GREENBOOK 2010




MINNESOTA DEPARTMENT OF AGRICULTURE

Greenbook 2010

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.

MINNESOTA DEPARTMENT
OF AGRICULTURE
AG DEVELOPMENT & FINANCIAL ASSISTANCE

August 2010

Thank you to the MDA's Agricultural Development and Financial Asssistance Staff who helped to make *Greenbook 2010* a reality. They include: Linda Bougie, Jean Ciborowski, Alison Fish, Mary Hanks, Wayne Monsen, Meg Moynihan, and Mark Zumwinkle. Special thanks to Stacy Gulden, Information Technology Division, for the layout and design of *Greenbook 2010.*

Minnesota Department of Agriculture
625 Robert Street North, St. Paul, MN 55155
651-201-6217

Introduction to the *Greenbook 2010*

It seems we just celebrated the 20th Anniversary of the Sustainable Agriculture On-farm Demonstration Grant Program and here we are again, with the 21st edition of the *Greenbook*, our annual publication that highlights the results of these grant projects. To date, the annual *Greenbook* has showcased 281 creative and innovative Minnesota farmers and researchers who participate in the Sustainable Agriculture Grant Program.

We have come a long way in the past 21 years. Many advances have been made in agriculture. The key, however, to quality farming is our Minnesota farmers. They work tirelessly to produce some of the finest crops in the nation. We are 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 our agricultural community the best!

The *Greenbook* is a publication of the Minnesota Department of Agriculture's Agricultural Development and Financial Assistance Division. I am proud of our MDA staff members who have worked diligently to help our farmers accomplish the goals of their grant projects.

Greenbook 2010 contains articles highlighting the results of the grantees' projects and provides practical and technical information. Each article includes personal observations and management tips from the participants. Additionally, these grantees are willing to share their knowledge and experiences with you. They are all dedicated to making Minnesota agriculture more profitable and environmentally friendly. Feel free to give them a call about their projects.

Congratulations on a job well done!

Gene Hugoson, Commissioner
Minnesota Department of Agriculture

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Sustainable Agriculture Grant Program

Program Purpose

The Grant Program provides 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 has received over 1,080 grant applications and has approved over $2.9 million in funding for 281 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 2010*.

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

Grant Summaries

The project summaries that follow are descriptions of objectives, methods, and findings of individual grant projects funded in the past 3 years. 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
Total Funded	**281**	**$2,993,416**		

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

Growing Cherries in Central Minnesota

Principal Investigator

Pat Altrichter
4176 - 230th St.
Randall, MN
56475
320-749-2154
ronpat@littlefalls.net
Morrison County

Project Duration

2009 to 2011

Award Amount

$5,000.00

Staff Contact

Meg Moynihan
651-201-6616

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.[1]

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.

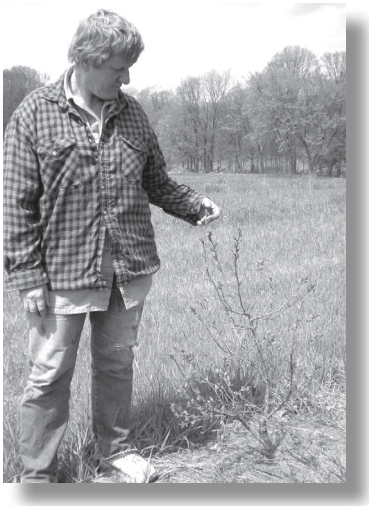
Sweet cherries do not survive the winters where we live. However, we learned about 'Evans,' a newer variety of sour cherry from Canada that is flavorful and not as tart as most sour cherries. 'Evans' is also reportedly very hardy and we expected it would survive in our area, which the USDA rates as hardiness zone 3. Dr. Leuan Evans, for whom the tree is named, collected the stock from Mrs. Borward near Edmonton, Alberta, Canada (Edmonton Journal, 2006). There are some reports that Mrs. Borward's seeds may have come from settlers who hailed from Minnesota, but these have not been confirmed.

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.

'Evans' cherry trees have a life expectancy of 20-30 years. According to our research, it is possible to harvest 50 lbs 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

Will May be cherry blossom time on this central Minnesota farm?

[1] *Followers of Pat and Judy's earlier project with Saskatoon berries reported in previous issues of the Greenbook may remember that Pat farmed with her husband Ron. We are sad to report that Ron passed away in August, 2008.*



Judy stands next to one of the little trees in May.

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 has been about $200-250 for alfalfa, $120-180 for corn, $90-120 for soybeans, and $40-50 for oats.

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 augur, 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)[2] We also put out some bait stations for mice.

Results

Judy has been selling the trees for a few years already and is very impressed with their growth and hardiness. 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.

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 qt. hot water until you have slurry. Dilute 2 cups of the slurry with 4 gal. 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.

Cooperators

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

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. Our address is 4176 – 230th St.

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*

Hardy plants for northern climates:
www.northscaping.com

Information about Evans cherries:
www.dnagardens.com/Articles/cherry_evans_tips.htm

Video about Evans cherries:
www.youtube.com/watch?v=qvy4jHJou3o

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

Hardwood Reforestation in a Creek Valley Dominated by Reed Canarygrass

Principal Investigators

Timothy and Susan Gossman
31924 Ninebark Rd.
Chatfield, MN 55923
507-867-3129
tgossman@northlc.com
Fillmore County

Project Duration

2007 to 2009

Award Amount

$5,395.00

Staff Contact

Wayne Monsen
651-201-6260

Keywords

hardwood reforestation, healthy understory, reed canarygrass removal

Project Summary

Thirty years ago the 20 acres of creek bottom land on our farm was dominated by a floodplain forest comprised mostly of American elm. As these trees were killed by Dutch elm disease, and the shade disappeared, reed canarygrass (RCG) *(Phalaris arundinacea)* began to move into the area. RCG is an aggressive perennial grass that threatens wetland and riparian areas where it forms a monoculture, eventually smothering the native grasses and forbs and preventing any regeneration of trees or shrubs. It now dominates most of the 20 acres except for pockets of natural stands of native hardwoods and trees that were planted before it moved in. RCG provides almost no wildlife benefits, makes poor pasture or forage if not intensely managed, and provides little economic gain.

Returning this area to forest will provide food and habitat for birds and wildlife and provide short-term economic returns from nut and acorn harvesting and hunting opportunities, and long-term economic benefits from the sale of timber. The trees will shade Lost Creek, a designated trout stream, providing better trout habitat. We have planted spruce, pine, and fir trees on our farm and have been selling Christmas trees for over 10 years. We have also planted hardwood trees in appropriate areas of our farm and restored native grasses and wildflowers in other areas. 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

Due to RCG persistence and its resistance to control by non-chemical practices, we were faced with an environmental decision: whether it was better to leave the creek valley and RCG untreated and allow the RCG to dominate and spread but not expose the area to herbicides, or to explore several alternatives including treating an area with chemical herbicides for several years in an attempt to reforest the area. After much research and deliberation, we believe the more sustainable and environmental decision would be using effective herbicides with low environmental impact at rates no higher than would be used in a field of soybeans for a period of only 3 or 4 years to reestablish a forest that should remain for over 100 years. We think of this as a transition period that will provide long-term environmental benefits to our farm and to the Lost Creek and Root River Watersheds. We plan to reach the goal of reforestation by testing four alternative plans using different techniques of suppressing the RCG and growing trees.

Tim discussing hardwood reforestation at field day.

Ginkgo tree seedling.

We realize that this is a long-term project and plan to complete the project over 7 to 10 years. This long-term plan exposes no more than 2 acres of tilled soil to erosion in any year. Over the past 20 years we have planted tree seedlings and tree seeds such as walnuts and acorns in the creek valley with fair survivability in the areas not yet overtaken by RCG, and near 100% failure in the RCG areas.

The four strategies that we are using to control the RCG and return the area to a mix of bottom land forest with a healthy understory and open areas of sedges, reeds, and native forbs are:

- Plan A: Control RCG with a combination of prescribed burning, herbicide application, mowing, and tillage followed by direct seeding a diverse mix of bottom land trees and shrubs. This area is about 1.5 acres in size each year.
- Plan B: Twenty-five fence post sized poles of willow and cottonwood were planted each year in areas that are not accessible by machinery to eventually shade out the RCG. We estimate that this area is just under an acre in size.
- Plan C: Plant a diverse direct tree seeding in areas where the shade of boxelders has already controlled the RCG followed by killing the boxelder trees. Approximately ½ acre was planted in both 2007 and 2008.
- Plan D: Follow a controlled burn on ½ acre with 1 year of herbicide treatment and tillage adjacent to stands of mature boxelder to encourage a natural seeding by the boxelders to shade out the RCG.

All four methods use the fact that RCG does not reproduce or survive in heavy shade. We repeated the four plans over the 3 years of the grant to test the procedures in different weather conditions.

Plan A Results

2007

The area for this practice in 2007, was about 1½ acres. To prepare the area, a prescribed burn was completed in April 2006, to remove a layer of thatch. The site was then sprayed with sethoxydim herbicide in late May 2006, to kill the grasses including RCG. Sethoxydim kills grasses without harming the forbs.

A second burn was planned for the spring of 2007, but a late winter flood deposited a layer of mud on the site preventing us from burning. Instead, the area was treated with sethoxydim herbicide in early June, mowed in late June, and treated with glyphosate herbicide in late August to kill all plants in the areas to be direct seeded. The herbicide treatments killed most of the RCG.

The site was mowed and tilled in mid-September and direct seeded to a mixture of burr oak, white oak, swamp white oak, walnut, butternut, bitternut hickory, Kentucky coffee tree, Ohio buckeye, chokecherry, wild plum, dogwood, redbud, ninebark, and false indigo in late September and early October. The larger seeds were disked in followed by the smaller seeds with oats as a cover crop and finished with a cultipacker. Warm wet weather allowed the oats to grow well, hopefully minimizing the effects of creek flooding.

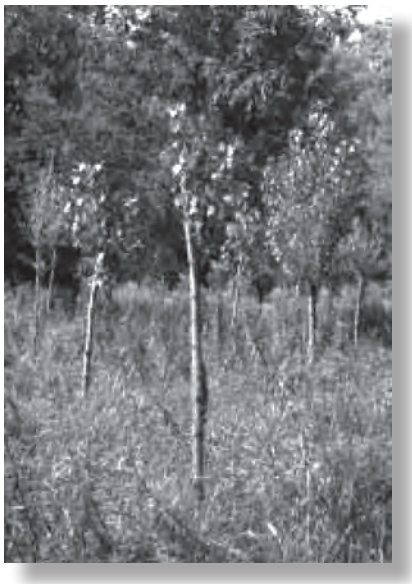
2008

Most of the species planted in the fall of 2007, were found growing throughout the area when observations were made from April to June 2008. In April, we planted willow, cottonwood, tamarack, and hackberry seedlings in this area. Silver maple seeds were sown in June. We mowed this area in July with the tractor mower set at a height of 1' to control weeds without clipping the seedlings.

The new 1½ acres selected for the 2008 planting was treated with Sethoxydim herbicide in early June, mowed in late June, and treated with glyphosate herbicide in late August. The herbicide treatments appear to have killed most of the RCG. The site was mowed and tilled in September and direct seeded to a mixture of burr oak, white oak, swamp white oak, walnut, butternut, shagbark hickory, Kentucky coffee tree, ginkgo, black cherry, hackberry, green ash, Ohio buckeye, chokecherry, wild plum, dogwood, ninebark, and false indigo seeds in October. The larger seeds were disked in followed by broadcasting the smaller seeds and then the entire area finished with a cultipacker.

2009

We over-seeded the 2008 seeding area with oats as soon as the snow melted. We did this because the planting was done too late in the fall to seed oats. The goal of the oats seeding was to provide cover to the bare ground to control



New growth on cottonwood and willow poles.

erosion from spring and summer flooding. It appeared to have the side benefit of suppressing weeds somewhat. It did not seem to have a negative effect on the tree seedlings. The seedlings of most tree and shrub species seeded last fall were found growing throughout the area in April to June. We seeded more willow, cottonwood, tamarack and hackberry seedlings in April. Silver maple seed was sown in June.

The 2009, 1½ acre planting area was treated with Sethoxydim herbicide in early June, mowed in early July, and treated with glyphosate herbicide in early September. The herbicide treatments appear to have killed most of the RCG. The site was mowed and tilled in September and direct seeded to a mixture of burr oak, white oak, swamp white oak, walnut, smoothbark hickory, Kentucky coffee tree, ginkgo, black cherry, hackberry, green ash, Ohio buckeye, highbush cranberry, wild plum, dogwood, ninebark and false indigo seeds in October. The larger seeds were disked in followed by the smaller seeds and finished with a cultipacker. In April, willow, cottonwood, and tamarack seedlings will be planted on a new 1½ acre site. Silver maple seed will be sown on the area when that seed is ripe, in June of 2010.

In the fall of 2009, I counted over 300 walnut seedlings per acre with an average height of 2 to 3 feet in the entire area. Other tree and shrub species were present in lesser amounts. Bud caps were applied to all trees over 2' tall to discourage deer browse.

Plan B Results

2007

Willow and cottonwood poles, 4" to 6" diameter and 6' to 8' long were gathered while still dormant in March 2007, and stored in a root cellar to keep them cool and moist. As soon as the frost was out in April the pole cuttings were planted in holes made with a post hole digger into a stand of solid RCG in an area of about 1/8 acre.

Most of the poles of both species sprouted, but deer browsed on the shorter poles causing some trees to die. Some of the taller poles, above the browse level, put on new growth of up to 3'.

In the spring of 2008, we unfortunately noticed that the willow and cottonwood poles planted in 2007 had less than a 10% survival rate after the first winter. This was due mostly, I believe, to deer browse. We dug up the dead posts and most had grown roots below ground as well as sprouts above, so they had started to grow. The trees that did live put on growth ranging from a few inches to several feet the first year. During the 2008 growing season they grew several more feet, not yet forming a central leader, but beginning to look more like young trees and less like fence posts!\

2008

We planted more willow and cottonwood poles in 2008. These poles were longer than the 2007 poles, ranging from 8½' to 10' long and were 4" to 6" in diameter. We gathered the poles in March while they were still dormant and stored them in a root cellar to keep them cool and moist. We planted these poles into solid RCG in April as soon as the frost was out of the ground. With a post hole digger we made holes 1½' to 2½' deep depending on the depth to rock. These taller poles had reduced deer browse so many more trees of both species were alive at the end of the growing season.

2009

Almost all of the trees that survived the first 2 years are still growing and putting on new growth of about 4' in 2009. The taller pole height limited deer browse. However, some trees were lost to male deer rubbing the bark off trees with their antlers.

Bud capped seedlings showing tree density.

For the 2009 planting, we again planted 4" to 6" diameter and 8½' to 10' long willow and cottonwood poles that were gathered while still dormant in March. In addition to the poles, we planted several stems from the tops of larger trees that had the terminal bud. We hoped that these stems would avoid the large area at the top of the poles that needs to heal before the wood begins to rot. This fall the willows planted this way showed excellent survivability, while the cottonwoods had more than 50% mortality. We will reassess the survival rate of this area when trees leaf out next spring.

Plan C Results

2007

The thick stand of young boxelder trees in this ¼ acre area was thinned so that trees are at least 4' apart. The lower branches on the remaining trees were removed to a height of 7' to allow the area to be worked up by a small tractor and tiller. The site was tilled in mid-September and direct seeded to a mixture of burr oak, white oak, swamp white oak, walnut, butternut, shagbark hickory, Kentucky coffee tree, horse chestnut, chokecherry, wild plum, dogwood, redbud, ninebark, and false indigo in late September and early October. The larger seeds were worked in with the tiller running at a slow speed with the smaller seeds sown on top of the ground.

2008

In February, the boxelder trees were treated with Garlon herbicide to kill them. Our original plan was to then cut the trees to discourage deer from coming into the area. However, we decided that this would also make future planting or weed control very difficult, so we left the dead trees standing. The insects and woodpeckers have taken advantage of this decision.

In April, we planted willow, cottonwood, tamarack, and hackberry seedlings into the area. We over-seeded oats into the late 2007 plantings as soon as the snow melted. In June, we seeded silver maple seeds. In the summer, we found seedlings of most species seeded in 2007 growing throughout the area.

2009

All of the area dedicated to Plan C was planted in 2007 and 2008. No additional land was planted in 2009. This fall we counted over 100 walnut seedlings/A with an average height of 2' to 3'. Other tree and shrub species were present in lesser amounts. Bud caps were applied to all trees over 2' tall to discourage deer browse.

Girdled boxelder.

Plan D Results

2007

A prescribed burn was conducted in April 2007, on about ½ acre. The area was treated with sethoxydim herbicide in early June, mowed in late June, and treated with glyphosate herbicide in late August. The herbicide treatments killed most of the RCG. The site was mowed and tilled in mid-September. The site was left as is to be a good area to germinate volunteer boxelder seeds in 2008.

2008

The 2007 burn area had a good germination of volunteer boxelder trees in 2008. Not a lot of RCG was noticed in this area.

2009

The volunteer boxelder trees continued to grow. However, as of October, RCG still dominates the site.

Conclusion

The main result we are looking for is a good stand of trees growing in each of the treatment areas. We are excited about how the project is progressing. We have thousands of young healthy trees that would not have been there without using these methods. We will assess the germination of new plantings in 2010 and the leafing out of trees over many years.

Management Tips

1. Acorns should be kept moist and cool to maintain viability. Soak acorns in cold water prior to storing to chill and hydrate them.

2. Store early collected seed at 40°F.

3. A chest freezer can be used for seed storage by installing an override thermostat to convert it to a refrigerator. When you add the first seeds to an empty freezer, set the thermostat 10°F colder than the current temperature of the seed and lower it 10°F daily until you reach 40°F. This will allow the interior of the seed to get chilled without freezing the seed at the edges. Look for the freezer/refrigerator override thermostat where wine and beer making supplies are sold.

4. Oak, dogwood, chokecherry, plum, and other early collected seed may need to be stored for up to 6 weeks before other later maturing seeds, such as walnuts, are ready for planting.

5. The use of the Nut Wizard saves considerable time and effort compared to picking by hand or raking. It is available in several sizes for various sized nuts to collect acorns, hickory nuts, butternuts, and walnuts.

6. Use cottonwood and willow poles that are at least 8½' tall. This will leave over 6½' of the pole above the ground, keeping the new growth that sprouts from the top above the RCG and protecting the new growth from browsing by deer.

7. Cottonwood and willow poles will not grow if planted upside-down. Make sure they are oriented the way they were growing when you cut them. You may want to mark the tops when harvesting the poles.

8. If your seed planting is near an existing forest, provide an easy food supply for squirrels by making several piles of walnuts around the edge of the planting, to discourage them from digging up your planted seeds.

9. Monitor your tree plantings weekly, monthly at least. This will allow you to do your maintenance on a timely basis and to deal with problems that arise such as finding varmints damaging trees and getting rid of them before they do severe damage to the plantings.

10. Contact your local DNR forester and county Soil and Water Conservation District for information on direct seeding, tree planting, and weed control in your tree plantings.

Cooperators

Fillmore Soil and Water Conservation District, Preston, MN
DNR Forestry, Preston, MN
Jon Alness, Zumbro Valley Forestry, Elgin, MN

Project Location

From the traffic lights in Chatfield, MN, go 5 miles west on Cty. Rd. 2 then 1.5 miles south on Cty. Rd. 101, also known as Ninebark Rd. Farm is on the east side of the road at #31924.

Other Resources

Cottonwood and willow pole planting website: *www.nm.nrcs.usda.gov/news/publications/pole-cutting-solution.pdf.* This website provides basic information about pole planting in riparian areas.

Direct seeding hardwood trees websites: *www.dnr.state.mn.us/treecare/maintenance/collectingseed.html* and *www.dnr.wi.gov/forestry/Publications/articles/HardwoodDirectSeeding-2004.pdf*

A detailed description of this project can be found on the Fillmore SWCD website: *www.fillmoreswcd.org*. Hardwood reforestation in a creek valley dominated by reed canary grass. Go to "Projects" and select "Other special projects".

Reed canarygrass control websites: *www.phalaris.pbwiki.com/* and *www.lrrb.org/pdf/200436.pdf* where best management practices are summarized on pp. 92, 93, and 94.

Seed collecting website: *www.nutwizard.com*

Organic Mushroom Cultivation and Marketing in a Northern Climate

Principal Investigator

Jill Jacoby
3971 Rehbein Rd.
Duluth, MN 55803
218-724-9786
pumilios@aol.com
St. Louis County

Project Duration

2009 to 2011

Award Amount

$8,680.00

Staff Contact

Wayne Monsen
651-201-6260

Keywords

inoculating, marketing, oyster mushrooms, shiitake mushrooms, substrates

Project Summary

There are several goals for this project. The first is to grow 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 shitake 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 common 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.

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 rodents removed some of the wax covering the inoculation holes on the shiitake logs. Next year I will use a thicker coating of wax on the holes to prevent this from reoccurring.

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 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.

Not being a patient person, I wanted to try inoculating straw so I would 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 straw bale (I used oat straw, but most any straw will work) and set up two cardboard boxes and one wood cold frame growing chambers. 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 weed 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. 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) and 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.

The presence of spotted beetles in the straw boxes alerts me to the need to provide protection for the totems when they fruit next summer.

Management Tips

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

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.

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*

Feasibility of Small Farm Commercial Hop Production in Central Minnesota

Principal Investigator

Robert Jones
4300 Lower Ray Lake Rd.
Nisswa, MN 56468
218-330-5310
stmathiasfarm@gmail.com
Crow Wing County

Project Duration

2009 to 2011

Award Amount

$12,535.00

Staff Contact

Meg Moynihan
651-201-6616

Keywords

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

Project Summary

One of our restaurant customers who supports locally grown foods approached us about the possibility of 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 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 potential market for small and medium sized sustainable farming operations. Further review suggested that existing 10' deer fence and posts could be modified to 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 fencing.

Project Description

The Farm on St. Mathias (The Farm) is an 80 acre fruit and vegetable farm located near Brainerd, MN. The Farm produces a wide variety of hybrid and heirloom vegetables on approximately 30 acres (8 of which are protected by a newly constructed woven deer fence). Local markets include an on-farm market and country store, a 50 member CSA (Community Supported Agriculture), and local restaurants. We also offer fall festival activities featuring pumpkin sales, corn maze, and hayrides. In June 2009, the local brew club (the Blue Ox Brewers Society) demonstrated beer brewing - including hop ingredients - during the annual farm 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 (Figure 1).

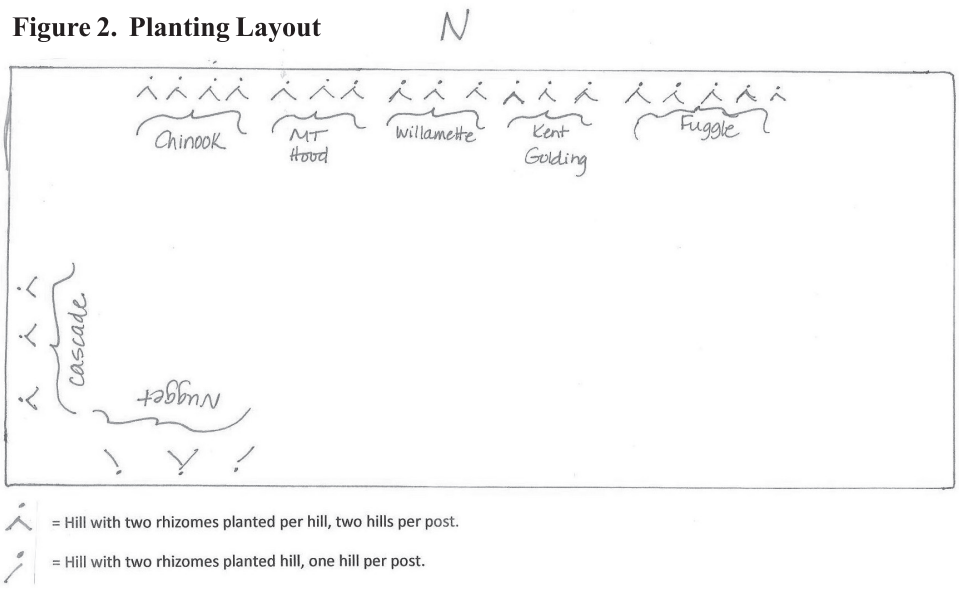
The hop plant is dioecious, meaning that it bears both male and female flowers on separate plants. The female flowers form papery "cones," which are 1 to 4" long and bear the seeds. It is these cones that are used in brewing. They contain a compound called lupulin, which is made up of the essential oils and resins that impart hops' unique aroma and bitter flavor (Carter et al., 1990).

We set out to determine which hop varieties would grow most successfully 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

Figure 1. Hops corkscrew clockwise around any support provided.

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.

Figure 2. Planting Layout



The basic design of this project involves establishing five varieties of hops (Table 1) within three planting areas inside the existing deer fence and using fence posts as trellis supports. One variety, 'Amarillo,' which was suggested by our cooperator, was not available because of infection by the hops stunt viroid disease. Another wasn't available because it had been patented privately and is no longer for sale. We selected the planting areas based on their exposure and soil types in order to create distinct comparisons between planting areas.

Table 1. Hop Varieties Used

Cascade	Mt. Hood
Chinook	Nugget
Fuggle	Willamette
Kent Golding	

The project will evaluate six specific measures for the varieties tested:

- yield;
- winter survival using organic and sustainable mulching;
- incidence of disease, pests, or hazards impacting rhizome survival;
- analysis of hop cones and associated plant structures;
- Standardized brew testing; and
- Marketability of the hop cones (finished product).

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 then 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) (Figure 2).

We planted all hop rhizomes on May 4, 2009 when we thought the risk of severe frost to the rhizome was over. We hoped that we could gain a few growing weeks by planting the rhizome in early May in order to gain root structure. By May 17, all the hops were up and growing. 'Fuggle' and 'Kent Golding' were the most vigorous at that time. We suspect these two varieties prefer a more moist growing condition – and we had planted them in a moist soil at the east end of the north fence.

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 (Figure 3).

Table 2. Hop Growth and Yield

Variety	# of Hills	Exposure	5-25-09	7-14-09	9-25-09 (Harvest)
Cascade	6	Eastern	Moderate growth	Vigorous growth; cones present	Total vine growth approximately 5'; cones harvested
Chinook	8	Southern	Two mounds absent, some growth	Moderate growth; cones present	Total vine growth approximately 4'; no cones
Fuggle	10	Southern	Vigorous growth	Vine viable; no cones	Total vine growth approximately 4'; no cones
Kent Golding	6	Southern	Vigorous growth	Vine viable; no cones	Total vine growth approximately 4'; no cones
Mt. Hood	6	Southern	Two mounds absent, Some growth	Moderate growth; no cones	Total vine growth approximately 4'; no cones
Nugget	4	Northern	Moderate growth	Vigorous growth; cones present	Total vine growth approximately 5'; cones harvested
Willamette	6	Southern	Moderate growth	Much vine growth, but not showing much cone growth	Total vine growth approximately 6'; no cones

Figure 3. We planted two hop plants per hill and trained them to sisal twine that ran from garden stakes to posts in our deer fence.

We harvested the hop cones on September 25 and dried them naturally for approximately 2 weeks. Harvested cones are sufficiently dry when springy to the touch and the yellow lupulin powder easily falls out.

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.

Results

Results of hop performance recorded on May 25, July 14 and September 25 (harvest) are provided in Table 2.

While in their first year many of our plants did not muster much more than 4' of growth, we suspect that they were investing energy establishing roots rather than above-ground vegetative growth. The research we did prior to planting suggested that in prime hop growing areas, mature hop bines can yield from 1 to 3 lb of dry cones per bine. In 2009, we harvested cones from two varieties, 'Cascade' and 'Nugget.' Each variety produced four cups of bines after drying.

Due to the low volume harvest, we air-dried the hops rather than using a commercial dryer. Dried hops must be stored in an airtight container in the freezer. Brewing tests have not occurred yet.

Management Tips

1. When the young vines are about 1' long, select two to six vigorous vines and remove the rest. Train one to three vines clockwise on the trellis. Lateral side arms extend from the main vine and produce flowers. The main concern is to support the vines 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 promote air circulation and reduce disease. This trimming is critical in years where the summers are cool and moist when fungal disease such as mildew and blight can be a problem. After pruning, allow additional bottom growth to remain to promote hardiness of the crown and plant vigor for next year.

3. At the end of the season, you can bury healthy bottom vines for propagating new plants next spring. Simply bury the vines in a shallow trench and mark their location. In spring, dig them up and cut them into 4" pieces. Make sure each new cutting has a node 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

Project Location

From Brainerd, travel south on Business MN-371. Turn left on CR 21/St. Mathias Rd. and travel about 3 miles.

Other Resources

Carter, P.R., E.A. Oelke, A.R. Kaminski, C.V. Hanson, S.M. Combs, J.D. Doll, G.L. Worf, and E.S. Oplinger. 1990. Hop. *In* Alternative Field Crops Manual. University of Wisconsin/University of Minnesota. Website: *www.hort.purdue.edu/newcrop/afcm/hop.html*

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National Agriculture Statistics Service. 2010. QuickStats: Hops. United States Department of Agriculture. *http://quickstats.nass.usda.gov*

Introducing Cold-hardy Kiwifruit to Minnesota

Principal Investigators

James Luby
University of MN
Department of Horticultural Science
1970 Folwell Ave.
342 Alderman Hall
St. Paul, MN 55108
612-624-3453
Lubyx001@umn.edu
Project sites are in Hennepin County

Robert Guthrie
University of MN
Volunteer Actinidia Curator
1810 Alameda St.
Roseville, MN 55113
651-488-7122
bobguthrie@comcast.net

Eric Theship-Rosales
9201 Audubon Rd.
Chanhassen, MN 55317
952-361-9691
Kathleenandsig@earthlink.net

Project Duration

2007 to 2010

Award Amount

$7,943.00

Staff Contact

Meg Moynihan
651-201-6616

Keywords

cold-hardy, kiwi, kiwifruit, orchard, pergola, trellis

Project Summary

The goal of this project is to introduce Minnesota growers to kiwifruit and provide them with information about the culture and management of growing this tasty and nutritious cold-hardy crop using two trellising approaches, pergola and T-bar, that prevent soil erosion, conserve soil moisture, and integrate natural biological measures. Articles in previous editions of the *Greenbook* described our activities in year one and year two of the project. This article provides the information about how to build a pergola system for kiwifruit or grapes.

Project Description

Cold-hardy kiwifruit is a deciduous vine that produces small, delicious, smooth-skinned berries and deserves greater attention in Minnesota. Kiwifruit are native to eastern Asia; there are about 70 different kiwifruit species. The most cold-hardy is *Actinidia kolomikta*, sometimes referred to as "Arctic Beauty" due to its colorful tri-color leaves. Native to Siberia, this particular species performs well throughout Minnesota when its cultural considerations are met. *A. arguta*, another species of merit, has a more vigorous growth habit, is sun-tolerant, and can be grown in southern Minnesota where winter temperatures are not expected to fall below -23°F. Kiwifruit prefers well-drained, silty soil that contains ample organic matter and retains moisture. The plants perform best in a partially shaded and sheltered location that provides protection from both late afternoon winter sun and strong summer winds. Generally the east side of a windbreak will satisfy the shade and wind protection conditions, but shallow tree roots may compete for soil moisture and nutrients during the growing season. The site should also have good air movement to avoid damaging frost pockets.

The University of Minnesota Horticultural Research Center (HRC) in Victoria, MN has been growing cold-hardy kiwifruit on a T-bar trellis since 1988 (Figure 1). However, for cold-hardy kiwifruit production, a pergola (horizontal trellis) structure offers several advantages over a T-bar (for kiwifruit and other vining fruit like grapes) including reduced vine stress, suckering, and weed growth because of the self-shading effect of the vegetative canopy. Other advantages include improved fruit appearance (due to less wind rub of skin), ease of harvest (the berries are easier to pick), ability to accommodate hilly terrain, and a cooler place to work on hot summer days.

[1]*Trellis system illustration used with permission of the Oregon State University Extension Service from page 10 (figure 1-A) of publication PNW 507, Growing Kiwifruit (reprinted April, 2005, Corvallis).*

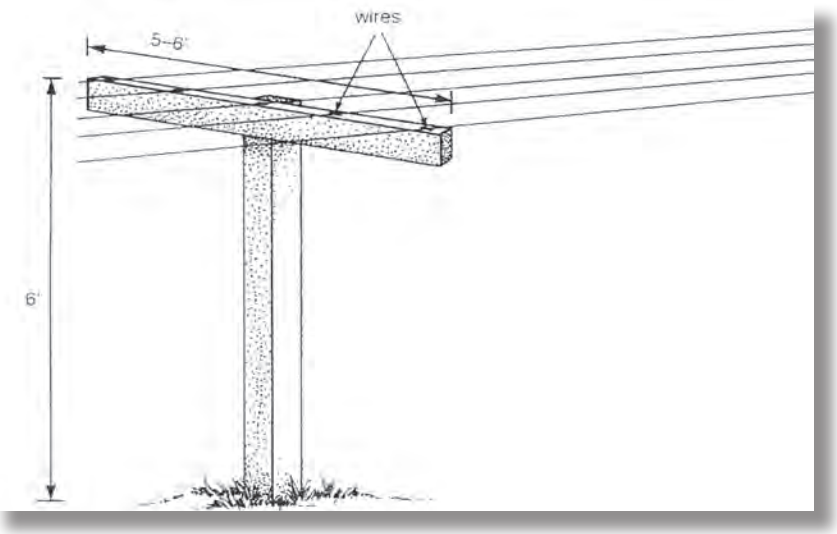
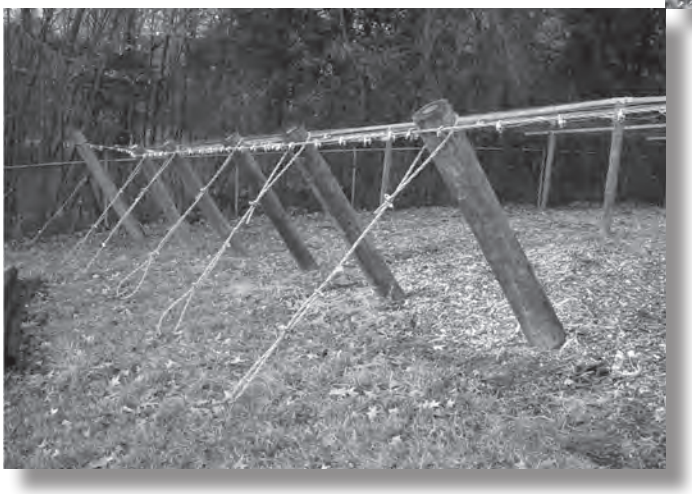


Figure 1. Standard T-bar trellis system for kiwifruit.[1]

Figure 2. The north-south pergola at the HRC runs along a hillside.

Figure 3. One 12' corner post and five 10' end posts (L to R). The posts are held in position using earth-anchor tie backs set opposite of the direction of pull.



For part of this project, we constructed a demonstration pergola at the HRC. Little information about how to construct a pergola is available, so we are including a large amount of technical information in this article. In 2009 dollars, the estimated material cost on a per acre basis was approximately $15,000.

A second part of this project was led by farmer-cooperator, Eric Theship-Rosales, who is constructing terraces and using trees as supports for kiwifruit on his steep acreage. His work is described toward the end of this article.

HRC Site Overview

The pergola trellis at the HRC is oriented north-south and measures 48' wide by 250' long. However, dimensions can be readily adjusted to accommodate available space. (One of the project partner's wooden-framed pergola in his backyard measures 12' x 75'.) At the HRC, more than 2 miles of high-tensile wire is strung across the top of the structure to support vine growth. The wires are fastened to steel cross-bars that are supported by wooden posts. At each end of the pergola, the wires are fastened to braided-steel cable that is secured to end posts and corner posts. Cables attached to earth anchors serve as a counter to the direction of pull when the high-tensile wires are tensioned (Figure 2).

Site Preparation

Prior to construction, we spread woodchips across the orchard site to serve as a mulch that would help retain soil moisture, moderate soil temperature, prevent soil erosion, promote root development, and effectively impede weed growth. Spreading this mulch *before* the posts were installed made uniform distribution much easier. A 4" layer of woodchips will typically last for 3 to 4 years before it needs to be replenished. When transplanting vines, scrape away the mulch before digging in order to avoid mixing the woodchips into the soil; otherwise the high carbon woodchips could scavenge nitrogen from the soil as they naturally decompose, creating a nitrogen deficiency for the vines.

Post and Cross-bar Installation

The HRC pergola structure runs parallel to a chain-link fence, which we used as a baseline for post installation. To ensure that layout was square, we measured the diagonal corner-to-corner distances with a tape. Once we were satisfied with the alignment, we used wire survey flags to mark the locations of the posts.

We spaced 45 10' x 5" pressure treated, round, wooden support posts 15' apart down the row and 21' apart (for cross-bar support). We installed these posts to a depth of 42" first using a hand auger to make a vertical pilot hole then using a scissor-type post-hole digger to enlarge the hole.[2] We marked the 42" depth on the shafts of both of the excavation tools with bright-colored tape. To keep the soil from sticking to the metal and to make digging easier, we periodically dipped both the auger bucket and post-hole digger clam shells in a bucket containing vegetable oil. We used a nylon toilet brush to quickly remove any soil that adhered to the steel between dippings.

[2] A scissor-type post-hole digger is hinged in the middle of the tool rather than at its base and produces a vertical hole, rather than one that is conically flared toward the ground surface.

Once the holes were dug, we dropped the tapered end of the post into the hole and used a level to make sure the post was vertical. We scraped some soil back into the hole and mounded up the remainder around the base of the post to further settle in around the post after rainfall events.

At each end of the pergola, we installed two round corner posts (12' x 12") and five 12' x 10" round end posts (one at the end of each row). We set these posts 4.5' deep using an auger mounted to a skidsteer. The holes were angled at about 75° (or 15° from vertical), leaning away from the pergola (Figure 3). We planted seven rows of kiwifruit beneath the pergola, spacing the end posts 7' apart.

Steel Cross-bars and Joiner Sleeves
After we set the internal posts, we notched them and installed 30 cross-bars. These were 24' x 1.5" x 2" rectangular 14-gauge galvanized steel tubes that we connected with 16" x 2" x 3" rectangular 14-gauge galvanized steel joiners (Figure 4). We used steel because it is structurally stronger than wood and will not readily deteriorate with age. We made adjustments necessary to compensate for the fact that we were building on a slope. Because treated wood can be highly corrosive to galvanized steel, we placed an adhesive membrane (ProtectoWrap) across the notch so the wood was not in direct contact with the metal. We used inverted U-shaped steel brackets and stainless steel screws to secure and stabilize the cross bars.

Steel Cable and Earth Anchor Tie Backs
We used 0.75" diameter braided steel (remnants from high tension cable median barriers that the Minnesota Department of Transportation uses on roadways) from a supplier who cut the cable to specified lengths. This cutting was very helpful, as the cable is quite stiff. Double-wrapping it around the corner posts proved challenging. We used a specialized clamp to hold the cable while it was tensioned by a ratcheting come-along, then we secured it with large fencing staples. We wrapped tie-back cables used to counter around the post and then tensioned and secured the cables to 4' earth anchors. All cables were double-clamped using two 5/8" cable clamps for each cable-loop. The earth anchors had been screwed into the ground and positioned so that the connecting cable would extend approximately 45° relative to the long-axis of the post (Figure 5).

High-tensile Wire
We used a spinning jenny to spool out 48 strands (totaling more than 12,000') of 12.5-gauge, high-tensile, Type 3 galvanized steel wire. The spinning jenny holds and unspools the wire coil to prevent it from kinking. The

Figure 4. A joiner sleeve connects the 24' sections of galvanized tubular steel and is clamped to a notched support post. A specialized membrane prevents the steel and clamp from coming in direct contact with the wood. The overhead high-tensile wires are secured in place using nylon clips secured here to the joiner.

Figure 5. Two earth-anchor tiebacks stabilize each corner post and prevent it from shifting when the high-tensile wires are tensioned. Each cable is double-clamped to nearly eliminate the potential for slippage.

Figure 6. A short wire loop connects the wire to the braided-steel support cable. The wire strainers enable the high-tensile wire to be tightened or loosened. The 5/8" cable clamps keep the wire loop from slipping across the cable as tension is applied to the wire.

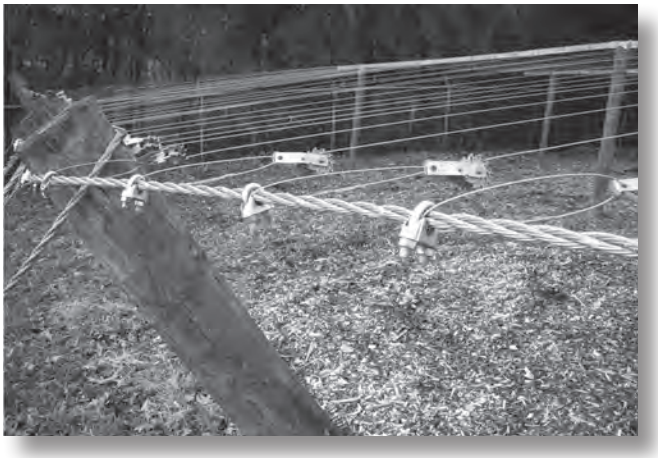


Figure 7. The kiwifruit plants growing under their new pergola at the HRC.

wires crossed the top of the cross-bars. The wire was looped around and secured using crimping sleeves and fastened to a small loop of high-tensile wire using wire-strainers. We found it helpful to use paint crayons to mark the positions of each wire loop/wire strainer combination before it was secured to the cable. Where the high-tensile wire groups crossed the steel cross-bars, we secured them with specialized nylon clips. Similarly, a special nylon clip snaps onto the high-tensile wire to keep the vine's support stake in position.

The 48 wire runs were mostly spaced about 15" to 16". Over the kiwifruit, we spaced them about 8" apart to allow for a higher planting density within the rows. This kind of layout will enable us to grow up to 500 vines on the HRC pergola. However, this double-planting approach also has potential benefits for the home or commercial growers, as the vine density can be doubled to increase fruit production in the first few years after planting. Once the vines are established and the vines are approaching full-production, some of the plants can be removed.

We held a field day in August 2009. Our press releases captured the media's attention and generated coverage in newspapers, on radio and television, and on all these media outlets' websites. Nearly 50 people attended the event, where they learned about growing cold-hardy kiwifruit, tasted some of the fruits, and saw various trellising alternatives, including the pergola. There has been considerable follow up interest since the event. The information we distributed at the field day is available on the web at *http://fruit.cfans.umn.edu/Kiwifruit/index.htm*

Terracing Kiwi

Not far away from the HRC, another method of growing cold-hardy kiwifruit is taking shape. Eric Theship-Rosales is a master shipwright and has applied these skills as he develops a kiwifruit orchard at his farm. Eric's Chanhassen orchard is located on a steep northeast-facing hillside, which is nearly ideal for kiwifruit, as it naturally shields the vines from the prevailing southwest winds during the growing season, offers good air drainage, and protects the trunks from winter sunscald injury.

Although the hillside is steep, Eric has diminished the potential for soil erosion by building 20 irrigated, 1.5' high steps, or terraces. The terraces are about 4' wide and range in length from 40' to 140'. The result is something that resembles an outdoor amphitheatre!

He has also planned an ingenious training system for the vines in his orchard. Rather than using pressure-treated wooden posts for the vine support structure, Eric is growing trees and has devised a specialized collar that will fit around the trunk and accommodate additional growth. Trellising wire will run from tree collar to tree collar, spanning the length of each terrace. At a field day in August, Eric showed visitors an elaborate, three-dimensional foam-board model that explained his orchard layout (Figure 9).

Eric has planted 300 kiwifruit vines and plans to add 500 more. He is top dressing the plants with compost to increase the amount of available organic matter and using woodchip mulch to help retain soil moisture and reduce weed competition.

Survival of newly planted vines was quite high – over 95%. Eric is growing the two cold-hardy species described at the beginning of this article, *A. kolomkita* and *A. arguta*. He is testing several other varieties as well, in order to determine which consistently performs best in his orchard. Once this is known, he would like to have two 1-acre blocks in production.

Figure 8. At our field day, visitors saw the newly-constructed pergola structure and tasted various varieties of kiwifruits.

Figure 9. Eric constructed an elaborate model of his kiwi orchard.

Predation by deer during the growing season and by rabbits in the winter has been problematic because young vines are particularly vulnerable to this type of damage. However, according to Eric, the local deer population appears to be dwindling with increased urban encroachment, and he is constructing individual wire cages to prevent rabbit injury.

Eric is in the process of standardizing his irrigation system and is doing some experimentation with the tree-wire-ground connections. He plans to continue growing cold-hardy kiwifruit and hopes to plant an additional 300 vines in 2010. He really likes the crop because the berries are quite delicious and he believes that kiwifruit will prove valuable to farmers and consumers in the not too distant future. He also thinks that the terraced-hillside growing of cold-hardy kiwifruit might bring land considered marginal or unsuitable for most other crops into production in a commercially-viable manner. Eric is really looking forward to harvesting and marketing his first crop so that others can enjoy this wonderful tasting and highly nutritious berry.

Summary

Cold-hardy kiwifruit growing in Minnesota has a promising future. For those interested in learning more about this niche-market crop, please feel free to contact project cooperators Eric Theship-Rosales, Bob Guthrie, or Jim Luby.

Management Tips

1. For kiwifruit, choose a partially shaded, sheltered location with rich, well drained but moisture retentive soil that is neutral or slightly acid in pH. Gentle north and east facing slopes are preferred, as are woodlots, windbreaks, or shelter belts that will provide shelter from strong winds.

2. Round posts are structurally stronger and cost less than square posts.

3. To keep soil from sticking while digging post holes, occasionally dip tools in vegetable oil.

4. If using trees as trellising posts, make sure the collar (that the trellising wire attaches to) doesn't damage the tree and can accommodate the tree as it grows in diameter.

Project Location

The HRC site is located in Victoria, MN near the Minnesota Landscape Arboretum. Travel 0.3 miles northwest of the intersection of MN State Hwy. 5 and Rolling Acres Rd.

The Theship-Rosales farm is located about 4 miles south and east of the Minnesota Landscape Arboretum on Audubon Rd., approximately 1 mile south of MN State Hwy. 5.

Other Resources

Growing kiwifruit. 1995. Oregon State University. Available at: *http://extension.oregonstate.edu/catalog/pdf/pnw/pnw507.pdf*

How to build fences with USS Max-10 200 high-tensile fence wire. 1980. United States Steel, Pittsburgh, PA, 75 pp. (Out of print but some of the information it contains is available at: *www.kencove.com/Guide.php*)

Kiwifruit Web Page. University of Minnesota. *http://fruit.cfans.umn.edu/Kiwifruit/index.htm*

Growing the Goji Berry in Minnesota

Principal Investigators

Koua Vang and
Cingie Kong
7862 – 465th St.
Harris, MN 55032
651-387-9246
tuajncigntuj@yahoo.com
Chisago County

Project Duration

2008 to 2009

Award Amount

$17,487.00

Staff Contact

Jean Ciborowski
651-201-6217

Keywords

goji berry, raspberry

Project Summary

In 2008, we started a goji berry patch on our farm in east-central Minnesota to determine if gojis can be a viable crop in Minnesota. We started all the plants from seed in the greenhouse then transplanted the vines. Although they grew rapidly and set fruit the first year, the seedlings showed too much variability in plant height and fruit quality. Most of the plants came through the cold winter of 2008-2009 with little or no winter injury. During the summer of 2009 the plantings were hit with a leaf disease, which destroyed the crop.

Project Description

Goji berries (*Lycium barbarum* L.) are a small fruit native to the mountainous regions of western China to Mongolia. Other names for goji berries include wolfberries, lycium berries, and matrimony vine. Goji plants are perennial vines, similar to climbing nightshade or woody nightshade. Goji plants produce red, oblong fruit with a unique, sweet flavor.

Worldwide, most goji berries are grown in the mountainous areas of northwestern China, where annual production exceeds 5 million kg/year. In the U.S., there are small fields in Utah and Iowa, but this crop has not been tested in Minnesota. Currently there is little reliable information on varieties, yields, or climate requirements for growing goji berries in the U.S. Ningxia, an autonomous province of China, is the leading producer of goji berries and has a continental climate with midwinter temperatures that often fall below -25ºF.

In order for a new crop to be commercially viable, it must have the following characteristics:

1. The plant must be hardy enough to survive zone 4 winters.
2. The fruit must be able to mature in our relatively short summers.
3. The plant must be resistant to common diseases.
4. The fruit must be good enough quality to attract new customers.
5. Yields must be high enough to be economically viable.

We bought goji seed from Fountain of Youth Goji Vineyard in Winterset, IA and from Timpanogos Nursery in Utah and planted the seeds in the greenhouse in early April, 2008. The vines grew rapidly in the greenhouse, reaching lengths of 1' or more within a month. We transplanted 600 seedlings on May 31, 2008 on a 4' by 6' spacing. Our farm near Harris, MN has a loamy sand soil. The plants were enclosed by a 4' high fence with chicken wire to keep rabbits and other pests away from the goji plants. Weeds were controlled by hoeing and all watering was done by hand. In the middle of summer, we tied all the plants to wooden stakes. In the fall, we mulched the plants with woodchips.

Goji flower and green fruit.

Results

The plants grew extremely well the first year, and some vines had over 7'of growth by the end of the first growing season. The fence proved to be critical because we placed a few plants outside the fence, and all the plants outside the fence were eaten by rabbits.

The winter of 2008-2009 was a test winter for many perennial plants. The temperature dropped to -27°F twice during the month of January. The goji plants came through a zone 4 winter with very little winter injury. The tips of the branches died on most plants, which is similar to grape vines or some raspberries. About one-fourth of the plants had severe winter injury and died either to snow level or died completely, but on most plants the only injury was the tips dying back a few inches.

In early June, many goji plants were healthy and growing rapidly, but in July, the plants were hit hard with a leaf blight. According to the University of Minnesota Plant Disease Clinic, the disease was caused by Alternaria fungi, which means that the disease probably was the same as early blight in tomatoes. Goji berries are closely related to tomatoes and peppers, and the disease could have spread from the tomatoes to the goji plants. Most goji plants were partially defoliated by the leaf blight, but a few seedlings showed some resistance. By early fall, many plants started to recover.

The leaf blight destroyed the fruit crop for this year. By September, the plants that recovered from the blight formed new leaves, but it was too late for the plants to start forming flower buds and ripening fruit. A few plants were setting fruit as the first hard frosts were starting in late September.

Most woody plants initiate flower buds from the middle of summer through late fall, and the buds stay dormant until the following spring when the plant blooms over a short period. By contrast, gojis appear to set fruit on new growth. The plant blooms throughout late summer, and fruit ripens over a long period, similar to an indeterminant tomato plant or a day neutral strawberry. From our experience, it appears that flower bud formation occurs when the plants are forming new leaves, with the flower buds emerging from the nodes just below the leaf. After forming fruit, the plant often forms a sharp spine. At no one time do gojis produce a large quantity of fruit, but they could have high yields if they bloomed and ripened fruit over a 2 month period. If goji plants are going to produce enough fruit to become commercially viable, we will have to find varieties that bloom from early summer so that berries can be picked over a 2 month period. Most likely, the low yields in 2009 were caused by the stunting resulting from loss of leaves from blight.

The fruit quality varied considerably among the seedlings. A few seedlings had small, yellow fruit that was bitter. Other plants had fruit that was nearly .75" long, with a deep orange color and excellent flavor.

The extreme genetic diversity of our seedlings kept our goji planting from being commercially viable. About half of the seedlings were inadequate either from winter injury or slow growth, which meant that only half the plants were vigorous enough to produce a crop before the summer leaf blight. Among the plants that produced fruit, many had fruit that was too small or too bitter to be sold. Only about one-fourth of all of the plants had growth rates and fruit set that were high enough to be commercially viable.

Management Tips

1. Goji berries are susceptible to the same leaf diseases as tomatoes, and those diseases can easily destroy the crop. Diseases should be controlled with either fungicides or resistant varieties.

2. Although goji berries are easy to start by seed, an orchard of goji plants started from seed is not commercially viable. Goji seedlings showed far too much variability in growth rates, winter injury, and fruit quality, and the planting was not nearly uniform enough.

3. In order for goji berries to become economically viable, we must find varieties suited for the Minnesota climate.

Project Cooperator

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

Project Location

We are 2 miles north of Harris, MN on Forest Blvd. (Hwy. 30). Take a right turn on 465th St. and we are the last house at the end of the street on the left hand side.

Other Resources

Dharmananda, Subhuti. Lycium Fruit: Food and Medicine. 2007. Website: *www.itmonline.org/arts/lycium.htm*

Fountain of Youth Goji Vineyard, Winterset, Iowa. Website: *www.fountainofyouth-gojiseed.com*

Timpanogos Nursery specializes in goji berry production and is located in the Rocky Mountains of Utah. Website: *www.timpanogosnursery.com*

Environmentally and Economically Sound Ways to Improve Low Phosphorus Levels in Various Cropping Systems Including Organic with or without Livestock Enterprises

Principal Investigator

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

Project Duration

2006 to 2009

Award Amount

$10,720.00

Staff Contact

Mark Zumwinkle
651-201-6240

Keywords

manure, organic farming, rock phosphate

Project Summary

The primary goal of this project is to seek viable alternative sources of phosphorus for farm operations where animal manures are not available or where commercial NPK fertilizers are not an option. Many organic farmers and others contemplating a transition to organic production do not have livestock and, consequently, do not have access to approved, readily available sources of phosphorus that are affordable.

The land included in the project has not been manured for over 40 years and has now completed transitioning to organic production. Yields have been diminishing steadily over the last 5 years, even with the abundant use of legumes, both as cash crops and as cover crops. The project is located a significant distance from any animal manure source. If we can begin to show how the organically approved sources of phosphorus impact yield and raise the phosphorus levels in fields without the use of animal manures, we can provide more opportunities for farmers without animals to transition to organic production. We can also become more creative in our crop rotations with improved soil phosphorus levels.

Project Description

Over time, it is becoming increasingly evident that many organic producers without livestock on their farms are facing phosphorus shortages in their fields. This can be explained in part due to the growing trend in the use of alfalfa as a cash crop in organic systems.

For non-livestock producers, alfalfa is an excellent tool for weed management. For example, inclusion of alfalfa in the rotation helps control Canada thistle. Alfalfa is also a well known soil building crop.

The cropping systems on my farm are a constantly evolving and complex rotation of corn, soybeans, oats, winter wheat, barley, flax, dried field peas, and alfalfa. Presently, I have no livestock. However, I do have access to hog manure from a neighbor who is renting one of my buildings to finish hogs.

Our farmland is gently rolling with some terraces and a fair amount of tile drainage. Our soils are primarily silty clay loam which allows me to use most conventional equipment to do my field work. The farm consists of about 400 acres, 350 which are tillable. This size operation, using the diverse crop rotation, assures me that I can accomplish most of the work by myself especially given the fact that the crop rotation provides an evenly spread workload over most of the growing season.

The inspiration for this project came from extensive soil testing of a troubled field in the fall of 2006. For several years, production in this field dwindled. My primary complaint about the field was poor productivity. There was also inconsistent crop performance across the field. The soil samples were taken based on crop growth patterns. The soil test results showed very low phosphorus (3 to 5 ppm) uniformly across the entire field. These levels are low enough to easily explain the low crop productivity. The soil tests also showed a dramatic variation in pH. It is commonly known in the soil science

community that soil pH is very influential in phosphorus availability to plants. What is unique about this site is that it has a range of pH values from slightly acidic (6.5) to strongly alkaline (8.3) all within the same field.

After consulting with several researchers and crop specialists, I decided the only two options available to me as an organic grower were animal manures and raw phosphate. In the fall of 2007, we applied two types of raw phosphate at a rate of 400 lb/A on GPS marked areas of the field and hog manure at a rate of 10,000 gal/A on a third area to begin the demonstration.

This project will allow us to assess the effectiveness of two different types of rock phosphate minerals, one originating in the southeast part of the U.S. and the other originating in the northwest part of the U.S. against one manure source (hog manure). It will help us to determine how these different phosphorus sources will affect crop production across a wide range of soil pH levels and which should be used where.

Results

Soil tests are being taken each fall on the GPS marked areas throughout the field to match the test results from year to year. Manure is being analyzed along with application rates. We are taking yields and tissue samples from the growing crops to determine the effect of the three phosphorus amendments.

2007

Preliminary results after the first year showed very little movement in the soil test phosphorus levels. However, it is my intention to continue the project for another two growing seasons to fully determine any change in phosphorus availability.

The dried field peas planted in the phosphorus treated areas yielded 10 bu/A. Part of this low yield can be attributed to the low soil phosphorus levels. A very hot spell right at blossom time also significantly curtailed the yield. As a result, our yield data is not directly correlated to the phosphorus issue. Alfalfa yielded 2.9 tons/A from four cuttings. A very hot and dry spell in late July and early August impacted the third cutting significantly. However, a wetter late August and early September contributed to a good fourth cutting.

As I mentioned above, phosphorus levels across the field have moved very little over the past growing season. Consequently, we have applied an additional 4,000 gallons of hog manure on the alfalfa area of the field and have left the remainder of the area without any additional applications of raw phosphate.

I will be working with my crop consultant to better analyze what may or may not be going on regarding the phosphorus. In 2008, I am seriously considering planting a strip of buckwheat diagonally across the phosphorus treatments after taking the oats crop off to see if this may be an additional and more economical practice to free up phosphorus. I think this would be an appropriate action to take seeing as this is a demonstration grant and not a strict research project.

2008

At this point in time, I am quite puzzled at the results of the soil tests over the last 2 years. I was hoping to see a lowering of the soil pH and an increase in the levels of available phosphorus over time. However, neither activity is occurring. I am especially concerned about the phosphorus levels. Some fields have received 15,000 gal/A of hog slurry over a 2 year period without any significant change in available phosphorus.

This points to several research questions for further study:

1. Does heavy application of liquid hog manure significantly impact available phosphorus levels in the soil especially where there are higher pH levels?

2. Do different manure types and sources impact soil phosphorus in different ways?

3. Are there other ways to positively impact both soil pH and available phosphorus other than commercial NPK applications?

There is a subset study that I am keeping track of. In the fall of 2007, I installed a significant pattern tile drainage system in areas with high soil test pH levels. I will be following future soil tests to see if this installation begins to impact the soil pH in these areas and not in other areas and, if so, to what extent.

Again, let me emphasize that the information I am seeking relates to practices that are acceptable in organic management systems. At this stage of the project I am not certain I can offer any answers. I am hoping the third year will really start to show some significant results. Following the third year of the study, I am hoping to continue the study with a more concerted effort in tracking the impact of cover crop legumes and buckwheat on various soil quality traits.

Given the information gathered so far, I think that more intensive scientific research is needed. The goal of maintaining or building phosphorus levels in organic systems that have not had access to livestock manures may be more difficult than first thought.

2009

We had significant rain in September and October, causing the tile system to run extensively. I have just recently taken fall, 2009 soil samples and water samples from the tile in the field to see if there may be any leaching out of the salts that are responsible for the high soil pH. The samples will be analyzed and made available next year.

This year we decided to add composted chicken litter as a soil amendment due to its high phosphorus content.

The results of the soil phosphorus tests from spring of 2009 show not only the available phosphorus levels, but also the total phosphorus present in the soil but not available to the plant (Table 1).

Table 1. Spring, 2009 soil phosphorus levels.

Sample	pH	Soil Test P	Total Extractable P
1	7.8	6	560
2	7.8	5	470
3	7.4	20	619
4	7.8	6	608
5	7.6	6	521
6	7.7	5	492

A soil test phosphorus level of 15 is considered to be sufficient. In other words, any further addition of phosphorus would not increase crop yield. Only Field #3 had sufficient available phosphorus. It also had the lowest pH. This is to be expected. The calcium present in the higher pH soils ties up the phosphorus. The final column in Table 1 shows that all the fields tested have a large reserve of total phosphorus.

As in the previous 2 years, the application of rock phosphorus and manure did not result in an increase in soil test phosphorus. At this stage of the project, I am very skeptical about the use of raw phosphorus as a fix for low phosphorus availability.

Weather did impact the field in, hopefully, a positive way. The heavy fall rains likely leached a substantial amount of salts from the soil. It is likely that measurable effects from the newly installed tile will not show up for 3 to 4 years.

In 2010, the field will be planted to small grain underseeded to alfalfa. I will keep the alfalfa in as a cash crop for the following 3 years in hopes that the deep root penetration will loosen and aerate the soil. A well drained, well aerated soil should encourage increased microbial activity and lower the pH.

I am hoping to begin to see some changes due to the tile drainage. If this actually happens, we may be moving in the right direction for correcting high soil pH levels and thus making more P available on farms without livestock, both conventional and organic.

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.

Other Resources

ATTRA – National Sustainable Agriculture Information Service. 2001. Alternative Soil Amendments. Available at: *attra.ncat.org/attra-pub/PDF/altsoil.pdf*

Brady, Nyle C. and Ray R. Weil. 2000. Elements of the Nature and Properties of Soils. Prentice Hall, New Jersey. Pp. 391-411. Refer to p. 398, Figure 13.5 (the phosphorus cycle in soils).

Evaluation of the Potential of Hybrid Willow as a Sustainable Biomass Energy Alternative in West Central Minnesota

Principal Investigator

Diomides S. Zamora
Assistant Extension Professor
University of Minnesota Extension
322 Laurel St.
Ste. 21
Brainerd, MN
56401
218-828-2332

Project Duration

2007 to 2009

Staff Contact

Mark Zumwinkle

Award Amount

$6500.00

Keywords

biomass energy, carbon sequestration, hybrid willow, phytoremediation, renewable energy

Project Summary

The overall objective of this project is to evaluate the potential of hybrid willow as an alternative energy crop for west central Minnesota. Willow offers economic and ecological potential for landowners. It serves as a bio-energy crop that has potential market value because of the increasing demand by biomass burning plants for bio-energy production. The ecological benefits of planting willow include improved wildlife habitat, improved water quality, and carbon sequestration. Specifically, this project is being conducted to:

- determine the hardiness of willow varieties from New York and compare them to the local or native varieties of willow growing in the Wadena County area;
- establish demonstration trials that can be used to guide future research and development in Minnesota; and
- provide a western Minnesota clonal trial to compare to similar plantings in Martin and St. Louis counties.

Project Description

Renewable sources of energy are becoming more important as the state strives toward independence from fossil fuel energy. Woody biomass offers an important option for the production of biomass for energy. Short rotation woody crops like willow provide both economic and ecological benefits.

Markets for biomass are developing in this region of the state. For instance, the Central Minnesota Ethanol Cooperative in Little Falls, MN has recently shifted its focus toward using biomass as a heat source in their boiler system for ethanol production. Further, the Chippewa Valley Ethanol Cooperative and the University of Minnesota at Morris have modified their boiler systems to accommodate wood biomass for heat and ethanol production. Willows are an appropriate option in this situation and can turn a profit in 3 to 4 years. Willows excel in various environments. Hybrid willows have proven to be a very high yielder of biomass in New York and surrounding states.

Willow cuttings ready for transplanting.

Willows are often planted along riverbanks at the edge of row crop fields to prevent erosion while improving water quality. In west central Minnesota, high levels of nitrate in soil water exist due to intensive agricultural production. Willows provide a perennial system that utilizes excess nitrate before it reaches surface or ground water (a process called phytoremediation). If planted in sites vulnerable to erosion and leaching, a willow biomass crop can provide a source of income for landowners while realizing these ecological benefits. Willows are also used to sequester carbon in other parts of the county. Our research trials could serve as a carbon sequestration pilot project in Wadena County in the future.

This project was conducted as a partnership among Minnesota farmer/landowners, researchers at the University of Minnesota Extension, the Center for Integrated Natural Resources and Agricultural Management (CINRAM) of the University of Minnesota, and the State University of New York. The 4 acre project is located at a farm in North Germany Township in Wadena County. The farmer owns 240 acres of land in the area.

Table 1 lists the willow varieties planted in Wadena. To compare willow production with hybrid poplar at the end of the project, we also set up four plots of hybrid poplar (NM6 variety) using 5'x 10' plant spacing.

In addition to hybrid willow cuttings from New York, we also included three native willow varieties growing in Wadena County in our experimental design (Figure 1). This design allowed us to compare biomass production and performance of hybrid willows to that of native willows in Minnesota. Overall, there are 11 willow species/varieties being tested in our experiment.

Table 1. Varieties used in planting trials.

SV1	*Salix dasyclados*
SX 64	*Salix miyabeana*
S25	*Salix eriocephala*
Fc185 (94001)	*Salix purpurea*
9882-34	*Salix purpurea*
9879	*Salix purpurea x S. miyabeana*
9871-31	*Salix sachalinensis x S. miyabeana*
SX 61	*Salix sachalinensis*
Black Willow	*Salix nigra*
Laurel Willow	*Salix pendantra*
Sandbar Willow	*Salix sessilifolia*

Results

Efforts were made to get the project going in the spring of 2007, including land preparation for planting by the farmer. Activities included tilling the soil and application of Roundup™ herbicide. However, planting stock was not available from New York, causing a 1 year delay in implementing the project. In late May of 2008, willow cuttings were received from State University of New York and cuttings were planted immediately to avoid their drying out. Also, in May 2008, we received cuttings of native Minnesota willow from Lincoln Oak Nursery. Two years in a row our farmer cooperator prepared the land intensively in order to have a weed-free environment. Willow plants survive well in areas without weeds.

Willow survival was measured twice during the first year of establishment. Measurements were taken 1 month after planting the willows, and again at the end of the first growing season. The first survival count ranged from 61.8% to 98.9%. However, the survival rate significantly decreased (ranging from a 2.6% to 52.1% reduction) at the end of the first growing season (Table 2). As a protocol in determining hardiness of willow varieties from New York in Minnesota, survival count was also carried out at the end of the growing season in year 2 (November, 2009). Survival of willow varieties from New York significantly declined in year 2, ranging from 6.2% to 60.5% (Table 3). Based on growth parameters such as survival, the number of stems produced per plant, and the height and diameter, there are at least six varieties from New York that could be grown in west central Minnesota. They include: 9871-31, SX64, 9879, 9882-34, FC185-9400, and SX61 (Table 3). These varieties that performed well in a sandy loam soil in Wadena are also proven to grow well in Martin County of southern Minnesota under clay loam and silty clay loam soils and in St. Louis County in northern Minnesota.

Based on first and second year survival measurements, willow varieties from New York outperformed native willow varieties growing in Minnesota. We observed that willow varieties from New York that could thrive in Minnesota have an average survival rate of 60 to 85%. These varieties could produce an average height of 100-176 cm at the end of the second year growing season. The average stem diameter of willow in our experiment is 10.8 mm (Table 3). However, the highest recorded diameter (on an individual basis) of willow in our experiment was 18 mm. The average number of stems per plant also varies depending on the variety (Table 3). For example, we observed that FC185-94001 willow variety produced at least 15 stems.

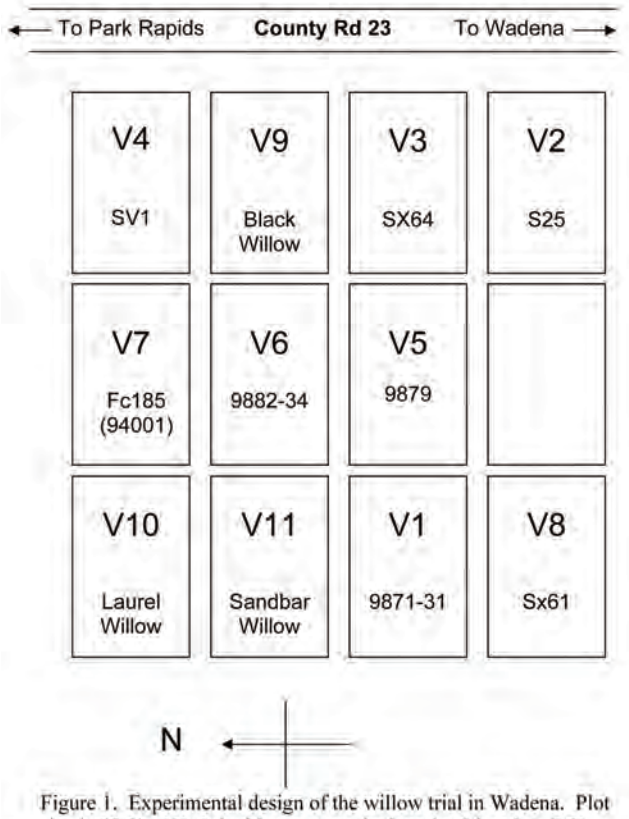


Figure 1. Experimental design of the willow trial in Wadena. Plot size is 22.5'x 35'. 3 double rows run the length of the plot. 2.5' spacing within double rows. 5' spacing between sets of double rows. 16 trees/row x 6 rows = 96 trees/plot. This design is randomized and replicated three times.

In November of 2008, when plants were into their dormant stage, plants were coppiced (cut to the base) at 2" above the top of the stool, and the biomass was collected, dried, and weighed to provide an estimate of biomass production (Table 2). Despite significant reduction of survival rate of native willow varieties, first year biomass production of native willows, particularly black willow and laurel willow was comparable with those of willow varieties from New York. However, due to a 1 year delay in implementing this project, assessment of overall biomass production of willow in our experiment could not be made, as willows are generally harvested on a 3-year cycle. We expect an average biomass production (on a dry basis) of these willows in the range of 10-16 ton/A as observed in the willow trials in Martin County. The 1 year delay of the project prevented us from comparing biomass production of willow with that of hybrid poplar.

There was considerable deer and insect damage. We performed insect and disease surveys focusing on rust and defoliation caused by insects. We found that some of the plants were infected by rust, which is a common problem of *Salix* species.

Table 2. First year survival rate and biomass production of willow plantings.

Variety	Number of Plants Planted	Early Growing Season*	Late Growing Season*	Survival Change (%)	Biomass (kg/ha)
SV1	384	377 (98.2)	360 (98.8)	4.5	40.5
SX 64	384	317 (82.3)	251 (65.4)	20.5	88.6
S25	384	353 (91.9)	230 (59.9)	3.5	38.8
Fc185 (94001)	384	380 (98.9)	338 (88.0)	11.0	61.4
9882-34	384	371 (96.6)	315 (82.0)	15.1	88.1
9879	384	377 (98.4)	321 (83.6)	15.0	35.0
9871-31	384	368 (95.8)	343 (89.3)	6.8	62.1
SX 61	384	377 (82.3)	360 (65.4)	17.1	27.6
Black Willow	384	269 (70.0)	262 (68.2)	2.6	44.0
Laurel Willow	384	340 (88.1*)	312 (81.3)	7.7	121.2
Sandbar Willow	304	188 (61.8)	169 (29.6)	52.1	12.6

**Number in parentheses represents survival rate (%).*

We discovered that, despite the intensive preparation of the land, weeds suddenly grew and affected the willow's growth and survival. In addition, severe drought occurred throughout the duration of the study. We initially employed mechanical weed control by cultivating the soil in between rows of plantings. However, the planting design developed by State University of New York did not allow us to continue cultivating throughout the duration of the study. Instead we hired laborers to manually weed for three days (every year) to clean up the 4 acre site.

Roundup™ was applied in the spring of 2009 before the start of the growing season to minimize weed pressure. However, weeds remained a major issue. To ensure adoption of such a system by farmers, there is a need to revisit the planting design based on the weed control problem we experienced. We learned that the planting design should be based on suitability of equipment employed by our farmer cooperator in doing mechanical weed control.

Future work should include the use of cover crops for planting between rows of willow. If proven to be effective, cover crops could serve as a weed suppression strategy and would reduce soil erosion especially on sloping terrain.

In Minnesota, there has not been a study conducted on the carbon sequestration potential of a willow biomass system. This demonstration trial could be used as a baseline for such a purpose in the future.

Management Tips

1. Design your willow plantings to facilitate your weed program.

2. Once established, the young willow saplings should be scouted for insects and disease pressure.

3. Coppice the plants at the end of the first year growing season (at the onset of the winter season) to enhance production of biomass through allowing the growth of a number of stems during the next growing season.

4. Continue to monitor the area for weeds so that appropriate actions could be conducted.

Cooperators

Curtis Krelau, Farmer, Wadena, MN
Dean Current, Center for Integrated Natural Resources and Agricultural Management – University of Minnesota, St. Paul, MN
Tim Volk, State University of New York, Syracuse, NY

Table 3. Willow survival rate, height, diameter, and number of stems produced per plant during the second growing season.

Variety	Survival Rate (%)	Height (cm)	Diameter (mm)	Stems/Plant
SV1	39.0	125.1	10.8	4.3
SX 64	85.3	94.7	7.3	3.3
S25	45.3	38.3	6.1	3.3
Fc185 (94001)	53.3	107.8	7.1	4.0
9882-34	62.3	176.8	8.6	5.1
9879	65.7	120.4	7.5	2.9
9871-31	77.7	111.8	8.0	3.7
SX 61	61.3	120.2	7.4	4.3
Black Willow	24.7	73.1	6.6	4.1
Laurel Willow	71.7	80.5	7.3	4.3
Sandbar Willow	15.3	75.5	5.9	2.7

Location

From Vendale, MN, take Cty. Rd. 3 north 13.5 miles to the project site on the left.

Other Resources

Minnesota Department of Agriculture. Greenbook 2008. Testing the potential of hybrid willow as a sustainable biomass energy crop in northern Minnesota, pp. 47-51. St. Paul, MN.

United States Department of Agriculture – Forest Service, Northern Research Station. 2008. Evaluation of the potential of hybrid willow as a sustainable biomass energy alternative crop in northern and west central Minnesota, General Technical Report NRS-P-31, p 74. US Forest Service Northern Research Station, Newtown Square, PA.

Short Rotation Woody Biomass Program. State University of New York – College of Environmental Science and Forestry. Syracuse, NY. Website: *www.esf.edu/willow*

Willow Biomass Producer's Handbook. 2002. State University of New York, Syracuse, NY. Website: *www.esf.edu/willow/pdf/2001%20finalhandbook.pdf*

Diomides displays second year willow growth.

Intercropping within a High Tunnel to Achieve Maximum Production

Principal Investigator

Mark Boen
26060 Cty. Hwy. 18
Fergus Falls, MN
56537
218-736-2563
Otter Tail County

Project Duration

2007 to 2010

Award Amount

$11,165.00

Staff Contact

Mark Zumwinkle
651-201-6240

Keywords

high tunnels, lettuce, onions, tomatoes

Project Summary

For many Minnesota vegetable growers, the growing season is too short! Just when the season's harvest enters the profit zone, cold weather storms in and the party is over. High tunnels provide a wonderful solution to this problem by greatly extending the season. High-value primary crops such as tomatoes, cucumbers, and pole beans have proven to be very lucrative in high tunnels. However, by the time a high tunnel is built, considerable expense is involved. Is there a way to make the high tunnel even more productive and profitable?

High tunnels have not only extended the growing season, they have also created a climate of curiosity. Experiments abound as growers explore many potential ways to get the biggest bang for the buck from each high tunnel. Our question in this investigation is, "What if we add a secondary crop to the primary crop in the high tunnel? Can we squeeze more income out of each row?"

The purpose of this project is to measure the profitability of planting secondary crops along with the primary crops of tomatoes and cucumbers. Generally, secondary crops such as onions, lettuce, radishes, spinach, beets, and carrots are of lesser economic value and would not occupy space alone in a high tunnel as the primary crop. But, if they were planted along with the primary crop, the added income would be a bonus. We also wanted to find out which of the secondary crops would do well in the high tunnel. We learned a lot from our first 2 years of the project and found that some secondary crops do have a place in a high tunnel.

Project Description

We started Bluebird Gardens in 1978 on a few acres of land near Fergus Falls, MN. We began selling vegetables directly to customers from a stand on Main Street in Fergus Falls. As our customer base grew, our operation did as well. We now raise vegetables on 110 acres and have six self-serve vegetable stands in Fergus Falls and the surrounding area.

We built two high tunnels measuring 30' x 96' in the spring of 2006. The high tunnels immediately allowed us to provide our customers with tomatoes and cucumbers over a much longer season. Even though we got a late start planting, we saw such potential that we leveled our old dairy barn in the fall of 2006 and used that land to build the frames

Leaf and romaine lettuce growing at the base of sweet slice cucumbers.

for four more high tunnels along with a starting greenhouse. We are finding that the secondary crops enable us to bring even more crops to our customers earlier in the season.

Results

2007. In each high tunnel, rows were 24" wide with 18" pathways. The primary crop planted in the first high tunnel was Estiva tomatoes. Plants were spaced 18" apart. In row one, we planted D'Avignon radishes on each side of the tomato row. This brand of radish was promoted to do well in high tunnels. The radishes were planted with a walk behind planter. Row two was planted with Tyee spinach in a similar fashion. Row three was planted with Hybrid Sweetness III carrots. Row four had no secondary crop (to serve as the control group). Row five had Walla Walla onion plants planted 4" apart. Row six was planted with Grand Rapids Red Romaine lettuce plants that had been started 4 weeks earlier in the starting greenhouse. They were planted 4" apart. Row seven had hybrid Scarlet Supreme beets. The second high tunnel followed the same pattern except that the primary crop was Tasty Jade cucumbers.

In any experiment, one can expect the unexpected. Often the mistakes provide the best learning. We learned many exciting things that should have a profound effect on next year's profit!

The radishes grew well, but were extremely hot in flavor, almost too hot to sell. The late planting may have been a factor since harvest did not occur until early June. By that time, the outside radishes were ready and had good flavor. Nevertheless, each 96' row produced about $45 worth of radishes.

The Grand Rapids Red Romaine lettuce, planted as transplants, produced very well. Each row grossed $350. Like the radishes, the last lettuce we harvested was very strong in flavor. I personally like it that way but I think we lost some sales due to the strong flavor. Once again, the late planting was a factor. Next year, with the high tunnels already up, planting should occur in late March or early April instead of the second week of May.

Spinach, beets, and carrots were all planted from seed. They germinated very poorly, likely due to the lumpy soil from a wet start. We have learned that the use of transplants maximizes the precious time there is to grow in the high tunnels. The use of lettuce transplants proved that.

The onion plants did poorly compared to the same ones planted outside. We learned from the tour of University of Minnesota high tunnels in late August that we had not applied enough nitrogen. In fact, the professors have found the most common mistake made by high tunnel growers across the state was underestimating the need for fertility. High tunnel production is intense and takes more fertilizer than one might expect. With an earlier start and more nitrogen, the onion plants should perform better next year.

We decided not to use plastic mulch and that decision invited a battle with weeds that never ended. The enormous time we spent weeding wiped out any benefit of secondary cropping. The more painful the lesson, the better it is learned!

In our operation, the high tunnels supply the strong demand for tomatoes in June and July. After that, the outside tomatoes take over. So far, we have planted indeterminate tomatoes. In 2008, we plan to plant determinate varieties in some high tunnels.

2008. The high tunnels again allowed us to provide our customers with tomatoes and cucumbers over a much longer season. The secondary crops enabled us to bring even more crops to our customers earlier in the season.

We are continuing to narrow down the search for the best secondary crops for a high tunnel. This year we considered new crops such as green beans and peppers. We gave the onions one more chance to see if they have a place in the high tunnel. We also tried many varieties of lettuce in an attempt to find ones that carry the best flavor in the midst of the high tunnel heat.

On the outside rows of the tunnels, where there is little space above for trellising, we planted a shorter, determinate tomato, Northern Exposure (Burpee). Plants were spaced 18" apart and Walla Walla onions (Dixondale) were fit 6" apart in the remaining space. We thought onions would do better by the side where it is cooler with more light. In High Tunnel One, we planted Sweeter Yet cucumbers (HPS) a foot apart with Snapper peppers (Rupp) in between the cucumbers but on the side of the row closer to the path. Mountain Spring tomato (Rupp) was the primary crop in High Tunnel Two planted 18" apart. Three Jade green bean plants (Jordan Seeds) were planted halfway between the tomato plants close to the pathway. High Tunnel Three had Early Girl tomatoes (Rupp) with Snapper peppers planted in the same fashion. High Tunnel Four grew Sweet Slice cucumbers (Rupp) with various kinds of romaine lettuce (Johnny's) and spinach (Rupp). In High Tunnel Five, we had Tasty Jade cucumbers (Johnny's) with Jade green beans as the secondary crop. In High Tunnel Six, we planted three rows of TomatoBerry grape tomatoes (Johnny's) and the remaining rows were Cobra tomatoes (Johnny's). Snapper peppers were the secondary crop there.

It seems that spring comes later each year. April of 2008 brought one snowstorm after another right to the end of the month. The cost of emergency heat to keep the plants in the six high tunnels alive in April was a staggering $3,000. Next year I plan to drape clear plastic over the netting posts to make a tent within a tent. This should diminish the cost for emergency heat and enhance the health and earliness of the primary and secondary crops. Having tried the full gamut of emergency heaters, I found the simple propane canister to be the best. It needs no electricity and, unlike the others, doesn't need frequent maintenance.

Last year we learned that we needed more nutrients in the soil with the intense growth that occurs in a high tunnel. So this year we added ten truckloads of a nutrient-rich peat called Dick's Super Soil to the six high tunnels. With that soil, we made raised beds. We also added composted chicken manure pellets to each raised bed.

With the added fertility and improved soil condition, the soil was ready to support growth. Last year, we harvested 200 Tasty Jade cucumbers every other day from the high tunnel. This year, the number grew to over 1,000! We also added plastic mulch to avoid the weed problem we faced last year. We covered the pathways with newspapers topped with a layer of hay.

I have grown vegetables for 31 years and have never experienced such an outpouring of tomatoes and cucumbers from such a small area. The quality of the Mountain Spring and Early Girl tomatoes from the high tunnels was stunning and those varieties will be back next year. The TomatoBerry grape tomatoes, in the unique shape of a strawberry, were highly sought after by our customers. The sparkling, eye popping flavor brought customers back again and again.

The tremendous yield from the primary crop also means much plant growth. This spelled bad news for any secondary crop growing below. The peppers, which started out strong, were soon dwarfed by the primary crops. Since peppers also produce the entire season long, they may not be the ideal secondary crop. The peppers only made $350 per high tunnel. If we hadn't had peppers in the field as well, we would have had a slim year on peppers.

I thought green beans would have been an early crop. Unfortunately, they, too, were caught in the stranglehold of a towering primary crop. Since they weren't strong like our outside beans, they became a tangled mass in the walkway. The energy we spent on beans was not worth the $280 made per high tunnel.

The lettuce was the major success story. The superb quality of the many kinds of lettuce we tried garnered an exciting following of customers. Coastal Star and Nevada, both very similar, make a most beautiful heavy head of romaine! There were no brown or yellow leaves. Once cut, the lettuce was clean (due to the protection of the high tunnel) and ready for market. Each had a crispy, rugged texture making superb eating compared to other limp lettuces. Cherokee, a beautiful red romaine, also performed well. It had a finer, lighter texture than Coastal Star and Nevada. Magenta lettuce produced a heavy head of incredible lettuce and was also a favorite. Concept produced a smaller head of lightly crispy lettuce and was a favorite of many.

Tyee and Melody Spinach were also a success in this high tunnel. Since all the lettuce and spinach were done by the end of June, they were not dwarfed by the primary crop. We produced 180 heads of romaine lettuce per row. At a mere price of $1.50 per head, this high tunnel still made $1,890. If each head were $3.00, as it should be, the secondary crop income would have been $3,780.

The onions once again performed poorly. Since the beautiful field onions were soon ready, we pulled the small high tunnel onions and bunched them together making only $50.00 per row. Since Walla Walla onions are a relatively early crop, I don't understand why they don't flourish in the high tunnel like lettuce.

Next year we should have enough demand to raise two high tunnels of lettuce as the secondary crop. We will also do one high tunnel of spinach. Each year I find a stray cabbage in the high tunnels determined to grow. Since those stray heads of cabbage seem to do well, I think they are trying to tell me something. We will do one high tunnel with Golden Cross Hybrid cabbage (HPS). It is a 40 day cabbage that should do well. We will also try a few rows of early kohlrabi and eggplant. We plan to begin marketing cut flowers. We will try some short, early cut flowers in the remaining high tunnel space. We built a new high tunnel last fall. Primary crops next year will be three high tunnels of tomatoes, three of cucumbers, and one of Fortrex pole beans (Johnny's).

2009. The first year, we tried root crops such as radishes, carrots, beets, and onions. They perform well in the cool outside air but did poorly in the high tunnel. We were unable to use plastic mulch on the root crops and weeds became a problem. The promising secondary crops that year were romaine lettuce and spinach.

The second year, we continued with spinach and romaine lettuce but added peppers and bush green beans. We decided to give onions one more try. While the peppers and beans grew very well, we found it became a jungle. The secondary crop was trying to produce fruit at the same time the towering primary crop was taking all the light. Romaine

lettuce and spinach were still a success and onions produced one more year of disappointment.

Thus, it seemed that crops that can be produced early in the season proved to be a good secondary crop. On this last year of our experiment we brainstormed to think what crops we could try as a secondary crop. Romaine lettuce and spinach were proven to be great. We decided to add cabbage, pak choi, early eggplant, kohlrabi, and cut flowers.

This year, the primary crop in three of the high tunnels was tomatoes including Early Girl, Mountain Spring, and cherry tomatoes (Apero and TomatoBerry). Early Girl provided a huge early crop of great tasting tomatoes starting at the end of June. Mountain Spring brought a beautiful harvest of large, meaty tomatoes from the high tunnels later in the season. Apero produced a very heavy load of incredible tasting cherry tomatoes. The production of Apero this year far surpassed that of TomatoBerry.

The primary crop in three high tunnels was cucumbers. Sweet Slice had great flavor and production. Tasty Jade is a beautiful cucumber with a natural shine. Sweet Success had the best flavor and production.

One high tunnel had a primary crop of Fortex pole beans. Fortex produces a continuous great crop of long slender green beans of gourmet quality.

We learned early in this grant that one does not want to waste precious time in the high tunnel planting seeds. Tomato plants were started in our house in the middle of January and all other primary and secondary crops were started in our main greenhouse in March. In early April after soil testing and fertilizing, we laid trickle irrigation tape and plastic. We learned the first year how important it is to have plastic mulch. Weeds flourish in the high tunnel climate.

The primary crops were planted down the center of each row to allow plenty of room on each side for the secondary crops. Cucumbers and pole beans were planted in groups of three, 1' apart. Tomatoes were planted 18" apart. The planting row was 24" wide. The secondary crops were planted 8" from the center of the row with a spacing of 12". This gave them adequate space from the primary crop.

April and May have been exceptionally winter-like lately. To buffer plants from this extreme cold, we added a sheet of plastic draped over the trellis system in each high tunnel. This provided earlier warm-up in the morning and kept the plant area much warmer after sundown. It took more monitoring during the day and we often had to lift the sides of this layer of plastic up on the trellis to avoid daytime overheating. Furthermore, when extra heating was needed, there was a much smaller space to heat. Because of this extra warmth, we were selling cucumbers and lettuce by mid-May. We removed this extra layer of plastic toward the end of May.

Our primary question throughout this experiment has been, "Can we improve the economic benefit of the high tunnel through the addition of a secondary crop?" The answer is a resounding "YES!!" We also learned many things we did not intend to learn. We learned the supreme secondary crop in the high tunnel is romaine lettuce. The quality and flavor of spring and early summer lettuce in the high tunnel is unbeatable. The customer demand for our lettuce is growing each year as a result of this experiment. Customer favorites include Concept, Green Star, Coastal Star, Cherokee, Magenta, and Nevada (Johnny's Seed).

To avoid all the high tunnel lettuce getting ready at once, we planted three stages of it in the main greenhouse in March and April. Even then, some heads of lettuce go a bit past their prime. This summer, our interns got the great idea of pulling those heads apart and taking the better of each one and putting it in mixed bags. This allowed all of our high tunnel heads of lettuce to be sold. Now that we have a customer following for our lettuce, our goal is to keep it growing all season. Next year, we plan to plant lettuce in raised beds on white plastic mulch to keep lettuce going the rest of the summer and fall.

Lettuce adds profit to each row of the high tunnel. When planted 1' apart in our 94' rows and lettuce on each side of the main crop, each row then has 188 lettuce plants. At $2.00/head, a row of lettuce yields $376. Seven rows in one high tunnel produce $2,632. The Sweet Success cucumbers in one high tunnel earned $15,500. The addition of lettuce brought the total to $18,132.

Our first year raising kohlrabi turned out to be a pleasant surprise. First of all, the customer demand was amazing. As a secondary crop, it takes up little space and seems to need fewer nutrients than some crops. At $2.00 each, the income potential is the same as lettuce. Kohlrabi proved to be a wonderful secondary crop. We used Rapidstar and Winner from Rupp Seed.

Spinach, too, is a great secondary crop. One leaf at a time makes harvesting more time consuming and it yields less than romaine lettuce. Income from a row of spinach was 25% that of lettuce. But, since diversity is desired, spinach is an important crop for us early in the season. Tyee spinach is our favorite.

We tried a few rows of Megal, Millionaire, and Nadia eggplant (Rupp Seed). Because they are early, we thought they might be a good secondary crop. But like peppers the

previous year, the eggplant wanted to produce all season and they competed with the primary crop. Customer demand is high for eggplant, so next year, eggplant will become a primary crop.

Cabbage did extremely well in the high tunnel. We tried early varieties such as Stonehead which we sold at a range from $2.00 to $3.00 per head. However, cabbage and pak choi both took so much energy from the primary crop that the primary crop became stunted. Next year, cabbage will have its own place on the sides of the high tunnels.

We chose early cut flowers to be secondary crops. Calendula and zinnias each did well. While they were early, we noticed some competition. We decided cut flowers should have their own row and next year will have a place on the side of the high tunnels.

In summary, over the course of 3 years, we found romaine lettuce, spinach, and kohlrabi to be the best secondary crops. There is demand for them and they grow quickly enough to be finished before the primary crop gains center stage. Peppers, eggplant, cut flowers, and cabbage are all wonderful crops for the high tunnel, but not as a secondary crop.

Our biggest surprise through this experiment was to discover the power of diversity. For a high tunnel to truly bring customer excitement and therefore income, a wide range of products certainly beats two or three. And with the frigid spring, we would never have paid the bills on our farm without the diversity from our seven high tunnels.

Management Tips

1. Unless the soil in the high tunnel is totally free of weeds, plastic mulch should be used. The warm, wet conditions provide a deluxe environment for weed germination and growth. Having newspaper on the pathway covered with hay also makes working in the high tunnels much more pleasant. We spent very little time weeding when we used mulch.

2. If at all possible, transplants should be used instead of direct seeding. Transplants maximize the use of time in high tunnels.

3. It is vital to watch the supply of nutrients. In addition to soil testing, watching the plants is a key to finding the balance between excessive leaf growth and good production.

4. Radishes, carrots, and beets do well outside and are of lower economic value. We will not grow them in the high tunnel again.

5. It appears that the successful secondary crops are those that are done before the primary crop gets too big.

6. Elliott Coleman says that each layer of plastic brings you 500 miles south. The addition of another layer of plastic over the trellis system made a profound difference, even though it required more careful monitoring.

7. The more diversity one can add to a high tunnel, the better.

Cooperators

Terry Nennich, University of Minnesota Extension Service, Crookston, MN
David Birky, Ag Resource Inc., Detroit Lakes, MN

Location

We are located 4 miles NE of Fergus Falls on Cty. 1 and 3 1/2 miles east on Cty. 18.

Other Resources

"Minnesota High Tunnel Production Manual for Commercial Growers" University of Minnesota Extension Service, 2004. You may obtain copies from Marilyn Johnson, Minnesota Fruit and Vegetable Growers Association, 763-434-0400.

"The Hoophouse Handbook" edited by Lynn Byczynski. Growing for Market. Fairplain Publications Incorporated, PO Box 3747, Lawrence, KS 66046, 800-307-8949.

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

Principal Investigator

Dallas Flynn
48677 Rice Lake Rd.
Frazee, MN
56544-8908
218-841-6380
drusadal@hotmail.com
Otter Tail County

Project Duration

2008 to 2010

Award Amount

$17,692.00

Staff Contact

Jean Ciborowski
651-201-6217

Keywords

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

Project Summary

In 2008, we installed a high tunnel that uses solar heat to warm the soil below the tunnel. We pump hot air from three solar panels through a series of corrugated tile lines buried beneath a 30' x 48' high tunnel. Only using solar heat, the soil and air temperature in the heated tunnel stayed above 45°F from March 14 until November 24. In 2009, we were able to compare temperatures, planting dates, and harvest dates in the heated high tunnel with a nearby unheated tunnel. We planted tomatoes in the new tunnel 6 weeks earlier and began harvesting tomatoes and cucumbers 8 weeks before the unheated tunnel.

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 farmer's market and to restaurants. Several years ago, we started raising vegetables in a small 20' x 24' high tunnel. The high tunnel expanded 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 put in a high tunnel that relies on solar heat to warm the soil beneath the high tunnel to address some of the issues with our original, smaller high tunnel. I excavated an area next to my old high tunnel that is 4' deep. The excavator separated 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 then I placed one layer of 4" corrugated plastic drain tile over the sand (Figure 1). 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 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[1]," a decomposed peat topsoil bought from a nearby dealer. The topsoil was supported on the outside with 2" x 12" white oak boards. The special soil had a higher nutrient holding capacity than my native soil. I formed the soil into raised beds and covered the raised beds with black plastic.

[1]*Inclusion of a trade or business name does not imply endorsement of that product or business by the Minnesota Department of Agriculture, nor does omission imply non-approval.*

Figure 1. The lowest layer of tile line with the traditional high tunnel in the background.

Figure 2. Solar panels on the south and east side of the high tunnel.

We put a 30' x 48' FarmTek high tunnel over the heated soil area (Figure 2). The covering for the tunnel consists of two layers of plastic with an insulating air chamber between the layers. Finally, 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 from the soil through the solar panels. The fan is controlled by a thermostat, which kicks the fan on when the temperature in the solar panel reaches 125°F, and turns off when the temperature in the solar panel drops below 85°F. We started pumping the hot air from the solar panels in October, 2008, and left the thermostat on all winter.

We planted tomatoes, cucumbers, spinach, Swiss chard, lettuce, and onions in the new high tunnel in September 2008. The cucumbers were stunted by the end of October and died in the middle of November due to a lack of light and cool weather. The tomatoes were still alive, but the temperature was too cool and the light too weak for the plants to set fruit. The greens are growing quite well. I was able to fill 9 weekly orders of lettuce, spinach, kale and Swiss chard to a local restaurant. The plan was to plant tomatoes and cucumbers again in late winter when the light and temperature conditions improve. We'll see if the spinach, chard, and lettuce will overwinter in the tunnel.

The winter of 2008/2009 was colder than average and the outside temperature dropped below -40°F twice during the month of January (Table 1). The solar panels received enough sunlight to trigger the thermostat 11 days in December, 20 days in January, and 18 days in February. 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. The soil at 2" in the heated tunnel was frozen from December 22 to March 3. For 6 weeks during the winter, the soil remained at 31.4°F.

Nighttime temperatures in the heated high tunnel continued to fall below freezing every night until March 7. 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.

Table 1. Temperature in the heated high tunnel, a traditional high tunnel, and outside from December 2008-March 2009.

Month	Outside (°F)			Heated High Tunnel (°F)			Old High Tunnel (°F)		
	Mean	High	Low	Mean	High	Low	Mean	High	Low
December	4.5	39.3	-37.0	31.6	67.7	2.2	12.5	55.9	-18.6
January	-1.1	47.2	-43.8	18.3	63.5	-4.3	10.3	68.4	-26.8
February	12.4	66.3	-26.8	28.4	77.4	-2.9	23.2	76.0	-18.6
March	25.3	66.3	-35.4	51.6	92.5	4.6	36.8	97.9	-16.8

Figure 3. Tomato plants in heated high tunnel.

We started harvesting tomatoes on June 7-8 and started selling tomatoes on June 15, which was 8 weeks earlier than in the unheated high tunnel (Figure 3). We started selling cucumbers in early June. The heated high tunnel helped our business and total returns were up 35%. We had very good comments from our customers. We sold out every time we went to the farmer's market and we became known for quality cucumbers and tomatoes. Seventy-five percent of our sales in 2009 were from high tunnels. We continued harvesting tomatoes until the end of November. We shut down the tunnel in December to give us a rest and allow the tunnel to freeze in order to reduce disease and insect pests.

In early July, we put a shade cloth over the high tunnels to reduce the daytime temperatures in the tunnel. We removed the shade cloth in the middle of September.

The heated high tunnel allowed us to increase the number of products we could sell. We sold radishes, lettuce, kale, and spinach very early in the spring, and allowed us to increase sales to a local restaurant. Both the spinach and the kale overwintered in the heated high tunnel. We were able to do some double cropping, including planting cucumbers with lettuce, and onions with kale. Green beans also did quite well in the new high tunnel.

Growing Degree Days (GDD) in the heated high tunnel were a third higher than outside, but were only slightly higher than in the unheated tunnel (Table 2). The heated high tunnel provided more GDD (base 50) during the critical months of March and April, when the heated high tunnel had a third more GDD than the traditional high tunnel. By the middle of summer, the GDD in the two high tunnels were roughly the same each month.

The GDD only partially explains why we were able to harvest tomatoes in the heated high tunnel 6 weeks before the traditional high tunnel. Warm soil temperatures are critical for proper growth in tomatoes and cucumbers. The soil temperature in the heated high tunnel stayed above 50°F every night after March 15, while the soil temperature in the traditional high tunnel did not stay above 50°F at night until April 14 (Figure 4). After April 14, soil temperatures in the two tunnels were similar.

Table 2: Temperature and growing degree days (Base 50) for the 2009 growing season.

Month	Outside		Heated High Tunnel		Traditional High Tunnel	
	Mean Air Temp (°F)	GDD	Mean Air Temp (°F)	GDD	Mean Air Temp (°F)	GDD
March	25.3	4	51.6	221	36.8	157
April	42.5	69	63.4	404	54.6	319
May	55.2	243	65.9	485	63.3	445
June	64	432	68.6	557	67.9	526
July	67.3	497	68.8	581	69.2	549
August	66	494	67.0	526	67.2	534
September	63	387	64.6	408	64.5	415
Total		**2,072**		**3,096**		**2,869**

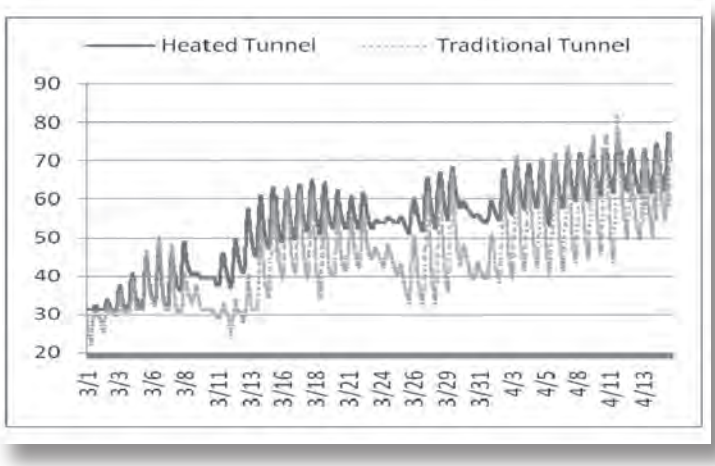


Figure 4. Soil temperature at 2" in the heated and traditional high tunnels. The temperature probe was placed in raised beds, which caused large diurnal temperature fluctuations.

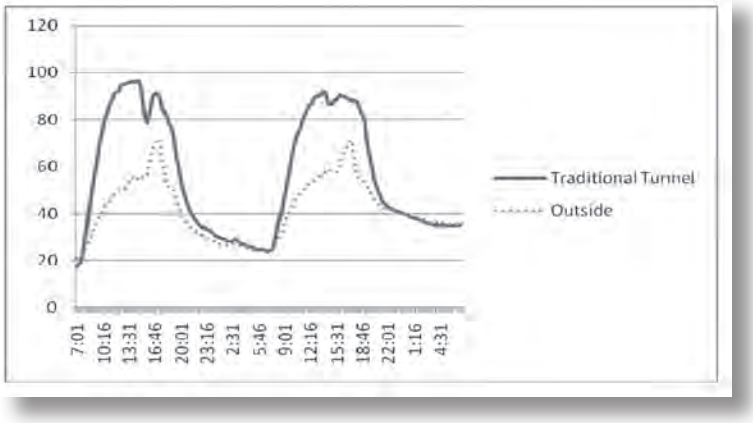


Figure 5. Air temperature in the traditional high tunnel and outside on April 10 and 11, 2009.

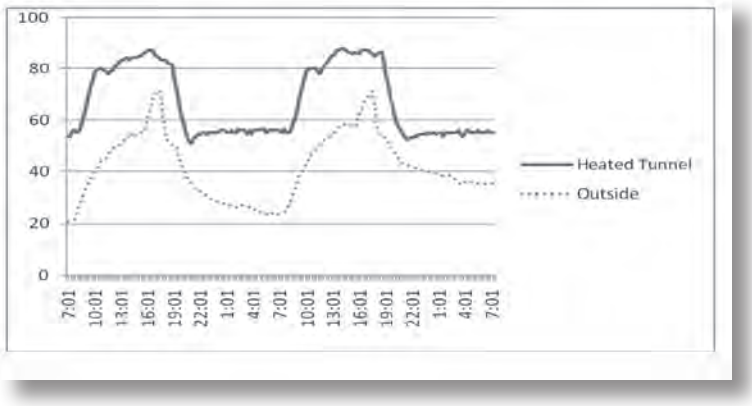


Figure 6. Air temperature in the soil heated high tunnel and outside on April 10 and 11, 2009.

Traditional high tunnels do an excellent job of heating air during the day, but do a poor job of warming the air at night. Once sunlight hits the tunnel in the morning, the temperature rises rapidly. On April 10, for example, the temperature rose to 80°F by 10:00 a.m. inside the tunnel, which was 40 degrees higher than the outside (Figure 5). Once the sun set, the temperature in the high tunnel quickly fell, and by early morning the temperature inside the tunnel was the same as the outside temperature. The temperature in high tunnels follows typical diurnal variation, with the overnight low occurring shortly before sunrise. In October, when the tunnel was filled with living plants, the tunnel stayed warmer than the outside air on frosty nights, but it still exhibited typical diurnal variation. The nighttime temperature in the unheated high tunnel stayed above 45°F from June 6 to October 9 for a total of 125 days, compared to 78 days outside. (Tomato and cucumber growth is reduced when the temperature falls below 45°F.)

In the heated high tunnel, the air temperature usually dropped shortly after sunset, but then the temperature rose 3°F, and the temperature stayed the same the whole night (Figure 6). The nighttime temperatures each day of the month were usually within 2°F of each other. During the month of April, the outside temperature dropped into the low 20s on 10 separate nights, while the heated high tunnel stayed at a balmy 55°F for 29 of the 30 days. The nighttime temperature in the heated high tunnel stayed above 45°F from April 6 to November 26 for a total of 234 days.

Problems encountered this year:

When we put in the tunnel, we bought Dick's Super Soil, which is a degraded peat from Otter Tail County. It is high pH (7.4) and high CEC (cation exchange capacity) soil, but is low in nutrients, especially potassium. We amended the soil with green sand to add potassium, but we encountered several nutritional problems.

The tomatoes in the heated high tunnel had gray wall and hard centers by late July. A few tomatoes in the unheated tunnel had hard centers, but overall the problem was not as severe in the unheated tunnel. Gray wall is typically caused by potassium deficiencies. The problem most likely occurred because we did not properly amend the soil with potassium before planting, and not because we were heating the soil. Our tomatoes bore fruit for over 5 months, which means there was a tremendous

demand for nutrients over the course of a growing season. By the end of July, we had already been harvesting tomatoes in the new tunnel for 6 weeks. We reduced the problem by spraying KDL (potassium dextro-lac) on the foliage twice a week for the remainder of the summer.

Cucumbers in the old tunnel did better than in the new tunnel, because some of the plants that were stunted in early March never grew well. We could avoid the problem in the future by planting cucumber seedlings when the soil temperature is higher than 50°F.

Red onions and 'Candy' onions did poorly in the new tunnel, probably due to overwatering. Candy onions did extremely well outside in the garden this year.

Our peppers and eggplants grew extremely well (Figure 7). In early summer the plants had aphids which later moved to the tomatoes. We released lady beetles to control the aphids. In spite of the healthy growth, the plants did not set fruit. Next year we will buy bees for the tunnel to increase fruit set.

Management Tips

The solar heated tunnel nearly doubled the growing season compared to the unheated tunnel during the cool summer of 2009. In the unheated high tunnel, the overnight low stayed above 45°F for 125 days, while in the heated tunnel, the overnight low stayed above 45°F for 234 days.

High humidity is a problem in high tunnels. We will start opening the ends of the tunnel during the growing season next year to decrease the humidity in the heated tunnel.

Proper irrigation is critical in high tunnels. We recommend two lines per row with separate valves. Water use increases as the plants put on new leaves, and we had to gradually increase watering as the plants grew in the early summer. Watering too much in early summer can cause root diseases, and watering too little in the middle of summer can stunt plants.

We recommend manually rolling up the sides of the tunnel when the weather becomes too warm instead of relying on a thermostatically controlled motor. During winter, we put foam strips along the sides where the plastic is rolled up to reduce heat loss.

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*

Figure 7. Peppers in the heated high tunnel, November 16, 2009.

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

Principal Investigator

Erik Gundacker
Scenic Valley Farms
12529 Danbury Way
Rosemount, MN 55068
651-423-4562
gun@uninternet.com
Dakota County

Project Duration

2009 to 2011

Award Amount

$19,445.00

Staff Contact

Jean Ciborowski
651-201-6217

Keywords

blackberry, high tunnel, trellis, winter protection

Project Summary

Can blackberries be grown organically in commercial quantities in southeast Minnesota? Scenic Valley Farms 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. 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 a goal of growing blackberries for commercial production in a northern climate. We have several business entities in addition to the farm. Under the name Gunds Acres, we start 10,000 annual and perennial plants in a high tunnel every year. We also raise koi in a pond and holding tanks inside a high tunnel. The water from the koi operation is filtered through a natural bog system and the fish waste is used to fertilize the berries.

Our interest in blackberries is based on our preliminary market analysis that indicates a market for one million pounds of organic blackberries per year in the Upper Midwest. Commercial buyers are interested in fresh, locally grown, organic blackberries. When I asked the president of Sun Belle, Inc. how many blackberries she would be willing to purchase, she said, "Everything you can grow." Sun Belle presently works with thousands of cases per day. That equates to millions of pounds per year. We plan to produce 3 acres of blackberries under high tunnels, anticipating a yield of 30,000 lb/A/yr. Considering the Upper Midwest demand for blackberries and the anticipated return per acre, we see an opportunity for an additional ten organic blackberry growers to meet the demand.

While the regional demand for organic blackberries is large and viable, growing commercial grade blackberries in Zone 4 or colder without winter protection is virtually impossible. 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 (results from 2007). 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 climate or colder unprofitable.

High tunnel site preparation using 6 mil black plastic for 2-3 months to kill weeds.

'Prime Jim' and 'Prime Jan' in high tunnel.

Currently, high tunnels are primarily used in Zone 4 for season extension (three seasons). They have not been used for winter crop protection. We have lots of experience with high tunnels and thought that we could design methods for using them for winter protection and develop a profitable, commercial organic blackberry operation. In 2009, we worked with Poly-Tex[1] of Castle Rock, MN and consulted with Terry Nennich to design a high tunnel suitable for blackberry production. Our high tunnel 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 cost competitive with that of existing high tunnels. Poly-Tex designed and developed the Field Pro with these specifications. We prepared the land for the high tunnel using black plastic to smother the weeds then fertilized the soil using well rotted horse manure and recycled mushroom compost. With help from our relatives and friends, we put up the high tunnel. Inside, we installed a wooden "T/V" trellis system to support the berry canes, buried a micro emitter irrigation system along with an inline fertigation system. The ventilation system consists of end doors, motorized side curtains, circulation fans, and gable end motorized ventilators. All of these systems are controlled using sensors and controllers.

We also planned to test seven blackberry cultivars under a high tunnel to determine which berries survive the winter and produce the highest yields. We attempted to order the seven varieties of thornless blackberries (Natchez, Ouachita, Apache, Doyle, Triple Crown, Chester, and Doyle) based on the recommendation of Dr. John Clark, a blackberry breeder from the University of Arkansas. These varieties were selected for their early to late season maturation dates. We were only able to obtain three of the seven varieties; the other varieties were sold out for the season by the time we ordered in May. We decided that, rather than starting just three varieties in 2009, we would order all seven varieties in January and plant them all at the same time in 2010. We will begin planting the earliest maturing varieties on the first of March and plant the middle to late season varieties in April. Starting when the cane begins to leaf out, it takes 3 months for fruit to set and begin to ripen. Our goal is to have fruit from June to the end of November.

Since we delayed planting in the high tunnels until 2010, we instead maintained, observed, and recorded winter survival and yields of three blackberry varieties that we had started outside the high tunnel in 2007 and 2008. These varieties were thornless 'Doyle' and very thorny 'Prime Jim' and 'Prime Jan'. We later erected a PVC constructed high tunnel over the 'Prime Jim' and 'Prime Jan' in an attempt to extend the season.

Results

Our berry production from the thornless 'Doyle' that we planted outside was minimal. For the second year in a row, we attempted to mulch the berry canes by laying the canes on the ground, covering them with oak leaves and straw, and, finally, with 2' of snow. Again we lost 50% of the canes and yield from the six plants was minimal.

Also in 2009, we planned to measure the total yield from the 'Prime Jim' and 'Prime Jan' varieties that had been planted in 2007 and 2008 outside of a high tunnel. Ninety-nine percent of the primocane yield was killed by an early freeze (32°F) on September 30. We were in the process of erecting a PVC constructed high tunnel to provide cold protection and season extension but we didn't complete it in time! We attempted to use a 6 mil row cover, but this did not provide enough protection. Basing a yield estimate on the size of earlier berries and the density of berries on the plants when they froze, we believe the two rows would have produced 50 lb of berries or 4,500 lb/A.

[1] *Inclusion of a trade or business name does not imply endorsement of that product or business by the Minnesota Department of Agriculture, nor does omission imply non-approval.*

High tunnel site preparation using 6 mil black plastic for 2-3 months to kill weeds.

Blackberry plants grow the first year and establish new growth for fruiting the following year. Berries are produced the second year then are ready for commercial production in the third year and reach full production in year five. Once we get some second and third year plants, we will measure yield per linear row foot and estimate potential yield per acre. To evaluate the blackberry cultivars, plant vigor, branching, fruit weight and color, sturdiness, lateral growth, pest damage, blossom set dates, harvest dates, and winter survival will be monitored in the coming years. To evaluate our particular production practices in the high tunnel, we will measure water needs, soil and plant nutrition, heating fuel and electricity costs, inside and outside temperatures, pollination, and the effectiveness of our use of compost and fish waste from our koi operation for fertility.

Because we are planning for commercial scale production, we are estimating yield potential and high tunnel needs on an acre-basis. Fourteen 30' x 96' high tunnels are needed for 1 acre of berries. The average yield of conventionally grown blackberries is 7,000 lb/A. By growing these unique blackberry cultivars in high tunnels, we expect to achieve 3 to 7 times the average yield of conventionally grown blackberries. Based on "Estimated Costs of Producing, Harvesting, and Marketing Blackberries in the Southeastern United States" in conventional systems plus the additional costs associated with a high tunnel operation, we have computed the break-even yield to be 17,500 lb/A.

Management Tips

1. If annual and perennial weeds are problems where you plan to erect a high tunnel, we recommend using a layer of 6 mil black plastic to smother and kill the weeds and roots. This will allow planting in 2-3 months.

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

3. 'Prime Jim' and 'Prime Jan' need a summer with at least a month of 80-85°F to mature the berry. The high tunnel would provide that extra warming if summer temperatures are too low.

4. Because they have thorny canes and mature late, we would not recommend growing 'Prime Jim' and 'Prime Jan' outside except for limited commercial production.

5. Using mulch for winter protection for 'Doyle' has had limited success on cane winter survivability in zones 4 and 5. With the added work to mulch and then uncover the plants in the spring, we would again not recommend growing 'Doyle' thornless berries outside except for limited commercial production.

6. Using fish waste from our koi ponds appears to have a big effect on average berry size. The average berry size for 'Prime Jim' and 'Prime Jan' is 9g. Our berry average size was 15g or about the size of a ping pong ball. We believe fish emulsion could be a good substitute.

Cooperators

Terry Nennich, University of Minnesota Extension, Crookston, MN
Brad Becker, Dakota County SWCD, Farmington, MN
Craig Gundacker, Scenic Valley Farms, Rosemount, MN

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. 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*

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. Website: *www.ncsu.edu/project/berries/extension/blackberry_budget.pdf*

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

Extended Growing Season for Lettuce

Principal Investigator

Michael Hamp
32251 Bunny Hill Rd.
Sebeka, MN 56477
218-472-3395
calico@wcta.net
Wadena County

Project Duration

2008 to 2010

Award Amount

$4,556.00

Staff Contact

Meg Moynihan
651-201-6616

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.

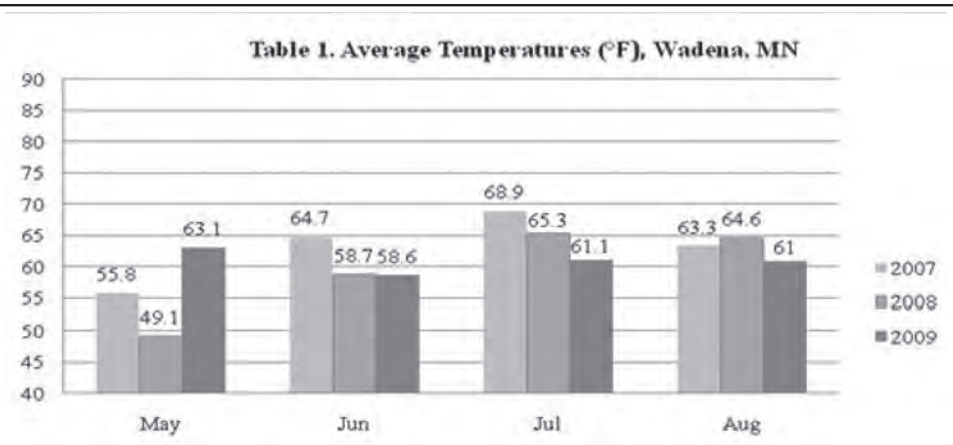
I use two shade cloth houses that I ordered from FarmTek®[1] in April of 2008. One provides 50% shade and one provides 70% shade. I also ordered the jet fog misters and filter from FarmTek®.

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.

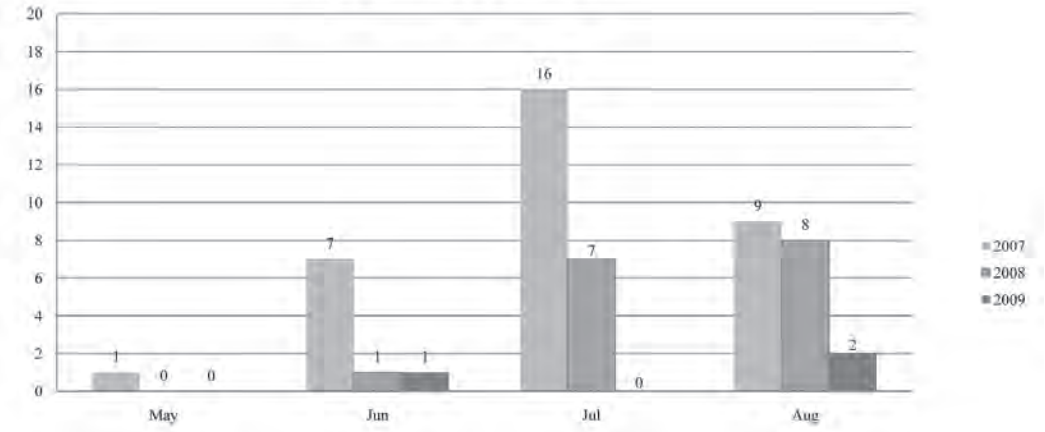
As a control, I left 5' of the beds without shade cloths or misters so I could compare performance of my old system (no shade, no mister) and two versions of the experimental system – 50% shade + misters and 70% shade + misters).

[1]*Inclusion of a trade or business name does not imply endorsement of that product or business by the Minnesota Department of Agriculture, nor does omission imply non-approval.*

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



Source: www.wunderground.com/history



Source: www.wunderground.com/history

Results

In 2008, a cool growing season 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, 2008, and 2009. In general, July and August of 2008 (mean temperature 64.95°F), were cooler than the same months in 2007 (mean temperature 66.1°F). In 2009, the July-August mean temperature was cooler still, at 61.05°F.

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). Last year was cooler still; the temperature reached 80°F on only three days! This is great weather for growing cool season crops, but not for testing the effectiveness of mist-cooled shade houses.

So far, the system does work as I had hoped. On the few days that I have used it to reduce air temperatures, it worked very well. I hope that in my third year (2010), we once again have some higher temperatures so I can test my system under more typical conditions. I know I echo the sentiments of many farmers throughout north central Minnesota in wanting warmer weather!

I also think the use of the weed burning each spring and then again in the fall will really show progress in the third year. Fewer weeds have been appearing each year, and what gardener and farmer doesn't like that?

On June 13 in 2009, it was still too early to put the shade cloth onto the structures, but the lettuces are doing great!

Management Tips

1. Using shade cloth really conserves moisture in windy areas.

2. Use 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).

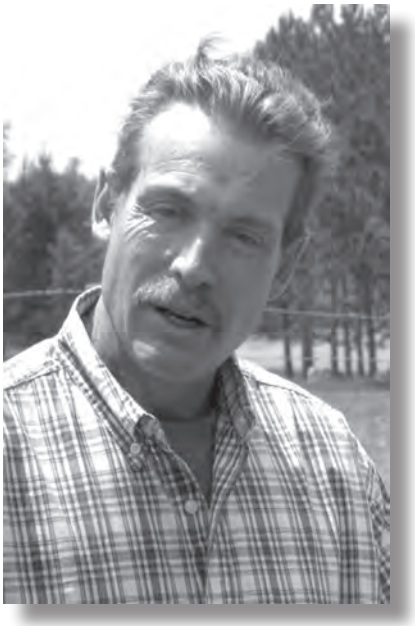
4. Depending upon your soil type, your soil may need to be amended with organic material before you put the shade cloth house in place. Select materials like peat or grass clippings that will hold moisture.

5. Thin the lettuce plants ruthlessly so that adjoining leaves don't touch because the high humidity conditions that the misters create can lead to disease problems.

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.

Michael answers questions at his 2009 field day.



Organic Day-neutral Strawberry Production in Southeast Minnesota

Principal Investigator

Sam Kedem
12414–191st St. E.
Hastings, MN
55033
651-437-7516
info@kedemroses.com
Dakota County

Project Duration

2008 to 2010

Award Amount

$13,695.00

Staff Contact

Jean Ciborowski
651-201-6217

Keywords

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

Project Summary

For the past 2 years, we have been comparing field-growing day-neutral (DN) with June-bearing (JB) strawberries using organic production methods. Day-neutral cultivars may be harvested from early August to mid-October in southern Minnesota when there is a large and ready market for local organic berries. The main challenges of growing DN in the field are insect pests, weeds, and diseases. In an organic setting the challenges are greater yet due to labor-intensive regimen, higher costs of natural plant food, and the lack of effective approved materials against insect pests, diseases, and weeds.

In 2008, we planted three DN and five JB strawberry cultivars. Straw mulch was applied in midsummer over the DN strawberries in one plot, resulting in winter wheat seedlings taking over the patch; black mulch was applied to another plot of DN, which kept the patch relatively weed-free. The June-bearing plants had a good harvest in 2009. Both plots of DN strawberries were unsalvageable in the spring of 2009 due to weed pressure from winter wheat or patchy rows from winterkill. A second planting was done in the spring of 2009, using only one DN along with five JB cultivars. The matted row system was used in both types of cultivars, with spacings of 6”x42” for DN and 18”x42” for JB. Only straw mulch was used on the DN rows in 2009 because the bio-degradable black mulch did not meet the National Organic Standard, as determined by the certifying agency.

Project Description

Sam Kedem Nursery and Garden is an organically certified farm and garden center. We raise nursery stock, bedding plants, apples, plums, raspberries, strawberries, and vegetables to sell on the farm and at the St. Paul Farmers’ Market. Strawberries have been a profitable product for us both on the farm and at the farmers’ market. Customer demand for strawberries remains fairly high throughout the summer, yet June-bearing strawberries are only available for 3 weeks each summer. One frost or hail event may destroy an entire crop of June-bearing strawberries, whereas day-neutral strawberries continue to produce flowers and fruit over an extended period.

DN strawberry production faces a number of challenges in Minnesota, especially when growing the berries organically. Weed control is tough because the plants are less vigorous than JB, and straw mulch is applied during the growing season. Mechanical cultivation is effective up until straw is placed over the rows, then it becomes impractical. Most strawberry growers plant the DN cultivars through plastic mulch to reduce weed pressure. Tarnished plant bugs are a bigger problem for day-neutrals than June-bearers because the tarnished plant bug population reaches a peak during June and July, when day-neutral strawberries are blooming. The disease anthracnose poses a serious problem in day-neutral strawberries because it primarily spreads during warm weather with heavy rains, especially from thunderstorms that are common in July and August.

In the season prior to planting the berries, we planted a cover crop of alfalfa. Composted dairy manure was banded over the rows after planting both DN and JB. In 2008, we planted .20 acres of day-neutral strawberries, and .80 acres of June-bearing strawberries. The day-neutral strawberries were planted both in ribbon rows (double or triple rows) with a biodegradable black plastic mulch and in matted rows where straw mulch was used. In 2009, we opted to plant day-neutral berries in single rows instead of ribbon rows. Although we planned to further investigate a new variety, Albion, which showed good results in 2008, the supplier shipped the Seascape cultivar instead. Two thousand-five hundred plants were planted at 6”x42”

Figure 1. Raspberries after a night of frost protection, October 10.

spacing, using a transplanter at 18", with additional plants planted manually. Planting was done on May 22. All runners and flower buds were removed from the DN plants until July 3. We allowed the blossoms to set fruit the rest of the season. We applied foliar sprays of fish emulsion, calcium, potassium, and fermented seaweed extract, as well as two soil applications of what I call my high protein house blend during the growing season and prior to harvest. The house blend is a mixture of alfalfa and kelp with a little feather meal. We started covering the DN with floating row cover (1 lb/yd^2) at night on September 3 when low temperatures approached 48-50ºF and removed it during daytime.

To control tarnished plant bugs, we've used Aza-Direct[1] and vegetable oil, which are both allowed for organic production. A drip system was installed and used to deliver water as needed. The majority of DN berries were sold at the farmers' market, the remainder as pick-your-own; a small amount was sold pre-picked at the farm and less than 2% was used in preserves, mostly damaged berries.

Results

Weed control continues to be a major challenge in day-neutral, field-grown strawberries because there are few materials approved for organic production. Labor-intensive weed management results in high production costs. Most DN strawberries around the world are planted in ribbon rows on plastic mulch for weed suppression. A downside of plastic mulch is that it is non-recyclable in most counties and ends up in landfills.

In 2008, we compared two in-row mulch systems: straw and bio-degradable synthetic film. In 2009, only straw mulch was used in the DN because the bio-degradable material did not meet the National Organic Standard for organic production. Instead, we controlled weeds by planting in single lines for easier mechanical cultivation between rows and augmented this with manual weeding within the rows. We aimed at eliminating seedlings before they attained second true leaves to avoid weed competition. The above ground drip lines slowed down the weeding process within the rows and we had additional work moving the lines back and forth, but more weed germination was observed near the drip line. Disturbing the soil crust resulted in reduced water demand, increased aeration, and faster incorporation of the plant food to the root zone, thereby helping in the development and overall health of the plants. The higher labor cost for hand weeding needs to be accounted for in higher price for the berries.

In 2009, we applied straw mulch to the DN plants on August 5, 2 weeks prior to the beginning of harvest, in order to maintain clean berries and reduce weed pressure. Straw mulch has the added benefit of reducing anthracnose and tarnished plant bug damage compared to plastic mulch. The biggest disadvantage of straw is leftover grain, which can sprout and become weeds. In 2008, we applied winter wheat straw on July 13. The leftover grain in the wheat sprouted shortly thereafter, and by early September, the volunteer wheat had crowded out the strawberry plants. The wheat overwintered and continued to choke out the strawberry plants this spring. Therefore, we decided to abandon the 2008 planting of DN straw-mulched rows. In 2009, we delayed applying straw until August 3 in order to reduce germination of grain before and during harvest. Oat straw was used instead of winter wheat straw because oat seedlings do not overwinter well in our climate. Despite the later application, grain seedlings emerged from the oat straw and continued to choke out strawberry plants, resulting in the reduction in berry yield.

[1] *Inclusion of a trade or business name does not imply endorsement of that product or business by the Minnesota Department of Agriculture, nor does omission imply non-approval.*

Table 1. Fruit quality of day-neutral strawberries, August 29, 2008 and August 25, 2009.

Day-neutrals	% Marketable	Berries with TPB damage	Berries with anthracnose	Berries with other damage*
All fields, 2008	57	35%	0	8
Field 1, 2009	86	19%	0	9
Field 2, 2009	12	88%	8	17
Average, 2009	49	56%	4	13

**Slug damage, Botrytis, water damage.*

We harvested the 2008 planted June-bearing strawberries from June 13 to July 13, which is about a week longer than normal. The longer season was due to cooler than average summer temperatures. We harvested 6,800 lb of JB strawberries from .8 acres, which is under the state average yield of 8,000 lb/A for pick-your-own strawberries. About one-third of the JB strawberry crop was lost due to late spring frosts, which occurred during early bloom on May 17 when the temperature fell to 24ºF. On June 4 and 5, the temperature fell to 28ºF during late bloom. The critical minimum temperature for strawberry flowers is 33ºF. Readings were taken using a remote sensor in the field at ground level. The Itasca cultivar was leading in yield and least frost damaged. There was little damage from tarnished plant bugs on summer berries, and fruit quality was good. The average price for the June-bearers was $2.37/lb. Roughly 95% were harvested pick-your-own and 5% pre-picked at the farm. In addition, we harvest and process 2-3% above the freshly consumed yield for preserves and freezing.

We picked DN berries from August 5 to October 3, 2009. Most years, we would expect to harvest berries through much of October, however temperatures dipped to sub-freezing in early October and remained cooler than normal for the rest of the month. Snow fell on October 12 and 15, and the vegetables in the high tunnel froze on October 12. Fall raspberries froze on October 10, despite having sprinklers on all night (Figure 1). Throughout October there were only a few sunny days to warm up the plants underneath the row cover, which did little to extend the season. Brix readings were consistently low (<6.5%), the result of inadequate photosynthesis during September. We ended up selling a total of 650 lb of day-neutral strawberries from a .125 acre plot, at an average price of $2.82/lb. Most of the strawberries were sold at the St Paul Farmers' Market for prices between $3.00 and $3.50/pint. The remainder was sold pick-your-own at $2.50/lb. Even at the higher price, we sold out of berries at the market early in the day. The high price for the fruit is necessary considering the high costs of production, low yield, and high demand. We were frequently asked by customers if the berries were genuine locally grown.

In 2008, there was a great deal of tarnished plant bug damage that seemed to vary according to mulch type, with less damage on the straw mulch compared to plastic. In 2009, the tarnished plant bug damage in the day-neutral berries still varied across the field even though all the plants were in straw mulch (Table 1). The combined Aza-Direct and Stylet oil applications did suppress, but did not completely control, tarnished plant bug. Over 90% of the berries in one section still had enough damage to make the berries unmarketable. A wet period in September resulted in increased Botrytis and anthracnose incidence on the fruit, with as much as 50% of the fruit considered unmarketable.

Conclusions

Strong points in favor of DN strawberry production observed this season were:

- High demand for local organic strawberries in late summer and fall;
- Increased variety of produce offered to the public;
- Greater flexibility by spreading the risk; and
- Improved overall cash flow.

In the third and last season of investigation, we will attempt to modify the mulching method, experiment with a new approach to weed control, evaluate at least one other DN variety, evaluate second year DN vs. standard summer-bearing varieties, experiment with intercropping rye, mustard, or buckwheat for weed suppression, look for ways to increase beneficial insect populations, and provide weather modification via installation of windbreaks.

Management Tips

1. Straw mulch is very useful in day-neutral strawberry production, but finding a source of straw that does not have grain in it is extremely difficult.

2. Approved materials for organic production of strawberries, so far, prove to be ineffective against certain diseases, specifically anthracnose.

3. Many customers are unaware that late strawberries can be produced locally, or skeptical as to the origin. Education and a promotional program may help strengthen the demand, given a reliable, steady supply is available to meet the demand.

4. Early cool temperature in fall will affect production in the field, regardless of whether floating mats are used or not; both quantity and quality will degrade when mean temperatures are below 68º-75ºF during the growing and harvesting seasons.

5. The limited number of approved organic materials for weed control results in very high labor costs; therefore, pre-planting a cover crop in the previous year is very important, as well as aggressive weed management after planting and throughout the growing season.

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

Guerena, Martin, and Holly Born. Strawberries: Organic Production. 2007. National Sustainable Agriculture Information Service.
Website: *www.attra.org/attra-pub/PDF/strawberry.pdf*

Minnesota Department of Agriculture. IPM for Minnesota Strawberry Fields. 2007. Website: *www.mda.state.mn.us/plants/pestmanagement/ipm/strawberry-manual.aspx*

Pritts, Marvin, and David Handley. Strawberry Production Guide for the Northeast, Midwest, and Eastern Canada. 1998. Northeast Regional Agricultural Engineering Service. Cooperative Extension. Ithaca, NY. Pub. #:NRAES-88. Website: *www.nraes.org*

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

Principal Investigator

Steve Poppe
University of Minnesota – West Central Research and Outreach Center
46352 State Hwy. 329
Morris, MN 56267
320-589-1711
poppesr@morris.umn.edu
Stevens and Douglas Counties

Project Duration

2009 to 2011

Award Amount

$13,346.00

Staff Contact

Jean Ciborowski
651-201-6217

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 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, 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

High tunnel raspberry harvest and taking yield data.

Volunteer U of M Morris students picking field trial raspberry experiment.

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, will provide an even 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.

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, winter injury due to low temperatures, and/or 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 University of Minnesota West Central Research and Outreach Center (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 weights, yield, and temperatures for primocane-fruiting raspberries in the high tunnel and in a field setting. Both cultivars tested showed substantially more growth in the high tunnel throughout the growing season (Figure 1). 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 (Figures 2 and 3). However, as you can see in Figure 2, berry size begins large and quickly decreases until berry

Figure 1.
Growth (in inches) of two primocane-fruiting raspberry cultivars grown in either a high tunnel or field situation at the WCROC.

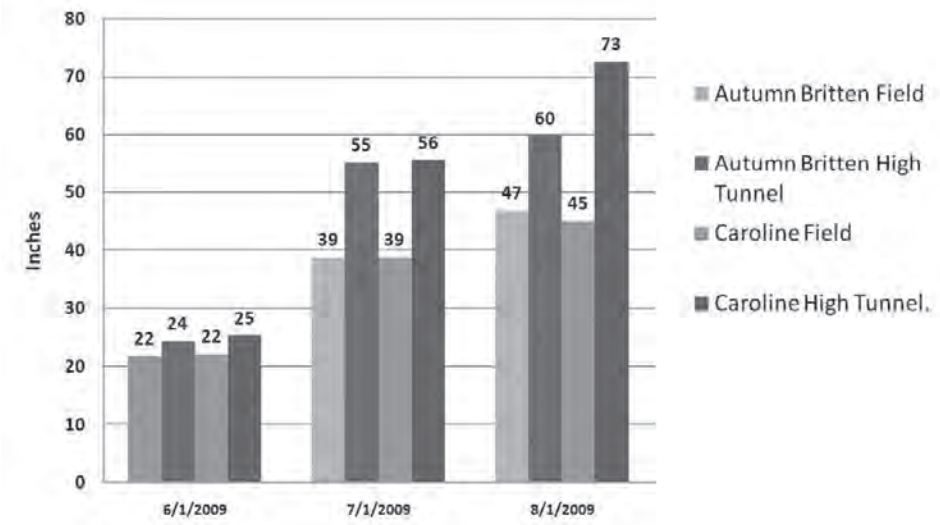


Figure 2.
Average weight per berry of two primocane-fruiting raspberry cultivars in either a high tunnel or field situation at the WCROC.

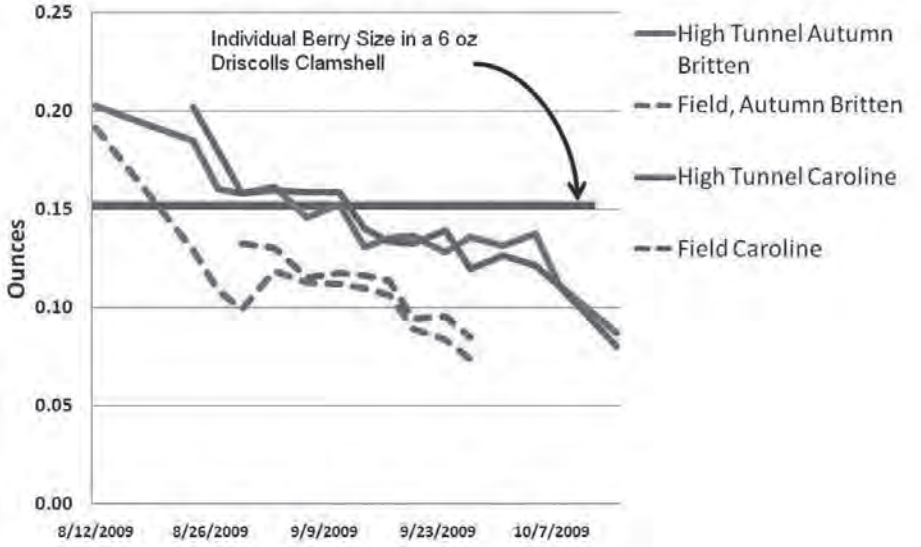


Figure 3.
Production (lb/36' row) of two primocane-fruiting raspberry cultivars grown in a high tunnel or field situation at the WCROC. Numbers on the graphs are total yield.

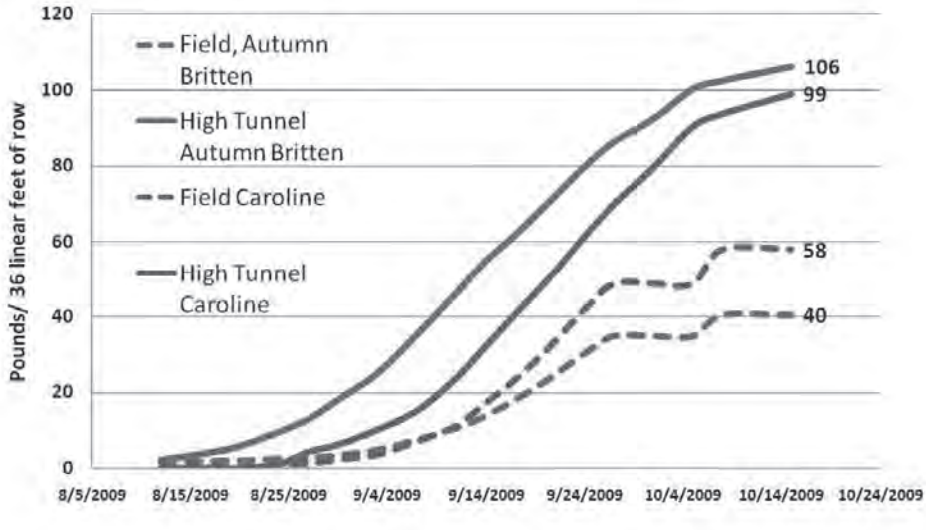
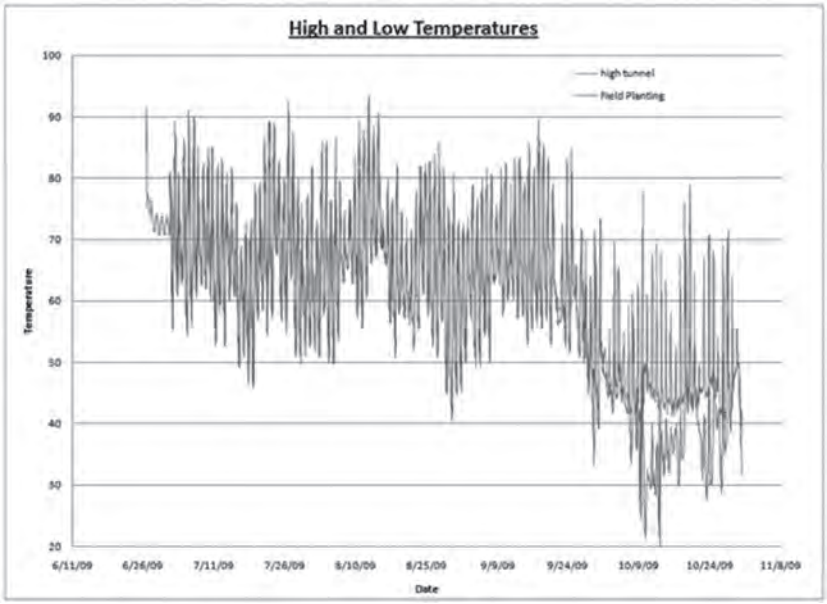


Figure 4. *Temperatures recorded at WCROC in high tunnel and field environments.*



size for both cultivars in both settings fell below the average berry size in a Driscolls clamshell by mid-September. The solid line in this figure shows the average berry size needed to fill one 6-oz container with 40 berries. The dramatic differences in temperature in the two environments by the end of the season had an obvious effect on berry size and yield (Figure 4).

At Berry Ridge, we wanted to determine if cultivar 'Joan J' was suitable for use in a high tunnel and which of three row spacings resulted in best growth and yield. We measured plant growth, berry weights, and yields for three different initial plant spacings. Row spacing did not have a major influence on plant growth; by the last measurement, there was no difference in growth among the three spacings (Figure 5). 'Joan J' at all three spacings produced berries larger than the average berry size in a Driscolls clamshell through the end of September (Figure 6). The 24" row spacing yielded substantially fewer pounds of berries than the other two closer spacings (Figure 7). 'Joan J' produced larger berries and higher yields at this site than the two cultivars grown at WCROC.

Soil Moisture

Irrigation scheduling at WCROC was based on readings taken from watermark moisture sensors in the high tunnel and field trial. 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 a period of 2 hr when the average reading was at 30 centibars. The irrigation system was a drip line tube with emitters every 8" and two tubes placed down each plant row.

Plant Nutrients

Plant tissue analysis samples were taken on June 25, 2009 to determine any plant nutrient deficiencies prior to first harvest on both plantings at WCROC. Overall, the nutrient levels looked pretty good. The macronutrients, nitrogen, potassium, and phosphorus (NPK) were all in the sufficiency range. The same was true for calcium and magnesium and for the micronutrients, iron and manganese. Boron and zinc were adequate, but they were both at the low end of the sufficiency range. All samples were at, or just below, the critical level of 4 ppm for copper. Sufficiency levels for nickel have not been well researched for most plants, but none of the samples looked deficient, although some of them were higher than what is usually seen.

Nitrate-N in petioles is a useful analysis for some vegetables, but not very meaningful for raspberries due to a lack of research. The results of our tissue samples were unusual because of their very wide range of 80-2,800 ppm. No plant fertilizers were applied after these plant tissue interpretations were received.

Pest Incidence

Weed issues were not a problem in either planting at WCROC. 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)[1] 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 planting 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. Occasionally, very small numbers of spider mites were detected. When they were spotted, we used high pressure

[1] *Inclusion of a trade or business name does not imply endorsement of that product or business by the Minnesota Department of Agriculture, nor does omission imply non-approval.*

Figure 5.
Growth (in inches) of primocane-fruiting raspberry cultivar 'Joan J' at Berry Ridge in Alexandria, MN at different initial plant spacings. Numbers at the top of the bar graph is the average growth.

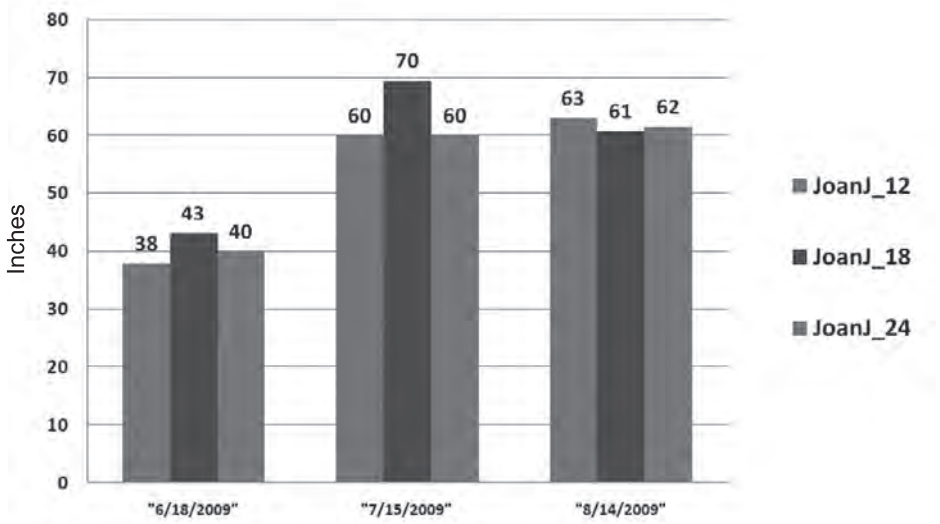


Figure 6.
Average berry size of 'Joan J' grown in a high tunnel at Berry Ridge Alexandria, MN at different initial plant spacings.

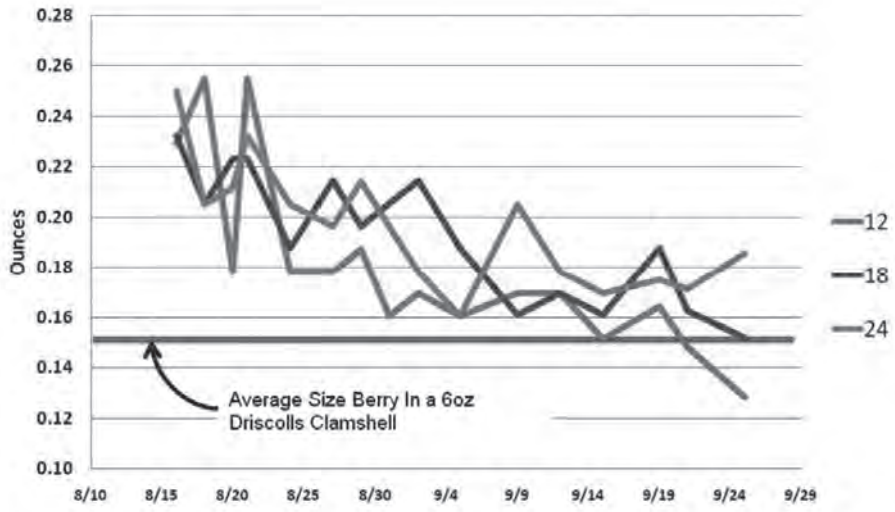
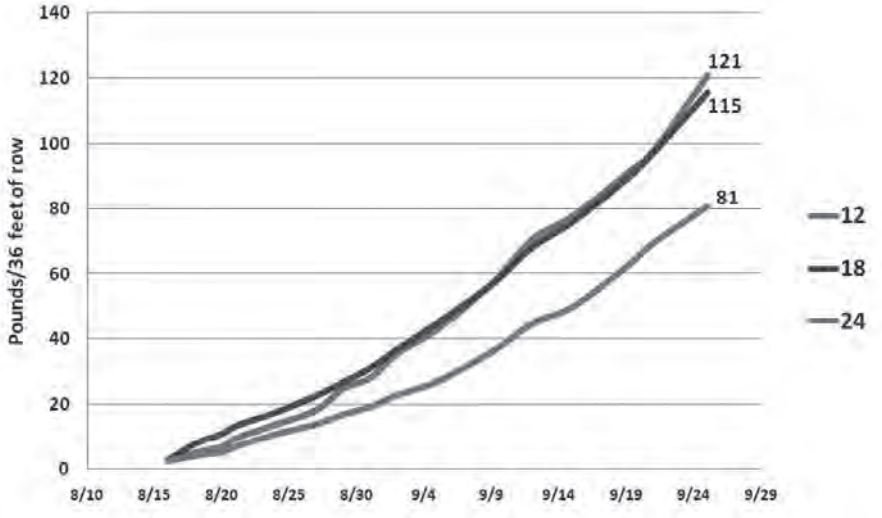


Figure 7.
Production (lb/36' row) of 'Joan J' grown in a high tunnel at Berry Ridge in Alexandria, MN at different initial plant spacings. Numbers on the graphs are total yield.



water to knock them off the foliage. This method worked extremely well for low spider mite infestations. Starting in mid-August, we applied a horticulture oil for red spider mite 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 $13.25 for four spray applications.

Harvest Labor and Markets
Another aspect of this research project was exposing University of Minnesota, Morris (UMM) students to the taste of locally-grown raspberries from the WCROC site. 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 fresh fruit, and staff processed and froze the remaining product for future use in their menus. Joshua O'Brian, executive chef for UMM Food Service was particularly pleased with the berries saying, "… in my personal opinion the raspberries produced from the high tunnel were absolutely phenomenal. Some of the biggest I have ever seen. The flavor wasn't lacking either, plump, sweet and tart! Nice bright color to them and not bruised at all. That also was the general consensus from my entire staff. We loved the raspberries and can't wait until our next local foods event so we can use the rest of them."

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.

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

Al Ringer
1765 Jackpine Rd.
Brimson, MN
55602
218-848-2475
aringer@frontiernet.net
St. Louis County

Project Duration

2008 to 2010

Award Amount

$6,265.00

Staff Contact

Wayne Monsen
651-201-6260

Keywords

blueberries, snow-making, winter plant covers

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 6 out of 7 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.

Our farm is located 40 miles north of Duluth, MN where winter temperatures typically bottom out at -40°F. We raise sheep, laying hens, a large garden, and a pick-your-own blueberry operation of 1,000 plants. Our blueberries consist of Northblue, Northcountry, and St. Cloud varieties and we can typically market 900 to 1,500 lb of berries. We use drip irrigation with water provided from a nearby creek. Fertilizing consists of one application of ammonium sulfate in the spring, and the plants are mulched with aged wood shavings.

One of the problems we have on our farm is trying to protect our plants in those years when we do not receive adequate snow cover to protect the blueberry fruit buds. Snow cover protects the buds from the temperatures and winter drying winds which adversely affect next year's blueberry crop.

The idea for our project came during the winter of 2006-07 when we only had a 3" snow cover for most of the winter, and February was cold with a low of -34°F. We received most of the snow in March but this was too late to protect the plants. Consequently, that berry season we picked a total of 5 lb of berries from 1,000 plants. We realized we need to provide some sort of plant protection for those winters when snow does not cover the plants. But what sort of cover to provide protection?

To address these concerns we are going to try a number of different covers in test plots in different areas of our berry fields. Below are the covers we plan to use in this study:

- straw alone;
- straw with 1.5 oz polypropylene row cover;
- 1.5 oz/yd polypropylene row cover;
- 1 oz polyester drawstring plant bags; and
- 55 gal plastic barrels

The second part of our project involves making snow. We know that natural snow provides excellent protection for blueberries. When it falls, it filters through the branches

Covering blueberry plants with straw.

Blueberry plants with various plant coverings in early winter.

Blueberry plants in November being covered with farmer made snow.

and protects the fruit buds from the cold and drying winds. We are wondering if it is feasible to make snow to cover the plants. Snow is made on ski hills, but could it be made on a small farm scale? We researched snow-making on the internet and found a company in Connecticut that made small scale snow equipment, basically for families in the south to make the ground white on Christmas Eve for their kids.

The questions we want to answer during this project are:

- Will the loose straw blow off of the plants?
- Will the plants with straw attract rodents?
- Will the row cover cause the branches to break if we receive a large dump of snow early?
- Will it be hard to remove the straw in the spring and what will we do with it?
- Can we reuse the row cover, and if so, for how many seasons?
- And most important of all, will any or all of the treatments provide the winter protection that we are looking for?
- Is it feasible to make snow to cover the plants?

Results

On November 14, 2008, we covered a total 68 blueberry Northblue, Northcountry, and St. Cloud plants with the five types of covers set up in plots. We also left six plants uncovered as a comparison.

Also in November, we made snow on 3 days and covered 25 Northblue plants for this study. The machinery setup is basically a set of nozzles, a pressure washer, and an air compressor. We found out that snow-making is an energy, water, and time intensive project. We tried using water from our well, but we had to run a hose 150' to the snow-maker and we didn't get adequate water flow. The next option was to use our irrigating pump and pump from the creek. This gave us a good flow of water and worked fairly well until a fitting on one of the high pressure hoses broke. After repairs were made, the operation worked well.

On February 10, 2009, we had almost ¾" of rain, which lowered the snowpack over the plants quite a bit, exposing them to the cold. This was followed by many days of sub-zero weather, including at least 3 days that were -30°F or colder. This might explain why production as a whole was down from previous years.

Yield results for the 2009 berry season were determined by weighing the berries from one plant from each of the plots. The results show that most types of covering are better than using no cover at all (Table 1). However, we found that plastic barrels and row covers with straw did not do very well as a whole.

The plastic barrels did not work at all. We think this is because the plants need to breathe during the winter, and the barrels do not allow that. Also, the barrels act like little greenhouses; they get very warm inside during the day, then at night they will drop down to very cold temperatures. These changes in temperatures most likely stressed the plants.

Plants that were covered with both row cover and straw also did not do very well as a whole. This might have to do with the breathing issue like with the use of barrels.

Covered plants had the added advantage of protection from deer browse. We noticed tracks throughout the field and buds that were nipped off by the deer on uncovered plants. We thought deer might be attracted to the plants that had

Table 1. 2009 yield results per plot of various cover types following the winter of 2008/2009.

Type of Cover	Yield of Berries by Variety (oz/plant)		
	Northblue	*Northcountry*	*St. Cloud*
Row cover	39.75	7.50	6.75
Straw only	25.75	-	-
Farmer made snow	23.30	-	-
Row cover	19.30	-	-
Row cover/straw	16.80	-	-
Straw only	9.75	-	9.75
Poly plant bags	8.50	-	-
Row cover	8.00	7.50	6.75
No treatment	6.37	-	3.50
Row cover w/straw	3.25	-	-
Row cover w/straw	3.10	2.60	-
Plastic barrels	0.00	-	-

the straw cover, and initially they checked them out, but it wasn't a problem.

We thought that the straw might attract rodents to nest and chew on the plants, but this was not an issue.

Making snow is labor intensive and relies on all types of mechanical devices (pump, air compressor, power washer, snow gun) working perfectly, otherwise the water stops flowing and everything freezes up. But, the plants that had early snow cover in mid-November did very well.

For the winter of 2009/2010, we are doing a few things differently. We are doing the study on 70 Northblue plants. We chose to use only one variety as this will help out with the variability between varieties. We are also eliminating plastic barrels and the treatment with both straw and row cover on the same plants from the study. We are adding a lighter weight (0.5 oz/yd) of row cover as well as adding burlap as a cover.

Here are the types of covers we are using in the winter of 2009/2010:

- 0.5 oz/yd polypropylene row cover
- 1.5 oz/yd polypropylene row cover
- 1 oz polyester drawstring plant bags
- 7 oz/yd burlap
- Straw only

Unfortunately, we were unable to make any snow in November 2009, so farmer made snow will not be part of the study in 2010. We had an average high temperature of 42°F for the month which is too warm for making snow.

The yield results of the berries will be collected in the summer of 2010.

We took soil samples on different parts of the field and found out that our pH varies somewhat. We are setting up the test plots this year in areas of the field that have similar pH.

Management Tips

1. Most types of plant coverings are better than no cover at all for winter protection.

2. Do not use plastic barrels to cover plants. They do not allow the plants to breathe and also act as greenhouses and warm up during the day then cool at night.

3. Do not cover plants with both row covers and straw.

4. The snow-making process uses at least 500 gal of water/hr, and it takes quite a while to cover many plants.

5. The temperature needs to be below 27°F with low humidity for making the best snow.

6. Make snow when it is not windy; any wind will blow the snow away from where you want it.

7. Monitor the equipment frequently because if any part of the operation stops, water will start to freeze in the hoses, pumps, etc.

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*

Growing Fresh Cabbage for Markets using Integrated Pest Management Strategies

Principal Investigator

Association for the Advancement of Hmong Women in Minnesota (AAHWM)
Ly Vang, Executive Director
1101 Snelling Ave. N.
St. Paul, MN 55108
651-255-0799
lyvangaahwm@yahoo.com
Dakota County

Project Duration

2009 to 2011

Award Amount

$20,000.00

Staff Contact

Jean Ciborowski
651-201-6217

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, a project consultant and the farm coordinator 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. Each farm had a demonstration plot consisting of four single rows of cabbage, each row received 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.

The cabbage variety planted was unknown. 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. Since 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 coordinator so that she 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 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.

Results

Throughout the summer, the project consultant and farm coordinator made nine visits to each farm to monitor pest pressure and instruct each farmer on the progress of the cabbage. Because of heavy rains and cooler 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 weights per row were determined at each of the two farms. Because the plot size was different at each farm, the number of samples pulled for weighing at each farm was different. At the Dia Xiang farm, 15 cabbage heads/row were weighed, while at the Yer Vang farm, four cabbage heads per row were weighed. Weights were determined in the field by placing the cabbage head in a large pail and weighing them using a Rapala 50 lb Digital Scale (hand held). The scale "tare" was set to expedite weighing the cabbage. 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 had a positive growth effect with cabbage leaves capturing more light and space. During the growing season, the collard greens were showing numerous eggs and small larvae of the imported cabbage worm and diamondback moth. Additionally, larval leaf feeding was observed on the trap crop. When visually observing the cabbage row next to the collard greens rows, one could see 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. When the row cover was being installed, Dia and the project consultant searched for and removed any eggs or larvae from the cabbage leaves then Dia's husband and the farm coordinator followed, securing the row cover over the cabbage. 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 it is imperative that row covers be installed 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 what it received.

The control treatment faired quite nicely in this demonstration plot 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 row.

The Dipel DF treatment row 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 the Dipel DF treatment row. The grasses in the strip grew to a height of 2-2 ½', which created a shading effect on this row. One application of Dipel DF was applied on July 28 during the cupping to early head

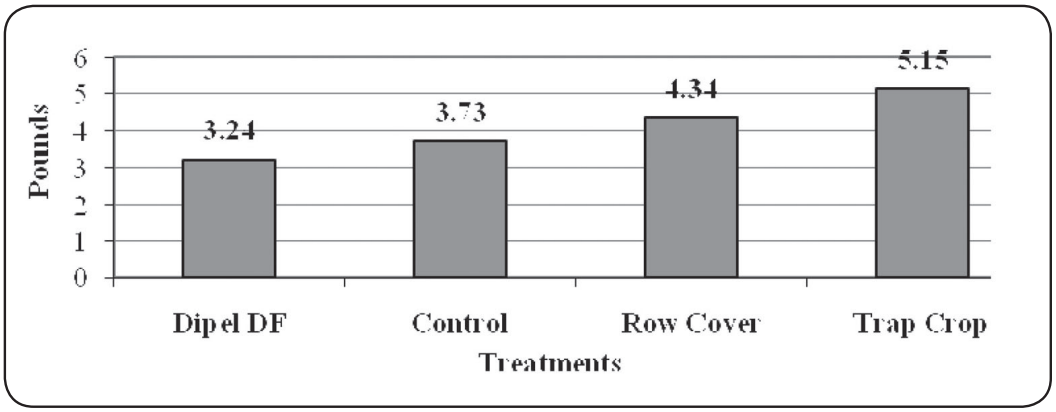


Figure 1. Dia Xiang Farm: 2009 Average Cabbage Head Weight/Treatment

development when the IPM threshold was at 20% (20% of plants have eggs or larvae at this growth stage). As stated earlier, heavy rainfalls during August greatly reduced the pest pressure throughout the demonstration plot on all treatments.

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. Because of the high presence of imported cabbageworm butterflies trapped under the row cover due to some tears in the fabric, 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 row 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 as there were many imported cabbageworms and cabbage loopers present as adults, eggs, and larvae at this time.

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 per foot of the row cover was $0.11/ft. September 2009, fresh market cabbage heads were selling at $1/head (K. Cavanaugh - personal communication with one farmer). 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. (NOTE: cost of row cover was calculated by linear foot and not square foot). 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.

Management Tips

1. If using row covers, apply a pre-emergent soil herbicide or mulch 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.

2. Apply row covers immediately (same day) over 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

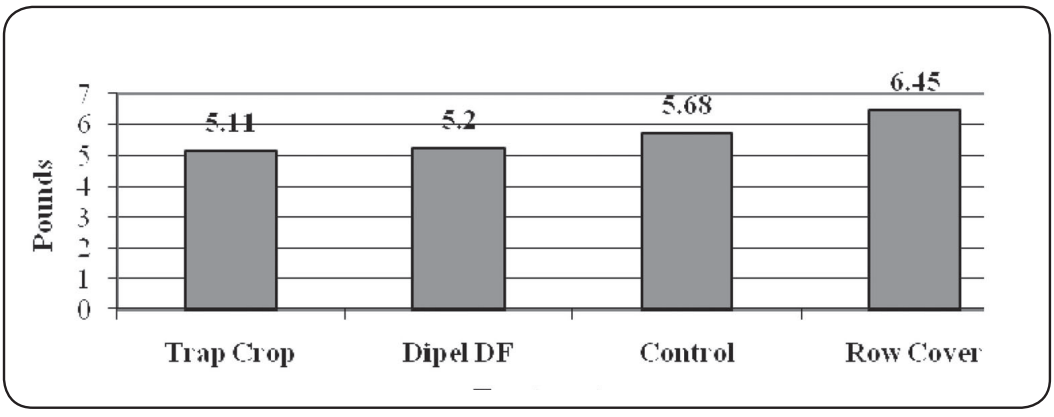


Figure 2. Yer Vang: 2009 Average Cabbage Head Weight/Treatment

second application would require lifting the row cover to complete the application.

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/*

High Tunnel Primocane Fruiting Blackberry Production in Minnesota

Principal Investigator[1]

Dr. Shengrui Yao
University of Minnesota - North Central Research and Outreach Ctr.
Dept. of Horticulture
1861 Hwy. 169 E.
Grand Rapids, MN 55744
218-327-4615
yaos@umn.edu
Itasca/Washington Counties

Project Duration

2009 to 2011

Award Amount

$23,932.00

Staff Contact

Jean Ciborowski
651-201-6217

Keywords

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

Project Summary

Primocane blackberry is a new crop for Minnesota that would need winter protection and a means to extend the growing season. High tunnels would extend the growing season into the fall and allow the berries to mature even if there is an early frost. We believe that high tunnels are a relatively low-cost investment for small-scale growers that would produce a high value, profitable crop. For the first season of this high tunnel blackberry project, primocane fruiting blackberries were planted in a newly erected high tunnel at Elm Tree Farm and in both a high tunnel and in a field trial at the North Central Research and Outreach Center (NCROC). The cultivars tested at the Elm Tree Farm were 'Prime Jan' and 'Prime Jim'. We are testing 'Prime Jan' and 'Prime Jim' at NCROC and evaluating new selections MNPF1001, MNPF01002, APF41, APF45, and APF48. Additionally, three thornless primocane fruiting blackberry selections, APF136, APF138, and APF139, were planted for demonstration purposes only. We are measuring winter survival, plant growth, yield, pest incidence, and fertility requirements.

Project Description

Blackberry production is not very common in Minnesota. There are a few small-scale floricane blackberry growers but no primocane fruiting (fall) blackberry producers in Minnesota. Delicious, locally-grown blackberries could be a nice alternative crop for the local farmers markets and local stores. However, most floricane fruiting blackberry plants are not hardy enough for Minnesota, especially for the extreme cold winter temperatures of northern Minnesota.

In 2008, we planted primocane fruiting raspberries in one of our NCROC high tunnels at Grand Rapids, and the project was very successful, resulting in the production of 154 lb of berries from our 21' x 48' high tunnel in the first year. We tried growing primocane fruiting blackberries in 2005-2006, but no berries matured in 2006 due to an early frost. Then, all the plants died after the winter of 2006/2007 when there was no snow cover. Inspired by our successful raspberry experiment and mindful of our unsuccessful experience with field primocane fruiting blackberries, we thought that

Figure 1. Site preparation in the high tunnel at Elm Tree Farm.

[1] *Current location of principal investigator is New Mexico State University, Dept. of Plant and Environmental Sciences, Box 3003 MSC 3Q, Las Cruces, NM 88003-8003, 505-852-4241, vaos@nmsu.edu. The new principal investigator is Terry Nennich, University of Minnesota, Extension Regional Center, 2900 University Ave., Crookston, MN 56716-5001, 218-280-7713, tnennich@extension.umn.edu*

Figure 2. High tunnel blackberries at Elm Tree Farm.

growing blackberries in a high tunnel might overcome our fall and winter climate issues. The high tunnel could extend the season for several weeks in the fall to allow the fruit to mature, and the warmer environment of the high tunnel in winter could protect the plants from winter damage. The goal of this project is to produce primocane fruiting blackberries in high tunnels in Minnesota.

If primocane fruiting blackberries could be grown successfully in Minnesota, they would be a good alternative crop for small farmers and could enrich the local community's diet. Also, blackberries are a high value crop and would generate some significant revenue for farmers in the fall. However, compared with fall raspberries, the commercial cultivars for fall blackberries are very limited, with only 'Prime Jan' and 'Prime Jim' available from University of Arkansas. Blackberry breeder Dr. John Clark from the University of Arkansas and Dr. Jim Luby from the University of Minnesota agreed that I should test some of their primocane fruiting blackberry selections at NCROC. At the same time, Tricia Bliska of Elm Tree Farm in Afton, MN, had an interest in planting high tunnel blackberries on her farm.

At Elm Tree Farm, Tricia will grow 'Prime Jan' and 'Prime Jim' organically on her farm. She ordered her plants from Nourse Farms, 'Prime Jan' as bare roots and 'Prime Jim' as tissue cultured plugs. She potted up the bare root plants and plugs while waiting for the new high tunnel to be ready. The FarmTek[2] 30' x 96' high tunnel was set up on June 5 and blackberries were planted on June 11, 2009. Tricia did not lose any plants after planting, compared with our experience at NCROC where last year's bare root raspberry planting resulted in 15-20% mortality.

Setting up the tunnel and planting often take longer than expected. Site preparation can be time consuming. From Figure 1, you can see that location for the high tunnel was sod. The soil was high in organic matter and would be managed organically. Tricia removed the grass hay only for the planting rows without disturbing the surface between rows. Pelletized poultry manure, rock phosphate, and potassium sulfate were amended into the rows as recommended from the soil test. Blackberry plants were transplanted from pots to the high tunnel at spacing of 2' between plants and 10' between rows. After planting, two T-tapes for irrigation were laid out for each row, and marsh hay was used to mulch the space within rows (Figure 2). A pressure regulator was set to 2 gal/hr and watering was done as needed, using a soil probe to test moisture at a 12' depth. Black geotextile (permeable fabric) was used to cover the space between rows at planting, and woodchips were laid on top of the geotextile in mid-September, 2009. Exhaust fans and a top vent were installed with thermostats set to open at 70°F. On August 7, insect screens were installed on both sides and at the north end for insect management. In general, plants grew well in the high tunnel in 2009 (Figure 2).

Blackberries were planted in the NCROC high tunnel on May 14 and in the field on May 22 using identical layouts. At NCROC, we would test 'Prime Jan', 'Prime Jim', MNPF 1001, MNPF1002, APF41, APF45, and APF48 with a traditional integrated pest management (IPM) program.

The NCROC high tunnel had been used to grow tomatoes, peppers, and lettuce in 2007, and a cover crop of Sudan grass in 2008. Soil samples were taken in March, 2009, and the site was tilled thoroughly before planting. In the tunnel, one-half of the recommended nitrogen (30 lb N/A of $Ca(NO_3)_2$ was applied before planting, with the rest to be added by fertigation.

Blackberry plants of 'Prime Jan', 'Prime Jim', APF41, APF45, and APF48 were received as small potted plants from Dr. Clark and plants of MNPF1001 and MNPF1002 were received as potted selections from Dr. Luby. Plants were spaced at 2' within rows and 7' between rows. Two T-tapes for irrigation were installed for each row in the high tunnel, and one T-tape was installed for each row of the field planting. The rest of the nitrogen for the high tunnel was added as weekly fertigation with Ca(NO3)2. Based on the soil sample results, Solubor (boron) was added at 9g/week in the fertigation solution for 6 weeks. However,

[2]*Inclusion of a trade or business name does not imply endorsement of that product or business by the Minnesota Department of Agriculture, nor does omission imply non-approval.*

Figure 3. Blackberries in the high tunnel and in the field at NCROC.

Field blackberries (9/18/09).

High tunnel blackberries (9/18/09).

the proximity of the T-tape to the plant roots caused boron toxicity in 2009. In the field, 60 lb N/A of Ca(NO3)2 was applied before planting.

Plants were watered approximately twice per week in the tunnel, based on soil moisture readings, and the field planting was watered as necessary.

In 2009, we measured plant growth, recorded temperatures inside the high tunnels and outside at both sites, and documented fertilizer and pesticide costs. We also sampled leaves for nutrient analysis in August, 2009.

Results

At NCROC, blackberry plants grew well both in the high tunnel and in the field in 2009 (Figure 3). Plants were much bigger in the high tunnel than in the field; however, due to the boron toxicity, the tips of some young canes showed damage with cupping leaves, burned leaf edges, or dead shoot tips. Some selections were more tolerant than others. Tables 1 and 2 show the plant growth measurements in the high tunnel. Leaf nutrient analyses were done for both high tunnel and field blackberry plants. The nitrogen level was quite high for plants in the high tunnel; therefore, the nitrogen application should be reduced in 2010.

In 2009, there were no significant pest or disease challenges in either the high tunnel or the field at NCROC. The plants had been infested with spider mites during the propagation period in the greenhouse and had been treated with predator mites repeatedly. While all plants were healthy at planting, we were concerned that there may have been some leftover mites on the plants and released 1,000 predator mites.

One problem that we did encounter was physiological in nature. We noticed symptoms of boron toxicity due to the placement of the Solubor in the fertigation mixture too close to the plant roots. We stopped adding it, and based on this experience, we suggest that the best way to supply boron fertilizer is to use a preplant application or side dressing. Later, part of the new growth recovered, and we hope that new suckers will show no symptoms next year. At the same time, the raspberry high tunnel was fertigated at the same rate but without noticeable symptoms. The possible reasons could be that the raspberry tunnel had 4 rows of plants which diluted the boron solution more than the 3 rows of blackberries or that the second year raspberries had more biomass than the first year blackberries which could have diluted the boron below the toxic level.

We did not harvest any berries in 2009. A limited number of flowers and fruits were noted, but there was not enough fruit to harvest. It seems that we need earlier and better cultivar selections than those that are currently available for primocane fruiting blackberries.

At Elm Tree Farm, blackberry plants also grew very well in 2009. The high tunnel tended to be too hot at the beginning; therefore, the owners installed roof vents and fans in mid-July. Around July 20, the plants were infested with aphids. Horticultural oil, insecticidal soap (M-pede), and lady beetles were used to control the aphids. In early August, insect screening was installed to both sides and at the north end of the high tunnel. There were no other pest problems later in the season. The weed pressure was low at Elm Tree Farm due to the hay mulch in the rows. Blackberry plants kept growing until late October. There were some flowers and green fruits, but no harvest in 2009.

Table 1. NCROC High Tunnel Blackberry Plant Height and Spread - 2009

	Height (in)				Spread (in)			
CULTIVARS:	**30-Jun**	**21-Jul**	**21-Aug**	**23-Sep**	**30-Jun**	**21-Jul**	**21-Aug**	**23-Sep**
APF-41	6.8 b*	12.8 b	21.1 b	26.8 b	10.9 bcd	20.8 ab	33.5 ab	47.8 a
APF-45	9.3 a	15.9 a	26.7 a	32.0 a	13.9 a	24.2 ab	35.9 ab	45.1 a
APF-48	7.3 b	11.1 bc	13.1 d	16.0 d	11.2 bcd	19.1 bc	25.0 cd	24.6 c
MNPF1001	7.0 b	10.8 bc	15.8 cd	17.7 cd	12.4 ab	16.0 c	27.8 bc	33.0 bc
MNPF1002	4.8 c	9.0 c	15.6 cd	17.9 cd	9.9 cd	14.6 c	20.6 d	23.4 c
'Prime Jan'	7.9 ab	12.3 a	19.2 bc	21.8 c	12.0 abc	21.6 ab	32.9 ab	41.8 ab
'Prime Jim'	7.1 b	10.9 bc	17.8 bc	18.7 cd	9.2 d	15.2 c	23.8 cd	32.1 c
ROWS:								
Row 1	7.3 a	11.2 b	17.3 b	19.5 b	10.7 b	16.6 b	26.3 b	32.4 a
Row 2	6.8 a	11.3 b	18.1 ab	21.6 ab	11.3 ab	18.6 ab	28.6 ab	35.8 a
Row 3	7.5 a	13.0 a	20.0 a	23.5 a	12.1 ab	21.0 ab	30.6 ab	38.1 a

**Numbers followed by the same letter do not differ significantly.*

Table 2. NCROC High Tunnel Blackberry Branching

	Branches (average #)			
Cultivars:	30-Jun	21-Jul	21-Aug	23-Sep
APF-41	1.6 ab*	2.2 a	2.7 b	4.0 b
APF-45	1.6 ab	1.8 abc	4.0 a	4.8 a
APF-48	1.8 ab	1.9 abc	2.3 b	3.0 cde
MNPF1001	1.2 b	1.2 c	2.7 b	3.2 cde
MNPF1002	1.7 ab	1.7 abc	2.2 b	2.4 e
'Prime Jan'	1.2 b	2.0 abc	3.1 ab	3.7 bc
'Prime Jim'	1.2 b	1.6 bc	2.7 b	2.9 de
Rows:				
Row 1	1.3 a	1.9 a	2.8 ab	3.4 ab
Row 2	1.5 a	1.7 a	2.5 b	3.1 b
Row 3	1.5 a	1.7 a	3.1 a	3.7 a

**Numbers followed by the same letter do not differ significantly.*

The goal of the first planting year at both locations was to allow the blackberry plants to become well established. We are expecting a successful crop in 2010.

Management Tips

1. Allow adequate time to prepare and erect your high tunnel.

2. Pre-pot the tissue cultured plugs or bare-root plants if you could not plant them soon enough like waiting for the high tunnel to erect.

3. Tissue culture plants are highly recommended.

4. Be cautious with boron or other micronutrient application, especially if the nutrients are applied through fertigation.

5. Insect screen installation to the sides of the high tunnel was very helpful for pest management for the first season. We may need to leave it open for pollinators during blooming period in later years.

Cooperators

Patricia Bliska, Berry grower, Elm Tree Farm, Afton, MN
Dr. Jim Luby, Professor/breeder, Department of Horticulture, University of Minnesota, St. Paul, MN
Dr. John Clark, Professor/breeder, Department of Horticulture, University of Arkansas, Fayetteville, AR
Dr. Emily Hoover, Professor, Department of Horticulture, University of Minnesota, St. Paul, MN
Dr. Carl Rosen, Professor, Department of Soil, Water, and Climate, University of Minnesota, St. Paul, 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: *http://hightunnels.cfans.umn.edu*

University of Minnesota North Central Research and Outreach Center. High tunnel raspberry production research. Website: *http://ncroc.cfans.umn.edu/High_Tunnel_Research2.html*

A Comparison between Cornstalk and Soybean Straw for Bedding Used for Hogs and Their Relative Nutrient Value for Fertilizer

Principal Investigator

John Dieball
33406 – 230th St.
Henderson, MN
56044
507-317-5522
jdballus@yahoo.com
Sibley County

Project Duration

2007 to 2009

Award Amount

$6,300.00

Staff Contact

Wayne Monsen
651-201-6260

Keywords

composting, cornstalk bedding, fertilizer values, hoop barns, soybean straw bedding

Project Summary

In this project, I compared cornstalks to soybean straw to determine which makes the most effective bedding material for hogs in hoop houses. I evaluated the two materials in terms of keeping the animals dry, how easily the material can be put into and removed from the hog hoop barns, the ease of composting, and the nutrient values they provide as fertilizer.

Project Description

I have two hoop barns that hold 175 hogs each. There is a 20' cement pad in each barn for the waterers and feeders. The majority of the barns are dirt based where the bedding is used.

One hoop house was bedded with cornstalks and the other with soybean straw. The bales were 4' x 5' round bales. I kept track of the bales used, how long it takes to clean the barns, temperature of the compost piles, how long it takes to compost the bedding, and the nutrient values of the compost.

2007 Results

I bedded one hoop barn with corn stalks and the other with soybean straw for each batch of hogs. After the hogs were sent to market, I cleaned the barns and composted the manure from each of the barns.

Bedding:
I used 39 soybean straw and 43 cornstalk round bales for bedding in 2007. Using the Versatile 9030 tractor, I put two round bales each week into each barn. I spread the bedding around a little. It took me about 20 minutes to do the bedding.

I noticed some differences between the soybean straw and cornstalks as bedding. Soybean straw absorbed moisture better than the cornstalks, so I used a few more cornstalk bales. However, the soybean straw bedding is more difficult to clean out of the hoop than cornstalk bedding and rolls up and holds its shape making it difficult to remove without a grapple on the bucket. The cornstalks broke apart and were removed easily with the bucket.

Cleaning a hoop barn took between 2.5 and 3 hours using the Versatile with a rock bucket. The rock bucket is deeper and larger than the factory bucket. I do not have a grapple for the

Removing bedding with the Versatile 9030.

bucket, but I plan to get one. I found the Versatile 9030 too large to clean next to the walls. I cannot feel the wall when I get close and I hit the wall a few times. I plan to use a skid loader to clean next to the walls.

Composting:
As I removed the bedding from the hoop barns I made compost piles of 20' x 20' x 10' high, one pile from the soybean straw and another pile from the cornstalks. I have found that piles of this size are much easier to turn and, if the piles are much larger, they have a tendency to get too hot and potentially start on fire. I turned the piles three or more times a week with the Versatile. I turned from one side one week and turned from another the next week.

The composting process is different for the two bedding types. The cornstalks heat-up really fast and will get over 200°F. When the pile gets this hot, I fill the bucket with water and dump it on top and then turn the pile. This helps keep the pile from getting too hot and burning. The cornstalk piles stay quite hot for 7 to 10 days and then cool down to 90°F and remain at that temperature for a few more weeks and break down to dirt. When the cornstalks looked like dirt, I sent the compost to the lab to see what the nutrient analysis was. The cornstalks had an analysis of 25 lb/ton for nitrogen, 45 lb/ton phosphorus, and 3 lb/ton potassium (Table 1).

The composting process for the soybean straw is much different than cornstalks. The soybean piles did not heat-up as fast or get as hot as the cornstalks. The hottest the soybean piles have gotten is 175°F. The piles stay at this higher range longer, sometimes 3 to 4 weeks. The soybean straw does not breakdown to dirt like the cornstalks do. After 6 months in the piles, you can still see stalks and hulls of the soybean plants. The nutrient analysis for the soybean compost is also different than the analysis for the cornstalks (Table 1).

I used two types of manure spreaders to spread the compost on crop fields, a Hesston 390 box spreader and a Meyers 3954 with an auger. The Hesston worked better to spread a more even amount of compost. I wanted to apply the compost using sound agronomic rates so I tried determining application rates by spreading on a tarp over a measured area. However, I could not get a consistent weight and I spread by looking at how much was applied.

The two compost materials look much different when applied. The cornstalk compost looks like dirt and therefore is not easy to see when applied to soil. For the cornstalk compost I tried to spread the material so that it covers the soil with a light coating. The soybean compost still has a lot of stalks and hulls so it can be seen when applied. To apply enough soybean stalk compost I spread it quite thick. The soybean compost often spread in clumps which would bunch up in piles when worked into the soil with the harrow. To try to improve the soybean straw breakdown I am going to try a finer straw chopper on the combine in 2008.

Table 1. 2007 Nutrient analysis of cornstalk and soybean straw compost.

Nutrient	Cornstalks	Soybean Straw
Nitrogen	25 lb/ton	9 lb/ton
Phosphorus	45 lb/ton	44 lb/ton
Potassium	3 lb/ton	38 lb/ton

I am looking at options for applying the compost. I would like to place the compost directly in the row by deep banding the compost. Using an air system on the fertilizer boxes on the planter may work well to place the compost directly in the row.

2008 Results

Two significant changes were made in 2008. The first was that the first group of hogs was older than usual, weighing an average of 125 pounds when they arrived. Consequently, this group spent less time in the barns than the second group which made for less bedding and smaller compost piles.

The second significant change was that I used a 1680 Case IH combine with a rotary stalk chopper for the soybeans this year. The straw was chopped much finer and was easier to work with than the longer stemmed straw used in 2007.

Bedding:
In 2008, the number of bales used for the first group was 25 cornstalk and 29 bean straw bales, and 50 cornstalk and 55 bean straw bales for the second group. The first group used less bedding because they were in the barn for a much shorter length of time. The second group used more than in 2007 because they stayed in the barn a couple weeks longer.

The finer bean straw is a lot easer to work with than the long vine bean straw. It spreads out easier as bedding and is a lot easier to remove from the barn while cleaning.

I used the Versatile 9030 again to clean the barns. In addition, I used a tracked skid loader to help with cleaning one barn. This skid loader worked much better than the larger 9030 tractor because it is so much more maneuverable. However, it still took the same amount of time to clean the barn.

Table 2. 2008 Nutrient analysis of cornstalk and soybean straw compost.

Nutrient	Cornstalks (Group 1)	Soybean Straw (Group 1)	Cornstalks (Group 2)	Soybean Straw (Group 2)
Nitrogen	14 lb/ton	1 lb/ton	14 lb/ton	10 lb/ton
Phosphorus	19 lb/ton	15 lb/ton	49 lb/ton	14 lb/ton
Potassium	17 lb/ton	15 lb/ton	37 lb/ton	38 lb/ton

Composting:
The compost piles from the first group were much smaller but more manageable than the larger piles from the second group. The piles were 10' x 10' x 10' high instead of 15' x 17' x 10' for the second group. The smaller piles also tended to have lower nutrient levels than the larger piles (Table 2). This difference may be due to the length of time that the hogs were on bedding.

I would have liked to make the piles from the second group small, like the first group, but I did not have the space for more piles. The temperatures of the piles were very similar to those in 2007. However, the finer chopped soybean straw seems to heat more, reaching 185°F, than the longer stemmed straw used in 2007 which reached 175°F. The finer straw also breaks down into soil faster and you see less straw remnants after the heating process.

I used the Hesston 390 spreader again in 2008 and applied the compost on approximately 10 acres per spreader load. The spreading of the compost was very similar for both types of material this year. The finer chopped soybean straw was much easier to handle and spread than longer stemmed straw that I had in 2007.

2008 Corn Crop:
I applied compost on new rented land in the fall of 2007. This land was short of nutrients so I also added 100 lb/A urea to ensure enough nitrogen for the corn crop. I was pleased with the 190 bu/A corn yield on these acres.

2009 Results

I did not make compost in 2009 because I did not raise hogs due to the low hog market.

When I do put more hogs in the hoop structures I plan to make a few changes. I plan to mix the bales in the barn to have a 50-50% cornstalks and bean straw mixture. I would also like to try comparing the nutrient content of compost from a barn with fewer animals to see if the number of hogs makes any difference in the nutrient content of the compost.

Management Tips

1. Keep the compost piles smaller rather than larger. It is easier to manage smaller piles.

2. Turn the piles often, at least 3 times a week.

3. Keep the piles moist to help keep the temperatures from getting too hot and add water when temperatures approach 200°F.

4. Make compost on two separate concrete slabs. This will make it easier to turn the piles and protects the ground from getting muddy when water is added.

5. Use a straw chopper on the combine when combining soybeans. This makes a finer stemmed straw which handles and composts better than long stemmed straw.

6. A large tractor with a bucket works well for cleaning the majority of the hoop barn. Use a skid loader to clean along the walls.

7. Use net wrap to wrap the bales. This material breaks down in the composting process.

8. Sell compost to gardeners for increased income.

Cooperators

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

Project Location

From Belle Plaine take State Hwy. 25 north and west for 9 miles to Sibley Cty. 16. Go south on Cty. 16 (gravel) for 2.5 miles. Turn right on 230th St., the farm is the first on the right.

Other Resources

Integrated Livestock 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. Compost Barn Basics (PDF) website: *www.extension.umn.edu/dairy/05dairydays/CompostBarnBasics.pdf*

University of Minnesota Extension Service. Composting 101 Brochure. Power Point Presentation. Website: *www.blog.lib.umn.edu/mgweb/sherburne/composting.pdf*

University of Minnesota Extension Service. 2001. Hogs your way: Choosing a Hog Production system in the Upper Midwest. Pub. No. BU-7641-S. University of Minnesota Extension, St. Paul, MN, 612-625-8173 or 800-876-8636. Website (PDF): *www.misa.umn.edu/vd/publications/hogsyourway_2009.pdf*

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

University of Minnesota Extension Service. 2005. Using Manure and Compost as Nutrient Sources for Vegetable Crops. Pub. No. M1192. Website: *www.extension.umn.edu/distribution/horticulture/M1192.html*

10' x 10' x 10' high compost pile.

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

Principal Investigator

Dean Thomas
Grazing Management Specialist
900 Washington St. SW
Preston, MN 55965
507-765-3878 Ext. 3
Fillmore County

Project Duration

2008 to 2011

Award Amount

$18,176.00

Staff Contact

Mark Zumwinkle
651-201-6240

Keywords

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 proposed

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

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"x30") 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.

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

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**

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 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.

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

Seeding Method	Rye	Residue	Bare Ground
Aerial	35	45	20
Drill	13	29	58

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	21.0	166	0.13
4-24-09			
Corn silage	25.6	169	0.12
4-24-09			
Soybean	20.7	149	0.23
4-30-09			
Corn silage	23.0	145	0.29
4-30-09			

**Sample size = 30"x30".*

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 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.

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.

Grazing the hay field. Jeff Gillespie turned his cattle onto his 60 acre hay field on November 15 and they grazed for 15 days. The hay field was seeded with alfalfa and Italian Ryegrass. His herd consisted of 100 cows weighing 1,300 lb each and 2 bulls weighing 2,000 lb.

The average height of the forage prior to grazing was 11.5" and they grazed it down to 2.5". Using 4% of body weight to estimate daily forage consumption, the herd consumed approximately 40 tons of forage dry matter during the 15

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"x30" 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"x30" area.*

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.

days. Table 7 (see page 86) 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 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 7). The alfalfa crude protein was over 30.23%; ADF was 22.9%; and NDF was 30.46%. 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 second 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 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

Table 7. 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.*

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.

Plans for 2010 Season

We plan on doing soil samples in winter rye fields at three depths to look at nitrogen retention and on doing alfalfa plant populations counts in the grazed alfalfa fields.

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. 1/2 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*

Samples, David H. and Mark R. Sulc. Winter Rye for Extending the Grazing Season. Ohio State University Factsheet AGF-02-00.

Thornton, Jane. 2004. Stockpiled Forages. In: Proceedings from Manitoba Agronomists Conference 2004: 132-135.

Volesky, Jerry D., Don C. Adams, and Richard T. Clark. 2002. Windrow Grazing and Baled-Hay Feeding Strategies for Wintering Calves. 2002. Nebraska Beef Cattle Reports: 17-19.

Other Resources

Forage Info: *www.forageinfo.com*

Forage Information System: *http://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: *http://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*

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

Principal Investigator

Dr. Ryon S. Walker
University of Minnesota Extension
550 Bunker Lake Blvd. NW
Andover, MN 55304
763-767-3847
Walke375@umn.edu
Carlton and Itasca Counties

Project Duration

2008 to 2010

Award Amount

$24,960.00

Staff Contact

Wayne Monsen
651-201-6260

Keywords

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

Project Summary

This project evaluates annual forages and forage establishment methods for grazing in winter feeding areas. Winter feeding areas for beef cattle typically create buildup of manure that is often underutilized during the forage growing season and can cause some concerns with manure contaminated runoff into waters of the state. Due to the nature of most annual forages, their vigorous growth characteristics can compete with potential weed establishment in these winter feeding areas. This project will be conducted at two producer farms and on two sites at the University of Minnesota research center in Grand Rapids. The winter feeding sites will be moved around the farms each year.

We want to demonstrate that by establishing annual forages in these winter feeding areas, a producer can eliminate the additional cost and labor of hauling manure from these feeding areas out to pastures and use the nutrients available for newly seeded forages. By comparing three different seeding methods with a cool and warm season annual forage, our goal is to evaluate the effectiveness and efficiency of these forage establishment systems so that we can 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 improved cool season grass/legume mix pastures grown on a clay soil, while intensively managing improved grass/legume

Ryon observing the conventionally seeded BMR sorghum-sudangrass on the Sandy Hills Ranch winter feeding area.

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. There are two sites at NCROC, South Farm and Main Farm.

Because the forage growing season is short in the Upper Midwest, beef cattle are typically fed in smaller, more confined areas for an extended period of time during the winter months. The feeding of cattle in a confined area creates excessive manure buildup. Manure buildup is a concern because it can lead to manure runoff into waters of the state. Most producers haul off the manure for fertilizer in pastures; however, this is not a very cost effective practice. By establishing annual forages in these winter feeding areas, a producer can greatly reduce manure hauling out to pastures and use the nutrients more efficiently for newly planted forages. Annual forages are of interest as they express characteristics for vigorous growth and can compete with weed growth in these wintering areas, providing a substantial amount of forage to alleviate grazing pressure on other pastures.

At each of the locations, there were six treatments established. We evaluated two forage species (cool season annual ryegrass and warm season Brown Mid Rib (BMR) sorghum-sudangrass) using three different forage establishment methods: conventional seeding (with heavy tillage), no-till inter-seeding, and broadcast seeding followed by light tillage for seed incorporation into the soil. Treatment sizes ranged from .5 acres to 3 acres in size.

In 2009, a separate experiment was conducted at the NCROC Main Farm evaluating only conventional tillage and no-till inter-seeding of annual ryegrass and sorghum-sudangrass on either a heavily wintered area or a sod base where no winter feeding was allowed.

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

Evaluation of stand establishment was measured in early summer to determine if the annual forage used and the seeding methods were successful. During the forage growing season, forage yield, prior to cattle turnout, and stocking rate data were collected for all three locations, based on forage establishment success. If stand establishment was less than 50% in a particular treatment, forage yield was not collected. 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

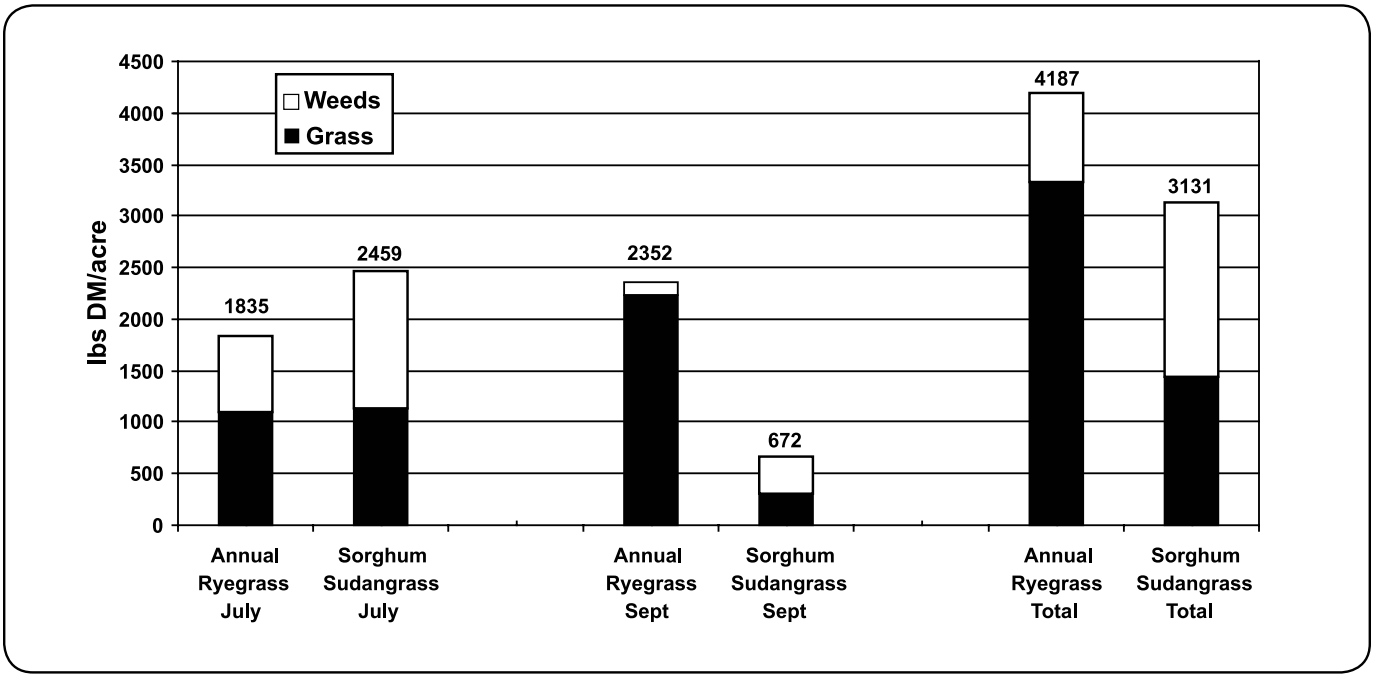
Soil samples were collected from each pasture at each location to establish critical soil nutrient values prior to pasture establishment in May. The concentrations for phosphorus (P) and potassium (K) ranged from 45 to 230ppm (P) and 300 to 2,200ppm (K) and were well above the maximum levels (P=21ppm 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 at B&G Ranch with 70%, 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.

Figure 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.***



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.

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

	Broadcast		Inter-seeding		Conventional	
Project Location	**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 1). Inter-seeding and conventional tillage in general had good success while location impacted species success. Annual

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.

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.

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 2). As a reminder, if stand establishment was less than 50% in a particular treatment, forage yield was not collected. As with 2008, the

Table 2. Total 2009 season forage yields for all treatments at each site.

	Broadcast (lb dry matter/A)		Inter-seeding (lb dry matter/A)		Conventional (lb dry matter/A)	
Project Location	**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.

Table 3. Number of animal unit months for each treatment at each location in 2009.

	Broadcast		Inter-seeding		Conventional	
Project Location	**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*)	0		12.0	0	11.1	6.7

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

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 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 tilled at the same time as the annual ryegrass treatments, however were seeded 8 to 44 days later. 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 3). 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/acre to get the value of standing hay (Table 4).

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/acre (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 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.

Management Tips

1. Inter-seeding appears to be a good low-cost option but will depend on exposure of soil, reducing sod competition, and winter feeding management.

2. Match up your goals to the advantages of each forage species you are considering. Both warm and cool season annuals have different advantages.

3. 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.

4. Managing winter feeding areas by rotating the feeding sites evenly throughout the feeding area offers many advantages: exposure to more soil increases success for newly seeded forages, reduces buildup of manure and run-off, and improves efficient use of manure for forages to be seeded vs. hauling off manure.

Cooperators

Troy Salzer, Sandy Hills Ranch, Producer and Extension Educator, Barnum, MN
Bob Staskivige, B&G Ranch, Producer, Bovey, MN
Russ Mathison, University of Minnesota North Central Research and Outreach Center, Agronomist, Grand Rapids, MN
Paul Peterson, University of Minnesota Department of Agronomy and Plant Genetics, Agronomist, St. Paul, MN

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.

The NCROC *Main Farm* is located 1.5 miles northeast of Grand Rapids on Hwy 169. Take left at second entrance to Itasca Community College (U of M Extension Service and North Central Research & Outreach Center).

Table 4. The value of standing forage, after seeding and harvesting costs, for each seeding method at each location in 2009.

	$/A					
	Broadcast		Inter-seeding		Conventional	
Project Location	AR*	SS*	AR*	SS*	AR*	SS*
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*)	0		201.05	- 55.20	162.92	66.88

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

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

New Demonstration Grant Projects - 2010

Alternative Crops

Tree/Shrub Establishment by Direct Seeding on Red Clay Soils

Carlton County SWCD
Brad Matlack
PO Box 29
Carlton, MN 55718
218-384-3891
bradmatlack@carltonswcd.org
Carlton County
Award amount: . . . . . .$3,704.00 for 3 years

We will evaluate three direct seeding methods for hardwood, conifer, and shrub mixtures on red clay soils in the Lake Superior Watershed. Traditional methods of establishing trees by transplanting seedlings on old fields for buffers to control erosion and stabilize slopes has often resulted in failure or poor stand establishment. While direct seeding on cropland and old pasture land is commonly used in southern Minnesota for regenerating woodlands, we do not know of any direct seeding of trees and shrubs being done in northeast Minnesota on crop or pasture land.

Cropping Systems and Soil Fertility

Fertilizing with Alfalfa Mulches in Field Crops

Carmen Fernholz
2484 Hwy. 40
Madison, MN 56256
320-598-3010
fernholz@umn.edu
Lac Qui Parle County
Award amount: . . . . . .$9,056.00 for 3 years

Providing the nutrient needs of corn and small grain on an organic farm without livestock is a challenge. I want to determine if on-farm produced alfalfa hay can provide an adequate and reliable source of nitrogen for growing corn and small grains in an organic system. I will also determine the efficiency of recycling farm-produced nutrients through the mulch process. In the spring, alfalfa hay will be green chopped, analyzed for nutrients, and spread with a manure spreader as a mulch prior to planting corn. I will also look at the feed quality of the grain, weed counts after last cultivation, plant tissue analysis for fertility levels, as well as comparing the economics of using alfalfa as a fertilizer vs. selling it as hay.

McNamara Filter Strip Demonstration

Goodhue County SWCD
Beau Kennedy
104 3rd Ave. E.
PO Box 355
Goodhue, MN 55027
651-923-5286
bkennedy@goodhueswcd.org
Goodhue County
Award amount: . . . . . .$7,094.00 for 3 years

Buffers and waterways are important for soil and water conservation on farms in southeastern Minnesota. Buffers can also be seen as an income generator for the farm. This project will measure associated environmental and economic costs and benefits for establishment of traditional cool season grass mixes and native grass mixes along public waterways. We will measure the biomass and relative feed values for livestock needs for each buffer seed mix.

Optimizing Alfalfa Fertilization for Sustainable Production

Doug Holen
220 Washington Ave. W., Ste. 201
Fergus Falls, MN 56537
218-998-5787
holen009@umn.edu
Otter Tail County
Award amount: . . . . . .$7,926.90 for 3 years

Alfalfa is a key component of sustainable cropping systems in Minnesota. Potassium, boron, and sulfur are three fertilizers that are commonly recommended for alfalfa production. However, the amounts and timing of these fertilizers are not well researched. In this project, we will test the timing and various amounts of potassium, boron, and sulfur on alfalfa. We will measure the response of the alfalfa to the amendments, collect yield, plant persistence, and vigor data, and calculate the economic returns of the different trials.

Energy

On-farm Horizontal Gasification Demonstration Project

Brian Borgen
362 Rice St.
Hendrum, MN 56550
218-861-6511
dborgen@loretel.net
Norman County
Award amount: . . . . . .$7,984.00 for 3 years

I will develop an automated, on-farm gasification system that uses different types of feedstocks such as yard waste, sugar beet pulp, native grasses, crop residue, and livestock manure. This gasification system will add value by lowering costs for energy needed for grain drying, heating, and electrical generation. The biochar that is left after gasification will be tested as a soil amendment to see if it stabilizes soil pH and increases soil fertility and water holding capacity.

Fruits and Vegetables

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

Judy and Steve Harder
1310 Mountain Lake Rd.
Mountain Lake, MN 56159
507-427-3200
jubilee@mtlake.org
Cottonwood County
Award amount: . . . . . .$6,000.00 for 3 years

The goal of this project is to discover which ethnic vegetables are adaptable to season extension practices. We will use a movable high tunnel and quick tunnels to research specific Asian and Latino vegetables such as bok choi, Asian greens, eggplant, and peppers in year-round production.

Comparison of Growing Strawberries Inside a High Tunnel with Strawberries Grown Outside for Quality and Input Costs

Debbie Ornquist
39995 State Hwy. 32 NE
Middle River, MN 56737
218-222-3540
mornqst@wiktel.com
Marshall County
Award amount: . . . . . .$5,000.00 for 3 years

I plan to determine the most economical way to grow day-neutral strawberries by comparing three growing methods inside a high tunnel with the standard practice of growing them outside. The three methods are: hydroponic, in grow bags, and in the soil. Production will be measured and crop quality compared from each growing method. I will also determine which varieties perform well in each growing situation.

Solar Energy Storage and Heated Raised Beds

Diane and Charles Webb
23750 State Hwy. 29
Henning, MN 56551
218-640-3276
Diane@GardensGourmet.com
Otter Tail County
Award amount: . . . . . .$8,000.00 for 3 years

We plan to extend the growing season on our vegetable farm by using solar collectors to heat water, and then run heated water through a series of PEX-AL-PEX tubing in raised beds. We will store the heated water in an underground, insulated storage area so that we can pre-heat the soil and continue to heat the soil during long cool spells during the spring. By heating the soil beneath two beds, and on top of the soil on the other two beds, we hope to lengthen our marketing season by 40-60 days and supply more vegetables to our customers during the peak selling season of July and August.

Livestock

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

Lori Brinkman
18980 – 102nd St.
Young America, MN 55397
952-467-3157
elmbrink@earthlink.net
Carver County
Award amount: . . . . . .$8,000.00 for 3 years

In this project we will implement a low stress, intensive rotational grazing system for two heritage pig breeds, Large Black and Red Wattle. We plan to supplement the grazed forage with milk whey and finish with a diet that includes acorns. We will secure agreements to harvest fallen acorns from oak pastures or rural residential developments and develop a method to collect them. Our goal is to determine the optimum acorn feeding rate when combined with a diet of milk whey to raise pigs to market weight and to maximize flavor.

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

Cindy Hale and Jeff Hall
6534 Homestead Rd.
Duluth, MN 55804
218-525-0094
cmhale@d.umn.edu
St. Louis County
Award amount: . . . . . .$4,000.00 for 3 years

We want to determine the impacts of grazing two broiler chicken breeds, Cornish Cross and Red Broilers, on pasture rejuvenation when the pasture is only grazed or is grazed and seeded. The goal is to increase botanical diversity and abundance of clovers to enhance the quality of poultry forage. We will also determine which breed uses feed the best and is more economical to grow on pasture.

Fall Forage Mixture for Grass Finishing Livestock Late in the Fall

Troy Salzer
310 Chestnut Ave.
PO Box 307
Carlton, MN 55718
218-384-3511
salze003@umn.edu
Carlton County
Award amount: . . . . . .$10,000.00 for 3 years

The goal of this project is to demonstrate an economically efficient way to grass finish beef in late fall. This will be done by grazing immature corn in mid-August and mid-September, after the cattle are out of the perennial pasture rotations. After the corn is grazed, a fall forage mixture of turnips and oats will be sown to be grazed later in the fall. This late forage mixture will also take up nutrients that would be lost to runoff and leaching.

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	

Final Greenbook Article	Title of Project	Grantee
	Using Key Farm Economic Ratios to Aid in Decision-making	Red Cardinal Farm
	Dry Edible Beans as an Alternative Crop in a Direct Marketing Operation	Bruce/Diane Milan
	Native Minnesota Medicinal Plant Production	Renne Soberg
1999	An Alternative Management System in an Organic, Community Supported Market	Candace Mullen
	Cultural and Management Techniques for Buckwheat Production and Marketing	Tom Bilek
	Pond Production of Yellow Perch	John Reynolds
1998	Establishing and Maintaining Warm Season Grasses (Native Grasses)	Pope County SWCD
	On-farm Forest Utilization and Processing Demonstrations	Hiawatha Valley RC&D
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

Final Greenbook Article	Title of Project	Grantee
2006	Gardening with the Three Sisters: Sustainable Production of Traditional Foods	Winona LaDuke
2005	Chickling Vetch - A New Green Manure Crop and Organic Control of Canada Thistle in 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

Final Greenbook Article	Title of Project	Grantee
2001	Applying Manure to Corn at Agronomic Rates	Tim Becket/Jeremy Geske/Dakota County Extension/SWCD
	Cereal Rye for Reduced Input Pasture Establishment and Early Grazing	Greg Cuomo
	Establishing a Rotational Grazing System in a Semi-wooded Ecosystem: Frost Seeding vs. Impaction Seeding on CRP Land and Wooded Hillsides Using Sheep	James Scaife
	Living Snow Fences for Improved Pasture Production	Mike Hansen
	Managing Dairy Manure Nutrients in a Recycling Compost Program	Norman/Sallie Volkmann
	Reducing Chemical Usage by Using Soy Oil on Corn and Soybean	Donald Wheeler
	Techniques for More Efficient Utilization of a Vetch Cover Crop for Corn Production	Carmen Fernholz
	Using Nutrient Balances to Benefit Farmers and the Environment	Mark Muller/IATP
2000	Forage Mixture Performance	Itasca County SWCD
	Inter-seeding Hairy Vetch in Sunflower and Corn	Red Lake County Extension
	Growing Corn with Companion Crop Legumes for High Protein Silage	Stanley Smith
	Legume Cover Crops Inter-seeded in Corn as a Source of Nitrogen	Alan Olness/Dian Lopez
	Surface Application of Liming Materials	Jane Grimsbo Jewett
	The Introduction of Feed Peas and Feed Barley into Whole Farm Planning	Ken Winsel
1999	CRP in a Crop Rotation Program	Jaime DeRosier
	Evaluating Kura Clover for Long-term Persistence	Bob/Patty Durovec
	The Winona Farm Compost Strategies	Richard J. Gallien
	Timing Cultivation to Reduce Herbicide Use in Ridge-till Soybeans	Ed Huseby
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

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

Final Greenbook Article	Title of Project	Grantee
	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
2007	Testing the Potential of Hybrid Willow as a Sustainable Biomass Energy Alternative in Northern Minnesota	Dean Current
Fruits and Vegetables		
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

Final Greenbook Article	Title of Project	Grantee
2001	Bio-based Weed Control in Strawberries Using Sheep Wool Mulch, Canola Mulch and Canola Green Manure	Emily Hoover
	Biological Control of Alfalfa Blotch Leafminer	George Heimpel
	Cover Crops and Living Mulch for Strawberry Establishment	Joe Riehle
	Sustainable Weed Control in a Commercial Vineyard	Catherine Friend/Melissa Peteler
1999	Development of Mating Disruption and Mass Trapping Strategy for Apple Leafminer	Bernard/Rosanne Buehler
1998	Alternative Point Sources of Water	Joseph/Mary Routh
	Comparison of Alternative and Conventional Management of Carrot Aster Leafhoppers	MN Fruit & Vegetable Growers Association
	Jessenland Organic Fruits Project	MN New Country School
	Propane Flame Weeding Vegetable Crops	Jean Peterson/Al Sterner
	Soil Quality Factors Affecting Garlic Production	Tim King
	Wine Quality Grapes in Otter Tail County	Michael/Vicki Burke
1997	Community Shared Agriculture and Season Extension for Northern Minnesota	John Fisher-Merritt
	Living Mulch, Organic Mulch, Bare Ground Comparison	Dan/Gilda Gieske
Livestock		
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

Final Greenbook Article	Title of Project	Grantee
2004	Comparing Performance of Hoop Buildings to an Older Conventional Building for Finishing Hogs	Kevin Connolly
	High Value Pork Production for Niman Ranch Using a Modified Swedish System	David/Diane Serfling
	Low Cost Fall Grazing and Wintering Systems for Cattle	Ralph Lentz
2003	Can New Perennial Grasses Extend Minnesota's Grazing Season	Paul Peterson
	Enhancement of On-farm Alfalfa Grazing for Beef and Dairy Heifer Production	Dennis Johnson
	Farrowing Crates vs. Pens vs. Nest Boxes	Steve Stassen
	Forage Production to Maintain One Mature Animal Per Acre for 12 Months	Ralph Stelling
	High Quality – Low Input Forages for Winter Feeding Lactating Dairy Cows	Mark Simon
	Pasture Aeration and its Effects on Productivity Using a Variety of Inputs	Carlton County Extension
	Potential of Medicinal Plants for Rotational Grazing	Management Intensive Grazing Groups/Dave Minar
	Programmatic Approach to Pasture Renovation for Cell Grazing	Daniel Persons
2002	Adding Value for the Small Producers via Natural Production Methods and Direct Marketing	Peter Schilling
	Grazing Beef Cattle as a Sustainable Agriculture Product in Riparian Areas	Frank/Cathy Schiefelbein
	Improvement of Pastures for Horses through Management Practices	Wright County Extension
	Increasing Quality and Quantity of Pasture Forage with Management Intensive Grazing as an Alternative to the Grazing of Wooded Land	Michael Harmon
	Supplement Feeding Dairy Cattle on Pasture with Automated Concentrate Feeder	Northwest MN Grazing Group
	Viability of Strip Grazing Corn Inter-seeded with a Grass/Legume Mixture	Stephen/Patricia Dingels
2001	Annual Medic as a Protein Source in Grazing Corn	Joseph Rolling
	First and Second year Grazers in a Year Round Pasture Setting Served by a Frost Free Water System	Don/Dan Struxness
	Low Input Conversion of CRP Land to a High Profitability Management Intensive Grazing and Haying System	Dan/Cara Miller
	Reviving and Enhancing Soils for Maximizing Performance of Pastures and Livestock	Doug Rathke/Connie Karstens
	Whole System Management vs. Enterprise Management	Dennis Rabe
	Working Prairie – Roots of the Past Sustaining the Future	John/Leila Arndt

Final Greenbook Article	Title of Project	Grantee
2000	Converting a Whole Farm Cash System to Sustainable Livestock Production with Intensive Rotational Grazing	Edgar Persons
	Dairy Steers and Replacement Heifers Raised on Pastures	Melissa Nelson
	Establishing Pasture Forages by Feeding Seed to Cattle	Art Thicke
	Grass-and Forage-based Finishing of Beef, with Consumer Testing	Lake Superior Meats Cooperative
	Learning Advanced Management Intensive Grazing through Mentoring	West Otter Tail SWCD
	Low Cost Sow Gestation in Hoop Structure	Steve Stassen
1999	Deep Straw Bedding Swine Finishing System Utilizing Hoop Buildings	Mark/Nancy Moulton
	Extending the Grazing Season with the use of Forage Brassicas, Grazing Corn and Silage Clamps	Jon Luhman
	Home on the Range Chicken Collaborative Project	Sustainable Farming Association of SE MN
	Hoop Houses and Pastures for Mainstream Hog Producers	Josh/Cindy Van Der Pol
	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

Final Greenbook Article	Title of Project	Grantee
1996	Dairy Waste Management through Intensive Cell Grazing of Dairy Cattle	Scott Gaudette
	Establishing Trees in Paddocks	Dave/Diane Serfling
	Evaluating Pasture Quality and Quantity to Improve Management Skills	Land Stewardship Project
	Expanding into Outdoor Hog Production	James Van Der Pol
	Grazing Limits: Season Length and Productivity	Doug/Ann Balow
1995	Evaluating Diatomaceous Earth as a Wormer for Sheep and Cattle	David Deutschlander
	Intensive Controlled Grazing and Pasture Rejuvenation on Fragile Land	Lyle/Nancy Gunderson
	Intensive Rotational Grazing on Warm Season Grasses	Jim Sherwood
	Rotational Top-grazing as a Method of Increasing Profitability with a High-producing Dairy Herd	Alton Hanson
1994	Economics of Rotational Grazing vs. Row Crops	Harold Tilstra
1993	A Comparison Study of Intensive Rotational Grazing vs. Dry-lot Feeding of Sheep	R & K Shepherds
	Controlled Grazing of Ewes on Improved Pastures and Lambing on Birdsfoot Trefoil	Leatrice McEvilly
	Improving Permanent Pastures for Beef in 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 2010

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 330 farmers have borrowed over $3.5 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.

Linda Bougie - Office Manager, has been working for the program since it began in 1988. Linda provides administrative clerical support to the staff and the program.

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, does word processing for the program, handles mail requests, and maintains the Sustainable Agriculture Loan and Grant files.

Mary Hanks - Program Supervisor, works with staff to develop project goals and implementation strategies. Mary's training is in plant pathology with a research focus. She came to the MDA in 1990 from private industry.

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.

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	Mary Hanks	Wayne Monsen	Meg Moynihan	Mark Zumwinkle
Alternative Crops & Livestock			•	•	•
Community Supported Agriculture (CSA)		•		•	
Composting		•			•
ESAP Grants	•	•			
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					•

MDA's Sustainable Agriculture Staff

Left to right:
Mark Zumwinkle, Alison Fish, Jean Ciborowski, Meg Moynihan, Wayne Monsen, Linda Bougie, Mary Hanks

Visit the *Greenbook* online at

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.