray, is a grass/legume hay field on moderately drained, rolling, loam to loamy clay soils. There is also a high deer population in the area. The farm was formerly forested, then a beef operation, and now is being reforested. It is located in the red clay hills above the St. Louis River. This farm is typical of others in the area. Lessons learned here will be applied to other properties.

The seeding plan for this project will follow the Tree/Shrub Establishment practice standard (612) of the Natural Resources Conservation Service (NRCS). Most tree and shrub seed need a cold treatment, such as overwintering in the soil, to germinate. Late fall seeding is usually considered optimal and will be used in this project.

Seeding site as hay field in August 2010.

We will also compare the costs of this seeding method with the costs the NRCS Environmental Quality Incentive Program (EQIP) cost share program use for tree and shrub establishment.

Results

The 2010 season was a challenge for seeding and establishing a good crop. Wet weather in November delayed the seedbed prep and the seeding so that the nurse crop of oats did not sprout. We will see next year if this caused any problems.

On August 3 and 17, the field was clipped to improve effectiveness of the herbicide. August 30 the field was sprayed with a glyphosate/water/ammonium sulfate solution at recommended rates; 2.5 gal of 41% glyphosate and 2 lb of ammonium sulfate used. The grass and legume control was generally good. On September 12 follow up spot spraying was done on green spots in the field, using the same amounts of chemical. October 14 the field was plowed. Heavy rains and wet fields delayed disking until November 11.

On November 12 the field was rototilled, seeded, and dragged, with the harrow teeth up, to cover the seeds lightly. All but the Red Oak seed was obtained from Williams Tree Seeds in Bemidji, MN. See Table 1 for the seeding mixture.

Table 1: Tree/shrub seeding mixture

White Spruce	2 oz
White Pine	10 oz
Green Ash	12 oz
Red Osier Dogwood	1 oz
Highbush Cranberry	3 oz
Choke Cherry	4 oz
Wild Plum	7.5 oz
White Cedar	1 oz
Balsam Fir	5.5 oz
Red Oak	3 lb

The Red Oak seed was obtained locally, but because of a regional acorn crop failure we were only able to seed 3 lb. We might be able to plant more Red Oak acorns next fall. Usually acorns are broadcast with a cyclone seeder and disked in an inch. Due to the small amount of acorns, John walked a grid pattern over the field, dropping and stepping on an acorn every two paces. John planted the Wild Plum seed the same way as the Red Oak but seeding at smaller paces.

The other seeds were planted with a walking cyclone seeder. Seeding 1/3 of the seed at a time, alternating a down and across pattern to ensure even coverage. However, the Green Ash seed did not spread well in the cyclone seeder as it was too light. John spread these by hand, walking a grid, tossing five seeds at a time. Fewer Green Ash seed were available to plant than were planned. However, the ash was sown mostly as filler trees which are to be mostly thinned out as the trees grew.

A seed spreader of 50 lb of oats was mixed in with the seed. We originally had planned to use floor dry as the seed carrier, but it got wet and did not work in the cyclone seeder.

We had planned on the oats sprouting in the fall, acting as a cover crop to prevent soil erosion and tree seed desiccation and would winterkill. But due to the late planting date the oats did not sprout but did act as a tree seed spreader.

The costs for the project spent in 2010 were $1,153.34 (Table 2). There will be added costs for weed control and more acorn seeds in 2011 and 2012. We will be able to assess the total actual costs over the next 2 years.

Seeding site on November 12, 2010 between disking and rototilling.

As a comparison the costs were compared with the 2010 payment schedule for the NRCS EQIP for direct seeding and two methods of tree plantings. The typical cost for direct seeding is $510/A. The cost for conventional planting 605 trees/A along with using tree mats and tree tubes for protection is $4,575/A. The conventional tree planting of 605 trees/A with mowing, spraying, and deer repellent is $1,645/A. These costs are for an acre, whereas our costs of $1,153.34 are for 1.7 acres.

Table 2. Project costs during 2010.

Seed	46 oz	$67.00
Glyphosate herbicide	5 gal	$110.70
Ammonium Sulphate	4 lb	$3.95
Oats	50 lb	$5.75
Floor Dry	50 lb	$6.94
Mowing	4 hours	$180.00
Spraying	4 hours	$180.00
Plowing	3 hours	$180.00
Disking	2 hours	$120.00
Rototilling	2 hours	$120.00
Seeding	3 hours	$135.00
Dragging	1 hour	$45.00
Total 2010 Costs		$1,153.34

Management Tips

1. Tree and shrub seed collection can be done locally or purchased from vendors.

2. If harvesting seed, select seed from within neighboring counties and on the same soil type for best adaptation.

3. Order seed from multiple vendors to reduce the chance of seed unavailability.

4. Prepare a weed free, firm seed bed.

5. Seed on the heavy side of standard recommendations to reduce weed and deer browse problems.

6. Seed early enough in the fall (before November 1) so the oats cover crop has a chance to grow.

Cooperators

John Murray, Land Owner, Carlton, MN
Dana Raines, Onanegozie RC&D, Mora, MN
Paul Sandstrom, Laurentian RC&D, Duluth, MN
Bruce Schoenberg, MN DNR Forestry, Cloquet, MN
Kelly Smith, Carlton SWCD, PO Box 29, Carlton, MN

Project Locations

From Carlton go south 2 miles on Cty. Rd. 1. Then east on Leimer Rd. ¼ mile to the planting site, on your left, just past the RR tracks.

Other Resources

The Minnesota Department of Natural Resources pamphlet, Direct Seeding of Native Hardwood Trees. This pamphlet also describes seed collection. Available at: *www.dnr.state.mn.us/treecare/maintenance/collectingseed.html*

The Natural Resources Conservation Service direct seeding of trees standard. Available at: *efotg.sc.egov.usda.gov/references/public/MN/612mn.pdf*

Tree & Shrub Seed Vendors:

Williams Tree Seeds . . . . .Bemidji, MN . . .218-751-7957
Cass Lake Tree Seed Co. . .Cass Lake, MN. .218-335-2336
F.W. Schumacher Co. . . . .Massachusetts . .508-888-0659
Scheffield Seed Co. . . . . .New York 315-497-1058
One Stop Forestry . . . . . .Iowa 563-864-3586
Lawyer Nursery. . . . . .Montana 406-826-3881
Cascade Forest Nursery. . .Iowa 319-852-3042
Smith Nursery Co. . . . . .Iowa 515-228-3239

Organic Mushroom Cultivation and Marketing in a Northern Climate

Principal Investigator

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St. Louis County

Project Duration

2009 to 2011

Award Amount

$8,680

Staff Contact

Wayne Monsen
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Keywords

inoculating, marketing, oyster mushrooms, shiitake mushrooms, substrates

Project Summary

There are several goals for this project. The first is to experiment with growing shiitake mushrooms on a variety of hardwood trees (maple, birch, and aspen). Shiitake mushrooms are known to grow best on oak species, however, in northern Minnesota oak trees are not abundant. The second will compare growing oyster mushrooms on locally available tree species as well as on straw. The third goal is to develop a market in the Duluth area for organically/locally grown mushrooms through farmers' markets, restaurants, and grocery stores.

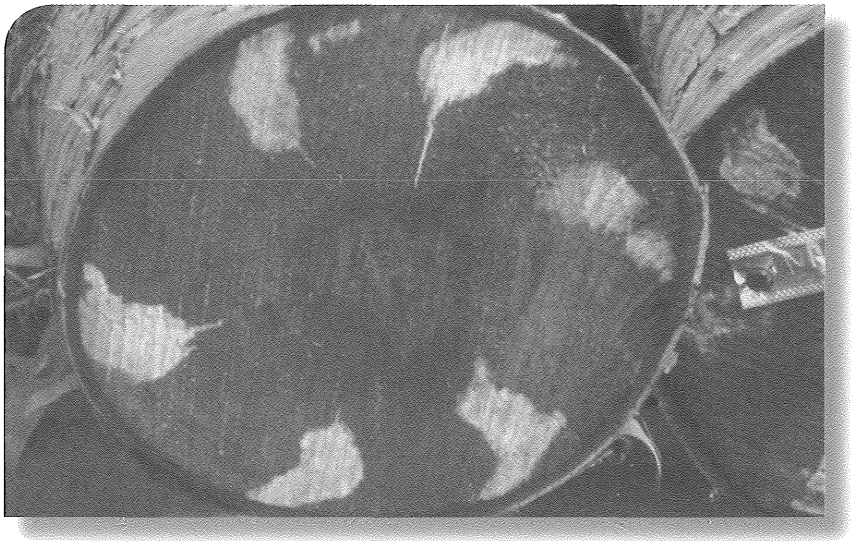
Project Description

I live in rural Duluth on 10 acres of land where I grow a variety of organic vegetables and fruits primarily for my own consumption. I have a hoop house for growing tomatoes, a raspberry patch, blueberry bushes, and two large vegetable gardens that supply me with food throughout the year. I have a background in agriculture and community organizing and am very interested in the Slow Foods, local, and organically produced food movements. This project will allow me to move from being a self-sustaining grower to being able to market mushrooms.

My cooperator, Rob Aptaker, introduced me to growing shiitake mushrooms several years ago. I have grown shiitake mushrooms since then, but on a very small scale. This project will allow me to grow enough mushrooms for market.

I will look at several aspects of growing mushrooms in a northern climate including researching different substrates for growing shiitake mushrooms. It is known that shiitake mushrooms prefer oak logs, however I have heard of success in growing them on aspen and there are new strains of shiitake mushrooms being developed for softer hardwood species. This led me to want to explore growing these mushrooms on birch, aspen, and maple trees, species common in northeast Minnesota and to compare the output from several tree species. In addition to shiitake mushrooms, I am also growing oyster mushrooms on popular tree species as well as on straw and will compare the output on both types of substrate.

Another goal of this project is to develop a market for oyster and shiitake mushrooms in my area. I intend to participate as a grower starting with the 2010 season in various farmers' markets in the Duluth area. As my output increases, I may also market to restaurants and grocery stores.



Birch log showing mycelium growth of oyster mushrooms.

This project is important because it will evaluate both growing and marketing mushrooms in a northern climate. Growing mushrooms provides an opportunity for developing an off-season specialty crop (trees are cut in winter and inoculated in early spring) that farmers can add to their market crops.

2009 Results

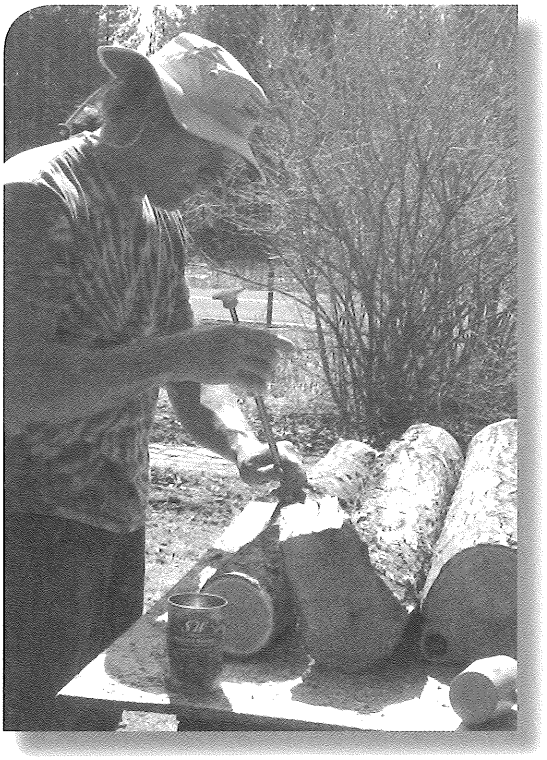
In April 2009, I ordered the equipment and mushroom spawn required to inoculate logs. For this first year I purchased nearly all of my logs from local loggers. My need for logs coincided with a severe ice storm in the Silver Bay area and the aspen, birch, and maple logs I used were salvaged from this ice storm. The oak logs were cut in Wisconsin and purchased through a local logger. I requested winter cut oak logs that were from 4 to 6" in diameter and 30 to 36" in length. Contrary to popular belief, mushroom cultivation must be done on live, healthy logs and the logs should be cut in the winter before the tree uses energy for leaf production.

Shiitake Mushrooms

The logs were inoculated for shitake mushrooms between April 17 and April 21. Inoculation of shiitake logs consists of drilling 7/16" diameter holes into the logs 1" deep and spaced at 6" intervals along the length of the log and in rows about 1½" apart to create a diamond pattern. The holes are then filled with spawn, which is a mixture of sawdust and mushroom mycelium (purchased commercially). The holes are covered with melted food-grade wax to reduce moisture loss. I inoculated 25 oak, 13 maple, 32 aspen, and 15 birch logs with three different strains of shiitake spawn. The three strains I used fruit under a variety of temperature ranges chosen for a northern climate. Each log was labeled with the type of spawn used and the date of inoculation and then was laid out in a lean-to stacking configuration under the shade of large spruce trees to allow the mycelium to run throughout the logs.

I noticed that either woodpeckers or chipmunks removed some of the wax covering the inoculation holes on the shiitake logs. I plan to use a thicker coating of wax on the holes to prevent this from reoccurring next year.

Shiitake logs generally take 6 months to a year before they are ready to fruit so I will not have results until next year. Next year I will try forcing fruiting to have mushrooms ready for a specific event such as a Saturday farmers' market. I plan to use a stock tank to soak the shiitake logs for 24 to 48 hours (depending on air temperature) and then place the logs in a vertical position for fruiting and picking. I expect it to take about 2 weeks to have mushrooms available for the farmers' market.



Rob Aptaker inoculating logs with shiitake mushroom spawn.

Oyster Mushrooms

I used two different growing methods for the oyster mushrooms: the totem method, which is used with large diameter soft hardwood tree species, and the "straw in cardboard boxes" method. The power company was clearing trees from a nearby right of way and I was fortunate to obtain winter cut, large diameter (8 to10") aspen logs cut in about 2' lengths. These logs were inoculated between April 20 and April 24 with the totem method. This involves placing a handful of spawn in the bottom of a large plastic bag, then placing the largest diameter log upright on top of the pile of spawn, then another handful of spawn on top of that log, then the next largest diameter log on top of that one, capped with more spawn. The idea is to create a totem pole of logs, using the largest diameter first for stability and then alternating logs and spawn, using two lengths of logs. Then the black plastic garbage bag is drawn up and over the entire structure and closed loosely at the top.

The logs need to incubate in temperatures of 60 to 80°F for at least 4 months and up to 1 year. I uncovered the logs on September 13 and found that they were covered with white fuzz which indicates mycelium growth. Because I used large diameter logs, I suspect it will be at least 1 year before the logs fruit. Similar to the shiitake mushrooms, I used several strains of oyster spawn to cover a wide range of temperatures and inoculated 30 logs with oyster mushroom spawn. I will have data on mushroom yield next year.

I also wanted to try inoculating straw to have mushrooms in the current season. Straw is a quick way to grow oyster mushrooms with a faster spawn run, but you sacrifice quantity for speed. I purchased one oat straw bale (oat straw is recommended) and set up two cardboard boxes and one wood cold frame growing chamber. Before the straw could be used, it was soaked in a stock tank of water for 3 days to kill other fungi and bacteria. Inoculating straw is like making lasagna, alternating layers of spawn and straw until the box is full. I placed two big handfuls of spawn on the bottom of the box, then straw, then more spawn, until I reached the top of the box. Then I used a clear, heavy plastic over the top, folded the box tops back into place, and placed a black plastic bag over the entire box to prevent any seeds in the straw from sprouting. The boxes are set in a shady location to rest for 1 month. After a month, I took off the black plastic, puffed the clear plastic up to make a little tent and every other day I misted the top of the straw with water. The three boxes were all started on May 10 and fruiting began on June 23 in the cold frame and July 8 and 10 in the cardboard boxes, and continued through September (Table 1).

Table 1. 2009 Oyster Strains and Straw Production

Oyster Strain	Total Grams Produced
Grey Dove (cold frame)	1,951.8
Grey Dove (cardboard box)	1,352.2
Italian (cardboard box)	1,320.9

As a point of reference, a container of oyster mushrooms purchased in a grocery store in Duluth weighed 100 grams (3.5 oz) and cost $3.49. The expense for this method of growing included the straw ($6.00), the spawn ($46.00), and a stock tank ($150.00) for soaking the straw in water. So, theoretically, if I sold all the oyster mushrooms that I grew from these three boxes of straw my income would have been $161.40 and my expenses would have been $202.00. Next year's expenses will only be for straw and spawn. The stock tank will be used for many years.

It was interesting to note that the cold frame produced more mushrooms than the two cardboard boxes. The cold frame was placed in a different location from the two cardboard boxes, but was still under a big tree for shade and received the same amount of misting as the cardboard boxes. I believe the humidity was better regulated in the cold frame because there was more space between the straw and the plastic top. There were more spotted beetles in the cardboard boxes than in the cold frame. This leaves me to consider building more cold frames for next season as well as trying floating row covers on the cardboard boxes.

2010 Results

There were many different results to report for 2010. Activities ranged from obtaining and inoculating logs with both oyster and shiitake spawn, as well as harvesting and selling mushrooms.

Obtaining Logs

Obtaining logs is labor intensive and is the aspect of this project that requires the most thought on my part. Purchasing logs from local loggers creates an expense and requires me to travel in order to pick up the logs and bring them to my inoculation site. The spring of 2010, as in 2009, provided an opportunity to obtain some free logs. Just about 6 miles from my home there was a large parcel of land being cleared primarily of aspen, with some birch as well, for future development. I introduced myself to the loggers and told them of my mushroom growing project, and came away with enough aspen for growing this year's oyster mushrooms, and some birch which I used with shiitake spawn. Additionally, I purchased maple, birch, and smaller diameter aspen from a logger in northern Minnesota, and oak from a logger in northwestern Wisconsin. These logs were used for shiitake production.

I am learning the importance of building relationships with loggers and explaining what is required for mushroom logs. The oaks that I had purchased in 2009 were cut, limbed, and moved mechanically – all of which injured the bark of those trees. A wound to the bark causes moisture loss, which can be detrimental to the mushroom growing process. Therefore, I had several conversations with my oak supplier to see how I could obtain logs that were cut by hand and treated gently! The log supply I received in 2010 was smaller in diameter and better treated, but they were still not the ideal logs in size and condition. My hope for 2011 is to be able to cut my own oak trees, or at least be present to supervise the cutting. The maple, birch, and aspen logs purchased in northern Minnesota were treated very well and I have had no problems with bark damage.

Inoculating Shiitake Logs

Inoculation for shiitake mushrooms occurred from April 15 to 18. An important difference between this year and last was the use of a drill bit with a stop on it, which allowed for drilling a hole to the exact 1" depth needed for use with the inoculation tool. Inoculating at this depth will help prevent chipmunks from getting at the spawn.

Birch log inoculated with shiitake spawn using the kerf method.

Totem method of inoculating aspen logs with oyster mushroom spawns.

This year I used four strains of shiitake spawn that provides for a range of fruiting temperatures. I used a warm weather strain that was developed specifically for use with softer woods on some of the maples, birch, and aspen. All totaled I inoculated 61 oak logs, 39 maple, 18 aspen, and 17 birch.

On 12 of the largest diameter birch I experimented with a "kerf" type of inoculation. Kerf inoculations are made by cutting across the log with a chainsaw to a depth of about 1", and then packing the cut with spawn and covering with melted cheese wax. I chose to do this because there were a few cuts in the bark of the larger birch logs. All other logs were inoculated with a palm inoculator and sawdust spawn and with the holes covered with melted cheese wax.

Inoculating Oyster Mushrooms

Once again I used the two common methods of growing oyster mushrooms: the totem method, which is used with large diameter aspen, and the "straw in cardboard box" method. I used large diameter (6 to 8") aspen trees, which were logged before the buds began to swell from an area that was being cleared for development. I set up 11 totem configurations (spawn, log, spawn, log, spawn, all in a large plastic trash bag) on April 24. The totems stayed covered in the plastic bag (which maintains both moisture and warmth) until August 19th when they were uncovered. All of the totems had white mycelium growth. The totems were labeled with the name of the spawn used and the date. The totems should produce mushrooms in 2011.

Additionally, I inoculated a total of 11 cardboard boxes and one cedar cold frame by alternating layers of spawn and straw. The bales of straw must first be soaked in water for 3 days as a way to sterilize and pasteurize it. After layering spawn and straw I placed clear plastic over the top of the box and placed the entire box in a large black plastic trash bag to retain moisture and temperature. These bags were opened 1 month later and the clear plastic was puffed up to create a little tent to retain humidity. I used three different strains of oyster mushrooms (Italian, PoHu, and Grey Dove) that fruit over different temperatures. I inoculated the straw at various times throughout the spring and summer to match the preferred temperature ranges. Refer to Table 2 for yield results. These strains were chosen because of good production in 2009 for Italian and Grey Dove and because PoHu is a strain designed especially for use with straw.

Fruiting Results - Straw

The results are given in grams to provide a reference point for market (Table 2). A container of oyster mushrooms purchased in a Duluth grocery store weighs 100 grams (3.5 ounces) and costs $3.49. The Italian strain planted in the spring produced more volume of mushrooms than in the summer. For a second year, the cold frame produced a higher volume than most of the cardboard boxes. Grey Dove did not perform as well in 2010 as in 2009 and this could have been a result of temperatures or moisture (locations were identical for both years). The super performer of 2010 was the PoHu strain, which was specifically developed for use on straw. It is interesting to note that when box #1 was opened on July 4 mushrooms were found growing all over the box and in one picking produced 1,221.7 grams or 2.69 pounds of mushrooms!

Oyster mushrooms growing in straw in a cardboard box.

Table 2. Oyster Mushrooms on Straw – 2010 Inoculation

Oyster Strain	Date Inoculated	Total Grams Produced
Italian 1	4/26/10	953.9
Italian cold frame	4/26/10	1,291.0
Italian 2	7/3/10	112.5
Italian 3	7/3/10	509.2
Italian 4	7/3/10	66.0
Grey Dove 1	4/26/10	156.6
Grey Dove 2	4/26/10	82.8
Grey Dove 3	4/26/10	0
PoHu 1	6/4/10	1,727.2
PoHu 2	6/4/10	1,520.4
PoHu 3	6/4/10	1,033.3

Fruiting Results – Oyster Totem Logs Inoculated in 2009. The fall of 2010 was fairly wet and this was very beneficial to the totem logs inoculated in 2009. Fruiting of the totem logs began on October 2 and continued on some logs until November 11 (Table 3). Most of the logs were large diameter (7 to 10") aspens that were winter cut and inoculated between April 20 & 23, 2009. I also inoculated a few birch logs to see if they worked.

Not all logs inoculated in 2009 bore fruit in the fall of 2010 (none of the Italian inoculated logs fruited) and those that did produce fruit provided a relatively small amount for totem log cultivation. This leads me to believe that the logs that did produce fruit will fruit again in 2011 and those that did not fruit at all very likely will this upcoming year.

The largest profusion of mushrooms was found closest to the ground around the base of the logs and in the leaf litter. Fewer mushrooms were produced on top of the log or in between the two logs. The mushrooms produced from the totem logs seemed to dry up faster than those produced in boxes (with plastic over the top) and this provided a smaller window for picking. It wasn't uncommon for me to note a small mushroom one day and find that it had dried up by the next day. Therefore, I picked these mushrooms at a smaller size than I did the mushrooms grown on straw.

Table 3. Oyster Mushrooms Grown on Totem Logs – 2009 Inoculation

Oyster Strain	Date Inoculated	Grams Produced in 2010
PoHu 1 – Aspen	4/23/09	510
PoHu 2 – Aspen	4/23/09	74.5
PoHu 3 – Aspen	4/23/09	869.9
Summer Blue 1 – Birch	4/23/09	24.8
Summer Blue 2 – Birch	4/23/09	208.3
Summer Blue 1 – Aspen	4/23/09	572.9
Summer Blue 2 – Aspen	4/23/09	289.3
Summer Blue 3 – Aspen	4/23/09	372.9
Summer Blue 4 – Aspen	4/23/09	741.7
Summer Blue 5 – Aspen	4/23/09	50
Blue Dolphin 1 – Aspen	4/20/09	309.1
Blue Dolphin 2 – Aspen	4/20/09	327.7
Blue Dolphin 3 – Aspen	4/20/09	534
Blue Dolphin 4 – Aspen	4/20/09	436.7
Blue Dolphin 5 – Aspen	4/20/09	473.5

Fruiting Results – Shiitake Logs Inoculated in 2009
Oak, aspen, maple and birch logs were inoculated in 2009 with three strains of spawn to cover a range of temperatures. The log diameters were about 5 to 6" which were on the large end of what is typically used for shiitake cultivation and I anticipated that mycelium runs would take longer, hence a delay of at least 1 year for mushroom production.

On April 19 I noticed shiitake mushrooms starting to develop on 1 oak log, 2 maple logs, and 1 birch log. I placed these logs upright against a large spruce tree and watched daily for additional growth. I was able to pick just a few mushrooms from each log and when no more

Soaking shiitake inoculated logs to stimulate fruiting.

mushrooms came, I decided to soak those logs in a tank of water to attempt to stimulate more fruiting. The logs were soaked in a stock tank for 24 hours and then reset upright against a large spruce tree. The oak log and two birch logs responded to the soaking, but again only with a few mushrooms. I will watch these 2009 inoculated logs closely for signs of fruiting in 2011 and will attempt to stimulate fruiting by soaking the logs in a stock tank.

Marketing Mushrooms

I had enough oyster mushrooms at the right time to attend three farmers' market days. I attended the market held on Wednesdays at the University of Minnesota, Duluth twice and attended the Brimson Farmers' Market once on a Saturday. Although I made very little money from my mushrooms, I learned some valuable information that will help me at future farmers' markets.

The first thing I learned is that oyster mushrooms do not have a long shelf life. I can hold them in my refrigerator for two days if they are picked just before their prime. This becomes a difficulty if market day is held once a week. Attending various markets on different days will help with this problem. Additionally, mushrooms do not like sun, requiring an umbrella or tent-like structure to shade them during market.

I spoke with some blueberry marketers at a market and they shared with me that they take orders in advance and when the berries are ready they call their customers. I thought this would be useful for my marketing and would help eliminate the short shelf life dilemma. I plan to try this next year.

I found that many people at the market were not familiar with oyster mushrooms and thought they were wild. I spent the bulk of my time educating potential consumers about how I grow them and how to cook them. This leads me to the idea that I should create a "science fair" type of display board showing the various procedures in growing shiitake and oyster mushrooms. I will have such a display for 2011 markets.

Another problem I ran into was the flush of mushrooms produced from the totem logs in late fall. All of the markets were closed for the season and I had several pounds of mushrooms. I called a restaurant that uses local and organically produced foods and told her about my mushrooms and I asked for $30.00 for the 2 pounds that I had. She told me that her supplier in Minneapolis sells them to her for $21.00 for 5 pounds. An industrial mushroom grower undercut my prices! I ended up drying the mushrooms in a food dehydrator, and realized this will provide a good way to save mushrooms I can't sell immediately.

Management Tips

1. Use a thick coating of wax to cover the inoculation holes to prevent damage from woodpeckers or chipmunks.

2. Use floating row covers on oyster mushroom boxes. These will protect the mushrooms from damage from spotted beetles.

3. Write the tree species on the metal labels as well and the strain of mushroom and the date. The logs are hard to identify as they age.

4. Use a drill bit with a stop on it to make the correct size hole in the logs.

5. Pay attention to oyster mushrooms fruiting on totem logs so that they don't dry up.

6. Build relationships with loggers so that they understand what is needed for mushroom logs.

7. If you cannot sell all of the mushrooms you can dehydrate them in a food dehydrator to use or sell later.

Cooperators

Rob Aptaker, Mushroom Grower and Consultant, Allentown, PA
David Abazs, Round River Farm, Finland, MN

Project Location

This project is located on the edge of Duluth and Rice Lake Township. Take I-35 north to the 21st Ave. East exit. Take 21st Ave. East to Woodland Ave. and bear right (north). Take Woodland Ave. to the three way stop sign at Calvary St. and turn left. The next street you come to is Arnold, turn right. Take Arnold to Rehbein and turn left.

Other Resources

Field and Forest Products, Inc. Mushroom spawn, instructions, and growing supplies. Peshtigo, WI. 800-792-6220. Website: *www.fieldforest.net*

Fungi Perfecti. Mushroom spawn and growing supplies. Olympia, WA. 800-780-9126. Website: *www.fungi.com*
Kozak, M.E.; Krawczyk, J. (1993). Growing shiitake mushrooms in a continental climate. Peshtigo: Field & Forest Products, Inc.

Feasibility of Small Farm Commercial Hop Production in Central Minnesota

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Project Duration

2009 to 2011

Award Amount

$12,535.00

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Keywords

beer, bines, brewing, cones, hops, lupulin, trellis

Project Summary

A restaurant that supports locally grown foods asked us about supplying locally grown hops and herb ingredients to a newly formed local brewing company. Preliminary review indicated that established hop rhizomes are known to survive winter temperatures down to -35°F and that the hop plant is compatible with soil types occurring in the Central Minnesota Lakes area. Locally grown hops for local and regional craft and micro breweries and brew pubs could be a market for small and medium-sized sustainable farming operations. Further review suggested that modification of our existing 10' deer fence and line posts could support hop trellises while protecting hop bines from deer damage. This project studies the feasibility of using existing farm infrastructure to develop a market for locally grown hops while increasing the return on investment made in deer protection.

Project Description

The Farm on St. Mathias (The Farm) is an 80-acre fruit and vegetable farm located near Brainerd, Minnesota. We grow a variety of hybrid and heirloom vegetables on approximately 30 acres, with eight of these located inside a newly constructed woven deer fence. Local markets include an on-farm market and country store, a 50 member community supported agriculture (CSA), a local restaurant supply store, and fall activities like pumpkin sales, a corn maze and hayrides. In June 2009 and 2010, the local Brew Club (Blue Ox Brewers Society) demonstrated beer brewing—including hop ingredients— during the annual Celtic Festival.

Hops are a perennial vine that grows from a crown and rootstock. Runners from the crown, called rhizomes, grow just under the soil surface. Cuttings from these rhizomes serve as planting stock for new hop vines. Hops produce shoots called "bines" that can grow as much as 25' in one season and that wind clockwise around whatever support is provided.

The hop plant is dioecious, meaning that it bears both male and female flowers on separate plants. The female flowers form papery "cones," which are 1" to 4" long and bear seeds. It is these cones that are used in brewing. They contain a compound called lupulin, which is made up of the essential oils and resins that impart hops' unique aroma and bitter flavor. Our research suggested that in prime hop growing areas, mature hops can yield from 1 to 3 lb of dry cones per bine.

Hops are a perennial vine.

We set out to determine which hop varieties would grow best in north central Minnesota and to test the suitability of using existing deer fence for hop trellises. Commercial hop production typically uses 18' vertical trellises, but recent studies have investigated a new management technique that could save 30% in labor costs when harvesting hops. This method involves growing the hops on lower trellises – about 10' high – with 15' diagonal trellis runs. Lower trellises eliminate the need for expensive mechanical support and labor for stringing, training, and harvesting of hop plants.

The basic design of this project involves establishing three planting areas within the existing deer fence and using the fence posts as trellis supports. We selected the planting locations based on radiant exposure and soil types in order to create distinct comparisons between planting areas. We are testing seven hop varieties: Cascade, Chinook, Fuggle, Kent Golding, Mt. Hood, Nugget, and Willamette.

We are evaluating six specific measures for each hop variety:

- yield;
- winter survival;
- incidence of disease or pests impacting rhizome survival;
- analysis of hop cones and associated plant structures;
- standardized brew testing; and
- marketability of hop cones.

2009

Since hops prefer well drained soil, we dug furrows approximately 5' long and filled them with black dirt mixed with peat from a local wild rice bog production farm. At each fence post, we formed two hills approximately 3' apart, 6' in from the deer fence. We planted two rhizomes of the same variety per hill (four of the same variety per post). We planted 10 hills (20 plants) of Fuggle, 8 hills (16 plants) of Chinook, and 6 hills (12 plants) each of Kent Golding, Mt. Hood, and Willamette along the north fence, creating the southern exposure that is recommended by most reference materials. We planted 6 hills (12 plants) of Cascade on the west fence (eastern exposure) and 4 hills (8 plants) of Nugget on the south fence (northern exposure). You can find a layout of our design in the 2010 Greenbook.

In 2009, we planted the hop rhizomes on May 4. By May 17, hops were up and growing, with Fuggle and Kent Golding being the most vigorous. The vigor may have been due to the moist soil, since these varieties prefer a more moist growing condition. By May 25, approximately five Chinook and five Mt. Hood plants had disappeared – lost either to frost or rabbits. We mulched the remaining hop plants with a mixture of llama and chicken manure combined with straw from our farm.

In July, we trellised the hops using 1/2" and 3/8" biodegradable sisal rope. At the bottom of each hill, we drove two 3' garden stakes into the ground. We cinched a rope to the garden stake, and anchored it to the fence post with fence nails or U shaped nails. This technique proved technically simple and provided strong, yet sustainable support for the hop bines.

Lupulin glands in a hop cone. This is the compound that imparts hops' unique aroma and bitter flavor.

We planted two hop plants per hill and trained them to sisal twine that ran from garden stakes to posts in our deer fence.

In their first year, many of our plants did not grow much more than 4'. We suspect they were investing energy in establishing roots, rather than producing above-ground vegetative growth. Only two varieties, Cascade and Nugget, produced any cones at all. We harvested them on September 25 and, due to the small amounts, air-dried them for about 2 weeks rather than using a commercial dryer. Cascade and Nugget, each produced four cups of cones after drying. We stored the hops in an airtight container in the freezer.

In October, we mulched the hills with at least 2' of straw on top of each mound. While several local ornamental hop growers do not mulch their hops at all, we felt we needed to provide some straw mulch to protect the plants. We were also hoping for good, insulating snow cover during this first critical winter.

2010

This was the first time we tried overwintering the hop rhizomes. In spring, the bines surfaced through the straw mulch. We had a survival rate of 90% (five mounds had no rhizomes). The varieties that struggled to survive include Chinook and Mt. Hood. It is interesting to note that both of these died after initial planting in 2009 and had to be replanted.

We allowed the vines to grow without interference until they were about 1' long. At that point, we left 2 to 6 vigorous vines growing in each hill and removed the rest. We did not remove the straw mulch we had applied last fall to protect the hop plants over the winter; it proved valuable in weed control and moisture preservation during the growing season. We conducted soil testing in April and, as in 2009, we fertilized the hops using a mixture of black dirt, peat from a local wild rice bog, and lama and chicken manure from our own farm. We think our soils are almost ideal, and that with the mulch and other organic nitrogen and micro-nutrient sources we have been applying, our soil organic matter will increase and benefit hop production.

The trellising we built in 2009 was still good this year, and we again trained the bines to grow clockwise on the trellis. With help from the local brewing club, we harvested the cones on August 30 and September 1, about 1 month earlier than last year.

We dried hops using a Lem stainless steel dehydrator with ten trays. Wet and dry yields are reported in Table 1. After dehydration, we used a Food Saver to vacuum seal each ounce of dried hops in a separate plastic bag. The amount of hops to use during beer brewing depends on the variety of beer being made and personal taste preference. Typically, 1-2 oz of dried hops per 5 gal of brew is considered a moderate amount. Less can be used if the brewer prefers a milder, less bitter flavor. A true "hoppy" brew can use as much as 4 oz of dried hops per 5 gal.

The hops are being tested in five different brews by two independent brewers. Since the project began, some of our original brewing project partners have dropped out, while new ones have joined. We expect to be able to report on brewing tests and marketability next year.

In the meantime, we have been in communication with Dr. Charlie Rohwer at the University of Minnesota's South

Table 1. 2010 Hop Cone Yields

Variety	Wet Weight	Dry Weight (oz)	Drying time at ~115°F (hours)
Cascade	4 lb, 6.25 oz	20.50	4.5
Chinook	4.5 oz	2.125	4
Fuggle	2 lb, 8.25 oz	15.25	4
Kent Golding	5.25 oz	1.875	4
Mt. Hood	2.875 oz	1.375	4
Nugget	2 lb, 1.875 oz	7.75	7
Willamette	6 oz	2.0	3
Total	10 lb, 1.875 oz	3 lbs, 2.875 oz	

We sealed the hops in airtight plastic bags.

Central Research and Outreach Center at Waseca. Dr. Rohwer is experimenting with a low-trellis vertical system, which might be adaptable to our project. The Waseca project uses a polypropylene mesh as vertical support for a low trellis design. Because our original biodegradable trellis support is not sustainable, next year we will try the polypropylene mesh. Based on the growth we observed in the project's first two years, we expect the change will significantly improve production without changing the effort required for harvest.

Management Tips

1. When the young vines are about 1' long, select 2 to 6 of the most vigorous to train on the trellis and remove the rest. Lateral side arms will extend from the main vine and produce flowers. Support the bines and prevent the side arms from tangling. Most cones are produced on the upper part of the plant.

2. In midseason, remove the lowest 4' of foliage and lateral branches to increase air circulation and reduce the opportunity for fungal disease. After pruning, allow additional bottom growth to remain, to promote hardiness of the crown and plant vigor for next year.

3. Harvest date will vary with hop variety, geographical location, the prevailing rate of late season desiccation, and grower experience. Monitor closely as harvest approaches. Cones that are mature and ready to harvest are light in color, as well as dry and papery. Lupulin will fall out readily when the cone is squeezed.

4. At the end of the season, bury healthy bottom vines in a shallow trench and mark their location. To propagate in spring, cut into pieces about 4" long, making sure each has an "eye" or bud.

Cooperators

Kevin Happke, Sustainable Farming Association of Minnesota – Central Chapter, and Rolling Hills Greenhouse, Pierz, MN
Jesse Grant and Dan Stanifer, Brainerd Lakes Brewery, Inc., Brainerd, MN
Erik Sjoberg and Patrick Sundberg, Independent Homebrewers

Project Location

From Brainerd, travel south on Business 371 and turn left on Cty. Rd. 21/St. Mathias Road and travel about 3 miles.

Other Resources

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Fertilizing with Alfalfa Mulches in Field Crops

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Project Duration

2010 to 2012

Award Amount

$9,056

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Keywords

Nitrogen, mulch, 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.

On August 23, 2010, following the harvest of winter wheat, alfalfa hay was spread as mulch in preparation for a crop of barley to be 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 will follow the barley in 2012. Fertility for the corn crop will be supplied by a second application of alfalfa hay mulch after barley harvest in August of 2011.

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

Table 2. Available Major Plant Nutrients in 6″ Soil Sample After Application of Alfalfa Mulch, Fall, 2011

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

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

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

A forage analysis revealed that 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 will be available to the barley crop.

Results

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

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

Although the mulch spread was fairly even, I am considering trying an even finer chop for a more even spread.

In this initial year of the demonstration, it appears that the application of alfalfa mulch is already improving my soil fertility.

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

McNamara Filter Strip Demonstration

Principal Investigator

Goodhue County SWCD
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Project Duration

2010 to 2012

Award Amount

$7,094

Staff Contact

Mark Zumwinkle
651-201-6240

Keywords

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

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 five buffers using different seed mixes. Test plots in a waterway and buffer setting have been established for this purpose.

The erosion control and soil filtering capacity 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 each test plot. The seed mixture producing the greatest forage value while still retaining soil stability may be marketed locally.

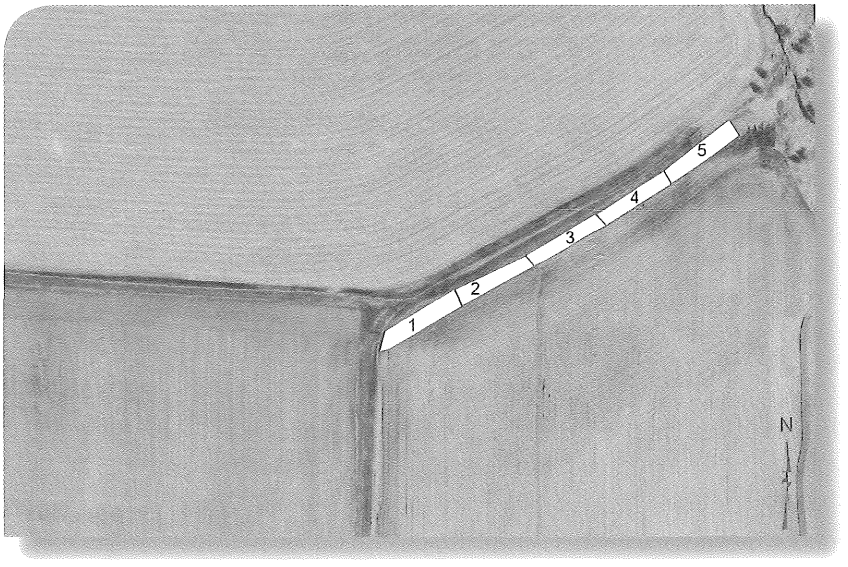
Project Description

This project is located in Goodhue County, roughly 4 miles west of the town of Goodhue. The five test plots are located in an existing grass waterway on Ed McNamara's farm (see photo). Ed has expressed interest 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 five test plots are situated on the landscape. The seeding was done in last year's corn stubble. We offset the test plots adjacent to an existing grass waterway. They are all approximately one tenth of an acre in size. The dimensions of each plot are roughly 150' x 30'. For the most part, the entire length of the test plots receives 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). The fifth plot was seeded in late August.



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

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

PLOT 1 Ed's Mix 1 (drilled)	lb/A	PLOT 2 SWCD Mix (drilled)	lb/A	PLOT 3 BC-17 Native Mix (drilled)	lb/A
Alfalfa	8	Timothy	2	Big Bluestem	3
Orchardgrass/Brome	15	Perennial Ryegrass	3	Canada Wild Rye	3
Winter Wheat cover	30	Kentucky Bluegrass	2	Switchgrass	4
Total	**53**	Smooth Bromegrass	10	Western Wheatgrass	4
		Winter Wheat cover	36	Perennial Ryegrass	4
		Total	**53**	Red Fescue (late)	3
				Winter Wheat cover	32
				Total	**53**

PLOT 4 CP 21 CRP Mix (broadcast)	lb/A	PLOT 5 Ed's Mix 2 (broadcast)	lb/A
Indian Grass	1.5	Winter Wheat cover	40
Big Bluestem	2.5	Ed will plant Winter Peas and Triticale in 2011	
Little Bluestem	1		
Sideoats Grama	1		
Canada Wild Rye	1		
Blue Grama	0.5		
Switchgrass	0.5		
Two Forbes	TBD		
Oat cover	25		
Total	**33**		

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

Plot 1 is a typical pasture mixture found in Goodhue County. Plot 2 is the SWCD grass waterway seed mixture we sell in our drill. These two plots are acting as a control during this project since they are the most prevalent buffer mixes used in our landscape.

Plot 3 is a 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 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 used in most CRP buffer acres.

Plot 5 was seeded to winter wheat in late August as a cover crop. Mr. McNamara plans on seeding grass/legume mix on this plot in spring of 2011.

Winter wheat cover crop development in buffer on August 2, approximately 3 weeks after seeding.

As of the fall of 2010, all plots were well established. Starting in 2011, in order to determine the cost-effectiveness of these traditional, native, and alternative buffer and waterway mixes, we will measure each test plot for biomass production and relative forage value. In June, all plots will be subjected to simulated rainfall to assess runoff quantity and quality.

2010 is the beginning of the 3 year project. We hope to learn more over the next 2 years about which plots sustain quality forage amounts and which plots retain soil.

Cooperators

Ed McNamara, Farmer, Goodhue, MN
Mark Zumwinkle, Minnesota Department of Agriculture, St. Paul, MN

Project Location

From St. Paul, take Hwy. 52 through Cannon Falls. 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 our Streams, 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

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Project Duration

2010 to 2012

Award Amount

$7,926

Staff Contact

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Author: Cassie Boadway

Keywords

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

Project Summary

Alfalfa is a perennial crop that is important in sustainable cropping systems because it fixes nitrogen, improves soil health, reduces soil erosion, and provides high-quality forage for ruminant livestock. Economic analyses have shown alfalfa to be a profitable crop for haying and grazing. For alfalfa to be productive and persistent it needs fertile soil. Fertilizing with potassium has generally been recommended because harvesting alfalfa for hay or haylage removes a large amount of this important nutrient. Emerging evidence indicates that boron and sulfur may be more important than first thought. This project is testing the effects and interactions of potassium, sulfur, and boron fertilizers to discover fertilization strategies that optimize the economic performance of alfalfa production on Minnesota farms, benefitting overall profitability and sustainability.

Project Description

On May 17, 2010, forage researchers from the University of Minnesota planted a replicated small plot experiment on the Paul Beckman farm in Otter Tail County.

Our experimental design included a fall or spring application of potassium, sulfur, and boron at different application rates (Table 1). The fertilizers and rates were combined into all possible combinations and replicated three times, for 144 total plots. Fertilization timing was used on the whole plot. Potassium application was used on a subplot, sulfur on a sub-subplot, and boron on a sub-sub-subplot.

Our field activities are listed in Table 2. While we harvested twice this year to control weeds, remove biomass, and stimulate regrowth, real data collection will begin in year 2.

Looking Ahead

In 2011 and 2012, we expect to take four cuttings per year, with the last one in October. Plots will be harvested with a small-plot flail harvester. Maturity and weed content will be documented at all harvests, and several representative samples obtained to determine dry-matter content. Fresh weights of harvested material will be measured on site, and then adjusted to a dry-matter basis. Stands will be measured each spring when spring growth is approximately 6" in height. Soil samples analyzing potassium, phosphorus, pH, organic matter, sulfur, boron, calcium and magnesium will be collected throughout the life of the study across treatments and cross-referenced with harvest data. In spring 2011 and 2012, we will take soil samples from all 48 treatment combinations. This data, combined

Our small-plot forage harvester.

Table 1. Timing, Fertilizer, and Rate Treatments

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

Table 2. 2010 Field Activities

Date	Activity
April 19	Host farmer fertilized entire site area with 120 lb N, 30 lb P, 30 lb K, 15 lb S, broadcast and incorporated, in anticipation of planting corn.
May 17	Seeded "Rebound 5.0" alfalfa at 16 lb/A with a 5-row Wintersteiger self-propelled forage planter.
June 1	Took soil samples and submitted them for laboratory analysis of K, P, S, B, Ca, Mg, pH and OM.
June 9	Sprayed Raptor® herbicide because of heavy weed pressure from lambsquarters and redroot pigweed.
July 13	Harvested entire site to remove biomass and stimulate regrowth. No yield data taken.
August 16	Harvested site again. No yield data taken.
August 20	Sampled and analyzed soil (as above).
Sept. 28	Applied lime at 1,140 lb of effective neutralizing power (ENP)/A to raise the soil pH from 5.8.
October 5	Applied fall fertility treatments.

with the yield and value of the alfalfa grown, will help us determine costs, returns, and the profitability potential of the various fertility treatments.

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 most often the factors that limit your production.

2. 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
Phil Glogoza, University of Minnesota Extension Crops Educator, Moorhead, 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.

Using Solar Energy to Heat the Soil and Extend the Growing Season in High Tunnel Vegetable Production

Principal Investigator

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Otter Tail County

Project Duration

2008 to 2010

Award Amount

$17,692

Staff Contact

Jean Ciborowski
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Keywords

high tunnel, solar heat, tile lines, tomatoes, vegetables

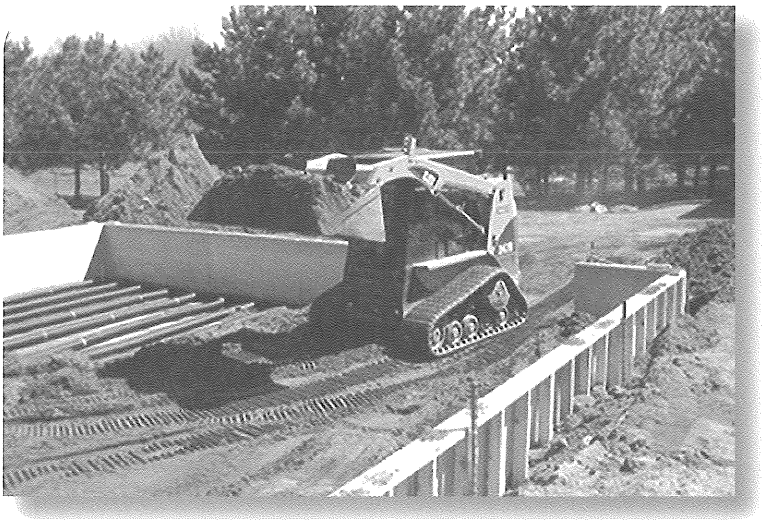
Project Summary

In 2008, we installed a 30' x 48' high tunnel that uses solar heat to warm the soil below the tunnel. We pump hot air from two solar panels through a series of corrugated tile lines buried beneath the structure. In addition to improving plant health with warmer soils, the heated tunnel had much warmer nighttime temperatures, especially during the critical period of early to late spring. During 2009 and 2010, our tunnel had no frost from the middle of March to the middle of November, and the temperature rarely dropped below 45°F during the growing season, increasing growing degree days by a third. We harvested some crops grown in the tunnel two months earlier than their counterparts grown outside and estimate that we could pay for the tunnel in 3 to 4 years by selling our early tomatoes and cucumbers at the farmers' market.

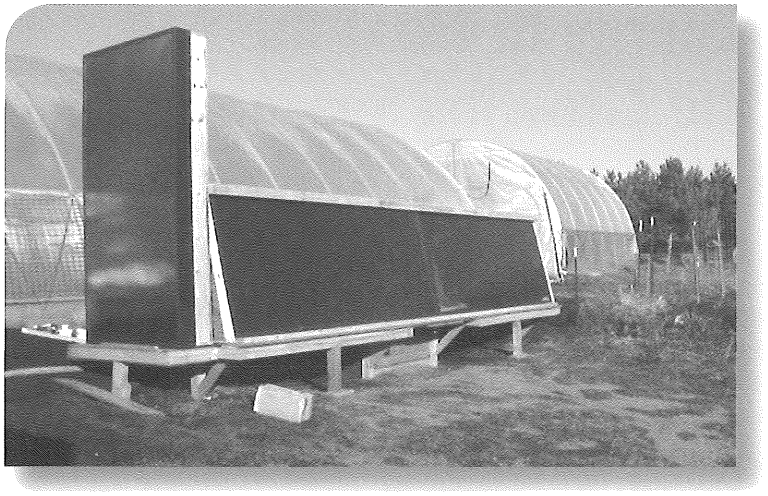
Project Description and Results

My wife and I raise vegetables and shiitake mushrooms at a small farm just south of Frazee to sell at a nearby farmers' market and to restaurants. Several years ago, we started raising vegetables in a small 20' x 24' high tunnel. The high tunnel extended our growing season from 120 frost free days to 150-170 days, but the traditional high tunnel did a poor job of warming the soil and preventing spring frost damage.

In 2008, we built a high tunnel that uses solar heat to warm the soil beneath. I excavated an area 4' deep next to my old high tunnel, separating the topsoil and the sand subsoil. I covered the bottom of the hole and the bottom 2' of the sides with 2" Styrofoam insulation. I used 4" thick insulation on the top 2' of the sides. The insulation at the bottom of the excavation was covered with 1' of sand and then I placed one layer of 4" corrugated plastic drain tile over the sand. After covering the tile with sand, I installed a second layer of drain tile 8" above the first line, with the lines perpendicular to the first line. This line was covered with sandy subsoil. The corrugation in the tile increased the surface area contact between soil and tile so that there is 8' of surface area for every 5 linear feet of tile. On top of the sand, I put 18" of "Dicks Super Soil," a decomposed peat topsoil. The topsoil was supported on the outside with 2" x 12" white oak boards. The special soil proved to be low in potassium, so we added compost made from cattle manure into the soil in 2009. I formed the soil into raised beds and covered the raised beds with black plastic.



Backfilling over the tile line during construction.



The high tunnel structure.

We installed a 30' x 48' FarmTek high tunnel over the heated soil area. The covering for the tunnel consists of two layers of plastic, which makes an insulating air chamber between the layers. While the double layer of plastic decreases the amount of sunlight reaching the crops, it increases insulation, which can be critical in early spring. It is important to note that the loss of sunlight from the double layer of plastic is not enough to negatively affect the growing of our plants.

We installed two solar panels to heat air that is pumped into the two layers of tile lines 3' below the soil in the tunnel. A fan pumps air back from the drain tiles in the soil through the solar panels. The fan is controlled by a thermostat, which turns the fan on when the temperature in the solar panel reaches 125°F, and turns it off when it drops below 85°F. We kept the thermostats operational all winter long.

2008/2009

The winter of 2008/2009 was colder than average. Although the heated high tunnel stayed much warmer than either the outside or the unheated high tunnel, the temperature was too cold for anything to grow during January and February. Key temperatures for both 2009 and 2010 are summarized in Table 1.

After March 7, soil and nighttime temperatures rose rapidly and we started planting tomatoes and cucumbers in the heated tunnel on March 15 when the soil temperature was 45°F. The tomatoes grew very well, but the first cucumbers either died or were permanently stunted by the cold. Radishes, lettuce, and chard were planted in the tunnel in early March as well. Spinach and kale that we'd planted in the fall overwintered in the tunnel.

We started selling cucumbers in early June. We started harvesting tomatoes on June 7 and started selling tomatoes on June 15, which was 8 weeks earlier than in the unheated high tunnel! We sold out every time we went to the farmers' market and we became known for quality cucumbers and tomatoes. Seventy-five percent of our sales in 2009 were from high tunnels. We calculated that the heated high tunnel helped our business and total returns were up 35%.

We planted kale and spinach in the fall for harvest next spring. We continued harvesting tomatoes until the end of November, then down the tunnel in December to give ourselves a rest and allow the tunnel to freeze in order to reduce disease and insect pests.

2009/2010

The winter of 2009/2010 was fairly mild, and spring arrived early. The coldest temperature we recorded for the winter was -34°F, but lowest recorded temperature in the high tunnel was only -1.6°F. The soil temperature in the tunnel first rose above freezing on March 1; the last freezing air temperature recorded in the high tunnel occurred on March 19. After March 22, the temperature in the high tunnel did not fall below 45°F for the rest of the growing season. As in previous years, we were able to add about two months to the growing season in the spring.

When the soil is adequately warmed, the air temperature in the heated tunnel typically stops dropping 2 hours after sunset and stays at the same temperature the rest of the night. In 2010, we had a cloudy and rainy spell from March 8 to March 16, before the soil in the tunnel had warmed up sufficiently. When sunny weather returned on March 16, it took three sunny days before the soil temperature rose sufficiently to keep nighttime temperatures warmer than outside. We think the availability of sunlight is more important in heating the tunnel in the spring than what the outside temperature is.

In the spring, before the soil warms it can act as heat sink, cooling the air in the tunnel. By contrast, in the fall when the soil is warm from summer heat, the tunnel stayed at the same nighttime temperature during more than a week of cloudy weather (Figure 4). During the second week of cloudy weather, the temperature in the tunnel dropped into the mid 40's, but was still 20° greater than the outside temperature.

Table 1: Comparisons between March 1-21, 2009 and March 1-21, 2010

Year	Date soil thawed	Date air remained above 40°F	Average air temperature	Days with sunshine
2009	March 8	March 14	25°F	19
2010	March 1	March 20	35°F	8

In both 2009 and 2010, the number of growing degree days (GDD) in the heated high tunnel was a third higher than outside (Table 2). The biggest difference between the outside and the high tunnel occurred during March, April and October, which are the months we are trying to extend our growing season.

A local restaurant ordered produce even before the farmers' market started. In March, we started harvesting the kale and spinach we had planted last fall. We planted lettuce and radishes in March and started harvesting both crops in April. The radishes grown in the high tunnel were double the size of those grown outside. We started selling fresh vegetables at the Detroit Lakes Farmers' market in the middle of May, which helped increase the customer count at the market.

All our crops produced quite well in 2010, except for tomatoes. Cucumbers had high yields through October.

Because we had a poor pepper crop in 2009, in 2010 we purchased and released bumble bees in the tunnel for pollination of the peppers and eggplants. Our eggplant, pepper and bush bean yields were quite high this year.

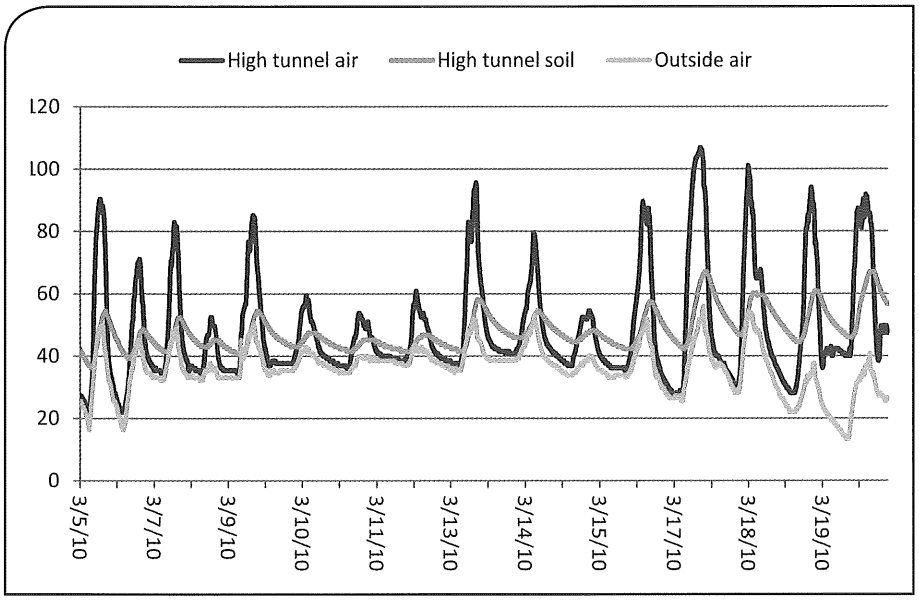
The 2010 growing season was a bad one for tomatoes grown both inside and outside. Outside, there was high disease pressure. In the high tunnel, high humidity contributed to disease pressure, including leaf spot and gray mold. The gray mold attacked some tomato vines which caused the tops of the vines to die. We think the milder winter temperatures inside the high tunnel might also have allowed more fungi to survive the winter. Out of the tomato varieties we grew the Cherry tomatoes had the fewest diseases.

Last year, we had "gray wall" on our tomatoes, which is a physiological disorder of the tomato fruit caused by low potassium. During the winter, we amended the soil with

Table 2: Temperature and growing degree days (base 50) for 2009 and 2010.

Month	Outside				Heated High Tunnel			
	Mean Air Temp 2009 (°F)	Mean Air Temp 2010 (°F)	GDD 2009	GDD 2010	Mean Air Temp 2009 (°F)	Mean Air Temp 2010 (°F)	GDD 2010	GDD 2009
Mar.	25.3	36.5	4	23	51.6	52.6	262	157
Apr.	42.5	51.5	69	173	63.4	63.1	391	319
May	55.2	57.0	243	307	65.9	64.1	434	445
Jun.	64.0	66.0	432	470	68.6	67.2	510	526
Jul.	67.3	72.2	497	671	68.8	73.1	712	549
Aug.	66.0	71.3	494	643	67.0	72.5	692	534
Sep.	63.0	55.0	387	173	64.6	60.3	302	415
Oct.	41.4*	51.3	0*	3	54.2*	59.0	280	51*
Total			2,072	2,383			3,470	2,920

**The temperature in October 2009 was only recorded for the first 12 days of the month.*



Outside temperature, soil temperature and the temperature inside the high tunnel throughout March, 2010.

green sand to add potassium. We still had gray wall this year, but not as bad as in 2009.

The temperature in the heated high tunnel stayed above 45°F through the middle of November, and we could have continued harvesting through the middle of December. However, the farmers' market closed by the end of October and the restaurant buying our produce closed for the season due to a fire. We were tired and ready for the growing season to end so we pulled the tomato and cucumber plants on November 5.

Conclusions and Future Plans

The heated high tunnel cost $23,000 for materials and labor. Our financial outlay would have been lower if we had done more of the construction work ourselves instead of hiring it out. The heated high tunnel gave us a frost-free growing season from the middle of March through the middle of November in a Zone 3 climate. The longer growing season gave us increased yields and we were able to sell vegetables at a time when there were no other locally grown vegetables at the local farmers' market. We estimate that we could pay for the tunnel in 3 to 4 years by selling our early tomatoes and cucumbers at the farmers' market.

We have more ideas to improve our heated high tunnel system. To improve soil warming I would like to install a third tile line that collected air from the top of the tunnel and moved the air back through the soil. High tunnels increase humidity around the plants and also increase the amount of dew; water vapor is often trapped inside the plastic, causing the humidity to rise and contributing to disease. In 2010, we kept the sides of the tunnel rolled up both day and night after the middle of April. If we were to do this project over, we would have designed the high tunnel with drop down top doors at the ends to get rid of the humidity that was coming off the high density of plants.

We would like to be organic in our high tunnel. Although we did not use chemicals on cabbages and radishes we did use two products that were not allowed in organic production on tomatoes. With the extremely long growing and harvest season, it is very difficult to supply tomatoes with adequate nutrients only using organic fertilizers and disease pressure.

We would and have recommended the heated high tunnel to other farmers. It would be beneficial if research was done to see if a high tunnel could financially support a family. Most of the people who have seen our high tunnel want to adopt its design, especially if they are involved in farmers' markets. The fact that the high tunnel is heated is a special benefit for farms that are this far north. Growers like us would benefit from attending seminars on disease and pest management. We also need to find cultivars that are more suited for this system.

Although there is always room for improvement, we are generally very happy with the design and performance of our solar heated high tunnel and are going to try growing small fruit trees in it next.

Management Tips

1. Install and use an exhaust fan in the high tunnel because it is critical to reducing humidity in early morning.

2. Always place solar panels to receive the maximum amount of sunlight throughout the day.

3. Be vigilant about rolling up high tunnel sides in the morning during early and late season. Consider installing a computer-controlled mechanism that automatically rolls up the sides when the temperature reaches a certain point.

4. Plant nutrition is critical in high tunnels. Always do soil tests in fall in order to make sure soil nutrients will be adequate the following growing season.

Cooperators

Terry Nennich, University of Minnesota Extension, Bagley, MN
Thaddeus McCamant, Northland Community and Technical College, Detroit Lakes, MN

Project Location

Forest Glenn Farm is 4 miles southeast of the town of Frazee. Take Hwy. 10 east of Frazee and go south on Black Diamond Rd. approximately 1.5 miles. The road will "T". At the "T", go right on Rice Lake Rd. approximately 2 miles. Our farm is located at the end of the road. Go through the public access and then you are at our farm.

Other Resources

FarmTek high tunnels. Website: *www.farmtek.com/farm/supplies/home*

High Tunnels website sponsored by Kansas State Research and Extension, University of Missouri Extension, and University of Nebraska Cooperative Extension. Website: *www.hightunnels.org/*

Nennich, T., David Wildung, and Pat Johnson. 2004. Minnesota High Tunnel Production Manual for Commercial Growers. Website: *www.extension.umn.edu/distribution/horticulture/M1218.html*

Pennsylvania State University High Tunnel Website: *http://plasticulture.cas.psu.edu/H-tunnels.html*

Growing Blackberries Organically under High Tunnels for Winter Protection and Increased Production

Principal Investigator

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Dakota County

Project Duration

2009 to 2011

Award Amount

$19,445

Staff Contact

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Keywords

blackberry, high tunnel, trellis, winter protection

Project Summary

Can organic blackberries be grown commercially in southeast Minnesota? Scenic Valley Farms (SVF) has been growing blackberries on a limited scale, and with limited success, using the labor intensive practice of tipping the plants and covering them with mulch for winter protection.

Growing blackberries in high tunnels with auxiliary heat should allow us the opportunity to commercially produce organic berries with a decrease in labor. We will evaluate the yields and survival of several blackberry varieties grown in high tunnels for winter protection.

Project Description

Scenic Valley Farms was started in 2008 in Rosemount, MN with the goal of growing blackberries for commercial production in a northern climate. Our company designs and manages high tunnels, semi and fully automated climate control systems, and subterranean solar thermal heating systems. SVF maintains five semi-automated high tunnels that produce blackberries, raspberries and tomatoes.

Market research indicates an annual demand for one million pounds of organic blackberries in the Upper Midwest. We have received interest from several U.S. organic wholesale food distributors; including Organic Valley Coop, Naturite Farms, and Sun Belle Inc. We plan to produce 3 acres of blackberries under high tunnels and anticipate a yield of 30,000 lb/A/yr.

While the regional demand for organic blackberries is large, growing commercial grade blackberries in Zone 4 or colder zones without winter protection is virtually impossible. For instance, commercial blackberry farms grow blackberry cultivars that are viable in Zones 5 –10. In Zone 5 and above, the practice of tipping blackberry plants and covering them with mulch for winter protection is commonly used. However, we have found that this practice in Zone 4 provides only minimal winter protection and results in the loss of more than 75% of blackberry plants. Poor winter survival and the resulting poor yield, combined with the high labor costs to cover and uncover the canes, makes growing blackberries in a Zone 4 or colder climate unprofitable.

Drip irrigation and fertigation system.

High tunnel T/V trellis system.

The *primary objective* of the project is to determine the viability of growing organic blackberries under a high tunnel for commercial production in a Zone 4 climate. The *second objective* is to research, record and evaluate the crop production processes required to grow organic high tunnel blackberries for commercial production. The *final objective* is to design a portable forced-air cooling system to provide post harvest management of the berries.

In 2009, we worked with Poly-Tex® of Castle Rock, MN and consulted with Terry Nennich to design a high tunnel suitable for blackberry production. Our requirements included straight side walls with sufficient height clearance to support a 7' trellis system; a gothic peak for optimal snow load capacity; and a price that is competitive with other high tunnels on the market. Poly-Tex designed and developed the Field Pro using these specifications.

We prepared the land for the high tunnel by using black plastic to smother weeds and then fertilized the soil using well rotted horse manure and recycled mushroom compost.

The high tunnel was put up with help from our relatives and friends. Inside the tunnel we installed a wooden "T/V" trellis system to support the berry canes. The "T" shaped posts were spaced 10' apart with two strands of wire that run tip of "T" to tip of "T" for a total of four runs. The canes that grew this year were tied to one side of the strand and they will bear next year's fruit. The canes that produce fruit next year will be pruned to the ground to make room for the following year's primocanes. The ventilation system in the tunnel consists of end doors, motorized side curtains, circulation fans, and gable end motorized ventilators. All of these systems are controlled using sensors.

In 2009, we planned to test seven thornless blackberry cultivars (Natchez, Ouachita, Apache, Doyle, Triple Crown, Chester, and Doyle) but they were not available when we went to purchase them. The blackberry varieties were selected for their early to late season maturation dates and by the recommendation of Dr. John Clark, a blackberry breeder from the University of Arkansas. We decided to order and plant the aforementioned varieties in May, 2010. Since, we already had 'Prime Jan' and 'Prime Jim' established we built a PVC high tunnel over them in an attempt to extend the season.

The soil in the high tunnel was amended by mixing in equal parts mushroom and dairy manure compost at a rate of one wheelbarrow full per ten row feet and was tilled in. After planting, the canes were mulched with a combination of mushroom compost and straw.

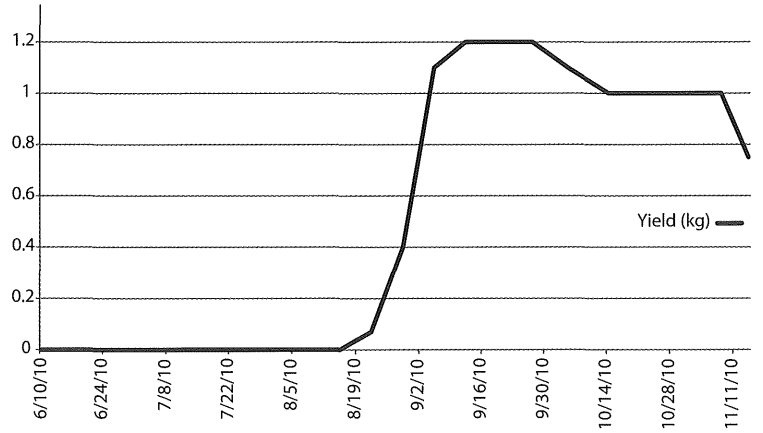
The floricane blackberry canes were planted on May 15 in a 30' X 60' gothic style high tunnel, which included: Triple Crown, Arapaho, Chester, Apache, Ouachita, and Natchez varieties. The canes were planted in four linear rows 7' apart with the outer two rows 4.5' from the side walls. The plants were spaced 3' on center with 80 total in the tunnel. The floricanes were tied to the trellis wire and tipped at 6' to encourage horizontal growth. The small PVC high tunnel we built over 'Prime Jim' and 'Prime Jan' protected the plants over winter.

As soon as the new canes reached 5' they were tipped and within 2 weeks laterals appeared that supported blossoms. We pruned during the season which encouraged new blossoms.

Acclima SC6 controller.

Both high tunnels employ in-line drip irrigation

Figure 1: Weekly 'Prime Jim' and 'Prime Jan' Blackberry Yields (kg).



and Acclima moisture sensors to regulate irrigation and fertigation cycles. The sensors measure moisture content as a percentage, soil temperature and soil conductivity. The Acclima controller monitors six zones and waters each as needed. Initially, the plants were provided 3 gal of water per day in two 1.5 hour cycles once in the morning and once in the evening. Once the primocane varieties began fruiting, the irrigation levels were increased to a total of 4.5 gal divided between three watering cycles. For fertilization we used a one gallon EZ flow fertigation system with an organic fertilizer containing bat guano.

Project Results

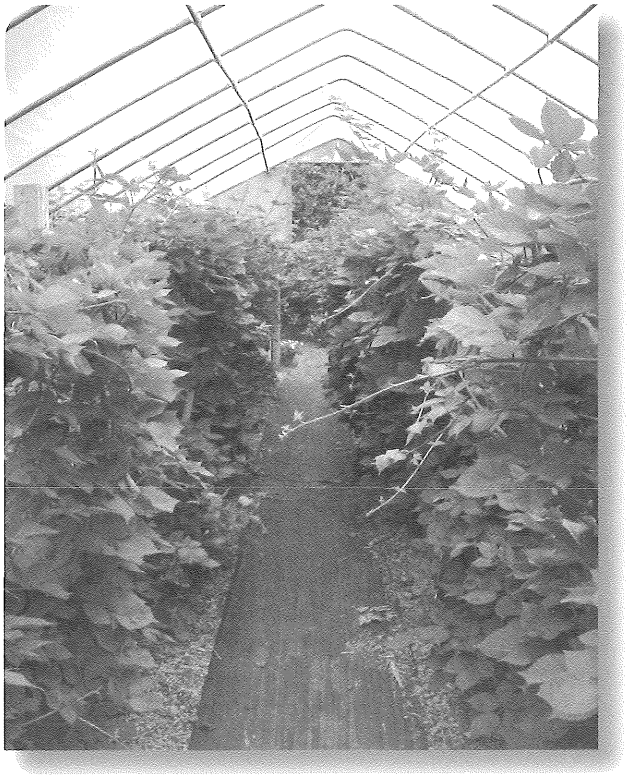
In order to control weeds we utilized three techniques. In the PVC high tunnel a layer of wood chips was spread on the floor. In the gothic style tunnel, we laid down sheets of cardboard before spreading wood chips. In a third high tunnel at our farm in Wisconsin, we rolled out 14-24 mil black polyester material in widths of 3' and 6'. The most effective technique appears to be the black polyester material, which also has the added benefits of controlling soil erosion and reducing labor. 'Prime Jim' and 'Prime Jan' began fruiting in early August. Harvest started in August and continued through November (Figure 1). Individual fruit size averaged between 6-15 g and was often difficult to pick at optimal ripeness because of its softness. These varieties have thorns that made picking more difficult and required that pickers wear gloves and flannel shirts.

During the summer it was difficult to maintain optimal temperatures of 80-85°F inside the high tunnel. Some poor drupelet formation occurred due to temperatures in excess of 100°F. We think high temperatures would be easier to remedy in the larger high tunnel because they have greater ventilation capabilities. High temperatures were not the only problem we had in our high tunnel. In early September a small amount of the berries experienced Botrytis fruit rot due to cool and moist conditions. We started closing the tunnel at night to raise the temperature and the fungus mostly cleared up as the result of the warmer temperatures.

The final harvest occurred on November 18. After that date, auxiliary propane heat was suspended and the brambles were allowed to enter the dormant phase. The photos below demonstrate the season extension capabilities of high tunnels when coupled with propane heat.

In the high tunnel containing Triple Crown, Arapaho, Chester, Apache, Ouachita, and Natchez floricanes contained a few brambles that bore small yields (several berries or less per plant). Typically, floricane blackberries do not produce until the second year and no approximate cause was detected for these plants early yields.

The floricanes displayed no visible signs of disease or pests throughout the growing season. This is typical during the first year when foliage development is relatively minimal. The second and third years have a much higher incidence of disease and pest outbreaks so the brambles will be monitored closely. However, in the early winter months rabbits entered the high



Primocanes 'Prime Jim' and 'Prime Jan.'

Photo taken on November 14 in 'Prime Jim' and 'Prime Jan' High Tunnel.

tunnel and girdled the canes. Roughly 10-15% of all the canes were either destroyed or badly chewed. Within 2 weeks, the rabbit would have destroyed all of the canes. Interestingly, the rabbit only attacked the young thornless floricanes. We blocked off the possible entrances and set two traps inside. A few days later, a rabbit was found in one of the traps and we have not experienced any girdling since.

The plants took a long time to freeze in the late fall due to the warmth provided by the high tunnel. In addition, snowfall in December created an insulating effect and the tunnel was 10-15°F warmer than outside temperatures. After they were dormant we used a thermostatically controlled 170,000 BTU propane heater that was set to maintain minimum temperatures of a zone 7b climate (5-9°F).

The plants were watered heavily before the irrigation system was turned off. A lack of moisture throughout the winter is a concern and we will provide updates on how this affected the plants. We are also concerned an expected temperature increase in the high tunnel in February may promote premature budding.

Overall, the project has reduced labor and input costs. The moisture sensors provide automatic irrigation and fertigation in the high tunnel. For instance, the drip emitters reduced the amount of water required and the in-line fertigation provided precise amounts of liquid fertilizers. The black polyester material and wood chips dramatically decreased the amount of time devoted to weed management. The major inputs of labor occurred during site preparation and harvest (although even these periods were very manageable). In addition, the same management techniques that reduce input costs also had a positive environmental impact by conserving water and reducing soil erosion.

Market Potential for Blackberries

We did not market any of our blackberries this growing season. Next year, we intend to develop markets for the floricane varieties under production at our farms in Rosemount and Readstown. Wholesale food dealers generally pay $5-6/lb for organic blackberries from June 1 through November 30. We have received strong interest from Sun Belle Inc. of Chicago and Bergin Fruit and Nut Company of St. Paul. Other outlets include supermarkets, grocer cooperatives, CSAs, restaurants, and farmers' markets.

The lack of locally grown blackberries creates a tremendous opportunity for any grower capable of bringing blackberry production closer to major cold weather markets. The local, organic aspect of the blackberries, along with their exceptional taste and freshness, should be emphasized in any marketing campaign.

Management Tips

1. Laying black polyester material between the rows is the most effective weed management technique. We recommend leaving sufficient space between the material and the base of the plant in order to allow new canes to form.

2. Be careful to monitor and manage temperatures within the high tunnel. Attempt to keep the temperatures between 80-85°F because higher temperatures increase the risk of improper drupelet formation, Botrytis blossom, and fruit rot.

3. Do not use fish emulsion based liquid fertilizer in a drip irrigation system with emitters because it will clog them.

4. When ordering brambles such as blackberries, order plants early, no later than February.

5. Continually pruning of 'Prime Jim' and 'Prime Jan' resulted in continual blossoming.

6. Partial shade negatively affects plant development.

Cooperators

Terry Nennich, University of Minnesota Extension, Crookston, MN
Brad Becker, Dakota County SWCD, Farmington, MN
Craig Gundacker, Scenic Valley Farms, Rosemount, MN
Rebecca Harbut, University of Wisconsin, Madison, WI
Kathy Demchak, Penn State University, University Park, PA

Project Location

From I-35E, exit at Pilot Knob Rd. (exit 97A) and go south about 5 miles to McAndrews Rd. Go east .7 miles to Danbury Way. Turn south. Scenic Valley Farms is .6 miles on the west side of the road.

Other Resources

High Tunnels website sponsored by Kansas State Research and Extension, University of Missouri Extension, and University of Nebraska Cooperative Extension. *www.hightunnels.org/*

Nennich, T., David Wildung, and Pat Johnson. 2004. Minnesota High Tunnel Production Manual for Commercial Growers. *www.extension.umn.edu/distribution/horticulture/M1218.html*

Safley, C. D., O. Boldera, and G. E. Fernandez. 2006. Estimated Costs of Producing, Harvesting, and Marketing Blackberries in the Southeastern United States. HortTechnology 16: 109-117. *www.ncsu.edu/project/berries/extension/blackberry_budget.pdf*

University of Minnesota High Tunnel Production Website: *hightunnels.cfans.umn.edu*

Raspberry and Blackberry High Tunnel Production Guide: *www.fruit.cornell.edu/berry/production/pdfs/hightunnelsrasp2009.pdf*

Pruning and Trellising Brambles: *http://agresearch.umd.edu/RECs/WREC/files/MDBayAreaBramble%20Pruningv2%202-18-09-Demchak.pdf*

Growing Raspberries and Blackberries in a High Tunnel – Iowa State University: *www.extension.iastate.edu/NR/rdonlyres/BA5DB27B-4472-4D15-89A0-185DD532C4DF/95187/Hitunnel09.pdf*

Extended Growing Season for Lettuce

Principal Investigator

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Project Duration

2008 to 2010

Award Amount

$4,556

Staff Contact

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Keywords

cooling, lettuce, season extension, shade, water misters

Project Summary

I undertook this project in order to see whether using shade cloth houses and jet fog misters to lower the air temperature over lettuce beds will create an environment that will provide a continuous supply of lettuce throughout the growing season here in central Minnesota. I farm near Sebeka and sell lettuce and herbs to several area restaurants. In spring and fall, my lettuce is of very high quality. The problem is that in July and August, we typically get high temperatures (above 80°F) that can cause lettuce to bolt or taste bitter. Seeing the use of water misters in local grocery stores and how effective they were sparked my interest and made me wonder if water misting could be used to create a cooler growing environment for lettuce.

Project Description

To prepare my two 10' wide by 25' long lettuce beds, I first use a weed burner over the area to burn any weed seeds in the soil. Then I haul and spread organic material (llama pellets in 2008, grass and composted materials in 2009) to a depth of 3" to 4" over the plots. I use a garden tiller to mix the organic material along with organic fertilizers (blood and bone meal) into the soil to a depth of 8". I then level the beds with a hand rake. Next, I push a 1/2" by 20' long pipe into the soil to form semi-circular indentations 1/2" to 3/8" deep. These long, straight indentations receive a sprinkling of lettuce seeds (Black seeded Simpson, Butter crunch, Oak leaf, Iceberg, etc.) along their length. I fill the indentations with peat, tamp lightly, and then use a common garden spray hose to keep the seed beds damp.

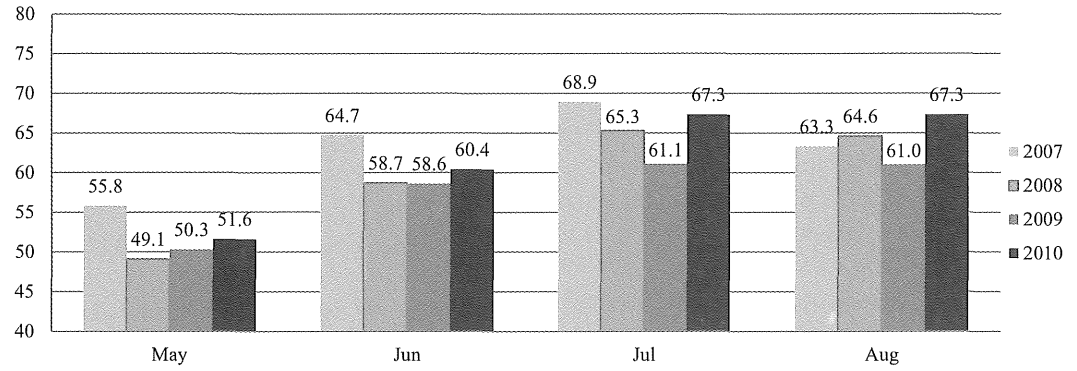
I use two shade cloth houses that I ordered from FarmTek® in April of 2008. One provides 50% shade and one provides 70% shade. I also ordered the jet fog misters and filter from FarmTek®.

As a control, I left 5' of the beds without shade cloths or misters so I could compare performance of my old system (no shade, no mister) and two versions of the experimental system – 50% shade + misters and 70% shade + misters).

In 2008, I used a total of 16 misters in each house: 2 rows of 8 misters placed 2' apart and concluded that was probably too many; instead of misting, it was almost raining in the shade cloth houses and the ground was way too wet for lettuce. In 2009, I changed the number and placement of the misters, doubling the space between them to 4'. This is a much better arrangement compared to last year, and gets the job done just right. My plan both years was to turn on the misters once the temperature reached 80°F in the shade houses. I used temperature gauges inside and outside the houses to record temperature differences.

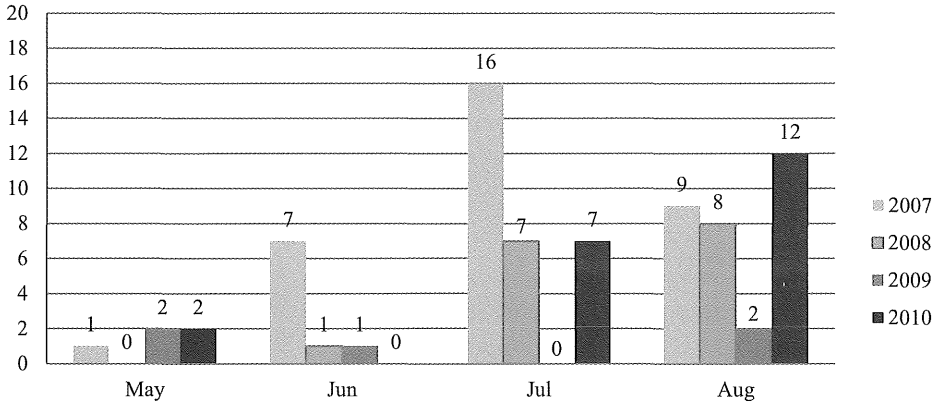
The farm is located on sandy soils and surrounded by the piney woods of west central Wadena County.

Table 1. Average Temperatures (°F), Wadena, MN



Source: www.wunderground.com/history

Table 2. Days over 80°F, Wadena, MN



Source: www.wunderground.com/history

Table 2 shows the number of days warmer than 80°F. In 2007, we had 33 days of weather that was 80°F or warmer. In 2008, we had about half that many (16). 2009 was cooler still; the temperature reached 80°F on only five days! This is great weather for growing cool season crops, but not for testing the effectiveness of mist-cooled shade houses.

A cool growing season in 2008 meant that I used the mister system on only 11 days. It lowered the temperatures over the lettuce by 15°F. However, I found the shade houses provided the unanticipated benefit of protecting my lettuce from the persistent winds we had. The lettuce beds under shade retained their moisture much better than the lettuce in the control bed and yielded about 20% better growth with an estimated 60% less water. In 2008, I observed that the darker house (70% sun reduction) outperformed the house with 50% reduction.

In 2009, the weather was even colder than the year before! Table 1 shows the mean (average) temperature in Wadena for 2007-2010. In general, July and August of 2008 were cooler than the same months in 2007. In 2009, the July-August mean temperature was cooler still.

2010 Results

What a difference in weather in the 2010 growing season. We had much warmer temperatures than the three previous years, with an average July-August temperature of 67.3°F and 21 days above 80°F! We also had much more rainfall. Sweet corn and field corn were outstanding in taste and yield. However, tomatoes and yes, even lettuce, could have been better.

Battling blackspot and powdery mildew was a constant challenge, since the ground in this area was wet most of the growing season. As a result, many area farmers, including myself, did not have to water much at all. The jet fog misters in the two shade houses worked fine when needed, but that was not very often. I placed the misters on timers this year and programmed them for 3 - 4 hr each day for the hottest part of the day (noon to 4:00). All the rain in late June and July made it necessary to turn the system off for about 6 weeks, however.

Thinning was the most important thing the lettuce beds needed, due to the almost constant rainfall. Thinning the lettuce plants was paramount because high density was causing disease to run rampant.

A second planting in July was a better test of the system this year. When needed, the jet fog misters worked great. On several occasions, I documented a 20° F difference in temperature inside houses compared to the outside temperatures. The shade houses did very well, compared to the outside beds. The lettuce in the control beds (outside) went bitter and bolted three weeks before that in the shade houses. In addition, the yields in 50 ft^2 control beds was 22% less than any 50 ft^2 area of inside the shade houses.

Once again, the house with the 70% reduction cloth outperformed the house with the 50% reduction, this year by approximately 10%. I think this system may be the way to grow lettuce, however, a very hot, dry summer will be the only true test. I calculate that this system can save approximately 60% on water, and in some years that's critical. It can also extend the growing season long enough to get a second crop of lettuce. I think precise measurement of soil moisture and different planting densities are two aspects of the system that need more attention. I would continue these practices, however, due to personal reasons I am selling my farm.

Management Tips

1. Using shade cloth conserves moisture in windy areas, sometimes as much as 60%.

2. Firmly bolt earth anchors on each leg of the shade houses.

3. Use eight misters per 250 ft^2 of growing area (or about 1 mister/31 ft^2). Set misters to 1 gal/hr at 40 PSI.

4. Amend soil in lettuce beds with highly organic materials that will hold soil moisture. Peat and grass and other composted materials work well.

5. Thin! I cannot over emphasize the importance of thinning of young lettuce plants. Adjoining leaves can lead to disease problems because the misters create high humidity conditions.

Project Location

From Sebeka, travel east on MN-227 to Nimrod. Turn left (north) on Cty. Rd. 18 for 6 miles. Then, turn east on 320th St. for 1 mile.

One of the lettuce beds before the shade cloth went on.

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

Principal Investigator

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Project Duration

2010 to 2012

Award Amount

$6,000

Staff Contact

Meg Moynihan
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Keywords

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

Project Summary

I undertook this project in order to see whether using shade cloth houses and jet fog misters to lower the air temperature over lettuce beds will create an environment that will provide a continuous supply of lettuce throughout the growing season here in central Minnesota. I farm near Sebeka and sell lettuce and herbs to several area restaurants. In spring and fall, my lettuce is of very high quality. The problem is that in July and August, we typically get high temperatures (above 80°F) that can cause lettuce to bolt or taste bitter. Seeing the use of water misters in local grocery stores and how effective they were sparked my interest and made me wonder if water misting could be used to create a cooler growing environment for lettuce.

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 with the remaining land sustainably managed. In June 2010 we started a business called Jubilee Fruits and Vegetables. We use a movable high tunnel, traditional outdoor gardens, and rows of quick hoops (sometimes also called "low tunnels"). We provide a large variety of locally grown fruits and vegetables from May through December for CSA members, two schools, a hospital, a nursing home, the local food shelf, and local grocery stores.

The overall goal of our project is to research which ethnic vegetables do best using season extension strategies such as quick hoops and the high tunnel (Figure 1). The high tunnel is 30' x 48' and is on tracks, so it can rotate between 5 plots. We plant in 30" wide raised rows, with 8 rows making up each plot. We also have a 7' x 48' plot in our outdoor garden. We are testing how several varieties of Asian greens grown in 3 different locations: 1) in a traditional garden setting under quick hoops and Agribon (polypropylene row covers), 2) in a traditional garden under quick hoops and a row cover to protect plants from flea beetles, and 3) under a high tunnel for fall and winter harvest. In addition, we are starting our own large scale composting system so we can use compost as a soil amendment.

2010

It was challenging to find seeds for the plants that were recommended by the grocers and local community. We purchased seeds from

Snow covered quick hoops are in the foreground and the high tunnel is in the background.

This picture (inside the high tunnel) was taken at the end of October.

a variety of sources but found that the best germination rates came from well-known companies such as Johnny's Selected Seeds.

In June, we direct seeded two varieties of pac choi, "Black Summer" and "Joi Choi" and "Green Lance" (a type of Asian kale) under quick hoops in our outdoor garden. About the same time, we also started several varieties of hot peppers (for use in Latino cooking) indoors in soil blocks with the idea of transplanting them into our outdoor garden in June, but they did not germinate. We set up quick hoops over the rows of greens and covered them with Agribon* floating row cover, anchoring it down to prevent flea beetle attack. We did experience some flea beetle damage when the row cover was not replaced immediately after harvest; these plants were not top market quality but were sold nonetheless. We knew flea beetles would attack so we didn't think it was necessary to have an uncovered control plot and risk losing all that produce. We had a run of very hot and dry days. A soil moisture monitoring system would have been helpful.

At the end of July, we started "Black Summer," "Joi Choi," "Green Lance," "Hon Tsai Tai" and "Kyona" mizuna (Asian greens both related to mustard), and "Tokyo Bekana" (another green similar to Chinese cabbage), in soil blocks indoors.

In August, we transplanted these greens into one row in a high tunnel plot. We did not observe any flea beetle damage, so no row cover was used. In September, we experienced heavy rains, but not the high winds that took out other structures in our region. We moved the high tunnel over the plantings the first week of October.

In November, before temperatures dropped into the 20s, we placed wickets (square wire structures) over each row and a draped a large sheet of Agribon* row cover over them. We used supplemental heat for 3 days the end of November in order to maintain an inside temperature of 20°F when outside temperatures were in the single digits because we needed to have good harvest through December 1 for our CSA market boxes. We didn't plan to use supplemental heat for the rest of harvest season because we wanted to note any freezing.

We also made a direct seeding of "Black Summer," "Joi Choi," "Green Lance," "Hon Tsai Tai", "Kyona" mizuna, and "Tokyo Bekana" into a plot in the high tunnel at the end of August. We used quick hoops for protection from cold temperatures and wind.

The pac choi in the high tunnels grew 2 to 3 times larger than those we planted in the summer garden and were much tastier. The pac choi's taste may have improved due to cooler weather and adequate soil moisture. We had a soil moisture monitor and drip irrigation installed in this area of the high tunnel. We were able to harvest the "Hon Tsai Tai," "Kyona" mizuna and "Tokyo Bekana" 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 flavor fresh in salads, and cooked them in stir-fries.

These greens proved to be fairly tolerant to cold. During November the plants froze and thawed many times. When the tempurature in the high tunnel rose above freezing we were able to harvest the greens. We just removed the row covers for harvesting and replaced them afterwards. Some

After much freezing and thawing, this pac choi still looks great on December 1.

Table 1: Cold Tolerance 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" in to observe its cold tolerance (Figure 3). 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. It never produced the flowers that are to be eaten along with its young leaves. We harvested the huge leaves and marketed them. They were very tasty. It is looking doubtful if it will maintain vigor.
"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. Again, there were supposed to be flowers along with small leaves to market which never occurred. The base of the plant is at ground level and seems to tolerate the cold. 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.

observations about these greens are offered in Table 1. We had our final harvest on December 6, prior to a forecasted sub-zero low during the coming night.

Summary and Future Plans

This project provided fresh vegetables for about 20 CSA families. Fresh Asian greens filled the CSA boxes since there aren't many other alternatives during the winter months. We were able to provide Asian greens for summer and winter shares, thus doubling the farm income. We also sold some products to the owner of the Lao grocery store who were interested in organic produce.

We have decided that our "control" (outdoor) site for fall harvest needs a protected area from the gale winds. Without snow or frozen rain to hold the Agribon or plastic down, it was almost impossible to maintain order. These plots need to be planted at the end of August in an area that is cleared and has adequate soil fertility.

Next year, we plan to start all our plants indoors in January and February for early transplanting under quick hoops outdoors. We have started windrow composting using a compost turner and now have our own compost to use for soil blocks. We'll purchase the additional ingredients needed to add to the compost and soil for making soil blocks in spring. Now that our high tunnel is in place, we plan to move it over the new plot in late February in order to melt the snow and warm the soil for early plantings in March.

To answer more of our season extension questions we plan to use different seed varieties, buy temperature and moisture monitors for air and soil, and purchase a field scale so we can record harvest weights in 2011. We need to monitor temperature control, humidity and irrigation to improve germination rates of the plants such as peppers. To help our marketing efforts, we are planning to offer harvest extravaganza dinners for share members and others. Our goal for these events is to build a feeling of community and sample new recipes. We tested the reception and marketability of the Asian greens through donations to a Lao women's bimonthly potluck, owners of the Lao grocery store, CSA share members, and friends.

Management Tips

1. Plan for differing germination rates and the temperatures the seeds require for germination.

2. Have a market for your produce. We suggest cleaning produce to be table-ready.

3. Learn the languages and culture of your community.

4. Use transplants to extend the growing season, either with early plantings or fall plantings.

5. Protect the greens from wind, rain and insects; plants will produce better quality and quantity when protected.

Cooperators

Kelley Belina, University of Minnesota Southwest Research & Outreach Center, Lamberton, MN
Dave Birky, Ag Resource Inc., Detroit Lakes, MN
Arnold and Saenchan Chantharak, KPS Asian Store, Mountain Lake, 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 Road and Highway 60, and to the west of Cty. Rd. 1 at 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 and 2010. *www.mda.state.mn.us/protecting/sustainable/greenbook.aspx*

Organic Day-neutral Strawberry Production in Southeast Minnesota

Principal Investigator

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Dakota County

Project Duration

2008 to 2010

Award Amount

$13,695

Staff Contact

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Keywords

anthracnose, day-neutral strawberries, June-bearing strawberries, strawberry cultivars, tarnished plant bug

Project Summary

For the past 3 years, we have been comparing day-neutral (DN) with June-bearing (JB) strawberries, using organic production methods. In southern Minnesota DN cultivars may be harvested from early August to mid-October within the same year of planting. During this time of year there is a market for local organic berries. In addition, to producing berries later in the season DN strawberries can overwinter to bear in early June.

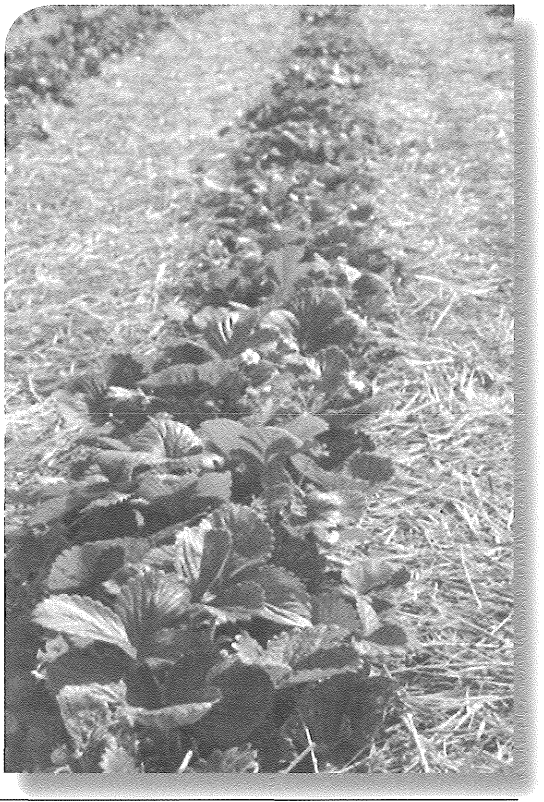
During our 3 year project we compared three varieties side by side in two growing environments (field and high tunnel), as well as ribbon and single rows. Compared to previous years we have improved pest control and weed suppression by using a dual mulching method. The addition of organic-approved paper in the third season enabled us to employ the old weeding technique of straw over paper. This "old" method was effective and our berries were higher in quality and quantity. Other benefits included reduced labor, material input, water consumption, and soil erosion.

In the final year of the project we planted strawberries in a cold frame located within the high tunnel. This was done in early March in order to extend the harvest season from May until November. The berries in the cold frame had higher quality and improved shelf-life compared to field-grown berries.

Project Description

Our small diversified farm has a garden center/nursery, an on-site store with organic produce (fruits and vegetables), preserves, and eggs. Most of our strawberries are sold as pick-your-own (PYO). Over the years we realized that there is a need for constant supply of fresh, locally grown organic berries throughout the summer.

In 2008 we began a 3 year study to develop a protocol for production and evaluate the market potential of organic, late season fresh strawberries. We thought southeast MN would be a suitable location for DN strawberries because of the length of growing season and our horticultural skills. Since customers asked us for fresh fruit later in the season, we assumed there would be a favorable market for early and late season berries. Also, we needed to see how organic production practices differed from conventional.



Row planting of strawberries.

In the first year we compared two cropping systems with three varieties grown in two different mulching systems. The cropping systems were single (matted) and multiple (ribbon) rows. The mulches included biodegradable black film and straw. The varieties included: Tribute, Seascape, and Albion. Results for this year were poor. There was major weed competition from grain seeds imbedded in the straw so the straw-mulched beds did very poorly and were discarded at the end of the season. In addition, the berries in the ribbon rows had unacceptable quality and quantity.

In 2009 only Seascape was available for evaluation. We chose the single row system for ease of transplanting and weed management. This year we only used straw mulch because the biodegradable black film no longer met the National Organic Standard for organic production. Despite varietal shortfall, we were able to confirm the findings from 2008 concerning cropping and pests. Seascape has a propensity for very early and heavy production. As in the year before, we had a steady increase in tarnished plant bug (TPB) and anthracnose between July and September, which decreased marketability significantly.

In 2010 we compared three cultivars under two growing conditions. The varieties were Seascape, Albion, and EV II which were planted in the field at 6" x 36" spacing. In the high tunnel Seascape and Albion were planted in raised beds in March. The raised beds were constructed with 1" x 8" lumber, lined with poly and weed block fabric on the bottom, and poly rollup side curtains. Prior to planting in the beds, paper was put over the beds too. At the end of September a second frame was erected over an established bed to create a cold frame. This allowed us the opportunity to compare quality and yield of the varieties grown either in a cold frame or the field.

Results

Results indicate that open-field DN strawberry production in SW Minnesota has limited value as a cash crop, due to frequent cold temperatures on both ends of the season, insect and disease pressure, and competition from weeds.

Varietal Observations

Seascape blooms very early for a June crop, and is highly vulnerable to spring frost damage. It has robust vigor and produces many runners, necessitating frequent clippings and thinning to maintain good size and quality of berries in the cold frame. This variety has the propensity to over-produce flowers and canopy which results in decline of fruit size during the season. There was an incidence of gray mold, and then the plant can become susceptible to anthracnose which causes lower quality. The PYO preference was acceptable and the hardiness level was very good.

EV II was grown for the first time in 2010. This variety produces mid-size berries during summer and when the temperature becomes more moderate in fall it bears larger fruit. While this variety's production is the best in the fall, flavor is average and quality fluctuated. EV II is susceptible to anthracnose. The PYO preference was acceptable when grown inside cold frame.

Table 1. Yield of day-neutral and June-bearing strawberries in 2010.

Month	Quantity sold lb	Total number	Average price ($/lb)	Comments	Process & cull (estimate) lb (not included in sale)
May	5		3.00	DN in cold frame	
June	4,865	13,156	2.70	85% JB, 15% DN 09 & CF	~150 lb into jam
July	220	570	2.59	60% DN in CF; 40% DN 09	
August	683	1,895	2.78	30% DN in CF; 70% DN 10 in field; bulk of sale to stores	150-200 lb
September	189	694	3.68	100% DN in field; 50% direct sale & 50% to stores	
October	109	363	3.32	100% DN in new CF; most sold to stores	
November	22	82	3.70	100% DN in new CF; most sold to stores, a few at FM	

Albion had the largest berries and highest quality among the three varieties. Plants are moderate in vigor and flower production. Runners are produced continually, thus frequent clippings are necessary to achieve higher yield. Albion is moderately susceptible to anthracnose and TPB. The PYO preference is very good to excellent when grown in either the field or high tunnel.

Fertilization

Organic production is distinctly different from conventional with regards to fertility and the resultant production costs. Manure and compost are primary sources of nutrients besides the existing reservoir in the soil. Despite higher costs when compared to synthetic fertilizers there are many benefits. These benefits include: less leachate, increased soil bio-diversity, greater mycorrhizal activity, a steady supply of nutrients to the roots, an improved soil profile, and possibly a higher nutritional value of berries. The main drawback to using manure is that it can only be used up to 120 days before harvest. As an alternative to manure, so we could fertilize up to and through harvest, we used foliar applications consisting of fish and kelp extracts. At the end of the season we applied composted poultry manure at a rate of approximately 1.5 t/A at a cost of approximately $380/t. In addition, we applied a custom-blend of kelp, alfalfa, fish, bone, and feather meal to newly established beds at a rate of 0.5 t/A, in order to boost flower production and the overall health of the plants. Unfortunately, the blend caused a heavy infestation of fly maggots inside the strawberry crown and resulted in a significant loss of plants. The custom blend still remains a viable option for early season and late fall applications but the cost fluctuates considerably, anywhere from $650-800/t.

In addition to more traditional fertilization methods we also incorporated fertigation. This allowed us to frequently apply fish emulsion, kelp extract, and other nutrients at low rates throughout the season. We used a drip system to efficiently deliver the nutrients and soon after noticed heavier fruit sets. One other method used was vermicompost (earthworm castings) which was initially applied at planting time and then again close to harvest. Although this material does not provide nutrients to plants, its phyto-enzymes stimulate root development which improves the absorption of nutrients.

Cultural Manipulations

During the summer, plants in all three varieties grew quite rapidly. The growth caused an overabundance of foliage, which created an ideal environment for gray mold. The mold was found on the fruit, flowers, and leaves of plants in the cold frame. As a result these plants had smaller berries.

To ensure a constant supply of berries, repeat clipping of runners are necessary throughout the entire season. In late summer it was essential to renovate the raised beds because we are growing the DN strawberries as perennials. Renovation included thinning out sprouts and removing flower clusters. Many growers use DN strawberries as annuals, thereby eliminating the need for thinning or renovation.

IPM

We observed that our DN strawberries were more susceptible to tarnished plant bug (TPB) damage than the June bearing varieties. TPB's population was high during the time DN strawberries were flowering and setting fruit. We encountered more TPB in the field than in the cold frame. Suppression of TPB was achieved using hydrolyzed vegetable oil mixed with neem oil extract (Aza-Direct).

In the cold frame we had anthracnose and gray mold late in the season due to higher humidity from the transpiration from the thicker canopy. Anthracnose became more severe in the cold frame towards the end of October and into November. This may have resulted from moving the row cover back and forth, thus spreading the disease.

No spider mite damage was observed in the field but a minor spider mite flare-up did occur in the cold frame. The spider mites were treated with dormant oil and Surround[1]. Soil-dwelling beetles were the principle pest in the raised beds, causing fruit loss throughout summer. We applied a single treatment of Micotrol[1] to treat the beetles.

Other pests included mice in the field and birds in the high tunnel. The presence of straw encourages mice activity and in late summer mice damage on fruit increased. Predators such as hawks and cats are the only means of mice management in the field. Damage from birds in the cold frame was minimal and prevented by hanging flashing strips over the crop.

Weed Management

Worldwide polyethylene film is used extensively with DN strawberries for weed control and to encourage early production. However, plastic mulch ends up in landfills at the end of the season so we do not want to use it.

We had the best weed control using a dual mulch method of straw over paper. Despite the late installation, the weeds that germinated and grew were manageable. The single row planting method enabled us to extend the mulch from one row to the next. The installation of the straw over paper is labor intensive but a dramatic reduction in weeding later in the season more than makes up for it. Straw mulch reduces insect and disease pressure, improves field cleanliness, and

Raised beds in cold frame along with flashing to deter birds.

makes harvest easier. In addition, this system allows band applications of dry fertilizers over the row.

Field vs. Cold frame

The strawberries that were planted in May 2010 were partitioned in early October. Approximately 20% were enclosed in a newly constructed cold frame. The remaining plants were left uncovered. The open-field strawberry patch was harvested until the end of September. The plants in the cold frame were harvested until mid-November, indicating a gain of 7 to 8 weeks of production.

All three strawberry varieties set flowers steadily and regularly, in the field and cold frames. However, the cold frame berries had better fruit quality, size, and a longer harvest. Application of row-cover inside the cold frame during cold spells in October and November extended the season for 4 weeks after the first hard frost occurred on October 8.

Raised Bed vs. Non-raised Bed in Cold frame

Temperature, humidity, light intensity and duration were normal in the raised beds. The sandy soil on the farm allowed for good water drainage. The non-raised beds also had normal growing conditions. There were differences with regards to fertility and water management between raised beds and non-raised beds. In general, more frequent applications of fertilizer and water was necessary in the raised beds. Anthracnose and gray mold became prevalent during late summer into fall for both methods, due to a combination of condensation from the poly and use of row covers for frost control.

Markets

The capacity to offer strawberries all season benefitted our business and our customers. We were able to set berry prices that were fair to us and the customer. Institutions that usually purchase strawberries from distant locations had the opportunity to buy locally. In addition, customers that came for the berries had interest in our other produce and nursery items. Lastly, presuming a higher nutritional value of organic over conventional berries, we hope to be able to tap into school cafeterias and high-end restaurants in the future.

Feasibility

We are still looking at how long a single planting will produce a good quality and high quantity of berries. DN strawberries differ from JB strawberries in spacing, production schedule, fertilization requirements, growing environment, production costs, IPM, and maintenance. A decision to treat DN plants as an annual, biannual or tri-annual crop hinges on their level of productivity, competiveness with weeds, labor demands, and resistance to pests and diseases.

Problems encountered during the season and some possible solutions. Regardless of how well we prepare for the season, invariably we will face new and challenging situations that ultimately dictate the success or failure of the crop. This season was no exception. Raised bed media containing composted manure had a toxic amount of sodium, resulting in loss of vigor and plants. We drenched out the media but early production was reduced significantly. Poor quality fish emulsion de-hydrolyzed, resulting in oxygen deprivation to roots, loss of plants, and productivity. To remedy the oxygen loss manual aeration of the root zone occurred. The cold frame structure did not stand up to some really strong winds. We solved this by hanging sandbags alongside the frame ahead of the storm to prevent heaving.

Even though this was our last year of research for the Greenbook we will continue to experiment with DN strawberries in cold frames. Overall, we feel that more research needs to be done by the university focusing on field growing conditions. There are many conditions that need to be just right for a successful crop of DN strawberries but we recommend that other experienced growers try our system. Not only are other growers interested in DN berry production but home gardeners and "foodies" too.

Management Tips

1. Preparation of the bed in prior seasons, including fertility and weed control, is crucial to growing organic berries successfully.

2. Growing DN berries organically in SE Minnesota is feasible when using a cold frame.

3. Producing DN berries is more challenging than conventional strawberry production due to greater labor input and material costs. Also, rodent control is problematic because of a lack of organic baiting.

Project Cooperator

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

Project Location

Sam Kedem Nursery and Garden. Three miles south of Hastings via Hwy. 61. Turn west on 190th St., we are 1/6 mile from Hwy. 61 on the south side of the road.

Other Resources

U of M publications: Commercial Strawberry Production in Minnesota. *www.extension.umn.edu/distribution/horticulture/DG2836.html*

Day-Neutral Strawberry Production in Minnesota. *fruit.cfans.umn.edu/strawbs/dayneutral.htm*

Martin Guerena & Holly Born 'Strawberries: Organic Production: *www.attra.ncat.org/attra-pub/strawberry.html*

High Tunnel Primocane Blackberry Production in Minnesota

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Project Duration

2009-2011

Award Amount

$23,932

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Keywords

blackberry, high tunnel, primocane fruiting, thornless blackberries, winter protection

Project Summary

This is the second season of the high tunnel blackberry project at the North Central Research and Outreach Center (NCROC) and Elm Tree Farm (ETF). Both locations had primocane fruiting blackberries planted in a high tunnel and a field trial in the late spring of 2009. The blackberries grown at ETF are managed organically, while NCROC is growing them conventionally. The cultivars/selections included were 'Prime Jan,' 'Prime Jim,' MNPF1001, MNPF1002, APF41, APF45, and APF48. Additionally, three thornless primocane fruiting selections, APF136, APF138, and APF139 were planted for demonstration purposes at NCROC. Some winter die-off occurred among several varieties in the tunnel and in the field at NCROC while ETF did not have any die-off. At both locations the plants grew vigorously throughout the season with little insect or disease pressure. Small quantities of berries began to be harvested in early September from the tunnel. Field fruit was slower to mature. In mid-October, plants in the tunnel continued to flower and produce small quantities of fruit, while immature fruit on the field plants had shriveled and dried from repeated light frosts. The quality of the fruit from the tunnel was high, but the quantity was less than expected, despite an unusually warm fall season.

Project Description

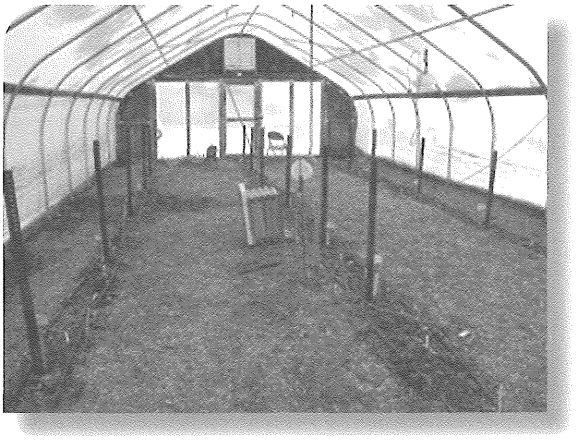
NCROC

Blackberries are a high value crop that could provide revenue for small farms in the fall. Blackberry production in Minnesota, however, is not very common due to the fact that floricane fruiting varieties are not typically hardy enough for Minnesota. In 2005/2006, primocane fruiting blackberries were grown in a field setting at NCROC, but no berries matured in 2006 due to the early frost. All the plants were killed after the winter of 2006/2007 during which there was no snow cover. Primocane fruiting raspberries have been a very successful crop in the north high tunnel at NCROC; therefore, a trial of primocane fruiting blackberries in the south tunnel seemed a reasonable next step. Primocane fruiting varieties were planted in the tunnel in May, 2009 to evaluate their potential as an alternative fall crop, using the high tunnel to extend the growing season into the fall. An identical field planting was established in June, 2009. Although the plants grew well, only a few flowers and fruit resulted from the 2009 season, as the plants were becoming established.

Winter preparation for the high tunnel took place the end of October, 2009. First, the T-tape irrigation was drained and irrigation terminated. Next, the sides of the tunnel were closed, and the plants were allowed to go dormant for the winter season. In January, 2010 temperatures approached -25°F in the tunnel and snow was added to the tunnel to provide some needed insulation. This protection may have been applied too late, however, as blackberries can be damaged in sub-zero temperatures. Adequate snow cover was available to insulate the field planting.

Grand Rapids experienced an unusually warm February and March, so the tunnel sides were opened in late February to remove excess heat. During the summer before, the sides were not enough to regulate temperatures in the tunnel, so gable end vents were added in March. The vents reduce the physical labor normally needed to regulate temperatures in the tunnel because they operate automatically. The vents were initially set to turn on at 70°F, but were later adjusted to activate at 80°F in order to provide more heat for the developing blackberries. The benefit of growing berries in the high tunnel was demonstrated when a late spring snowstorm occurred in early May. By June it was warm so the tunnel sides were generally left open and the gable vents were set to remove excessive heat.

Installation of gable end vents and woodchips as mulch in early spring.



Snowstorm on May 7, 2010, with views outside and inside the tunnel.

When nighttime temperatures began to cool in late August, tunnel sides were closed in the mid-afternoon to capture the heat of the day, and reopened in the morning to remove accumulated moisture.

Wood-chip mulch was added to the tunnel in early spring, and soil samples were taken in late April, 2010. Soil fertility was quite good, as the high tunnel had been used to grow tomatoes, peppers, and lettuce in 2007, and a cover crop of Sudan grass in 2008. It was decided that, fertilizer rates used in 2009 would be adequate for the coming growing season; however, no supplemental boron would be applied this season due to boron toxicity problems in 2009. After an initial pre-soak, fertilizer was applied by weekly fertigation in the tunnel, beginning May 4. Nitrogen at the rate of 30 lb N/A was supplied by alternating applications of Ca(NO3)2 and urea (70% of N from Ca(NO3)2 and 30% of N from urea). Micronutrients were added on May 24 and June 8. On May 5, field plantings were fertilized with 40 lb N/A in the form of Ca(NO3)2.

Irrigation in the tunnel was initially supplied weekly and then increased to twice per week as temperatures warmed. Approximately 120 gallons per week were provided over the course of two hourly sessions when plants were actively growing. Soil moisture sensors were installed to monitor moisture requirements. Supplemental field irrigation was seldom needed as the summer rains exceeded normal patterns, but it was supplied on several occasions.

Some winter damage occurred in both the tunnel and field plantings. In June, 2010 a total of 18 plants were replaced in the tunnel (13 among the main cultivars/selections and five among the demonstration selections). Only two plants were replaced in the field but there were seven more field locations where plants could have been replaced but the variety needed was unavailable. A grass cover crop, which was growing between plants in the field, was removed with an application of glyphosate in late May, 2010.

During the growing season, plant height and spread measurements were taken four times. Plants in the tunnel grew quite vigorously, so a trellis system was put in place to contain the large and expanding canes. No thinning of canes was done, and minimal pruning was done only at the end of September, and only to canes with no visible fruit.

During the 2010 season, flower and fruit development, as well as insect and disease pressure, were monitored weekly. Although no spider mites were observed in the blackberry tunnel, parasitic mites were released twice, once in June and once in August, as a preventative measure. The decision to

Trellis system added to manage vigorous growth.

ETF high tunnel, June (left) and November (right) 2010.

release the predatory mites was based on the large spider mite population in a nearby raspberry tunnel.

Temperatures were recorded inside and outside the tunnel on a daily basis. In late July, leaves were sampled for nutrient analyses. Some fruit was harvested in early September. Starting in September, supplemental heat was used on cold nights to keep the tunnel above freezing, even though a severe frost did not occur until the end of October. On November 3, harvesting ended, so the plants could go dormant over the winter.

ETF

2010 was a surprising year for high tunnel blackberry production at Elm Tree Farm. The spring started out warmer than normal with a devastating outside freeze May 10. The high tunnel protected the blackberries and temperatures were kept above freezing. However, it is possible that the cold temperatures at this stage of growth may have had some effect on fruit formation and yield. As the season progressed, the plants grew well. While both 'Prime Jan' and 'Prime Jim' had vigorous growth, 'Prime Jan' had considerably more growth with canes as long as 8'. No serious winter damage was observed for the winter of 2009-10. In 2009, insect netting was installed on the sides of the tunnel as a precautionary measure to keep out harmful insects. While no harmful insects were observed above IPM thresholds, the screening may have limited the number of pollinating insects that entered the high tunnel. If the sides are to be screened again we are considering bringing pollinators inside the tunnel for pollination. Weed pressure in the tunnel was minimal, so no herbicides were used. Irrigation was done in a timely manner. The plants had excellent dark green color throughout the entire growing season. The growth of the blackberry plants was so intense that we feel winter cover may be unnecessary, so at this time we are not planning to put any snow or other artificial covering over the blackberries.

Results and Conclusions

NCROC

Many plants in the tunnel suffered from winter damage. Because of this, the decision was made to replace the plants that showed no new growth. We used potted plants of the same cultivar that had been overwintered in cold storage. Since the plants appeared to suffer from the lack of insulating snow cover, we will mulch the tunnel with straw and a layer of foam insulation board. We will cover half of the plants to see if this added protection aids in surviving over-wintering during the 2010-11 season.

Table 1. NCROC Blackberry Tunnel Map with 2010 Replacements

Plot	ROW 1	ROW 2	ROW 3
8	Prime Jan	APF-45 (1)	MNPF 1001 (2)
7	APF-48	Prime Jim	MNPF 1002
6	MNPF 1001 (2)	APF-41 (1)	Prime Jan
5	APF-45	Prime Jan	APF-41 (1)
4	Prime Jim	MNPF 1002	APF-45 (3)
3	APF-41 (2)	MNPF 1001	APF-48
2	MNPF 1002 (1)	APF-48	Prime Jim
1	APF-136 (2)	APF-138 (1)	APF-139 (2)

Table 2. NCROC Blackberry Field Map with 2010 Replacements

Plot		ROW 4	ROW 3	ROW 2	
9		APF-139 ***	APF-138 ***	APF-136	
8		APF-138 ***	APF-136 ***	APF-139	
7	BORDER ROW	Prime Jim	APF-48	MNPF 1002 ***	BORDER ROW
6		APF-48	MNPF 1001 (1)	APF-41 ***	
5		APF-45 ***	MNPF 1002 ***	Prime Jim	
4		APF-41	Prime Jan	APF-45 ***	
3		Prime Jan	APF-41	MNPF 1001 (1)	
2		MNPF 1002 ***	Prime Jim	APF-48	
1		MNPF 1001	APF-45	Prime Jim	

Notes:
Cultivars where plants were replaced are shaded. The number of replacements is included in parentheses.
Field cultivar plots marked with *** needed replacements, but either none was available or the field plant(s) was weak but better than the available replacement.

In the field, several plants appeared to be dead, and were replaced if the same cultivar/selection was available. In some instances, weak field plants were not replaced if they appeared to be healthier than the potted plant that was available. In some instances, no replacement was available for dead or weak field plants. Tables 1 and 2 show the maps and where replacements occurred. Field plants began to grow but were set back by an application of glyphosate to the grass growing between the plants. Although the glyphosate was applied with a shield to protect the blackberry plants, some drift or uptake occurred that adversely affected them. Most plants grew out of the herbicide damage within 4 to 6 weeks. Additional precautions will be taken if additional herbicide applications are required in 2011.

Both field and tunnel plants generally grew well as the temperatures warmed into June. Plant size was somewhat better in the field than in the tunnel at the beginning of June, but the tunnel plants rapidly caught up as temperatures warmed throughout June. By early July, tunnel plants were generally larger than the field ones and they continued to outpace the growth of the field plants throughout August and September. See Tables 3 and 4 for growth comparisons and "field and tunnel" photo for temperature differences between inside tunnel values and outside field ones.

Since the advantage of a high tunnel is the higher heat available for the plants, it would be helpful to quantify this advantage. One way to do this is to measure heating units using growing degree days. For the period June 1 through September 31, the growing degree days inside the tunnel totaled 2,329, while outside the total was 1,765. The high tunnel structure provided more than a 30% increase in heating units for the heat-loving blackberries, which contributed to their increased growth over the field planting. Supplemental heat began to be provided in the tunnel during cold nights in September, adding to the degree day differential. See Figure 1 for views of the field and tunnel in the middle of the growing season.

Since the plants in both the field and the tunnel were more established this season as compared to last, it became difficult to count the actual number of canes or branches. A count was attempted but became inaccurate as the plants grew together within plots. Instead, a rating for branching was done, using a 1 to 5 scale (5 = most branching). Additionally, two ratings for vigor and one for sturdiness were done. A zero rating for vigor was given to those plants that showed no growth in June. Results of these ratings are shown in Table 5. Most plants grew quite vigorously both in the tunnel and the field, with an edge going to the tunnel-grown plants. The most vigorous cultivars in the tunnel

Glyphosate damage to field planting.

were 'Prime Jan' and 'Prime Jim,' and in the field they were APF-41 and APF-45.

Foliar samples were taken for nutrient analyses in late July (Table 6). Both field and tunnel plants showed adequate nutrition. Boron toxicity in the tunnel, which had been a problem during 2009, was no longer evident. Some buildup of salt in the tunnel is becoming apparent and may need to be addressed before the 2011 growing season. Further investigation into the salt levels will be done.

While plant growth was encouraging, overall fruit yield was disappointing. Tunnel cultivars/selections began to flower during the week of July 7, while field plants were about 1 week behind. Green fruit was evident in the tunnel starting the week of July 26, and during the week of August 2 for the field. Red fruit appeared in the tunnel starting in the latter part of August, and ripe fruit began to be harvested on September 1. As of November 3, the best tunnel plots produced approximately 500 grams of fruit, or slightly more than one pound (Table 7). In the field, no measurable harvest has occurred. Only the occasional berry has been found. Much green fruit developed in both the tunnel and in the field, but the majority of that fruit did not fully develop into harvestable fruit. Oftentimes, the green fruit dried and shriveled on the plant. This occurred more often in the field, probably due to scattered frost that hampered development beginning in early September. Tunnel fruit development was generally more complete than in the field. The fall season had been an unusually warm one, extending the growing season for several weeks, but that still was not enough for field blackberries to develop fully. With supplemental nighttime heating to keep temperatures above freezing, the tunnel blackberries were still flowering and producing harvestable fruit throughout October, but not in quantities that would justify the cost of their maintenance. The quantity of berries was low, but the fruit quality was high. Harvested berries were generally large and well-formed.

Work with primocane blackberries will continue next season, and we hope that by providing additional winter protection in the tunnel, plants will get an earlier start and have more time to develop fruit. The continued development of cultivars/selections that mature earlier would be beneficial to growing primocane blackberries in high tunnels in cold climates. We have made improvements to our tunnel to provide optimum growing conditions, and we hope to have a more successful harvest in the next growing season.

ETF

To prepare for the upcoming growing season the canes were cut back to 8" tall on March 15. To measure vigor we used a 1 to 5 scale (5 = most branching), 'Prime Jan' = 5 and 'Prime Jim' = 3. The amount of new growth this year was phenomenal. 'Prime Jan' grew between 48" and 96" while 'Prime Jim' grew between 12" and 65." Even though the growth was much greater than NCROC, the fruit yield, which was very low, was about the same.

Plans for next growing season will include ways to manage growth and increase data collection. We will prune canes again and build a T-trellis with wire supports to support the plants. In case pollination was a problem, we are considering introducing pollinators into the high tunnel. In addition, a data logger will be installed to record temperature highs and lows, and a soil test will be done to check nutrient levels. These cultivars may need 2 years of growth and development before producing a reasonable yield of fruit. Year three of the project will answer a lot of questions, and will indicate if blackberry production in high tunnels will be feasible in Minnesota.

Table 3. NCROC Field Blackberry Plant Height and Spread

	Height (inches)				Spread (inches)			
Cultivars	6/1/2010	7/7/2010	8/20/2010	9/28/2010	6/1/2010	7/7/2010	8/20/2010	9/28/2010
APF-41	10.1	19.9	37.6	47.8	9.8	17.1	32.0	47.6
APF-45	10.4	23.3	44.4	48.2	8.9	23.6	50.8	50.0
APF-48	9.8	19.2	26.0	27.0	10.1	16.9	31.0	34.9
MNPF1001	11.1	24.9	36.4	47.0	9.6	16.2	30.8	32.8
MNPF1002	8.4	19.7	29.4	29.2	8.0	15.8	24.3	24.2
Prime Jan	10.9	21.6	34.7	41.3	11.3	24.8	37.9	45.6
Prime Jim	7.7	24.9	35.4	39.9	8.3	23.2	39.4	40.9
Average	9.8	21.9	34.9	40.1	9.5	19.7	35.2	39.4

Table 4. NCROC High Tunnel Blackberry Plant Height and Spread

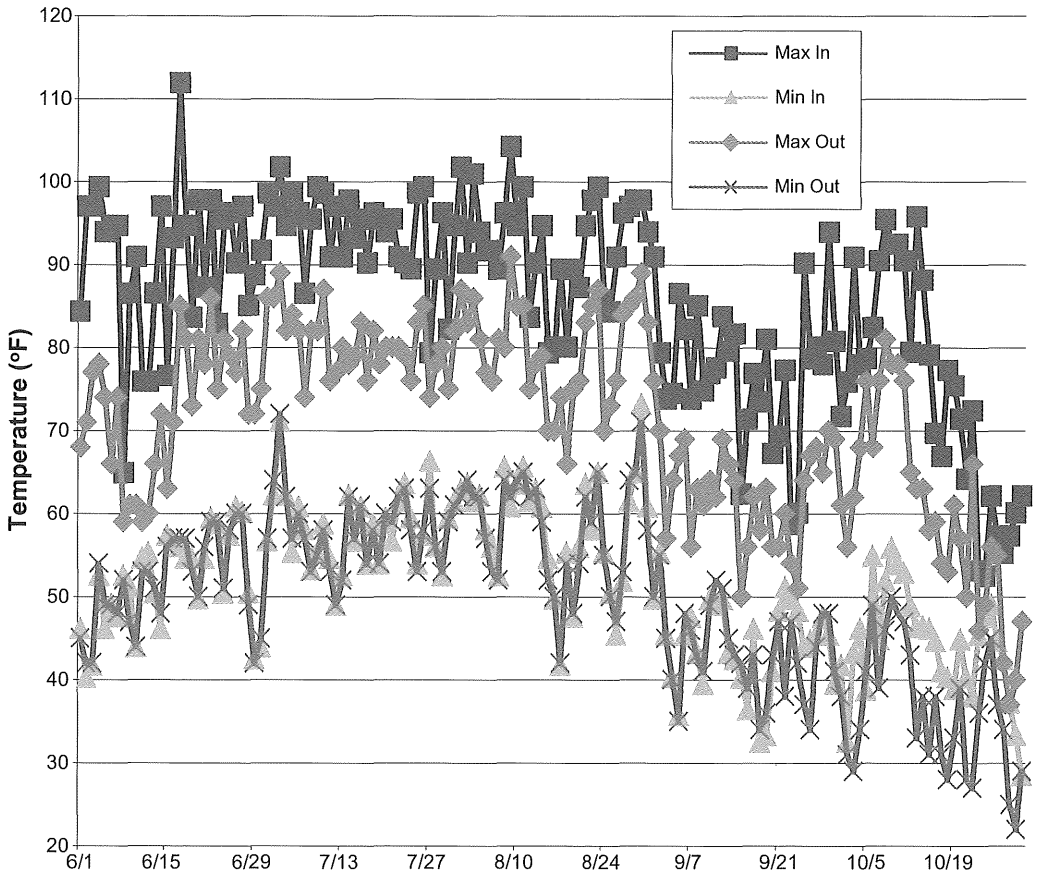
	Height (inches)				Spread (inches)			
Cultivars	6/1/2010	7/7/2010	8/20/2010	9/28/2010	6/1/2010	7/7/2010	8/20/2010	9/28/2010
APF-41	2.0	21.4	46.9	53.4	4.0	20.4	39.3	47.7
APF-45	4.0	17.2	45.3	63.8	7.3	15.0	37.0	52.3
APF-48	5.8	22.3	38.3	42.7	10.1	35.2	37.6	48.1
MNPF1001	3.0	17.7	37.6	45.6	5.8	25.0	36.1	46.3
MNPF1002	4.2	23.5	35.2	42.6	7.1	26.3	36.5	42.4
Prime Jan	6.3	24.7	47.9	56.2	11.0	38.2	42.0	60.4
Prime Jim	12.1	37.4	54.8	72.4	14.2	41.6	42.7	51.2
Average	6.3	23.6	44.2	54.2	9.7	28.9	38.6	50.1

Table 5. NCROC Field and Tunnel Vigor Ratings

	FIELD				TUNNEL			
	Vigor		Branching	Sturdiness	Vigor		Branching	Sturdiness
Cultivars	6/10/2010	9/28/2010	9/28/2010	9/28/2010	6/2/2010	9/28/2010	9/28/2010	9/28/2010
APF-41	1.7	4.3	4.2	4.2	0.4	4.3	4.2	4.3
APF-45	1.6	4.6	4.6	4.7	0.4	4.3	4.4	4.3
APF-48	1.7	2.8	3.2	3.5	1.6	3.6	4.6	4.2
MNPF1001	4.2	3.5	3.4	4.1	0.6	4.0	4.3	4.2
MNPF1002	0.9	2.8	3.0	3.7	1.4	3.7	4.0	4.0
Prime Jan	2.5	3.9	4.2	4.4	1.9	4.9	5.0	4.2
Prime Jim	1.7	3.8	3.9	4.3	3.0	5.0	4.9	4.9
Average	2.0	3.7	3.8	4.1	1.4	4.3	4.5	4.3

Ratings are on a 0-5 scale, 0=no growth, 1=least to 5=most

Figure 1. High Tunnel Outside Max and Min Temperatures - 2010 Growing Season NCROC



Field and tunnel growth in mid-July.

Table 6. Foliar Mineral Nutrient Analyses for NCROC - August 2010

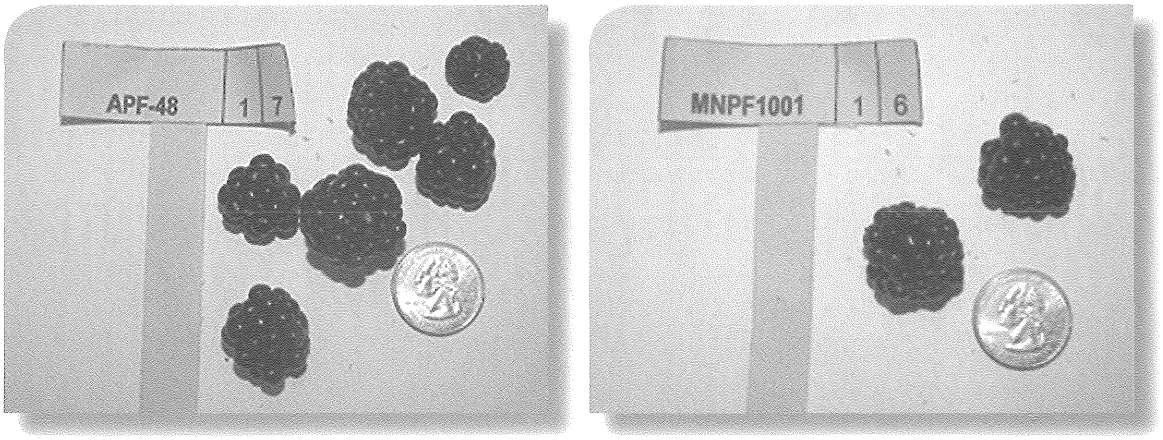
Cultivar	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Mn (ppm)	B (ppm)	Cu (ppm)	Fe (ppm)	Zn (ppm)	Na (ppm)
NCROC Field											
MNPF-1001	2.88	0.23	1.45	0.75	0.43	128.0	64.2	5.9	55.0	37.0	16.8
MNPF-1002	3.29	0.22	1.72	0.88	0.40	114.6	66.4	5.3	60.3	33.3	28.3
APF-41	3.24	0.27	1.51	0.68	0.37	115.7	53.1	6.1	55.3	37.2	15.5
APF-45	3.26	0.23	1.41	0.69	0.40	91.7	59.0	6.1	57.9	31.1	16.2
APF-48	3.12	0.23	1.38	0.74	0.39	69.9	50.6	5.7	52.7	32.1	18.1
Prime Jan	3.08	0.23	1.45	0.68	0.43	129.6	53.9	6.0	63.2	32.6	16.6
Prime Jim	2.71	0.20	1.51	0.54	0.28	45.9	39.6	5.5	48.3	26.8	15.5
NCROC Tunnel											
MNPF-1001	3.51	0.23	1.32	1.11	0.63	71.7	71.6	4.0	86.9	25.9	53.8
MNPF-1002	3.35	0.18	1.40	1.21	0.59	99.9	73.2	2.9	81.2	21.1	88.8
APF-41	3.56	0.23	1.51	0.86	0.45	66.7	51.1	4.3	72.8	26.9	37.8
APF-45	3.34	0.23	1.47	0.77	0.46	40.7	54.8	5.2	70.3	24.1	34.1
APF-48	3.08	0.19	1.37	0.83	0.38	62.3	48.0	3.4	63.4	21.0	42.6
Prime Jan	3.18	0.21	1.24	1.04	0.58	71.5	59.8	4.6	74.1	27.2	36.5
Prime Jim	2.96	0.18	1.39	0.83	0.37	70.9	57.6	4.1	67.6	25.0	60.0

Table 7. NCROC 2010 High Tunnel Blackberry Yields (through November)

Cultivars	% Early Harvest by Oct 1	Total Grams	Total Pounds	# Berries	Average Gr/Berry
APF-41	18%	120	0.26	15	8.00
APF-45	2%	482	1.06	58	8.31
APF-48	35%	492	1.08	125	3.94
MNPF1001	24%	499	1.10	107	4.66
MNPF1002	62%	398	0.88	93	4.28
Prime Jan	51%	87	0.19	23	3.78
Prime Jim	35%	511	1.13	95	5.38
Average	33%	370	0.81	74	5.48

Dried fruit on field and tunnel plants on 9/28.

'Prime Jan' developing fruit in tunnel on 9/1, 'Prime Jim' fruit in tunnel on 9/28.



Samples of ripe fruit from late September harvests.

Management Tips

1. Temperature regulation in the high tunnel can be problematic. The installation of temperature-controlled ventilation can be effective for dissipating excessive heat.

2. A layer of mulch in the high tunnel can be effective for weed prevention and for the retention of soil moisture. Wood chips were used in our tunnel for these purposes.

3. Providing adequate winter protection for tunnel-grown plants is important, as winter injury can result from lack of snow cover. An insulating layer of straw or other material applied before winter temperatures plunge below 0°F may prevent winter-kill, and we will try several methods this winter.

4. Existing primocane cultivars may not be suitable for the cold climate of Minnesota, but growers should keep informed about new cultivars that incorporate a higher degree of winter-hardiness.

Cooperators

Patricia Bliska, Berry Grower, Elm Tree Farm, Afton, MN
Dr. Jim Luby, Professor/Breeder, Department of Horticulture, U of MN, St. Paul, MN
Dr. John Clark, Professor/Breeder, Department of Horticulture, U of AR, Fayetteville, AR
Dr. Emily Hoover, Professor, Department of Horticulture, U of MN, St. Paul, MN
Dr. Carl Rosen, Professor, Department of Soil, Water, and Climate, U of MN, St. Paul, MN
Patricia Johnson, M.S., M.Ag., U of MN - North Central Research and Outreach Center, Grand Rapids, MN
Keith Mann, Plot Coordinator, U of MN - North Central Research and Outreach Center, Grand Rapids, MN

Project Locations

Elm Tree Farm is located at 14726 Afton Blvd. S., Afton, MN. From St. Paul, travel about 11 miles east on I-94. Merge onto MN Hwy. 95 S/Manning Ave. (Exit 253) toward Hastings. Go about 4 miles then turn left on 40th St. S/CR-18. Follow CR-18 for about 3 miles and the farm is on the left.

North Central Research and Outreach Center – From St. Paul, take I-35E north about 110 miles. Merge onto MN Hwy. 33 N (Exit 237) toward Cloquet. After traveling about 11 miles, take the exit for US Hwy. 2 toward Grand Rapids/Duluth. Turn left (west) onto US Hwy. 2 and travel about 60 miles. Turn slightly right onto US Hwy. 169/NE 4th St. and go 1.7 miles to our location on the left.

Other Resources

Dr. John Clark, Professor/Breeder, Department of Horticulture, University of Arkansas, Fayetteville, AR 72701, 479-575-2810, jrclark@uark.edu

FarmTek high tunnels.
Website: *www.farmtek.com/farm/supplies/home*

Nennich, T., David Wildung, and Pat Johnson. 2004. Minnesota High Tunnel Production Manual for Commercial Growers. Website: *www.extension.umn.edu/distribution/horticulture/M1218.html*

Nourse Farms, 41 River Rd., South Deerfield, MA 01373, 413-665-2658.
Website: *www.noursefarms.com*

University of Minnesota. High tunnel research. Website: *hightunnels.cfans.umn.edu*

University of Minnesota North Central Research and Outreach Center. High tunnel raspberry production research. Website: *hightunnels.cfans.umn.edu/2010Manual/Raspberry.pdf*

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

Principal Investigator

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Project Duration

2010 to 2012

Award Amount

$5,000

Staff Contact

Jean Ciborowski
651-201-6217
Author: Cassie Boadway

Keywords

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

Project Summary

Day-neutral strawberries produce berries all summer long, giving our farm the opportunity for income most of the growing season. The growing season in northwestern Minnesota is short, thus we are trying to find the most profitable way to grow day-neutral strawberries. We will be comparing strawberries grown hydroponically, in homemade grow bags on a table, and in the soil. In addition, we will compare strawberry plant yields from plants grown with the aforementioned treatments both outside and in a high tunnel.

Project Description

For the past 26 years we have operated a dairy farm just north of Middle River. Four years ago, we put in a high tunnel to raise vegetables and bedding plants. The vegetables and bedding plants are sold at our farm and at a small farmers' market in Middle River. In the high tunnel, we have focused on tomato and cucumber production but we want to increase the diversity of products we grow on our farm. At the farmers' market, the few strawberries we have produced always sell out. There is a good market for strawberries because few people have successfully grown them in this area. We have also noticed a demand for late-summer fruit but need to increase production and overcome pest issues to harness this opportunity.

The overall goal of our project is to discover a way to produce day-neutral strawberries profitably. Hydroponic systems have always interested us so we chose to try one as a method in our study. We also decided to use more traditional growing methods, including grow bags and in the soil. The short growing season in our area influenced our decision to compare hydroponics, grow bags, and soil production in a high tunnel versus outside.

The grow bags were handmade from locally sourced peat and soil. The style of grow bags that we made are similar to growing systems in England, where the bulk of strawberries in the country are grown in a peat mixture on tables and irrigated with trickle tape. A mix of 1/3 peat, 1/3 compost, and 1/3 garden soil was used for each bag and the bags were placed on a table supported by pallets.

Our strawberry planting system outside.

The high tunnel in early July.

For the hydroponic system we purchased vertical towers from the Verti-Gro® company. The Verti-Gro system consists of a series of Styrofoam containers that are stacked on top of each other. The advantage of the tower system is that many plants can be grown in a small area. We found it helpful that the Verti-Gro system came with technical help and detailed directions on how to grow strawberries.

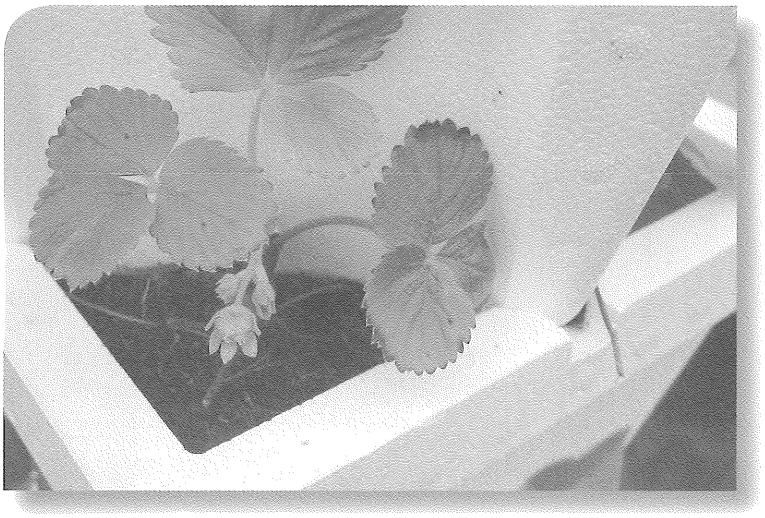
On May 10 we planted Seascape strawberries both in the high tunnel and outside using three identical setups. We chose this strawberry variety for the first year of our project because they reliably produce with good quality. The following set-ups are identical between the high tunnel and outdoors. For our hydroponic system we had towers which were four pots high. They contained a total of 112 plants and the pots were filled with Verti-Gro-supplied cocoa hulls as a substrate for strawberry roots. Our system does not circulate water, so the extra water drips out the bottom of the last pot. We planted romaine lettuce in the bottom plastic pot to use the extra water and then sold the lettuce at the farmers' market. In the grow bags, we planted the berries 6" apart, so we could plant 80 plants in a 4' x 12' grow bag. We also planted a bed of strawberries directly into the soil with 80 plants spaced 8" apart. We removed blossoms until early July, and then we allowed the fruit to set.

Results

Approximately one month after planting, the strawberries in hydroponic towers were stunted due to severe nutrient deficiencies. The symptoms indicated a potassium deficiency, but there were almost certainly other deficiencies as well. We contacted Verti-Gro and they said our water was too hard to deliver the nutrients to the roots, and suggested we needed to start acidifying the irrigation water. After June 9, we started adding distilled vinegar to the hydroponic irrigation system to lower the pH from 7.5 to the desired 5.0. The company recommended that the water coming out of the last pot should have a pH of 5.5. For us to achieve that, we used 60 gallons of vinegar for 110 plants.

By July, the nutrient deficiency disappeared in the top plants of each tower, but the bottom plants continued to be stunted. In a typical hydroponic operation, the substrate holding the roots does not have a cation exchange capacity (CEC), so it does not capture or store nutrients. Thus, any nutrients not absorbed by the first plant should flow through the water to the next plant. However, our cocoa hull substrate had a CEC, and the cocoa hulls captured nearly all the nutrients in the top container preventing any from making it to the bottom plants. Since we could not change substrates in the middle of summer, the tube with the water/nutrient solution was split into two tubes, and one was placed in the top container while the other inlet was placed in the third container. After changing the watering arrangement, the plants in the bottom container grew to normal size, but some production was already lost.

The strawberries in towers used less space than those on the table or in soil and they used more water. We irrigated until the water ran out the bottom of the tower, and we ended up using almost double the water in the hydroponic system than we used in the other treatments. For example, in a



Potassium deficiency symptoms in hydroponically grown Seascape strawberry 3 weeks after planting.

By mid-July, the plants in the top container of the tower were healthy, but the plants at each lower layer were smaller both in the high tunnel (left) and outside (right). Some plants in the lowest container died due to lack of nutrients.

typical watering, the plants in the towers used 40 gallons of water while those in the soil and grow bags each used 20 gallons.

We also had problems with the plants grown in the soil. In the middle of summer the leaves of the plants in the soil started to turn yellow. The yellowing started on one side of the beds and slowly spread to the rest of the bed. The yellowing was due to either high sodium or high soil pH. Our soil has a pH of 7.4, which proved to be too high for Seascape. By the end of August, some of the plants in the soil had stopped growing.

The first berry harvest was on August 2 and harvesting continued until October 18. We harvested almost every day during this 3-month period. The strawberry plants that were outside in the grow bags had the highest yield (Table 2). However, the yield of the plants in the grow bags in the high tunnel was low due to spider mites. The plants grown in the outside soil had the lowest yield. The plants stopped producing in late August due to a combination of yellow leaves and tarnished plant bug (TPB) pressure. TPB feed on the flower and cause the berry's shape to deform and makes the fruit unsalable.

TPB pressure was very high outside the tunnel and damaged many plants (Table 2). We sprayed all the outside plants with malathion, an effective pesticide for TPB, but still lost some fruit. Overall, plants grown on the table or in the towers had lower TPB damage than those grown in the ground. In August, the plants in the high tunnel developed a severe infestation of spider mites, and by the end of August, the strawberries stopped producing fruit in the grow bags and in the soil. Spider mites primarily feed on leaves, and damaged leaves can cause a decrease of sugar content in the berries. Surprisingly, there was little mite damage on the strawberry plants growing in the towers. At first, we only sprayed the plants in the grow bags but then sprayed all the plants in the tunnel, as a precaution. We sprayed the leaves with insecticidal soap, which appears to have controlled the problem.

Management Tips

1. The hydroponic grow towers appear not to be an economically viable option, due to the amount of inputs including; high water consumption, fertilizing every day, and the constant adjusting of water pH.

2. Tarnished plant bugs need to be controlled in late summer, since they are more common once the weather gets hot.

3. Strawberries are sensitive to high soil pH, especially when there is a combination of a clay soil with a high pH. For instance, we noticed the strawberry plants had yellow leaves when the pH was above 7.3 in a clay soil.

Cooperators

Thaddeus McCamant, Northland College, Thief River Falls, MN

Project Location

We are exactly 1 mile north of Middle River on the west side of MN 34. 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 tracks into our driveway.

Other Resources

Verti-Gro Company, Summerfield, FL. *http://vertigro.com/*

Table 1. Yield for Entire Season

Location	Number of plants	Total pints produced	Pints/plant	Number of cull berries
Outside tower	112	31.50	0.28	605
Outside grow bag	80	47.50	0.59	267
Outside soil	80	17.40	0.21	282
Inside tower	112	41.75	0.37	360
Inside grow bag	80	34.00	0.42	211
Inside soil	80	30.50	0.38	617

Table 2. Berry Quality on August 18

Location	Berries with TPB damage	°Brix
Outside tower	73%	10.4
Outside grow bag	21%	6.8
Outside soil	100%	
Tunnel tower	0%	6.9
Tunnel grow bag	0%	5.25
Tunnel soil	27%	

Minimizing the Environmental Impact and Extending the Season of Locally Grown Raspberries

Principal Investigator

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Project Duration

2009 to 2011

Award Amount

$13,346

Staff Contact

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Keywords

fall bearing raspberry, high tunnel, pesticides, primocane fruiting, red raspberry, season extension

Project Summary

Our project is looking for ways to eliminate fungicide use in raspberry production and minimize insecticide use with cleaner water and safer food as a result. In addition, we will evaluate primocane-fruiting (fall-bearing) raspberry cultivars grown in high tunnels at both the University of Minnesota West Central Research and Outreach Center (U of M WCROC) at Morris and at Berry Ridge Farm in Alexandria to increase producers' knowledge about potential markets for locally produced fruit crops. The project invites growers to observe our research through our website devoted to high tunnel crop production as well as through field days and educational conferences.

Project Description

The objectives for this project are:

- Eliminating fungicide and herbicide use and minimizing insecticide use in high tunnel raspberry production.
- Extending our raspberry season with high tunnels and working with local food markets to establish new potential relationships to benefit farmers.
- Evaluating vegetative growth, pest incidence, and yield of high tunnel primocane-fruiting red raspberries.
- Providing high tunnel raspberry production and marketing information to farmers.

This research focuses on the potential market of growers interested in extending the raspberry season in the Upper Midwest. The high-value raspberry industry in this part of the country consists of small farms selling their product directly to the consumer with little wholesale marketing or processing. In 2002, USDA estimated that 1,300 acres of raspberries were grown in the Upper Midwest (IN, IL, IA, MI, MN, and WI) on 830 farms. Specifically in Minnesota, there are an estimated 189 farms producing raspberries on 284 acres.

The public health community encourages Americans to consume more fruit as part of a healthy diet rather than as an occasional "healthy indulgence." As a result of nutritional research and improved cultivars, raspberry consumption is increasing in the United States. Many of the berries contain high concentrations of antioxidants important to reduce certain human diseases. Raspberries have excellent nutritional qualities being high in vitamin C, and containing soluble fiber and elegiac acid, a potential anti-cancer agent. Diets containing raspberries have been shown to lower blood cholesterol and slow the release of carbohydrates into the bloodstream of diabetics. Total consumption of raspberries has increased by one-third in the United States from 16 million pounds in 1996 to 24 million pounds in 2002.

Another of our study's objectives is to minimize pesticide use in raspberry production. Even though there are many compounds labeled for use, commercial raspberry growers have limited availability of pesticides to control insects, diseases, and weeds in traditional systems. Diminishing availability and increasing costs of these compounds is causing growers to seek non-chemical methods to reduce economic loss due to pest infestations. Investigating new methods of producing raspberries is desirable as growers are looking to eliminate synthetic chemicals in their production systems. Non-chemical replacements via new production methodologies will not only eliminate the need for fungicides, but will also curtail ill-advised use of off-label chemicals, and ultimately provide a safer product for human consumption. Our goal is to eliminate fungicide use in raspberry production and minimize insecticide use resulting in cleaner water and safer food.

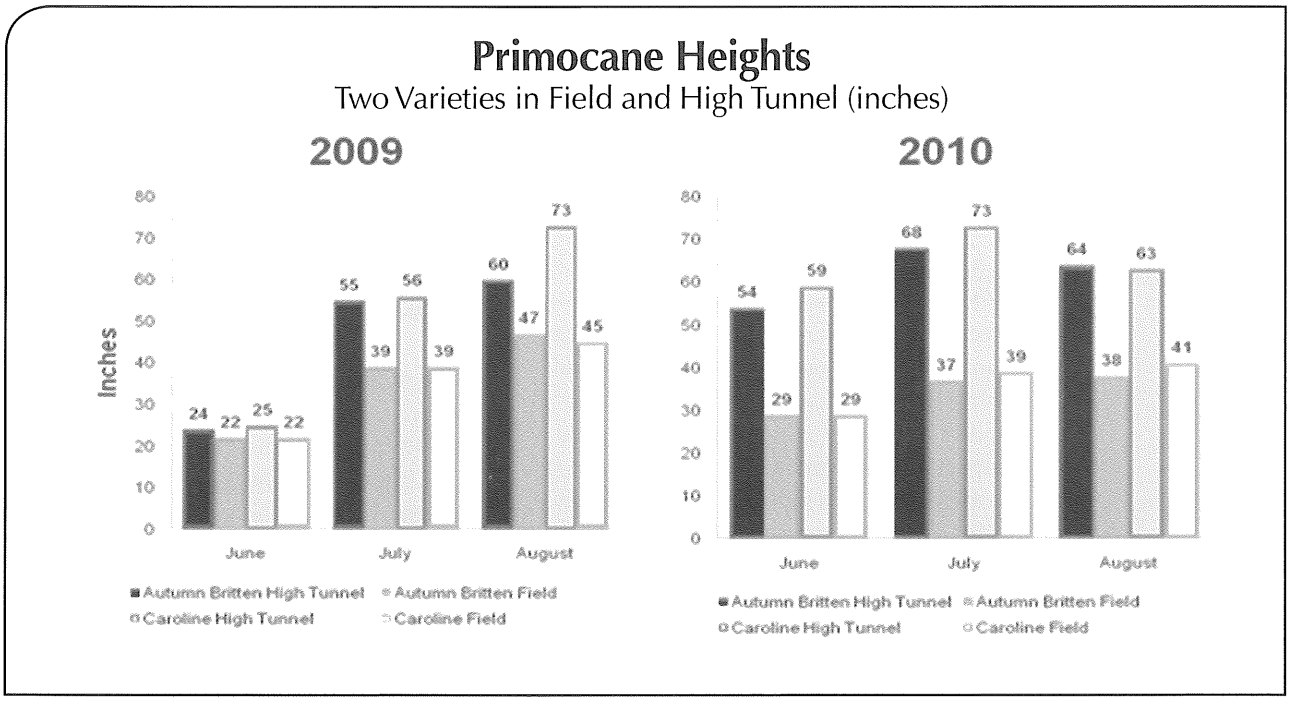

Figure 1. **2009-2010 Growth in inches of two primocane-fruiting raspberry cultivars grown in either a high tunnel or field at WCROC.**

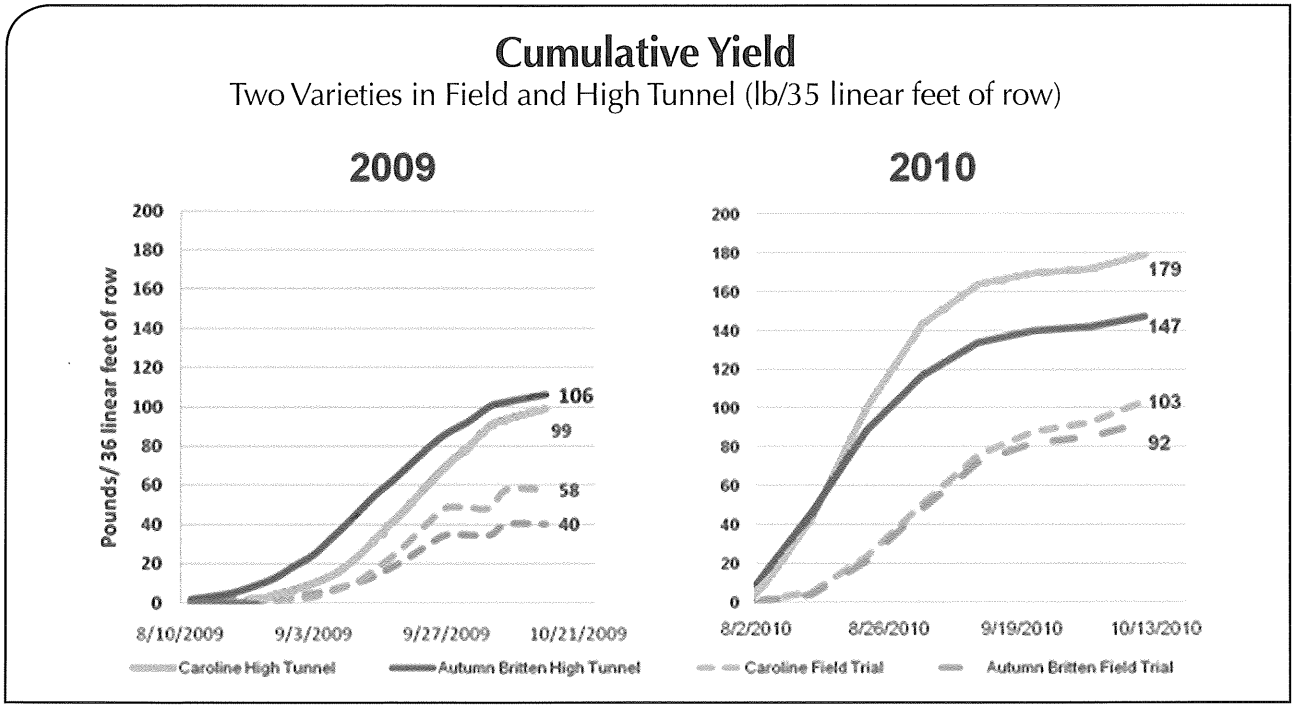

Figure 2. **2009-2010 Production (lb/36' row) of two primocane-fruiting raspberry cultivars grown in a high tunnel or field at WCROC. Numbers on the graphs are total yield in pounds.**

At Berry Ridge, we wanted to determine if cultivar 'Joan J' was suitable for use in a high tunnel and what row spacing resulted in best growth and yield. We measured plant growth, berry weights, and yields for each of the 12", 18", and 24" plant spacings. Row spacing did not have a major influence on plant growth; by the last measurement, there was not a difference in growth between the three spacings (Figure 4). 'Joan J' at all three spacings produced berries larger than the average berry size in a Driscolls clamshell through the end of September (Figure 5). However, the 24" row spacing yielded substantially fewer pounds of berries than the other two closer spacings (Figure 6). 'Joan J' produced larger berries and higher yields at this site than the two cultivars grown at WCROC.

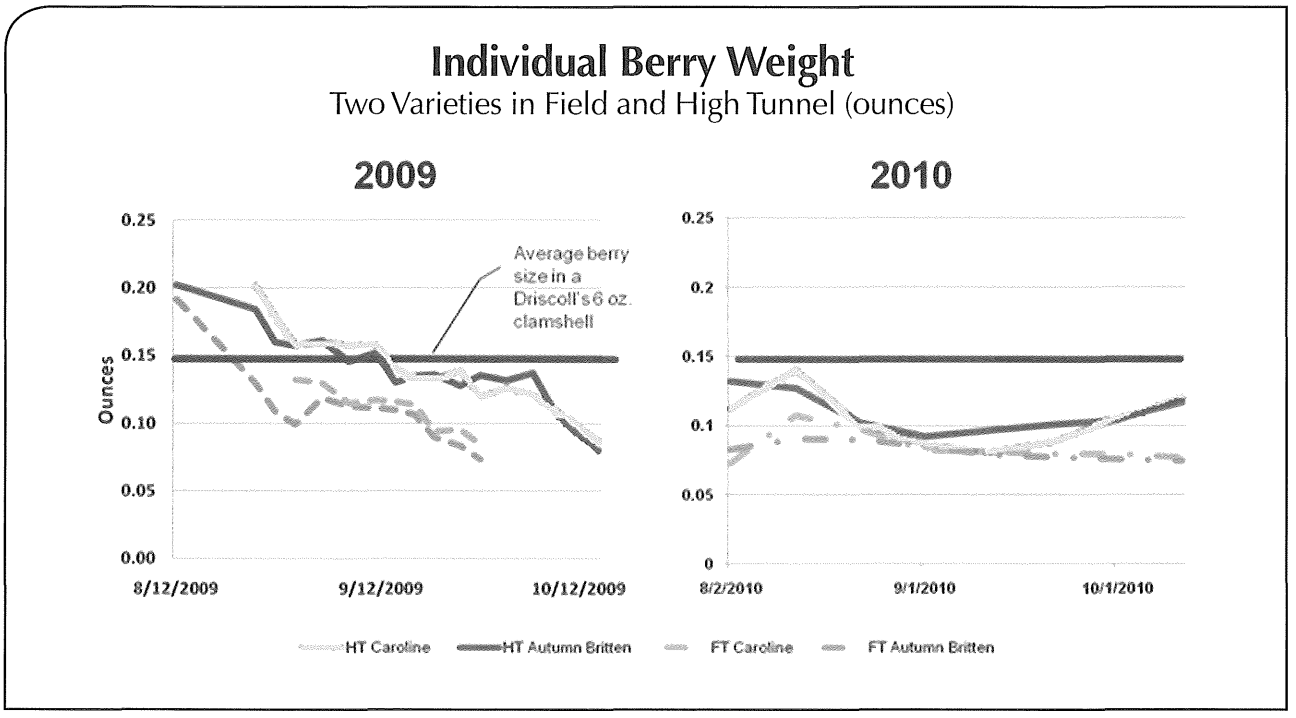

Figure 3. 2009-2010 Average weight per berry of two primocane-fruiting raspberry cultivars grown in either a high tunnel or field at WCROC.

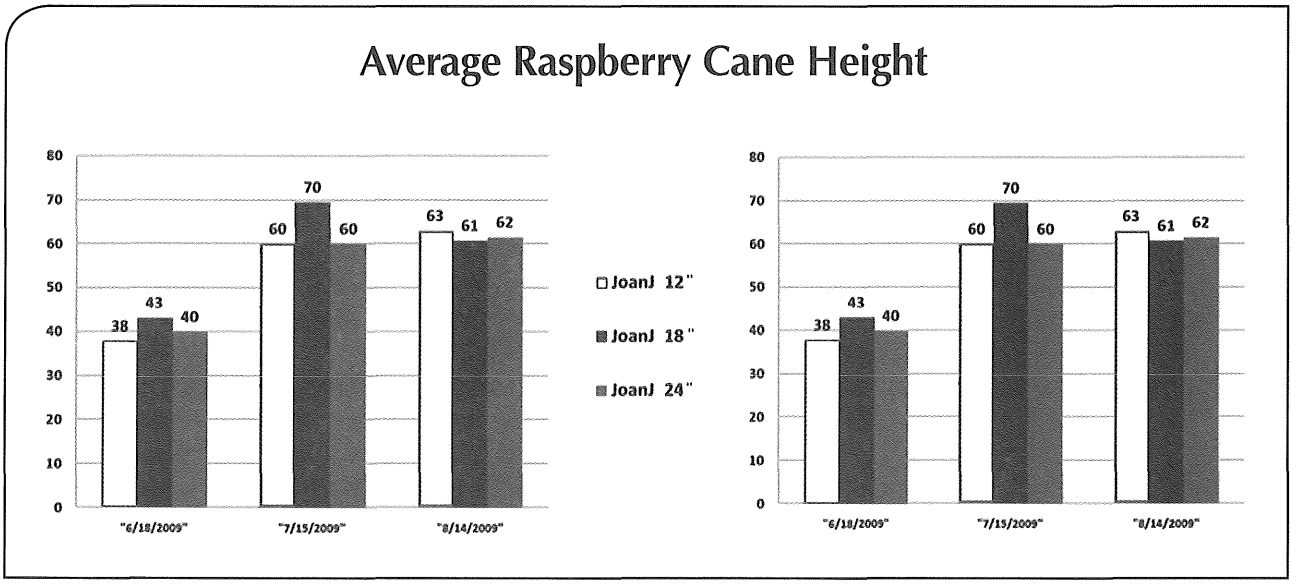

Figure 4. 2009 Growth of primocane-fruiting raspberry cultivar 'Joan J' at Berry Ridge in Alexandria, MN at each of the different spacings. Numbers on top of the bars in the bar graph are the average growths in inches.

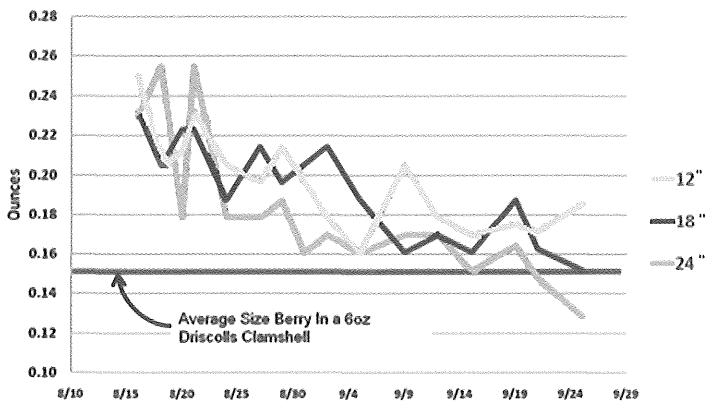

Figure 5. **2009 Average berry size of 'Joan J' grown in a high tunnel at Berry Ridge Alexandria, MN at different initial plant spacings.**

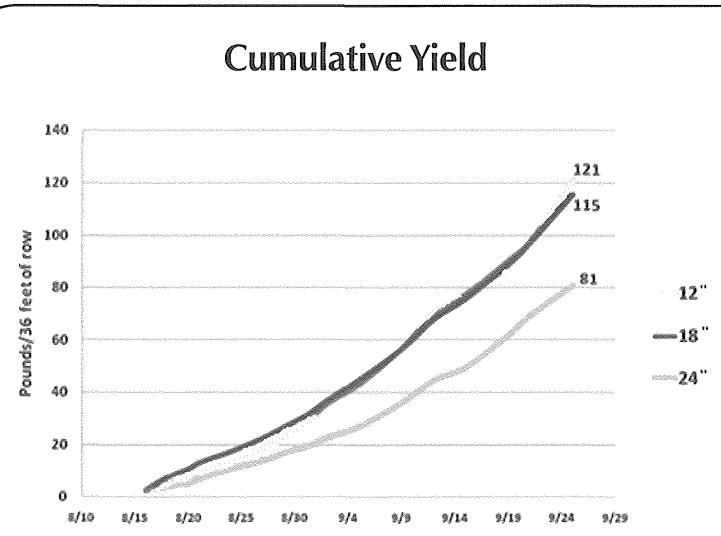

Figure 6. **2009 Production (lb/36' row) of 'Joan J' grown in a high tunnel at Berry Ridge in Alexandria, MN at different initial plant spacings. Numbers on the graphs are total yield.**

Raspberry production in the Upper Midwest has a number of challenges. If producers grow summer-bearing cultivars, the fruit quality is low due to hot temperatures during July harvest. In addition, winter injury to the cultivar results due to low temperatures, and they are susceptible to fungal infection. Some producers have tried fall-bearing cultivars. These cultivars are harvested as the temperatures are cooling in late summer and fall. The disadvantage of these cultivars is that peak production may occur after the first average frost date. For example, in Minnesota in 2007, the first freeze occurred the night of September 17. Fall-bearing raspberries that were not harvested at that point were lost to the freeze. Some growers estimated 80% of their crop was not harvested. With the protection of high tunnels, fall-bearing cultivars made it through this freeze event and harvest continued into early November with the associated increase in income and profitability. The other disadvantage of summer-bearing cultivars is the need to apply fungicides to reduce fruit loss due to fungal infection. Raspberries grown under high tunnels have very little fungal growth due to the lack of moisture on the fruit. Therefore, raspberries in high tunnels can be grown without fungicides.

Our high tunnel raspberry plots were established in May 2008 at two sites: The U of M WCROC at Morris and the Berry Ridge Farm in Alexandria, owned by Ron Branch.

The WCROC high tunnel is a 30' x 48' unit with thermostatically controlled roll-up sides. We are evaluating the effect of cultivar and row spacing (12" and 18") on vegetative growth and yield. The two cultivars we are testing are 'Autumn Britten' and 'Caroline', chosen for their outstanding fruit size and flavor. We are also growing the same two cultivars outside in a deer fence enclosure to compare non-high tunnel vegetative growth and yield to high tunnel production. We are using standard production practices for field production of primocane-fruiting raspberries.

At the second site, Ron Branch has three established high tunnels used primarily for vegetable production. The trial planting is a row of the fall-bearing raspberry cultivar 'Joan J', chosen to determine its suitability for growth in high tunnels. Bare-root plants were set at three spacings (12", 18", and 24").

Results

At the WCROC we measured plant growth, berry weight, and total yield for primocane-fruiting raspberries in high tunnel and field settings during 2009-2010. Both cultivars tested had substantially more growth in the high tunnel during both growing seasons (Figure 1). In 2009, high tunnel grown berries were larger and yields were almost double for cultivar 'Caroline' and almost three times higher for 'Autumn Britten' than the same cultivars grown outside the tunnel. In 2010, high tunnel grown berries were again larger and yields were higher than the same cultivars grown outside the tunnel (Figures 2 and 3). Interestingly in 2009, 'Autumn Britten' had a higher total yield than 'Caroline' but in 2010 the opposite occurred (Figure 2). The baseline for berry size was based on Driscolls clamshell which contains 40 berries per 6-oz container.

In 2009, berry size began large and quickly decreased until berry size for both cultivars in both settings fell below the Driscolls berry size (Figure 3). In 2010, berry size was always less than the average berry size in a Driscolls clamshell. In the high tunnel there was a sharp decline in average fruit size in early August 2010 which may have been due to temperatures in the 80's.

Soil Moisture
Irrigation at WCROC was based on readings taken from watermark moisture sensors in the high tunnel and field trials. The sensors were placed at 3" and 6" soil depths in the raspberry plant row. Readings were taken twice per week. Irrigation was turned on for 2 hours when the average reading was at 30 centibars. The irrigation system was a drip line tube with emitters every 12" and two tubes placed down each plant row with a flow rate of 1 gallon/hr.

Plant Nutrients
Plant tissue analysis samples were taken 2010 mid-season to determine plant nutrient deficiencies for 'Caroline' and 'Autumn Britten.' The plant lab completed the analysis and determined the nutrient levels were reasonably normal with the exception of a low level of Potassium (K). In the spring a soil analysis will be done and be compared to the plant tissue analysis. At that time a decision to add fertilizer could be made. Potassium is important for maximum raspberry yields.

Pest Incidence
Weeds were not a problem for either 'Caroline' or 'Autumn Britten' and only a small amount of hand-weeding took place in the high tunnel. Weeds were minimal because of the shading effect of the large plants. Weeds in the field trial raspberries were generally controlled with a granular herbicide called XL2 G (Surflan) which was applied once in early spring. The granular herbicide was applied at a rate of 6.9 lb/1,000 ft^2 at a cost of $20.70/1,000 ft^2.

Plant diseases were monitored during the growing season. No apparent diseases were noticed and plants remained in good health in both high tunnel and field planted raspberries.

Insects were monitored very closely during the entire growing season. A 10X magnifying glass was used twice per week to scout for insects, especially red spider mites. Early in the season a very small number of spider mites were detected and we used high pressure water to knock them off the foliage. This method worked extremely well for low spider mite infestations early in the season. Starting in mid-June, we applied organic horticulture oil for red spider mite and sawfly control. The product used was Pure Spray Green and used at a rate of 2.5 oz/gal of water. This natural product was used until mid-September at a cost of $45.00 for eleven spray applications.

Harvest Labor and Markets
Another aspect of this research project was to expose University of Minnesota, Morris (UMM) students to production practices of locally-grown raspberries at WCROC. In partnership with student garden volunteers at UMM and building on past successful relationships, we exposed these students to our science-based experimental project. Raspberries were harvested by volunteer student organizations and taken to UMM Dining Services. Dining Services served the fresh fruit, processed and froze the remaining product for future use in their menus.

The UMM Food Service is managed by Sodexho Campus Services, Inc. Their contract with UMM mandates that they purchase and use local foods in their meals, when available, and that they expose UMM faculty, staff, and students to locally-produced, wholesome food products. This project connects to the Pride of the Prairie Local Foods initiative and a new program enhancing healthy eating on campus and in the community. Engaging student leaders and volunteers in the harvest and consumption of the raspberries will hopefully stimulate increased interest in local foods and future marketability for area growers.

In addition, to involving UMM Food Service and UMM students we also share our knowledge with the community. On July 29, 2010 WCROC had a Horticulture Night. Community members were invited to learn about the raspberry high tunnel and the important role that plants have in our lives.

Management Tips

1. Monitor heat inside high tunnel closely. Excessive heat can have detrimental effects.

2. Monitor for red spider mites twice a week in high tunnels. If left unchecked, they can be devastating.

3. Normal raspberry harvest intervals should be twice per week; however, if temperatures are warm, consider three times per week for better quality fruit.

4. Have a reliable supplemental heat system to extend your picking season.

Cooperators

Ron Branch, Berry Ridge Farm, Producer, Alexandria, MN
Emily Hoover, University of Minnesota Department of Horticultural Science, St. Paul, MN
Emily Tepe, University of Minnesota Department of Horticultural Science, St. Paul, MN
Sandra Olson-Loy, Vice Chancellor for Student Affairs, University of Minnesota-Morris, Morris, MN

Project Location

UMN West Central Research and Outreach Center (WCROC) at Morris is south on Hwy. 59 from Hwy. 28. From Hwy. 59, watch for a large sign indicating University of Minnesota (right) and West Central Research and Outreach Center (left). Turn left. The administration building will be on your left.

Berry Ridge Farm is located at 1301 Firemen's Lodge Rd. SW, Alexandria, MN. From I-94, take exit 100 (Hwy. 27), going north, cross Hwy. 27 to Cty. Rd. 45. Go about .5 miles and turn left (west) on Latoka Lane. Go .6 mile then turn right (north) at lake. This is Fireman's Lodge Road. The farm is .8 miles and on the right.

Other Resources

FarmTek high tunnels.
Website: *www.farmtek.com/farm/supplies/home*

High Tunnels website sponsored by Kansas State Research and Extension, University of Missouri Extension, and University of Nebraska Cooperative Extension.
Website: *www.hightunnels.org/*

Nennich, T., David Wildung, and Pat Johnson. 2004. Minnesota High Tunnel Production Manual for Commercial Growers.
Website: *www.extension.umn.edu/distribution/horticulture/M1218.html*

Pennsylvania State University High Tunnel
Website: *http://plasticulture.cas.psu.edu/H-tunnels.html*

University of Minnesota High Tunnel Production
Website: *http://hightunnels.cfans.umn.edu*

Winter Plant Protection of Blueberries in Northern Minnesota

Principal Investigator

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Project Duration

2008 to 2010

Award Amount

$6,265

Staff Contact

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Keywords

blueberry varieties, snow cover, snow-making

Project Summary

Raising blueberries in northern Minnesota can be a profitable operation if adequate snow cover comes in a timely manner, and the grower has the ability to cover the plants and provide winter protection of the fruit buds. In years past, adequate snow cover has not been a problem, but for the past 5 out of 6 years, there has been little snow, or it has arrived too late in the winter to provide any protection for the plants. Our project will investigate the feasibility of using different types of winter plant protection, including the ability to make snow to cover the blueberry plants.

Project Description

Pine Creek Farm is located 40 miles north of Duluth, where winter temperatures typically get down to -40°F. We operate a pick-your-own blueberry patch that consists of 1,000 plants. During a typical year we market between 900 and 1,500 lb of berries.

The idea for our project came during the winter of 2006/07 when we only had 3" of snow cover for most of the winter and temperatures down to -34°F. Blueberry fruit buds are susceptible to damage from cold temperatures and dry winter winds, but adequate snow cover will protect the buds. During the 2007 berry season we picked a total of 5 lb of berries from 1,000 plants. The poor harvest was due to the buds not having protection from the elements over the winter, thus we realized we needed to provide protection when adequate snow cover was not happening in a timely manner.

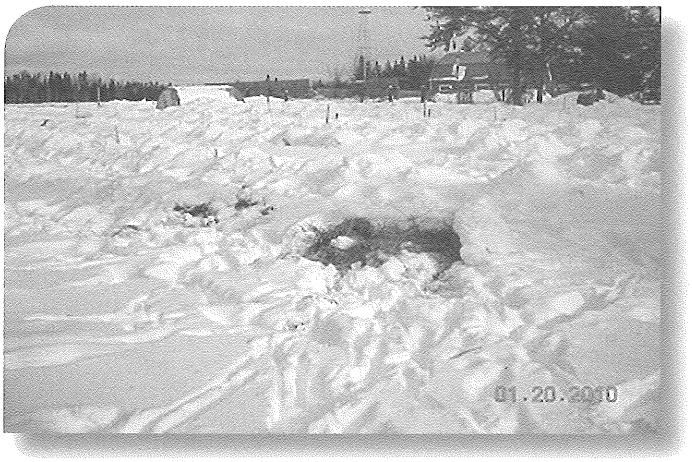
We have now completed two full growing seasons for our project and each year we have improved our methods for protecting the blueberry plants. This year we used the following types of cover:

- 1.5 oz/yd polypropylene row cover;
- 0.5 oz/yd polypropylene row cover;
- 1.0 oz/yd polyester drawstring plant bags;
- 7.0 oz/yd burlap;
- straw; and
- control plots (no cover).

Results

We had planned to make snow again this winter, as we did in the previous years but the weather conditions prevented that. To make snow, the temperature needs to be at 27°F with low humidity. This winter temperatures were above 30°F through the first week of December. Right after that adequate natural snow came and we did not need to make snow (Figure 1). This year we covered 62 plants on November 30, 2009 and uncovered them on March 29, 2010.

Adequate natural snow cover on the field in December 2009.



Deer dug through the snow to eat the hay that was mixed in the straw that was covering the blueberry plants.

This year we only used the variety Northblue in our study in order to have less variability in the results. Overall we found that it is better to have some type of winter cover than no cover at all (Table 1). Light weight row cover and lightweight plant bags do not last more than a few seasons, and so we have found that it might be worth getting the heavier row cover, as the labor is the same to apply either. In addition, the straw we used this year was not as clean as the previous years. The straw was mixed with hay and the hay attracted deer. The deer found the plots with the straw/hay mix and dug through 18" of snow to get at the hay (Figure 2). In the process they chewed on some of the blueberry stems which damaged the plants.

Our production yields were down this year and we have three possible explanations. First, we did not see very many bugs this spring; especially black flies. Black flies are important because they pollinate most of the blueberries in our area. We suspect our plants did not receive the pollination they needed for a good crop. Secondly, June 29, 2010 it was only 31°F and we had frost. During a "normal" year on June 29th we would have had blossoms on our plants. Typically blueberry blossoms can withstand temperatures down to 26°F, however this year, because everything was early, there were berries on the plants. Berries are less hardy than blossoms and at 31°F many of them froze, dried up, and fell off. Lastly, there was rain on January 23, 2010 which caused the natural snowpack to settle and branches of the blueberry plants were exposed to the elements until the next snowfall.

Table 1. 2010 yield results per plot of Northblue berries overwintered under various covers.

Type of cover	*Number of plants*	*Berry yield per plant (oz)*
Burlap	4	26.5
Row cover	4	15.5
Light row cover	4	12.7
Burlap	4	12.5
Straw	4	10.7
Row cover	4	9.5
Row cover	4	6.5
Row cover	4	6.2
Plant bag	1	6.0
Control-sheltered	4	6.0
Row cover	4	5.7
Straw	4	5.7
Plant bag	1	5.0
Row cover	4	4.0
Row cover	4	3.0
Row cover	4	2.0
Light row cover	4	1.5
Straw	4	1.0
Control-open area	4	1.0

Conclusions and Future Plans

This project gave us the opportunity to learn a lot more about blueberry production and we are glad we did the project. We are more aware of how the weather, amount of snow cover, type of winter protection the plants have and how these affect yield.

Even though the project is over we are going to continue to use some type of row cover for winter plant protection. The heavier 1.5 oz/yd polypropylene row cover is our first choice and we plan to use it for as many seasons as it will hold up (Figure 3). Straw has to be purchased and disposed of every year which makes it too expensive. The straw also requires more labor to apply and remove so we will not be using straw again. Making snow was very effective, but very labor and energy intensive.

At this time we are not planning on trying other types of covers because the project allowed us to try all of the coverings we could think of. Overall, we found that some types worked well, like the heavier row cover while some did not work at all, like the plastic barrels (no yield in 08/09). Our experience using row covers was good and we will recommend the practice to other farmers and even gardeners who wish to protect their plants over the winter.

The project had a positive effect on our customers. Each summer I set up a poster display and our berry pickers enjoyed seeing it. They asked questions about the plots, our results and also reading the write-up in the Greenbook. In addition, our pickers could see the yield differences of the berry crops on the bushes that had the different coverings.

Management Tips

1. Most types of plant coverings are better than no covering.

2. When conducting a study use only one variety to reduce variability.

3. When using snow as a cover be aware that a midwinter rain can uncover buds and expose them to harsh winter conditions.

Cooperators

Dave Olafson, Local berry grower, Duluth, MN
Robert Olen, University of Minnesota Extension, Duluth, MN

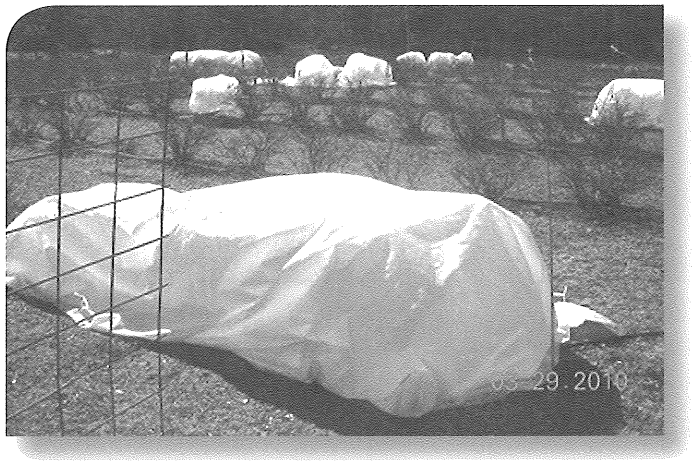
Project Location

Our farm is located 12 miles north of Two Harbors on Hwy. 2, then 12 miles west on Cty. Rd. 14 to Hugo's Bar, left for ¼ mile, then right on Jackpine Rd. for 1 mile to Pine Creek Farm sign.

Other Resources

Factory Direct Landscape & Greenhouse Supply. Row cover information. Palm Harbor, FL. 727-474-6226.
Website: *www.factorydirectlandscape.com*

Snow at Home. Snow-making advice and equipment. Terryville, CT. 860-584-2991.
Website: *www.snowathome.com/index.php*



Polypropylene row covered plants after the winter.

Growing Fresh Cabbage for Markets Using Integrated Pest Management Strategies

Principal Investigator

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Project Duration

2009 to 2011

Award Amount

$20,000

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Keywords

cabbage, cabbage looper, diamondback moth, Dipel DF insecticide, imported cabbageworm, integrated pest management, row cover, trap crop

Project Summary

The American Association for Hmong Women in Minnesota's project focuses on two Hmong women growers producing cabbage for the local fresh market. The purpose of the project is to demonstrate the effectiveness of timely pest management strategies using integrated pest management (IPM) and to demonstrate other agronomic production practices that would result in higher yields. A project consultant provides technical expertise in IPM strategies, safe pesticide use, general vegetable production practices, and also trains the AAHWM farm coordinator. The project consultant and farm coordinator worked together to translate materials and procedures into the Hmong language.

Project Description

Cabbage produced in the Rosemount and Vermillion areas of Minnesota are subject to several Lepidoptera pests that can cause serious damage to fresh market cabbage. These pests include cabbage looper (*Trichoplusia ni*), imported cabbageworm (*Pieris rapae*), and diamondback moth (*Plutella xylostella*). Working collaboratively, the project consultant and the farm educator set up cabbage demonstration plots at each of the two farms to: 1) demonstrate effective low impact pest management methods and 2) demonstrate how some general vegetable production methods can increase yields.

2009 Results

Each farm had a demonstration plot consisting of four single rows of cabbage, each row receiving one of four treatments. There were no replications of treatments at either farm as these were demonstration plots. The four treatments included:

1. Control - no treatment.

2. Dipel DF - a Bt (*Bacillius thuringiensis*) bacterial-based insecticide. This insecticide is specific to the larval stage of the three cabbage insects and does not harm beneficial insects. It is inexpensive and has a very low toxicity so it is safe for the applicator and environment. Dipel DF was applied using a Hudson 4-gallon backpack hand-pump sprayer.

3. Row Cover - a spun-bound polyester fabric was placed over the rows and supported with wire hoops. Row covers allow light, air, and water to penetrate but keep aboveground insects out.

4. Trap Crop - two rows of collard greens were planted adjacent to a cabbage row. A trap crop serves as a food source that attracts insect pests and keeps them away from the main crop. Research indicated that collard greens act as a trap crop for diamondback moths. The farmers tested this to determine if a trap crop would have any success in attracting imported cabbageworm butterfly and cabbage looper.

A late flathead cabbage variety was planted in all plots. Plants were spaced approximately 18" apart in each row and rows were 3' apart. A small handful of starter fertilizer (about 1/4 cup) was soil incorporated at the time of planting near each cabbage transplant. No soil analysis was done in 2009 due to the late establishment of the rows. The project consultant calculated and weighed out the proper amount of nitrogen fertilizer to deliver 120 lb N/A. The "Midwest Vegetable Production Guide for Commercial Growers, 2009" was used as a guide for cabbage fertility requirements. The project consultant reviewed the calculation process with the farm educator so that he could demonstrate the procedure in Hmong for each farmer. Fertilizer amendments were made using a

split application of fertilizer incorporated along the side of each cabbage row and applied at 2 and 4 weeks after cabbage plants were transplanted. Both fertilizer sidedress applications were completed at Dia Xiang's farm, but only one was completed at Yer Vang's farm. No fertilizer costs were measured as the farmers already had it on hand.

Throughout the summer, the project consultant and farm educator made nine visits to each farm to monitor pest pressure and review with each farmer the progress of the cabbage. Because of heavy rains and cooler than normal summer temperatures, pest pressure was greatly reduced.

The demonstration plots were harvested in late August at Dia Xiang's farm and in mid-September at Yer Vang's farm. Average cabbage head weight per row was determined at each of the two farms. Weights were determined in the field by placing the cabbage heads in a large pail and weighing them using a Rapala 50 lb Digital Scale (hand held). Since there were no treatment replications, no statistical analysis was conducted. Both farmers were pleased with the results of using a row cover and quickly recognized its value in preventing insect damage on cabbage plants.

Dia Xiang Farm

The trap-crop treatment resulted in the highest average head weight of 5.15 lb (Figure 1). One possible explanation for this is that there was more space between rows adjacent to the double collard green rows to the north. At harvest time, all rows showed a dense leaf canopy between rows, except the outside row, which was the trap crop. This extra space could have allowed the cabbage leaves more light and space.

During the growing season, the collard greens harbored numerous eggs and small larvae of the imported cabbage worm and diamondback moth. Additionally, larval leaf feeding was observed on the trap crop. Visual observations showed less leaf feeding on the cabbage. One application of Dipel DF was made to the trap crop cabbage on July 28.

The row-cover treatment had an average head weight of 4.34 lb. Although the purpose of a row cover is to keep aboveground insects out, the installation of the row cover was not done immediately at planting. This delay allowed adult imported cabbageworms to lay eggs on cabbage leaves before the row cover was installed. At the time of the row cover installation, many eggs and larvae of the imported cabbageworm were observed on the underside of the cabbage leaves. An attempt was made to remove any eggs or larvae from the cabbage leaves. Despite this effort, it was impossible to remove all eggs and larvae. During the course of the growing season, the row cover was lifted twice to remove any adult imported cabbageworm butterflies. Dia learned that it is imperative to install the row covers immediately after transplants are planted.

Another possible reason for a smaller yield in this treatment was overcrowding. Although the wire hoops were raised during the growing season to allow for leaf expansion, many leaves were curled back at harvest time as they were forced against the top of the row cover. Evidently, the row cover needed more adjustment than it received.

The control treatment fared quite nicely with an average head weight of 3.73 lb. Heavy leaf feeding was observed early in the season, but heavy August rains, cool temperatures, and beneficial insects may have all played a role in reducing the pest pressure in the control treatment, thereby out-yielding the Dipel DF treatment.

The Dipel DF treatment was adjacent to a gravel farm road and resulted in the lowest average head weight of 3.24 lb. A small grass strip existed on the shoulder of the gravel road that butted up against this row. The grasses in the strip grew to a height of 2½', partially shading the cabbage. One application of Dipel DF was applied on July 28 during the cupping to early head growth stage when the IPM threshold was at 20% (20% of plants have eggs or larvae).

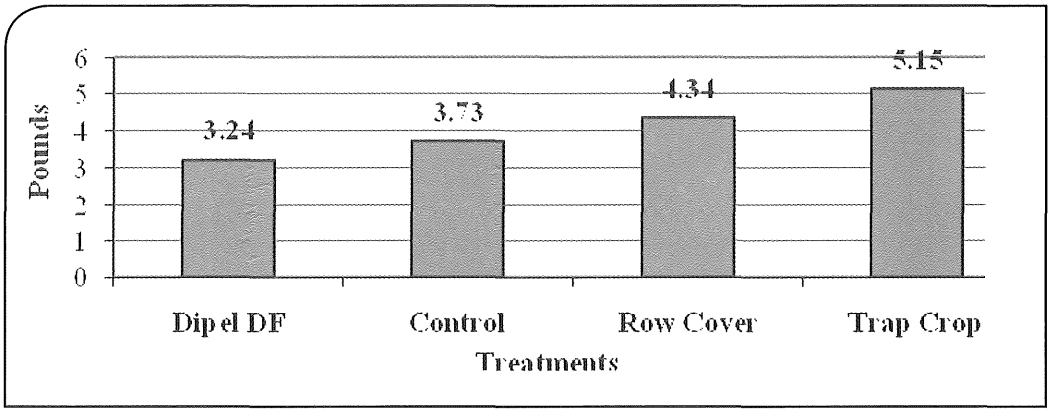

Figure 1. Dia Xiang Farm: 2009 Average Cabbage Head Weight/Treatment.

Yer Vang Farm

The row-cover treatment resulted in the highest average cabbage head weight of 6.45 lb (Figure 2). Although the row cover was installed 2 weeks after planting, this treatment faired very well. Twice during the growing season, the row cover was lifted to remove adult imported cabbageworm butterflies. There was a high presence of imported cabbageworm butterflies trapped under the row cover due to some tears in the fabric. Consequently, the row cover treatment received two Dipel DF treatments on August 11 at 1 tsp/gal, and August 27 at 2 tsp/gal. The fabric was not completely repaired so some insects were trapped under the row cover for the entire season. The row cover treatment was in full sun and had the best location of all rows.

The control treatment row had an average head weight of 5.68 lb. Despite heavy insect pressure, this treatment also did very well. Two explanations are possible. There was a high presence of beneficial insects drawn into the area because of the many flowering Brassicae plants nearby. Also, there were heavy August rains which washed off and drowned many of the larval insects.

The Dipel DF treatment had an average head weight of 5.20 lb. This plot was treated once on August 27 at the rate of 2 tsp/gal. Insect pressure was high at this time and there were many imported cabbageworms and cabbage loopers present as adults, eggs, and larvae.

Finally, the trap-crop treatment had the lowest average head weight of 5.11 lb. This row had some shading effect from adjacent corn and trellised bean plants. It was observed that the collard greens received heavy feeding from larval insects during the growing season. This gave an indication that the trap-crop treatment was working.

At the Vang farm, weed pressure was high. Hand weeding had to be done to ensure that the cabbage plants would grow sufficiently. At one time, the row cover treatment had to be lifted to remove the tall weeds.

Input Costs

The row cover for the project was purchased at Jordan Seeds, Woodbury, MN. A roll of 5' x 250' cost $28.35. This was split between the two farmers. The linear cost of the row cover was $0.11/linear ft. During September of 2009, fresh market cabbage was selling at $1/head. At this market price and using 18" spacing between plants, the row-cover cost per cabbage head was $0.17 (one cabbage per 1.5' of row x $0.11), providing a return of $0.83 per head of cabbage. This return does not include other costs. The cost of a 5 lb bag of Dipel DF was $86.60, or $17.32/lb. Dipel DF was used at 1 or 2 tsp/gal at a cost of $0.17/tsp. Because of the low spray volume used, the cost to treat a row ran from $0.17 to $0.34/row.

2010 Results

Cabbage was planted into the same four treatments as were applied in the previous year (control, dipel, row cover, and collards trap crop) but with one exception. Biodegradable paper weed mats were added to all cabbage rows in 2010 to deal with the heavy weed pressure experienced in 2009. Before planting the cabbage, the weed mats were laid down in all rows and secured along the edge with soil. Using a sharp knife, X-slits were made in the weed mat every 15" to accept the cabbage transplants.

Cabbage planted in biodegradable weed mat. Cabbage in weedmat and row cover at left.

The row covers were closed immediately after setting the transplants in 2010 to prevent egg-laying by Lepidoptera insects.

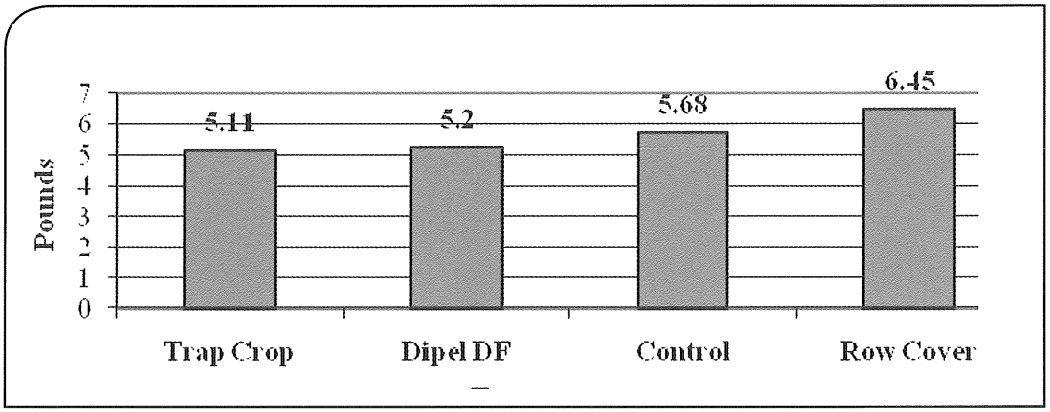

Figure 2. Yer Vang: 2009 Average Cabbage Head Weight/Treatment.

Cabbage planted in biodegradable weed mat. Cabbage in weedmat and row cover at left.

A comprehensive soil test taken in July revealed a very low soil pH of 5.0-5.3. This is below the acceptable range for any vegetable production. These fields will not achieve optimal production until lime is applied to raise the pH to at least 6.3. The lime should be added in the fall and worked into the top several inches so that it affects the pH of root zone for the following spring crop. Optimum pH will not be fully achieved until the second year.

Unfortunately, Yer Vang's field was flooded in August by the Vermillion River and no comparisons could be made between cabbage treatments on her farm. An error occurred in May when planting the cabbage plots at Dia Hiang's farm. Three cabbage varieties were mixed together, making final cabbage weight comparisons impossible. This problem was corrected for the second planting on July 21. The cabbage variety Bronco was uniformly planted across all treatments.

Throughout the summer the cabbage was scouted for plant growth and insect pressure. Heavy rains occurred periodically during the growing season, reducing Lepidoptera insect pressure. Consequently, no Dipel DF insecticide was applied to the fall crop.

In late September, the cabbage from Dia's second planting was harvested and weighed. The cabbage averaged 3.7 lb/head with no apparent treatment differences.

Farm educator Chianeng Thao shows Dia Xiang's husband the quality and weight of cabbage.

Throughout the 2010 growing season, the weed mats did a very effective job of controlling weeds within the cabbage rows. The weed mats added an additional cost of $0.22/head. The total cost for materials was $0.34/head. Using a $1.00 minimum for a fresh market price, the profit was $0.66/head minus other production costs.

Management Tips

1. If using row covers, apply a pre-emergent soil herbicide, mulch, or weed mat to control the weeds before planting the cabbage. Heavy weed pressure will push the row cover up as well as rob water, light, and nutrients from the cabbage.

Farm educator Chianeng Thao shows Dia Xiang's husband the quality and weight of cabbage.

2. Apply row covers immediately after setting cabbage transplants to prevent Lepidoptera insects from laying eggs on young leaves.

3. Calculate needed fertilizer requirements based on soil analysis and split the applications at the time of planting and 30 days later. Since granular fertilizer was used, the second application would require lifting the row cover to complete the application.

4. Apply and incorporate lime in the fall if a soil test reveals a low pH.

Cooperators

Dia Xiong, Farmer, Rosemount, MN
Yer Vang, Farmer, Vermillion, MN
Kevin Cavanaugh, Independent IPM Consultant, St. Paul, MN
Maiker Vang, Farm Educator, St. Paul, MN

Project Locations

Dia Xiong Farm: Travel on US 52 south and exit at Dakota Cty. Hwy. 42 west. Follow Hwy. 42 to Dakota Cty. 73. Do not follow Hwy. 73 detour. Turn north on Cty. Hwy. 73 (Akron Ave.), just past Dakota County Technical College. Disregard "ROAD CLOSED" sign and proceed on new gravel road until you see the "Railroad Crossing" sign. Turn right off of the gravel road and follow the field roadway up the hill to the farm buildings.

Yer Vang Farm: Travel on US 52 south to 200th St. E. also called Cty. Rd. 66 exit. Turn left onto Cty. Rd. 66. You will see a farm vegetable stand on the left corner. Turn left into the driveway.

Other Resources

Growing Broccoli, Cabbage, and Cauliflower in Minnesota. 2009. University of Minnesota Extension Publication. M1247. Website: *www.extension.umn.edu/distribution/horticulture/M1247.html*

Midwest Vegetable Production Guide for Commercial Growers. 2010.
Website: *www.btny.purdue.edu/Pubs/ID/ID-56/*

Minnesota Fruit and Vegetable Growers Manual for the Beginning Grower. 2004. University of Minnesota Extension.
Website: *http://smfarm.cfans.umn.edu/mfvgmanual.pdf*

Nutrient Management for Commercial Fruit & Vegetable Crops in Minnesota. 2009. University of Minnesota Extension Bulletin. WW-05886.
Website: *www.extension.umn.edu/distribution/cropsystems/DC5886.html*

Perimeter Trap Cropping Works! University of Connecticut – Integrated Pest Management.
Website: *www.ipm.uconn.edu/IPM/veg/htms/ptcworks.htm*

Row Cover Vegetable Production Techniques. 2004. New Mexico State University Extension. Guide H251.
Website: *http://aces.nmsu.edu/pubs/_h/H-251.pdf*

University of Minnesota Extension Commercial Vegetable and Fruit Production.
Website: *www.extension.umn.edu/Vege&Fruit/*

Solar Energy Storage and Heated Raised Beds

Principal Investigator

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Project Duration

2010 to 2012

Award Amount

$8,000

Staff Contact

Jean Ciborowski
651-201-6217
Author: Cassie Boadway

Keywords

solar-heated water, season extension, vegetables

Project Summary

The goal of our project is to be able to supply local fruits and vegetables earlier in the season when demand from our customers is high. We have designed a system that will use solar-heated water, stored in an underground tank and then pumped through PEX-AL-PEX tubing to warm the soil in spring, which will allow us to plant outdoors sooner. In addition, we have also designed 3' high growing tables that will house the tubing and allow for less labor-intensive vegetable growing.

Project Description

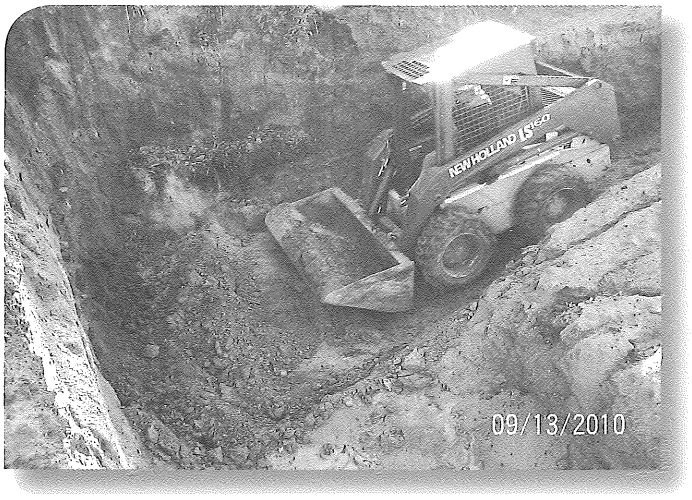
For the past four years we have been operating Gardens Gourmet, a market garden and CSA. Our farm is located in east Otter Tail County which is in central Minnesota. We grow many vegetable and fruit varieties in order to supply our customers with an assortment of produce all season long. Over half of our production is sold on the farm, approximately one-third is sold through the CSA, and the rest is sold through farmers' markets.

Our frost-free growing season averages 100 days. In many years, our tomatoes, peppers, and melons don't ripen until late August or early September. By then most of our customers, who are primarily tourists, have made their last trip to our area. Our soil-warming system will hopefully move our harvest dates up by 40 to 60 days so that our produce harvest will peak at the same time as the main tourist season. In addition, harvesting earlier in the season will allow us to compete with produce being shipped in from other states. We would also like to expand our market and sell to restaurants. Restaurants will not commit to buying from local producers unless the producer can supply the product over a long period of time, so an earlier harvest could give us the option of selling to them.

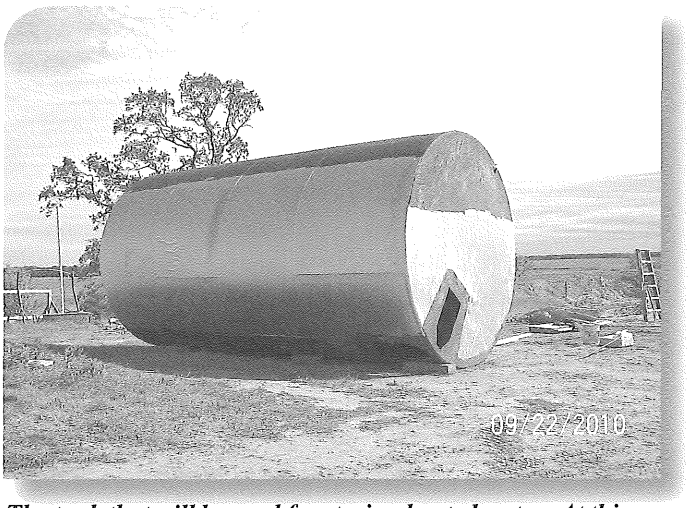
Spring production is limited by low soil temperatures. The low soil temperatures delay seed germination, cause nutrient deficiencies, and can stunt the plants. High tunnels do not heat the soil well in the spring and that is why we will be using a new system to heat the soil without a high tunnel.

Our goal is to build a system of outside raised and shaped beds that are heated with solar-heated water. First, we picked an area next to our greenhouse to put the heating units, the storage tank, and the raised beds. We chose this particular site because it is close to our house, a water supply, and electricity. Originally, we had a different site picked out near our market garden, but a tornado blew

The future location for the vegetable beds. The electrical outlet in the foreground will provide electricity for the water pumps. The large stack of wood in the background was cut from trees blown down during the tornado.



Digging the hole for the storage tank.



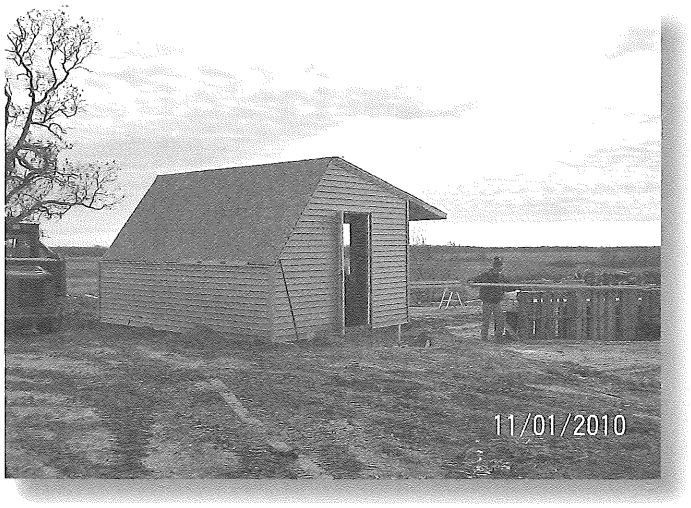
The tank that will be used for storing heated water. At this point, we were halfway done painting the tank.

down our old wooden barn, and when we had cleared the debris, the new site was perfect for the raised beds.

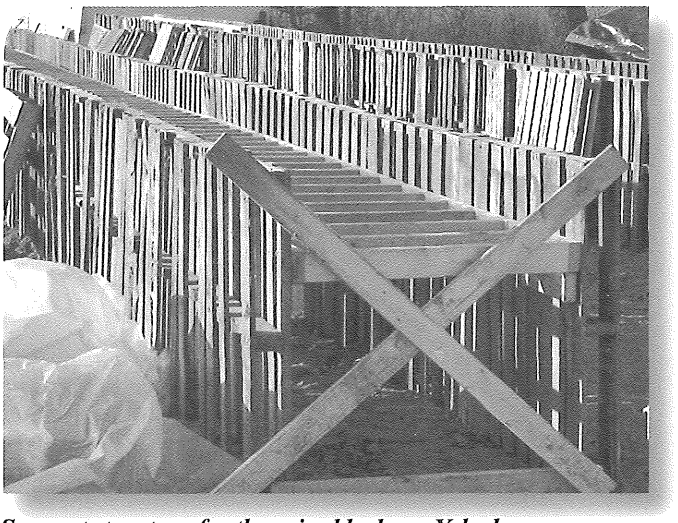
Once the location for the beds was settled on, we dug a hole 24' x 14' x 14' next to the future location of the beds. A steel tank 11' in diameter and 21' long was purchased to go in the hole. The tank holds 10,000 gallons and we want to use it to store heated water from the solar collectors. We painted the tank with oil based enamel paint and placed it in the hole. The hole has 1" Styrofoam® insulation on the bottom, 2" Styrofoam® on the top and sides of the water tank, and is backfilled with sand.

After the hole with the tank had been filled, a small shed was constructed over the tank. Next, we will install four solar water-heater panels on the shed's roof. In addition, the shed will house two pumps that will operate two separate pumping systems. The first system will be a completely closed system with water and antifreeze that will flow through the solar panels and into coiled PEX-AL-PEX tubes placed in the tank, and then back into the solar collector. PEX-AL-PEX tubing retains its shape when bent and also minimally contracts or expands with temperature changes so it will work well with the demands of our soil heating project. Inside the tank, the water-antifreeze system will flow through 500' of ½" PEX-AL-PEX tubing that will act as a heat exchanger. The four solar panels will be able to collect 8,800 BTUs per hour in average sunlight. With good sunshine, we hope to heat the water in the tank between 100 and 120°F. If the water temperature rises 22° above the ambient temperatures, we will be able to store 1,760,000 BTUs in the tank.

The second pumping system will take water that has been stored in the tank and pump it out to the planting beds. Heated water will be pumped out through ½" PEX-AL-PEX tubing to both raised beds and into a section of leveled soil and back into the tank. When we are finished, we will have 400' of tubing in each of the four beds. The raised beds, which we are calling X-beds, are about 3' off the ground. The sides of the X-beds are made from pallets with 2 x 4 cross framing. Styrofoam® insulation will form the base for the soil in the frames. PEX-AL-PEX tubing will be placed on top of the Styrofoam and then be covered with 9" of soil. The X-beds will be used for high-value, labor-intensive crops such as lettuce and green beans. At this time we have 160' of X-beds constructed and hope to complete a total of 400'. For the other beds, we will place the tubing directly into the soil. In these beds we will grow heat-loving crops, such as tomatoes, cantaloupes, and zucchinis.



The shed that will hold the solar panels and house the pumps. Chuck is working on the X-beds.



Support structure for the raised beds, or X-beds.

Results

On June 17, 2010 a tornado that went through Wadena also went through our farm. The tornado flattened all our outbuildings, including our greenhouse, but left our house intact. Once a big section of our yard was cleared of debris, we began planning our project. In spite of spending a great deal of time cleaning up our property and installing a new greenhouse, barn, and shop, we were able to get a lot of the bigger construction projects done. Our goal is to have the system fully operational during the summer of 2011 for fall planting and harvest.

Management Tips

1. Always check with your local officials to see what permits are required when doing major construction projects.

2. Budget more money than you think you need since major projects can cost more than planned.

3. Start on the most level ground you can find.

4. Try to source materials as close to home as possible to reduce shipping costs.

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, 1 mile south of the intersection of Hwy. 29 and State Hwy. 210. We are on the east side of the highway.

Determining the Cost of Raising Pastured Pork on a Diet Including Whey and Finishing on a Diet Including Acorns

Principal Investigator

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Carver County

Project Duration

2010 to 2012

Award Amount

$8,000

Staff Contact

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Keywords

feeding acorns and whey, heritage pig breeds, meat flavor, niche marketing, rotational grazing

Project Summary

I am raising heritage breeds of pigs including Red Wattles and Large Black hogs on pasture. My first objective is to implement an intensive grazing plan for the pigs. I will compare 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 will use them as a control group as they do not have the reputation as grazers.

In addition to raising the pigs on pasture, I will also be finishing them on an alternative diet including acorns and cow milk and determining how a varied diet affects meat flavor. It is my hope that a varied diet including acorns and milk will enhance the quality and flavor of the pork and will 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

The main portion of our farming operation has been a dairy typical of many small dairies in Minnesota. We milk 70 head of Holsteins in a tie stall barn. We raise a rotation of corn, soybeans, small grains, and alfalfa. Our soils are rich and support commodity crops well. The topography is flat to gently rolling. Labor is provided by family members with one hired individual.

We have decided to sell our dairy cattle this year. This sale will definitely affect our farm's income. I plan to use this project to demonstrate a transition from commodity based marketing to local and niche marketing to support the income on small farms as well to provide environmental and social benefits to the local communities.

It is my goal to produce a high quality pork product while demonstrating a successful grazing plan using Red Wattle pigs and Large Black Hogs. I also added a small group of Hampshire and Berkshire pigs to use as a control group of pigs not noted for their grazing habits. I will be testing the feasibility

Our boar grazing in the pasture.

of incorporating alternative feeds including acorns into the pigs' diets to determine the effect diet has on the flavor of the meat.

2007 Results

My first year in implementing my project was a year of learning experiences. I had many questions to answer for myself including: What type of fencing am I comfortable with? What forage do pigs prefer? How do I handle farrowing? And, what is the best marketing approach?

I decided to focus this first year on developing markets for our pork and becoming familiar with raising pigs in general, not just on pasture. In March I purchased a small group of three Hampshire feeder pigs to raise and market. I also worked towards establishing a herd of heritage hogs by purchasing two Red Wattle gilts and bred them to farrow in July and August.

Feeder Pigs:
I raised the pigs on a diet including a 5 lb ration of grain and mineral ration, 3 lb fresh alfalfa, 4 lb cow milk and 2.5 lb windfall apples from a local orchard. The alfalfa was fresh and hand harvested every day. Apples were added to the diet during the last 6 weeks before butchering. I was allowed to have the apples for free if I gathered them. The pork from the pigs finished on apples will allow me to test any difference in the flavor of pigs finished on apples verses acorns.

The pigs were ready for market in 208 days. The live weights were 240 lb for one pig and 230 lb each for the other two. The hanging weights were 170 to 160 lb.

Windfall apples are an alternative feed source that I plan to include in some of the pigs diets in the future. I like using apples because they are easy to collect and store. Feeding apples is also an intriguing selling point. Many people I spoke to about the pigs finished on apples seemed to have an immediate vision of a good pork product and showed interest in purchasing pork in the future. The orchard I used for getting apples did not charge me for the apples. But by the end of the season the owner mentioned charging me a price if I collected apples in the future. The price for collecting windfall apples may limit the number of pigs I can finish on apples in the future.

While I secured agreements to harvest acorns from oak trees throughout Carver County, I did not pursue finishing the pigs on acorns this year. The Red Wattle pig litters that will farrow in January 2011 will have a finishing date which coincides with acorn harvest. Increased efficiencies in raising the pigs in the coming year will allow more time to adequately measure the results of the acorn harvest.

I did not have enough pigs this year to make a good assessment of pasture use, but I do have some observations. By having both grass and clover pastures, I observed that clover is much more palatable to the pigs. I also noted more rooting when the pigs were on grass. I will follow this observation in subsequent years to test its reliability. In the coming year, feeder pigs will be placed on clover pastures and sows and boars will be placed on grass pastures.

Marketing:
I used a blanket approach for marketing in 2010, including a local farmers' market, direct marketing to a local restaurant, a booth at the Carver County Fair, becoming a member of MN Grown, and developing a website and a Facebook page.

Most of our customers were very happy to find someone in Carver County who is raising both pigs and chickens as we are. Some had been driving farther distances to purchase products. We invited our customers to our farm and always offered them to see how the animals were raised. It was a very positive experience.

The farmers' market was not successful due to poor customer participation. I think participation in a farmers' market has good potential and I will be getting involved in organizing a different farmers' market in a residential setting in 2011.

The Carver County Fair offered some good contacts and the opportunity to talk to interested customers one on one. I have not decided if I will have a booth at the fair in 2011. The website was successful in gaining exposure, but I feel I can gain the same exposure with continued membership in MN Grown and maintaining the Facebook page.

We were very fortunate that a restaurant named Terra Waconia opened in Waconia in February 2010. They source local foods for their menu and we hope for their continued success as it will fuel our success. It has been a good starting point in learning about sourcing to restaurants and we hope to expand that in 2011.

We have had very positive feedback on the quality and flavor of our pork during the first year. The pigs processed in 2010 were three Hampshire piglets purchased in March 2010 for just $15 each. It was difficult to set a price for the pork I sell. To assist me I have researched what other farms charge and found a price my clientele and I are comfortable with. I have enjoyed a profit from each pig sold and with

One of the Red Waddle gilts.

expanded marketing I hope to see a profit in the near future which will sustain our farm.

Farrowing Red Wattles:
In 2010, I farrowed two Red Wattle sows in July and August. Both farrowed in pens were allowed to move freely about their pens. I feel summer was not an ideal time of year to farrow due to the heat. However, I bred them when I did because the gilts were of breeding age at 12.5 and 8 months of age when I purchased them in February. I did not want to put off breeding allowing the gilts to get too large.

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. The first gilt farrowed 15 piglets and weaned 8. There were 3 stillborn, 2 were runts, and 2 were crushed. The second gilt farrowed and weaned 8. Despite the losses experienced with the first litter, I will pen farrow while allowing the mother access to outdoors again in 2011 and may experiment with pasture farrowing.

I gave the first litter iron shots and they thrived. When I let them go out on pasture I noticed the piglets perked up their energy levels. So, for the second litter instead of giving iron shots I put in 5 gal of soil while they were in the pen. These piglets rooted in the soil and thrived without the iron shots.

Fencing and Watering:
I did not have enough pigs to gather reliable data on implementation of a grazing plan. Instead, I experimented with different fencing for different groups of pigs. Five foot high panels pounded to wood posts worked well for pigs from 30 pounds and over, but small piglets seemed to constantly find a way out. Our first litter of piglets earned the title of 'free range' rather than 'pastured'.

Electric wire fencing proved to be very effective for our feeder pigs greater than 60 pounds. Smaller pigs either found a way under, over, or through the electric fencing. I constructed an electric fence training area surrounded by a cattle panel perimeter to restrict the pigs from getting out entirely. I don't have a good explanation of why the younger group challenged the electric fence so consistently. I will observe things again next year to make a better determination.

I also noted that although the electric fence alone is very effective once pigs are trained to it, pigs are very intelligent and I witnessed their varied attempts at shorting out the wire including rooting up soil along the fence line and forming a mound which would touch the lowest wire or pushing any object they could find against the wire including large rocks, watering tubs, and feed tubs.

I have decided that the fence I am most comfortable with is a high tensile woven or welded wire fence with holes small enough to contain piglets with a strand of electric wire around the inside perimeter and portable electric wire between paddocks. The woven or welded wire is less expensive than cattle or hog panels and the electricity offers an additional security measure. I want to avoid building a negative reputation of pastured pigs getting out of their fencing.

I used two different watering systems in 2010: nipple waterers attached to a watering hose and water tubs. Both had good points and bad. I liked the nipples because the pigs had a consistent supply of fresh water. However, the pigs had a tendency to run the water to create a mud hole at the watering location. I liked the tubs because they were portable so if one watering location got too muddy, I could easily move it. The problem with the tubs is that some pigs like to step into them muddying the water. Next year I will try a portable nipple system which will allow consistent cold, fresh water and avoid unwanted mud holes.

While I am mentioning mud holes, I will insist that they are absolutely necessary. On the hottest days during the summer of 2010, they were a savior to the health of the pigs. I would highly recommend implementing them into a pasturing system. In 2011, I will have a central mud hole much like a dry lot and the pigs will have the freedom to go back to that location as they are rotated through the paddocks.

In 2011, I plan to farrow the two Red Waddles sows in January, and possibly again in August or September. I also plan to breed some of the gilts that were born in 2010 for farrowing in August and September. I plan to get a few Large Black gilts to add that breed to our farm. I will have a greater number of pigs and more experience of managing pigs by then.

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. Provide a warming lamp while piglets are very young. This helps keep the pigs away from the mother when she lies down preventing crushing.

3. Put 5 gal of soil in the farrowing pen so the piglets can root in the soil. This gives them enough iron and iron shots are not needed.

4. Mud holes in the pastures are needed on hot days.

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 Avenue 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.

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 Extension, St. Paul, MN, 612-625-8173 or 800-876-8636.

University of Minnesota Extension Service. 1999. Swine source book: Alternatives for pork producers. Publication No. PC-7289-S. University of Minnesota Extension, St. Paul, MN, 612-625-8173 or 800-876-8636.

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

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Project Duration

2010 to 2012

Award Amount

$4,000

Staff Contact

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Keywords

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

Project Summary

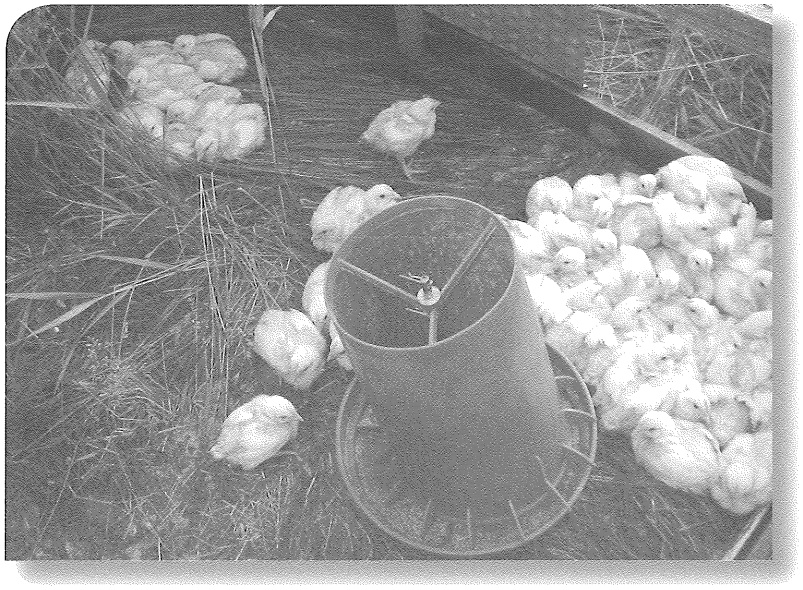
This project will measure the ability of two chicken breeds (Cornish Cross and Red Broilers) to improve the quality of an unproductive hay field. We will monitor the relative changes in plant composition and productivity after grazing alone and by a combination of grazing and seeding over three years. The financial break-even point will be determined for each breed on pasture enhanced by grazing alone vs. that enhanced by grazing and seeding in order to demonstrate which breed will be more economical to grow for the long-term profitablity and growth of our operation, and to demonstrate whether or not seeding is needed to achieve the best results. We will also survey our customers who buy both breeds to get feedback on the perceived differences in flavor or value between Cornish Broilers and Red Broilers. We 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 consumers, pastured poultry operation using 10' by 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 per 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 are 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 will use a 5-acre hay field for the study. This field has had no fertilizer applied for many years. Half of the area grazed will get



Two week old Cornish Cross chicks on pasture.

seeded with a 50-50 mix of red and white clover while the other half will be left as a "no-seed control." A section of the field will remain ungrazed by chickens, half of which will be 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 will compare the cost efficiency of each chicken breed based on the forage available to them and the impacts each breed has on forage quality and abundance. In year 1, all chickens will be grazing on unimproved pasture, half of which will get a seeding of clover after the chickens pass over it. In years 2 and 3, chickens will be grazed on the same area as in year 1, so half of the birds will be grazing on clover-seeded areas and half on the no-seed control areas.

Results

Since this is the first year of a 3-year study, we did not expect any differences in finished weights, feed consumption rates, and the economics for a given breed. This year's data does provide the baseline against which we measure any improvements in the coming years. It will be very interesting to see if we begin to see changes in feed consumption rates, costs, and/or finished weights in the coming years in response to any changes we may see in plant abundance or composition as a result of chicken grazing, seeding, or both.

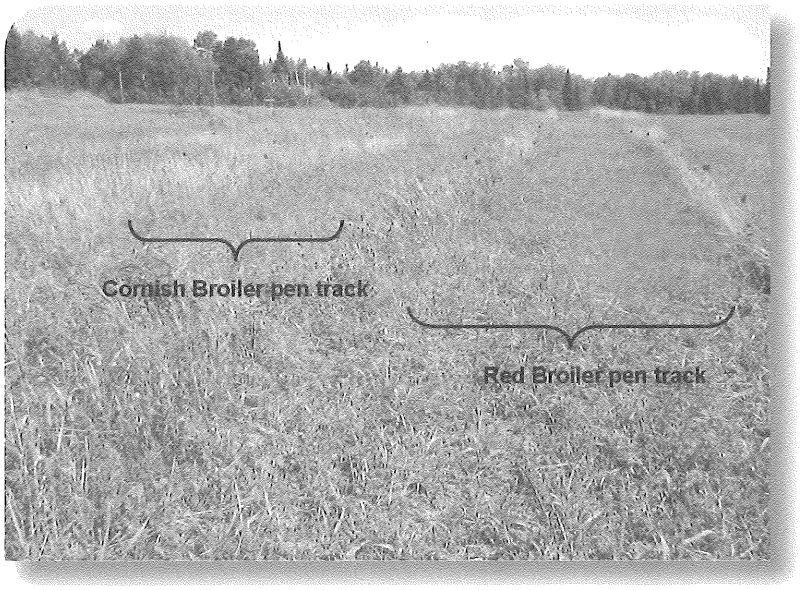
We raised 50 Cornish Cross or Red Broilers in each pen in 2010. There were substantial differences in both the costs and finished weights between the Cornish Cross and Red Broilers. The Cornish Cross outperformed the Red Broilers in the costs/bird, finished weights, and the time to get to finished weight.

The average feed cost per bird per day was the same for both breeds at $0.10/day. However, because the Red Broilers were on pasture for 12 weeks, the average total feed cost/bird was much higher at $6.25 to $8.24. The Cornish Cross grew to market weight with only 6 weeks of feeding on pasture. It cost $3.84 to $3.98 for feed/bird for the Cornish Cross.

Also, there was a large variability in the average finished weights of the Red Broilers in each pen. They ranged from 2.9 lb/bird to 6 lb/bird. The average finished weight of the Red Broilers was significantly lower than the Cornish Cross despite the fact that they grew for 14 weeks as compared to 8 weeks for the Cornish Cross. The Cornish Cross birds were much more consistent with weights of 4.5 to 5.5 lb/bird.

Two major issues arose that we will address in the next 2 years of the project. First, we were unhappy with the growth rates and economic performance of the Red Broiler variety in general and the variability in growth rates and finished weights between pullets and cocks. Next year, we intend to raise cocks only for 11-12 weeks (rather than 14 weeks). We will also change to the Freedom Ranger broilers which have been shown to have better growth qualities than the Red Broiler variety.

Second, we had planned to conduct plant sampling throughout the summer (i.e. each plot sampled 8 weeks after chickens had gone over it and it received seed/no seed treatment). However, as the season progressed we realized that the plant establishment and growth patterns over the season were very inconsistent. Therefore, we will be conducting plant sampling in all the plots in the spring. This will allow for more consistent measures of the plant response based on the chicken and seeding treatments without the confounding influence of seasonal weather conditions and/or the time since a plot was grazed or seeded.



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

Management Tips

1. Know the breeding of the birds you buy! Whether Cornish Cross or others.

2. Buy chicks from hatcheries that breed the chicks. They know the genetics of the chicks.

3. 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 have a higher mortality during the last 2 weeks before processing.

4. Provide fresh pasture during the day and feed rations in the evening 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.

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*

Methods to Establish Grazing of Annual Forages for Beef Cows on Winter Feeding Areas

Principal Investigator

Principal Investigator
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Project Duration

2008 to 2010

Award Amount
$24,960

Staff Contact

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Keywords

annual cool and warm season forages, establishment, grazing, winter feeding areas

Project Summary

Winter feeding areas for cattle can be unfavorable sites for persistence of perennial forages due to high stocking rates for extended periods of time, heavy hoof traffic and manure deposition, especially around hay feeders, feed troughs, and uneaten forage. Annual forages with vigorous growth traits to compete with weeds and high seeding year production may be useful to produce valuable forage and utilize abundant plant nutrients in cattle winter feeding areas. Another potential benefit of seeding annual forages may be the rapid establishment of a plant canopy to reduce manure-contaminated runoff. This 3 year project was conducted at two producer farms and at the University of Minnesota's North Central Research and Outreach Center (NCROC) in Grand Rapids.

Our goal of this project was to evaluate options for producers to utilize the nutrients built up in these winter feeding areas through the use of seeding high producing forages for grazing and thereby reducing overall production cost. This in turn allows the producer to utilize practices that reduce the risk of manure contaminated run-off from these winter feeding sites. By comparing three different seeding methods with a cool and warm season annual forage, our objectives were to evaluate the effectiveness and efficiency of these forage establishment systems so that we could provide recommendations for renovating winter feeding areas to reduce or eliminate hauling of manure to pastures, increase use of manure as fertilizer in the feeding area, increase total season forage production, and reduce manure contaminated runoff.

Project Description

Farm Descriptions

Troy Salzer and his family own and operate Sandy Hills Ranch, a commercial beef cow/calf and backgrounding operation. Sandy Hills Ranch consists of mostly improved cool season grass and grass/legume mix pastures, grown on a sandy soil, for grazing and haying. Troy uses intensive management practices for grazing these pastures as well as grazing alternative forages such as corn, brassicas, oats, peas, and sorghum-sudangrass to improve production efficiency on his operation.

Bob Staskivige has owned and operated B&G Ranch, a commercial beef cow/calf operation consisting of mainly shorthorn genetics, for 38 years. Bob grazes both naturalized and

Shows difficulty of establishing annual ryegrass on an area consistently used for winter feeding at the NCROC Main Farm.

Strip grazing annual ryegrass on winter feeding area at Sandy Hills Ranch.

improved cool season grass/legume mix pastures grown on a clay soil, while intensively managing improved grass/legume and legume pastures for hay production. Bob uses intensive rotational grazing while trying new methods to improve production efficiency.

The North Central Research and Outreach Center (NCROC), a cooperating location in this project, is approximately 380 acres of grazing land on a silty loam soil with 250 purebred Angus cattle. A focus of the research program at the Center is developing strategies to improve grazing efficiency in beef cow/calf production systems.

At each of the locations, there were six treatments: two forage species (cool season annual ryegrass and warm season Brown Mid Rib (BMR) sorghum-sudangrass), and three different forage establishment methods (conventional seeding (with heavy tillage), no-till inter-seeding, and broadcast seeding), followed by dragging for seed incorporation into the soil.

All pastures used in the study were heavily stocked the previous winter with beef cattle. Cooperators managed each of the pastures so that winter feeding sites were rotated throughout the pastures as much as possible. Once cattle came off these winter feeding areas in late spring, pastures were divided and assigned to a treatment and soil samples were collected.

Evaluation of stand establishment was measured visually in early summer to determine if the annual forage used and the seeding methods were successful. During the forage growing season, forage yield data were collected prior to each grazing for all three locations, based on forage establishment success. Pregnant beef cows and/or pairs were used to graze each treatment paddock. After each grazing, pastures were allowed to rest for a minimum of 21 days before cattle were allowed to re-graze the treatment pastures.

In addition, the costs associated with each treatment were evaluated and used to determine which method(s) can be recommended to effectively and efficiently provide additional grazing in winter feeding areas during the forage growing season.

2008 Results

Soils

Soil samples were collected from each pasture at each location to establish critical soil nutrient values prior to pasture establishment in May. The concentrations for phosphorus (P) and potassium (K) ranged from 45 to 230ppm (P) and 300 to 2,200ppm (K) and were well above the maximum levels (P=21ppm) and (K=160ppm) recommended for root growth and development. It was evident that wintering cattle in confined feeding areas for any length of time creates rich sources of nutrients that can be used as fertilizer. The pH levels for all three project sites were greater than 6.0 indicating that soils were not too acidic.

Stand Establishment

Cool season pastures were seeded on May 27 at Sandy Hills Ranch and May 29 at B&G Ranch and NCROC. Warm season pastures were seeded on June 9 at Sandy Hills Ranch and June 11 at B&G Ranch and NCROC. Stand establishment was evaluated for each treatment at all three project locations in mid-July, estimating visually newly seeded forage cover as a percent of pasture cover.

- Broadcast seeding did not work with either forage species - all locations had less than 5% seed establishment.
- Inter-seeding had mixed results. Sorghum-sudangrass was poor at all three locations with 10% or less actual stand establishment. Annual ryegrass had good success with 70% at B&G Ranch, fair with 25% at NCROC, but poor with 5% at Sandy Hills Ranch.
- Conventional seeding was the most successful method. Sorghum-sudangrass had excellent success with 95% at Sandy Hills Ranch, good with 50% at NCROC, but poor with 5% at B&G Ranch. Annual ryegrass had great success with 90% and 80% at B&G Ranch and NCROC, respectively, and 70% at Sandy Hills Ranch.

Forage Yield

Forage yield was only collected at NCROC due to emergency use of pastures for grazing during the summer at the two cooperator locations because of drought. Forage yield was collected prior to each of the two grazing periods at NCROC. Figure 1 shows that forage yield of sorghum-sudangrass alone (no weeds weighed) was slightly greater (37 lb/A) than annual ryegrass in July, but significantly less (1,920 lb/A) than annual ryegrass in September. Annual ryegrass had a total season forage yield advantage of 1,883 lb/A. These numbers reflect yield of the forage species alone, without weeds.

Table 1 also shows total forage production, including weeds, was greater for the warm season annual sorghum-sudangrass treatment during the first yield collection. This could be explained by the slow cool season annual ryegrass response to warmer temperatures, delayed planting to late May, and its limited ability to compete with weeds for establishment, if planted later in the season. Forage production of sorghum-sudangrass then tapered off due to cooler temperatures later in the summer, offering more advantage to the annual ryegrass.

Over the course of the summer, cattle grazed the B&G Ranch pastures three times whereas Sandy Hills Ranch and NCROC were grazed twice. Due to the setup at B&G Ranch, and with only annual ryegrass having limited success, cattle had access to all six treatments at the same time; therefore, stocking rate and number of grazing days for each treatment were not collected for that location.

Based on the stocking rate and number of grazing days recorded, and assuming that cow and calf weights are similar for both locations, we can estimate the number of grazing days/A that each annual forage provided for one animal unit (1 animal unit = 1,000 lb):

- At Sandy Hills Ranch, sorghum-sudangrass provided 180 days of grazing whereas annual ryegrass provided 40 days for one animal unit. Troy had great success with sorghum-sudangrass establishment and growth with less than 5% weed population in the stand; however, annual ryegrass established well, but growth was poor during the growing season.
- At NCROC, sorghum-sudangrass provided 152 days of grazing whereas annual ryegrass provided 162 days of grazing for one animal unit. The sorghum-sudangrass pasture provided more yield (with a high percentage of weeds) for the first grazing; however, annual ryegrass took off prior to the second grazing due to its vigorous cool season growth potential.

One of the things observed at NCROC was weed invasiveness in both conventional seeding treatments. These heavily wintered areas offer an optimal environment for weed growth. During the grazing period though, cattle consumed most of the weeds. By managing weed growth and maturity, palatability levels were acceptable to cattle if grazed at the right stage of production.

Table 1. 2008 Forage yield of each annual forage, weeds, and combination of forage and weeds for the conventional tillage method collected prior to each grazing at the North Central Research and Outreach Center.

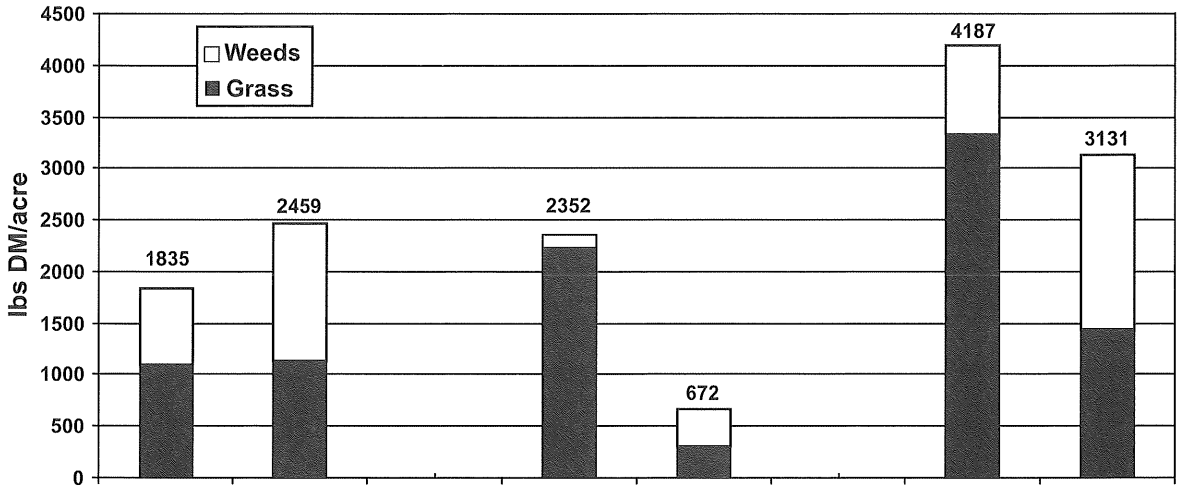

Table 2. 2009 stand establishment for all treatments at Sandy Hills Ranch, B&G Ranch, and NCROC *South Farm*.

Project Location	Broadcast		Inter-seeding		Conventional	
	AR*	SS*	AR*	SS*	AR*	SS*
Sandy Hills Ranch	30%	<5%	65%	90%	15%	80%
B&G Ranch	65%	<5%	85%	50%	80%	50%
NCROC (*South Farm*)	30%	<5%	75%	50%	95%	80%

**AR = annual ryegrass, SS = sorghum-sudangrass*

Economics
Cost associated with each seeding method was not calculated in 2008 due to establishment failure of both broadcasting and inter-seeding methods at all three locations. In terms of the conventional method, the question is still unknown, is it worth using a conventional tillage system to seed annual forages?

- At Sandy Hills Ranch, sorghum-sudangrass was the best option for Troy as sorghum-sudangrass was cheaper to seed ($22.50/A) vs. annual ryegrass ($26.50/A) and based on grazing data produced 140 more days of grazing/A for one animal unit.
- At NCROC, annual ryegrass was the best option. Even though sorghum-sudangrass seed was $4.00/A cheaper, annual ryegrass produced 1,883 lb/A more forage than sorghum-sudangrass.

2009 Results

Soils
New project locations were established in 2009. Soil samples were collected in May to establish critical soil nutrient values prior to pasture establishment. Concentrations for phosphorus (P) at all locations were >100ppm, well above the maximum levels (P=21ppm) recommended for root growth and development. Potassium levels at all locations ranged from 155 to 2,200ppm and were well above the maximum level for growth and development (K=160ppm), except at the NCROC *South Farm* where K levels were below the maximum threshold (142ppm), but still adequate. The pH levels for all project sites were greater than 6.0 indicating that soils were not too acidic, with the exception of NCROC *Main Farm*, where soils ranged from 5.4 to 5.9.

There were noticeable differences in pH and organic matter at the NCROC *Main Farm*. Areas that were heavily wintered on had higher pH and organic matter while areas where there was no winter feeding had a lower pH and percent organic matter, which could be attributed to differences in manure accumulation. It is evident that wintering cattle in confined feeding areas for any length of time creates rich sources of nutrients, such as P and K, which can be utilized as fertilizer, as well as potentially increasing the organic matter concentration in those soils.

Stand Establishment
Annual ryegrass was seeded on May 5 at Sandy Hills Ranch, June 2 at B&G Ranch, and June 3 at NCROC *South Farm*.

BMR sorghum-sudangrass was seeded on June 11 at NCROC *South Farm*, June 13 (broadcast and inter-seeding treatments) and June 19 (conventional treatment) at Sandy Hills Ranch, and all treatments June 16 at B&G Ranch.

It is evident that, in 2009 as in 2008, the broadcast method had limited establishment success with annual ryegrass and did not work with sorghum-sudangrass (Table 2). Inter-seeding and conventional tillage in general had good success while location impacted species success. Annual ryegrass grew well at B&G Ranch and at both NCROC sites, but establishment was low for the conventional tillage treatment at Sandy Hills Ranch.

Much thought went into why the establishment of annual ryegrass with conventional tillage was so low at Sandy Hills Ranch in 2009 and was so good at the other locations. In previous years Sandy Hills Ranch has had success conventionally seeding annual ryegrass; however, forage yield has been poor. It is logical that because Sandy Hills Ranch has a sandy soil, when preparing the soil with heavy conventional tillage, some organic matter is broken down; allowing moisture to evaporate or drain at a faster rate than if the soil was not broken. Breaking down organic matter in this soil type reduces the capacity of the soil to hold moisture for forage development and growth. Annual ryegrass requires significant amounts of moisture for establishment. The spring of 2009 was unusually dry, making it difficult to get newly seeded pastures established.

Table 3. Total 2009 season forage yields for all treatments at each site.

Project Location	Broadcast (lb dry matter/A)		Inter-seeding (lb dry matter/A)		Conventional (lb dry matter/A)	
	AR*	SS*	AR*	SS*	AR*	SS*
Sandy Hills Ranch	0	0	4,050	2,880	0	5,117
B&G Ranch	312	0	5,186	5,619	1,969	0
NCROC (*South Farm*)	0	0	3,600	360	5,065	1,079
NCROC (*Main Farm*)**			8,110	0	7,266	3,359

**AR = annual ryegrass, SS = sorghum-sudangrass*
***Forage yield values collected from the winter feeding area only.*
Treatments with stand establishment estimates of <50% have a value of 0 for forage yield.

Sorghum-sudangrass grew well at Sandy Hills Ranch; however, establishment was only fair at B&G Ranch and at both NCROC sites. It is not clear why sorghum-sudangrass had good establishment at Sandy Hills Ranch only, but with their location further south, it may have a longitudinal barrier for production due to its warm season nature.

The results of the separate experiment at the NCROC *Main Farm* show that inter-seeding into sod did not work as well as conventional seeding. Annual ryegrass was seeded on May 21 and the sorghum-sudangrass was seeded on June 9.

Inter-seeding in the sod area did not work well for either annual ryegrass (5% success) or sorghum-sudangrass (0% success). In the winter feeding area there was better success with 75% establishment for annual ryegrass and 30% establishment for sorghum-sudangrass.

Conventional seeding at the *Main Farm* had great success with annual ryegrass at 85% in both sod and winter feeding areas and good success with sorghum-sudangrass at 50% in both the sod and winter feeding area.

It is important to discuss differences seen in establishment success at the NCROC *Main Farm* based on soil management. Success for the inter-seeding method was very low for both annual ryegrass and sorghum-sudangrass in the areas where a heavy sod was present at seeding. Success may be limited as existing sod had the advantage once soil and air temperatures permit cool season forage growth. However, inter-seeding success may have improved if seeded earlier, allowing for the seed to be in place at the first opportunity for growth. Obviously, areas that were heavily manured had higher establishment success, similar to the conventional tillage method.

Forage Yield

Forage yield data were collected prior to each of the two grazing periods (Table 3). As a reminder, if stand establishment was less than 50% in a particular treatment, forage yield was not collected. As with 2008, the broadcasting treatment had very little success producing insignificant yields. Surprisingly, inter-seeded annual ryegrass consistently yielded more than inter-seeding sorghum-sudangrass and both conventional treatments. Over 2 tons of dry matter/A were produced with inter-seeding annual ryegrass at B&G and Sandy Hills Ranch, with an impressive 4 tons of dry matter/A at the NCROC *Main Farm*.

Inter-seeded sorghum-sudangrass was highly successful at B&G Ranch, yielding over 2 tons of dry matter/A. However, we have consistently seen poor production at the NCROC site.

Conventional annual ryegrass has consistently been successful at the NCROC site with yields of 2.5 (NCROC *South Farm*) and over 3.5 (NCROC *Main Farm*) tons of dry matter/A. However, success was limited at the other two cooperator locations.

Conventional sorghum-sudangrass at Sandy Hills Ranch was excellent yielding over 2.5 tons of dry matter/A, as seen in the previous year, but has had poor production at both NCROC and B&G Ranch.

We were able to separate the weeds from the forage of interest and determine yields for each at both NCROC locations. The ratio of grass to weeds was higher for annual ryegrass seeding treatments vs. the sorghum-sudangrass seeding, particularly in the conventional treatments. As

Table 4. Number of animal unit months for each treatment at each location in 2009.

Project Location	Broadcast		Inter-seeding		Conventional	
	AR*	SS*	AR*	SS*	AR*	SS*
Sandy Hills Ranch	0	0	5.9	4.2	0	7.4
B&G Ranch	0.5	0	7.5	8.1	2.9	0
NCROC (*South Farm*)	0	0	8.2	3.9	11.7	4.5
NCROC (*Main Farm*)			12.0	0	11.1	6.7

*AR = annual ryegrass, SS = sorghum-sudangrass

Table 5. The value of standing forage, after seeding and harvesting costs, for each seeding method at each location in 2009.

Project Location	Broadcast		Inter-seeding		Conventional	
	AR*	SS*	AR*	SS*	AR*	SS*
	$/A					
Sandy Hills Ranch	-51.25	- 56.00	72.96	32.56	- 77.35	73.90
B&G Ranch	- 41.74	- 56.00	107.57	116.01	- 9.45	-74.20
NCROC (*South Farm*)	-51.25	- 56.00	122.84	26.67	177.09	20.78
NCROC (*Main Farm*)			201.05	- 55.20	162.92	66.88

**AR = annual ryegrass, SS = sorghum-sudangrass*

seen for the second year in a row, there is a large population of weed seeds in these winter feeding areas. However, if managed correctly, cattle will consume the majority of the established weeds. Pastures in the conventional sorghum-sudangrass treatments were seeded 8 to 44 days after tillage. It is likely that in that time, some of the annual weeds developed and had a head start over the sorghum.

Over the course of the summer, cattle were allowed to graze each treatment twice at all locations. Based on forage yields collected for each treatment at each location, we estimated stocking rates/A based on animal unit months (AUM, 1 animal unit month = 1,000 lb animal eating 2.3% of their body weight in dry matter for 30 days) (Table 4). For example, if you take the highest stocking rate of 12 AUM/A (inter-seeding annual ryegrass) and spread that over a 5 month grazing period, you have a stocking rate of 2.4 AUM/A/year.

Economics

Costs associated with each seeding method were not calculated for some of the treatments due to establishment failure. Using the 2009 Iowa Farm Custom Rate Survey and current hay prices for November 19, 2009 (Sauke Centre Hay Auction) hay prices at $80.00/ton dry matter, we estimated the seeding and harvesting cost and subtracted the value of hay produced/A to get the value of standing hay (Table 5).

Seeding Cost

The cost of broadcast seeding is $16.60/A (broadcast seeding w/tractor plus harrowing), no-till inter-seeding is $15.80/A (no-till planter w/tractor), and conventional tillage is $34.80/A without land rolling (disking-tandem, harrowing, and no-till planter w/tractor) or $42.70 with land rolling (only used at Sandy Hills Ranch for conventional treatments). Seed cost/A this year was $23.50/A for sorghum-sudangrass and $18.75/A for annual ryegrass.

Harvesting Cost

Harvesting cost is $15.90/A (includes mowing and raking) and $9.70/bale (bailing large rounds without plastic wrap). Bailing cost figured per ton is $16.20 at 85% dry matter.

Looking at the value of standing forage after seeding and harvesting costs have been deducted, it is easy to see that

Table 6. 2010 Treatment establishment dates for each treatment at each location.

Project Location	Broadcast		Inter-seeding		Conventional	
	AR*	SS*	AR*	SS*	AR*	SS*
Sandy Hills Ranch	10 May	12 June	10 May	12 June	10 May	12 June
B&G Ranch	25 May	1 July	25 May	1 July	25 May	1 July
NCROC	4 May	3 June	4 May	3 June	4 May	3 June

**AR = annual ryegrass, SS = sorghum-sudangrass*

while certain seeding methods and forage species work well at certain locations, inter-seeding had the most consistent positive value for standing forage, with annual ryegrass having the highest average standing forage value for all locations combined.

After 2 years of trials, both conventional and no-till inter-seeding methods are proving to be good methods of establishing cool and warm season annuals into winter feeding areas. What is important is that there is good seed to soil contact. Broadcasting onto the existing sod or manure pack does not allow enough soil contact for good stand establishment.

2010 Results

Treatment Establishment

Seedbed preparation for the conventional treatment consisted of disking to level the soil and incorporate manure and wasted feed/forage, then dragging to firm the seedbed. The broadcast and inter-seeding treatments received no seedbed preparation; however the broadcast treatment was dragged following seeding to incorporate seed. All seeding was done with a Great Plains inter-seeding drill. For the broadcast treatment, the disk openers were lifted above the soil surface. Seeding rate for both forage species was 25 lb/A. Seeding dates for each location are listed in Table 6.

Soils

Soil samples were collected from each treatment at each location prior to seeding. Results are listed in Table 7. As observed in previous years, available phosphorus and potassium levels exceeded recommended nutrient requirements for grasses grown for forage production. It is evident the available plant nutrients in cattle winter feeding areas are a resource many producers could benefit from.

Stand Establishment Success

Stand establishment success was visually evaluated by estimating the percentage of area within treatments which contained plants of the seeded species. Estimates were collected from four random 2.5 x 2.5' areas within each treatment. Averages of the four estimates for each treatment at each location are listed in Table 8.

Stand establishment success was generally better for most treatments in 2010 than in the two previous years, likely because of more favorable soil moisture conditions. One notable difference was the increase in success of the broadcast annual ryegrass, inter-seeded sorghum-sudangrass and the conventional treatments at B & G Ranch. Favorable soil moisture combined with cattle being kept in the wintered feeding area up until seeding allowed for weed control, resulting in the greatest stand establishment success for these treatments of this three year study. Another notable difference was the establishment success of the conventional annual ryegrass treatment at Sandy Hills Ranch. In previous years, stand establishment was poor due to the dry growing conditions from spring tillage. The sorghum-sudangrass broadcast and inter-seeded treatments at NCROC had poor success even though soil moisture was favorable. Weed competition at seeding was the likely cause.

Forage Yield

Forage dry matter yield data were collected by hand-clipping multiple random areas within each treatment (Table 9). Weeds were hand-separated, so yields reported for Sandy Hills and B & G Ranch are for seeded forage only. At NCROC, yields are reported for both weeds and seeded forage separately. Forage dry matter yield at B & G Ranch was collected at the first harvest only due to cattle management considerations. Dry matter yields for the broadcast annual ryegrass and sorghum sudangrass treatments at B & G Ranch and broadcast sorghum sudangrass treatment at NCROC were higher than previous years, likely the result of better soil moisture at seeding and throughout the growing season. It is also likely that location of these treatments within the pasture also contributed to higher dry matter yield than in previous years.

The broadcast treatments at B&G Ranch and NCROC in 2010 contained mostly exposed soil, so broadcast seeding was effective. Dry matter yields at Sandy Hills Ranch were much higher than previous years for the inter-seeded and conventional treatments. Forages seeded on the coarse-textured soil at this site benefited much from good soil moisture. Annual ryegrass most often yielded more forage dry matter than sorghum-sudangrass. This result is likely linked to the cool season growth pattern of annual ryegrass. It gets seeded earlier in the spring, so there is less competition from germinating weeds, and continues to be productive later into the fall after sorghum-sudangrass growth has been slowed by cooler temperatures. During the course of this study, it was observed that stand establishment on bare soil was superior to establishment on existing sod, likely due to lack of earlier growth and competition from existing sod.

Table 7. Soil type, pH and nutrient concentrations collected at all three project locations in 2010.

Project Location	Soil Type	pH	Phosphorus (ppm)	Potassium (ppm)
B & G Ranch	Clay	7.0-7.6	80-173	1,416-2,266
Sandy Hills Ranch	Sand	7.0-7.4	153-154	248-273
NCROC	Silty Loam	6.1-7.2	98-252	455-1,560

** Soil pH and nutrient concentration values show ranges from six samples collected from each project location.*

Table 8. Percent of stand establishment for all treatments at all three locations in 2010.

Project Location	Broadcast		Inter-seeding		Conventional	
	AR*	SS*	AR*	SS*	AR*	SS*
Sandy Hills Ranch	25%	5%	70%	80%	75%	90%
B&G Ranch	95%	10%	85%	70%	95%	70%
NCROC	40 %	<1%	65%	<2%	90%	80%

**AR = annual ryegrass, SS = sorghum-sudangrass*

Table 9. Total 2010 season forage yields for all treatments at each site.

Project Location		Broadcast (lb dry matter/A)		Inter-seeding (lb dry matter/A)		Conventional (lb dry matter/A)	
		AR*	SS*	AR*	SS*	AR*	SS*
Sandy Hills Ranch		0	0	6,514	5,285	12,402	6,346
B&G Ranch**		1,919	528	1,079	2,711	1,367	624
NCROC	*grass only*	3,526	192	3,046	384	5,228	1,943
	weeds only	1,080	1,631	768	1,727	744	2,351
	combined	**4,606**	**1,823**	**3,814**	**2,495**	**5,972**	**4,294**

**AR = annual ryegrass, SS = sorghum-sudangrass*

*** Forage yield data from first grazing only. Annual ryegrass was grazed two additional times. Sorghum-sudangrass did not regrow after grazing.*

Table 10. The 2010 value of standing forage baled for both annual ryegrass (AR) and sorghum-sudangrass (SS) for each seeding method at each location.

Project Location	Broadcast		Inter-seeding		Conventional	
	AR*	SS*	AR*	SS*	AR*	SS*
	$/A					
Sandy Hills Ranch	- 54.35	- 50.60	79.89	58.61	173.59	53.97
B&G Ranch	- 15.26	- 39.84	-30.82	6.17	- 44.65	- 56.04
NCROC	17.48	- 46.69	9.25	- 41.23	34.00	- 29.17

**AR = annual ryegrass, SS = sorghum-sudangrass*
Values are based on total value of forage/acre subtracted by seeding, harvesting, and baling cost.

Individual dry matter yield of weeds and grass collected at NCROC illustrated the importance of species selection. Annual ryegrass was better able to compete with weeds than was sorghum-sudangrass. Dry matter yield of annual ryegrass in all treatments was at least three times greater than that of weeds. In contrast, dry matter yield of sorghum-sudangrass was always much less than that of weeds.

Economics
Using the 2010 Iowa Farm Custom Rate Survey, we can estimate cost associated with each seeding method and compare based on yields and value of standing forage baled (Table 5). The cost of broadcast seeding is $17.25/A (broadcast seeding w/tractor plus harrowing), no-till inter-seeding is $15.70/A (no-till planter), and conventional tillage is $35.40/A without land rolling (disking-tandom, harrowing, and no-till planter) or $41.95 with land rolling (only used at Sandy Hills Ranch for conventional treatments). Seed cost/A this year was $17.50/A for sorghum-sudangrass and $21.25/A for annual ryegrass.

Let's look at the value of standing hay. We will use current hay prices at $60.00/ton dry matter (November 18, 2010, Sauke Centre Hay Auction Results) and subtract the seeding and harvesting cost to get the value of standing hay. Based on the 2010 Iowa Farm Custom Rate Survey, harvesting cost was $15.85/A (includes mowing and raking) and $9.80/bale (baling large rounds without plastic wrap). Combined seeding and harvesting (without baling) cost/A for broadcasting (sorghum = $50.60 and ryegrass = $54.35), inter-seeding (sorghum = $49.05 and ryegrass = $52.80), conventional (sorghum = $68.75 and ryegrass = $72.50) without land rolling, and conventional (sorghum = $75.30 and ryegrass = $79.05) with land rolling. Table 10 shows the value/A (based on forage yield) of standing forage baled after all expenses have been accounted for (baling cost figured/ton is $16.37 at 85% dry matter).

There were seeding method and species differences between locations, but clearly the broadcast seeding method most consistently had negative values of forage produced for the current and previous years whereas the inter-seeding method had the most consistent positive values. Annual ryegrass had a higher average value of forage produced than sorghum-sudangrass in most cases. Positive values for the inter-seeding and conventional seeding method at Sandy Hills Ranch reflect high forage yield resulting from good soil moisture during the growing season. Negative values at B & G Ranch are partially the result of forage yield data having been collected for the first harvest only and are not reflective of total season forage yield. Sorghum-sudangrass had negative values at NCROC for all seeding treatments, reflecting that poor species adaptation to that site.

End of Project Summary

Soils
This project confirmed the abundance of soil phosphorus and potassium in cattle winter feeding areas available for plant growth. At all locations in all years soil tests were in the high range for both nutrients. There were differences between locations reflecting soil type and cattle management differences. Generally, the coarser textured soils at Sandy Hills Ranch contained lower levels of phosphorus and potassium, however cattle management was different at this location as well. The presence of available water sources at several locations on the Sandy Hills Ranch permits access to more areas to winter cattle on than at B & G Ranch and NCROC, where cattle have been wintered on the same sites for many years.

Stand Establishment
This project evaluated three seeding methods to enable the establishment of annual forages on cattle winter feeding areas using as few inputs as possible, yet achieving acceptable stand establishment. Results with each

treatment varied with soil moisture and with competition at seeding, either from germinating weeds or existing sod.

The broadcasting method had limited success in most cases. It has potential to be an acceptable method for annual ryegrass only when:

- soil moisture is not limiting,
- seeding is done when competition from germinating weeds is less (early in the season), and
- the soil is essentially bare enabling good seed to soil contact.

The inter-seeding method cost the least and often resulted in successful stand establishment, but required the availability of a specialized piece of equipment. However, many farms would have access to a seeder with double disk openers that should work well in many winter feeding areas. Annual ryegrass had better establishment success and greater yields for most locations. Again, the most important consideration is managing cattle and seeding to optimize soil moisture and minimize competition from germinating weeds and sod.

The conventional method cost about twice as much as the other two treatments and did not have the stand establishment success, forage yield, or value of forage produced of the inter-seeding method.

An important management decision is selecting a species well adapted to local soil and weather conditions. Competition from weeds will likely be intense, so a species that germinates and develops a canopy quickly will have the greatest chance of successful establishment. Many weeds are readily consumed by cattle if grazed before seed heads develop and when stems are tender.

Management Tips

1. Forage species selection is very important. Cool season annual ryegrass performed better than warm season sorghum-sudangrass at the two northern sites in this project. Producers should choose species adapted to soil and weather at their location.

2. Inter-seeding appears to be a good low-cost option but success with this seeding method is closely linked to managing competition with existing sod or germinating weeds.

3. Broadcast seeding on existing sod has very little chance of succeeding to establish new forages. Stand establishment success will increase on areas with exposed soil and good growing conditions.

4. Moving bale feeders uniformly within the winter feeding area distributes manure and waste feed more uniformly, creating a better seedbed.

5. Weed competition can become an issue in winter feeding areas where feeding is concentrated and sod is broken up. However, weeds may not be a total disadvantage. If you allow cattle to graze weeds at an early stage of development, the weeds are quite palatable, offering more total season forage yield.

Cooperators

Troy Salzer, Sandy Hills Ranch, Producer and Extension Educator, Barnum, MN
Bob Staskivige, B&G Ranch, Producer, Bovey, MN
Dr. Ryon S. Walker, Louisiana State University, Hill Farm Research Station, Homer, LA

Project Locations

Sandy Hills Ranch 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.

B&G Ranch is located northwest of Warba, MN. From Warba, go west on Hwy. 2 for .5 miles to Cty. Rd. 10. Go north on Cty. Rd. 10 for 5.7 miles. Go east on Cty. Rd. 445 for .3 miles, the field site is located on the north side of Cty. Rd. 445.

The NCROC *South Farm* is located 4 miles south of Grand Rapids. From Grand Rapids, take Hwy. 169 south for 4 miles. Go east on Harris Town Rd. (Cty. Rd. 64) for .5 miles. The field site is on the north side of Harris Town Rd.

Other Resources

Iowa State University. A publication on 2010 Iowa Farm Custom Rate Survey at: *www.extension.iastate.edu/publications/FM1698.pdf*

Minnesota Pollution Control Agency. Publication #8.45. October 2002. Best Management Practices for Supplemental Feeding Areas at: *www.pca.state.mn.us/index.php/download-document/3731-pastures-winter-supplemental-feeding.html*

University of Minnesota Beef Center. A publication on Establishing Winter Feeding Areas for Grazing at: *www.extension.umn.edu/beef/components/pdfs/WinterFeeding_Walker.pdf*

Fall Forage Mixture for Grass Finishing Livestock Late in the Fall

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Project Duration

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$10,000

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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 both the beginning of the grazing season and extending the grazing into the fall and winter. By growing winter rye for early grazing and grazing corn in late summer followed by a planting of turnips and oats you may be able to graze late into the fall and winter.

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

We have been working 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 plan to compare 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 can reduce feed costs which will allow us to be more profitable into the future. This project will provide information we 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 will be 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. Salzer's site has very sandy soils and Mach's has a loam soil.

The two cooperators are interested in adding corn for grazing followed by a fall seeding of turnips and oats to increase the yield of dry matter per acre. The annual crops in

Cattle grazing corn on the Salzer farm.

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

Treatment	Seeding Rate	Seed Cost/A	Seeding Cost/A
Winter rye	2 bu/A	$19.00	$26.50
Corn	29,000 seeds/A	$35.00	$205.00
Annual ryegrass	20 lb/A	$12.40	$19.90
Oats – Turnips	Oats . . . . . .1.5 bu/A Turnips. 3lb/A	Oats . . . . . $8.78 Turnips. $5.40	$21.68

Please refer to Tables 2 and 3 to see the comparisons of the different cover crops on the Mach and Salzer farms.

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

Crop Type	Cost/A	Avg Daily Gain (lb)	Lb Gain/A	Grazing days/A*	Cost of Gain
Corn	$205.00	1.8	472	262	$0.43
Winter rye	$26.50	1.8	64	36	$0.41
Annual ryegrass	$19.90	1.5	26	17	$0.77
Oats - turnips	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.

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

Crop Type	Cost/A	Avg Daily Gain (lb)	Lb Gain/A	Grazing days/A*	Costs of Gain
Control (corn)	$205.00	2.0	405	202	$0.51
Winter Rye	$26.50	1.7	66	38	$0.40
Annual ryegrass	$19.90	1.5	28	20	$0.71
Oats - turnips	$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.

the rotation helps breakdown the sod which improves the seedbed for the new pasture. The corn is grazed from mid-August through September.

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 will use a no-till drill to plant the turnips and oats directly into the corn stubble. The drill is equipped with a cutting coulter to cut up any remaining corn stalks.

The project consists of monitoring the cattle gain during each of the management aspects of them grazing on each of the treatment areas. Each farm will graze about 20 head of finishing cattle on the plots. From the data and the costs of each of the treatments we will calculate the cost of gain for each of the treatments.

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. 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 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. 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 Salzer's and September 9 at Mach's 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 on a typical fall. The delay in grazing the cover was due to starting late because we did not correctly calculate the amount of time it would take to graze an acre of corn.

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 to 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 would suggest that a cover crop reduces the risk of nitrogen being transported by rain into lakes and rivers as well as the drinking water.

Management Tips

1. The earlier you can plant any of the cover crops the better. This includes moving the cattle off a strip and sowing it. Every day counts.

2. Annual ryegrass needs to be planted the earliest as it takes a long time to get established. If planting later, winter rye is a better option as it can also be utilized in the spring if enough growth doesn't occur in fall.

3. Look at using a staggered planting to allow for a more optimum corn maturity at grazing. If the corn gets too mature it gets tough and the animals, especially younger ones, don't like the stalks. If corn gets too tough use a different class of animals to at least do the cleanup.

Table 4: Summer and fall 2010 soil test results for nitrate nitrogen for the Salzer and Mach farms.

SALZER FARM		MACH FARM	
	Nitrogen		Nitrogen
Summer 2010	88	**Summer 2010**	64
Fall 2010		**Fall 2010**	
Corn	60	Corn	41
Winter rye	52	Winter rye	38
Annual ryegrass	50	Annual ryegrass	37
Oats - Turnips	49	Oats - Turnips	34

4. Match the amount of forage corn produced with the size of the herd to efficiently graze corn.

5. The use of the cover crops can be extremely useful in small grain stubble and after silage corn as the crop is removed early and could be quickly drilled.

Cooperators

Russ Mathison, Agronomist, University of Minnesota North Central Research and Outreach Center, Grand Rapids, MN
Tom Gervais, NRCS Grazing Specialist, Duluth, MN

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.

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.

Oats and turnips cover crop.

Increasing the Profitability of Raising Livestock: An Evaluation of Two Methods to Extend the Grazing Season

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Project Duration

2008 to 2011

Award Amount

$18,176

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cover crops, grazing hay fields, season extension

Project Summary

Most of the costs of producing beef cattle are associated with winter feeding. Forages need to be harvested, stored, and fed back to the animal during the non-growing season. This project addresses the costs of performing these tasks by extending the grazing season, thus reducing the amount of time spent feeding stored forages to the livestock. Extending the grazing season results in considerable labor and equipment savings associated with harvesting forages and feeding animals. These savings will increase the profits of raising beef cattle. The two primary season extension methods examined in this project are: 1) planting winter rye as a cover crop/grazed forage; and 2) grazing hay fields.

Project Description

As the Grazing Specialist for the Root River Watershed, I saw the need to examine methods to extend the grazing season. This would help livestock producers be more profitable and keep more livestock on the landscape in southeastern Minnesota, a rolling topography, with pasture and hay land as major components.

Two producers are participating in the project:

- Tom Boelter is seeding winter rye into croplands to provide fall and spring grazing forage. Tom currently grazes 70 beef cow/calf pairs and grows corn, soybeans, and hay. The winter rye is being aerially seeded by helicopter into standing corn and soybeans and drilled into corn stubble after silage has been taken off. The ground cover provided by the winter rye will also reduce run-off that normally occurs on bare crop fields during spring snow melt and heavy spring rains.

- Jeff Gillespie is grazing hay fields with 80-100 beef cow/calf pairs and grows conventional and organic crops. Hay crops are grazed in the fall. Jeff hopes to show that by grazing hay fields and allowing the animals to harvest their own forage, he can cut down on labor and expenses associated with mechanical harvesting and feeding.

The cost of equipment, fuel, feed, and other inputs are increasing steadily. To stay competitive in today's agricultural economy, livestock producers need to become more efficient with their resources. These

Doug Keene, Fillmore County Resource Conservation Technician, examines excellent rye stand uniformity in soybeans (October 6, 2008).

Winter rye in soybeans that is approximately 7" tall on October 21, 2008.

proposed methods for extending the grazing season will make these farms more profitable, ensuring that they are economically sustainable in the future.

Extending the grazing season also results in environmental benefits. Seeding winter rye into crop fields reduces erosion, increases ground cover, improves soil physical properties, and increases water infiltration into the soil (Dabney et al., 2001).

Measurements

Productivity. To measure the productivity of these systems, we are clipping biomass samples (30" x 30") in the hay field, aerially seeded rye, and drill seeded rye to determine standing yield. We are also documenting days on pasture and animal units. With this information, we are able to determine the amount of dry matter intake the animals obtained from the pasture.

Feed quality. Samples are being tested for protein and neutral detergent fiber (NDF) digestibility. These data are used to compute relative forage quality (RFQ).

Profitability. With the before and after grazing yield data, we are estimating the total animal intake from the field. We can then compare the cost of grazing to the cost of either buying or producing hay and feeding it to the animals during the time they spent grazing.

2008 Results

Winter rye. On August 28, winter rye was aerially seeded on 33 acres of soybeans on the Tom Boelter farm. The soybeans were still in full leaf stage at this time. **This is important. The rye must be flown on before the soybean leaves drop. This ensures that the rye has close contact with the soil.** The rye seeding rate was 75 lb/A. The aerial seeding took one-half hour to accomplish (66 A/hr). There were three people on hand to assist with loading the seed.

The weather after seeding remained dry with little precipitation until early November. The rye stand establishment and growth was impressive considering the drought.

Early observations showed that the seed germinated earlier underneath the full soybean canopy than in gaps in the soybeans or areas where the soybean stand was thin. Despite the lack of rain, the rye cover was uniform throughout the field, except for narrow strips missed along field edges.

The stand was checked weekly. As the winter rye grew, it tillered out and filled in the interspaces between individual rye plants. The soybeans were harvested on October 10, 6 weeks after seeding the rye. By this time, the rye was well established and provided almost 100% ground cover. Tom Boelter reported that the young winter rye did not get in the way of soybean harvest. By October 21, the average height of the winter rye was 6" - 7".

The aerially seeded soybeans resulted in excellent establishment. Two-thirds of the seeds applied resulted in germination. Approximately 31 seeds/ft^2 were seeded (75 lb/A) with an average of 20.6 plants/ft^2 observed, a 66.5% seedling establishment rate.

The helicopter cost was $20/A to perform the seeding (Table 1). Three people assisted with loading the helicopter for a total of 1.5 hours of labor input. Another 3 hours of labor were associated with grazing the rye to accomplish: fence maintenance, moving cattle, and checking cattle. Recent market value for winter rye seed has ranged from $9.50 to $12.00/50 lb bag. Using the labor inputs from this project and the average seed prices from local seed dealers, producers aerially seeding winter rye could have expected to pay between $35.78 and $39.53/A this past summer.

On October 2, Tom Boelter seeded rye into 33 acres of corn that had been harvested for silage. The seeding rate was 50 lb/A. The stand establishment was excellent for this field and on October 21, the average height of the rye was estimated at 4".

Tom used a no-till drill to seed the winter rye into corn silage stubble at an estimated cost of $16.81/A (Table 2). Three hours of labor were associated with moving cattle, checking cattle, and fence maintenance. Using the labor inputs from this project and the average seed prices from local seed dealers, producers drill seeding winter rye could have expected to pay between $27.29 and $29.79/A this past summer.

Table 1. Cost of aerially seeded rye system through fall.

Rye seed: $9.50/50 lb bag	Cost/A	Acres	Total cost
Seed (75 lb/A)	$14.25	32.3	$460.28
Helicopter	$20.00	32.3	$646.00
Total			$1,106.28
Cost of grazing livestock	**Time (hr)**	**Cost (hr)**	**Total cost**
Checking/moving livestock	4.5	11	$49.50
Total grazing system costs			$1,155.78
Total cost/A			**$35.78**
Rye seed: $12.00/50 lb bag	**Cost/A**	**Acres**	**Total cost**
Seed (75 lb/A)	$18.00	32.3	$581.40
Helicopter	$20.00	32.3	$646.00
Total			$1,227.40
Cost of grazing livestock	**Time (hr)**	**Cost (hr)**	**Total cost**
Checking/moving livestock	4.5	11	$49.50
Total grazing system costs			$1,276.90
Total cost/A			**$39.53**

Table 2. Cost of drill seeded rye system through fall.

Rye seed: $9.50/50 lb bag	Cost/A	Acres	Total cost
Seed cost	$9.50	33.7	$320.15
Seeding cost	$16.81	33.7	$566.50
Total			$886.65
Cost of grazing livestock	**Time (hr)**	**Cost (hr)**	**Total cost**
Checking/moving livestock	3	11	$33.00
Total grazing cost			$919.65
Total cost/A			**$27.29**
Rye seed: $12.00/50 lb bag	**Cost/A**	**Acres**	**Total cost**
Seed cost	$12.00	33.7	$404.40
Seeding cost	$16.81	33.7	$566.50
Total			$970.90
Cost of grazing livestock	**Time (hr)**	**Cost (hr)**	**Total cost**
Checking/moving livestock	3	11	$33.00
Total grazing cost			$1,003.90
Total cost/A			**$29.79**

No data was gathered for the drill seeded field. However, higher seedling germination was expected due to better seed to soil contact. A seeding rate of 50 lb/A results in approximately 21 seeds/ft^2. So, even with a higher expected seedling establishment rate, fewer plants will be present in the drill seeding. In the future, we may record the drill seeding plant populations for comparison.

The aerial seeding method had almost three times as much ground cover associated with the rye as the drill seeding method (Table 3). The soybean field was aerially seeded 5 weeks before the drill seeding. This added time allowed the individual rye plants to produce many more tillers and spread laterally. Also, due to the late spring in 2008, the corn silage was harvested later than usual and led to a late drill seeding. The rye drilled after corn silage was more indicative of a seeding date after soybean harvest in an average year. Taking these factors into account, the aerial seeding will most likely lead to more forage production than waiting until after soybean harvest to seed the rye.

The livestock were turned into the winter rye on October 25 and removed November 10. The herd consisted of 25 cows weighing 1,300 lb each, 25 calves weighing 500 lb each, and 1 bull weighing 2,000 lb. The drill seeded and aerially seeded portions of the project were part of a large 66 acre field. These two fields were grazed together because there is no cross fence to separate them. This delayed the use of the aerially seeded rye this fall because the drill seeded portion needed more time to become well established. Growers should consider drill seeding and aerial seeding in separate fields unless the field can be fenced and grazed separately.

After the livestock were removed, the average stubble height of the winter rye was 3". The cattle were on the winter rye for a total of 16 days and did not receive any supplemental feed during this time. In addition to the winter rye, the livestock grazed

Table 3. Winter rye ground cover by seeding method (% cover).

Seeding method	Rye	Residue	Bare ground
Aerial	35	45	20
Drill	13	29	58

Cattle grazing on the aerially seeded rye in November on the Tom Boelter farm. Note the high amount of ground cover associated with the rye.

on grass along the field edges and terraces in the field, on corn stalks that were run over by the chopper during silage harvest, and on soybean residue left after harvest. The animals appeared to favor the winter rye the most because it was lush, new growth. They probably did not eat much of the other forage that was available in the field.

Due to timing constraints, the plots were not clipped for yield and forage value analysis prior to the livestock being turned out onto the field. However, the average daily dry matter needs for the herd to maintain good body condition were estimated. Each animal was projected to intake 2.5% of their body weight daily in dry matter. Thus, the entire herd needed 1,175 lb of forage daily or 18,800 lb (9.4 tons) for the 16 days that the animals were on the rye.

These estimates show that the value of the fall grazed rye has offset much of the cost of establishing the rye. It is likely that after the value of next spring's grazing has been taken into account, the grazed rye system will be significantly more profitable than purchasing or producing hay. We appear to be on target for lowering production costs and making livestock operations more profitable.

Grazing the hay field. Jeff Gillespie turned his cattle onto his 20 acre hay field on October 5 and they grazed for 13 days. The hay field was seeded with alfalfa and Italian Ryegrass. His herd consisted of 51 cows weighing 1,200 lb each, 45 calves weighing 550 lb, and 2 bulls weighing 2,000 lb.

Prior to the animals entering the field, plots were clipped, dried, and weighed to determine the amount of standing dry matter per acre. After the animals left the field, plots were clipped, dried, and weighed again to determine the amount of dry matter remaining. The average height of the forage prior to grazing was just shy of 11.5" and they grazed it down to 2.5". From the yield estimates, the herd consumed approximately 19 tons of forage or almost 1 ton/A.

2009 Results

Winter rye. In April, prior to turning out Tom Boelter's 80 beef cows, two sets of clippings were done in the rye that had been drilled or aerially seeded in 2008. The livestock had access to the rye from April 30 through May 20 for a total of 21 days with no supplemental feed. The clippings were analyzed for dry matter (tons/A), relative feed value, and crude protein (Table 4). The dry matter estimates can be used to compare the farming systems being studied but they underestimate the biomass harvested in grazing systems because they do not include regrowth during grazing.

In the spring, average quality hay was bringing $120.00/ton. Tom saved an average of $71.25/cow in feed costs for the 21 days that the cows were out in the rye.

On August 17, winter rye was aerially seeded in 20 acres of soybeans and 33.7 acres of standing corn for silage on Tom's farm. The soybeans were still in full leaf stage at this time. The rye seeding rate was 70 lb/A. The aerial seeding took one-half hour to accomplish (107 A/hr). There were three people on hand to assist with loading the seed.

The weather before seeding was sufficiently wet for germination of rye. We received 2" of rain 3 days before seeding and a 1" rain after seeding. Three days after

Table 4. Winter rye biomass and feed value prior to grazing in spring 2009.*

Previous crop-date sample collected?	Crude protein	Relative feed value	Dry matter (tons/A)
Soybean 4-24-09	21.0	166	0.13
Corn silage 4-24-09	25.6	169	0.12
Soybean 4-30-09	20.7	149	0.23
Corn silage 4-30-09	23.0	145	0.29

** Sample size = 30" x 30".*

seeding, the rye was beginning to germinate. The rye stand establishment was impressive in the standing corn, but the rye population in the beans was disappointing (Tables 5 and 6).

The corn silage was harvested on 9-24-09. The rye plant population was sufficient in non wheel traffic rows, but on the end rows and heavy traffic areas it did not hold up as well. Modern silage harvesting equipment is heavy so one should expect this problem to increase.

Table 5. Rye plant populations in corn for silage on Boelter farm (10-13-09).

Replication	Wheel traffic	Plant population*
1	none	170
	light	81
	heavy	69
2	none	191
	light	142
	heavy	100
3	none	157
	light	128
	heavy	67
Mean	none	172
	light	117
	heavy	79
Field mean		123

** Number of plants in 30" x 30" area.*

Table 6. Rye plant populations in soybeans on Boelter farm (10-13-09).

Replication	Plant population*
1	9
2	20
3	35
Mean	21

** Number of plants in 30" x 30" area.*

Two factors were responsible for the poor stand of rye in the beans. First, the cold summer of 2009 led to late maturation of all field crops. Second, the aerial seeding was done early to coordinate with other fields being aerially seeded in the area. The beans in this field were drilled on 7.5" row width which allowed for little light penetration until bean leaf drop in late September. The soybeans were harvested on 10-31-09. After looking at the field on 11-17-09, it appeared to have reasonable rye cover on 75% of the field.

The fall of 2009 saw unusually variable weather. The month of September set a record for lack of rainfall. The month of October was abnormally cloudy, cool, and wet. November had essentially no rainfall. Overall, these conditions were very detrimental to the growth of the rye. We decided not to graze the rye due to the lack of fall biomass.

2010 Results

Winter rye. The rye was sampled for biomass and feed quality on May 5 prior to turning out Tom Boelter's 25 beef cows (Table 7). The livestock had access to the rye from May 5 through May 20 for a total of 15 days with no supplemental feed on the 33.7 acre field.

On September 2, winter rye was aerially seeded on 33.7 acres of soybeans on the Boelter farm. The soybeans were still in full leaf stage but were beginning to yellow.

The weather was perfect for aerial seeding. We received a 1.5" rain the night before seeding and a 0.5" rain 2 days later. The month of September continued wet and warm. Unfortunately, the distribution of seed by the helicopter was uneven, including areas that were missed altogether. The soybeans were harvested October 8, further exposing the uneven nature of the stand.

On October 2, Tom no-till drilled winter rye into 32.3 acres of corn that had been harvested for silage in September. The seeding rate was 70 lb/A. The stand establishment was excellent for this field and on October 21, the average height of the rye was 4". The livestock were turned into the winter rye on November 2 and removed November 19. The herd consisted of 27 cows weighing 1,500 lb each, 27 calves weighing 550 lb each, and 1 bull weighing 2,000 lb.

Tom has successfully established and grazed winter rye in each of the last 3 years. Each year, the value of the rye forage more than paid for the cost of establishing the cover crop.

Grazing the hay fields. Jeff Gillespie turned his cattle into his 18.8 acre hay field on November 20 and they grazed for 17 days. The hay field was seeded with alfalfa, Brome,

Table 7. Winter Rye Dry Matter and Relative Feed Quality on 4-24-10.

Sample	Dry Matter (tons/A)	Crude Protein	RFQ
1	0.13	11.34	150
2	0.11	9.01	141
3	0.14	10.67	151
Mean	0.13	10.34	147

Table 8. Rye plant populations in aerially seeded soybeans on the Boelter farm 10-03-10.

Replication	Plant population*
1	61
2	51
3	74
4	68
5	59
6	0
Mean	52

**Sample size = 30" x 30".*

Table 9. Relative Feed Quality in Hay Mix on 10-14-10.

Sample	Crude Protein	RFQ
1	24.12	211
2	25.19	263
3	25.73	247
Mean	25.01	240

Orchard and Italian Ryegrass. His herd consisted of 51 cows weighing 1,400 lb each and 2 bulls weighing 2,000 lb. (See Table 3 for forage results).

The average height of the forage prior to grazing was 18" and they grazed it down to 3". Using 4% of body weight to estimate daily forage consumption, the herd consumed approximately 25.5 tons of forage dry matter during the 17 days. Table 7 depicts the projected total cost per day of buying and producing hay compared to grazing the hay field. Grazing the hay field is the cheapest method of feeding the animals when compared to buying hay at current prices or producing hay.

Forage value analysis taken from the 18.8 acre hay field showed that the forage was of high quality. The RFQ was greater than 154, which is equivalent to prime quality hay. Buying prime quality hay and feeding it to the animals would cost almost three times as much as grazing it (Table 10). The alfalfa crude protein was over 25.5%; ADF was 21%; and NDF was 33.4%. All of these factors mean that the forage quality was high for the animals and well within their daily nutritional requirements.

Grazing hay fields resulted in significant savings over feeding for all methods, especially over prime quality hay. However, most beef producers would be more likely to purchase lower quality feed, such as Grade 1. Even Grade 1 feed costs over twice as much as allowing the animals to graze the hay field. Overall, the third year of the study has shown a reduction in feeding costs ranging from 16-66%, depending on the type of hay being fed.

There are some management issues to take into consideration when grazing hay fields. First, the longer livestock spend in a field, the more likely it is that they will start to develop trails. This was evident in the field, especially along fence lines. Trailing will have negative impacts on yield the next year if you plan to keep the field in hay. Further subdividing fields to give the livestock access to only a few days worth of grazing at one time will reduce the amount of trailing.

Wet weather may present problems because the animals may cause damage to the forage. Fortunately, this has not been evident so far in this project. However, if wet weather is imminent, the livestock should be removed to prevent damage to the hay field and returned when the field has sufficiently dried.

First year alfalfa stands may not be the best fields to graze. The animals may pull the seedlings out of the ground if their root systems aren't well developed. In our case, the field grazed was a first year seeding but this did not seem to be an

Table 10. Cost of buying or producing hay vs. grazing hay fields.

Method	Total cost/ton	Total cost/day	Total cost (15 days)
Buying hay*			
Prime (>151 relative feed quality)	$103.22	$268.37	$4,025.58
Producing hay**			
Large round	$94.14	$138.39	$1,801.80
Grazing hay fields***	$55.18	$81.11	$1,053.90

** Current average hay prices as of October 24, from data compiled by the University of Wisconsin Extension. Found at www.uwex.edu/ces/ag/haybuying.html. The cost of feeding the hay (Volesky et al. 2002) is also factored into the total costs.*

*** Data gathered from Barnhart et al., 2008. The cost of feeding hay (Volesky et al., 2002) is also factored into the total costs.*

**** Cost of grazing hay fields takes into account cost of maintaining the field as well as producer inputs while grazing. Hay field production data gathered from Barnhart et al., 2008.*

issue (this was a different hay field than was grazed the first year of the project).

With all of these factors taken into account, hay fields that are well-established or being tilled under the next year are likely candidates for grazing. Hay fields near existing pastures are ideal choices for fall grazing because parts of the field will already be fenced, reducing the cost of putting up temporary or permanent fencing. Fields next to pastures or building sites also allow for easier access to water. If more fencing or watering systems are needed, the savings from grazing these fields will offset those costs within a few years.

Grazing hay fields has many benefits. The most prominent benefit is the potential to reduce the overwintering cost, which accounts for most of the cost of producing an animal. A less obvious, but important benefit, is the reduction in the use of fossil fuels associated with making hay and feeding livestock. Many gallons of fuel were conserved in our project by grazing instead of haying. Another potential impact is keeping more livestock on the landscape in critical areas, reducing erosion that is associated with intensive row-cropping.

Management Tips for Winter Rye

1. Fields that are adjacent to permanent pasture are great to work with because part of them will already be fenced. This reduces fencing and labor costs. Also, a water source is most likely nearby.

2. Rotational grazing practices will maximize the value of the winter rye and reduce the amount that the animals waste via trampling.

3. Plan ahead. Know when you want to plant your spring crop so that the animals can graze the rye and leave enough time to control the rye prior to seeding your row crop.

4. Do not graze drilled and aerially seeded winter rye in the same pasture area. These will most likely be seeded at different times and be at different stages of growth. For example, the aerially seeded field used in the first year of this project was ready to graze before the drill seeded field. We had to wait to graze the aerially seeded rye because the two methods were being grazed together.

Management Tips for Grazing Hay Fields

1. If you are maintaining the alfalfa stand the year following grazing, make sure to allow 4-6 weeks of re-growth prior to the first killing frost, and then graze. Alfalfa needs this time to build its root reserves, which will help those plants survive the winter.

2. Legumes, such as alfalfa, may cause bloat. Watch the animals for signs of bloat when they are first turned into the hay field. The animals may need to be fed dry hay prior to grazing a hay field to fill the animals up. Consider providing free-choice dry hay in the field.

3. Hay fields that are adjacent to permanent pasture are great to work with because part of the field will already be fenced. This reduces fencing and labor costs. Also, a water source is most likely nearby.

4. This practice is ideal for older stands of alfalfa that have well established plants and root systems because the animals will likely cause less damage to the plants. First-year alfalfa stands may be damaged by the impacts of grazing.

5. Sub-divide the field so that the animals will have access to no more than a 3 day supply of forage. The longer animals spend in a pasture, the more forage they will waste and the more trailing they will do.

Cooperators

Craig Sheaffer, Professor, University of Minnesota Department of Agronomy and Plant Genetics, St. Paul, MN
Doug Keene, Fillmore SWCD, Preston, MN
Howard Moechnig, Midwest Grasslands, Cannon Falls, MN
John Zinn, United States Department of Agriculture/Natural Resource Conservation Service, Rochester, MN
Jeff Gillespie, Producer, Fountain, MN
Mark Zumwinkle, Minnesota Department of Agriculture, St. Paul, MN
Tom Boelter, Producer, Chatfield, MN

Project Locations

Winter rye fields: Tom Boelter
From Preston, go north on Hwy. 52 for approx. 6 miles. In Fountain, take a left (West) on Cty. Rd. 8 for approx. 7 miles, take a right (North) on Cty. Rd. 5 until the road meets a stop sign (approx. 2 miles), take a left (West) on Cty. Rd. 4 for approx. ½ mile, take a right (North) on 181st Ave. (first road). Aerially seeded field is on the left after the first driveway on the right (fields located in Jordan Township 28).

Grazing hay fields: Jeff Gillespie
From Preston, go north on Hwy. 52 to Fountain (approx. 6 miles), take a right on Cty. Rd. 8, follow for approx. 4 miles and the site is the long driveway on the left (Carrolton Township, Section 7).

References

Barnett, Ken. 2008. Weekly Hay Market Demand and Price Report for the Upper Midwest as of October 24, 2008. University of Wisconsin Extension. Retrieved from *www.uwex.edu/ces/ag/haybuying.html*

Barnhart, Steve, Michael Duffy, and Darnell Smith. 2008. Estimated Costs of Pasture and Hay Production. Iowa State University Extension Factsheet A1-15.

Dabney, S.M., J.A. Delgado, and D.W. Reeves. 2001. Using Winter Cover Crops to Improve Soil and Water Quality. Communications in Soil Science and Plant Analysis. 32:7: 1221-1250.

Lazarus, William. 2008. Machinery Cost Estimates. University of Minnesota Extension. Retrieved from *www.extension.umn.edu*

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Thornton, Jane. 2004. Stockpiled Forages. In: Proceedings from Manitoba Agronomists Conference 2004: 132-135.

Other Resources

Forage Information System:
forages.oregonstate.edu/index.cfm

Blanchet, Kevin, Howard Moechnig, and Jodi Dejong-Hughes. 2003. Grazing Systems Planning Guide. University of Minnesota Extension, Natural Resources Conservation Service, and University of Minnesota Water Resource Center. BU-07606-S. *www.extension.umn.edu*

National Sustainable Agriculture Information Service:
attra.ncat.org/

Plant Management Network:
www.plantmanagementnetwork.org/fg

University of Missouri Forage Systems Research Center:
www.aes.missouri.edu/fsrc/research/fsres.stm

University of Nebraska-Lincoln Extension:
www.ianrpubs.unl.edu/epublic/pages/index.jsp

University of Wisconsin-Extension: Forage Resources:
www.uwrf.edu/grazing

Completed Grant Projects...

Final Greenbook Article	Title of Project	Grantee

Alternative Markets and Specialty Crops

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

Final Greenbook Article	Title of Project	Grantee
2000	Native Minnesota Medicinal Plant Production	Renne Soberg
1999	An Alternative Management System in an Organic, Community Supported Market	Candace Mullen
	Cultural and Management Techniques for Buckwheat Production and Marketing	Tom Bilek
	Pond Production of Yellow Perch	John Reynolds
1998	Establishing and Maintaining Warm Season Grasses (Native Grasses)	Pope County SWCD
	On-farm Forest Utilization and Processing Demonstrations	Hiawatha Valley RC&D
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

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

Final Greenbook Article	Title of Project	Grantee
2005	Chickling Vetch - A New Green Manure Crop and Organic Control of Canada Thistle in Northwest Minnesota	Dan Juneau
	Feasibility of Winter Wheat Following Soybeans in Northwest Minnesota	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
	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/Shane Johnson
	Soil Conservation of Canning Crop Fields	Andy Hart
	Using Liquid Hog Manure as Starter Fertilizer and Maximizing Nutrients from Heavily Bedded Swine Manure	Dakota County SWCD/Brad Becker
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

Final Greenbook Article	Title of Project	Grantee
2001	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
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 Minnesota 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

Final Greenbook Article	Title of Project	Grantee
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 Minnesota	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 Southeast Minnesota	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 Minnesota	Steven Grosland/Kathy Zeman
	Modified Ridge-till System for Sugar Beet Production	Alan Brutlag
	Soil Building and Maintenance	Larry H. Olson
1992	Strip-cropping Legumes with Specialty Crops for Low-cost Mulching and Reduced Fertilizer/Herbicide Inputs	Mark Zumwinkle
	Using Nitro Alfalfa in a No-till Corn and Soybean Rotation	Jeff Johnson
1991	Alternative Methods of Weed Control in Corn	Sr. Esther Nickel
	Hairy Vetch and Winter Rye as Cover Crops	Mark Ackland
Energy		
2009	Environmentally and Economically Sound Ways to Improve Low Phosphorus Levels in Various Cropping Systems Including Organic with or without Livestock Enterprises	Diomides Zamora
2008	On-farm Biodiesel Production from Canola	Steve Dahl

Final Greenbook Article	Title of Project	Grantee
2007	Testing the Potential of Hybrid Willow as a Sustainable Biomass Energy Alternative in Northern Minnesota	Dean Current

Fruits and Vegetables

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
	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

Final Greenbook Article	Title of Project	Grantee
2001	Sustainable Weed Control in a Commercial Vineyard	Catherine Friend/Melissa Peteler
1999	Development of Mating Disruption and Mass Trapping Strategy for Apple Leafminer	Bernard/Rosanne Buehler
1998	Alternative Point Sources of Water	Joseph/Mary Routh
	Comparison of Alternative and Conventional Management of Carrot Aster Leafhoppers	MN Fruit & Vegetable Growers Association
	Jessenland Organic Fruits Project	MN New Country School
	Propane Flame Weeding Vegetable Crops	Jean Peterson/Al Sterner
	Soil Quality Factors Affecting Garlic Production	Tim King
	Wine Quality Grapes in Otter Tail County	Michael/Vicki Burke
1997	Community Shared Agriculture and Season Extension for Northern Minnesota	John Fisher-Merritt
	Living Mulch, Organic Mulch, Bare Ground Comparison	Dan/Gilda Gieske
Livestock		
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
	High Value Pork Production for Niman Ranch Using a Modified Swedish System	David/Diane Serfling

Final Greenbook Article	Title of Project	Grantee
2004	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
2002	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

Final Greenbook Article	Title of Project	Grantee
2000	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
	Management Intensive Grazing Groups	Dave Stish
	Renovation of River Bottom Pasture	Jon Peterson
	The Value Added Graziers: Building Relationships, Community and Soil	Values Added Graziers
1998	Buffalo: Animal from the Past, Key to the Future	Richard/Carolyn Brobjorg
	Marketing Development - Small Farm Strategies Project	Sustainable Farming Association of NE MN
	Pastured Poultry Production and Riparian Area Management	Todd Lein
1997	Butcher Hogs on Pasture	Michael/Linda Noble
	Developing Pastures Using Various Low-input Practices	Ralph Lentz
	Grass Based Farming in an Intensive Row Crop Community	Douglas Fuller
	Grazing Hogs on Standing Grain and Pasture	Michael/Jason Hartmann
	Grazing Sows on Pasture	Byron Bartz
	Low Input Systems for Feeding Beef Cattle or Sheep	Dennis Schentzel
	Raising Animals for Fiber	Patty Dease
	Rotational Grazing Improves Pastures	MISA Monitoring Team
	Seasonal Dairying and Value-added Enterprises in Southwest Minnesota	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

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

Sustainable Agriculture Loan Program

Loan Technical Review Panel for 2011

Gregg Bongard, Ag Lender

Robin Brekken, Farmer

Ralph Lentz, Farmer

Thaddeus McCamant, Farm Management Specialist

Bob Mueller, Farmer

Ray Rauenhorst, Farmer

Keith Schoenfeld, Ag Lender

Chuck Schwartau, Extension Educator

Program Purpose

The Sustainable Agriculture Loan Program was created to accelerate the adoption of sustainable farming information and technology in Minnesota. Loans of up to $40,000 per farmer or up to $160,000 for joint projects (four applicants) are made at a fixed 3% interest rate for a term of up to 7 years. These low-interest loans are made to farmers for purchasing new or used equipment and temporary structures such as high tunnels or hoop houses and for making building improvements that help make the farming system more sustainable.

Background

When this program began in 1988, the concepts of sustainable agriculture were less understood and less accepted by farmers and lenders than they are today. Many farmers had difficulty obtaining the capital necessary to refocus their farm operations since lenders were reluctant to finance changes during the volatile economy of the 1980s. The state chose to assist these farmers through direct lending.

The initial $1 million appropriation from the state legislature was set up as a revolving fund. As loans are repaid, the funds are pooled and redistributed to other farmers in the form of new loans. Many farmers will benefit from this continuing program with no additional cost to the state.

Evaluation Criteria

Applications for the Loan Program are accepted throughout the year and are competitively evaluated. A review panel representing a cross-section of agricultural professionals from various regions of the state determines which loan projects to recommend to the Commissioner of Agriculture for funding.

The loan proposals are evaluated based on the following criteria:

a) **Long-term Plans for the Farm:** How does this investment fit the long-term plans for the farm?
b) **Effect on the Farming System:** How will this investment lead to a more sustainable farm system?
c) **Environmental Impact:** Is there an environmental benefit to the proposed project?
d) **Farm Income:** What is the added return to the farming operation from the proposed project?
e) **Input Reduction:** Does the project reduce or make more efficient use of inputs?

Each proposal is judged on its relative merits. A farming method considered to be highly innovative in one region of the state may be commonplace in another region.

Impact of Program

The loans have given Minnesota farmers added incentive to make changes toward more efficient use of inputs while enhancing profitability and protecting the environment. More than 340 farmers have borrowed over $3.6 million from the Sustainable Agriculture Loan Program.

As loans are repaid and the funds redistributed, approximately $250,000 is available each year for new loans. When farmers implement innovative changes, their neighbors have an opportunity to observe and decide whether to adapt changes to their farming system. In this way, the farmers are demonstrating new, innovative, and alternative ways of farming and are serving to accelerate the rate of adoption of sustainable agriculture in Minnesota.

Project Categories

Loan projects typically fall into six categories: energy savings and production, livestock management, conservation tillage, weed and nutrient management, on-farm processing, and alternative crop production including season extension. Almost one-half of loans have been made for livestock management and this category continues to be the most common. Projects have included fencing, livestock handling equipment, milking parlor upgrades, and building improvements. Conservation tillage and weed management projects have accounted for about one-fourth of the loans and include the purchase of rotary hoes, flame cultivators, and ridge tillage equipment. Energy production, on-farm processing and handling equipment, and fruit and vegetable projects have been increasing in the past few years.

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 - Integrated Pest Management (IPM) Program Coordinator, has been part of the staff since 1997. During her tenure at the MDA, she has coordinated the Biological Control Laboratory (1989-91) and the Exotic Pest Program (1991-97). Jean works on development and implementation of statewide strategies for increasing the use of IPM on private and state managed lands.

Alison Fish - Secretary, provides administrative clerical support to the staff and the program.

Wayne Monsen - Alternative Livestock Systems Specialist, provides rotational grazing planning services for livestock producers (in cooperation with NRCS), and cooperates with local, state, and federal agencies on livestock and non-point source pollution issues. He began working for MDA in 1992 after farming for 12 years near St. James, MN.

Meg Moynihan - Organic and Diversification Specialist, joined the Minnesota Department of Agriculture in 2002. She helps farmers and rural communities learn about crop, livestock, management, and marketing options, including organic. She has also 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 a certified organic dairy farmer.

Mark Zumwinkle - Sustainable Agriculture Specialist, 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 ESAP staff in 1993.

Staff Resource Directory

	Jean Ciborowski	Wayne Monsen	Meg Moynihan	Mark Zumwinkle
Alternative Crops & Livestock		•	•	•
Community Supported Agriculture (CSA)			•	
Composting				•
ESAP Loans		•		
Farming Systems/Tillage, Weed Control, Crop Rotation	•	•	•	•
Integrated Pest Management (IPM)	•			
Livestock Production/Managed Rotational Grazing Planning		•		
Living Mulch/Cover Crops				•
Organic Production/Livestock,Vegetables, Grain, Fruit			•	•
Organic Rules and Certification			•	
Soil Quality and Soil Fertility				•
Vegetable Production				•

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WWW.MDA.STATE.MN.US/PROTECTING/SUSTAINABLE/GREENBOOK.ASPX

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