Minnesota Department of Agriculture

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Final Performance Report

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Table of Contents

Project A- Enhancing the competitiveness of selected 3rd crops for domestic markets……..3
Project B- Specialty Crop Enterprise Management…….. 13
Project C- Maximizing the market for MN specialty crop production……...20
Project D- Expanding Opportunities for Local Specialty Crop Business in Lanesboro…….34
Project E- Building Local Markets for Local Farmers……...38
Project F- Growing farmers, growing farm-Big River Farms……....45
Project G- Impacts of Biochar Amendments on Specialty Crop Production…….…54
Project H- Development of Nitrogen Management Practices in MN & ND…….90
Project I- Expanding sales & consumption of specialty crops at farmers markets……...108
Project J- Connecting Specialty crop producers to institutional buyers to increase MN grown foods……118
Project K- Increasing GAP adoption through regional grower training……124
Project L – 7th Annual Immigrant and Minority Farmers Conference, February 2012 …....128

Appendix

Project A- Enhancing the competitiveness of selected 3rd crops for domestic markets……132
Project E- Building Local Markets for Local Farmers ……..201
Project G- Impacts of Biochar Amendments on Specialty Crop Production…….…203
Project H- Development of Nitrogen Management Practices in MN & ND……..261
Project I- Expanding sales & consumption of specialty crops at farmers markets……...281
Project J- Connecting Specialty crop producers to institutional buyers to increase MN grown foods ……..287
Project K- Increasing GAP adoption through regional grower training……291

<u>FINAL</u> PERFORMANCE REPORT

December 1, 2012 [Additions- March 5th, 2013]

PROJECT TITLE

Enhancing the Competitiveness of Selected 3rd Crops for Domestic Markets

PROJECT SUMMARY

Building from our previous work with 3rd crops, the goals of this project were to increase the competitiveness of fruits and vegetables for farm to cafeteria markets and to explore value added processing for hazelnuts, small fruits, vegetables and for other 3rd crops. As we bring this project to a close, we have met all the goals of the project and the activities are summarized in the following report.

In Minnesota and beyond there is growing interest in a variety of specialty crops. Currently, it is hard for other crops to compete-economically-with corn or soybeans. One of the biggest challenges production agriculture is facing is how to address agricultural nonpoint source pollution in a common sense way that minimizes economic risk to the producer. Rural Advantage staff have been working with 3rd crops since 2001 to assist in resolving these issues by identifying crops that can be strategically placed in the landscape to provide environmental benefit [cleaner water, habitat improvement, carbon sequestered, etc.]; that produce a commodity that has existing or potential market value; and that can position rural communities for growth in additional value added processing enterprises. Most of our previous work has been centered on establishing and growing 3rd crops which has reached a threshold where there is a need to advance by assisting growers to develop value added processing and connections to new and developed markets.

Rural Advantage has worked with hazelnut and small fruit growers to provide leadership in the development of the Minnesota Hazelnut Foundation. There are approximately 40 -50 small scale [< 20 acres] plantings across Minnesota. The hazelnut bushes are beginning to produce and there is a need to develop processing [harvest, husking, cracking, pressing, grinding] and identify and develop markets [local foods, white cloth restaurants, chocolatiers, etc.]. We have not been involved with vegetable marketing except to assist the expansion of the local farmers market. There is increasing interest from the growers to expand their market opportunities so we will be assisting with the development of a farm to cafeteria network in the Martin County area. Growers are excited about this effort and cafeterias are interested. We look forward to expanding our programming in this area. *The purpose of this project is to enhance the farmer competiveness of three distinct specialty crop areas by providing technical assistance to growers; market identification and development; connecting growers with markets; and assisting with the development of value added processing to meet market demand*.

PROJECT APPROACH

Rural Advantage worked with growers in southern Minnesota raising hazelnuts, small fruits, vegetables and other eligible 3rd crops to assist with direct sales, value added processing and identification of new markets. Consulting with existing and new vegetable and fruit growers Rural Advantage facilitated the development of a local farm to cafeteria network in the Martin County, MN area. We utilized a variety of methods to deliver this programming in Minnesota and provided assistance including one-on-one technical assistance to growers, technical workshops, seminars, 3rd Crop Walk-N-Talks, market research,

assistance with business plan development, limited grower grant writing assistance and as a "resource" connector for growers. Several of the growers Rural Advantage worked with, grow and sell multiple crops. Specialty Crop grant funds were not used for non-specialty crops. Funding from the McKnight Foundation and SHIP [Statewide Health Improvement Program] were used to cover staff time associated with non-specialty crops.

Rural Advantage worked with hazelnut and small fruit growers to provide leadership in the development of the Minnesota Hazelnut Foundation, a grower group of hazelnut growers. Jeff Jensen, Rural Advantage staff person, worked with the MN Hazelnut Foundation members as an Advisory Team for the hazelnut related efforts of this project. There are approximately 40 -50 small scale [< 20 acres] plantings across Minnesota. The hazelnut bushes are producing nuts and the development of processing [harvest, husking, cracking, pressing, grinding] and market development [local foods, white cloth restaurants, chocolatiers, etc.] were valuable to the growers. As their hazel bushes continue to produce, they will be able to meet market demands.

Rural Advantage had not been involved with vegetable marketing except to assist the expansion of the local farmers market. With increased interest from growers to expand market opportunities we assisted with the development of a farm to cafeteria network in the Martin County area. An Advisory Group of five growers was formed from the local grower group and helped advise the project on markets to be developed and opportunities to grow economic enterprises focused toward fruits and vegetables. Marketing assistance ranged from broader topics such as how to advertise your specialty crop, facilitating between growers and new cafeteria markets, developing and providing press releases and news articles on the growers, farmers markets and related topics to bring exposure to the growers. We developed and distributed 2,000 copies of a "grower guide." The grower guide was 11 x 17 size folded in fourths and was distributed at banks, churches, grocery stores and other places that people tended to frequent. The guide listed the growers we were working with and then gave a description of that growers operation, where they sold goods and how they could be contacted. This document was well received by consumers and resulted in increased sales, according to the growers participating.

One method to increase value of fruits and vegetables was to produce fruits and vegetables with a higher nutritional density. A very good method to measure this is using refractometer. This measures the Brix or sugar content in the plants juices and is an indicator of nutritional density. A chart indicates premium Brix scores for various vegetables. Consumers familiar with Brix scores can purchase higher quality foods when growers identify the Brix score in their produce when it is offered for sale. Rural Advantage provided education to growers and consumers and increase their understanding of the food value. We were able to offer three different sessions through our outreach efforts to inform, train in the usage of a refractometer and sample various fruits and vegetables with a refractometer score for comparison. In addition, we were able to purchase 20 refractometers and extraction tools at a discounted price to cost share with growers. Growers paid $50 per refractometer set with $50 per unit paid from the Specialty Crop Grant.

We were not able to progress to develop a labeling program in this area as growers were just getting themselves familiar with the refractometers and wanted to be more comfortable with their usage prior to developing a marketing plan for more nutrient dense foods. Growers are excited

about this effort and cafeterias are interested. We look forward to expanding our programming in this area in coming years.

Another purpose of this project was to enhance the farmer competiveness of three distinct specialty crop areas by providing technical assistance to growers; market identification and development; connecting growers with markets; and assisting with the development of value added processing to meet market demand. Building from our previous work on 3rd crops, we were able to assist growers with hazelnuts, small fruits, vegetables and other eligible 3rd crops on direct sales, value added processing and identification of new markets; and working with existing and new vegetable and fruit growers we have facilitated the development of a local farm to cafeteria network in the Martin County, MN area. We utilized a variety of methods to deliver this programming and provided assistance including one-on-one technical assistance to growers, technical workshops, seminars, 3rd Crop Walk-N-Talks, market research, assistance with business plan development, limited grower grant writing assistance and as a "resource" connector for growers.

During the project we were able to leverage our relationships from our past partners to identify new growers with resources [education, knowledge, equipment, etc.] to help elevate the overall effectiveness of achieving our goals. These growers were willing to share their expertise with other growers. Mechanisms we used to disseminate information included educational programming including meetings, field days and presentations. Site visits to their farm at critical times, such as pruning, pest treatment or harvest, were especially valuable. We were able to learn a lot about marketing effective processes for developing a successful farm to cafeteria program by talking with growers who were involved in similar programs outside of our immediate area. Talking and learning from them, including visiting their site, was very worthwhile and enable our staff to disseminate it out to our growers as was appropriate to their operation.

For the outreach and education components we drew from our resource base of people and organizations who were able to provide specific expertise on a given topic. This included several growers who were growing a specialized crop, University of MN faculty and staff, other nonprofits and business development organizations in the region. Rural Advantage has a contract with the University of Minnesota Extension for a Conservation Agronomist Extension position that is housed in our office. This person, Jill Sackett, leads the development and delivery of our outreach and education programming. Most of our consulting with growers is one on one, many times at their farm. Our staff facilitated bringing experts [financial, marketing, agronomy, etc.] to growers as specific issues came up and it was beyond our staff's capacity to answer. This outreach is complimented with group collaboration and discussion through:

- Grower Learning Group- This group is made up of our local growers who are interested in learning more. The group varies in number but generally is 12 -20 people. The group meets monthly from November through April. During the first meeting of the season the group discusses which topics they want to learn about and then Rural Advantage staff identifies and coordinates with the individual speakers for each meeting. Example topics include food safety plans, insurance, new varieties, marketing techniques or proper handling of produce after it is harvested.

- 3rd Crop Winter Series- Each winter Rural Advantage develops a four meeting series to inform growers on a variety of topics. The meetings are scheduled for every other Monday in February and March. 2012 was our 8th year of sponsoring this event. The meetings, held in Fairmont, MN, run from 9:30 to 3 or 4:00 depending on the topic and slate of speakers. The meetings are free and open to the public. Each of the four days has a theme and then the speakers that day present around that topic. For example, a marketing themed program has included: Economics of Grape Growing by Brigid Tuck, U of MN Extension; Marketing the MN Garlic Festival by Jerry Ford, Coordinator; Financial Management Tips for Specialty Crops and Small Businesses by Dale Nordquist, U of MN; Rural Development Programs for Small Business Owners by Paul Pierson, USDA Rural Development; and Fruit and Vegetable Harvest and Storage, Cindy Tong, U of MN Extension. Not every Winter Series meeting is associated with specialty crops, but is associated to Rural Advantage's 3rd crop efforts.

- 3rd Walk-N-Talks- Rural Advantage developed the "Walk-N-Talk" name in 2006 to represent field days that were developed to inform growers and others on a variety of crops, innovative practices, management techniques and other activities that are better suited to viewing and learning in the field, rather than in a classroom. Since 2006 we have developed and hosted Walk-N-Talks every year with 12 – 20 events held each year around the state of Minnesota. Events are held spring through fall. These are mostly single topic events, but periodically we do group two or three landowners together for an event. Examples of topics included over the years are grape production and management; hazelnut production, harvest and processing; season extension with high tunnels; pruning; decorative woody floral management; pollinators; and marketing garden produce to urban audiences. Like our winter series, not all of our walk-n-talks are for specialty crops as they include rural Advantage's broader repertoire of project work.

- Other educational events included meetings mostly related to a specific topic. For example, we hosted a workshop on "Scaling Up Local Foods" and brought growers together for a webinar on crop insurance and on high tunnel management. We also had a booth at FarmFest, a 3 day farm show in Redwood Falls, MN where we provided educational materials and information on our overall programming including our specialty crops. During the show the main specialty crop promoted was hazelnuts. We had samples of nuts, a plant that was propagated through mound layering and then management and production information for growing hazelnuts.

GOALS AND OUTCOMES ACHIEVED

We had three overarching goals of expected measurable outcomes as follows:

1.] Provide value added and marketing technical assistance to growers.

2.] Assist in connecting growers to new and developed markets.

3.] Assist growers with the development of value added processing.

Rural Advantage staff worked directly with growers in southern Minnesota throughout the project timeframe [November 1, 2010 to September 30, 2012] to provide the following:

1.] Provide value added and marketing technical assistance to growers.

Objective: The project will assist a minimum of 85 additional growers each year with marketing, value added and educational outreach on the targeted specialty crops.

Rural Advantage was able to meet this objective through the following activities:

- technical assistance through group or one to one consulting
    - held a monthly learning group [met 12 times x 18 attendees (ave.)= 216 people]
    - Marketing assistance to fruit, nut, vegetable growers [25 growers]
        - Researched and identified possible market opportunities. Informed appropriate growers and facilitated activities to try to get into those markets or identify gaps that needed to be met. Helped develop a marketing brochure, helped develop business plans, advised on business operational procedures, developed a meeting on food safety plans and assisted with development of food safety plans for growers, assisted with identification and development of decorative woody florals to local flower shops and a market in Nebraska. Identify markets for hazelnuts and small fruits. Assist with consolidation of hazelnuts from several growers to get enough to meet a specific market demand. Example is for a chef/restaurant or a special market event. Crop specific research to identify market opportunities for the grower.
    - One on one consulting with growers [46 people]
        - Assisted with business plans and operations, development of an advertising strategy, preparing their produce for various markets, how to prepare and display it to optimize sales. Visited their operation and advised how they might improve their farm system.
    - Facilitated two advisory groups – one on hazelnuts and one on fruits and vegetables- to provide direction on which market and value added ventures to pursue and develop
        - Group discussions and learning on marketing crops being raised by members. Developing strategies such as getting a higher volume of hazelnuts harvested, processed and sold. Working collectively to meet market demand. Rural Advantage lead and facilitated these efforts with the growers.
    - Over 66 different vegetable and fruit species were marketed at various venues
        - Markets that were utilized included on-farm sales, community supported agriculture shares, farmers markets, direct markets, fall harvest events, sales to cafeterias [daycare, school, senior living, nursing home] and sales from a farm stand at a local business.
- education/ outreach
    - 3rd Crop Winter Series --Specialty Crop Topics only [3 day long meetings -144 people]

- 3rd Crop Walk-N-Talks – Specialty Crop topics only [18 events- 275 attendees]
- Other education Events –Scaling up local foods, hazelnut meetings, brix measurements and conferences [90 attendees]
- Established and coordinated a five county Food Policy Council including a multi-sector facilitated meeting to determine priority issues
- Provided information on GAP [Good Agricultural Practices] and Safe Food Handling, offered training on these issues and are assisting three growers with developing a GAP plan for their operation.
- Farmers market and local food promotion, advertising, flyers, news stories and mailings supporting the purchase and support of local farmers growing specialty crops. [6 news stories, 18 Farmer's Market ads, 5 presentations at local civic groups, 3 flyers distributed]

- Facilitation
  - Coordinated Fairmont Community Gardens for two years – 145 free garden plots [20' x 20'] to community members. Advised about 25 first time family gardeners, experienced gardeners and farmer's market gardeners.
  - Facilitated between growers and cafeterias to supply fresh, local food to those markets. Worked with 13 cafeterias to buy from local growers during the project. Assisted with locating the growers to supply needed inventory.
- market development
  - Assisted with marketing and promoting 6 area farmer's markets each year. Activities included press releases, advertising, signage, advising growers on display methods, doing food sampling at the market and providing a merchant terminal for processing EBT, debit and credit cards at the Fairmont Farmers Market using tokens.

2.] Assist in connecting growers to new and developed markets.

Objective: a. The project will assist in connecting at least twenty five growers to at least ten new farm to cafeteria markets offering at least 30 products by the end of the grant period.

We were able to assist 28 growers to supply over 66 different products to 13 new cafeterias, 8 farmer's markets and specialty markets, such as decorative woody florals to area florist shops; hazelnuts to restaurants; and herbs to cafes and specialty markets during the project period.

Specialty crops marketed include:

o Asparagus	Kohlrabi	Cantaloupe
o Broccoli	Sweet Corn	Apples
o Beets	Pumpkins	Tomatoes
o Cabbage	Winter Squash	Cucumbers
o Carrots	Potatoes	Brussel Sprouts

- Cauliflower
- Fresh Herbs
- Grapes
- Sweet Potatoes
- Horseradish
- Rutabaga
- Zucchini
- Peas
- Yellow Wax Beans
- Pears
- Raspberries
- Gourds
- Flame Willow
- Hydroponic tomatoes
- Maple syrup
- Yellow Tomatoes

Radishes
Watermelon
Lettuce
Rhubarb
Spinach
Summer Squash
Sunflowers
Okra
Popcorn
Turnips
Red Potatoes
Golden Willow
Honey
Basil
Decorative Pumpkins
Grape vine

Eggplant
Peppers
Green Beans
Garlic
Parsnip
Onion
Cut Flowers
Strawberries
Plums
Honeydew Melon
Mini Pumpkins
Curly Willow
Bedding Plants
Hazelnuts
Grape Tomatoes
Bittersweet

Farm to Cafeteria and other Markets Utilized include:

1. Stepping Stones Learning Center
2. Sheri's in Northrop
3. Lakeview Health Services
4. Truman Senior Living
5. REM Heartland
6. Trimont Senior Living
7. Temperance Ridge
8. Edie's Restaurant
9. Mexican Restaurant (El Agave)
10. Bean Town Grill
11. St. James Lutheran School
12. Interlaken Golf Club
13. The Ranch Restaurant

1. Fairmont Farmer's Market
2. Dunnell Farmer's Market
3. Trimont Farmer's Market
4. Ward's Park Farmer's Market
5. Steve's Vegetable Stand
6. Brandt's Greenhouse and Truck Market
7. Welcome Farmer's Market
8. Sherburn Farmer's Market

Objective: b. The project will assist at least 30 farms with at least three direct marketing opportunities and identify at least ten value added markets by the end of the grant. Currently, there is only one grower direct marketing a value added product.

Rural Advantage worked with a diverse group of growers to meet this objective, assisting them with identifying market opportunities, helping to add value and develop the markets. Finding an appropriate balance between grower supply and market demand was, at times, a challenge. We had to anticipate demand for the coming year so growers had supply, but not too much extra supply so product was wasted. Some growers also sell products that are not specialty crops. Rural Advantage has other funding [The McKnight Foundation] that pays for staff time associated with these non-specialty crops.

Here is a list of the farms and the value proposition:

1. Don & Judy Moritz – Vegetables, hazelnuts, decorative woody florals; farmer's market & direct store sales
2. Countryside Gardens – Vegetables at farmer's market
3. Sue Wilkin – Cut flowers, arrangements, some vegetables; farmers market sales
4. Dean Maschoff – aronia berries, asparagus. On farm sales
5. Pat Murphy – sweet corn sold to area grocery store
6. KGE Farmers Market – vegetables; farmer's market and on farm sales
7. Ernie Hand – vegetables, apples – farmer's market and on farm sales
8. Judie Orr – on farm store
9. Center Creek Orchard – apples, pumpkins, tours, farm recreation & games; on farm
10. Lori Sukalski – vegetables; on farm and farmer's market
11. Mike Oltman – herbs, vegetables to specialty markets and farmer's market
12. Ann & Gary Jacobson – Vegetables and fruits; CSA and farmer's market
13. Rex Oberhelman – vegetables & fruits; on farm, direct to store, farmer's market
14. Sun Borchardt – vegetables – on farm and farmer's market
15. Sandy Kuhlers – jams & jellies; direct to stores, web store, farmer's market
16. Timberlake Orchard—fruits and vegetables; on farm store, farmer's market, direct
17. Abel Family Farms – vegetables; farmer's market, direct to customer, direct to store
18. Dan & Donna Maday - Vegetables - farmers markets, cafeterias, on farm
19. Corrine Wolner – vegetables; farmer's market
20. Bill Brandt – Bedding plants, vegetables; on farm store, delivery truck to local businesses when employee get off work; cafeterias
21. Deb Mertens – Hydroponic Tomatoes, Basil, herbs; direct to stores and café's
22. Steve Bulfer – vegetables; own vegetable stand at farm
23. Lorraine Tlam- vegetables; farmer's market
24. Kris Fuller- vegetables; farmer's market, direct to store
25. Norm Erickson – hazelnuts; on farm, cafeterias, specialty markets for roasted nuts, raw nuts, oil and press cake[meal]. Developed own cracking, husking and sorter for hazelnuts.
26. Steve Flohrs – grapes; developing a winery [small scale]
27. Roy Cerling – hazelnuts & maple syrup; sell to local farmer's markets and café's
28. Harlan & Joan Thilges- small fruits; developing fresh and juice markets locally
29. Neal Potthoff- vegetables; sell on farm and at farmer's markets
30. Landsteiner Family- vegetables & fruits; sell direct on farm

Objective: c. The project will assist at least five farms growing eligible 3rd crops with at least three direct marketing opportunities by the end of the grant. Currently, there are two growers direct marketing medicinal herbs and decorative florals.

i. Don & Judy Moritz – Woody Decorative Florals
    1. Farmers Market
    2. Hy-Vee Floral Shop
    3. J & R Drug & Gift
ii. Norm Erickson - Hazelnut oil

1. Lake City Restaurant
2. Off the farm – cosmetic oil
3. Riverbend Market

iii. Dean Maschoff
1. Aronia Berries
2. Asparagus

iv. Roy Cerling
1. Hazelnuts
2. Maple Syrup

v. Harlan & Joan Thilges
1. Aronia Berries
2. Other small fruits

vi. Pat Murphy
1. Sweet corn sales direct to HyVee

vii. Bill Brandt
1. Vegetable Sales to targeted markets [employees of large employers during shift changes]
2. Developing a processing area for preparing his produce for off farm markets on his farm. This includes washing, trimming and packaging. Developing a GAP plan to be able to sell to schools and other industrial markets.
3. Take orders on the web and then deliver to a local community once a week

3.] Assist growers with the development of value added processing.

The project will develop value added processing capabilities for hazelnut and small fruit growers by 3 each year of the grant. Currently, there are no opportunities available for these crops in the region.

Working with the MN Hazelnut Foundation and their member growers there were several advancements we were able to assist with relative to value added processing. Norm Erickson, hazelnut grower from Lake City, MN was a key cooperator as he was working on developing processing equipment for hazelnuts to prepare for the hazelnuts that were coming into production here in Minnesota.

Rural Advantage was able to provide him with business planning assistance; identify resources to secure a patent on his equipment; and assist with proof of concept, product testing and evaluation. Mr. Erickson has developed equipment for husking, sorting, cracking and a *system* for hazelnut processing from picking through finished product. His husking, sorting and cracking equipment he has secured patents on and is pursuing commercialization of them. His equipment is designed for hazelnuts and may be adaptable to other nuts. The machines he has developed will be less costly than the existing equipment on the market and especially with the cracking machine, much improved from what is currently available. These machines will have transferability to other nut crops as well and he is working to make adjustments and test these additional markets which

include walnuts and pecans. The MN Hazelnut Foundation members have been included in the discussions and equipment evaluations in collaboration with Mr. Erickson and Rural Advantage as these methods have developed.

Specific hazelnut markets developed include:

1. Husked Hazelnuts – In the Shell – sell at local farmer markets or from the farm
2. Cracked Hazelnuts – Kernels – sell to local café's or bakery's for cooking/food
3. Hazelnut Oil – sell to local café's, farmer's markets and massage oil
4. Press Cake- the hazelnut meal left after pressing the oil, used as a food additive/ flour in baking and cooking, selling to local markets, café's and bakery's
5. Hazelnut Nut- Roasted in an oven which enhances flavor, does a light roast and a heavy roast, sells to local markets and café's, bakery's
6. Hazelnut Shells – used for a fuel in a wood burner [self-utilized currently], ash is then applied to field where hazelnuts are grown. As the hazelnut industry grows, there will be a significant supply of shells which can have a value added market developed.
7. Husks – Mixed with leaves and applied as compost mulch to fields on Erickson farm. Husks contain an interesting 'juice' which may be able to be developed in the future as a special additive for certain products. Because there will be a significant supply of husks in the near future, this would be something to explore.
8. Hazelnut equipment developed
    a. Husker
    b. Aspirator
    c. Sorter
    d. Cracker – also can be used for other nuts such as walnuts and pecans

In addition to hazelnuts, Rural Advantage assisted with value added markets for:

- Small fruits into jellies/ jams/ juice for sale at local markets, grocery stores and on web, explore canning process to sell as a value added product
- Woody decorative florals- assisted with finding local florists who purchased for sale to customers or use in their arrangements. Sales for curly willow, dogwood, bittersweet and grape vines. Product was also sold at the farmer's markets with growers vegetables.
- Woody decorations are arrangements/designs/wreaths/hangings made from natural materials. Helped identify and develop markets for on farm sales.
- Developed written documents [attachments to this report] for the following topics:
    - Cracking the Processing Nut No. 1 Hazelnut Fact Sheet
    - Cracking the Processing Nut No. 2 [Adding Value Through Husking] Hazelnut Fact Sheet
    - Hybrid Hazelnut Production Guide
    - Woody Decorative Florals
    - Pick Your Own – A Case Study

BENEFICIARIES

Groups that will benefit from this project are mostly the 28 individual growers who are growing these specialty crops. They will benefit from increased sales due to increased markets in the immediate region [13 new cafeterias, 8 expanded farmers markets and new direct, specialty markets], increased knowledge to better prepare and deliver their produce in a safe manner, and increased consumer awareness of local food availability and support for local farmers. Input from participating growers indicate at least a doubling of market sales and five growers have sales > $3,000 annually with produce where they had no sales prior to this project.

The MN Hazelnut Foundation members and other hazelnut growers in the upper Midwest will benefit greatly from the developments of processing equipment and identification of café and bakery markets. The Midwest hazelnut industry is just on the verge of emergence. Rural Advantage assisted several growers with establishing hazelnut plantings in the mid 2000's. These plantings and others [about 50 acres in MN] are just starting to produce and reaching prime production. The thousands of pounds of hazelnuts that will be available annually will help fill the hazelnut gap which is currently supply from Turkey [country] or Oregon/Washington areas. Fresh, local hazelnuts will be very appealing to local taste buds. The advancement of the hazelnut industry will contribute at least $200,000 to the area economy in the next two years with jobs, nut sales and equipment sales.

LESSONS LEARNED

There are many different personalities to deal with as a person works on these types of projects. Rural Advantage staff enjoyed the opportunity to work with a wide variety of people, interests and goals. Our staff grew and learned probably as much, if not more, that the clients we worked with as we tried to assist them in meeting their personal goals with their specialty crop. Having staff cross trained was really a benefit when we had staff advance their own careers by accepting positions with other entities. This helped us get through critical times and being able to carry through the project.

The balance of supply and demand mixed with weather made for challenging times in supplying produce within a pre-planned time frame. At times there was too much supply and not enough

demand [consumers] but we tried to go with the ebb and flow. Increasing consumer purchasing of specialty crops is an area we plan to put more emphasis on in the future.

The hazelnut industry is coming along faster than we expected. This is a good thing, but there is much work to do in the areas of mechanical harvesting and developing larger markets.

We are seeing increasing requests from cafeterias for growers to have GAP certification or some other food safety plan before they will purchase from local growers. This is especially important for those wanting to sell to schools. We have been providing basic training on this through our education and outreach programming. We also have been working with a couple of growers to develop GAP plans for their operation. Most of our growers do not want to be commercial scale and are reluctant to go through the process so we are focusing on the larger growers in the short term.

CONTACT PERSON

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ADDITIONAL INFORMATION:

- **Project Budget and Expenses**
- **Documents Developed:** [attached]
  - 2011 3rd Crop Winter Series Meetings
  - 2011 3rd Crop Walk N Talks
  - 2012 3rd Crop Winter Series Meetings
  - 2012 3rd Crop Walk N Talks
  - Cracking the Processing Nut No. 1 Hazelnut Fact Sheet
  - Cracking the Processing Nut No. 2 [Adding Value Through Husking] Hazelnut Fact Sheet
  - Hybrid Hazelnut Production Guide
  - Woody Decorative Florals
  - Pick Your Own – A Case Study

Project B- Specialty Crop Enterprise Management

SUBMITTED BY: Meg Moynihan, Project Director, Minnesota Department of Agriculture, 651-201-6616, meg.moynihan@state.mn.us

PROJECT TITLE

Specialty Crop Farm Business Management (SCBG FY 10)

PROJECT SUMMARY

The purpose of this project was to improve the financial and business management literacy of specialty crop farmers in order to increase the competitiveness of existing or potential farmers who grow six target fresh market specialty crops: apples, berries, grapes, fresh market mixed vegetables, pumpkins, and sweet corn in Minnesota and to increase the overall competitiveness of specialty crop production in the state.

Minnesota agriculture is dominated by commodity cash crop and livestock production. However, increasing consumer interest in purchasing local– especially fruits and vegetables – has caught the attention of many. Specialty crop growers (and prospective growers) need reliable cost of production and profitability data in order to make informed decisions about whether to undertake these enterprises. While commodity crop performance is readily available from tools like the University of Minnesota Center for Farm Financial Management's (CFFM) FINBIN financial benchmarking database, real-world cost of production specialty crops is still lacking, putting specialty crop producers at a disadvantage.

This project built on previous SCBG funding by 1) increasing the number of growers participating 2) expanding the availability of financial benchmarking data for these crops; 3) developing and delivering business/financial education programming for specialty crop growers.

PROJECT APPROACH

We promoted this project using traditional and social media, as well as brochures, paid advertising in newspapers and newsletters, a display, and participation at conferences and workshops. In spring 2011 we reviewed, approved applications for, and provided scholarships to 53 growers of the targeted specialty crops (apples, berries, grapes, pumpkins, sweet corn, assorted vegetables). In Fall 2011, we awarded 43 scholarships. Because of lower than expected enrollment, we were able to provide 15 scholarships in spring 2012, as well. The total students reached by the program during this period was 70 (some enroll for two semesters each year, some for just one.)

These partial scholarships defrayed growers' cost to enroll in farm business management (FBM) education courses. Participating growers worked one-on-one with instructors, learning to keep and use farm records to make sound business management decisions for their farming operations. They received comprehensive year-end analyses that could've be used for tax preparation, discussions with lenders and enterprise planning. They did provide their data, stripped of all identifying characteristics, for inclusion

in the public farm financial database at www.finbin.umn.edu, which is available to growers, researchers, policy makers, and other members of the public and allowed the growers to benchmark their operations against other Specialty Crop growers of similar crops.

In Spring, 2011, CFFM made the data from 2010 availabe in FINBIN, and the MDA published a summary report (included in project annual report submitted in 2011). In Spring, 2012, CFFM posted the 2011 data, and MDA published a comprehensive report, *Minnesota Specialty Crops: An Analysis of Profitability & Performance 2008-2011*.

The project was successful at generating reportable data for all of the project target crops. (A minimum of five farming operations per enterprise is required in order for summary data to be made available.) We posted the 2008-2011 report online, promoted it directly to Minnesota Grown program's 1,000+ direct marketing members and with news releases to approximately 500 farm and rural media outlets and via electronic newsgroups and listservs. We distributed printed copies to participating growers, approximately 80 Farm Business Management (FBM) instructors and administrators, and at grower meetings and conferences.

We also impacted growers through a number of public workshops held in concert with partner organizations' events. Minnesota Grape Growers Association (MGGA) conducted a daylong grower education workshop in that combined financial and hands-on topics. About 44 people attended. Nearly 85% of those who attended said they would adjust their business plan or marketing practice based on what they learned in the session. The Minnesota Fruit and Vegetable Growers Association (MFVGA) offered a "Farm Business Management and Marketing" workshop at its 2011 annual conference. About 20 people attended. Attendees rated "usefulness of topic" as 4.25 out of 5.

We also used the MFVGA newsletter (circulation approx. 3,000) as an educational delivery tool, publishing five articles on business management, including, "*Whole Farm Statistics for Fruit and Vegetable Growers*," "*What is Farm Management*? *Using Partial Budgets to Make Decisions*, and *Using Financial and Productions Records to Make Decisions.* In addition, we disseminated information about the project and the data it generated at conferences such as, MFVGA Annual Conference, Sustainable Farming Association of Minnesota Annual Conference, and the Minnesota Organic Conference.

In Winter, 2012, Ridgewater College FBM instructors offered a six hour seminar for agricultural producers entitled "Business Workshop for Small and Specialty Crop Farms – How to Organize Your Farm Business." Approximately 30 people attended. The seminar included goal setting, recordkeeping, interpreting farm financial data, marketing, and business planning. Pre- and post surveys indicated that understanding of financial concepts increased from 1.85/4 to 2.38/4.

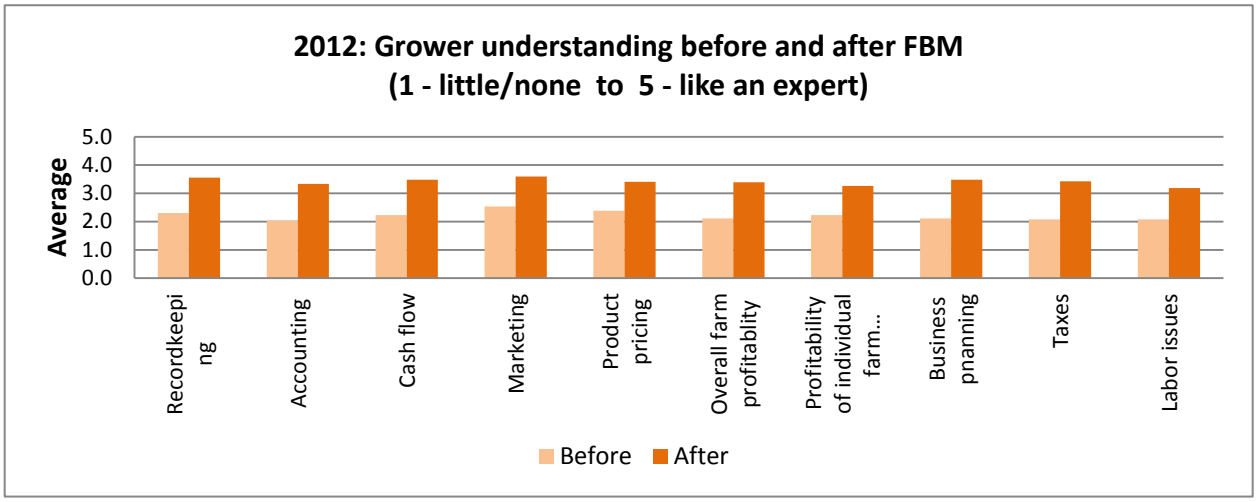
We evaluated the experience of participants enrolled in the Specialty Crop FBM program using surveys. In Spring, 2011, we conducted two surveys – one of growers enrolled in the program, another of their instructors. We repeated the grower survey in 2012.

In 2011, 31 growers responded (63% response rate). More than three quarters of respondents said they had used what they learned in FBM to make pricing or marketing decisions and to assess profitability. More than half used it to monitor cash flow and/or make planting decisions. More than a third used it at tax time. In 2012, 28 growers responded (45% response rate). This year, more of them (85%) said they used what they learned in FBM to assess their profitability. Three quarters still said they used the

inormation to make pricing or marketing decisions. This year, more than 60% used it to make planting decisions and at tax time. More than a third used it to monitor cash flow or when talking to lenders/investors.

In both years, all respondents said the program has helped their farming operaton, rating it of 3.38 in 2012 and 3.37 in 2012 (with 1 being "not helpful at all" and 4 being "extremely helpful.") In both years, nearly 90% gave it a "top box" rating of 3 or 4.

In 2012 we asked how FBM had impacted partcipating growers' knowledge in several specific areas:



In their survey (13 instructors responding for a 72% response rate), the instructors characterized their specialty crop students as highly motivated, and reported that about half of their students were interested in "scaling up" production of specialty crops (more crops, or more acres.) They rated recordkeeping, accounting, and evaluating profitability (whole farm and individual enterprise) as the most critical topics for their students. More than half said that access to more benchmarking data and mini-grants to develop innovative educational programming would be helpful.

The project partners contributed to this effort in a number of ways:

Minnesota Department of Agriculture (MDA): Coordinated project steering team. Led publicity and outreach efforts. Administered scholarship payments and subcontracts for educational programming. Produced *Minnesota Specialty Crops: An Analysis of Profitability & Performance 2008-2011*, the 20-page report summarizing detailed production and profitability data for seven specialty crops. Promoted and represented the project at grower conferences and trade shows.

Minnesota State Colleges and Universities (MnSCU): delivered farm business education to growers. Completed year-end financial analyses for participating operations and provided data to CFFM for synthesis and publication. Instructors at one college developed and delivered a stand-alone seminar described elsewhere.

Center for Farm Financial Management (CFFM): revised financial management software packages to accommodate specialty crops (e.g. charts of accounts). Synthesized and summarized data, prepared summary report for publication. Organized a workshop on financial management and special characteristics of specialty crop farms with a presentation by a specialty crop producer at the Minnesota Association of Agricultural Educators winter technology conference, 2011.

Others: MFVGA and MGGA provided farm business and financial educational sessions at meetings and conferences. In addition, MGGA published a series of FBM articles in its newsletter.

GOALS AND OUTCOMES ACHIEVED

1) **Benchmarking information regarding the comparative performance of the target specialty crop enterprises is available.** Data is available for all six target crops, exceeding target of five.

2) **Growers of the target specialty crops improve understanding of financial management production efficiencies.** 70 growers served, exceeding target of 50. 90% say program has benefitted their farming operation, exceeding target of 75%

3) **Educational sessions increase the financial management literacy specialty crop growers.** At 94, we missed our target of 100 attendees by six, however, when we count the number of MFVGA subscribers (3,000) who read one or of five educational articles we exceeded the target.

BENEFICIARIES

Project beneficiaries included:

70 growers of apples (8), berries (21), grapes (12), pumpkins(12), sweet corn (14), and/or assorted vegetables (20) who improved their farm business and financial acumen by working 1:1 with a FBM instructor.

94 specialty crop farmers or prospective farmers who improved their financial literacy by attending educational specialty crop business/financial events at conferences or stand-alone seminars.

3,000 readers of the *Minnesota Fruit and Vegetable Growers News*, who received educational articles in five issues of this publication.

30 farm business management instructors who increased their student load with specialty crop producers and increased their familiarity with this type of agriculture.

Center for Farm Financial management, whose financial management software (FINPACK) and reporting database (FINBIN) has improved capacity to handle data from specialty crop operations.

Minnesota Department of Agriculture, which improved its reputation as a supporter of farm diversification and specialty crop production by leading and being so visibly associated with this project.

Thousands of members of the public to whom specialty crop data is now available online or in print, in both summary reports at www.mda.state.mn.us/fbm and in the searchable FINBIN database at www.finbin.umn.edu

LESSONS LEARNED

Including a variety of stakeholders in project creation and "steering" results in programs that reflect broader experience and perspective, but are administratively challenging.

Many specialty crop growers are content with their current size and scale.

Specialty crop growers and their instructors agree about many areas where improved business/financial knowledge would be helpful.

While also referred to as "high value crops," specialty crops are neither consistently productive nor profitable.

The FBM education program, as currently structured, does not automatically "fit" specialty crop growers in terms of cost, credits, and topics.

The data made available through this program has whet the appetites of growers and advisors (inside and outside Minnesota) for more benchmarking information.

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Specialty Crop Block Grant FINAL Report

Minnesota Grown Promotion Group, Inc.

USDA FY'10

MDA Contract B50060

September 25, 2013

Project Title: Maximizing the Market for Minnesota Specialty Crop Producers
Minnesota Grown Promotion Group, Inc.

Award Amount: $88,470.00

Term: October 22, 2010 to September 3, 2013

PROJECT SUMMARY

The Minnesota Grown Program is the statewide umbrella marketing program for Minnesota specialty crops. The program connects buyers (both individual consumers and wholesale buyers) with Minnesota specialty crop growers. This project was proposed to make improvements to the program that would improve marketing efficiency, provide additional marketing tools and increase sales of products for Minnesota specialty crop producers. The program has more than 1,000 members who grow and market specialty crops, making this program a very cost-effective way to increase the competitiveness of Minnesota specialty crops. Specific activities proposed include the following:

Expand and improve the online database of fruit and vegetable growers selling to wholesale markets.

- *This project built on a previous SCBG that partially funded creation of this database.*
- *Because this database is new and because the concept of restaurants and schools purchasing from local growers is relatively new and rapidly expanding, we needed a way to allow buyers to express interested in buying a specific product that they weren't able to find in the database. This improvement makes farmers aware of the marketing opportunity and allows them to contact the buyer and decide if it's a product they'd like to grow for them in the future. Having a single, statewide database of growers who sell to wholesale buyers increasing the marketing efficiency for growers.*

- *For this database to be successful it was also important that we could quickly increase the number of farmers listed. During the period of this grant we worked hard to increase the number of participating growers.*

Continuation of previous SCBG funded initiatives to improve functionality of the Minnesota Grown website.

- *This project builds on previous SCBG projects which have allowed us to make major improvements to our online directory that connects individual consumers with local farms.*
- *Previous SCBG projects provided consumers with the ability to search by product and by location but we didn't have a way for consumers to search for a specific farm. We received comments from consumers saying they knew the farm's name or part of the name but didn't have a convenient way to find the farm's information. This project solved that issue.*
- *Although the Minnesota Grown Directory is the most comprehensive database of Minnesota farmers markets, we often received calls from the general public asking us to help find markets that were open on a specific day of the week. While that information was in the market's detailed listing, there was no way to search for a market based on the day(s) of the week they were open. This project addressed that issue.*
- *The number of Community Supported Agriculture farms and the level of consumer interest in purchasing shares in CSA farms have grown rapidly. Our directory was created to allow consumers to find farms based on the location of the farm but because most CSA farms have multiple drop site locations that may not be near the farm it was important to add the ability for consumers to search for a CSA farm based on drop site locations instead of just farm location. This project solved that problem by giving consumers the option of seeing drop sites in addition to the farm location.*

Continuation of previous SCBG funded initiatives to increase consumer purchases of fruits and vegetables by driving traffic to the Minnesota Grown website

- *The pay-per-click (PPC) campaign includes Google Adwords and Microsoft adCenter (Yahoo and Bing). Funding our pay-per-click campaign is important for specialty crop growers because our website aggregates consumers who are seeking locally grown produce, nursery products and Christmas trees. Approximately 60% of our web traffic results from our pay-per-click campaign.*
- *Pay-per-click is an effective tool for SCBG funded projects because we are able to measure and target our ads by product. This allows to ensure that these dollars are used specifically for specialty crop.*

Production of point-of-sale materials to identify and promote Minnesota Grown fruits and vegetables in grocery stores and other markets. This project allowed for production and distribution of four categories of point-of-sale materials for various Minnesota Grown specialty crops.

- *Variety specific apple cards to help growers and retailers identify individual varieties of apples.*

Most common apple varieties grown in Minnesota are not the common national or international varieties that consumers are familiar with when Minnesota varieties are not in season. These varieties include Sweet Sixteen, Haralson, Cortland, Regent, Fireside, and Zestar. Our apple price cards make it easy for retailers and consumers to identify these apples and their key flavor characteristic.

- *Minnesota Grown Organic stickers. These stickers are for use with certified organic products that also qualify for the Minnesota Grown label.*
- *Minnesota Grown twist ties. These are commonly used to close bags of produce. The ties are similar in appearance to "bread bag" twist ties but they have the Minnesota Grown logo printed on them. Based on grower feedback, we increased the length of the twist ties from 6" to 8".*
- *SE Asian vegetable ID/recipe cards. Minnesota has a large population of immigrant farmers who were originally from Southeast Asia. The farmers market is the primary market for most Hmong growers but they face marketing challenges because the vegetables hey commonly grow are not well known by typical Minnesota shoppers. This project allowed us to create a series of 4" x 6" cards with a photo of a SE Asian vegetable on the front along with basic information about how to use and store the veggie. On the back is a recipe from a local chef. We now have cards for 12 vegetables: Bitter Melon, Chinese Spinach, Kabocha Squash, Chinese Broccoli, Long Beans, Thai Eggplant, Thai Basil, Bok Choy, Sweet Potato Leaves, Daikon Radish, Pea Shoots, and Lemon Grass.*

PROJECT APPROACH

Activity #1: Expand and improve the online database of fruit and vegetable growers selling to wholesale markets.

- *Activities 1 and 2 are both related to online directories that include a percentage of non-eligible products in addition to eligible products. To ensure that we are not spending SCBG funds for non-eligible products, we review the listings in both the wholesale database and the consumer directory to determine the per cent of eligible listings compared to non-eligible listings. Programming costs are then allocated accordingly and the portion of programming costs attributable to eligible products is allocated against SCBG funds and the portion of programming costs attributable to non-eligible products is paid by the MGPG and shown as a matching contribution. For this project, $7,583 of programming was paid directly by the MGPG to cover the non-eligible products included in the online directories.*
- *In addition to technical changes and bug fixes, we successfully launched a new feature that lets buyers express interest in buying a specific product that they weren't able to find in the database. This request can then automatically be forwarded by Minnesota Grown Program staff to all the farmers in the database so that they can contact the buyer and decide if it's a product they'd like to supply for them in the future.*
- *The number of farmers listed in the wholesale database has grown from 50 to more than 100. We continue to recruit additional farmers in hopes of making the database as comprehensive as possible.*
- *MDA staff worked closely with interested parties such as those interested in the Farm to School*

movement. We received matching funds from the MN Department of Health's Great Trays Program as well as a Healthy Eating Minnesota program via Hennepin County. The database was also promoted by the University of Minnesota Extension Service and the Institute for Agricultural and Trade Policy. Each of these partners have an interest in seeing more locally grown produce marketed to schools, restaurants and other accounts.

- *MDA staff recruited new members and populated the database. Programming was handled by the same contractor (IV Desk) that programmed the database originally.*

Activity #2: Continuation of previous SCBG funded initiatives to improve functionality of the Minnesota Grown website.

- *MDA staff worked with a contract programming firm to implement a series of improvements to the online Minnesota Grown Directory.*
    - *Consumers can now search by farm name (in addition to being able to search by product or location).*
    - *Consumers can now search for farmers markets based on the day of week they are open.*
    - *We partnered with a national organization called Local Dirt on a pilot project to enable consumers to place orders for products online.*
- *We modified the online Directory to enable consumers to search for a CSA farm based on drop site locations instead of just farm location.*

Activity #3: Continuation of previous SCBG funded initiatives to increase consumer purchases of fruits and vegetables by driving traffic to the Minnesota Grown website

- *The pay-per-click (PPC) campaign includes Google Adwords and Microsoft adCenter (Yahoo and Bing). Total pay-per-click expenditures during this SCBG project totaled $60,152. Google continues to be the dominant search engine in terms of results although Microsoft adCenter delivers enough results to justify continued investment.*
- *The number of unique visitors increased from 223,353 in calendar year 2010 to 240,000 in calendar year 2011. More than 60% of our unique visitors come from our PPC campaigns.*
- *We conducted an online survey of people using the online directory to determine whether or not they actually would be purchasing products from farmers they found on the website.*
- *We conducted extensive consumer surveys of consumers at apple orchards, Christmas tree farms, berry farms and farmers markets. Among other key demographic information, these surveys also provided feedback on the effectiveness of the online Directory.*
- *Ensuring that SCBG funds are used solely to enhance the competitiveness of specialty crops is relatively easy with PPC advertising because each PPC ad is triggered by specific keywords that we choose and because the amount of expense incurred is based on how many people actually click on a specific ad. For example, our apple ad is triggered by consumers searching for keywords related to apples and apple orchards. We are billed based on the actual number of people who click on a specific ad. This report only shows PPC expenses for eligible products. The MGPG also conducts PPC advertising for non-eligible products such as meat and livestock but these expenses are paid directly to Google and Microsoft Ad Network and are not reflected in*

this report.

Activity #4: Production of point-of-sale materials to identify and promote Minnesota Grown fruits and vegetables in grocery stores. We produced and distributed items for several specific specialty crops.

- *Variety specific apple cards to help growers and retailers identify individual varieties of apples. We produced a total of 2,500 laminated apple price cards for Honeycrisp, Sweet Sixteen, Cortland, Regent, Haralson, Fireside and McIntosh.*
- *Minnesota Grown Organic stickers. These stickers are for use with certified organic products that also qualify for the Minnesota Grown label. We printed just over 50,000 stickers. Growers who use these stickers must provide us with evidence that they are currently certified organic. This certification also indicates the products that are certified organic.*
- *Minnesota Grown twist ties. These are commonly used to close bags of produce. The ties are similar in appearance to "bread bag" twist ties but they have the Minnesota Grown logo printed on them. We previously used 6" ties but based on member feedback we printed 8" ties this time. We printed 200,000 ties.*
- *SE Asian vegetable ID/recipe cards. These are 4" x 6" cards that Hmong farmers use to help promote the unique vegetables that they sell at the farmers market. The full-color cards have a photo of the item on the front along with basic information about how to use and store the veggie. On the back is a recipe from a local chef. The cards come on tear-off pads of 50 cards. We now have cards for 12 vegetables: Bitter Melon, Chinese Spinach, Kabocha Squash, Chinese Broccoli, Long Beans, Thai Eggplant, Thai Basil, Bok Choy, Sweet Potato Leaves, Daikon Radish, Pea Shoots, and Lemon Grass. We printed 100 pads of 50 cards for each of the twelve items.*
    - *We worked closely with a non-profit organization (The Minnesota Project) to help create and distribute these cards. They have worked with immigrant farmers for a number of years and were instrumental in distribution of the cards to growers.*

GOALS AND OUTCOMES ACHIEVED

Measurable Outcome #1

Goal: To improve the new online database of Minnesota specialty crop producers who are marketing produce to wholesale markets such as grocery stores, restaurants, and school food service programs.

- Performance Measures:
    - Number of producers listed
        - Benchmark: 50 producers
        - Target: 100 producers
        - ***Result: 108 producers***
    - Number of visits to the database pages
        - Benchmark: 0
        - Target: 200 unique visitors per year

- ***Result: In calendar year 2010 the wholesale database received 1,168 unique page views. In calendar year 2011 it received 4,855 unique page views***

Measurable Outcome #2

Goal: To increase the number of consumers using the online Directory at www.minnesotagrown.com compared to the previous year because of improved design and functionality and through a pay-per-click campaign.

- Performance Measures:
  - Unique visitors
    - Benchmark: 151,000 unique visitors in calendar year 2009
    - Target: 175,000 unique visitors
    - ***Result: 223,000 unique visitors during calendar year 2010 and 240,000 unique visitors during calendar year 2011.***

Measurable Outcome #3

Goal: To design, develop and distribute new point of sale items for use in grocery stores or food service establishments to identify and promote locally grown specialty crops.

- Performance Measure:
  - Items distributed
    - Benchmark: 290,000 total items in calendar year 2009
    - Target: 400,000 items distributed per calendar year
    - ***Result: The total number of items distributed to grocery stores dropped slightly to 280,000 items per year.*** *The benchmark of 290,000 was an unusually high number due to a large order of rolls of 500 stickers. Grocery stores don't normally apply individual stickers to produce at store level – they prefer to have the grower apply them before delivery. New items proved to be most popular with the growers than with grocery stores, although many of the items end up in stores after being applied to the product by the grower.*

BENEFICIARIES

The direct beneficiaries of this project are the growers who are listed in the Minnesota Grown Directory and Minnesota Grown Program members who have access to the free point-of-sale materials. In calendar years 2011 and 2012, there were more than 900 farms listed in the printed Minnesota Grown Directory. All of them benefited from the increase in customer traffic via the www.minnesotagrown.com website. Approximately 1,200 farms were licensed to use the Minnesota Grown logo during calendar years 2011 and 2012 and have access to the free point-of-sale materials. Key beneficiaries above are often members of the Minnesota Fruit and Vegetable Growers Association, Minnesota Apple Growers Association, Minnesota Grape Growers Association, Minnesota Honey Producers Association, Central Minnesota Vegetable Growers Association, Minnesota Nursery & Landscape Association and/or the St. Paul Growers Association.

A clear measure of how our pay-per-click campaign and online website benefits various specialty crop growers can be illustrated by the results or our pay-per-click campaign. The only consumers who are shown the ads are those who have entered key words into their search engine. For example, a person who searches Google for "apple orchards" is shown the apple ad. If they click on the ad they are taken to our online Directory where they can locate an orchard near them. Here are results for our most popular Google pay-per-click ads during the time when this SCBG was paying for these ads (November 15, 2010 to November 30, 2011).

- *Apples {35,750 clicks}*
  - *Most popular keywords:*
    - *Apple orchards in Minnesota*
    - *Minnesota apple orchards*
    - *Apple orchards*
    - *Apple orchard*
    - *Mn apple orchards*
- *Pumpkins {17,800 clicks per year}*
  - *Most popular keywords*
    - *Pumpkin patch*
    - *Pumpkins minnesota*
    - *Pumpkin patches*
    - *Pumpkin patches in minnesota*
- *Christmas Trees {14,927 clicks}*
  - *Most popular keywords*
    - *MN Christmas trees*

        - *MN Christmas tree*
        - *Cut your own Christmas trees*
        - *Christmas tree farms*
    - *CSA Farms {13,180 clicks}*
        - *Most popular keywords*
            - *Community supported agriculture*
            - *Community supported agriculture mn*
            - *Community supported agriculture Minnesota*
            - *Organic farms*
    - *Berries {13,091 clicks}*
        - *Most popular keywords*
            - *Minnesota strawberries*
            - *Strawberries*
            - *Mn berry picking*
    - *Wineries {12,647 clicks}*
        - *Most popular keywords*
            - *Minnesota wineries*
            - *Minnesota winery*
            - *vineyards*
    - *Honey {3,733 clicks}*
        - *Most popular keywords*
            - *Honey in minnesota*
            - *Honey*
            - *Natural honey*

The Minnesota Grown Promotion Group (MGPG) also conducts pay-per-click advertising for various products such as meat and livestock that are not specialty crops. These expenses are paid directly by the MGPG to Google and Adwords and are not treated as matching funds for the purposes of this grant.

To help quantify the fact that consumers who visit the online Directory actually purchase from growers, we created an online survey and invited people using our website to take the short survey. The sole purpose of the survey was to get feedback about the website and to ask them if they had actually purchased or planning to purchase from farms they found on the site.

- The question asked: "Because of finding them on this website, how many farms/markets have you purchased from?
    - None yet, but I plan to: 25%
    - 1-2: 44%
    - 3-4: 25%
    - 5 or more: 6%

An even stronger indication of the fact that sales are generated through the online Directory comes from a series of surveys completed by actual consumers of apple orchards, berry farms, and Christmas tree farms.

- Apple orchard customers: In a survey of 469 customers at 18 different orchards, 6% of respondents indicated that they used the online Minnesota Grown Directory to find out about the orchard this year. The average amount spent per visit by respondents was $38.75.
- Pick-your-own berry farm customers: In a survey of 744 customers at 30 different pick-your-own berry farms, a whopping 20% of respondents indicated that they used the online Directory to find out about the berry farm this year. The average amount spent per visit by respondents was $31.68.
- Christmas tree farm customers: In a survey of 191 customers from 11 different locations around the state, 6% of respondents indicated that they used the Minnesota Grown Directory to find out about the farm this year. The average amount spent by a respondent at a choose and cut Christmas tree farm was more than $78.

LESSONS LEARNED

Pay-per-click continues to be a remarkably effective method of delivering customers to our online Directory. It is easy to target geographically allows the user to create specific ads for specific search terms. Both Google Adwords and Microsoft AdNetwork have very detailed reporting tools that provide feedback on each search term, cost-per-click, average position of the ad for shown for each search term, etc. Because of our experience with pay-per-click advertising, we have given workshops for specialty crop growers on how they can use pay-per-click advertising to promote their own businesses. We've given these workshops at the Minnesota Fruit and Vegetable Growers Association educational conference, the Minnesota Grape Growers Association educational conference and the Minnesota Apple Growers Association educational conference.

We've also learned that because our online Directory features so many different products, it is often difficult for us to rank highly on the "organic" (non pay-per-click) search engine results. Also contributing to our search engine ranking difficulties is the fact that housing our online Directory on the Minnesota Department of Agriculture's website results in URL addresses that are not search engine friendly. These are issues we will be working hard to address in our future SCBG projects.

Our targets for the number of promotional materials distributed to grocers were unreasonable due to the fact that many retailers have policies that make it difficult for stores to use promotional items that weren't made by the retail chain. These entities often use the Minnesota Grown logo but don't necessarily use our actual promotional items. The positive side is that the items developed through this project are very popular with specialty crop producers and are often utilized at farmers markets, on-farm retail markets or are applied directly to the product by the farm prior to delivery to the store.

ADDITIONAL INFORMATION

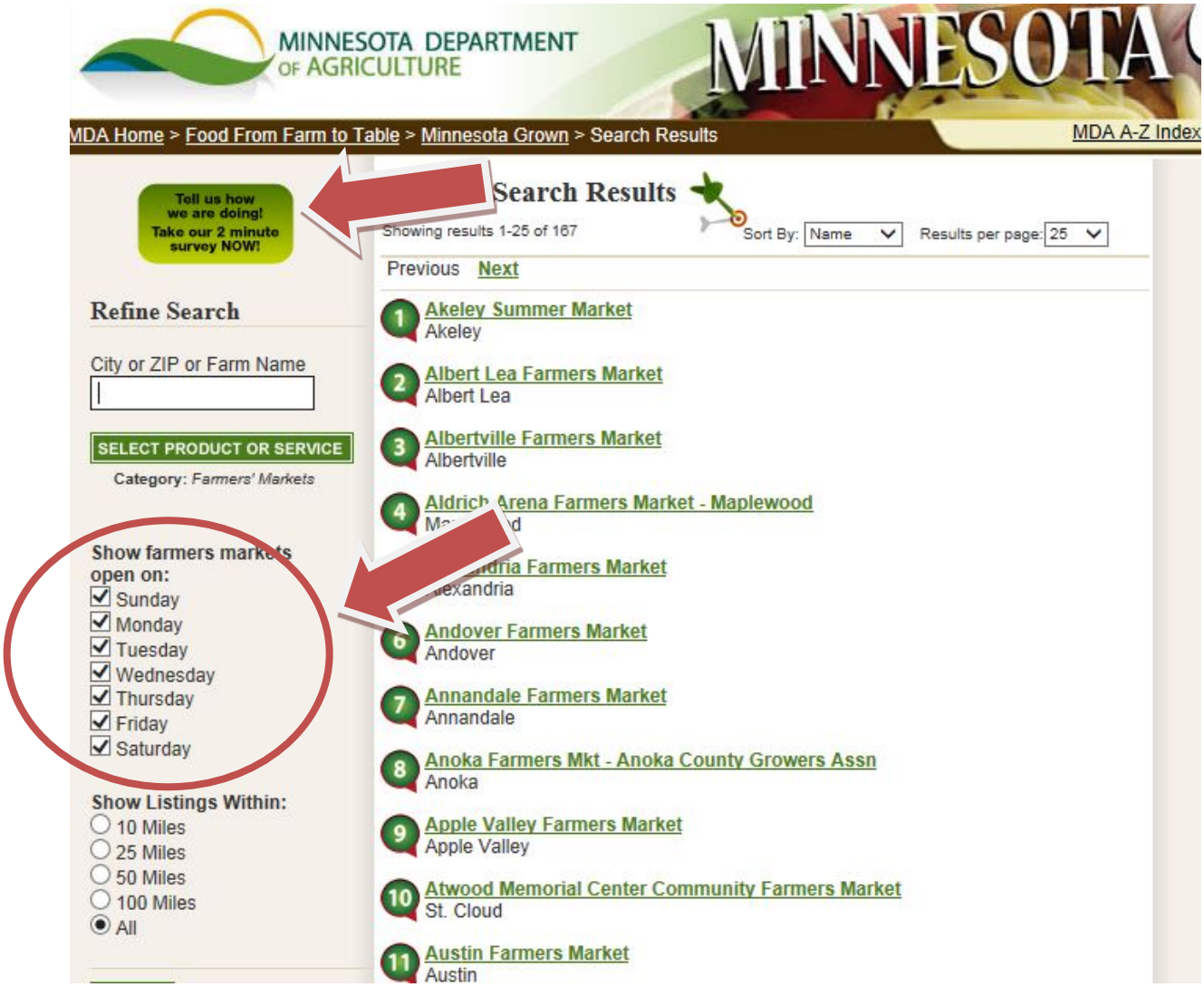
All of the website improvements can be viewed online at www.minnesotagrown.com

Screen shots of the SCBG funded website improvements follow:

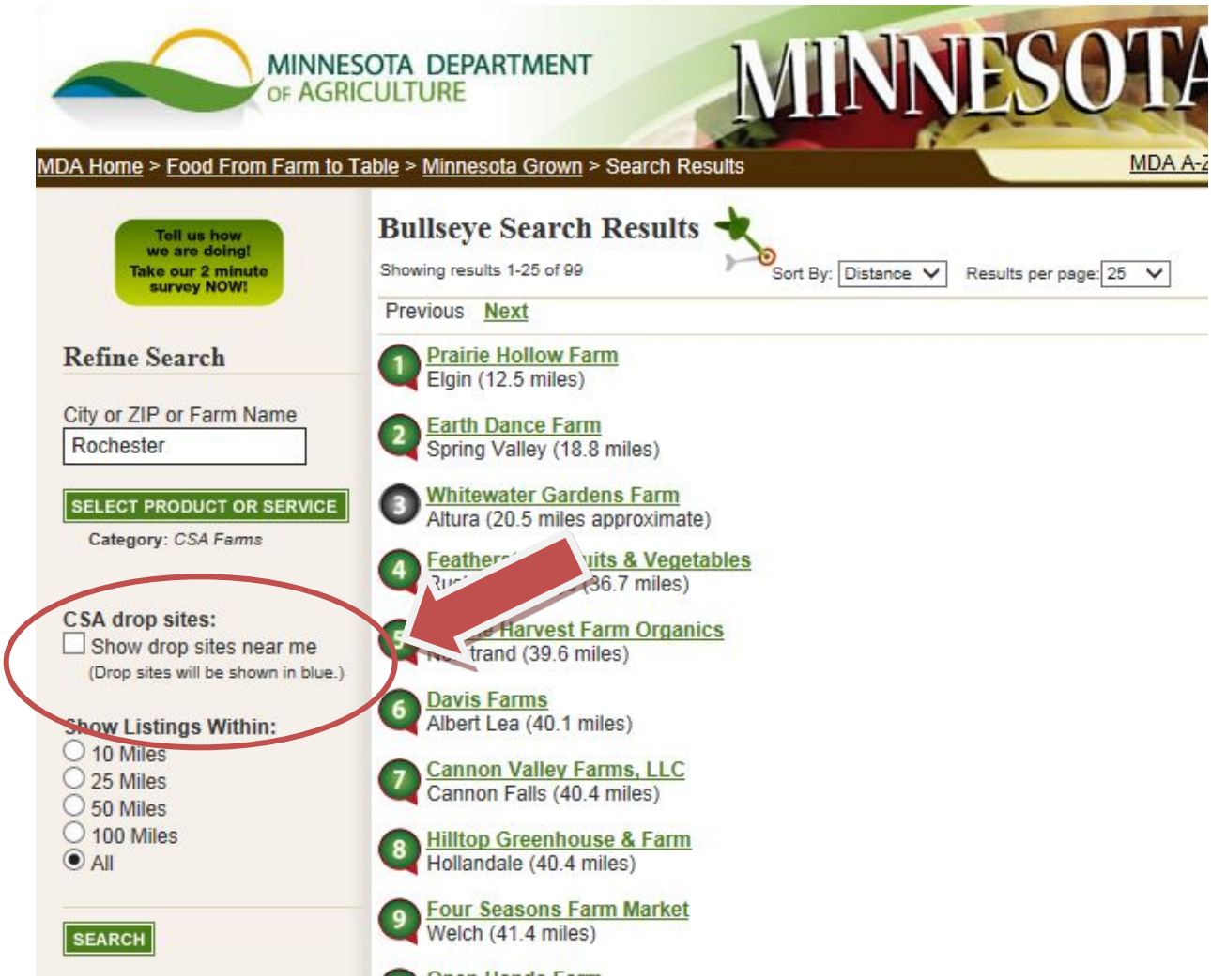
This screen shot shows the addition of the "search by farm name" option to our main search box on the home page of www.minnesotagrown.com

This screen shot shows two things:

1. The link to our survey of people using the site, and
2. The new feature allowing users to locate a market based on the day of the week that the market is open



This screen shot shows a detailed farm page with the link to the online survey.


MINNESOTA DEPARTMENT OF AGRICULTURE
MINNESOTA
MDA Home > Food From Farm to Table > Minnesota Grown > Search Results
MDA A-Z
Tell us how we are doing! Take our 2 minute survey NOW!
Refine Search
City or ZIP or Farm Name
Rochester
SELECT PRODUCT OR SERVICE
Category: CSA Farms
CSA drop sites:
Show drop sites near me
(Drop sites will be shown in blue.)
Show Listings Within:
10 Miles
25 Miles
50 Miles
100 Miles
All
SEARCH
Bullseye Search Results
Showing results 1-25 of 99
Sort By: Distance
Results per page: 25
Previous Next
1 Prairie Hollow Farm
Elgin (12.5 miles)
2 Earth Dance Farm
Spring Valley (18.8 miles)
3 Whitewater Gardens Farm
Altura (20.5 miles approximate)
4 Feather
its & Vegetables
36.7 miles)
5 Harvest Farm Organics
trand (39.6 miles)
6 Davis Farms
Albert Lea (40.1 miles)
7 Cannon Valley Farms, LLC
Cannon Falls (40.4 miles)
8 Hilltop Greenhouse & Farm
Hollandale (40.4 miles)
9 Four Seasons Farm Market
Welch (41.4 miles)

This screen shot shows the CSA search results when the “show drop site” option is selected.

SUMMARY OF EXPENDITURES:

Total Project Expenditures:

New wholesale database ..... $ 4,125

Improvements to online Directory $26,206

Pay-per-click advertising $60,152

Point of sale materials ..... $ 5,570

TOTAL PROJECT EXPENDITURES..... $96,053

Matching Funds:

Wholesale database..... $1,031

Online Directory..... $6,552

TOTAL MATCHING EXPENDITURES $7,583

NET SCBG EXPENDITURES $88,470

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Project D- Expanding Opportunities for Local Specialty Crop Business in Lanesboro

FINAL PERFORMANCE REPORT: Lanesboro Local

PROJECT TITLE: Expanding Opportunities for Local Specialty Crop Businesses in Lanesboro Region

PROJECT SUMMARY

Beginning, small-scale, diversifying and disadvantaged farmers who opt to grow food for local markets require professional development and viable year-round market channels in order to enter and effectively compete in local and regional food markets. In addition to the need for education and mentoring, an infrastructure of accessible market channels is necessary to justify investments by new and developing local food producing businesses. While commodity crop production is the base of Midwestern agriculture, secondary small-scale fruit and vegetable production is an increasingly important way for rural families to supplement farm income. Those who are most readily able to fill the role of small entry businesses tend to be female, new to farming, and Amish stakeholders.

According to a 2009 report by rural economic analyst Ken Meter of the Crossroads Resource Center, farmers in Minnesota lost money producing food commodities for all ten years studied, 1997-2007, were it not for federal subsidies. The southeast region spent about $500 million each year buying food from outside the region. If the region's consumers were to buy 15% of their food from local sources, it would generate as much income for the region as two-thirds of farm subsidies. Despite the fact that this area is ideally suited for mixed small-scale food production, only a small percent of local food consumption is produced locally, resulting in an economic drain that local farmers could be capturing. Lanesboro itself has been without a grocery store since 2008. Recent growing consumer awareness of local foods promises increased selling potential for specialty crops, giving this project true multi-dimensional gravity.

PROJECT APPROACH

Lanesboro Local began the grant year by surveying specialty crop producing members about their experience with our organization and what they would like to see over the next year. In doing this, the Marketplace Development Directors gained momentous insight into the attitudes toward licensing, organization involvement and future goals of members. Moving forward, staff and select board members began working on a comprehensive marketing plan which is currently being implemented, but is always evolving.

In order to ensure that grant dollars were expended solely to enhance the competitiveness of specialty crops, we put several management mechanisms in place. First, we developed a very clear work plan for staff funded by this grant and held weekly supervisory meetings to ensure that only grant objectives were carried out with these funds. Second we secured and pledged as a match a $14,500 grant from the Southern Minnesota Initiative Fund to cover all related non- specialty crop focused activities. That grant has also been successfully completed in 2011. Third, we initiated a time sheet that required staff to report their hours spent specifically on this project, and on other projects, ensuring that specialty crop funds were only spent on specialty crop activities.

The staff organized four educational experiences for the public to partake in, to promote consumption of local specialty crop products. These courses included a tour of a passive-solar greenhouse showing participants how to grow salad greens and other foods during even the coldest months of the year. Nature's Pharmacy was a discussion of herb and plant remedies conducted by Clinical Herbalist Bonnie L. Kreckow, who sells herbal lotions and remedies. Two cooking

demonstrations focused on using local specialty crop ingredients and scratch cooking methods including one class on fresh herbs, for use in infused vinegars, butters, and cooking oils; as well as a class on use of fresh produce including carrots, celery, asparagus, garlic and onions in simple Japanese cooking.

Lanesboro Local hosted a membership meeting in April, and had a great turnout. Members discussed ways that they could collaborate and work with each other. Connections were made between member Amish farmers, and local restaurants, and B&B owners to supply produce and berries for the summer season. Lanesboro Local Marketplace Development Directors assisted Kari's Restaurant with menu engineering for their new menu and finding sources of local food items for that menu.

As Lanesboro is largely a tourism-driven community and the summer months are the busiest of all, Lanesboro Local spent the middle of the grant period working with members to bring specialty crop products to the retail space while looking for new products to add to the current selection. Thirty-nine new specialty crop producers added items to the retail store. As the tourist season winds down, staff at Lanesboro Local has continued to develop classes on using specialty crops while engaging members in planning for next year. A meeting has been planned for late winter 2012 to connect our members with business and food professionals who can answer our members' questions about licensing, labeling, financing, marketing, and other topics related to retail sales of value added food items.

Additionally, Marketplace Development Directors are expanding Lanesboro Local's web presence and social media usage, while inviting new members to the organization. The web site, www.lanesborolocal.org, was greatly improved over the course of this project, receiving a peak of 166,000 hits in October, and 800,000 hits throughout 2011. We added a blog (with in depth postings promoting local producers' tatsoi greens, sorrel, hazelnuts, fruit and vegetable relishes, shiitake mushrooms, honey, squash and black walnuts.) Facebook postings kept our followers up to date on product availability and seasonal specialties. Our electronic newsletter went out weekly during the fresh market season and monthly during the winter.

Many of the other businesses and organizations in Lanesboro have supported our efforts to expand opportunities for local specialty crop businesses in Lanesboro region. The Lanesboro Chamber of Commerce was a significant partner through the entire project. Always willing to assist with professional development, as well as send out press releases and distribute relevant information to residents and tourists, the staff at the Chamber of Commerce played a crucial role in getting the message of local food importance to the public. In conjunction with the Lanesboro Arts Center, Lanesboro Local Marketplace hosted local food tasting before the screening of six different documentary films giving our members the opportunity to promote their products. The Rhubarb Festival is a key event for the town of Lanesboro and through our connection with local growers of rhubarb over 400 pounds of local rhubarb were used by Ruhland's Strudels to make and sell strawberry rhubarb strudel at the festival. Art in the Park is another key event for the town that draws tourists and local residents, alike. Down Under BBQ sauces including tomatoes and other vegetables were served with lefse chips and a pulled pork sandwich and received rave reviews. The annual fund raising dinner for Lanesboro Local was held at Quarter/quarter restaurant in Harmony, MN. Chef Steven Larson developed the menu for the event around specialty crop products produced by our members. Lanesboro Farmers Market, the Cottage House Inn, and Lanesboro Local Marketplace co- sponsored a children's garden at Kari's restaurant to educate and promote growing and eating local produce. Additionally, The Cottage House Inn of Lanesboro has provided meeting space for member and board of director activities.

GOALS AND OUTCOMES ACHIEVED

In reviewing the work plan and expected outcomes submitted with our grant proposal, Lanesboro Local has achieved and exceeded all of our goals initially set forth.

Original Workplan

Design marketplace interior to optimize food sales: While Lanesboro Local did not move forward in constructing a new retail space, the staff and board of directors collaboratively developed a new design scheme for our current location. Signage, paint, layout and fixtures were installed to enhance sales of specialty crop products.

Research and draft business plan: Lanesboro Local Marketplace Development Directors have worked tirelessly on a comprehensive marketing plan that will engage consumers from Lanesboro and the surrounding Driftless region. A profitability plan will ensure increased sales for producers.

Support producers in becoming licensed to process products: Lanesboro Local members were offered staff assistance in exploring how they could sell processed products year-round. Seven attended the Certified Food Manager Licensing class held in Lanesboro on October 26, 2011. Members are looking to process vegetable products, make salsa, as well as a myriad of other products. Furthermore, Marketplace Development Directors have been in constant communication with our state food inspector, Keri Plude, to ensure that we have a working knowledge of the guidelines applicable to processing and selling specialty crops.

Recommend web sales strategy: Lanesboro Local is working with our web management group to make the most of our web presence. Although Lanesboro Local has not moved into web sales at this time, our organization is moving in that direction. Lanesboro Local is increasing its presence on social media fronts by actively engaging customers through our blog and Facebook page. A consultant has developed a new overall design to upgrade the website, and progress is being made toward revamping and uploading a new look with enhanced marketing of specialty crop products to viewers.

Original Expected Outcomes

Expand the number of specialty crop growers: Lanesboro Local expanded its membership from 89 members to 112 members in 2011. 39 of these are specialty crop growers and/or food processors adding value to specialty crops. In order to ensure that this grant only funded activities to benefit the specialty crop growers and processors, we developed a very clear work plan for staff funded by this grant and held weekly supervisory meetings to ensure that only those grant objectives were carried out with these funds. Second we used matching funds to cover all non-specialty crop activities. Third, we initiated a time sheet to report hours spent specifically on this project, and on other projects, ensuring that specialty crop funds were only spent on specialty crop activities.

Expand annual sales of specialty crops: Lanesboro Local has increased specialty crop sales from $6000.00 in 2010 to $21,000.00 to date in 2011. Lanesboro Local saw a wider variety of specialty crops in our retail space this year. Fresh salad greens year round. Heirloom eggplant and shitake & oyster mushrooms graced our shelves and the plates of local consumers. Hazel nuts, black walnuts, and chestnuts are available in season. We are looking forward to continuing to grow and expand the varieties available to consumers.

Expand the number of licensed, value-added specialty crop producers: In working with Lanesboro Local member Lars Johnson, the Food Safety Guy, seven members will be taking the initial course needed for Food Manager Certification. Three kitchens have been visited by the local MDA inspector and approved as potential locations for our members to prepare their value added products. As Lanesboro Local continues to grow, we will encourage other interested persons to

pursue certification.

BENEFICIARIES

Thirty-nine local specialty food producers and food processors have directly benefited from the ongoing work of Lanesboro Local by expanding their sales. By expanding our retail space dedicated to food sales, offering delivery to housebound individuals, and engaging consumers through social media, Lanesboro Local is continuing to reach an increasingly wide audience to make these sales possible. Consumers residing in Lanesboro and surrounding communities have benefited from the fresh, healthy and seasonal supply of locally produced and/or locally processed specialty foods that are available in Lanesboro.

LESSONS LEARNED

Lanesboro Local staff has learned that it is difficult to find members interested in taking the next step to processing their specialty crops. While several enjoy planting, growing, and harvesting these crops, the practice of processing this produce is seen as added work and expense. Furthermore, several members expressed that they were not interested in any sort of involvement with government inspection. This was eye opening for the staff and board of directors.

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Project E: Building Local Markets for Local Farmers

NOTE: This project includes two components: Mini Markets Program and Farm to Childcare. Each component has separate time lines, goals and activities. For this report, we answer the programmatic questions for each component separately.

PROJECT SUMMARY

1. *Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.*
2. *Establish the motivation for this project by presenting the importance and timeliness of the project.*
3. *If the project built on a previously funded project with the SCBGP or SCBGP-FB describe how this project complimented and enhanced previously completed work.*

Mini Markets

The **initial purpose** of the Mini Markets was to bring fresh, locally grown specialty crops to low-income neighborhoods that lack access to healthy and locally grown foods and to provide a less expensive market experience for beginning and socially disadvantaged farmers. Our **motivation for this project was the opportunity for growth we saw in 2010 when Minnesota moved to allow the use of new WIC Fruit and Vegetable Vouchers at farmers markets**. (This was after the federal WIC program had expanded to allow the purchase of a full range of fruits and vegetables in 2009.) The **project did not build on previous funding from the SCBGP.**

Farm to Childcare

The **initial purpose** of Farm to Childcare was to improve the food offerings in childcare centers with locally grown specialty crops. Our **motivation for this project was to develop a model for the childcare sector as a market for small and mid-size farmers of specialty crops at a time when the Farm to School movement had become main-stream in Minnesota.** This **project did not build on previous funding from the SCBGP.**

PROJECT APPROACH

4. *Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.*

Mini Market Program

The Mini Markets have become an integral part of Minneapolis' local food system, with a particular benefit to Minneapolis Metro Area family farmers and low-income neighborhoods. Over the two year project period, IATP increased average sales across the markets ($63,480 in 2011 and $72,600 in 2012) and successfully transferred oversight of the markets to a new Mini Market Network of four community organizations. We also met the goal of creating a diverse group of 30 beginning and socially disadvantaged farmers to sell at the Mini Markets. Hmong family farmers

continue to make up the majority of the market vendors and we also recruited African American, West African and urban farmers for the project. In successfully transferring leadership to community organizations we developed and empowered knowledgeable leaders who are invested in the Mini Market mission of bringing healthy local produce to their communities. We believe this combination of skills and commitment has effectively set the stage for the ongoing operation and development of Mini Markets in Minneapolis.

Grant funds were used solely to support the competitiveness of specialty crops. Please note that by ordinance of the City of Minneapolis, the Mini Markets were only allowed to sell fruits and vegetables. (Larger farmers markets follow a different set of ordinances).

Farm to Childcare

With support from the Specialty Crops Block Grant Program and other funders, we researched, planned and piloted a very successful Farm to Childcare program model with our partner New Horizons Academy (NHA). We also conducted rigorous evaluation of the program operations and key outcomes for farmers, children and families. For example, NHA's local food procurement for the participating childcare centers went from no documented local purchases to $ 8,500 for the pilot locations. We found that 84% of the participating children could correctly identify the featured specialty crops, with 72% of those children indicating that they liked them.

Grant funds were used only for work with farmers of the following 8 specialty crops: zucchini, peppers, pea pods, tomatoes, cucumbers, cabbage, carrots and winter squash. Financial controls in place to ensure proper use of funds include: (1) IATP accounts for government grants separately from private funds. (2) We track staff hours related specifically to the project budget from our Specialty Crops Block Grant contract.

GOALS AND OUTCOMES ACHIEVED

5. *Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.*
6. *If outcome measures were long term, summarize the progress that has been made towards achievement.*
7. *Provide a comparison of actual accomplishments with the goals established for the reporting period.*
8. *Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.*

Mini Market Program

Activities included:
Operated the Mini Markets Network in Year 1. Trained 15 market managers; Enlisted farmers to sell at the market by conducting outreach through the Minnesota Food Association and enlisting referrals from participating famers. Market Managers also conducted outreach to vendors at other farmers markets. A total of 30 vendors participated, an increase of ten vendors over the 2010 Benchmark. (See evaluation table.); Provided assistance to market managers on site and by phone; Coordinated with the State Departments of Health and Agriculture to provide umbrella certification to enable markets to participate in the WIC program; Promoted the use WIC Fruit and

Vegetable Voucher (FVV) coupons at markets; Conducted qualitative in-person interviews in Hmong to more fully understand the experiences of Hmong family farmers (who represent the majority of the farmers); Monitored and estimated sales across the Mini Market Network in 2012.

Implemented transfer of leadership from IATP to a new Mini Markets Network in Year 2. Conducted an RFP process to identify four organizations to assume leadership of the Mini Market Network, with each overseeing a cluster of markets in their neighborhood; Designed a Memorandum of Understanding and training materials for these new leaders; Established an advisory committee of vendors and market managers; Conducted two training workshops with Market Network Leaders; Up-dated and distributed our Mini Market Manager Handbook in the summer of 2012; Coordinated with MDA and Network leaders on umbrella certification for WIC FMNP and FVV; Coordinated with our four Network leaders to identify any outstanding information needs and trouble-shooting support, and provided on-doing technical assistance throughout the market season; Network leaders also gathered feedback from Market Managers about their satisfaction with the experience at the end of the season and reported to us that the responses were at the level of "satisfied" or "very satisfied"; Coordinated with Network leaders to monitor and estimate sales activity at their sites.

Evaluation Table for the Mini Markets - Please see evaluation table attached and a discussion of the indicators of sales, farmer participation and the leadership transition below.

Our ***outcome measures were achieved within the grant period****. In* ***comparing the actual accomplishments to the project with the project goals***, we would like to note two key successes: (1) In each year, the Mini Markets have continued to increase sales and exceeded the original target of $55,000 ($63,480 in 2011 and $72,600 in 2012). We believe this is due to the strength of the original model as well as important modifications made along the way. For example, over the years, we were able to refine our training approach to address the markets' logistical barriers, build in more peer support among market managers (for instance, providing informal networking opportunities and the means to share ideas and materials across the markets electronically), and better screen potential sites relative to consumer shopping habits and foot traffic in their area. (2) We met the top end of our target to engage 25-30 farmers in selling at the Mini Markets with a total of 30 farmers. One key indicators of the benefit of this model to farmers is that the majority of those who participate tend to return to the program each year and several have even recruited family members to sell at the markets.

Farm to Childcare

***Activities* included:**

Research and planning on Farm to Childcare in year 1.

- Researched Farm to Childcare type programs throughout the U.S. (See final publication here: Farm to Childcare: Opportunities and Challenges.)
- Researched and explored the possibility of partnership with 5 childcare providers, eventually identifying and negotiating a Memorandum of Understanding with New Horizons Academy (NHA).

Develop, implement and evaluate pilot in year 2.

- Worked with NHA to develop the pilot (scope, location, special crops to feature); developed menu plans, curriculum and parental outreach strategies; Trained 40 staff from pilot locations on the project (two workshops); Implemented the pilot and evaluation from June – November 2012. The pilot began at 14 locations and later expanded to 19 sites due to strong demand from parents.

- Five parent strategies developed and implemented include: 1) Farm to Childcare displays at each participating childcare center; (2) information about local food and agriculture on NHA's website; (3) Monthly notices to parents about the featured local foods on menus and in newsletters; (4) Open houses highlighting the Farm to Childcare program; (5) connecting parents with Farm to Childcare resources such as home-size recipes featuring locally grown fruits and vegetables, cooking-with-kids tools, and age-appropriate books about food, farming and related themes.
  - Conducted thorough evaluation and documentation throughout the pilot period, including: (1) Bi-weekly electronic surveys of participating teachers and kitchen staff after each food item is featured; (2) Phone interviews with center directors
    (3) Pre- and post-curriculum evaluations with children at four pilot centers to measure the effects of menuing and curriculum on children's knowledge and taste preferences.

All but one of the ***outcome measures were achieved within the grant period***. We had aimed for the purchase of $12,000 in specialty crops. We fell short of that goal due to unforeseen weather and distribution issues that prevented New Horizon from purchasing local apples and cantaloupe. Specifically:

- NHA was not able to procure locally grown apples due to the spring 2012 freeze which decimated the local apple crop and made product unavailable through NHA's distributor in Fall 2012.
- NHA's distribution partner (with whom they have an exclusive procurement contract) chose to source cantaloupe only from large farm operations in California and Arizona following a food safety problem that occurred with cantaloupe from a farm in Indiana last summer. Unfortunately, they were not willing to purchase cantaloupe from Minnesota growers in the wake of the problem in Indiana.
- Over the course of the pilot, NHA and the distributor also became more skilled at estimating procurement needs from farmers based on the specific ways that foods were menued, portion sizes, yields/waste rates in the kitchen and other factors.

In ***comparing the actual accomplishments to the project with the project goals***, we see that the overall experience was positive. As mentioned above, we conducted bi-weekly electronic surveys of participating teachers and kitchen staff after food items were featured to monitor implementation in the classroom and in the kitchen. In the early months we heard about the issues that are typical to new Farm to Institution efforts (finding fresh food required more preparation time and more care to keep from spoiling). However, most cooks reported that recipes were relatively easy to follow. In the classroom, teachers found that it was a challenge to get kids to try new foods, particularly older children. They reported that arts and sensory activities with the foods appeared to be the most effective. In the later months, we were pleased to see staff become more comfortable with recommended classroom activities and become more creative in integrating Farm to Childcare activities into the classroom. Some cooks made minor changes to recipes that they felt made them a success with students and eased logistical challenges in their

kitchens (such as more efficiently using ovens and storage space, and better tying menu activities to the timing of food deliveries, etc). Teachers also created more sensory activities (like creating a "cabbage monster" with kids). In one center, teachers gave parents a sample of some of the foods to take home, while others held tasting demos for parents and children as children were being picked up at the end of the day. (The following is a link to summaries of these interview responses: https://www.dropbox.com/sh/w7c2l1ntwrc54so/AjmWqFfjIo.) The pilot required a lot of change for childcare staff in a very short time period. Given the impact on food procurement, menus, food preparation and classroom activity, staff's willingness to experiment demonstrated to us a high level of engagement and interest in local and healthy food issues. We are pleased that NHA is committed to expanding its use of locally grown specialty crops and will implement the program at all 60 of its childcare sites in Minnesota in mid-2013.

Evaluation Table for Farm to Childcare - Please see evaluation table attached and discussion of more detailed quantitative benefits section below).

BENEFICIARIES

9. *Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.*
10. *Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.*

Mini Market Program

The Mini Market project **beneficiaries** were 30 small-scale and family farmers. For some, the mini markets provided a low key, low cost venue for selling their produce for the first time. For others, it complemented sales at other (typically morning) markets by providing a second opportunity to sell product that had already been harvested, transported into the city, but went unsold earlier in the day. As many of the markets took place in the late afternoon to attract people on their way home from work, some farmers who sold produce elsewhere in the morning hours were able to generate income in the afternoon **Other beneficiaries** were 1) patrons of the Mini Markets, including low-income consumers, who were able to purchase fresh produce at sites near their home or place of work[1]**.** 2) neighborhood organizations who hosted the Mini Markets as a way to expand access to healthy foods in their community and build bridges between neighborhood residents and farmers.

Quantitative Benefits: Sales at the markets have increased continually since the project's inception back in 2006 average sales across the markets ($18,000 Benchmark in 2008. $63,480 in 2011 and $72,600 in 2012), and many beginning farmers have benefitted from the markets by learning the ropes of farmers market sales and selling product that had gone unsold earlier in the day.

Farm to Childcare

[1] We did not attempt to collect data on the number of individuals making purchases at each of the markets on each market day. As a result, we don't have a reasonable basis for estimating numbers of customers for this report.

The key **beneficiaries** for this grant (primarily for research and program development) were the five specialty crop growers, 1,350 children and their families at the 19 NHA childcare centers who participated in the pilot.

Quantitative Benefits: Our more detailed evaluation with NHA provides some promising quantitative descriptions of Farm to Childcare's impact on participants:

- Five specialty crop growers benefited from an additional $8,500 in sales and access to a new market.
- 84 percent of participating children could correctly identify the featured foods (82 percent on the pre-test).
- 42 percent of responding parents said their child had talked with them at home about the featured foods or Farm to Childcare activities (no pre-testing).
- 48 percent have done something different at home as a result of the program such as eating more fruits and vegetables or buying local foods at a farmers market (no pre-testing).
- 91 percent of parents said they would like to see the Farm to Childcare program continue (no pre-testing).
- Younger children (e.g., ages 2–3) were often more receptive to new foods than older kids.

We did note in our evaluation that the prevalence of children who reported "liking" the local foods that were featured decreased slightly (from 76 percent on the pre-test to 72 percent on the post-test). In part, we believe this reflects the challenges of accurately testing "liking" experiences among very young children. For instance, children were asked to identify a food and to indicate if they had tried the food. If they could correctly identify the food and indicate that they had tried it, they were then asked if they "liked" it. Some children who are very likely to have tried eating the food within the preceding two weeks given their center's menuing activity expressed uncertainty about whether they had actually tried it. The ways foods are presented in menus may also influence the degree to which a child retains taste information about a food. Given the very short term memory of two and three year olds in particular, this makes it difficult to accurately assess changes in taste preferences. Also, as the national literature indicates that children generally need to be exposed to a new food six to ten times in order to influence their taste preferences, we realize that it will take more time and exposure to new foods before it is possible to document a statistically valid and sustained change in preferences among children.

LESSONS LEARNED

11. Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
12. Provide unexpected outcomes or results that were an effect of implementing this project.
13. If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

Mini Markets Program

Key **lessons Learned** include:

Relationships with staff at market sites are vital to its success. While the Mini Markets program has grown rapidly over the years, some markets have had mixed succeeded. The more challenged markets tended to be smaller markets (typically one vendor) or those with less visible

locations. The most common reason for difficulty at the market level was staff limitations and turnover within the host organizations that manage individual markets on their property. Markets are most effectively hosted by organizations that are stable and are committed to adequately staffing the market, are very familiar with the shopping and daily routines of market customers in their community, and see clearly how hosting a Mini Market fits within the larger goals of their organization.

Increasingly unstable weather patterns have been a major challenge for growers and for farmers markets. Growers across Minnesota have been significantly affected by adverse weather conditions over the past two growing seasons (including drought, extreme heat, floods, hail, and early and late frosts). This has made it challenging for growers to provide a full range of products on a consistent basis and to maintain product quality. High heat, especially in July, is likely to have dampened customer attendance at some markets. In future, it may be beneficial for markets to expand the range of products that are sold and incorporate products (like value-added items) that are less dependent on growing conditions.

There were no **unexpected effects of this project** and **all of the goals and outcome measures were achieved** for this component of the project.

Farm to Childcare

Key **lessons Learned** from both our research and experience with the pilot include:

- Childcare centers have shown themselves to be a potentially significant, though still largely untapped, source of demand for Minnesota specialty crops.
- Efforts are most effective when these programmatic elements are deliberately woven together and designed to be mutually reinforcing. Having a curriculum that positions care providers to teach children where their food is coming from is a critical tool for informing and engaging children and building taste preferences for locally grown foods.
- When introducing new foods, it may be more effective to familiarize young children thoroughly with one new food at a time rather than introducing multiple foods simultaneously or in rapid succession.
- Telling the story of participating farmers is a key vehicle for engaging parents in local agriculture and building support for Farm to Childcare programs.

An **unexpected effect of this project** is the level of interest it has generated, even in its pilot phase. As mentioned above, we expanded the scope of the pilot mid-season to include five additional NHA centers due to parent demand. News of the pilot effort, our background research and blogs has also generated significant attention locally and nationally. All of this interest bodes well for the ongoing development of the childcare sector as a new market for local specialty crops growers. All **goals were achieved** for this component of the project. (Please see a discussion of the one target we did not achieve on page 4.)

ADDITIONAL INFORMATION

14. Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

The following are links to related publications and postings:

- Networking Small Urban Farmers Markets: Lessons Learned from IATP
- Managing Small Urban Farmers Markets: Handbook for Mini Farmers Market Managers
- Farm to Childcare: Opportunities and Challenges for Connecting Young Children with Local Foods and Farmers
- Childcare: Fertile ground for healthy young eaters

West Broadway Coalition to Lead North Minneapolis Mini Farmer Market Network

No income for IATP was derived from the project.

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Project F- Growing farmers, growing farm-Big River Farms

Grant FINAL Report:

Minnesota Food Association. Growing Farmers, Growing Food – Big River Farms. (Grant # B49885) Specialty Crops Block Grant with Minnesota Department of Agriculture

Date: January 10, 2012

1. PROJECT SUMMARY

More consumers, restaurants, institutions and stores are seeking fresh produce, from local growers, that is safe and, many times, organic. More and more new immigrants want to become local production farmers but face both regular farming challenges and the navigation of new language, culture, markets and systems. **Minnesota Food Association's Big River Farms trains and supports socially disadvantaged and limited resource farms in the Minnesota and the St. Croix River Valley in establishing and growing their organic specialty crop farm enterprises.** The training approach includes classroom and in-field sessions, numerous individual sessions, practical in-field production and marketing to BRF CSA and wholesale and developing their own direct markets. The participant farmers come from various immigrant communities including Latino, East Africa, South East Asia (Burma, Laos, Cambodia, Hmong, Bhutan), and Caucasian women. Many of these farms are led by women. **The objectives for this project were that all farms will complete organic certification, practice food safety, continuously develop their own business plans, and increase skills and knowledge in marketing and have at least 2 types of marketing outlets. These are key components towards operating and enhancing the competitiveness of their own independent vegetable farm enterprises, which directly impacts the specialty crop industry.** The objectives were all met for the 10 farms in the Big River Farms Training Program in 2011(except the business plan development was not as strong). The participant farmers come from

various immigrant communities including Latino (Mexico), East Africa (Somailia, Kenya), South East Asia (Burma, Laos, Cambodia, Hmong, Bhutan), and Multi- racial from North Minneapolis. Many of these farms are led by women.

2. PROJECT APPROACH

In 2011, MFA worked comprehensively and directly with 10 "farms", representing 29 farmers. The participants included Guatemalan, Hmong, Cambodian, Karen, Kenyan, Bhutanese and Somali farmers. All the farmers in our program are considered "low income" by IRS standards and are "socially disadvantaged" by USDA standards. The farmers all come from the 7 county Twin Cities Metro Area and the St Croix River Valley of MN and Wisconsin. All but one of these farmers have a primary full time job as teachers, translators, factory workers, maids, nurses, and other jobs. MFA also worked with an additional 50 "food farmers" in the program who are primarily Hmong elders who produce mostly for themselves and community. An additional 20 or so farmers attended our classroom and field training classes that are open to the public. We had between 2 – 10 farmers from outside the program at each session. We reached another 170 immigrant farmers through the Annual Minority and Immigrant Farmers Conference in February 2011 and expect another 180-200 in February 2012. MFA's reach is moving beyond MN and WI now. New immigrant farmer training programs from WI, NE, IA and ME visited our program in the 2011 season. We will soon be developing a standardized curriculum based on our 5 -6 years experience on our current training site that can then be reproduced and replicated in other parts of the county. Overall, MFA reaches about 300 immigrant farmers annually with training, technical support and outreach.

One farm applied for and received a FSA loan and bought their own farm. One farm applied for and received an import permit for "water spinach" seeds (a leafy green from Southeast Asia) to be grown in MN – this is the first permit of this kind issued by AHPIS in MN. One farm signed up for NAP insurance but the other farmers declined.

There is an improved status and perception of immigrants, and their professional and productive role as citizens in society. Many people tell us how impressed they are with the farm production of some of the trainees in our program. The farmers in the program are the only certified organic immigrant farmers in MN. More immigrant communities are entering MFA's training program. The diversity of trainees in the program continues to increase. We had new farmers from Karen (Burma), Bhutan and Somalia this season. However, the newer refugees find it very difficult to get into farming in the US too quickly. They face significant language, transportation and capital (basic operating funds) barriers. They just do not have the 'community capacity' (people who have some time, some English ability, a drivers license and a car, and some disposable income). Those individuals with some capacity to operate in America are in full demand all the time. It appears that the Bhutanese farmers will not be able to continue in 2012 because they can not find a translator, transportation to and from the farm, and the basic funds for seeds, equipment and tools.

Training Sessions and Farmers Forums for October 2010 – October 2011

When	Topic	Facilitator	Comments
Oct 25, 2010	End of the Year All Farmers Meeting	MFA staff and Farmers in Training	20 people
Jan 10, 2011	Business Planning	John Middleton	10 people
Jan 18, 2011	Business Planning cont.	John Middleton	11 people
Jan 24, 2011	Finances of Business Planning	Laura Frerichs	11 people

Feb 7, 2011	Organic Farming Principles	MFA staff	20 people
Feb 14, 2011	Crop Profiles	MFA staff	18 people
Feb 22, 2011	Plot planning, crop mapping	MFA staff	20 people
Feb 24-26, 2011	MOSES Organic Conference		4 MFA staff and 5 farmers
Feb 28	Marketing	MFA staff and Mills City Market Manager	21 people
March 7, 2011	Seed starting and Greenhouse production	Melanie Timpano and May Lee	15 people
March 14, 2011	Succession Planting	Laura Frerichs	25 people
March 21, 2011	Marketing	Linda Halley, Amy Douen	22 people
Mar 28, 2011	Record keeping – financial, organic certification	MFA staff	19 people
April 4, 2011	Farming Tax preparation	Alan Gregerson (IRS)	20 people
April 23, 2011	Orientation to Big River Farms	MFA staff	25 people
May 7, 2011	Farmers forum meeting	MFA staff	15 people
May 8, 2011	Farm visit to Foxtail farms CSA – weed management, cover cropping	Paul Burkhouse	22 people
May 14, 2011	Spring Open House	15 farmers	15 farmers
May 22, 2011	Farm visit to Blue Gentian Farm – small livestock and vegetables	Darryle Powers and MFA staff	21 people
June 4, 2011	Farm visit to Natura Farms – soil fertility and berry production	Paul Otten	21 people
June 16, 2011	Field skill session – Irrigation and mulching	MFA staff	15 people
June 19, 2011	Field workshop - Post-harvest Handling	Linda Halley	24 people
June 30, 2011	Field skill session - Trellising	MFA staff	15 people
July 11, 2011	Field skill session - Pests	MFA staff	17 people
July 30, 2011	Farmers forum meeting	MFA staff	14 people
Aug 29, 2011	Field skill session - pests	MFA staff	15 people
Sept 12, 2011	Field Workshop – Post-harvest handling	Linda Halley	18 people
Sept 17, 2011	Field Workshop – Seed Saving	Kathleen Plunckett-Black	19 people
Sept 19, 2011	Farm visit to Prairie Farm CSA	Kate Stout	12 people
Oct 9, 2011	Big River Slow Food and Tour of the farms	MFA Staff and 4 farmers	4 farmers gave tours
Oct 15, 2011	Fall Harvest Party, tour of the farms	4 farmers	4 farmers gave tours
Oct 23, 2011	End-of-the-Year Farmers Meeting	MFA staff	

Throughout the season, MFA staff works individually with the farmers on numerous production and marketing issues. The majority of the Training Coordinator's, and now the Farm Manager and Assistant Director, time is spent in working with farmers on their plot plans, business plans, marketing approaches, organic certification applications, food safety planning, applications to USDA SARE Farmer grants, pest intervention and control, quality control and produce grading, packaging, and so on. While the number of farmers is relatively small, the relationship is close, intensive and supportive. All of the farms worked in the greenhouse at least once in April and

many worked 4 -5 days on Saturday or Tuesday to learn propagation and greenhouse management. Each farm also participated in BRF CSA produce receiving and CSA box packing at least once during the 2011 season. This not only provides income but is also an excellent practical training mechanism for the farmers in production and distribution for different markets.

Concerning eligible specialty crops, the Big River Farms Training Program only works with specialty crop producers. We do not produce any non-specialty crops and the producer participants in the program do not produce any non-specialty crops. We only train about and produce certified organic vegetables for direct sales, CSAs, farmers markets and various wholesale and intermediate markets as distributors, schools and restaurants. Big River Farms and the producer participants produced over 40 types of certified organic vegetables and herbs in 2011.

3. GOALS AND OUTCOMES ACHIEVED

The 4 specific objectives for this project include:

1. **Provide technical assistance by training for USDA Organic Certification** to 10 socially disadvantaged farms annually; increasing their knowledge and skills in organic crop production and the certification process and audit.

Result: 10 socially disadvantaged farms were officially Certified Organic in the 2011 season. Five farms were returning farms so their certification was renewed. Five were new farms so this was their first year of certification. The number of new certified organic farms operated by socially disadvantaged farmers in MN increased by 5 farms.

Activity	Deliverables
Workshops on application process and recordkeeping	All farmers understand organic concepts. All maintain their own records and completed their own application packet.
One-on-one meetings plot planning, applications	Each farm had a detailed plot plan
Meeting with certifier, and field audit	Build relationships with MCIA. All farms successfully passed the field audit
Field walks; monitoring inputs and activities	The Farm Manager and Training Coordinator met with each farm 1 – 2 times each week from early May through End September to monitor production and record keeping and estimate production yields and quality.
Cover crops	Cover crops were planted on 10 acres in 2011. Two acres were for the 2011 rotation and 8 acres will be used in 2012. And additional 10 acres was planted in hay.

2. **Provide technical assistance by training for food safety following USDA Good Agricultural Practices (GAP)** to 10 socially disadvantaged farms; increasing their knowledge and skills in harvest, post-harvest, food safety and packing and distribution.

Result: MFA provided classroom sessions on food safety. MFA also conducted two comprehensive in-field workshops on Post-Harvest Handling, which covered food safety in the field, during production, during harvest and during washing, packing and distribution. MFA also presented the Big River Farms Food Safety Plan to all the 10 farms during the initial orientation and discussed this with the farmers on a regular basis. All the farms practiced food safety actions through out the season and this was monitored by the MFA staff (washing hands, washing totes and crates after each use, use of approved disinfectant in produce washing water, use of clean tarps in the field when harvesting, etc.). While all farms practiced food safety, three farms actually developed their own written food safety plans as well. The number of socially disadvantaged / immigrant farms in MN practicing food safety procedures well increased by 5 farms in 2011. We did not conduct a GAP audit or certification. We did have an un-announced visit and inspection by an inspector from the MN Dept of Agriculture, who gave our farm very high marks and complimented us on how well organized and clean our facilities were.

Activity	Deliverables
Classroom session on food safety procedures and recordkeeping	All farmers understood food safety concepts and practices and all the farmers followed these the full season. Farmers actually understood the benefit to their produce quality and reputation.
One-on-one meetings on Planning	Each farm followed MFA's food safety procedures and three farms wrote their own plans as well.

3. **Provide farm business management training** to 10 socially disadvantaged farms including records management, risk management, marketing management and financial management through one to one meetings.

Results: MFA conducted three classroom session on business planning and held numerous individual sessions with all the 10 farms in developing a business plan. However, only one farm actually completed a comprehensive business plan. In this case, they used it to secure a FSA loan and purchased their own farm. Five other farms had variations and drafts of business plans, which included marketing plans and budgets with costs of production. Four farms did not really attempt an actual 'plan' besides very good plot plans. Most of the cultures in the program are not really literary cultures. We need to continue to work on business planning in the coming years. This is one of the most challenging aspects for our program. However, as farms advance and begin to seriously look at buying farm land and/or capital investments, and look to secure loans to do this, the incentive to develop comprehensive business plans becomes greater.

Activity	Deliverables
Conducted intake assessments for each farm, set goals	We enrolled 5 new farms into the program. All the farmers set goals, and wrote down the goals with assistance from MFA staff on most occasions. For most of the 10 farms, these were annual/seasonal goals and not long-term goals.

Conducted 12 off-season workshops, including 3on business planning	All the farmers definitely increased their knowledge on farm business management, as evidenced by their regular and detailed record keeping
Numerous one-on-one meetings with farmers to develop Business Plan	Only one farm completed a comprehensive business plan. But all the farms had good plot plans and maintained good records.

4. **Provide technical assistance towards accessing non-traditional markets** to 10 socially disadvantaged farms. Teaching and practical marketing through BRF CSA and wholesale distribution and connecting farmers to their own direct markets, including CSA, restaurants, stores, coops, and schools.

Results: MFA conducted 3 training sessions specifically related to markets, CSA marketing, farmers marketing and retail/wholesale marketing. Five farms developed good marketing plans while five others did not really have 'plans' but were still able to produce for market. While MFA does not usually purchase produce from 1st year farmers, all the farms in the program produced well in 2011 and MFA purchased some produce from all the farms in the program. These were for the Big River Farms CSA and for the Emergency Food Shelf Network Harvest for the Hungry Program.

MFA operated Big River Farms CSA and sold to 8 additional markets, which about 75% of the produce came from the farms in the program and 25% from our own production. Four farms in the program operated their own CSAs in 2011. Four farms sold directly to restaurants. Three farms sold to schools. Four farms sold to Coops. Four farms sold to whole sale distributors. Seven farms sold at farmers markets. BRF and the farms-in-training distributed about $220,000 worth of certified organic, local produce from about 19 acres and 2 hoophouses, and $9,000 worth of certified organic transplants from 2 mid-sized greenhouses. Each farm was able to produce and sell gross revenue yields of $8,000 - $12,000 per acre, so even farms of ¼ acre were selling up to $2,000 worth of produce. We are not sure of their actual 'profit' because it is still very difficult to get farmers to keep accurate records of expenses and calculate costs of production. We know our best, most experienced farm grossed over $50,000 in sales for the 2011 season

Activity	Deliverables
Held individual meetings with each farmer to establish prices, yield goals, and estimated contracts	All farmers had initial marketing goals and markets outlined
Conducted three training sessions in Marketing to different markets	All the farmers understood pros and cons and methods of different marketing approaches. Because of this season's experience, many farmers learned better what markets they like and do not like and at what scale they can produce consistent quantity and quality
Provided training on purchase orders, invoicing, payment and record-keeping	Each farm had its own system for purchasing and keeping records. MFA provided 'purchase order' to the farmers and the farmers were able to provided invoices to MFA for payment
Provided training in CSA, wholesale grading and selecting	Grading is a very challenging concept and practice for our farmers. Yet each farm understood different grades of produce for different markets

4. BENEFICIARIES

The program primarily serves communities of immigrants, particularly Latino, Hmong, Laotian, Cambodian, Burmese, Karen, Kenyan, and Bhutanese and others from East Africa and Southeast Asia, and other historically underserved communities as African-American and Native American farmers. About half the farmers are women. All the farmers in our program are considered "low income" by IRS standards and are "socially disadvantaged" by USDA standards. The farmers all come from the 7 county Twin Cities Metro Area and the St Croix River Valley of MN and Wisconsin. All the farmers but one have other primarily jobs, all low-paying, as maids, janitors, factory workers, etc. They farmed on plots ranging from ¼ acre to 7 acres. The program reached about 300 farmers over the 2011 season. However, the main beneficiaries of this project were the 10 farms (29 people) in 2011. All the farms had good production. All the farms were able to sell produce and in 2011, all the farms had at least 2 significant market venues. Each farm was able to produce and sell gross revenue yields of $8,000 - $12,000 per acre, so even farms of ¼ acre were selling up to $2,000 worth of produce. Their actual 'profit' is difficult to determine because it is still very difficult to get farmers to keep accurate records of expenses and calculate costs of production. And in many cases, we do not know their total amount of gross sales; we only know for sure the amount of sales that MFA purchased from them. We estimate their other sales and total sales by knowing who/what are their other markets, how often they sell and harvest yield estimates from their fields. The most experienced farm grossed over $50,000 in sales for the 2011 season.

We sold $6,200 worth of produce, a total of 6,200 pounds of produce, to the Emergency Food Shelf Network which was then distributed to other food shelves in the Twin Cities Metro Area.

BRF and the farms-in-training distributed about $220,000 worth of certified organic, local produce from about 19 acres and 2 hoophouses, and $9,000 worth of certified organic transplants from 2 mid-sized greenhouses. The farmers also distributed food among their own communities on a weekly basis but this was not counted and quantified.

The diversity of the farmers continues to increase. We have farmers of 7 different ethnicities and a number of them are relatively new, under 5 years in the USA. The 2011 season was the first year of our new apprenticeship program with World Relief-MN and Karen Organization of MN where we had 4 Karen folks working on the Big River Farms fields for the season. They worked work 3 days / week, 8 hours/day and were paid $7.25 (this became $8/hour in September) through the grant (RAPP, ORR, HHS). In 2012, they will work 10 – 16 hours/week on the farm and have their own plot(s). Then in 2013, they will not work on the farm and have larger plots with complete marketing plans. The diversity of farmers also challenges us with cultural and language issues. We require each farmer to bring their own translator as they need one and so far this has worked well.

5. LESSONS LEARNED

CSA farming and marketing is an increasingly popular approach for the farmers in our program. We will continue to increase our connections with experienced CSAs and increase our training components related to CSA farming and marketing because the farmers in our training program are interested in this. However, we are clear that CSA farming and marketing is not for every farmer. It requires sophisticated production skills and advanced record keeping and people skills. We found that modifications of the traditional CSA model help newer farms by providing an additional market and by allowing them to get some money in the pre-season to purchase supplies and seeds. These modifications include:

- Start and stay small. 10 – 30 members are plenty.
- Reduce the number of dropsites to only one or two dropsites.
- Reduce the number of weeks. Traditional CSAs in MN normally do 18 weeks but there is no need to. Reduce to a 10 week season, or divide the season up in an early leafy green / brassica section of 3 – 4 weeks in the Spring and then a 6 – 8 week section in mid-to-late summer of traditional crops (peppers, tomatoes, beans, zucchini, etc.).

We will further assess whether a traditional CSA model can be an appropriate means of bringing affordable and accessible fresh produce to low income communities but it appears that it needs more exploration. From our experience, these communities tend to not have the income to pay the farmer the price they need. Possibly a combination of using EBT payments to pay on a weekly basis would work but by itself it (just paying on a weekly basis) is not really a "CSA" where the consumer is sharing the risk with the farmer by paying ahead of the season. This may be combined with a "revolving fund" where by the farmer has a fund that they tap in the beginning of the season for expenses, arranges commitments from the number of customers that the farmer wants, and then uses the weekly payments to re-supply the revolving fund. We may also look at other direct marketing models like 'agreed purchase' – to put down a deposit ($20 or $30) in the pre-season and then agree to purchase that amount and more as the season progresses.

Another issue is with the exponential growth of CSAs in the western Wisconsin and Minnesota region and how this relates to the quality of the CSAs and the reputation of the CSA movement. Since 2006, the number of CSAs has more than doubled from about 40 to now well over 80 CSA farms. Most all the new CSA farms have less than 3 years experience in farming and end up having to buy in produce form other farms to fill their boxes. Another phenomenon is large conventional vegetable farms who have traditionally only supplied large distributors are now beginning CSA operations and usually starting out on a very large scale, over 200 members. This creates strong competition for new, beginning farmers trying to develop their small farm enterprise.

Our main plan is to continue to work with farmers in developing their own 'market portfolio' that fits the types of farming and marketing that they prefer and excel at. MFA remains in an excellent position to be 'brokering market relations', whereby MFA can initiate the market relationship with new buyers and then work with the farmers and the buyers to hand the market completely over the farmer. MFA has done this on many occasions in the past 3 years. MFA will focus on securing resources to hire a Marketing Coordinator to lead this forward. In addition to this, MFA will focus on training in grading produce and proper post-harvest handling and food safety which we have identified as the weak links in the production-for-market chain for new and immigrant growers of organic specialty crops.

MFA's model is based on working intensively with a relatively small number of farms and farmers. This involves regular one-on-one consultation and work and is therefore time intensive. But we have found that this is the most effective in producing change and results. Connecting farmers to farmers by doing field trips to other farms in the area is also very effective, but the challenge is that this should be during the season as the best time to visit other farms, but farmers do not have time during these times. So we have designed our farm visits to be relatively shorter (1/2 day, or about 2 – 3 hours on the farm, compared to a full day or 6 hours on the farm) and we are going to pay a gratitude fee to the farms that we visit.

Another change has been opening up our training classes to the general public. This has worked well because we clearly advertise the classes as targeting immigrant and minority farmers. We have had between 2 – 10 outside folks come to any given training class. We have also scaled down our 'in-field' training sessions because farmers expressed concern that they do not have the time for long sessions during the season. In 2011 the 'skill sessions' in the field were 30 - 60 minutes only and addressed one particular production skill (driptape, trellising, pest control, mulching, planting cover crop, etc.) – short and to the point and the farmers can get back to their fields. This season we were also diligent in scheduling a weekly field walk, or two, with each of the farms where the Farm Manager and/or Training Coordinator walked their fields with them for 30 – 60 minutes. This was to specifically provide advice and analysis for their plots – pests, yield estimates, succession plantings, etc.

The main challenges remain:

- Development of actual business plans that incorporate all the components that the farmers now are doing separately – plot plans, market plans, food safety plans, record keeping on costs and income, etc.
- Development of credit and building the resources for farmers in which they can have the secure ability to invest in land and capital to move their operations to a viable level.
- Transportation and initial start up costs for the newer refugee and immigrant communities.

The project proceeded well. We were very pleased with the progress of the farmers in our training program especially in the areas of marketing, understanding different markets, post-harvest handling and food safety and organic production. Our farmers understand different markets extremely well; much better than the average immigrant grower some of whom have been doing this for 10 – 20 years. As the farmers markets are mostly full with venders, and many have 2 – 5 year waiting lists, it is vital that farmers find other ways of selling their produce and connecting with buyers. MFA excels in filling that niche. We warmly welcome a visit from any MDA staff to our farm and program, preferably during the growing season but anytime is fine.

6. CONTACT PERSON

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PROJECT G

Impacts of Biochar Amendments on Specialty Crop Production

PROJECT SUMMARY

> "*The use of charcoal (biochar) as a fertilizer is not a new thing, though it is only within the few last years that agriculturists have taken much notice of it*."
>
> *-Pennsylvania Farm Journal (1852) p. 57*

There is an immediate need to examine the potential impacts (both positive and negative) of biochar on specialty crops production. Biochar has been gaining attention, both in the public and scientific circles, as a means to combat climate change and at the same time improve soil fertility (*See Additional Information; Biochar*). Popular press coverage on biochar amendments impacts, as well as the potential climate mitigations effects, have peaked interest in all aspects of biochar use. Furthermore, analogies drawn between biochar and the fertile soil in the Brazilian Amazon [*Terra Preta*] have created an image of benign and positive environmental effects. As highlighted by the quote above, the use of charcoal in specialty crops is not a new idea or concept. Despite this long history, the detailed scientific data to base guidelines for soils and specialty crops is lacking.

Biochar amendments could provide tremendous benefits for specialty crop production from improved soil fertility, soil nutrient availability, crop productivity, disease and weed suppression. On the other hand, there could be unforeseen negative aspects of biochar use, such as uptake and bioaccumulation of toxic organic compounds that are sorbed to the biochar. However, the benefits of biochar particularly on specialty crop production for the Upper Midwest have not been adequately investigated. There currently are no recommendations on biochar application rates, or more fundamentally, whether biochar is intrinsically safe for specialty crop production. The aim of this project was to generate data to answer these two basic questions:

(1) What benefits does biochar have for specialty crop production, and

(2) What are the potential negative impacts from biochar use in specialty crop production?

These are vital questions, and data necessary to answer these questions did not exist prior to this project.

PROJECT APPROACH

Research was conducted both on greenhouse and field plot scales to collect data on the impact of biochar on specialty crops. This funding provided partially supporting for 5 undergraduate student workers, support for a MS graduate student, and 2 part-time high school student summer interns. The four main factors that were investigated: 1) Germination impacts (percent germination and timing), 2) Initial plant growth rates, 3) Sorbed PAH and organic content of various biochar and biochar amended soils, and 4) PAH uptake in specialty crops.

Parts I & II. - Specialty Crop Growth – Initial Germination and Seedling Growth

Due to high number of biochars, soils, and specialty crop types investigated here, this research was conducted in the greenhouse. In order to accommodate all the various soil, biochar, and specialty crop treatments (Table 1), we used a combination of two primary types of greenhouse seedling containers. The first were "Deepots" (D-40; 40 in^3 volume; Stuewe and Sons, Tangent, OR) with a corresponding tray that allowed a total of 20 cells per square foot of greenhouse bench space (*See Figure A1*). The other tray was a 288 well seed germination tray (Model # 720528C -- PL-288-1.25; T.O. Plastics, Clearwater, MN), which allowed a total of ~100 cells per square foot of bench space (*See Figure A1*). The various combinations of *specialty crop x soil type x biochar type* were grown at various stages throughout the two years of the project. The experimental design was a fully-randomized block design to minimize systematic errors in the light intensity and microclimate differences on the table in the greenhouse.

Table 1. Various soil, biochar, amendment rate, and specialty crops evaluated in this project.

Soil Types (6)	Biochars Types (8)	Amendment Rates (4) (w/w)	Specialty Crop Types (11)
Potting Soil Mix (Sun Gro Hort., Bellevue, WA)[2]	Macadamia nut shell (fast pyrolysis)	1%	Lettuce
Rosemount, MN [Wauken silt loam]	Wood pellet (slow pyrolysis)	5%	Radish
Hayward, WI [Vials loamy sand]	Waste Wood Biochar (slow pyrolysis)	10%	Sweet Corn
Becker, MN [Hubbard loamy sand]	Corn Cob Biochar (slow pyrolysis)	20%	Cabbage
Morris, MN [Barnes-Aastad clay loam]	Wheat mids Biochar (slow pyrolysis)		Spinach
University Park, PA [Birdsboro silt loam]	Softwood (Pine) Biochar (slow pyrolysis)		Peas

[2] - Formulated with vermiculite, Canadian Sphagnum peat moss (25-35%), coarse perlite, starter nutrient charge (with gypsum) and dolomitic limestone.

	Non-functionalized Carbon Black Functionalized Carbon Black		Carrot Onion Broccoli Basil Bean

<u>Part III.</u> Sorbed Organic Content of Various Biochars and Biochar Amended Soils

Qualitative identification of sorbed volatile organic compounds (VOCs) on biochar was conducted by headspace thermal desorption coupled to capillary gas chromatographic-mass spectrometry. VOCs in the soil system may have a mechanistic role influencing plant and microbial responses to biochar amendments, since VOCs can directly inhibit or stimulate microbial and plant processes (Insam and Seewald 2010).

Polycyclic aromatic hydrocarbons (PAH) compose a large group of compounds (200+), that share the common characteristic of two or more fused aromatic carbon rings in the structure (Wild and Jones 1995). The one unique aspect of the PAH chemical family, is that the compounds are solely composed of carbon and hydrogen atoms. The simplest PAH is naphthalene (Figure 1).

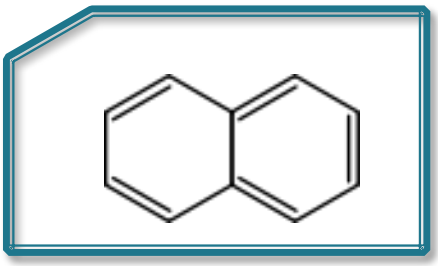


Figure 1. Chemical structure of naphthalene.

Biochar is part of the black carbon spectrum of thermally altered biomass products. We reviewed the literature for PAH contents in various forms of black carbon, including biochar. From this review, the PAH content of various black carbons do vary (Table 2). Previous studies have indisputably illustrated that biochar has the potential for sorbed PAH compounds (Hale, Lehmann et al. 2012, Hilber, Blum et al. 2012, Meynet, Hale et al. 2012) and other organic compounds (Spokas, Novak et al. 2011) that could be of potential health concern. From this review and supported by our new data, sorbed PAH content on biochar is controlled by pyrolysis conditions (temperature as well as resident time), moisture content of the pyrolyzed feedstock, and the amount of oxygen present during the pyrolysis (See Additional Information, PAH Content on Biochar). Our data suggests that the quantity of sorbed compounds on biochar can be controlled by a combination of pyrolysis/feedstock control and/or post-creation activation, which results in removing the PAHs from the biochar.

A new analytical method for the determination of the sorbed 16 USEPA PAHs in biochar and soil amended with biochar was developed (Table 3). Samples were Soxhlet extracted with acetone:cyclohexane 1:1, and PAHs were analyzed by GC-MS after silica gel clean-up. In a comparative study based on reflux solvent extraction, the solvent system of acetone:cyclohexane (1:1) exhibited a higher extraction efficiency, particularly for low molecular weight PAHs (e.g.

naphthalene), than pure toluene or dichloromethane solvents as well as superior to hexane or dichloromethane.

This new analytical method was successfully validated through the analysis of a certified reference contaminated PAH soil material, and was capable to quantify PAHs once the biochar was embedded into the soil at 1 to 20% (w/w) levels. We then used this method to characterize the sorbed PAH content of various biochars. In addition, samples were sent out to a certified USEPA laboratory (Columbia Analytical) for confirmation of the findings in this study.

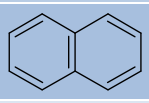
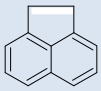
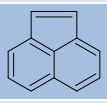
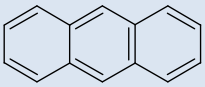
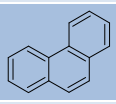
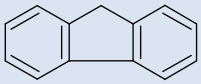
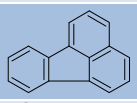
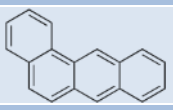
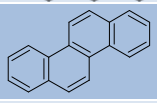
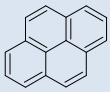
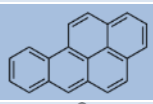
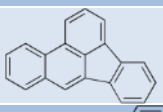
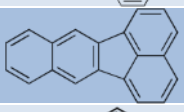
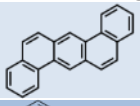
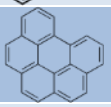
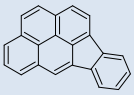
In total, the sorbed concentrations of the 16 USEPA PAH compounds ranged from 10 to 83,000 $\mu g\ g^{-1}$ (0.01 to 83 $mg\ g^{-1}$). Higher moisture and higher levels of oxygen presence during the pyrolysis resulted in higher levels of sorbed PAH compounds, although these trends are pyrolysis unit specific. The combined variability in all of these factors confounds our ability to accurate predict the presence of sorbed PAH across biochars from various pyrolysis units.

Over 70 biochars were evaluated and observed to possess diverse sorbed VOC composition, which encompassed a variety of parent materials and manufacturing processes. There were over 140 individual chemical compounds thermally desorbed from some biochars, with hydrothermal carbonization (HTC) and fast pyrolysis biochars typically possessing the greatest number of sorbed volatiles. In contrast, gasification, thermal or chemical processed biochars, soil kiln mound, and open pit biochars possessed low to non-detectable levels of VOCs. Slow pyrolysis biochars were highly variable in terms of their sorbed VOC content. There were no clear feedstock dependencies to the sorbed VOC composition, suggesting a stronger linkage with biochar production conditions coupled to post-production handling and processing. Lower pyrolytic temperatures ($\leq$350 ^{o}C) produced biochars with sorbed VOCs consisting of short carbon chain aldehydes, furans and ketones; elevated temperature biochars (>350 ^{o}C) typically were dominated by sorbed aromatic compounds and longer carbon chain hydrocarbons. Oxygen presence during pyrolysis also reduced sorbed VOCs. These compositional results suggest that sorbed VOCs are highly inconsistent and that their chemical dissimilarity could play a role in the wide variety of plant and soil mediated responses of biochar addition to soils noted in the literature. In addition, this variability in VOC and PAH composition may argue for chemical characterization of biochar prior to use in specialty crop production systems.

Table 2. Presence of polycyclic aromatic hydrocarbons in various materials

Material	Range of total PAH (EPA 16) [µg g^{-1}]	Reference
Specialty Crops		
Strawberries, apples, tomatoes, lettuce, kohlrabi, potatoes, parsley and kale	0.01 to 0.12	(Rojo Camargo and Toledo 2003)
Lettuce, cabbage, Ipomoea aquatica, Chinese milk vetch, mustard, Chinese flowering cabbage, kidney bean, towel gourd and cucumber	0.08 to 1.3	(Li, Li et al. 2008)
Soils		
Urban soil (roadside)	0.04 to 14.0	(Ritschel 2008)
Arable soil (farmland)	0.16 to 0.43	(Ritschel 2008)
Terrestrial rocks	<0.1 to 45	(Mahajan, Plows et al. 2001)
Coal 11 global coal basins	0.3 to 58.0 6.0 to 253.0	(Wang, Liu et al. 2010) (Laumann, Micić et al. 2011)
Coal Fly Ash	95.0 to 185.0	(Gohda, Hatano et al. 1993)
Municipal solid waste incinerator - bottom ash	0.48 to 4	(Johansson and van Bavel 2003)
Pine Needles	0.04 – 2	(Ratola, Amigo et al. 2010, Navarro-Ortega, Ratola et al. 2011)
Wood Chips	0.01 to 0.015	(Chinnici, Natali et al. 2007)
Sewage sludge	2.2 to 126.0	(Wild, McGrath et al. 1990, Ritschel 2008)
Composts Wood chips/leaves/grass clippings Fall leaves/twigs Wood chips/sewage sludge	sum of 11 PAHs 16.0 14.4 20.8	
Bottom/fly ash mixture (wood feedstock)	57 to 77	(Davies, Harrison et al. 1976, Dugenest, Combrisson et al. 1999, Johansson and van Bavel 2003)
Black Carbon Residuals		
Wood Ash (3.7% C)	16.8	(Rey-Salgueiro, García-Falcón et al. 2004)
Natural and synthetic charcoal	1.0 to 4	(Brown, Kercher et al. 2006)
Wood charcoal (*Acacia mearnsii* and *Newtonia buchananii*)	0.001 to 1.1	(Gachanja and Worsfold 1993)
Coconut shell charcoal (CocoNara™)	2.9	(Sepetdjian, Saliba et al. 2010)
Hardwood Lump Charcoal	0.5	(Sepetdjian, Saliba et al. 2010)
Three Kings™ (waterpipe charcoal)	1.2	(Sepetdjian, Saliba et al. 2010)
Biochars 11 biochars/5 feedstocks: Wood, manures, sewage sludge, paper mill pulp, leaves/twigs	<0.5	(Singh, Singh et al. 2010)
Various biochars (>75 different sources)	0.07 to 3.3	(Hale, Lehmann et al. 2012, Meynet, Hale et al. 2012)

Table 3. USEPA's 16 priority-pollutant PAHs, chemical structure, CAS number, and formula.

	Polycyclic aromatic hydrocarbon (PAH)	Structure	CAS #	Chemical Formula
1	Naphthalene		91-20-3	$C_{10}H_8$
2	Acenaphthene		83-32-9	$C_{12}H_{10}$
3	Acenaphthylene		208-96-8	$C_{12}H_8$
4	Anthracene		120-12-7	$C_{14}H_{10}$
5	Phenanthrene		85-01-8	$C_{14}H_{10}$
6	Fluorene		86-73-7	$C_{13}H_{10}$
7	Fluoranthene		206-44-0	$C_{16}H_{10}$
8	Benzo(a)anthracene		56-55-3	$C_{18}H_{12}$
9	Chrysene		218-01-9	$C_{18}H_{12}$
10	Pyrene		129-00-0	$C_{16}H_{10}$
11	Benzo(a)pyrene		50-32-8	$C_{20}H_{12}$
12	Benzo(b)fluoranthene		205-99-2	$C_{20}H_{12}$
13	Benzo(k)fluoranthene		207-08-9	$C_{20}H_{12}$
14	Dibenz(a,h)anthracene		53-70-3	$C_{22}H_{14}$
15	Benzo(g,h,i)perylene		191-24-2	$C_{22}H_{12}$
16	Indeno[1,2,3-cd]pyrene		193-39-5	$C_{22}H_{12}$

Part IV. PAH content of specialty crops grown in biochar amended soils

An on-farm collaboration was established with John Weis of Elko, MN for additional field plots that were in addition to the field plots established in Rosemount, MN. The seedlings grown in the greenhouse study (Part I) were utilized, along with partnerships with the MN Master Gardeners (three field plots and 5 collaborative partners), field plots, and Penn State University to achieve additional combinations of soils, biochar, and specialty crops to evaluate the presence of organic compounds in specialty crops grown in biochar amended soils. Depending on the sorbed concentration of PAHs on the biochar and the corresponding application levels, these organic compounds were observed accumulate in some specialty crops. We did observe the accumulation both in greenhouse and field plots, but the levels of bioaccumulation were the highest in the greenhouse grown specialty crops. The levels of observed contamination were a function of the crop, biochar, amendment rate, and soil type that was used. There was a general trend observed between the PAH level in the soil-biochar system and the levels observed in the plant of a particular species, which has also been observed previously for specialty crops grown in PAH contaminated soils (Fismes, Perrin-Ganier et al. 2002). Indicating that a potential mode of transport is root uptake, which also has been confirmed (Edwards, Ross-Todd et al. 1982). However, the levels were not equivalent across different species in the same biochar amended soil. Organic matter was an important controlling variable, with high organic matter soils reducing the amounts of plant uptake of PAH compounds from biochar amended soils. Similarly, in low PAH containing biochars there was sorption of the native soil PAH compounds resulting in lower plant PAH values than the controls for these low PAH containing biochar, which has already been demonstrated (Chen and Yuan 2011).

This was the first project to document the bioaccumulation potential of the PAH compounds sorbed to the biochar. However, do the the high variability in the observed PAH contents across the range of biochars, each biochar is recommended to be tested to ensure its safe use. Our results do indicate the need for guidance on the use of biochars to avoid the negative aspects observed from high application amounts with biochars with high amounts of sorbed organics. Furthermore, similar to other soil amendments, application amounts should be targeted at remedying a particular soil deficiency.

The research in this project was accomplished with the collaboration of the following project partners:

1. Penn State University – (PI: Randy L. Vander Wal)
    a. Greenhouse assessments with soil from Pennsylvania
    b. Analyzed various biochars for chemical structure data
2. Lac Courte Oreilles Ojibwa Community College
    Summer intern student – investigated the role of biochar in container boxes
    University of Bologna (Italy - Centro Interdipartimentale di Ricerca Industriale C.I.R.I Energia Ambiente) – (No direct costs to project)
    Assisted in method development of PAH analysis on soil and biochar mixtures
3. Columbia Analytical
    US-EPA certified laboratory that was used for confirmation of analyses.
4. John Weis – On-farm collaborator in Elko, MN

GOALS AND OUTCOMES ACHIEVED

We have observed a variety of impacts, including positive increases in growth, germination, and yield of some specialty crops when grown in biochar amended soils. Some of these increases have been significant improvements in growth and yield. On the other hand, negative impacts on growth, germination, and yield have also been observed.

Biochar Chemistries:

Overall, the direct fertilizer content of biochar is of minor importance. However, there are a few biochars that hold some promise for direct fertilization value as a function of the feedstock used (Table 4). As shown in Figure 2, the elemental composition does various as a function of the biochar type. In particular, the biochar created from dried distillers grain solids (DDGS) by microwave assisted pyrolysis did contain a high amount of N present in the biochar (Figure 2).

This high N containing biochar was from dried distiller grain and created by microwave assisted pyrolysis (MAP). One advantage of MAP is a reduction in the volatile loss of important plant nutrients (N, P, and K) compared to other production techniques (i.e., traditional kiln or fluidized bed reactors). These nutrients are typically lost through volatilization in thermally produced biochars. For the MAP, the nitrogen content is enriched compared to the original DDGS feedstock (original DDGS; N = 5.3% w/w).

The ability to increase N content in biochar was first reported in the early 1980's (Reed 1975, Mubayi, Lee et al. 1980). Radlein et al. (1997) submitted a patent for a technique to produce a nitrogen rich-slow release fertilizer from biomass pyrolysis products. This was accomplished by exposing the formed biochar with N-rich products to create a slow release fertilizer, primarily through sorption of the N containing compounds. As further studies have shown, this was a critical basis for slow release fertilizers creation from biochar (González, Alvarez et al. 1992, Khan, Kim et al. 2008). Ammonia exposed to black carbon surfaces is known to react with surface oxygen groups leading to the formation of amines and amides under ambient (<100 ^{o}C) conditions (Seredych and Bandosz 2007, Spokas, Novak et al. 2012). Further investigation of these N-sorption mechanisms has shown that some of the sorbed N is bio-available (Taghizadeh-Toosi, Clough et al. 2011). The use of DDGS as a biochar feedstock offers unique opportunities to further allow optimization of the soil N delivery/fertilization and reduce the environmental impacts of specialty crop production.

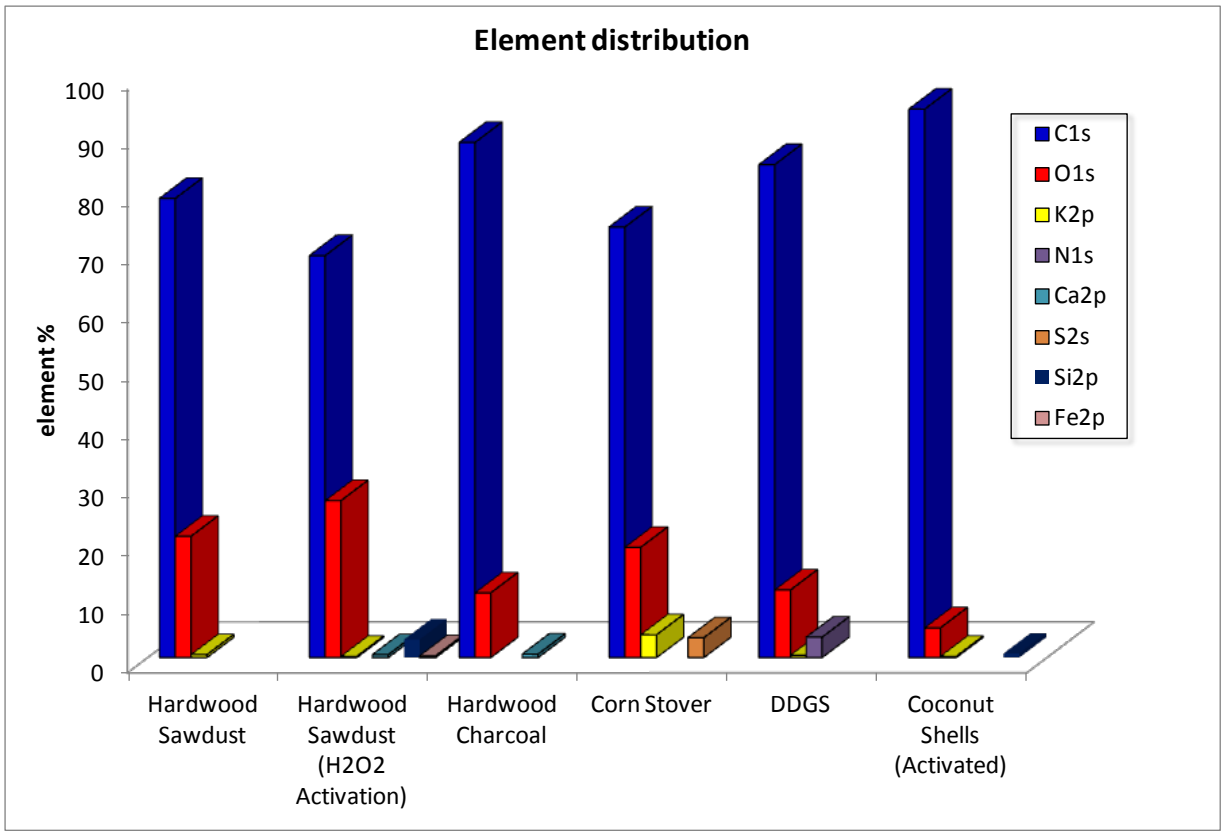
As expected, carbon is the dominant element, but the relative high content of atomic oxygen does suggest abundances of phenolic, carbonyl and carboxylic acid functional groups. Figure 3 illustrates the predicted bonding orbitals and carbon-oxygen bonds in various biochars. Certainly, there will be other oxygen containing groups such as quinones, lactones, anhydrides, but their identification by XPS is more tenuous. Minor elements are as plotted, notably the hydrogen peroxide activated hardwood sawdust biochar has more trace elements than the other biochars (Figure 2). This data supports the conclusion that the elemental data is largely controlled by the feedstock selection, with some modification by post-production processing. Therefore, for remedying soil nutrient deficiencies the selection of the feedstock type largely control the mineralogical composition of the biochar.

Table 4. Elemental content for the various biochars evaluated in this study (% dry weight basis)

Feedstock	Pyrolysis Temperature and Type	pH	% C	% N	% O	% H	% S	% Ash	% Moisture (air dried)	Surface Area (m^2g^{-1})
Hardwood Sawdust	550 (FP)	5.8	63.86	0.22	11.78	3.03	0.01	21.11	20.30	46.02
Corn stover	815 (SP)	9.5	40.40	0.44	1.26	1.66	0.04	56.20	54.72	4.40
Pine wood chip	465 (SP)	6.8	81.02	0.25	9.36	3.38	0.06	5.93	5.62	0.10
Peanut hulls	481 (SP)	8.0	64.21	3.37	13.46	2.26	0.18	16.62	15.33	1.00
Turkey manure wood chip	850 (FP)	10.9	1.47	0.04	3.16	0.48	2.14	92.71	89.12	4.80
Hardwood	550 (SP)	9.3	71.91	0.75	9.91	2.38	0.02	15.03	14.06	19.20
Pine wood chip	465(SP)	6.8	74.07	0.24	12.32	3.27	0.05	10.05	9.33	0.20
Peanut hulls	481 (SP)	5.1	68.27	1.04	12.24	1.07	0.13	17.25	14.45	286.00
Coconut shells (activated)	450 (SP/Act)	7.6	87.90	0.40	<0.01	0.06	0.65	12.99	12.28	976.20
Wood chip (pellet)	650 (SP)	9.8	73.37	0.21	18.75	1.28	0.01	6.38	6.03	177.19
Hardwood Lump Charcoal	538 (SP)	8.7	56.98	0.41	10.50	2.77	0.41	28.93	27.11	33.72
Macadamia shells	N/A (FP)	6.2	93.15	0.67	1.68	2.56	0.02	1.92	1.74	6.90
DDGS	400 (MAP)	6.9	69.43	7.43	5.98	4.31	0.90	11.96	11.72	0.28
Corn cob	350 (SP)	8.7	78.85	0.67	13.25	4.31	0.01	2.92	2.83	<0.10
Corn cob	400 (SP)	9.0	82.62	0.61	9.08	3.85	0.01	3.84	3.72	<0.10
Wood waste	Unknown Temp(SP)	6.9	72.08	0.43	NA	NA	<0.01	3.26	5.04	3.51
Hardwood	500-600 (SP)	6.6	74.54	0.25	NA	NA	<0.01	2.35	1.71	NA

Notes: FP – Fast pyrolysis, MAP- microwave assisted pyrolysis, SP-Slow pyrolysis, SP/Act – Slow pyrolysis followed by steam/nitric acid activation, and NA – not available.

(A)



(B)

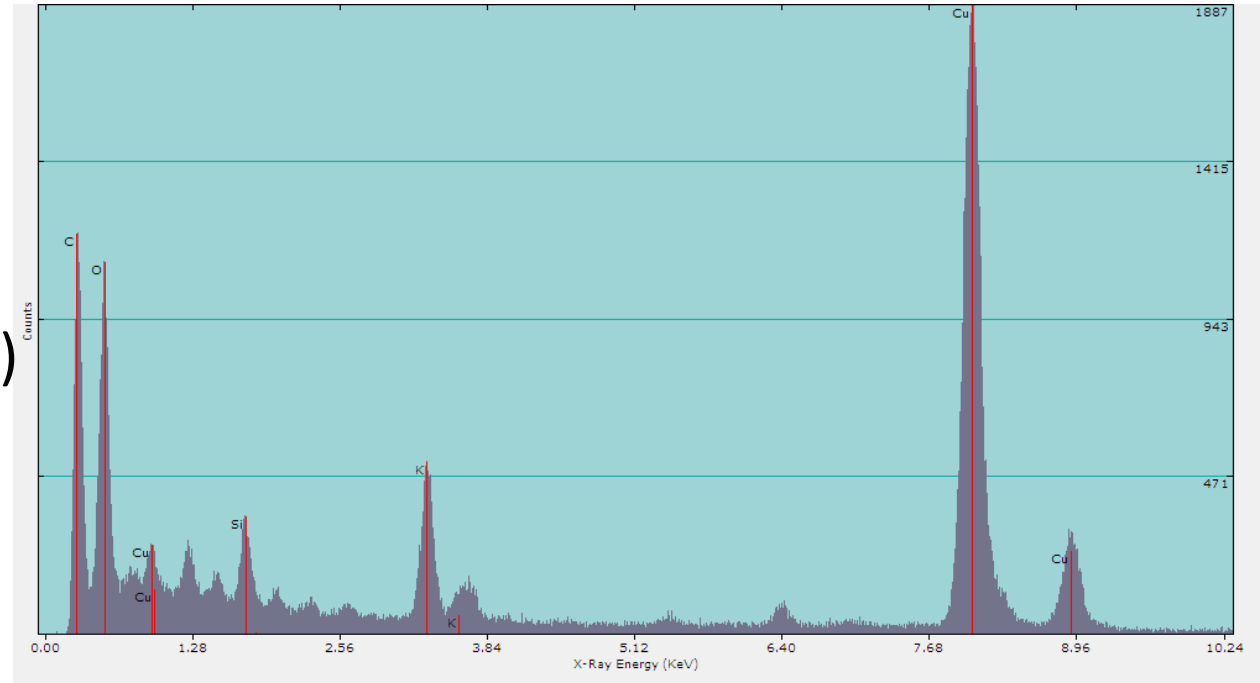


Figure 2. A) Elemental distribution in various biochars as analyzed by SEM-EDX and B) illustration of sampled EDX energy spectrum which can be correlated to elemental composition (Data and images courtesy of R. Vander Wal).

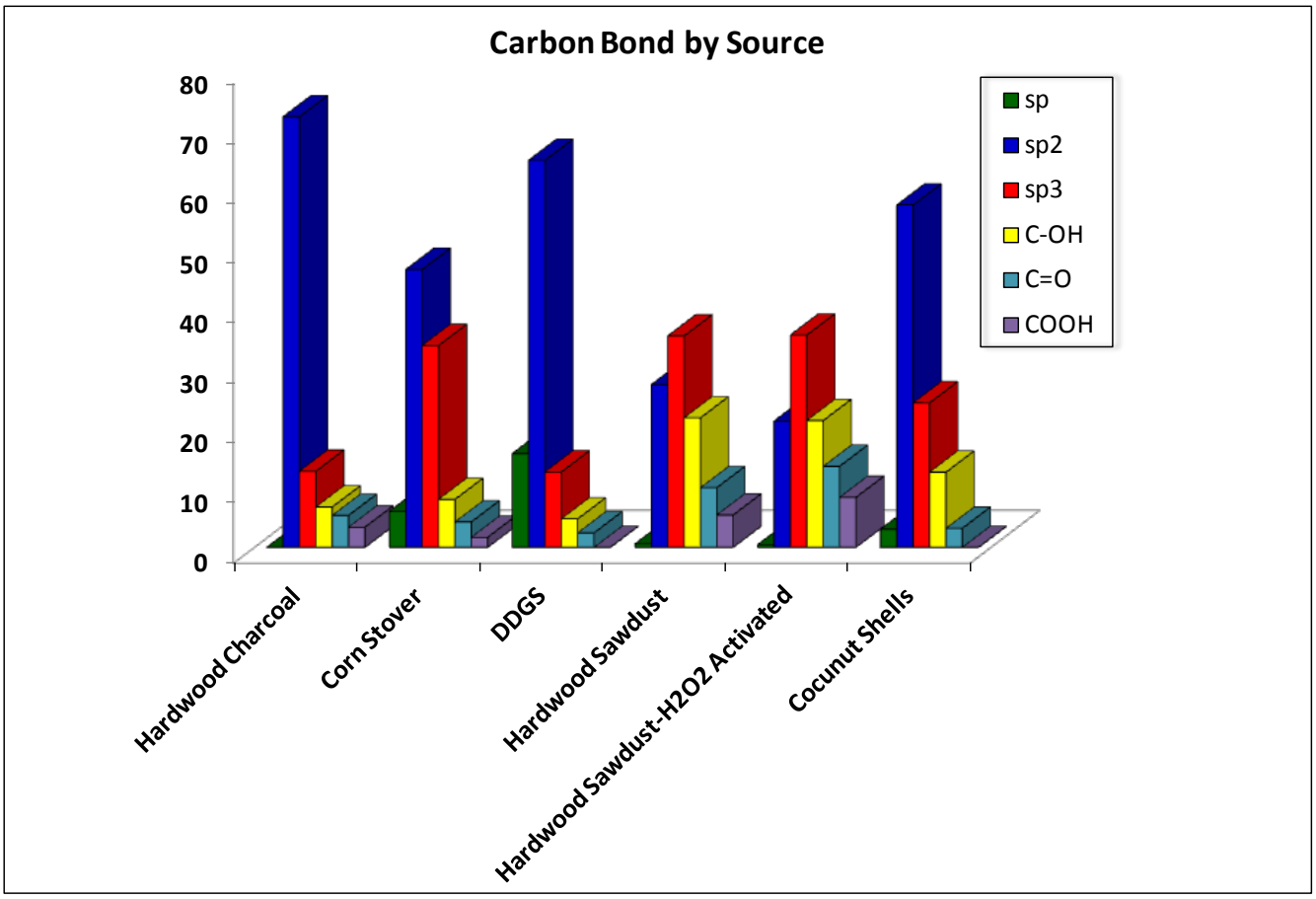


Figure 3. Predicted carbon bonding orbital configuration as well as carbon-oxygen bonding groups as estimated from X-ray photoelectron spectroscopy (XPS) data (Data courtesy of R. Vander Wal).

(1) What benefits does biochar have for specialty crop production?

Some of the biochars evaluated here do offer benefits as a soil amendment for specialty crop production (Table 5). In particular, the corn cob biochar that was used here offered the most consistent positive effects on germination and growth across all the soils evaluated here (Table 5). However, the corn cob derived biochar was not beneficial for sweet corn and beans. Despite these lower germination percentages, after germination plant growth was usually better than the companion soil control in the corn cob biochar amended soils. However, only modest increases were observed for all specialty crops (10-24% increase in above ground biomass of crops) grown in corn cob derived biochar in Rosemount, Morris, and potting soils. The larger percentages of benefit (>100% plant germination improvement) were observed in low nutrient containing soils (sandy textures; Becker, Hayward) and which also possessed reduced plant performance in the control soil (compared to more productive or potting soil mixtures).

Table 5. Impacts of various biochars on seed germination as a function of soil type

5A. Rosemount, MN Soil

Biochar (feedstock)	Amended Amount	Lettuce	Radish	Sweet Corn	Cabbage	Spinach	Pea	Carrot	Onion	Broccoli	Basil	Bean
Macadamia nut shells	1%	92.9	88.9	**111.8**	**129.4**	84.6	90.0	100.0	*	*	*	90.4
	5%	35.7	83.3	70.6	64.7	**115.4**	84.0	88.0	*	*	*	80.5
	10%	34.2	44.2	30.1	20.1	84.9	70.0	*	*	*	*	*
	20%	22.0	85.0	*	*	78.0	*	*	*	*	*	*
Wood pellet	1%	**128.6**	**108.1**	76.5	**117.6**	76.9	98.0	80.0	*	*	*	*
	5%	**107.1**	88.9	**111.8**	**123.5**	**130.8**	**110.0**	98.0	*	*	*	*
	10%	99.0	78.0	95.0	98.0	90.5	*	*	*	*	*	*
	20%	80.0					*	*	*	*	*	*
Wood waste	1%	92.9	102.4	**116.7**	98.5	102.4	**125.0**	**133.3**	54.5	93.3	**114.3**	87.5
	5%	**114.3**	110.0	**125.0**	102.6	101.2	**175.0**	**125.0**	**118.2**	**106.7**	**114.3**	87.5
	10%	*	*	*	*	*	*	*	*	*	*	*
	20%	*	*	*	*	*	*	*	*	*	*	*
Wheat mids	1%	85.7	98.0	**116.7**	101.4	100.0	60.0	100.0	66.7	82.6	57.1	69.2
	5%	92.9	95.0	**116.7**	98.7	98.4	100.0	88.9	55.6	**130.4**	53.6	**107.7**
	10%	*	*	*	*	*	*	*	*	*	*	*
	20%	*	*	*	*	*	*	*	*	*	*	*
Pine (bark/chips)	1%	85.7	*	83.3	70.0	64.0	40.0	83.3	55.6	**113.0**	78.6	69.2
	5%	92.9	*	**108.3**	*	*	40.0	**150.0**	61.1	**113.0**	89.3	84.6
	10%	*	*	*	*	*	*	*	*	*	*	*
	20%	*	*	*	*	*	*	*	*	*	*	*
Corn cob	1%	92.9	*	83.3	*	*	**145.0**	**118.3**	100.0	**126.7**	**124.3**	87.5
	5%	**107.1**	*	91.7	*	*	**115.0**	**117.0**	**117.3**	**116.7**	**114.3**	93.8
	10%	**115.1**	**112.0**	90.1	*	**125.2**	**110.0**	**115.4**	**111.8**	98.5	102.4	94.2
	20%	*	*	*	*	*	*	*	*	*	*	*

Table 5. (Continued)

5B. Hayward, WI Soil

Biochar	Amended Amount	Lettuce	Radish	Sweet Corn	Cabbage	Spinach	Pea	Carrot	Onion	Broccoli	Basil	Bean
MacNut	1%	90.0	71.4	100.0	45.5	**400.0**	85.5	80.1	50.0	*	*	*
	5%	90.0	71.4	87.5	63.6	100.0	80.0	79.5	65.0	*	*	*
	10%	44.0	65.0	77.4	58.4	90.4	*	*	*	*	*	*
	20%	65.0	77.4	58.4	90.4	*	*	*	*	*	*	*
Wood Pellet	1%	40.0	100.0	100.0	55.4	80.1	*	*	*	*	*	*
	5%	80.0	85.7	**112.5**	**127.3**	**900.0**	*	*	*	*	*	*
	10%	80.0	85.7	100.0	54.5	**500.0**	*	*	*	*	*	*
	20%	90.0	71.4	100.0	45.5	**400.0**	*	*	*	*	*	*
Corn Cob	1%	**250.0**	98.4	95.7	*	99.0	**225.0**	**108.3**	100.0	**106.7**	**114.3**	*
	5%	**300.0**	110.5	90.1	105.0	**115.0**	**125.0**	**125.0**	**127.3**	**106.7**	**114.3**	**200**
	10%	**125.0**	*	*	*	*	**120.0**	**115.4**	**121.8**	98.5	102.4	*
	20%	*	*	*	*	*	*	*	*	*	*	*

Table 5. (Continued)

5C. Morris, MN Soil

Biochar	Amended Amount	Lettuce	Radish	Sweet Corn	Cabbage	Spinach	Pea	Carrot	Onion	Broccoli	Basil	Bean
MacNut	1%	**125.0**	**116.7**	100.0	60.0	80.0	85.5	80.1	50.0	*	*	*
	5%	25.0	50.0	75.0	40.0	90.0	80.0	79.5	65.0	*	*	*
	10%	44.0	*	*	*	*	*	*	*	*	*	*
	20%	*	*	*	*	*	*	*	*	*	*	*
Wood Pellet	1%	0.0	50.0	112.5	70.0	60.0	*	*	*	*	*	*
	5%	**175.0**	50.0	87.5	70.0	**110.0**	*	*	*	*	*	*
	10%	80.0	85.7	100.0	54.5	**500.0**	*	*	*	*	*	*
	20%	90.0	71.4	100.0	45.5	**400.0**	*	*	*	*	*	*
Corn Cob	5%	**115.0**	**150.0**	**135.4**	**122.5**	**135.4**	*	*	*	*	*	*

5D. Becker, MN Soil

Biochar	Amended Amount	Lettuce	Radish	Sweet Corn	Cabbage	Spinach	Pea	Carrot	Onion	Broccoli	Basil	Bean
MacNut	1%	90.9	75.0	**113.3**	62.5	28.6	85.5	80.1	50.0	*	*	*
	5%	**109.1**	70.0	**126.7**	**118.8**	**114.3**	80.0	79.5	65.0	*	*	*
	10%	*	*	*	*	*	*	*	*	*	*	*
	20%	*	*	*	*	*	*	*	*	*	*	*
Wood Pellet	1%	**118.2**	55.0	73.3	31.3	28.6	*	*	*	*	*	*
	5%	**118.2**	50.0	93.3	75.0	**114.3**	*	*	*	*	*	*
	10%	90.9	75.0	**113.3**	62.5	28.6	*	*	*	*	*	*
	20%	109.1	70.0	**126.7**	118.8	**114.3**	*	*	*	*	*	*
Corn Cob	1%	*	*	*	*	*	*	*	*	*	*	*
	5%	**125.4**	**130.0**	**150.0**	98.5	**120.0**	**145.0**	*	*	*	*	*

Table 5. (Continued)

5E. Pennsylvania Loam/Potting Soil – Functionalized and non-functionalized carbon blacks

% Germination relative to PA loam soil control:

Biochar	Amended Amount	**Radish**	**Tomato**	**Corn**	**Lettuce**	**Carrot**	**Bean**
Potting Soil		**150.00**	**118.75**	**155.56**	**103.13**	**1700.00**	**800.00**
PA Loam		100.00	100.00	100.00	100.00	100.00	100.00
Non-functionalized CB	1%	73.08	25.00	88.89	37.50	100.00	50.00
Functionalized CB	1%	65.38	37.50	66.67	43.75	0.00	0.00

Note: 0.00 indicates no germination of the seeds in the 14 days.

% Growth Relative to PA Loam Soil Control:

Biochar	Amended Amount	**Radish**	**Tomato**	**Corn**	**Lettuce**	**Carrot**	**Bean**
Potting Soil		**250.00**	**147.44**	**166.67**	**160.00**	**400.00**	**760.00**
PA Loam		100.00	100.00	100.00	100.00	100.00	100.00
Non-functionalized CB	1%	**138.89**	64.10	77.78	20.00	80.00	**250.00**
Functionalized CB	1%	**138.89**	83.33	77.78	30.00	0.00	0.00

Note: 0.00 indicates no germination of the seeds in the 14 days.

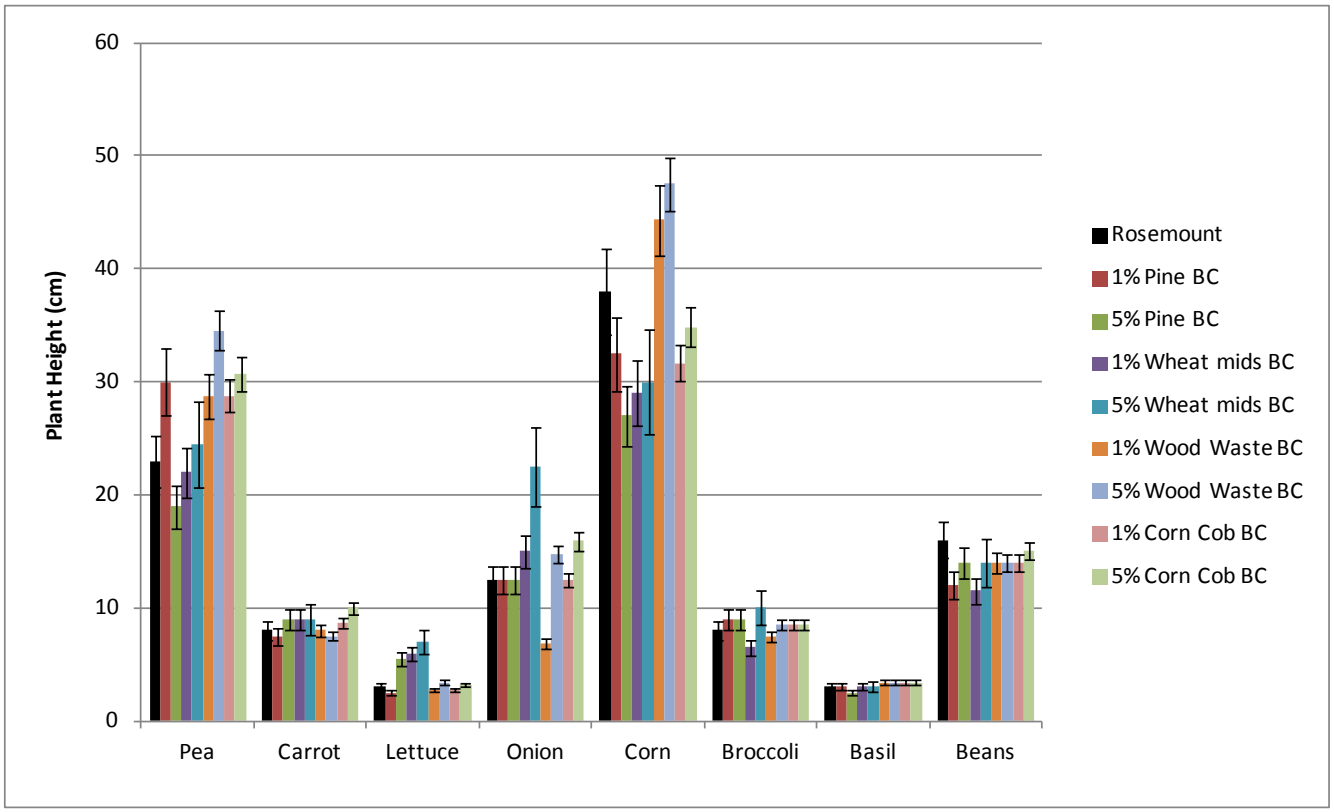


Figure 4. Illustration of various plant growth at 40 days in Rosemount, MN soil along with the selected biochar amendments. All replicates were conducted under equivalent growing conditions.

(2) What are the potential negative impacts from biochar use in specialty crop production?

Potential negative impacts of biochar use in specialty crop production observed during this study:

1. *Reduced seed germination and plant growth*

The most consistent result that was observed with biochar use was suppressed seed germination. Although not all amendments suppressed initial germination, the plant growth that followed germination was typically more vigorous in the biochar amended soil. However, there were also cases of suppressed growth (Figure 4, 5, & 6).

At 20% w/w additions, there was significant suppression in the germination and growth of the crops. In addition, even if the germination was not impacted at this high amendment rate, typically growth was reduced. Consistent with other recent research into the impact of "high volatile matter" biochars, there is the potential for negative plant effects (Deenik, McClellan et al. 2010). This can be seen with the macadamia nut shell biochar, with high amendment rates negatively impacted the germination of some of the specialty crops (Table 5). Even without impacting germination rates, there could still be negative impacts on the plant growth and yield (Figure 5).

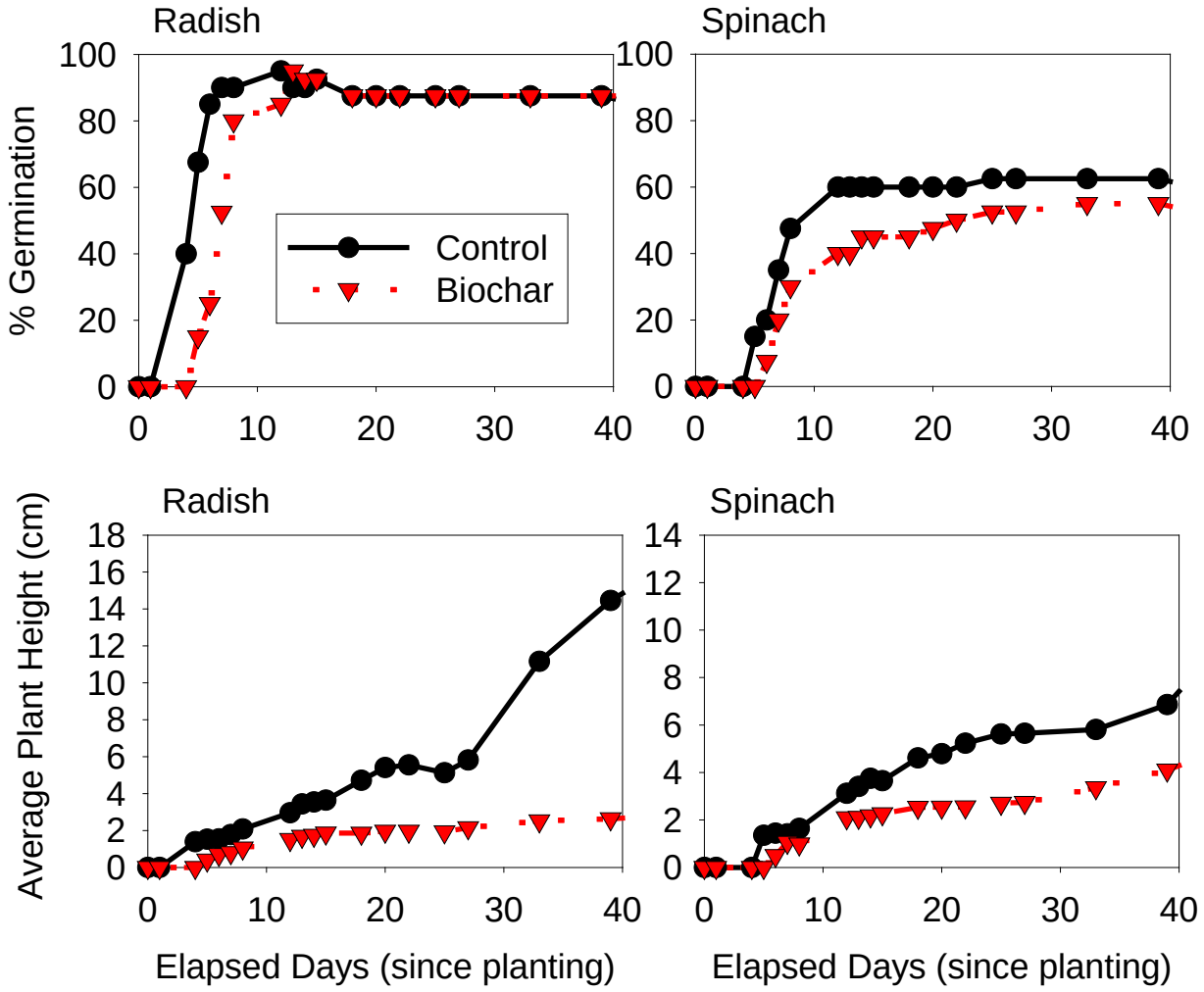


Figure 5. Illustration of the germination of A) radish and B) spinach in the presence of macadamia nut shell biochar (20% w/w) in potting soil. Despite the lack of significant differences in seed germination, there was a significant suppression observed in the corresponding seedling growth of the C) radish and D) spinach in the first 40 days under identical greenhouse conditions.

We also observed response differences as a function of the particle size of the biochar. Unground (>4 mm) and ground (<4 mm) biochar was applied at 10% w/w in a potting soil (Figure 6). An added complication in this project was the different behaviors observed for the ground and un-ground biochars, particularly in relation to the weathering or aging of the biochar in the soil system. Figure 6 shows the relative height and growth rates (which is the slope of these cumulative height graphs at any point), with the initial growth after mixing shown in Figure 6A. In particular, note the drastic difference in behavior of the control (no biochar) and the two biochar treatments. At day 39 when rapid growth was seen in the control and this growth behavior was not seen in the biochar treatments (slope of the graph is lower indicates slower growth rates). Figure 6B illustrates the 3rd consecutive growth in the same soil mix (after 3 consecutive plantings of 50 days), and Figure 6C is the 5th consecutive growth period (250 days after initial mixing of the potting soil and biochar). As seen in this Figure, there is a gradual reduction in the suppression action of the unground biochar with consecutive growth cycles. This data suggests a temporary suppression that is eliminated with sequential growth periods. This trend is also seen with macadamia nut shell biochar additions to a potting soil for a total of 8 sequential growth periods (Figure 7). Initially, the amended soil suppressed growth, but then after 8 growth cycles resulting in the biochar amended soil surpassing the control soil in plant growth (Figure 7d). There have been hypotheses on the impact of weathering at field scales on year time periods (Major, Rondon et al. 2010). However, our data shows that this weathering can occur within the first 150 days after soil application.

We also detected a significant drop in the sorbed organics observed on these biochars that were used sequentially in the greenhouse experiments (Figure 8). In addition, we observed a drastic alteration in nitrate availability during these same periods compared to the soil control (Figure 9). In a majority of the treatments with reduced plant growth, there was also reduced nitrate availability (as assessed with a 2M KCl extraction) between the control soil and biochar soil (Figure 9). These results are in agreement with other studies on biochar that have illustrated a reduced nitrate leaching potential of biochar (Knowles, Robinson et al. 2011). This reduction in nitrate availability could be one of the factors responsible for the decreased growth in some biochar x soil mixtures (see Figure 4). However, despite the interactions between biochar and nitrate, there is no clear relationship between the reduced nitrate and plant growth, thus indicating involvement of other factors.

Just recently, we were able to collect transmission electron microscopy (TEM; JEOL Lab6 TEM) images of a limited number of biochars. Despite the limited nature of the biochars surveyed, these images provided clues that the microscopic-physical structure could be an important facet of this interaction. As seen in Figure 10, there are three major groupings of biochar nanoscale physical structures:

1) highly graphic structure, where the highly lamellar structure of graphene sheets are visible (Figure 10A),
2) amorphous, where there is no discernible structure and could even entrap inorganic species [such as Fe] into this amorphous carbon globule (Figure 10B), and
3) potential carbon nanotube layers/structures (Figure 10C).

It is hypothesized that these structures and understanding how to control their creation during pyrolysis could be vital in tailoring individual biochar's properties. Alterations of these microscopic structures could greatly influence particular interactions (e.g., interaction with N-compounds).

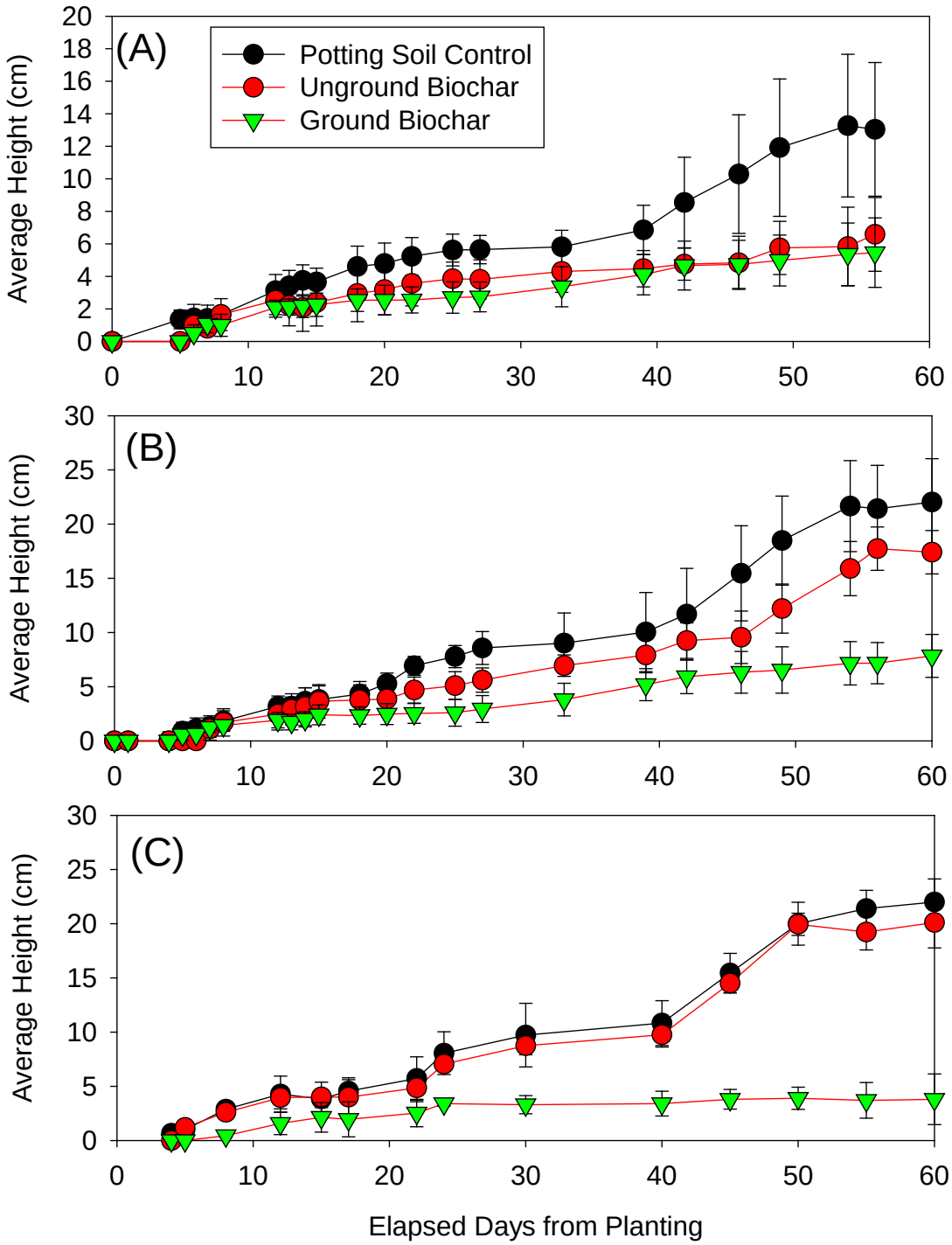


Figure 6. Illustration of the aging effect of ground and unground macadamia nut biochar amendment (10 % w/w) in potting soil on sweet corn growth. A) Initial growth after mixing biochar and soil, B) third consecutive growth, and C) the 5th consecutive growth period in the same soil mixtures.

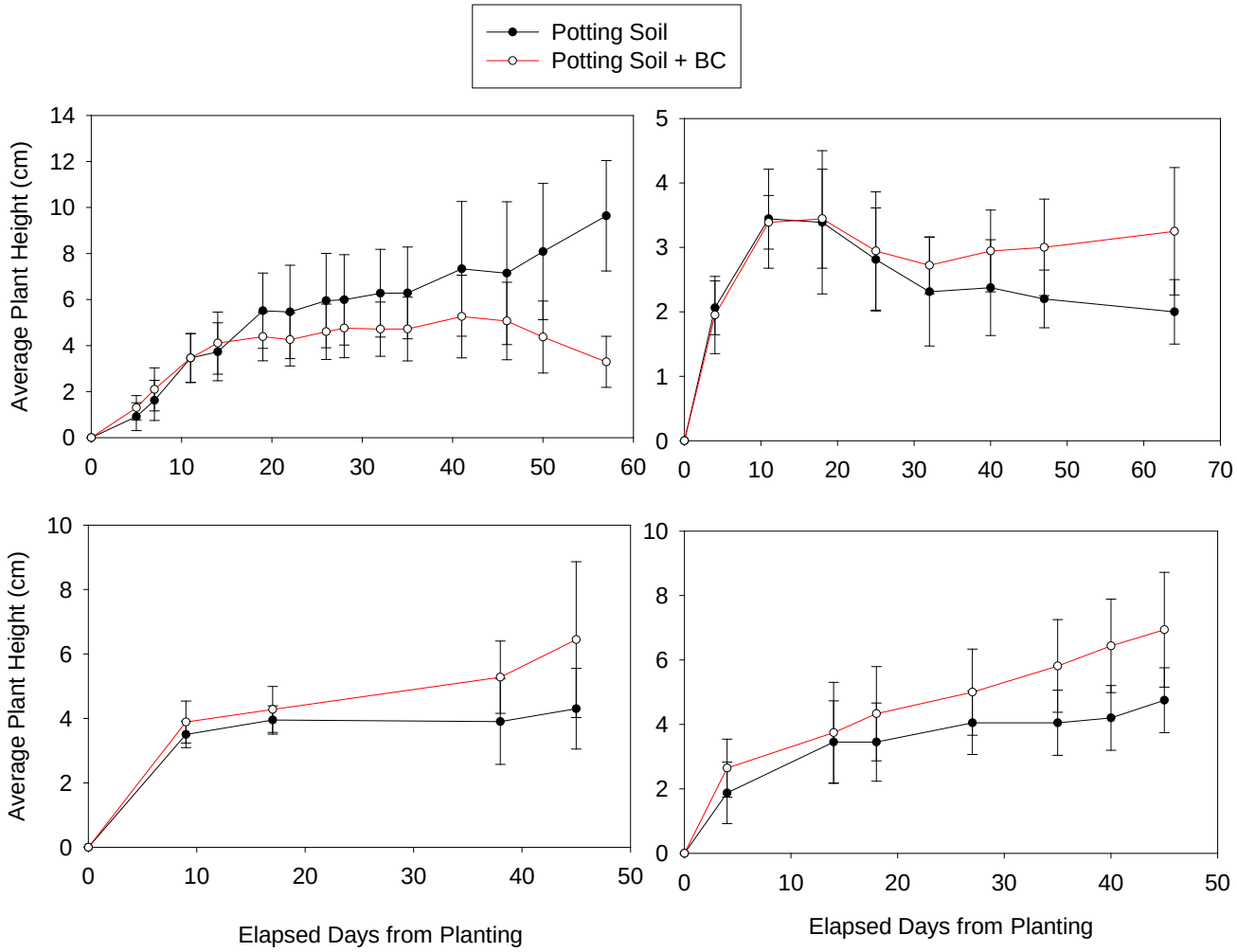


Figure 7. The weathering trend of macadamia nut biochar mixed with potting soil, with a) initial results on the growth of spinach, b) after three 60 day growth cycles, c) after five growth cycles, and d) after 8 growth cycles.

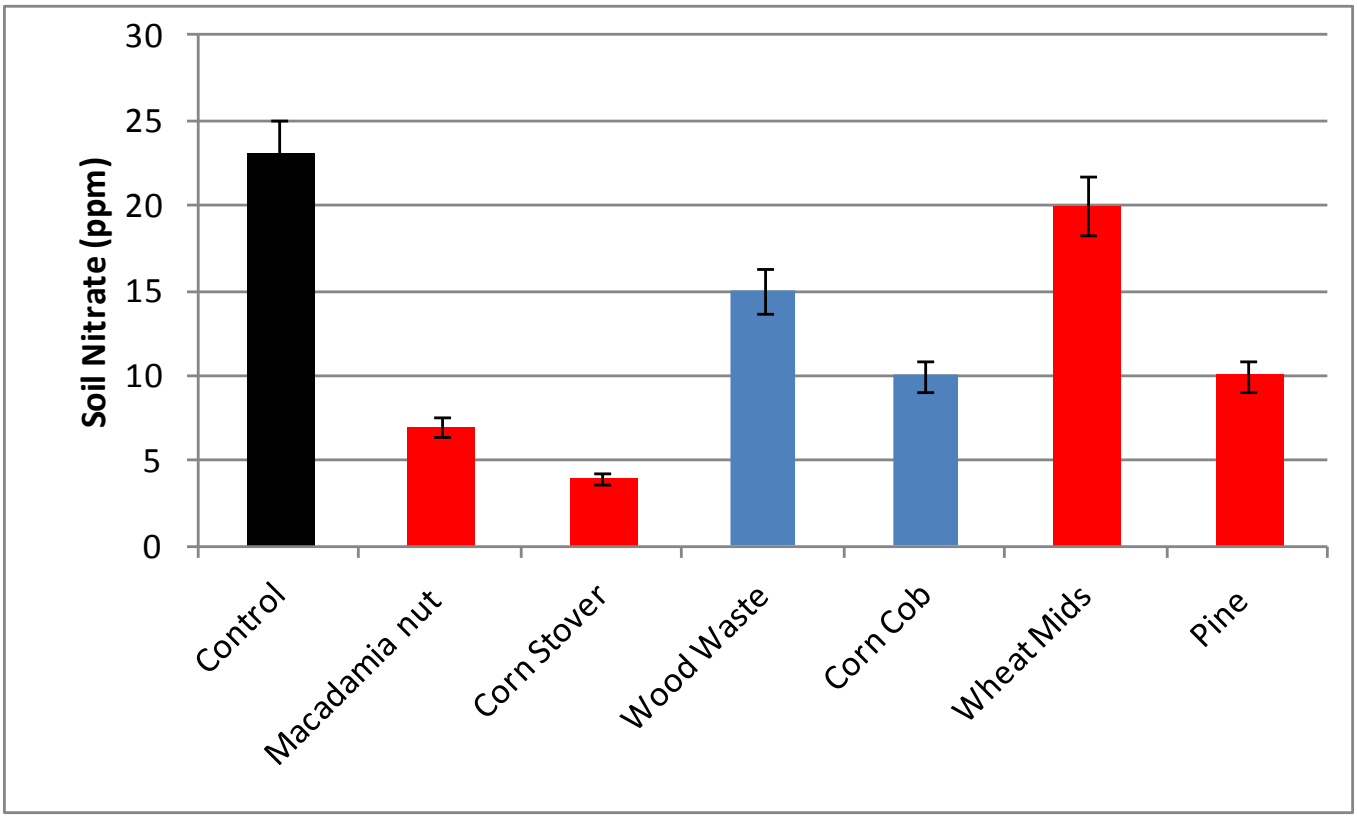


Figure 8. Illustration of the soil nitrate (2M KCl extraction) from various Rosemount, MN soil + biochar mixtures (5% amendment level). A red bar indicates a sample were the corresponding plant growth (spinach) was also reduced and the blue bars indicate no effect or stimulated plant growth.

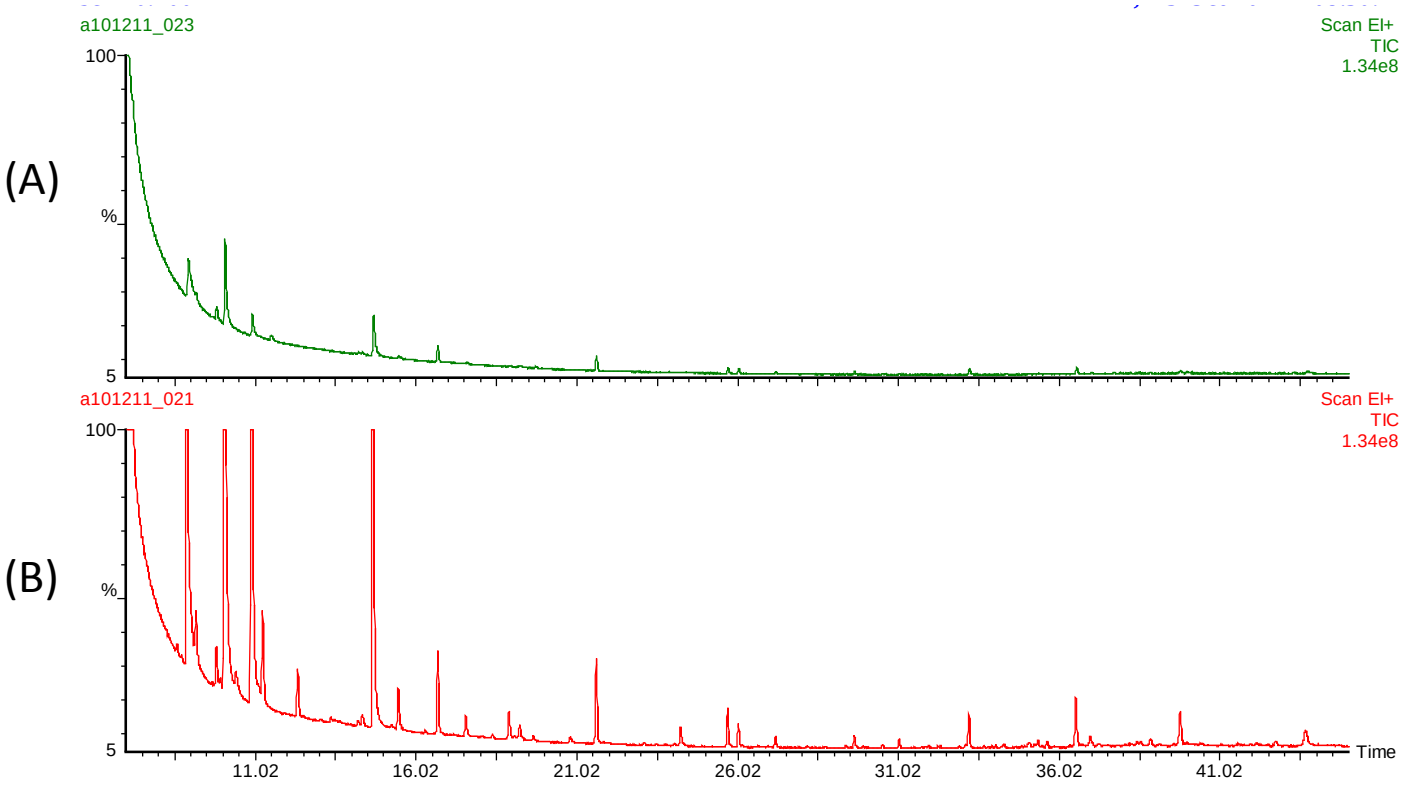


Figure 9. Total ion chromatograms from A) "weathered" and corresponding B) "Fresh" biochar (hardwood). These chromatograms are scaled equally, thus the lower intensity and number of peaks seen in the weathered biochar (A) indicates lower quantities and number of sorbed organic species on the biochar (~90% reduction in amounts). Similar results were observed for other weathered biochars.

(A)

(B)

(C)

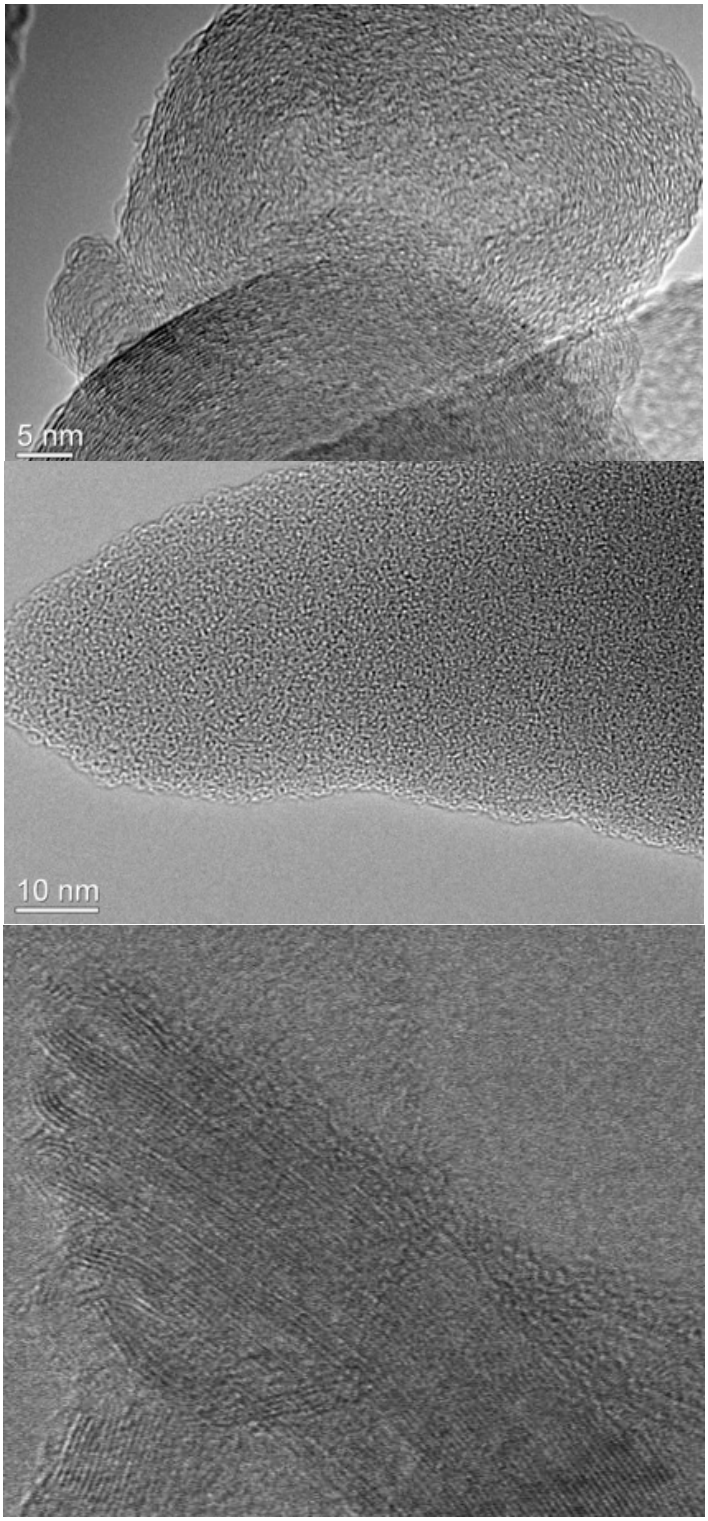


Figure 10. Transmission electron micrographs of the three general categories of microscopic structural elements of: A) graphene sheets, b) amorphous carbon globule, and c) carbon nanotube-like structures.

The concentration of the 16 USEPA-PAHs along with the 15 EU-PAHs (priority hazardous substances in food) was determined in a suite of currently available biochars for agricultural field applications created from the pyrolysis of different feedstocks under different conditions. The total levels ranged in the 1.2 to 33 µg g^{-1} and 0.2-5 µg g^{-1} interval for USEPA (Table 6) and EU PAHs, respectively, while benzo[*a*]pyrene ranged between 0.01 and 0.76 µg g^{-1}. Considering a typical application of 10-60 t biochar ha^{-1}, the degree of PAHs contamination will be dependent on the presence of background PAHs in soil and the sorbed concentrations of PAHs in the biochar. Our data, along with PAH levels determined in other studies, suggest that biochars produced by slow pyrolysis from woody biomass possess the lowest level of sorbed PAHs (< 10 µg g^{-1}). (*See Supplemental Information: Sorbed Organic Compounds on Biochar*).

The data collected during this project suggest that:

- Oxygen presence is a requirement in order for PAHs to be formed. Therefore, the recommendation to reduce the amount of PAHs that are sorbed to biochar can be accomplished by excluding oxygen and also the use of an inert sweep gas during pyrolysis as well as cooling.

- Water (moisture) content is also a factor in the production of PAH compounds, due to the limitation on thermal heat transfer. Therefore, dry feedstocks should be used in thermal pyrolysis conversions to limit conditions that favor PAH formation.

- No PCBs were detected in any of the biochar samples.

- The quantity of sorbed PAH compounds is skewed towards the lighter PAH fraction (2-4 ring species) (Figure 11). All biochars analyzed contained detectable amounts of naphthalene and 1-methlnapthalene (Figure 11). These were the sole PAHs present in all biochars above the detection limits (0.1 ng/g). Due to the collaboration with University of Bologna (Italy), a new method for analyzing PAH content of biochar and biochar amended soils was developed. (*see Additional Information*).

- Biochar amendment did increase the levels of detected PAH compounds in soil-biochar mixtures as a function of the original soil PAH levels and corresponding amendment rate and sorbed biochar levels. Specialty crops did accumulate PAHs from biochar amended soils when biochar possessed elevated concentrations of sorbed PAH compounds and/or when biochar addition occurred at high rates.

- In the field plot results, this bioaccumulation was not observed (Figures 13 and 14). We hypothesize that this is due to the lower amendment rates that occurred in the field plots compared to the greenhouse study. Furthermore, as seen in Figure 14, the biochar amendment actually reduced the concentration of some of the specialty crop PAH content when compared to the control soil, potentially indicating lower bioavailability due to the biochar addition.

- The ability of biochar to improve the growth of specialty crops, depended both on the crop, biochar, and soil type. Indicating, a complex relationship in the "weathering" of biochar

and its influence on biochar's ability for improving the agronomic performance. The biochar with the largest benefit in this project was corn cob biochar.

- Grinding appears to reduce the amount of PAH present in biochar, which would suggest that the PAH compounds are sorbed solely to the outside surfaces and these could be release by grinding or other post-processing steps (Figure 16).

- If biochar does possess high levels of sorbed PAH compounds, we observed at high amendment rates the potential of bioaccumulation of sorbed biochar PAH compounds into various specialty crops. Additional research is needed to fully evaluate the treat and human risk of this bioaccumulation.

Table 6. PAH Analyses of select biochars

Units ng g^{-1}	**Macadamia nut**	**"Weathered" macadamia nut**	**"steam activated" macadamia nut**	**Wood pellet**	**Wood pellet**	**Hardwood**	**Mixed Wood**	**Hardwood**	**Hardwood**	**Hardwood**	**Coconut shell**	**Green Waste**	**Hardwood Sawdust**	**Pine Bark**
Naphthalene	2100	1100	54	41	1000	410	120	250	330	41	120	470	620	820
2-methylnapthalene	2600	1300	24	-	480	200	84	120	160	31	73	220	300	160
1-methylnapthalene	2200	1100	32	10	470	160	74	98	100	28	63	160	230	120
Acenaphthene	1000	640	17	10	100	21	10	22	26	-	32	43	-	36
Acenaphthylene	1300	860	8.5	-	83	75	25	7	20	10	13	130	260	34
Anthracene	2000	1400	-	-	-	21	8.8	-	14	-	9.5	18	-	17
Phenanthrene	9400	5900	150	-	110	81	57	39	97	18	70	230	130	130
Fluorene	3200	2300	34	-	100	7.5	18	16	26	10	32	70	-	38
Fluoranthene	4700	3400	130	-	22	27	16	9	22	-	9.5	34	41	19
Benzo(a)anthracene	1200	620	21	-	-	-	-	-	8.1	-	3.2	-	-	-
Chrysene	1400	1200	45	-	-	-	-	-	-	-	6.3	-	-	-
Pyrene	5000	3800	130	-	45	30	20	9	26	15	9.5	-	41	19
Benzo(a)pyrene	750	620	-	-	160	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	790	630	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	680	600	-	-	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	110	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	320	280	-	-	-	-	-	-	8.1	-	-	-	-	-
Indeno[1,2,3-cd]pyrene	280	250	-	-	-	-	-	-	6.1	-	-	-	-	-

Table 7. Data on the detection of PCB isomers sorbed to the biochar (No detects were observed)

PCB Analyses (ng g^{-1})	**Macadamia nut**	**"Weathered" macadamia nut**	**"steam activated" macadamia nut**	**Wood pellet**	**Wood pellet**	**Hardwood**	**Mixed Wood**	**Hardwood**	**Hardwood**	**Hardwood**	**Coconut shell**	**Green Waste**	**Hardwood Sawdust**	**Pine Bark**
Aroclor 1016	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1221	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1232	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1242	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1248	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor1254	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1260	-	-	-	-	-	-	-	-	-	-	-	-	-	-

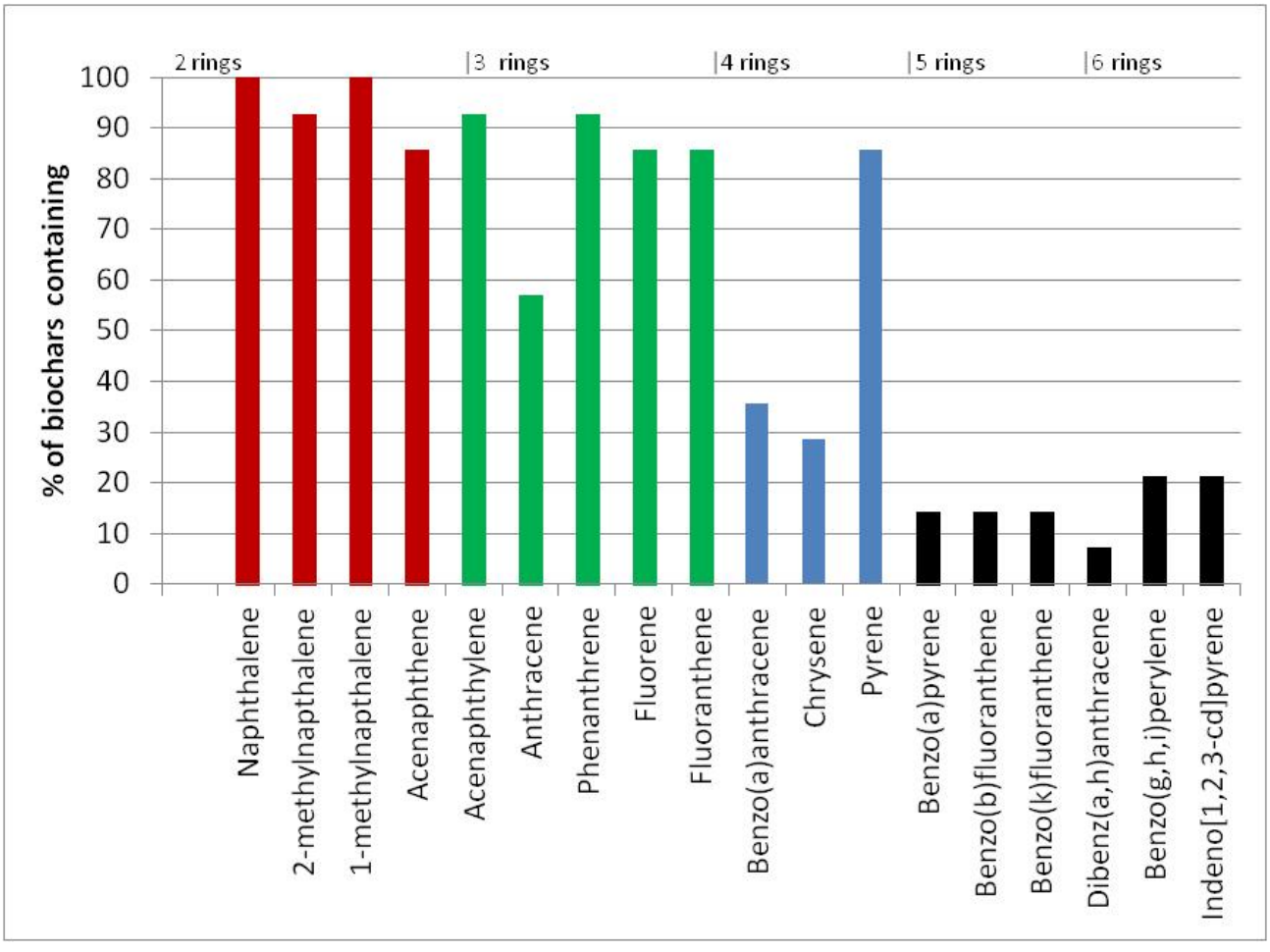


Figure 11. Frequency of observed PAH detected in the sampled biochars (n=37), indicating the higher occurrence of the low molecular weight PAHs (2-4 ring structures) in biochar tested in this project.

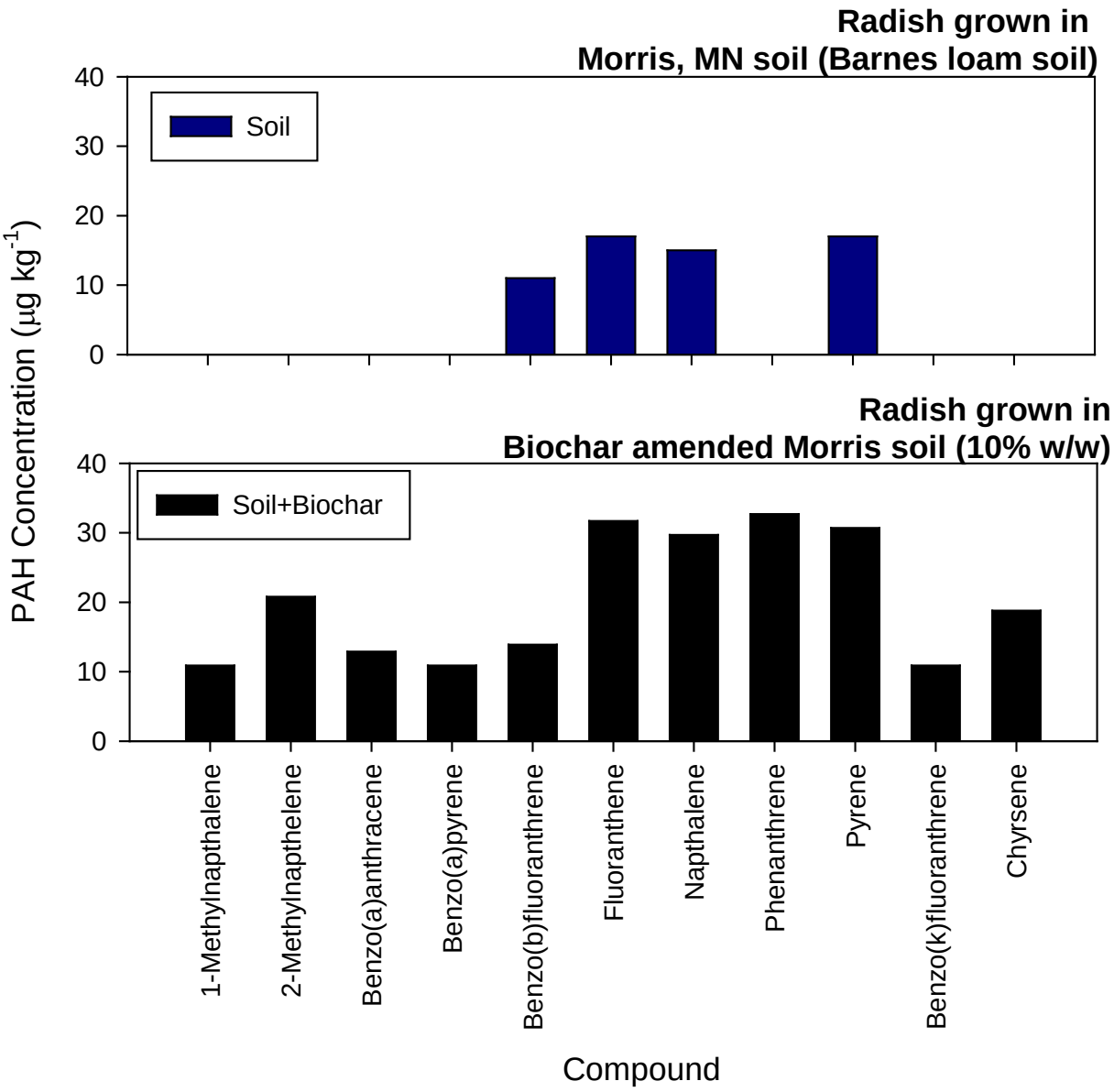


Figure 12. Illustration of different PAH contents in radishes grown in the greenhouse in a) control and B) macadamia nut shell biochar amended Morris, MN soil.

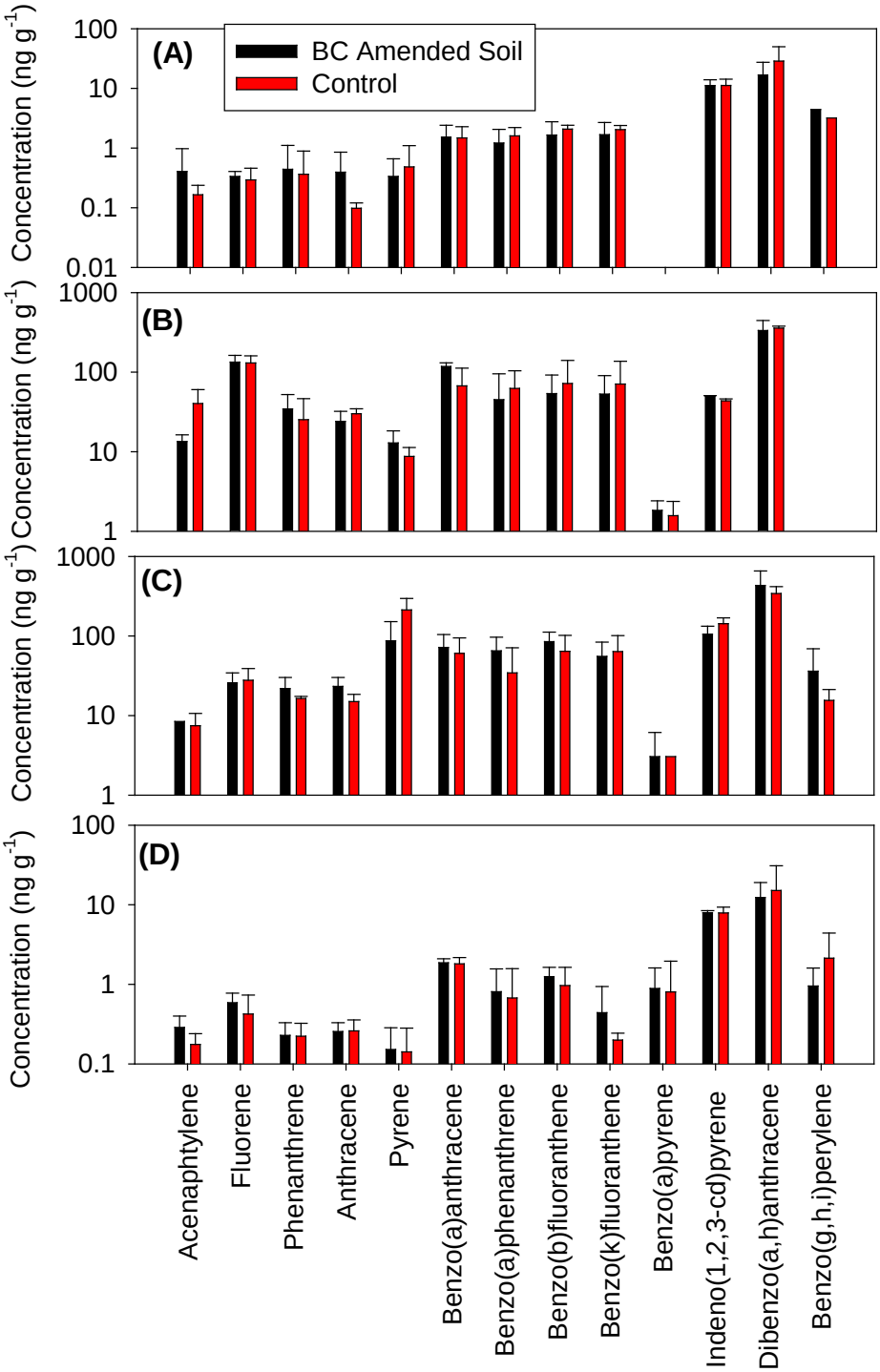


Figure 13. PAH levels in a) lettuce, b) butternut squash, c) sweet corn, and d) carrot (roots) from field plots in Elko,MN which were either control (no biochar) or amended with wheat mids biochar at 7,000 lb ac^{-1} application rate.

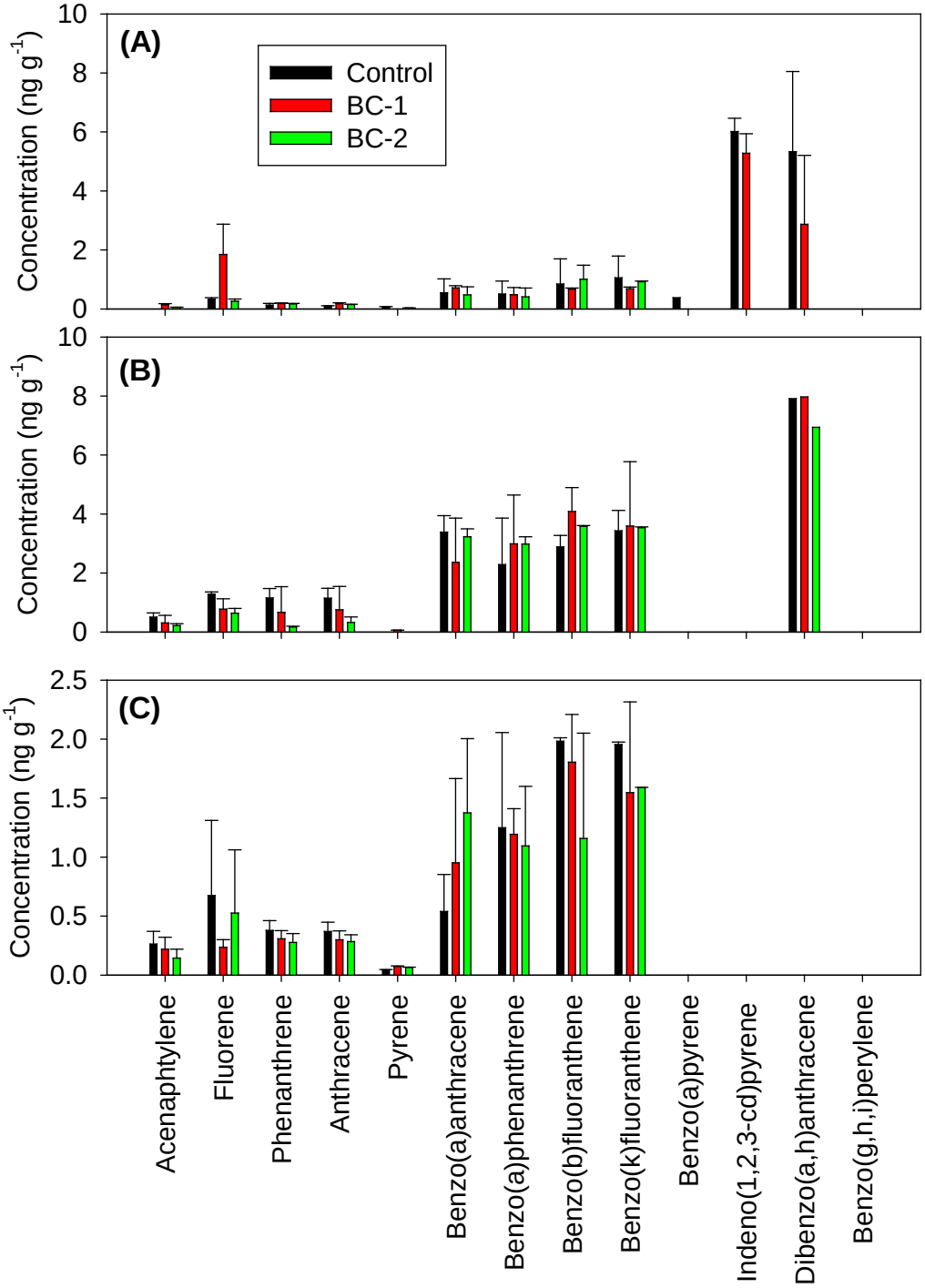


Figure 14. Illustration of PAH content observed in a) kale, b) banana peppers, and c) tomatoes grown in control plots and plots amended with 5,000 lb/ac (BC-1) and 10,000 lb/ac (BC-2) hardwood biochar in St. Paul, MN (Specialty crops grown by MN Master Gardner volunteers). Note the reductions observed in the lower molecular weight PAHs as a consequence of biochar additions.

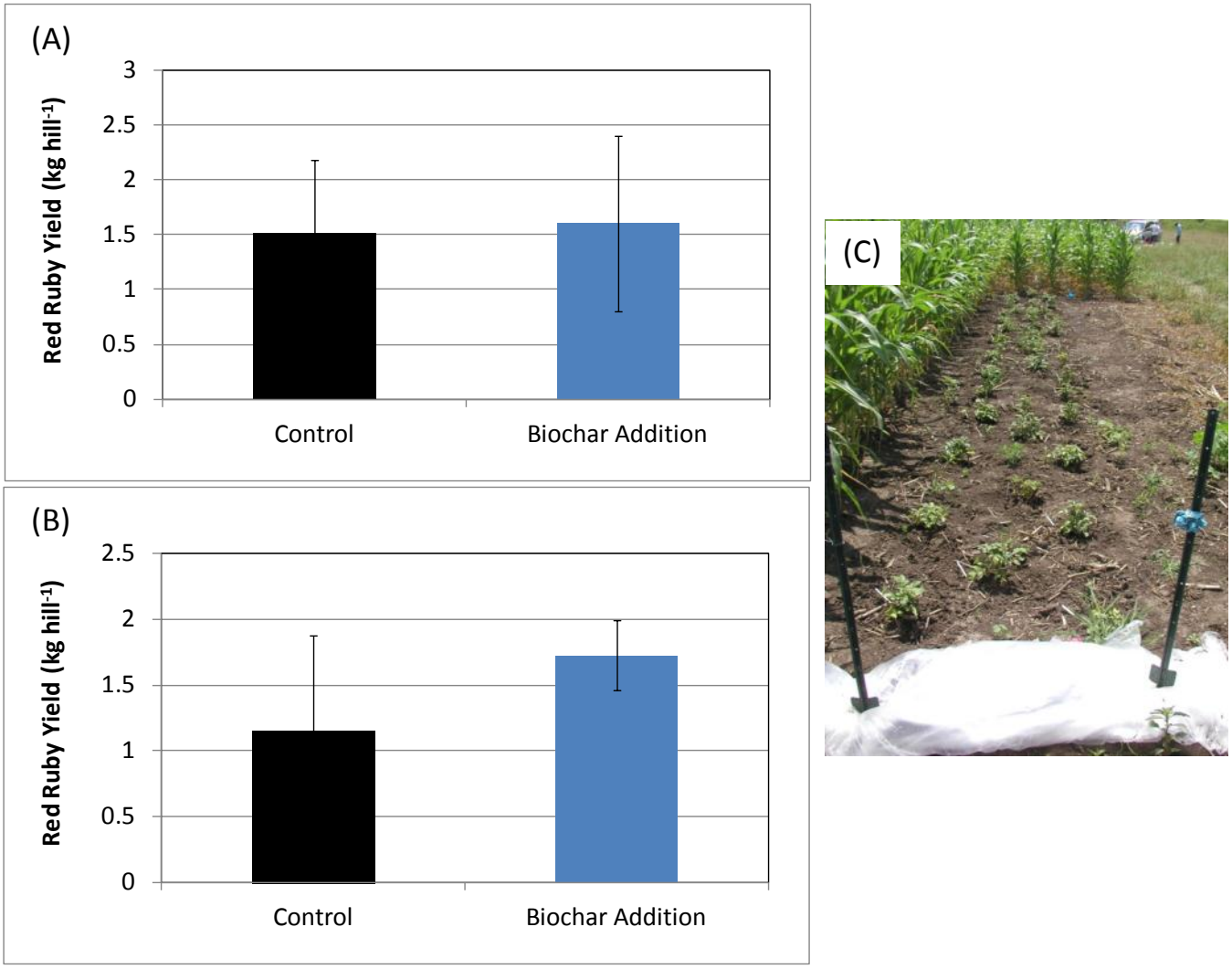


Figure 15. Illustration of yield of Red Ruby (*Solanum tuberosum*) potato yield in A) 2011 and B) 2012 in field plots at Rosemount, MN, as shown in C) with macadamia nut shell biochar additions (~5,000 lb/ac).

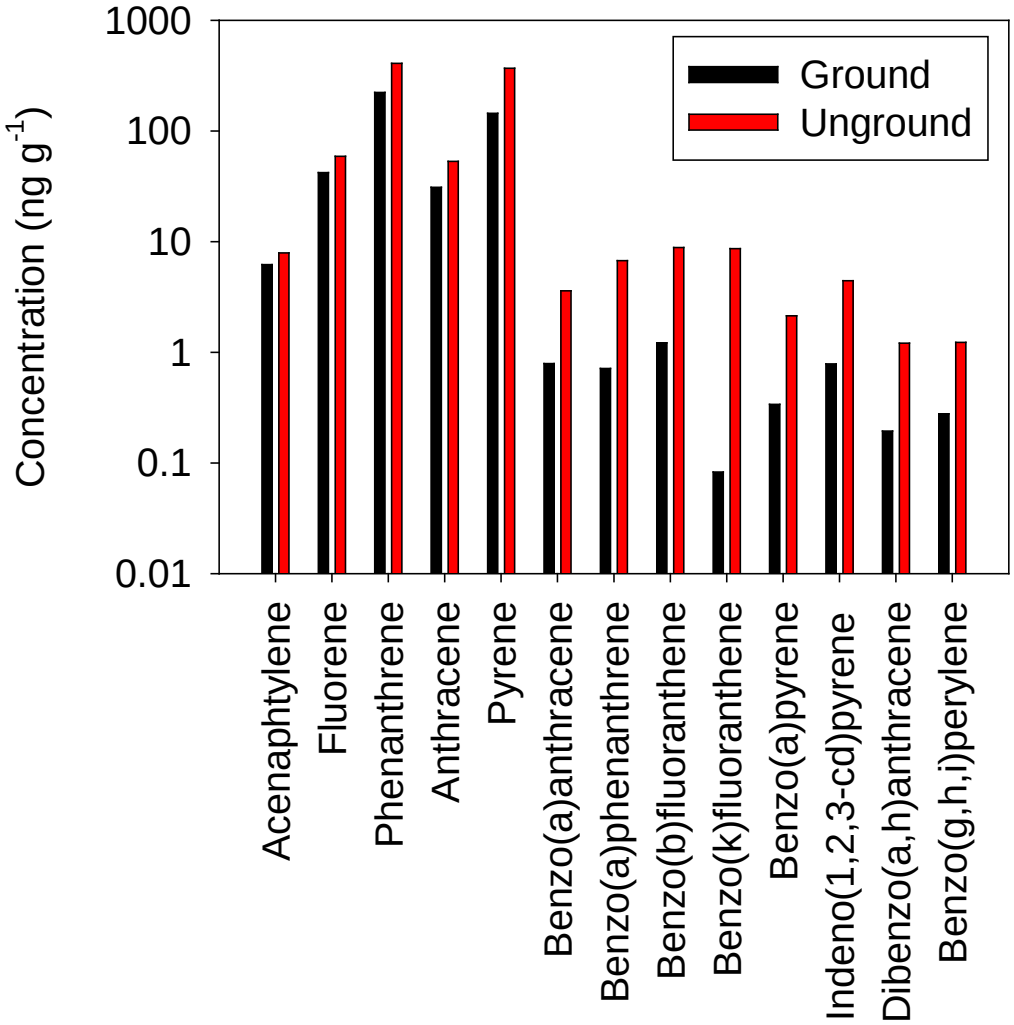


Figure 16. Illustration of the impact of grinding on sorbed PAH compounds on fast pyrolysis macadamia nut biochar.

Overall Conclusions:

- Organic Matter (soil C) is increased following biochar addition. This effect was usually statistically significant after 1% (w/w). The main purpose for the creation of biochar is for the C sequestration value. Thereby, this result was expected.
- The interaction of *biochar x soil x specialty crop growth* is complex, and the type and time since biochar application are controlling factors.
- The availability of nitrate appears to be one of the factors related to the poor seedling growth performance. Biochar applied to fertile soil appears to reduce nutrient availability, and thus crop yields. Adding fertilizer with the biochar treatment negates this effect.
- There is strong indication that the aging of biochar will alter the impacts, such as to go from a growth suppression to a growth stimulant after successive growing periods in the amended soil (See Figure 6).
- The highest yield improvements across all soils were seen with the corn cob biochar. However, the exact reasons for this remain unknown.
- Biochar does interact with the nitrogen cycle in the soil, potentially through direct sorption of ammonium/ammonia/nitrate/nitrite onto the charcoal surface or other chemical reactions.
- There is the potential of bioaccumulation of PAH in specialty crops grown in biochar amended soils as a function of original PAH content of the biochar and the amendment rate – This is expected since plants have been shown to be able to uptake PAH compounds through their roots and have the PAH compounds translocate into the steam and leaves (Edwards, Ross-Todd et al. 1982).
- There needs to be further research to fully assess the potential human health impacts.

Unexpected Results:

- The time since mixing (or incorporation) did have a very strong effect on the impact of biochar on specialty crop growth and germination effects.
- Grinding of biochar reduced PAH contents, suggesting that the majority of PAH compounds are solely on the external surfaces.
- There is high variation in the sorbed organic compounds on biochars, which possesses a strong dependency on the pyrolysis conditions and post-production handling/storage, and less dependent on biomass feedstock types.

BENEFICIARIES

The data from this project spans across state lines and even had interest from national organizations. The results from this project have been widely disseminated through national level meetings (American Chemical Society, American Society of Agronomy, and the US Biochar conference) as well as peer-reviewed journal articles (5 published to date). The research also attracted the attention of the analytical instrument manufacture, and the PI was invited to speak at their meeting, highlighting the innovative use of the thermal headspace instrumentation for the quantification of sorbed organics on biochar (http://www.eventbrite.com/event/2869714393).

This research has been shared directly at presentations to approximately 815 individuals; these were tabulated as shown below:

Meeting	Approximate Number of Attendees at Presentation
American Chemical Society (Boston, MA)	50
American Society of Agronomy	150
North American Biochar Meeting	250
Minnesota Master Gardener Monthly meetings	250
Seminar at Univ. of MN	40
Perkin Elmer- Innovation North American Tour	75

The actual readership numbers for each of the publications mentioned above isn't easily available, but I was able to locate the overall ranking which includes the H-index calculation for the journal (larger numbers represent a higher cited source journal) and the total number of references, which could serve as a surrogate for the journal's readership numbers. Based on these two indexes it is safe to assume that these journals that these results have been published in are referenced often and have a broad readership.

SCImago Journal & Country Rankings

Journal Title	SJR	H index	Total Docs. (2011)	Total Docs. (3years)	Total Refs.	Total Cites (3years)	Citable Docs. (3years)	Cites / Doc. (2years)	Ref. / Doc.	Country
Chemosphere	1.674	117	937	2,765	37,398	9,916	2,722	3.35	39.91	
Journal of Environmental Quality	1.272	95	210	779	9,746	1,959	756	2.34	46.41	
Plant and Soil	1.145	93	439	1,058	24,065	3,067	1,002	2.81	54.82	
Journal of Analytical and Applied Pyrolysis	1.195	59	144	383	4,726	1,172	377	2.84	32.82	

Journal data taken from : **http://www.scimagojr.com/index.php**

The data from this project establishes the potential of elevated sorbed organics into specialty crops grown in biochar amended soil and is the groundbreaking research into the safety issues and plant implications of biochar use. Provided that the health risk is low or benign, this research could result in reduced producer input costs along with increasing productivity of specialty crops. However, these high yield improvements were only observed when biochar is added to already low productivity (soil nutrient) soil. This project provided some of the initial scientific data that could be used to establish guidelines and recommendations for the safe and efficient use of biochar in specialty crop production. However, currently the data indicates a very complex relationship between biochar-soil-crop, which appears to still require individual testing and evaluation. We foresee that this information has and will be of interest to the farmers of all specialty crops and potential users of biochar amendments.

LESSONS LEARNED

This project was one of the first research efforts examining the impacts of biochar additions on specialty crop production. The conclusions that can be drawn from this work:

1. Biochar can be a beneficial amendment for specialty crop production. However, there are some unidentified problems remaining with its wide-spread utilization. One of the biggest hurdles that still exist in establishing guidelines is the lack of consistency across all biochars. In other words, not all biochars are similar chemically and detailed pre-

application analyses are still needed to assess the potential use of biochar for a particular soil type. In general, low application rates (1% w/w) have a greater tendency to have null to positive effects, versus the negative effects observed at higher application rates. However, due to the variability in individual biochars universal application rate guidelines are not yet feasible. The application of biochar to already productive soils does not appear advisable for solely increasing plant yields.

2. Sorbed volatile organics on biochar could have implications into the initial mechanisms of the soil-plant system response. However, the fact that the bioavailability of individual organic compounds (i.e., PAHs) are highly variable (Parrish, White et al. 2006) restricts our ability to state generalized conclusions. As is common practice with other soil amendments, the biochar should be screened to assess its suitability for soil application.
3. Specialty crops grown in biochar amended soils have elevated PAH levels when compared to specialty crops grown under identical conditions in non-biochar amended soils. This has been shown in this data both in greenhouse and field plot studies, although exception do exist. The preferential presence of the low molecular weight PAH compounds in the crops potentially supports a gas phase transport mechanism versus a water or root-biochar transfer route.
4. Difficult to draw universal conclusions due to the range of pyrolysis units/conditions and resulting chemical and physical properties of biochar.

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PROJECT H

USDA-ARS Specialty Crop Block Grant
Final Report

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February15, 2013

Project Title
Development of Nitrogen Management Practices in Minnesota and North Dakota to Reduce Acrylamide Levels in Processed Potato Products

Project Start Date: December 2010
Project End Date: October 2012

Project Summary
The most important vegetable and horticultural crop in the Northern Plains continues to be potato. Potatoes were planted on about 84,000 ac in North Dakota and 49,000 ac in Minnesota in 2011; the total area harvested was approximately 77,000 ac in North Dakota and 47,000 ac in Minnesota. The average yield was 245 cwt./ac in North Dakota and 355 cwt./ac in Minnesota. Total production for 2012, despite drought conditions across the region, is estimated at 25 million cwt. in North Dakota, an increase of about 32% over 2011 production. Production in Minnesota in 2012 was up 13%, to 18.8 million cwt. About 60% of potato production in North Dakota and Minnesota goes for processing into frozen products such as French fries (and others) and chip production.

Health concerns have become a topic of interest to potato processors, producers and consumers, following the discovery of the neurotoxin, acrylamide, in processed potato products (Tareke et al, 2002). The US Food and Drug Agency is currently developing mitigation plans to reduce risk from consuming processed foods containing this byproduct. This research is particularly important and timely, because French fries from North Dakota and Minnesota appear to have higher acrylamide levels than those from other regions (Collindge, 2010); thus, the issue becomes a threat to our local potato industry.

Acrylamide levels in potato are affected by cultivar, processing method, and gene expression for sugar accumulation and amino acids. Altering cultural management practices, such as nitrogen fertilization rates, influences the levels of reducing sugars and asparagine, precursors to acrylamide (Mottram et al, 2002; Stadler et al, 2002 and Becalski et al, 2004), and may reduce acrylamide levels immediately. Our research efforts reported here will aid in establishing baseline acrylamide levels in French fries and potato chips made from Russet Burbank and Snowden, compared to newer processing cultivar releases, including Alpine Russet, Dakota Trailblazer, and Ivory Crisp, which initial research indicates have lower reducing sugar levels, and in some cases lower asparagine levels, as well. Secondly, the effect of nitrogen rate on processing quality attributes, including acrylamide, for these cultivars was also evaluated.

Project Approach
In 2011, five genotypes (Alpine Russet, Dakota Trailblazer, Russet Burbank, Ivory Crisp, and Snowden) were grown at varying rates of nitrogen (30, 120, 180, 2400, and 300 lbs/ac) in order to determine nitrogen management effect on acrylamide levels and processing quality. A randomized complete block design was used with four replicates and cultivar and amount of nitrogen fertilizer applied as main effects.

The trials were planted at the Northern Plains Potato Growers Association (NPPGA) research site at the Forest River Colony, Inkster, ND, on June 2, and at the Sand Plain Research Farm in Becker, MN, on May 3. Four, 20-ft rows were planted for each plot, with the middle 18 feet of the middle two rows used for sampling and harvest. Row spacing was 12 inches within each row and 36 inches between rows.

Different methods of nitrogen fertilization were used at the two sites. In ND, 23 lbs/ac N was broadcast over the trial area prior to planting; 26 lbs/ac was banded at planting to all plots. Split, in-season fertilizer applications were broadcast per treatment on June 29 and July 19, and 27 lbs/ac and 18 lbs/ac were fertigated across all treatments on August 9 and 19.

In MN, potassium was added before planting, and multiple nutrients were applied at planting, on May 3. These included 30 lbs N/ac as monoammonium phosphate and ammonium sulfate. Environmentally Smart Nitrogen (Agrium, Inc.; referred to hereafter as ESN) was banded per treatment at emergence, on May 25, and mechanically incorporated during hilling. Weeds, diseases, and other insects were controlled using standard practices. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling.

In ND, petioles were sampled on August 3, August 17 and September 26 (prior to vine flailing on Oct. 4), dried, and will be analyzed to determine nitrogen status. Plots were harvested on October 6 and samples stored at about 55 ˚F to suberize until grading.

In MN, plant stand was measured on June 6 and stem number per plant on June 14. Petiole samples were collected from the fourth leaf from the terminal on four dates: June 20, June 28, July 11, and July 26. Petioles were analyzed for nitrate-N on a dry weight basis. The vines of the chipping cultivars were mechanically beaten on September 15 and those of the frying cultivars on September 23. The plots were machine harvested on September 29, and total tuber yield and graded yield were measured. Tuber sub-samples were also collected and used to determine the incidence of hollow heart, brown center, and scab, and tuber dry matter and specific gravity. Additional sub-samples were collected for whole-tuber analyses and frying tests. Whole-tuber nitrogen concentration was measured on tubers collected at harvest and assumed not to change substantially throughout subsequent storage.

From both sites, approximately 50 lbs of tubers in the 6- to 10-ounce size category from each plot were shipped to the USDA-ARS Potato Research Worksite in East Grand Forks for sugar analysis and frying. Whole-tuber sucrose and glucose concentrations were determined at harvest and after three, six, and nine months of storage at 45˚F. At the same times, a subset of the tubers was processed into fries (Alpine Russet, Dakota Trailblazer, and Russet Burbank) or chips (Ivory Crisp and Snowden), and the fresh-weight acrylamide concentrations of the fried products were determined.

In addition to tubers from the two study sites, tubers were also collected from growers' fields in MN to determine if acrylamide levels in fried potatoes from the commercial fields were similar to those in the study. Three, 50 pound bags of tubers were collected from each field and shipped along with tubers from the Becker study samples to East Grand Forks.

Fried samples were shipped frozen to the University of Minnesota's St. Paul Campus for acrylamide analysis. The amount of acrylamide was determined and expressed as ng acryamide/g solid material (ppm fresh weight). All analyses were conducted at the University of Minnesota Center for Mass Spectrometry and Proteomics.

For the North Dakota site, ANOVAs of chip color, Agtron score, whole-tuber sugar concentrations, and fried-potato acrylamide concentrations as functions of treatment, cultivar, and replicate were conducted.

For the Minnesota site, ANOVAs of above-ground plant traits, petiole nitrate, tuber yield, tuber characteristics, chip color, Agtron (AGT) score, whole-tuber nitrogen and sugar concentrations, and fried-potato acrylamide concentration as functions of treatment, cultivar, their interaction, and replicate, were conducted. Because fresh-weight acrylamide concentration differed greatly between the two preparation methods (French fries are moister than potato chips), ANOVAs were also performed for chipping and frying cultivars separately for these variables (Table 4). Because of grower interest in varietal performance, results for each cultivar were also analyzed separately. Regressions of fried-potato acrylamide concentration against whole-tuber nitrogen and sugar concentrations were performed for each cultivar at each sampling time.

Outreach activities performed

North Dakota

We presented updates and status of the project at the Northern Plains Potato Growers Association (NPPGA) Research Reporting Conferences in February 2011 and 2012 and the Minnesota Area II Potato Promotion Council Educational Conference in March of both years, at the NPPGA Field Days in late August of 2011 and 2012 and the Sand Plains Research Center Field Day in both years. Additionally, the work was mentioned at the RDO/Lamb Weston field day (late August both years), regional research meetings, and meetings of the US Potato Board Processing Consortium.

Minnesota

A field day was held for growers at the study site in Becker, MN, in the summer of 2012. Twenty-five growers attended. Only yield and quality data were discussed, as the data on whole-tuber sugar concentrations and acrylamide concentrations in French fries and potato chips had not yet been fully collected and analyzed. Some of the research was discussed at an RDO/Lamb Weston think-tank session to about 10 people in November 2012.

Preliminary results for 2011, excluding acrylamide concentrations all data for tubers after 3, 6, and 9 months of storage, were published in the Minnesota Area II Potato Research and Promotional Council and Northern Plains Potato Growers Association (NPPGA) 2012 Research Reports. All results for 2011, as well as growing-season results for 2012, have been submitted for publication in the 2013 Research Reports. An update will be provided at the 2013 NPPGA in growers meeting in February with about 100 growers and industry personnel attending.

This research was discussed at the NPPGA Field Day event (attended by producers, seeds men, processors, and other research and industry personnel) on August 23, and results to date were shared with producers at the NPPGA Research Reporting Conference (Grand Forks, ND) in February 2013.

Field day events were held in Inkster and Becker in 2012. **Approximately 25 growers attended the field day in Becker**. Acrylamide analyses were not complete; only yield and quality results were discussed. **Approximately 200 people attended the Inkster field day, primarily producers and those in the industry**. The trial was briefly described in a field day handout, and a brief verbal update was given as to status of the FY11 trials. No formal feedback was received from the attendees at either event, but the potato processors (chips and frozen) and their producers (both non-irrigated and irrigated) are very interested in the project and the results. They are progressive and want to be proactive before regulation may occur, and they want good reasons to persuade quick-serve restaurants to adopt more sustainable and better quality potato cultivars. Approximately **210 growers/consultants/industry personnel attended the NPPGA conference.**

Goals and outcomes achieved

Clone (cultivar) means for sucrose, glucose and acrylamide content across nitrogen rates in the North Dakota site are presented in Table 1 for each storage period. Sucrose is broken into the reducing sugars, fructose and glucose, in storage. Sucrose levels were highest at harvest (0 time). Across clones, sucrose levels were lowest following the six month storage period. Glucose levels trended toward an increase with time, with the exception of the six month storage period when levels were the lowest. Acrylamide levels for the improved and more recent cultivar releases (Alpine Russet, Dakota Trailblazer, and Ivory Crisp) were significantly lower compared to industry standards Russet Burbank and Snowden, across nitrogen rate. Acrylamide levels were lowest following the three and six month storage period, seemingly influenced by sugar levels and native asparagine levels.

Effect of nitrogen rate across clones on sucrose, glucose, and acrylamide levels following storage at 0, 3, 6, and 9 months storage at 45 ˚F for the North Dakota Site is presented in Table 2. At 0 time, sucrose and glucose levels increase with nitrogen rate. There was no trend for acrylamide level based on nitrogen rate. Following three months storage, sucrose and glucose levels were not significantly different based on nitrogen rate. Glucose levels were highest at the 270 lb. rate, however. Following six months storage, sucrose, glucose and acrylamide levels were not significantly different for nitrogen rates. However, glucose and acrylamide levels increased as nitrogen rate increased. Nine month storage results mimicked the six month levels and trends.

Effect of nitrogen rate on sucrose, glucose and acrylamide level of five potato cultivars, grown at Inkster, ND, in 2011, are presented in Table 3. Per results presented above and found in Tables 1 and 2, cultivars tended to vary, with the older cultivars Snowden and Russet Burbank having higher levels of sucrose, glucose and acrylamide across nitrogen rate and storage time. Notably

on Table 3, acrylamide levels for the chip cultivars (Ivory Crisp) was considerably higher when evaluation of processed chips occurred versus French fry processing cultivars processed as French fries prior to acrylamide determination.

The effects of nitrogen fertilization on acrylamide concentrations varied among sites, between years, and among varieties. ANOVAs were performed for each site and year for acrylamide concentration as a function of treatment, cultivar, and their interaction, for French-fry cultivars and potato chip cultivars separately (because fresh-weight acrylamide concentrations are much higher in potato chips, due to their low moisture contents).

Acrylamide concentrations were higher for tubers from Becker than from Inkster in 2011, except for Dakota Trailblazer, for which they were similar or slightly lower. So far in 2012, Alpine Russet and Russet Burbank tubers grown at Becker yield lower acrylamide concentrations than tubers from Park Rapids, while the other three cultivars have similar concentrations between the two sites. Acrylamide concentrations are higher at Becker in 2012 than they were in 2011. The treatment-by-cultivar interaction term was sometimes highly significant, reflecting variation among cultivars in how their acrylamide concentrations responded to nitrogen treatment. Overall, the optimum nitrogen fertilization rate for minimizing acrylamide formation was found to be specific to cultivar, site, year, and (in 2011) storage time, and we therefore discuss fertilization recommendations specific to each circumstance. The control treatment (30 lbs N/ac) will be excluded from consideration due to its extremely low marketable yields.

Acrylamide concentrations in Alpine Russet decreased with increasing application rate at Inkster in 2011 for all sampling times except nine months' storage, when the trend was reversed. At Becker that year, acrylamide concentrations generally increased with increasing nitrogen application rate at six and nine months' storage, with no directional effect of treatment before six months. Acrylamide concentrations increased with storage time at Becker, but not at Inkster. In 2012, there was no clear relationship between nitrogen treatment and acrylamide concentration for either site. Based on acrylamide concentrations alone, we would recommend fertilizing at 240 – 300 lbs N/ac at Inkster and 120 – 180 lbs N/ac at Becker in 2011, and we would advise against long storage at Becker. We can offer no recommendations for Becker and Park Rapids in 2012 based on data collected to date.

For Dakota Trailblazer tubers from Inkster in 2011, acrylamide concentration tended to increase with increasing nitrogen application rate for all sampling times except at three months' storage, when there was no clear trend. At Becker that year, acrylamide concentration tended to increase with nitrogen application rate at three and nine months' storage, with no trend at harvest or six months' storage. Acrylamide concentration was lowest for freshly-harvested tubers, but showed no response to storage time after three months. In 2012, acrylamide concentration at harvest tended to increase with increasing nitrogen application rate at Becker, but showed no clear relationship to nitrogen treatment at Park Rapids. Based on acrylamide concentration alone, we would recommend a fertilization rate of 120 – 180 lbs N/ac for this variety. It is best used fresh,

but acrylamide levels did not increase greatly after three months' storage or change substantially thereafter.

Acrylamide levels in French fries made from Russet Burbank tended to decrease with increasing nitrogen application rate for tubers grown at Inkster in 2011, for all storage times. At Becker in 2011, acrylamide concentration was not linearly related to fertilizer treatment. There was a weak tendency for acrylamide levels to increase with storage time for Becker tubers. At both Becker and Park Rapids in 2012, acrylamide concentration tended to increase with increasing nitrogen application rate for freshly-harvested tubers. Based on acrylamide concentration, we would recommend fertilization at 240 – 300 lbs N/ac at Inkster in 2011 and at 120 – 180 lbs N/ac at both sites in 2012. We cannot make a recommendation for Becker in 2011, except that it would be preferable to use tubers early in storage.

Acrylamide concentrations of Ivory Crisp chips increased with increasing nitrogen application rate for tubers grown at Inkster in 2011. The trend was stronger at harvest and after three months' storage than it was later. For tubers grown at Becker, nitrogen treatment had no effect on acrylamide concentration at harvest before nine months' storage, when acrylamide concentration decreased with increasing application rate. Acrylamide levels decreased with storage time at both sites. In 2012, acrylamide concentration decreased with increasing application rate for Park Rapids tubers, but was not related to treatment at Becker. We would recommend fertilizing at 120 – 180 lbs N/ac at both sites in 2011, but at 240 – 300 lbs N/ac at Park Rapids in 2012. We can make no recommendation for Becker in 2012. It appears that storing this cultivar for more than three months decreases its potential to form acrylamide.

Acrylamide concentrations of Snowden potato chips were unrelated to nitrogen treatment at Inkster in 2011. At Becker, acrylamide concentration declined with increasing nitrogen application rate at all times except harvest, when there was no directional relationship. At both sites, acrylamide concentrations increased dramatically between 6 months' and 9 months' storage, without changing directionally over time before 6 months. At harvest in 2012, nitrogen treatment had no clear effect on acrylamide concentrations. Based on the results at harvest at Becker in 2011, we would suggest fertilization at 240 – 300 lbs N/ac. None of the other results offer any basis for a recommendation. However, it is clear that this cultivar should be stored no longer than six months, in order to minimize acrylamide formation.

The application rate that maximized marketable yield differed between the two years. In 2011, the highest yield was seen at 180 lbs N/ac for all varieties except Ivory Crisp, for which the peak yield was observed at 240 lbs N/ac. In 2012, yield was maximized at 240 lbs N/ac for Dakota Trailblazer and Snowden, and at 300 lbs N/ac for the other three varieties. 2012 was a warmer year, with more heating-degree-days between planting and harvest, and yields were higher overall, so yield was probably limited more by nitrogen than by other factors in that year. In contrast, in 2011, with growing time limiting tuber production more than nitrogen, nitrogen applied at high rates may have resulted in a greater allocation of photosynthate to canopy growth

instead of tuber growth, with insufficient growing time for this investment in canopy to yield increased sugar availability for tuber production.

Table 1. Whole-tuber sucrose and glucose concentrations and French-fry or chip acrylamide concentrations at harvest in 2011 and 2012, at Becker (both years), Inkster (2011), and Park Rapids (2012), for treatments receiving 120 – 240 lbs N/ac, for each cultivar. (Mean ± S.D., *min – max* for each; N = 12.)

Cultivar	Sucrose (mg/g dry)	Glucose (mg/g dry)	Acrylamide (ppb fresh)
Alpine Russet (fry)	1.68 ± 0.25 *1.34 – 2.22*	1.35 ± 0.95 *0.22 – 3.34*	872 ± 636 *205 – 2192*
Dakota Trailblazer (fry)	1.63 ± 0.39 *1.05 – 2.41*	0.61 ± 0.45 *0.18 – 1.19*	321 ± 172 *85 – 554*
Russet Burbank (fry)	0.94 ± 0.11 *0.78 – 1.08*	2.05 ± 1.18 *0.40 – 3.82*	1159 ± 886 *355 – 2754*
Ivory Crisp (chip)	1.27 ± 0.44 *0.61 – 2.05*	0.34 ± 0.27 *0.14 – 0.94*	4378 ± 1849 *1898 – 7515*
Snowden (chip)	1.28 ± 0.19 *0.95 – 1.67*	0.35 ± 0.23 *0.06 – 0.73*	4016 ± 1618 *2084 – 6247*

Table 2. Whole-tuber sucrose and glucose concentrations and French-fry or chip acrylamide concentrations at each sampling time in 2011 at Becker and Inkster, for treatments receiving 120 – 240 lbs N/ac, for each cultivar. (Mean ± S.D., *min – max* for each; N = 6.)

	Sucrose				Glucose				Acrylamide			
	0 months	3 months	6 months	9 months	0 months	3 months	6 months	9 months	0 months	3 months	6 months	9 months
Alpine Russet	1.65±0.32 *1.3–2.22*	1.41±0.32 *0.92–1.78*	0.93±0.04 *0.89–0.98*	0.73±0.23 *0.38–1.11*	0.93±0.69 *0.22–3.34*	1.32±1.01 *0.23–2.64*	1.64±1.59 *0.10–3.48*	1.81±1.54 *0.40–3.80*	342±137 *205–532*	500±180 *302–824*	583±302 *287–1010*	723±590 *111–1520*
Dakota Trailblazer	1.38±0.21 *1.05–1.67*	0.97±0.45 *0.51–1.79*	0.57±0.38 *0.17–1.13*	0.64±0.43 *0.25–1.18*	0.49±0.16 *0.25–0.64*	0.80±0.35 *0.42–1.16*	0.50±0.21 *0.20–0.74*	0.82±0.19 *0.59–1.11*	169 ± 68 *85–263*	421 ±135 *254–663*	338 ± 206 *162–707*	351 ± 106 *192–459*
Russet Burbank	0.93±0.11 *0.78–1.08*	0.99±0.13 *0.85–1.22*	0.60±0.14 *0.42–0.76*	0.42±0.16 *0.23–0.60*	1.03±0.58 *0.40–1.76*	1.47±0.67 *0.64–2.42*	1.12±0.64 *0.49–1.98*	1.24±0.71 *0.60–2.24*	489±148 *355–760*	824±212 *575–1085*	766±218 *466–1118*	676±294 *288–996*
Ivory Crisp	1.14±0.46 *0.61–1.66*	0.64±0.07 *0.52–0.70*	0.82±0.23 *0.41–1.10*	0.96±0.19 *0.79–1.30*	0.18±0.03 *0.14–0.21*	0.22±0.07 *0.11–0.29*	0.32±0.30 *0.03–0.66*	0.52±0.36 *0.16–1.10*	2883±632 *1898–3615*	2097±869 *1219–3484*	1184±335 *936–1802*	1463±900 *661–2832*
Snowden	1.25±0.26 *0.95–1.67*	0.87±0.11 *0.67–0.96*	1.20±0.37 *0.83–1.87*	1.86±0.48 *1.22–2.67*	0.16±0.09 *0.06–0.30*	0.18±0.15 *0.67–0.96*	0.31±0.31 *0.03–0.77*	1.89±0.90 *0.63–2.93*	2622±532 *2084–3363*	1420±934 *636–3152*	1850±763 *1165–3035*	6830±3740 *3277–11632*

For potato chips made from tubers grown at the North Dakota site, mean chip color determined by the USDA Chip Color Chart or Agtron value across chip clones and nitrogen rate was not significantly different at 0 time. Snowden had higher Agtron values, while Ivory Crisp had a lower mean (data not presented). Similar results were obtained following three months storage. Agtron values declined following 6 months storage and the mean was below industry acceptable levels. Clone was significant for the nine month storage period, but not nitrogen rate. Mean Agtron value following 9 month storage was slightly higher than for the six month storage period; both clone and nitrogen rate were significant. Ivory Crisp had significantly better chip color values across nitrogen rates than Snowden.

Mean chip color was not significantly different (chart and Agtron values) across clones for nitrogen rate at 0 time. Following 3 months storage the Agtron value for the 150 nitrogen rate was lower than for the other rates. After 6 month storage chip color chart values were equal, however the Agtron values were significantly different and slightly darker for the 150, 210 and 270 lb. nitrogen rates. By the 9 month storage period, chip color chart values for the 150, 210 and 270 lb. nitrogen rates were higher than for the 0 and 90 lb. rate. The Agtron values also followed this pattern.

In Minnesota, plant stand two weeks after emergence was significantly lower for Alpine Russet (61.4% stand) than for Ivory Crisp (88.4% stand), which had significantly lower stand than the other three cultivars (all over 98.5% stand). The low stand for Alpine Russet was likely due to dry rot. Plant stand was not significantly related to the amount of nitrogen applied. The cultivars also differed significantly in their numbers of stems per plant three weeks post-emergence. Snowden (5.0 stems per plant) had significantly more than Russet Burbank (4.5 stems), which had significantly more than Ivory Crisp (3.6 stems) and Alpine Russet (3.5 stems), which had significantly more than Dakota Trailblazer (2.7 stems). The number of stems per plant was significantly related to nitrogen application rate for three cultivars, but the relationship was neither linear nor quadratic for Dakota Trailblazer (Table 6) and Ivory Crisp (Table 8). For Russet Burbank, the control treatment had significantly more stems per plant than the ESN-fertilized treatments.

Petiole nitrate increased significantly with increasing application of ESN for all combinations of cultivar and testing date (Table 4, Tables 5 – 9).

Petiole nitrate also varied significantly among cultivars in all four sampling periods (Table 4), but the rank-order of the five cultivars changed over time. On June 20, Alpine Russet plants had significantly higher petiole nitrate than all other cultivars, and on June 28, the same cultivar still had significantly higher nitrate than Russet Burbank or Snowden plants. On both July 11 and July 26, Russet Burbank plants had significantly higher petiole nitrate than any other cultivar, while Ivory Crisp plants had significantly lower nitrate than Snowden or Dakota Trailblazer.

Snowden had significantly greater total yield than Dakota Trailblazer, which had significantly greater yield than Ivory Crisp, which had significantly greater yield than Alpine Russet. Russet Burbank had total yield intermediate between and not significantly different from those of Dakota Trailblazer and Ivory Crisp. For yield U.S. No. 1 tubers and total marketable yield, Dakota Trailblazer had significantly higher yields than Snowden or Ivory Crisp, which had significantly higher yields than Russet Burbank, which had significantly higher yields than Alpine Russet. The lower yield of Alpine Russet tubers was likely due to dry rot of the seed tubers.

For each variety, total and marketable yields and yields of U.S. No. 1 tubers peaked at a nitrogen application rate of 180 or 240 lbs N/ac (Tables 10-14), although, for Snowden, yields were similar for all treatments receiving 180 to 300 lbs N/ac. The yield of U.S. No. 2 tubers was low for all treatments for Dakota Trailblazer, Ivory Crisp, and Snowden. For Alpine Russet, yield of U.S. No. 2 tubers decreased with increasing application of nitrogen, while the opposite trend was seen in Russet Burbank (though the effect was not statistically significant).

Tuber size distributions shifted toward larger size classes with increasing nitrogen application rate, although this tendency was weak for Dakota Trailblazer. The percentage of yield in tubers over 6 or 10 ounces generally increased with increasing nitrogen application rate. This trend was not evident among ESN-fertilized treatments for Dakota Trailblazer tubers over 6 ounces (though it was for tubers over 10 ounces).

The ranks of the cultivars by tuber dry matter and specific gravity were Dakota Trailblazer > Snowden > Ivory Crisp > Russet Burbank > Alpine Russet. For tuber dry matter, each of these differences was statistically significant. For specific gravity, the difference between Snowden and Ivory Crisp was not significant.

Tuber dry matter increased with increasing rate of nitrogen application rate for all cultivars except Russet Burbank, for which there was not treatment effect (Tables 15-19). Tuber specific gravity was greater for all or most ESN-fertilized treatments than for the control for Russet Burbank and Ivory Crisp. There was no effect of nitrogen treatment on this trait for the other three cultivars.

The prevalences of hollow heart and brown center in Dakota Trailblazer were significantly greater than those in Alpine Russet, which were significantly greater than those in the other three cultivars. The prevalence of scab was significantly greater in Ivory Crisp than in any other variety, and significantly greater in Snowden than in Alpine Russet. The other two varieties had prevalences between, and not significantly different from, those of Snowden and Alpine Russet.

The prevalences of hollow heart and brown center increased with increasing nitrogen application rate for Dakota Trailblazer and Russet Burbank. These flaws were rare on not significantly related to nitrogen treatment for the other three cultivars. The prevalence of scab was not related to nitrogen treatment for any cultivar.

For all cultivars combined, tuber nitrogen concentration increased with increasing application of ESN (Tables 20-24). Alpine Russet tubers had significantly higher nitrogen concentration than Ivory Crisp tubers, which had significantly higher nitrogen concentration than Snowden or Russet Burbank tubers, which had significantly higher nitrogen concentration than Dakota Trailblazer tubers.

There was a treatment-by-cultivar interaction effect, attributable to differences in the strength of the response to nitrogen application rate. There was no relationship between treatment and tuber nitrogen for Snowden, and Russet Burbank showed only a weak response to additional ESN above the rate of 120 lbs total N/ac, while the other cultivars showed a more consistent increase in tuber N with increasing application of nitrogen.

At harvest, Alpine Russet and Dakota Trailblazer had significantly higher whole-tuber sucrose

concentrations than the other three cultivars, and Ivory Crisp had a significantly lower tuber sucrose concentration than any other cultivar. Three months later, Snowden and Ivory Crisp had significantly lower tuber sucrose concentrations than the other three cultivars, and Alpine Russet had a significantly higher tuber sucrose concentration than Russet Burbank. After six months in storage, Snowden tubers had significantly higher sucrose concentrations than those of any other cultivar, while Russet Burbank tubers had significantly lower sucrose concentrations than those of any other cultivar. A similar pattern was seen at nine months, except that Alpine Russet joined Russet Burbank in having a significantly lower sucrose concentration than the other cultivars. Overall, sucrose concentration tended to decline with storage time for the frying cultivars and increase for the chipping cultivars.

At harvest, Russet Burbank tubers had significantly higher glucose concentrations than Alpine Russet tubers, which had higher glucose concentrations than Dakota Trailblazer tubers, which had higher glucose concentrations than Snowden or Ivory Crisp tubers. After three months in storage, the glucose concentrations of Alpine Russet and Russet Burbank tubers were significantly higher than those of Dakota Trailblazer tubers, which were higher than those of Ivory Crisp and Snowden tubers. At six months, Alpine Russet tubers had significantly higher glucose concentrations than Russet Burbank tubers, which had higher glucose concentrations than any of the other three cultivars. After nine months in storage, Alpine Russet and Snowden tubers had significantly higher glucose concentrations than Russet Burbank tubers, which had higher glucose concentrations than Ivory Crisp or Dakota Trailblazer. Glucose concentration tended to increase with storage time for all cultivars.

There were no significant effects of nitrogen treatment on sucrose concentration for the frying cultivars or the chipping cultivars as groups, nor was there a significant treatment-by-cultivar interaction for either group (Table 4). In contrast, at all four sampling periods, glucose concentration decreased with increasing application of nitrogen, although this trend was not significant for chipping varieties at 6 and 9 months' storage. The treatment-by-cultivar interaction effect was significant for the frying varieties at all four sampling periods and for the chipping varieties at harvest (Table 4).

Among individual cultivars, nitrogen treatment only influenced whole-tuber sucrose concentration at harvest in Snowden (Tables 19-24), but the relationship was not linear or quadratic. Three months after harvest, nitrogen treatment was significantly related to sucrose concentration in Alpine Russet, Dakota Trailblazer, and Snowden. Sucrose concentration generally declined with increasing nitrogen application rate for Dakota Trailblazer and Snowden, but followed no simple pattern in Alpine Russet. At six months' storage, sucrose concentration was not related to fertilizer treatment for any cultivar. After nine months, sucrose concentration generally declined with increasing nitrogen application rate, except that the treatment receiving 120 lbs N/ac had a significantly lower tuber sucrose concentration than any other treatment.

Tuber glucose concentration at harvest generally declined with increasing nitrogen application rate for all cultivars except Dakota Trailblazer, though the effect was not statistically significant for Russet Burbank (Tables 19-24). The relationship between nitrogen application rate and glucose concentration at harvest for Dakota Trailblazer was not linear or quadratic. Three months after harvest, nitrogen treatment was significantly related to tuber glucose concentration for all varieties

except Dakota Trailblazer. Glucose concentration generally declined with increasing nitrogen application rate for all varieties. At six months' storage, glucose concentration still tended to decline with increasing rate of nitrogen application for all five varieties, but the effect was only significant for Alpine Russet, for which the treatment receiving 300 lbs N/ac had a very low mean glucose concentration. After nine months in storage, there was no tendency for tuber glucose concentrations to decline with increasing nitrogen application rate in Dakota trailblazer, and in Snowden, the trend was only seen in a difference between the control group and the ESN-fertilized groups. For the other three varieties, tuber glucose did tend to decline with increasing nitrogen application rate, though this relationship was not significant for Russet Burbank.

Frying quality analysis was only performed for the chipping cultivars, Snowden and Ivory Crisp (Tables 25 and 26). There was no significant treatment by cultivar interaction effect at any sampling time (Table 4). For all treatments combined, there were significant effects of cultivar on both chip color and Agtron score at six and nine months' storage (Table 4). At both of these sampling times, chips made from Snowden tubers were darker than those made from Ivory Crisp, resulting in significantly higher chip color scores and lower Agtron scores. For both cultivars combined, nitrogen treatment only significantly affected chip color at nine months' storage (Table 4). At this time, the control treatment produced darker chips than the fertilized treatments.

Agtron scores were significantly related to treatment for Ivory Crisp at three and nine months' storage. At three months' storage, the treatment receiving 180 lbs N/ac had significantly darker chips than those receiving 240 or 300 lbs N/ac. After nine months, both Agtron scores and subjective chip color scores showed that ESN-fertilized treatments produced significantly darker chips than the control. This was the only case where subjective chip color was significantly related to treatment.

Potato chips had 3.5 to 8.3 times as much acrylamide (in ppb of fresh weight) as French fries. For that reason, the results for the frying cultivars and the chipping cultivars are considered separately.

For the frying cultivars as a group, nitrogen treatment had a marginally significant effect on the acrylamide concentrations of fries made soon after harvest, but the relationship was neither linear nor quadratic (Table 4). After three months in storage, nitrogen treatment was not significantly related to the acrylamide concentrations of fries. However, after six months in storage, there was a significant effect of nitrogen treatment, with the treatments receiving nitrogen at intermediate rates tending to have more acrylamide than those receiving extremely high or low rates. After nine months in storage, this pattern was weaker, so that the only significant difference between treatments was that the control treatment had significantly lower acrylamide than the treatment receiving 240 lbs N/ac.

The chipping cultivars showed significant responses of acrylamide concentration to nitrogen treatment at three and nine months' storage (Table 4). The response at three months was neither linear nor quadratic in shape. At nine months, acrylamide concentration declined steeply with increasing nitrogen application rate. This trend was also seen at six months, but it was not statistically significant.

There was a significant effect of tuber cultivar among both the frying cultivars and the chipping cultivars at each sampling period (Table 4). Fries made from Dakota Trailblazer had significantly

lower acrylamide concentrations than those made from the other two cultivars at all four sampling periods. Alpine Russet fries had significantly lower acrylamide concentrations than Russet Burbank fries at harvest. Ivory Crisp chips had significantly higher acrylamide contents than Snowden chips at harvest and after three months in storage, but the relationship was reversed at six and nine months.

The frying cultivars showed significant treatment-by-cultivar interactions at harvest (Table 4). At harvest, the acrylamide contents of Russet Burbank fries varied significantly but unpredictably with nitrogen treatment (Table 29), while Alpine Russet showed a muted version of the same pattern (Table 27), and Dakota Trailblazer showed very little response (Table 28). There were no significant interaction effects at the other sampling times.

The chipping cultivars showed significant treatment-by-cultivar interaction effects at three and nine months' storage, the same sampling times when they showed significant responses to nitrogen treatment (Table 4). At three months, the two cultivars showed contrasting responses to nitrogen treatment (Tables 30 and 31). Neither response was linear or quadratic in form. Only Snowden's response was statistically significant; the treatment receiving 120 lbs N/ac produced more acrylamide than the others. At the nine-month sampling time, acrylamide concentrations decreased with increasing rate of nitrogen application. Both cultivars had this relationship, but while Snowden showed the effect between 180 and 300 lbs N/ac (Table 31), Ivory Crisp showed it between 30 and 240 lbs N/ac (Table 30).

For individual cultivars, the acrylamide concentrations of fries or chips were not significantly related to nitrogen treatment for most combinations of cultivar and sampling date, except that Snowden showed significant treatment effects at three, six, and nine months of storage (Tables 27-31). Significant results for the frying varieties tended to show an increase in acrylamide concentration with increasing rate of nitrogen application, while significant results for the chipping varieties tended to show the opposite effect. However, the linear component of the relationship between nitrogen application rate and acrylamide concentration was much cleaner for the chipping varieties.

Acrylamide concentration versus precursor concentrations:

To determine whether the acrylamide concentrations of fried potato products were related to the concentrations of acrylamide precursors in the raw tubers, we performed linear regressions of acrylamide concentration as a function of precursor concentrations. Because there were significant treatment-by-cultivar interactions for the concentrations of acrylamide and its precursors, even when we considered the frying cultivars and chipping cultivars separately, we tested for relationships between acrylamide concentration and the concentrations of its precursors for each cultivar separately (Table 32).

Acrylamide concentrations in Alpine Russet fries made from freshly harvested tubers had a marginally significant positive relationship to whole-tuber sucrose concentrations, and acrylamide was positively related to tuber glucose concentration at six months' storage. Acrylamide concentrations for Dakota Trailblazer fries from freshly harvested tubers had a marginally significant negative relationship to tuber nitrogen concentration at harvest. The acrylamide concentration of Russet Burbank fries was significantly positively related to sucrose concentration at six months' storage. Acrylamide concentration in Ivory Crisp chips was significantly positively related to

sucrose concentration at three months and glucose concentration at nine months in storage. Acrylamide concentration for this cultivar at nine months was also negatively related to tuber nitrogen concentration at harvest. Acrylamide concentration in Snowden chips showed a marginally significant positive relationship to tuber sucrose concentration at six months' storage and significant positive relationships to glucose concentration at three months and six months' storage. Snowden acrylamide concentration at three months' storage was also positively related to tuber nitrogen concentration at harvest.

Growers' potatoes:

Tubers from participating growers' farms often had somewhat different concentrations of sucrose and glucose (Table 33) than tubers of the same cultivar from our study site. Alpine Russet tubers from K+O tended to have high sucrose and low glucose concentrations relative to tubers of this cultivar from our study plots. Dakota Trailblazer tubers from Perham-Karsina had sugar levels similar to those found for this cultivar in our study plots. Russet Burbank tubers from K+O, Park Rapids Bliss, and Park Rapids HCBE initially had similar sucrose levels to those from our study sites, but did not exhibit the decline in sucrose in months six and nine that tubers from our site did. These growers' tubers also had lower glucose than Russet Burbank tubers from our study site throughout the storage period. Ivory Crisp tubers from Perham-RDO generally had high sucrose concentrations and low glucose concentrations relative to tubers of this cultivar from our study site. Snowden tubers from Goenners had glucose concentrations slightly lower than tubers of this cultivar from our study plots at all sampling times. They initially had similar sucrose concentrations to our study tubers, but their late-storage sucrose increase lagged behind that of the tubers from our study site. As sucrose concentrations began to rise in tubers from our study site at six months, the Goenner tubers retained steady, low sucrose concentrations. However, by nine months, even as sucrose concentrations continued to rise in Snowden tubers from our study site, the tubers from Goenners had converged again on similar concentrations.

Chips made from Ivory Crisp potatoes from Perham-RDO (Table 34) had similar chip color scores and AGT readings to chips of the same cultivar from fertilized treatments in our study site at all three sampling times for which we have data for the Perham-RDO chips. Chips from Snowden tubers grown by Goenners (Table 34) tended to have higher AGT scores (i.e., lighter color) than chips from Snowden tubers grown at our site, especially at harvest and after nine months in storage.

Acrylamide concentrations were also determined at each sampling period for fried products made from growers' tubers (Table 35). Acrylamide concentrations for fries made from K+O Alpine Russet tubers were similar to those found for this cultivar grown in our study site. Fries made from Dakota Trailblazer tubers grown at Perham-Karsina had higher acrylamide concentrations than those made from tubers grown at our site, except at three months' storage, when they had similar acrylamide concentrations. Fries made from Russet Burbank tubers from growers' farms had similar acrylamide levels to those found for our study site, except that K+O tubers had particularly high acrylamide levels after nine months in storage. Chips made from Ivory Crisp tubers grown at Perham-RDO had similar acrylamide levels to those found with tubers from our study site, except that the Perham-RDO tubers yielded slightly lower acrylamide levels at nine months' storage. Snowden tubers from Goenners yielded chips with lower acrylamide levels than found in Snowden chips from our study site tubers, except at nine months' storage, when the Goenner chips and our

study site chips had similar acrylamide levels.

Problems and Delays

In North Dakota, unusual developments included the sampling of the materials prior to grading, thus, yield and grading data are not presented. This situation did not arise in 2012, as the potatoes were stored in Fargo at NDSU instead of the Potato Research Worksite. Additionally, the petiole analysis is not complete at this time. Thus, no correlation with high or residual nitrogen at harvest can be made with chip/French fry color, nor can recommendations be made regarding petiole nitrate levels for growers to use in season at this time. However, the results will be available and presented with the results and summary of the second year of the project (FY11 Specialty Crops Block Grant). Two years of data is always preferable to one when trying to make any type of recommendation for producers and will be very important given the extreme diversity of the two growing seasons of 2011 and 2012.

In Minnesota, data collection and analysis is currently on schedule. There was some delay in collecting data on acrylamide concentrations for French fries and chips made from tubers that had been in storage for 6 months, as many samples had undectably low levels. However, Bruce Witthuhn of the University of Minnesota Mass Spectrometry Laboratory discovered that these results were attributable to high accumulations of a (not yet identified) low-molecular-weight molecule not much smaller than acrylamide. He was able to correct for this, and acrylamide analysis is back on schedule.

Beneficiaries

Since this is a preliminary project (ie. a single year), beneficiaries will be more apt to receive benefits after a second year (and perhaps even a subsequent year) of trial results. Potato producers growing for the chip and frozen processing markets are potential beneficiaries. Additionally, based on yield and petiole information, not only will their product have potentially less acrylamide formation, but they may find that new cultivars are more sustainable from a production standpoint using less nitrogen to produce a high yield of a high quality crop. This may also positively impact the environment and consumers concerned about leaching. A second group of beneficiaries would include the potato processors. In North Dakota and Minnesota potatoes grown by ND and MN growers are made into French fries and other frozen products at Simplot (Grand Forks, ND), Cavendish Farms (Jamestown, ND), and Lamb-Weston/ConAgra (Park Rapids, MN). Potatoes grown by MN and ND producers for chipping are processed at Barrel of Fun (Perham, MN), Old Dutch (Twin Cities area, MN), and also by Frito-Lay plants outside our states. These manufacturing sites benefit if the raw product has low levels of reducing sugars and asparagines, resulting in a finished product with reduced levels of acrylamide. Finally, consumers of frozen processed products including French fries, and snack foods containing potato, such as chips, benefit when acrylamide levels are reduced.

The results for the FY10 project was shared by the following methods:

1) Presented to the Northern Plains Potato Grower's Annual meeting on Feb 18. The presentation will soon be available on the NDSU potato management

website: www.ag.ndsu.edu/potatoextension

2) Results were also provided to all growers on a CD given out at the meeting

3) A proceedings bulletin was also published by the Minnesota Area II Potato Research and Education Council and was handed out at the meeting on Feb. 18 and also will be handed out on March 4 at the Minnesota Area II meeting.

4) There were approximately 90 growers that attended the research reporting session on February 18 and there will be about 50 growers that attend the Area II meeting on March 4.

5) Total outreach with the CD and website will be approximately 200 growers and 5 Processors - Simplot, Black Gold, RD Offutt, Cavendish, Barrel O Fun.

Lessons Learned

North Dakota

Based on sampling of the 2011 yield, prior to grading, storage of raw product prior to sampling should occur where the materials can be monitored.

Based on a single year of evaluation, cultivar seems to play more of a role in acrylamide formation than nitrogen rate. The newer cultivar releases, Alpine Russet, Dakota Trailblazer, and Ivory Crisp, had lower levels, compared to the industry chip and French fry standards of Snowden and Russet Burbank, respectively. In previous research, Alpine Russet and Dakota Trialblazer have been shown to respond favorably in terms of yield, grade and French fry processing quality when produced at lower nitrogen levels than required for Russet Burbank. While generally not significant, across cultivars and storage time, nitrogen rate does tend to increase sucrose, glucose and acrylamide levels.

Minnesota

We have made substantial progress on establishing baseline values for sugar concentrations in mature tubers, chip color for chipping cultivars, and acrylamide concentrations for French fries and potato chips following 0, 3, 6, and 9 months in storage. Based on data from Becker, Inkster, and multiple growers, all of these characteristics show significant geographic variability. Furthermore, results for the 2012 season to date indicate a high degree of year-to-year variation, as well.

Nitrogen management had a limited effect on tuber sugar concentrations and the acrylamide concentrations of fried potato products. What effects we found differed between the North Dakota site and the Minnesota site. This does not support the hypothesis that the concentrations of tuber sugars and the concentration of acrylamide in fried products can be manipulated through nitrogen management in the field. However, nitrogen management did have a significant effect on tuber nitrogen concentration, and may therefore limit the accumulation of the acrylamide precursor asparagine in mature tubers. This may be significant in cases where the asparagine concentration limits the formation of acrylamide in fried potato products.

In the Minnesota site, acrylamide concentrations were not well predicted by the concentrations of sucrose, glucose, or nitrogen in raw tubers. This does not support the hypothesis that the acrylamide concentrations of French fries and potato chips can be controlled by manipulating the concentrations of acrylamide precursors in mature tubers. Acrylamide formation may have been limited by something other than the concentrations of acrylamide precursors in this system

Genetic approaches (e.g., cultivar selection, targeted breeding) are more likely to yield positive results in the effort to reduce acrylamide concentrations, based on this first year's data. Cultivars often varied significantly in the acrylamide concentrations of the French fries or chips produced from them, and some responded better than others did to long storage times. The Minnesota acrylamide results for cultivar were generally consistent with those reported by North Dakota

Future project plans

We have added this section because our project has received a second year of funding (FY11). A second field trial, petiole sampling, determination of yield and grade, sampling for determination of sugars, processing, and determination of acrylamide levels at 0, 3, 6, and 9 month storage periods has taken place. Sugars and acrylamide for the 0 time sampling have been determined. A second year of data will be significant in determining if our first year findings are consistent based on the protocol, or if environmental differences between growing seasons 2011 and 2012 resulted in significant differences.

The results for the 2011 growing season will be presented at the Northern Plains Potato Growers Association Research Reporting Session in Grand Fork, ND during the week of February 18.

Tubers from the second season, from both sites, are approaching 3 months' storage. Whole-tuber sucrose and glucose concentrations will be determined at 3, 6, and 9 months' storage, as will the acrylamide concentrations of French fries and potato chips made from these tubers. Statistical analyses will be conducted for both sites and both years, and the results will be reported the full results for both years will be reported to the Northern Plains Potato Growers Association. Results will also be reported at the Potato Association of America annual meeting in 2013 or 2014.

Acknowledgements

Project partners providing significant contributions included the Bruce Witthuhn of the University of Minnesota Mass Spectrometry Laboratory, Marty Glynn and staff at the USDA-ARS Potato Worksite (East Grand Forks, MN), Ron Faber of the Sand Plain Research Farm in Becker, MN, the Northern Plains Potato Growers Association and Minnesota Area II Potato Research Council, and many producers in these areas (perhaps indirectly) contributed by providing, seed potatoes, land, crop medicines, etc. for the plots, as well as encouragement and interest in this important project. The following growers in Minnesota contributed tubers for analysis and comparison with tubers from the study plots: R. D. Offitt Company, K & O Farms, and Goenner Farms.

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Project I- Expanding sales & consumption of specialty crops at farmers markets

PROJECT TITLE

Expanding Sales and Consumption of Specialty Crops at Farmers' Markets - **Minnesota Farmers' Market Association**

PROJECT SUMMARY

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.
- Establish the motivation for this project by presenting the importance and timeliness of the project.

The purpose of this project was to expand adoption of Electronic Benefit Transfer technology to benefit a wide array of specialty crop producers at farmers' markets in Minnesota by:

- increasing their sales
- strengthening existing farmers' markets
- increasing market development opportunities by providing regional, educational workshops throughout the year, especially geared towards expanding magnetic card (EBT, debit and credit) acceptance at farmers' markets.

With several years of a weak economy, specialty crop farmers have been struggling financially. Many struggle just to plant crops and handle basic farm operations, expenses and sales. Most do not have the means or time to implement additional factors into their operations, considering that most also hold second jobs.

Many farmers' markets in Minnesota are also newly structured markets within the past 5-10 years. Farmers' markets have been rapidly developing from an estimated 80 farmers' markets in 2008 to over 150 in 2012. (According to MN Grown data.)

This project assisted specialty crop producers by promoting their fruit, vegetables, honey and more at farmers' markets to low-income EBT participants. By providing accessibility of EBT terminals to farmers' markets, EBT participants gained access to fresh, locally grown fruits and vegetables that they would not have had access to, thus increasing farmer's markets/vendor sales. The farmers' market managers and vendors have had the

opportunity to attend educational conferences to learn new techniques to strengthen their farmers' markets and increase their understanding of how to be a successful vendor at the market.

In addition, markets had the opportunity to use the EBT technology to accept debit and credit cards. This was also a sales expansion, as specialty crop vendors at farmers' markets could accept new forms of payment, yet did not individually have to own and operate card reader machines. Customers without cash were not forced to run to an ATM or write multiple checks. Instead, they could purchase tokens at a central booth with their cards, just like EBT customers, and spend them at any vendor of their choosing.

In order to place SNAP into 9 markets in 2012, MFMA secured two grants: this one from the MDA/USDA; and one from Blue Cross Blue Shield (BCBS) of Minnesota to fund activities that would be ineligible under the Specialty Crop Block Grant. Therefore, between the two grants as well as MFMA's contribution to this effort, the varied activities occurred. Although the original grant language specified "Recipients of EBT terminals will be required to sign contract that says that they will only accept tokens for specialty crops as designated in USDA website.", the MFMA found that condition was not possible without causing great confusion to both the vendor and the SNAP participant. There were some markets that commented on the fact that the contract, resulted in lost sales. Therefore, MFMA chose instead to combine BCBS and MFMA resources to the total for the project and track expenses to ensure the project proceeded as well to ensure that only eligible expenses were allocated and charged according to legitimate expenditures.

- If the project built on a previously funded project with the SCBGP or SCBGP-FB describe how this project complimented and enhanced previously completed work.

In 2008, the *Enrichment of Minnesota Farmers' Markets* was funded through the Specialty Crop Block Grant Program (SCBGP). This grant provided direction, materials and EBT technology to eight markets which did not have these capabilities prior to this grant. Three of the eight markets continued the EBT program on their own; five did not have the means to continue on their own but felt it was valuable to participate as they had a better idea of what to expect and would be better prepared should the opportunity arise for them to be able to participate in the EBT program in the future.

Since the 2008 SCBGP, the USDA Food and Nutrition Service streamlined EBT application to meet the needs of farmers' markets. Workers were hired earlier so that everything was underway for the markets to utilize the EBT terminals at the beginning of the market season. MFMA partnered with the University of Minnesota Extension Service and Blue Cross/Blue Shield of Minnesota, who assisted in the development and implementation of EBT marketing campaigns and also conducted surveys to measure the total increase. With a more streamlined application process and EBT terminals in the markets at the beginning of the season the specialty crop vendors realized an increase in sales throughout the year, giving them extra income to sustain the EBT terminals in their markets in future years.

Attendance at MFMA's educational conferences increased as attendees discussed with others what they had learned. Funding from this grant helped make it possible to continue conducting these educational conferences. Subject matter was determined from comments/requests made on the evaluation sheet of previous conferences along with information shared by other groups of similar interests. Many of the vendors are excellent growers but are unfamiliar with marketing strategies, business plans, food safety and other business aspects of having a strong farmers' market organization.

Both the EBT project and educational conferences have been valuable to the specialty crop producers/vendors in that it has introduced them to new technology; in turn, gaining additional clientele that otherwise would not be able to or might chose not to purchase produce from the vendors without magnetic card acceptance.

PROJECT APPROACH

- Briefly summarize activities performed and tasks performed during the grant period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.
- Present the significant contributions and role of project partners in the project.

Work progressed and grant funds were well-utilized in supporting the needs of fruit and vegetable producers at the participating markets. With approval, the MFMA bought out the leased POS terminals from 2011's portion of the program to ensure producers had continued access to equipment after this program's end in 2012. In addition the MFMA, through its in-kind organizational funds and contracted funds through Blue Cross & Blue Shield of Minnesota, equipped each of this year's nine participating markets with:

- Full market bucks incentive program (matching EBT sales up to $5 for each customer per market day); *Market Bucks were NOT funded by this program, but by a separate grant from BCBS.*
- $4,500 in printed promotional brochures in multiple translations (English, Spanish, Hmong & Somali) to advertise EBT/Market Bucks Program and vegetables in season locally; *Approximately 257,000 promotional brochures were distributed by the University of Minnesota Extension Service. Every SNAP household in the state of Minnesota received a brochure in addition to several produce heavy recipes and tips for using farmers' market produce. (See the appendix)*
- $1,250 in additional market banners and signs to advertise acceptance of EBT/credit cards; *Each of the 9 farmers markets that participated in the program received banners and signage to help them promote the program. A total of 25 banners (of various sizes) were utilized by these markets. The banners only featured specialty crops. (See appendix for examples)*
- $300 monthly staffing supplements for each of the nine markets to use for program outreach in their community;
- $900 per each of the nine markets to use for advertising the program in local media

The MFMA continues to be an active resource to personally consult with the increasing number of individual

farmers markets and farmers across the state who wish to implement EBT & credit card acceptance to increase their sales potential and community benefits.

The educational portion of the grant funds contributed in part to the MFMA's Spring Workshop in order to increase attendance from local growers. This effort saw an increase from 62 attendees to 81 attendees in March 2012 with a competing event on the same day. Survey comments from the producers at the workshop were very positive and appreciative of the resources available and the workshop components regarding marketing components and mentoring sessions were the components that prompted the most appreciation from local producers.

The majority of attendees at MFMA conferences are the managers of the farmers markets, who represent the vendors at their markets, including specialty crop producers. At the 2012 MFMA Spring Conference, there were 65 in attendance, with 48 representing farmers' markets; or 73.8% representing farmers' markets with specialty crop producers. (Survey results are attached in the appendix)

The actual surveys are included within the Appendix and below is a summary of the results. The same survey format was used at both Spring Conferences. The ranking system was 1-4, with 1 = poor and 4 = excellent. Both Spring Conferences were considered very successful.

Question	2012 rating	2011 rating
Your Overall Experience Today	3.4	3.6
The Overall Quality of Presentations:	3.3	3.5
Provided Handouts & Reference Materials:	2.95	3.1
Information at Exhibitor's Booths/Displays:	3.2	3.3
Would You Have Liked More Time for Any of the Following: Speed Mentoring Presentations Exhibits Networking	A quick overview was helpful, more time for presentations would allow them to go into more depth on the topics, very timely information, well worth my time	Scaling up for local food movement, concern about next farm bill undoing the progress made to this point, better understanding of EBT and SNAP
Please Submit Your Topics of Interest for the Next MFMA Conference:	More information on market events, meeting requirements of state inspectors, use of social media	No child left behind information, Local Food College, Cooking demos to increase vegetable purchases

The fall workshops were held in two out-state locations in the state and used a different survey format. A summary of those responses are included within the table and the fall workshops were considered very successful.

Remaining funds were used for 'scholarships' for market managers to attend the 2012 Fall conference, where they served on a panel describing the challenges and successes of implementing and sustaining EBT at their

respective markets. With a high level of intimidation when it comes to the technology and bookkeeping associated with EBT, having farmers/market managers explain in their own words how things worked is a valuable tool to encourage other markets to take the plunge; that the additional work is worth increased market sales, increased community visibility and good will, and most importantly, increased access to and education about healthy fruits and vegetables to those who need it most.

MFMA allotted $5,000 for educational leadership purposes; it was these funds that were utilized as scholarships to the 2012 Fall conference. Five market managers received $30 scholarships each for a total of $150. No scholarships were provided to individual vegetable growers. It was important for the market managers who had experience with the EBT program to present their experiences at this conference in order to grow the acceptance of this technology and grow our efforts to further promote specialty crops.

Additionally, scholarships were offered to local vegetable producers to assist in workshop fees required to attend a Minnesota High Tunnel & Beginning Growers Workshop.

Another significant partnership was with both the University of Minnesota Extension Service's Simply Good Eating Program and Minnesota Health and Human Services. Using mailing information from Health and Human Services, an estimated $100,000 in financial contributions, from Extension's existing Healthy Eating funding, allowed a direct mail piece to be sent to the full 257,000 SNAP recipients across the state. A full four-page document was sent out that included a list of farmers markets accepting SNAP/EBT (and Market Bucks) across the state with locations, healthy eating tips, and recipes for local fruits and vegetables along with an in-season produce chart. Tips about food preservation for “recipe excess” or “buying ahead while in season to preserve” were included. The mailer was written in simple terms with colorful photographs to assist with limited literacy concerns.

While word-of-mouth has been demonstrated by Blue Cross/Blue Shield of Minnesota's surveys as the #1 way EBT users learn about EBT access at farmers' markets, we feel this June mailing played a big part in 'breaking the ice' and encouraging SNAP recipients to use their benefits at farmers markets' and receive additional matching funds through BCBS

GOALS AND OUTCOMES ACHIEVED

- Supply the activities that were completed in order to achieve the performance goals and measurable outcomes for the project.
- If outcome measures were long term, summarize the progress that has been made towards achievement.
- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieving outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.

Adding the SNAP program to the farmers' markets required the FMs to designate a central location for the POS machine, which in turn became their central 'welcome' or 'information' tent. This allowed the FMs to gather all their organizational and promotional items into one place, and helped the flow of traffic in their markets. Additionally, all the FMs had to solidify their accounting procedures because they handled substantially more transactions every market day. All of these pressures contributed to making the FMs more operationally efficient.

By the end of the Minnesota farmers' market 2012 season, this project successfully:

- placed POS terminals and accompanying wooden tokens in 9 farmers' markets
- developed and distributed EBT marketing material to all 9 markets
- compiled monthly data from all 9 markets

Following is data that reflects the increase in sales at the nine participating farmers' markets, as well as the actual and percentage sales directly attributed to the EBT program. (Further analysis on hours spent managing the EBT program at the farmers' markets will be available from BCBS in 2013.)

Market	Total Count	Total Sales	EBT Count	EBT Count % of Total	EBT Sales	EBT Dollars % of Total
1	116	$1,744	71	61.2%	$704	40.4%
2	178	$2,219	123	69.1%	$1,493	67.3%
3	240	$2,508	192	80%	$1,730	69%
4	421	$5,957	336	79.8%	$3,744	62.9%
5	1,276	$16,332	378	29.6%	$5,071	31%
6	365	$6,619	115	31.5%	$1,387	21%
7	1,000	$17,882	344	34.4%	$3,951	22%
8	783	$28,185	398	50.8%	$7,972	28.3%
9	590	$9,867	284	48.1%	$3,257	33%
TOTAL	**4,969**	**$91,303**	**2,241**	**45.1%**	**$29,309**	**32.1%**

Adding this system allowed for EBT, debit and credit card sales at these farmers' markets – all sales that had not existed before. Since these farmers' markets did not capture sales reports from their markets nor individual vendors prior to the grant, we have no baseline to compare sales increases to. We can, however, verify through the automated reports from the credit card service we contracted with, TransLink, that the 9 markets added $91,303 in sales in 2012 – sales that did not exist before.

Of those $91,303 total sales, $29,309 was in EBT sales (32.10%); thus $61,994 (67.9%) was in debit or credit card sales. Interestingly, there was significant difference in the EBT sales vs. non-EBT sales between different markets. E.g., EBT sales in Market 6 comprised 21% of their total card sales; while EBT sales in Market 1 comprised 69% of total card sales.

From the numbers reported above, the $29,309 in EBT sales were new dollars to these markets, which contributed to their profitability. Although we do not have any hard numbers

on the productivity and market performance of the specialty crops purchased via this project, it can be shown based on this experience that this type of project would encourage additional specialty crop growers to participate in farmers' markets. So adding SNAP (plus BCBS' Market Bucks) to the FMs is a direct and specific incentive to those growers. We anticipate we will see a growth in specialty crop growers going forward, since there is at least a 1-year gap between the incentives and getting those specialty crops to market.

However, adding this system to these farmers' markets significantly increased their time needed to manage the system – as well as time needed to document the required data for the various grants we secured to bring this system to their markets. Anecdotally, we know some of these farmers' markets have now had to increase their vendor fees in order to continue using the card system, while other farmers' markets have sought community donations to pay for the system. We will know later in 2013 if the increase in vendor fees worked for those farmers' markets or if they lost vendors because of it.

The documents the farmers' markets were required to complete compared the dollar amount of EBT tokens redeemed from produce vendors vs. other vendors.

On the self-reporting forms conducted by the markets the total EBT sales was reported with 65.8% were spent on 'produce and the remaining 34.2% were spent on 'other'. The self-reporting forms were cross checked and matched up to the automated reports from the TransLink service. The SCBG portion of the project was 38% ($60,100) of the total project which cost $157.850. The $60,100 was completely spent on 'produce' type items as defined by the eligible fruits and vegetables defined within the USDA definition of specialty crops.

BENEFICIARIES

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.
- Clearly state the quantitative data that concerns the beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

Based on the data provided above, both specialty crop growers and EBT (SNAP, debit and credit) participants benefited from this program. Specifically there were 150 individual vendors, from nine markets who provided Specialty Crops to the farmers markets that had produce purchased through this program, the number of transactions were tracked but not the individual purchasers.

For a large amount of specialty crop growers in Minnesota, farmers' markets are the #1 point of purchase. Hours are set, and the location is standard. Conversely, most farmers' markets' goods are a majority of specialty crops.

Educating markets about the benefits and challenges of accepting EBT as well as credit/debit cards was a major part of the program. Whether through conferences and workshops or individual consulting, there were a lot of questions and concerns to be addressed. Offering continuing one-on-one support, the MFMA, through this grant, enabled an estimated 300 specialty crop growers access to additional customers.

The purchase of hardware was incredibly important, though, and can't be understated. For these markets, many of which rely on volunteer labor, the capitol outlay for a wireless POS card reader and high-quality serialized EBT/credit/debit tokens was far too prohibitive to undertake. The same is true for marketing materials, making sure that the public knew about the expansion of payment options and resulting increase of access to fresh local produce.

Low income Minnesotans were able to use their SNAP benefits to put $29,309 of healthy local produce on their dinner tables.

$61,994 was spent via debit and credit cards at the nine participating markets. While one could argue that these consumers could have written a check or left to use an ATM and returned to market, the MFMA feels this represents a significant increase in sales, especially during the economic recession.

Specialty crop growers at farmers' markets benefited in three ways.

First, by gaining an entirely new group of customers who have been unable to use their food assistance benefits at farmers' markets since the advent and implementation of EBT technology. Not only were these customers well informed about market EBT acceptance and ways to use produce, thanks to our partnership with the University of Minnesota Extension Service and their mailing to every SNAP household in the state, but they were financially motivated by the prospect of receiving up to a 50% discount on local fruits, vegetables, honey and maple syrup thanks to our partnership of this program with the Blue Cross/Blue Shield of Minnesota's Market Bucks Program. In addition, most SNAP recipients have children, especially as household size greatly affects SNAP benefits. By introducing fresh local produce and the specialty crop growers who provide them to children from as young as 1 year old up to teenagers of 18 years, cultivation of future consumers of specialty crops takes place.

Second, specialty crop growers at farmers markets were able to accept credit and debit card funds for their produce. As many consumers no longer carry cash, and accepting personal checks remains a financial liability for specialty crop producers/vendors, being able to accept what for many consumers is a preferred method of payment meant added convenience for consumers who had no limit, save for their magnetic card limits, to the amount of fresh produce they could purchase.

Third, the implementation of EBT in these farmers' markets strengthened the bonds that these specialty crop producers have within their community. EBT acceptance offered a real opportunity for these markets to reach out to churches, community aid organizations and clubs, and the

public. These markets visibly demonstrated that they are working to give back to the community and to help struggling families. The potential media coverage is enormous. One participating market had two television stories, several radio stories and several newspaper articles on their implementation of EBT, all positive, feel-good stories and free publicity.

The TransLink reports show that the EBT card was swiped 4,969 times total among the participating farmers' markets. There is no way to tell from these reports if they were unique users. Additionally, there was no pragmatic way to verify unique participants without undue discourtesy to them.

EBT participants benefited in three ways:

First, they were offered new access to healthy local fruits, vegetables, honey and maple syrup, all specialty crops, that would have been unavailable for purchase using SNAP benefits.

Second, our partnership of this EBT implementation and promotion program with Blue Cross/Blue Shield of Minnesota's Market Bucks Program reduced the cost of these products to SNAP recipients by up to 50% while keeping the amount collected by specialty crop farmers at the same level.

Third, EBT participants benefited by having increased access to the educational aspects of farmers' markets and the specialty crop vendors within. Unlike EBT transactions at conventional stores, each EBT transaction with specialty crop grower/vendors was an opportunity to learn about different kinds of produce, when it is in season, and how to prepare and or preserve it in a healthy and delicious way. Children in SNAP households were also introduced to and educated about healthy, local fruits and vegetables. Our partnership of this program with the University of Minnesota's Extension Service also provided recipes, cooking, purchasing, and storage tips to SNAP households.

LESSONS LEARNED

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
- Provide unexpected outcomes or results that were a effect of implementing this project.
- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

While not unexpected, we definitely reinforced our opinion that specialty crop growers/farmers' market vendors as a group are independent, wary-of-change individuals. We found many growers skeptical of the idea of *electronic* payments and unsure of incorporating the necessary logistics into the market administration. With an estimated average age well over 50, many of these were specialty crop growers who had gladly accepted paper food stamps into the early nineties.

The MFMA found that a two-step education progress is really needed. The first step is a general, example-based, keep-it-simple education for the specialty crop growers/vendors to explain the benefits and requirements of participation. We found it much more reassuring for these technology-weary growers to

learn from fellow growers, and the MFMA plans to integrate this kind of education/testimonial education in future EBT implementation education in the future.

The second step is a very thorough training of the market manager and any other POS administrators. Hiccups can and will occur. For example, the entire EBT system for the state of Minnesota went off line Saturday, August 4th. Had contingency plans been clearly laid out, instead of buried in POS card-reader manuals, managers/POD administrators could have used the 'Store and Forward' option that would have effectively saved card information and charged the appropriate accounts when the system came back online. Instead, frustration on both sides of the booth was incurred, as folks trying to use their EBT benefits at most markets that day were unable to, and managers/administrators on a very busy market day in the peak of growing season were left frustrated and confused.

This manager/administrator training needs to go beyond technical training, however, and the MFMA plans to visit each and every MFMA administered EBT participating market in person at least once next season. We are dealing with growers who work with living, growing objects in a physical space, not virtual numbers and instructions that perhaps seem unintuitive.

Every manager has different skill sets. Some of the information was sent in with little need to edit or change. Some markets sent in data that literally took hours to re-create what was originally asked for. It is obvious that some markets, not all, need on-site training, to show visually what is needed for our data/records and just importantly, why. We believe demonstrating in person why these hard-working underpaid (if paid at all) managers need to take the extra time to properly complete different data sets. Again, using the exemplary managers as peer trainers will help make the information and education easier to comprehend.

On-site visits by the MFMA will also offer another advantage – localized assessment of low-cost and free marketing options. Some markets made very successful efforts using these grant funds in getting out the word concerning EBT and other card acceptance. Others did practically nothing. Part of the on-site visits will offer localized planning on how to continue to promote card acceptance as well as how to fund POS maintenance, card fees, and other costs associated with card sales as grants decrease. Examples of how some markets used free media, such as writing articles and press releases, gave radio interviews about EBT use, or successfully invited local TV stations to feature POS sales at markets will be covered. Other sources, like community internet bulletin boards, Facebook, neighborhood associations, churches, and community foundations will also be included.

POS booth staffing is also an issue that needs to be addressed. The time running and administering the card reader booth is substantial, and serious discussion on compensation needs to be brought up. Many local institutions exist that are willing to help with staffing, like churches, banks, and hospitals, and markets could use assistance in reaching out to these entities. Extreme care must be given in training, however. Just as the

MFMA had to dedicate many extra hours in untangling anomalies of markets who incorrectly submitted their data, so too will a market manager/administer have to spend precious extra time correcting mistakes of a well-meaning but under-trained volunteer.

Overall, the MFMA has discovered tremendous goodwill towards this project – the partnerships with Blue Cross and Blue Shield of Minnesota and the University of Minnesota Extension Service are just two of many testaments to that. Community goodwill has been outstanding as well, and the MFMA feels that there is a carry-over benefit to offering and promoting EBT/SNAP at farmers' markets. Consumers wholly unaffected by EBT implementation at farmers' markets expressed major support. The simple act of promoting farmers' markets, whether concerning EBT or not, also served to remind people of the community importance of the markets and their specialty crop grower/vendors.

These lessons and improvements will also be implemented into the Minnesota Farmers' Market Manager Certification Course and Vendor Certification Course. Through a separate grant, the MFMA is creating an online, Moodle software-based course that will train market managers or vendors as to not only the rules and regulations of properly and successfully running a farmers' market or stand, but best practices as well. That will include how to successfully implement and market EBT acceptance at markets, and will include much Minnesota farmers' market manger input.

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Project J- Connecting Specialty crop producers to institutional buyers to increase MN grown foods

Final report submitted by Renewing the Countryside

Project Title:

Connecting Specialty Crop Producers to Institutional Buyers to increase the use of Minnesota Grown Foods

Project Summary

While farmers have several established avenues for directly marketing to consumers (such as farmers markets, CSA's, u-pick, farm stands, and grower directories), they often find it difficult to connect with chefs and institutional buyers who want to serve local foods. Developing such connections can be especially difficult for the growing population of immigrant farmers who face cultural and language barriers that can hinder their sales objectives. This project addresses that gap by creating spaces where chefs, restaurant buyers, school lunch administrators, B&B owners, caterers, and food

distributors can effectively and efficiently connect with specialty crop producers. A number of Minnesota farmers have discussed the need for such a tool, and see it as an important step for increasing profits from the growing public interest in local foods. As we have heard from numerous past participants, the workshops are a highly effective mechanism for the establishment of new revenue streams for Minnesota specialty crop producers as well as local sources for Minnesota food buyers. The feedback we have received from past events has been very positive, and on several occasions we have learned of new long-term business relationships developing between producers and buyers at the events. These connections have a significant economic impact for the farmers and their rural communities by making small and mid-sized operations more financially viable, but they also support the shift in consumer tastes towards greater consumption of locally and sustainably grown products.

Project Approach

This series of six regional farmer-buyer networking workshops was a continuation of a previous Specialty Crop Block Grant funded project consisting of statewide "Got Local?" Farmer-Buyer Networking workshops designed to expand opportunities for small scale specialty crop producers to direct market to bigger players in the Minnesota food industry who desire to feature local foods on their menus. Through one-day, interactive, "speed-dating" style workshops, farmers and food buyers establish the vital connections that make wholesale purchasing of local specialty crops possible. These activities help farmers boost revenues while reducing the time, expense, and marketing necessary to make individual contact with food buyers. Accordingly, the workshops also assist buyers seeking to source from Minnesota farmers by connecting them to a wide variety of specialty crop producers in one place, at one time.

During this project, we also sought to expand the benefits of this networking approach for socially disadvantaged farmers. We did this by partnering with the organizers of the Immigrant and Minority Farmers conference to develop and implement a farmer/buyer networking component to their conference. This provided an opportunity for local minority and immigrant farmers to connect with institutional buyers demanding the unique and diverse specialty crops they can offer. It also provided a platform to acknowledge and showcase minority restaurant owners who are featuring local foods on their menus.

Additionally, by devoting time for presentations and lectures from food-industry leaders, the workshops educated producers on effective marketing to institutional buyers. The workshops provided producers with important information about industry standards in terms of product quality and quantities for various goods, freshness and appearance, packaging, as well as information about delivery options. Such producer education components greatly enhance the value of the workshops to participating producers, who can use the information and feedback they receive to build customer satisfaction that leads to repeat sales.

Goals and Outcomes Achieved

How the performance goals and measurable outcomes were achieved for each project(s). If outcome measures were long term, summarize the progress that has been made towards achievement. It is encouraged to clearly convey progress toward achieving outcome measures by graphing baseline data and showing the progress toward achieving set targets.

This project met the major goals as stated in the project proposal: 1) to develop new and expanded markets for Minnesota specialty crop producers; 2) to increase the volume and diversity of locally and sustainably grown specialty crops being served in Minnesota restaurants, school cafeterias, catering services, and other institutions; and 3) to increase access for socially disadvantaged and immigrant farmers to the restaurant and institutional food service markets. At least half of the attendees at the Farm to Cafeteria workshops in 2010 indicated that the farmer/buyer networking session was the most meaningful part of the entire day's workshop. One participant said "Wonderful networking opportunity. Was unsure at first if it would be worth my time and delighted to say it definitely was." One of the networking workshops under this project took place at the 2011 Immigrant and Minority Farming Conference in Saint Paul, MN. Among minority and immigrant producers who were surveyed after this workshop, 58% were inspired by the farmer's story and 53% found it useful to learn from the restaurant owners. We met or exceeded our goals for expected measurable outcomes we specified at the outset of the project.

1. **Number of participants registered for workshops**

   Our goal for attendance was 150 participants at the Twin Cities metro area workshops and 75 for workshops held throughout greater Minnesota. We ended up with a total of 255 participants which was 30 more than we anticipated.

   They breakdown in attendance is listed below:
   Chaska - Landscape arboretum, December 2nd, 2010: 62
   Mahtomedi, November 30th, 2010: 54
   Saint Paul - Immigrant and Minority Farmers Conference, February 4-5, 2011: 40
   Moorhead, March 26th, 2012: 28
   St. Charles, April 4, 2012: 23
   Minneapolis - Kitchen in the Market, November 13, 2012: 48

2. **Number of new business relationships developed between specialty crop producers and institutional food buyers**

   To assess new business relationships that were established by participants as a result of the workshops, we conducted follow-up online surveys of workshops participants. We set a conservative goal of 20% of participants at all workshops establishing at least one new business relationship that results in actual sales (for producers) or purchases (for buyers). As predicted, we exceeded this goal, finding that on average, over 60% of participants established at least one new business relationship that resulted in actual sales due to participation in the networking workshop. At a workshop held at the Midtown Global Market in November 2013, about 70% of respondents made 3 or more new direct marketing connections at the workshop. One pair of producers commented that they "really enjoyed networking with colleagues and of course meeting many vendors. We probably connected with at least 5 new potential vendors, which is super efficient - time well spent!" When asked how the plan to use the Farm to Cafeteria workshop information moving forward, 15 of the 35 responses included a comment about intending to use their new connection with a farmer or buyer for actual sales or purchases in the

near future.

When asked about the duration of these direct marketing relationships in follow-up surveys, producers and buyers responded that at least 80% of them are at least over 1 year old. When asked to rate the quality of these relationships, the majority of producers and buyers rated these business relationships anywhere from good to excellent to fantastic. One school food service buyer commented: "The relationship and value it brings to our meal programs has been IMMEASUREABLE!"

3. **Economic value of new specialty crop sales resulting from workshops**

We also gathered quantitative data to begin analyzing the economic impact of the workshops via follow-up surveys. With no preexisting data, only anecdotal information, this round of analysis will be used to establish a baseline for future evaluation of success. Results of follow-up surveys indicate there is significant economic value of new specialty crop sales resulting from the workshops. About 30% of producer survey respondents indicated that 5-15% of their total sales to partnerships made at these networking events, while 20% can attribute over 25% of their sales to these workshops. Some producers reported that this value fluctuates by season, with 25% of sales attributed to Got Local networks in the summer and only 5% of sales in the winter. One producer reported $20,000 in sales from new partnerships made as a result of the Got Local workshop(s). A similar impact was found among buyers. Thirty one percent of buyer survey respondents indicated that 5-15% of their total food sourcing is dependent on the partnerships they made by attending the networking workshops, while 31% of respondents can attribute over 25% of sales to these workshops. Some reported that this value fluctuates by season with 40-75% of sales attributed to Got Local workshop networks during the summer growing season and only 10-15% during the winter. Dollar amounts of purchases made via Got Local workshop networks range from less than $3,000 to $50,000 per year.

4. **Specific alteration of growing and production practices (specialty crop producers) and sourcing and preparation practices (food buyers) as a result of workshop participation and feedback received from new farmer-buyer business partners**

We also asked survey respondents what practices they have changed in their farm or restaurant as a result of either new institutional marketing education received at the workshop(s) they attended, or as a result of feedback they received from institutional food buyers. Overall, many respondents reported either planning to or actually implementing a variety of changes to their operation as a result of the workshops. Evaluation surveys from the 2010 Farm to Cafeteria workshops indicate that many growers and buyers made plans to modify their operation as a result of the Got Local networking session. Some growers mentioned plans to plant more crops in order to be able to sell to schools in the quantity they need, expand farm sales to several institutional buyers, create a better business plan, and initiate more planning in general around the growing season. Some buyers mentioned they would start looking into farms in their area to start ordering food from them, try to set up accounts with more farmers with different products, work with immigrant farmers, bring in farm-fresh fruits and vegetables and ground turkey directly from the farmer, and use the reference list provided at the event to call farmers and order from them for school meals. Others mentioned they feel more confident to approach a school

administrator or farmer to set up wholesale accounts for farm to school, while others mentioned they plan to continue growing their direct marketing network to more schools, nursing homes, and other institutions. Survey results from the workshop held at Kitchen in the Market, Midtown Global Market in Minneapolis indicated that about half the producer respondents plan to change something about their growing or production practices as a result of conversations they had with buyers at the workshop, and a majority of food buyer respondents plan to change something about their sourcing or preparation practices to better accommodate producers.

Follow-up surveys of producers indicate several changes have been made as a result of relationships made at the networking workshops. In response to buyers who they met via the workshops, several producers have pursued a transition to organic production, while many growers added varieties of certain fruits and vegetables to their production. Several others mentioned scaling up the size of their production to meet buyers' desired quantity of produce, while a few said they found the workshops beneficial in understanding buyers' needs in general. Follow-up surveys of buyers indicate similar results. Several buyer respondents reported ordering and serving a greater variety of products and offering "fun" and unique menu items as a result of the partnerships made at the workshop(s). A few buyers reported using more seasonal ingredients in their menu. One buyer was able to establish an educational opportunity with a school district and made plans to give a presentation to students in the classroom. Another buyer realized they needed to make some changes to their tracking and inventory procedures as a result of creating more direct purchasing accounts.

Beneficiaries

Provide a description and quantitative data for the number of people or operations that have benefited from the project's accomplishments, and/or the potential economic impact of each project.

The focus on these events were on specialty crops, as the markets (buyers) were schools, and our experience is that schools are mainly interested, thus far, in specialty crops. We did not restrict attendance, but rather supplemented the budget with outside funds to be sure that we didn't use specialty crop funds for non-specialty crop producers.

The 2010-2012 workshops reached over 250 individuals representing farm operations, grower co-ops, restaurants and cafés, food trucks, K-12 schools, university dining, hotel restaurants, caterers, and more. It is nearly impossible to determine the number of individual consumers who benefited from the new direct marketing relationships that were formed as a result of these workshops, but it can be assumed that number is several thousand. The multiplier effect of local economic activity gained as a result of these the new connections made at these workshops is nearly immeasurable as well. As mentioned in the previous section, several workshop participants reported an increase in sales/spending for local products that amounts to anywhere from $3,000 to $50,000 per year as a result of these workshops. It is clear that there is more than just a quantitative, economic benefit to

be gained from participating in these workshops. In evaluation surveys, many participants provided positive feedback on the value of the workshops beyond the potential for new business relationships. One participant stated that the workshop "reinforced my belief in the importance of buying locally. Enjoyed meeting the farmers and hearing their stories."

Lessons Learned

Lessons learned, results, conclusions, for each project. If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

While attracting farmers and growers to the events was fairly easy, soliciting buyers to attend proved to be a challenging task. The result was a perpetually uneven ratio of farmers to buyers of at least 3:1 at each workshop. We speculate this attendance ratio is partly due to farmers perceiving a greater incentive for attending - creating more direct marketing accounts. Producers seem to have more to gain from the new relationships that will be created as a result of the workshops. For buyers, creating new direct marketing accounts can result in more time needed to coordinate and organize a greater number of vendor accounts.

Another challenge in orchestrating these workshops was deciding when and where to host them. Knowing that most restaurants are closed on Mondays, we originally thought Monday would be the ideal day for chefs to attend. We soon found that many chefs do not like to engage in work-related activities outside their work week, therefore making Monday a less than ideal day to host these workshops. Time of day is also challenging because many restaurant chefs need to be present at their restaurant for a few hours before and after each meal rush, leaving very little time during the day to leave and attend our workshop. While we originally thought venue locations outside of the city would be ideal for farmers who are not accustomed to driving and finding parking within the city, we soon realized their incentive to attend is so much that they will attend at nearly any venue. Finding a venue that is convenient for buyers is more challenging, as their daytime work schedules are tight, as mentioned above.

We have therefore concluded that the location, time, and day of the week are not nearly as important as marketing and promotion. We found it beneficial to create partnerships with organizations and individuals who have strong networks among our target audience, and to use those partnerships to spread the word about upcoming workshops. It is more likely that someone will attend an event if they are invited to by a trusted friend or acquaintance than someone they haven't met or don't recognize. We have also learned that directly inviting individuals via personalized e-mails and phone calls is more successful than sending out e-mails to entire groups at a time. Inviting past participants and asking them to invite others from their area or network, who may have missed the event the first time, seems to be a useful marketing strategy as well.

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Additional Information

Additional information available (e.g. publications, web sites, photographs).

As a result of partnerships with other organizations to promote and facilitate programming for these workshops, a number of website pages, blog entries, and publications about these events were published about the workshops. Foodservice News editor Mike Mitchelson helped spread the word about the events by posting them to the Foodservice News website. Dinner on the Farm creator Monica Walch also publicized the events via posting information on the Dinner on the Farm website, blog, and Facebook page. A description of the networking workshops can be found on our website www.renewingthecountryside.org. Pictures taken at the November 13th, 2012 event can be found in Appendix A.

PROJECT K

Increasing GAPs Adoption through Regional Grower Trainings, Demonstration Audits and the Development of a Minnesota Leafy Greens Agreement

PROJECT SUMMARY

Increased interest in local produce and associated health benefits supports local producers. However, increased consumption of fresh fruits and vegetables has been linked to increased outbreaks of food borne illness. Consequently, food safety issues prompted food distributors, institutional buyers, even consumers, to require producers to follow Good Agricultural Practices (GAPs).

National news reports and produce recalls can also have a local impact on consumer confidence and purchases. Helping local growers develop their own food safety plans helps prepare them to quickly respond if a local food-borne illness occurs. Growers who can easily show that their product is not contaminated and who can quickly share that information with authorities can aid authorities in determining the source of the problem. Producers who follow good food safety plans can also help increase the consumer's confidence in the safety of the local produce supply.

A proposed national Leafy Greens Marketing Agreement focused on food safety practices for large leafy greens producers primarily in California, Arizona, Georgia and Texas. Implementing those practices put undue regulatory and economic burdens on small acreage producers growing leafy greens for sale at farmers' markets or through Community Supported Agriculture (CSA) operations.

This project looked at the feasibility of adopting a Minnesota Leafy Greens Marketing Agreement and concluded such an agreement was not necessary at this time and that information on the costs associated with the adoption of major GAPs related practices by small farms (2-3 acres with 2-4 employees) would be more useful and practical. The information will be used to encourage growers to adopt the practices that are cost-effective and have the greatest potential to reduce microbial contamination in fresh fruits and vegetables.

In Minnesota, little research has documented the extent of adoption of food safety practices or the costs associated with adopting those practices. One study, funded by the University of Minnesota Healthy Foods Healthy Lives Institute (Tong et al, forthcoming) concluded that growers are lagging in key areas of GAPs,

such as the use of single-use hand towels, treating wash and processing water, taking measures to keep animals out of production fields, and cleaning and disinfecting harvesting tools on a scheduled basis.

Although this project did not build on work previously funded by a Specialty Crop Block Grant, it did build on projects funded through the USDA Risk Management Agency. RMA dollars funded the development and updating of the "Food Safety Plan 4 You (Template)" which forms the basis of individual food safety plans and was distributed to producers at the GAPs workshops on flash drives or hard copy as appropriate. Videos funded by RMA dollars were also used during the workshops.

PROJECT APPROACH

The goal of this project was to increase the awareness and use of Good Agricultural Practices (GAPs) through a series of five workshops throughout Minnesota plus two GAPs demonstration audits. The workshops were led by Michele Schermann from the University of Minnesota and included an overview of GAPs and a discussion of why GAPs are important followed by practical examples and hands-on activities. Workshops were initially scheduled to correspond with locations where Farm to Cafeteria workshops had previously been held because it was felt the GAPs workshops would be a good next step to prepare the producers who wanted to sell their products to schools or other institutions.

Under that premise, workshops were scheduled for the following Minnesota locations - St. Cloud, McIntosh, Slayton, Stewartville and Baxter, and promoted through a variety of ways including the MFVGA newsletter, U of M Extension, University of Minnesota Regional Partnerships, partner websites and targeted brochure mailings. We did not get a good response and later learned that most of the people attending the Farm to Cafeteria workshops were affiliated with the schools and not our target audience. Early workshops scheduled for McIntosh, Slayton and Baxter were cancelled due to lack of attendance. Workshops were rescheduled for McIntosh and Slayton and again cancelled. Workshops were scheduled and held in the spring of 2012 in St. Cloud, MN, Minneapolis, MN and McIntosh, MN.

Our initial plan was to hold two GAPs demonstration audits. Demonstration audits held in 2009 were well attended and we anticipated a similar response. We had producers agree to host audits, then re-schedule and/or cancel. The circumstances created a lot of confusion. One grower volunteered to host on short notice after a cancellation, but because of the change in plans only nine people attended.

Most of the people who came to the workshops did not have working knowledge of food safety issues or good agricultural practices. They left the workshops, however, with a much better understanding of how they could reduce the risk of microbial contamination.

Based in part on the study by the Healthy Foods, Healthy Lives Institute, the project initially sought to determine the impacts of creating a California-style marketing agreement for leafy greens growers in Minnesota to encourage adoption of best practices to reduce microbial contamination and assure customers that locally grown leafy greens were safe. However, initial interviews indicated that there are very few leafy greens growers in Minnesota and none grow only leafy greens. It appears that at this time Minnesota growers have difficulty competing economically with large California growers who benefit from mechanization and very large operations to reduce per-acre harvest and production costs. Furthermore, growers and distributors on the advisory panel indicated that they were not comfortable with a marketing agreement of any sort at this time, given the farming environment and economics in Minnesota.

The focus of the project shifted to all fresh market vegetable growers with modified objectives to obtain cost estimates for GAPs practices for Minnesota fresh market vegetable growers and to determine which food safety practices would make the most sense to implement and give growers cost-effective ways to reduce the risk of microbial contamination. Data was collected via in-person and telephone interviews with farmers who had successfully implemented some food safety practices on their farm or who had gone through a 3rd party GAP food safety audit. Particular attention was paid to growers of foods that pose the greatest food safety risk, including leafy greens, melons, tomatoes and fresh herbs. Both organic and conventional growers as well as Caucasian and Hmong growers and growers near the Minneapolis/St. Paul area and growers from farther away were interviewed. Growers were given a list of suggested best practices and asked to estimate the cost of implementing those practices based on past experience or estimations of future plans. Cost estimates were averaged and information based on publicly available costs (paper towels, sanitizer for rinse water, rental rates for portable toilets) were added.

GOALS AND OUTCOMES ACHIEVED

The goal was to increase awareness and implementation of Good Agricultural Practices and the development of food safety plans to help growers be better prepared for food safety audits and to enhance the safety of locally grown leafy greens in ways that were cost-effective for producers. Another goal was to better prepare producers to complete a food safety audit. This was to be done through five workshops, two demonstration audits and the development of a Minnesota Leafy Greens Agreement.

Five workshops were held in various areas of Minnesota (St. Cloud (2), Stewartville, Minneapolis and McIntosh). Forty-five to fifty farms were represented. Additional attendees represented University interests, farmers markets, schools and community gardens. Several of the workshop participants were new growers who were gathering as much information as possible before officially starting their produce operations. We had several growers agree to host a demonstration audit who later changed their minds so we were only able to offer one demonstration audit.

Additional “introductory” GAPs presentations were made to interested grower groups, distributors and farm-to-school coordinators to increase awareness and encourage growers to attend a more in-depth workshop.

The target attendance was 75 to 150 producers. We had 103 producers attend full day workshops plus 9 producers who attended the demonstration audit.

Participants had varied backgrounds and started with different experiences and different levels of food safety knowledge. Participants in the workshops and demonstration audit indicated they learned a lot about food safety issues and would be implementing good agricultural practices on their farms even if they did not plan to go through a formal audit.

BENEFICIARIES

The primary beneficiaries were fruit and vegetable producers who attended the workshops and demonstration audit. 103 producers attended full day workshops (2 Native American, 8 Amish, 7 Hmong, 1 Indian, 1 African American, 1 Hispanic, 2 Asian and 81 Caucasian). 55 growers attended short workshops (9 Hmong), a demonstration audit (9) or had extended contact or farm visits related to their food safety documentation. Another 15 plus multiplier people with either direct connection or influence to growers and

grower groups were in contact with Schermann and Hultberg throughout the grant period.

Workshop evaluations indicated that the majority of people attending the workshops were not food safety certified and did not have a good understanding of the meaning and implementation of Good Agricultural Practices or steps involved in developing a Food Safety Plan.

Attendees found the workshops to be filled with useful and practical information. Although few are likely to become GAP certified because it isn't necessary for them to do so at this time, they do plan to implement appropriate Good Agricultural Practices on their farms and will work on developing their own food safety plans. They are committed to providing a safe product for the consumer.

Of those who responded to a follow up survey, 15 percent indicated they are working on food safety plans or have completed an audit and another 13 percent plan to complete their food safety plans or an audit in the near future.

LESSONS LEARNED

Discussions with producers indicated a lot of confusion and misunderstanding among growers regarding food safety audits and who needs them, how the Food Safety Modernization Act applies to fresh produce growers and the importance of food safety in general. There is resistance to change, especially when mandated by the government, for practices that growers may have been using for years or generations, or when an outbreak has not been associated with a small farm, a product they produce, or their production/market area.

It was difficult to get people to attend workshops and it was difficult to get people to host demonstration audits. Reasons for not attending workshops included the distance was too far to travel, people were too busy, an audit wasn't needed, bad weather, etc. Reasons given for not hosting a demonstration audit were not wanting competitors on their farm to see how they did things, not wanting to reveal proprietary machinery or not wanting to be in the one in their area who invited the state auditor on their farm because then any new regulations for growers would eventually be blamed on them.

It also appears that the challenges we faced in Minnesota aren't unusual. It appears common throughout the country that people want to attend a demonstration audit, but they don't want to host one. It is also common that people don't want to attend a workshop that covers "common sense" issues of worker health and hygiene, general housekeeping on the farm and record keeping. Food safety is often perceived as "boring" by the target audience.

It seems that few growers in Minnesota currently need to pass a food safety audit and those that do are being asked to pass the USDA Harmonized Standard audit which is more comprehensive and expensive. Since most small fruit and vegetable producers sell directly to consumers, schools or restaurants and are not currently required to have a food safety audit, the emphasis for the food safety workshops shifted to more general on-farm food safety with less of an emphasis on the elements necessary to pass an audit. We focused on risk assessment and food safety record keeping as part of good business practices using examples from other growers to highlight the benefits and costs of food safety. We are also helping growers develop their own food safety plans using the USDA GAP audit as a framework. In the event that an audit or food safety plan is required by school food service or a farmers' market manager or a grower decides to sell wholesale, they will be better prepared after attending a workshop and developing their food safety plan.

Growers want to "do the right thing" and grow safe and healthy product. We expanded promotional efforts beyond our typical avenues and worked more with representatives from sustainable agriculture groups and University of Minnesota Regional Partnerships.

CONTACT PERSON

Marilyn Nysetvold Johnson
Minnesota Fruit and Vegetable Growers Association
Phone: 763-434-0400
Email: mfvga@msn.com

Project L - **7th Annual Immigrant and Minority Farmers Conference, February 2012**

Grant FINAL Report:

Program or Agency Name: Minnesota Food Association.

Project: 7th Annual Immigrant and Minority Farmers Conference February 2012

Date: February 24, 2012

I. PROJECT SUMMARY

The Minnesota Food Association, the Association for the Advancement of Hmong Women in Minnesota, and the USDA-Farm Service Agency co-hosted the 7th Annual Minority and Immigrant Farming Conference on February 3 - 4, 2012 in St. Paul. The on-going theme of the conference was *Growing Profits on Your Small Farm*. This conference continues to promote the goal to promote the success and viability of small and beginning minority and immigrant farmers. Only sustainable and organic agriculture was presented. The funds from the Specialty Crop Block Grant were solely used to benefit specialty crop growers. The topics covered included beginners guide to finding markets (who are my customers), beginners guide to sustainable farming (different ways and basic rules of growing vegetables), best management practices (identifying pests and diseases, managing weeds) and do you want to join a co-op (who, what, where and why of marketing through a co-op). From initial registration numbers, about 230 farmers participated each day, from the communities of Hmong, Laotian, Karen (Burma), Somali, Latino, Kenyan, Bhutanese, African-American and Native American. The conference had 2 keynote speeches by Dr. Joe Leonard, USDA Assistant Secretary for Civil Rights and Ly Van, Executive Director of the Association for the Advancement of Hmong Women in MN. The conference had 12 break out workshops about seeking land and negotiating leases, marketing, organic practices and certification, costs of production and record-keeping and seeking grants and loans, among other things. The 8th annual conference is planned for Feb 1-2, 2013.

'Socially-disadvantaged' farmers, those from communities of color, are historically underserved by a variety of aspects in American society. This is also evidenced in the various USDA agencies and State Departments of Agriculture. This demographic of farmers faces numerous barriers in getting into farming. One of the highlights of the conference was a special session on Equitable Access to USDA programs held by Geraldine Herring and Justin Rhee of the USDA Office for Civil Rights.

Another highlight of the conference was the 1 ½ hour lunch-time story sharing sessions where farmers stood up and talked about their farming stories from previous times in their home country and about new stories as they farm in America. The conference included simultaneous interpretation in 6 languages. All the workshops were presented by at least 2 presenters and they were all actual practitioners (farmers, marketers, distributors, etc.). The conference provided transportation to and from the conference by a leased bus service for farmers living within one hour of the conference site. Farmer participants are free to attend and non-farmer (agency people) are charged $50/day. Minnesota Food Association was the lead organizer for the conference in cooperation with USDA FSA, USDA NRCS, and the Association for the Advancement of Hmong Women in MN. The Planning Committee for the conference included 22 people, of which 6 were farmers. The subjects of the workshops were chosen by the Planning Committee. There were approximately 24 sponsors contributing money to the conference including private foundations, non-profits, businesses, UMN Extension and USDA FSA, NRCS, NASS, RMA, and APHIS. MFA led the fundraising efforts and was the fiscal agent.

This project built on previous years' conferences and continued to grow in size, scope and relevance for immigrant farmers. We had 465 people register for the conference and had about 330 people participating at the conference each day.

This remains a very unique conference. The farmers were definitely front and center and felt that this was their conference. This was very evident on the 2nd day as participants were greeting each other with hugs and stories and eating breakfast together, and their highly enthusiastic participation in discussions during all the sessions.

II. PROJECT APPROACH

The Conference Planning Committee was comprised of 22 people from 8-9 agencies and 6 farmers and met from early September to February to plan the conference. MN Department of Agriculture was a part of the Planning Committee so they know all the details. The MDA Commissioner and 3 -4 MDA staff participated in the conference so they also know.

The Committee met 12 times between September and the first week of February. The MFA Executive Director and other partners contacted a variety of sponsors to seek funding between August and February. The Committee handled all the logistics. The Interpreters and the Presenters met for 2 hours on Jan 31 before the conference to get to know each other and the subject matter.

The Conference proceeded as planned. Evaluations were held in most all the individual workshop sessions but some sessions went overtime and did not have an evaluation session. The Committee will be having an evaluation forum in March 2012 to take a more in-depth look at the conference.

III. GOALS AND OUTCOMES ACHIEVED

All the components of the conference went according to plan. There were 465 participants registered of which 330 were farmers. There were 14 different ethnicities represented. The final numbers estimate that there were 230 farmers each day and a total of 330 people each day, with and about 60% of the participants attend both days. About 40 farmers from 5 other states also attended the conference. So the goal of increasing the number of farmer participants from 160 to 200 was achieved.

All the exhibitors expressed their great satisfaction with being able to really connect on a personal basis with the farmers. All appreciated that the farmers visited the booths in small groups with their interpreters so that they could really explain their programs. There were 21 exhibitors, compared with 15 in 2011, so the goal of increasing the number of organizations and agencies making direct contact with immigrant farmers was achieved.

There were representatives from the 2 MN Senators at the conference which was also a first and they were able to bring new information and perspectives back to their Senators. For the first time, the USDA Office of Civil Rights participated and held an excellent roundtable with about

70 – 80 farmers to explore the barriers to equitable access to USDA programs. So more and different organizations and agencies were able to make new contacts with immigrant farmers.

IV. BENEFICIARIES

The conference participants came from communities of immigrants, including Latino, Hmong, Laotian, Cambodian, Burmese, Karen, Kenyan, Somali, Iran, Bhutanese, African-American, Native American, other East African countries and multi-racial. Most all the farmers are considered "low income" by IRS standards and are "socially disadvantaged" by USDA standards. The majority of the farmers came from the 7 county Twin Cities Metro Area and the St Croix River Valley of MN and Wisconsin. However, we had farmers from we expect farmers from 5 other states, including NE, KY, IA, OH, WI, and KS.

Another main group of beneficiaries were the non-farmer participants, especially the USDA agencies of NASS, APHIS, FSA, NRCS, and Office of Civil Rights who were able to make direct contacts with immigrant farmers.

V. LESSONS LEARNED

Clearly there is a need for this type of conference that focuses on immigrant and minority farmers and creates the space and comfort level that they need in order to learn and share.

All the details matter in creating this atmosphere. Preparing interpreters and presenters; accompanying the farmers with the interpreters around to each table; an experienced facilitator for the lunch-time story telling; appropriate food for breakfast and lunch; highly accessible staffing and volunteers for the participants; preparing award certificates at the end of each day for the farmer participants, etc.

Partnerships among a wide variety of organizations, agencies and individuals is the only way to make this conference happen in the best way that it can.

More funding resources are going to be need to allow this conference to grow. The main expenses are food, interpreters and presenters.

Limiting the number of non-farmer participants is an effective way of creating the atmosphere for a real immigrant and minority farmers conference. This was done by only allocating 3 participants per day per sponsor and increasing the fee for non-farmers from $15 to $50 per day.

VI. CONTACT PERSON

Glen Hill
Minnesota Food Association
14220-B Ostlund Trail North
Marine on St. Croix, MN 55047
Tel: 651-433-3676, ext 11
Email: glenhill@mnfoodassociation.org

Appendix

Project A Enhancing the competitiveness of selected 3rd crops for domestic markets

Rural Advantage

Promoting the Interconnection of Agriculture, the Environment & Rural Communities

Rural Advantage
1243 Lake Avenue, Suite 222
Fairmont, Minnesota 56031-1974

2011 Third Crop Walk-n-Talks

3rd Crops are a variety of alternative crops that provide economic return and when placed strategically on the landscape, can build soil health, sequester carbon (increase soil organic matter), retain water and nutrients, and improve the overall sustainability of agricultural production. They can also improve rural vitality and supply food, fiber, and fuel in a diversified agroecosystem.

We would like to thank our 3rd Crop Initiative programming funders: The McKnight Foundation, North Central Region - Sustainable Agriculture Research and Education, Practical Farmers of Iowa, Minnesota Department of Agriculture, and the Greater Blue Earth River Basin Alliance [via Minnesota Pollution Control Agency - Clean Water Partnership and Board of Water and Soil Resources - Clean Water Legacy funding].

Rural Advantage
Promoting the Interconnection of Agriculture, the Environment & Rural Communities

University of Minnesota EXTENSION

For more information about the 3rd Crop Walk-n-Talks, please contact the Rural Advantage office.

Rural Advantage
1243 Lake Avenue, Suite 222
Fairmont, MN, 56031
Phone: 507-238-5449
Fax: 507-238-4002
Web: www.ruraladvantage.org
Email: sacke032@umn.edu
kim@ruraladvantage.org
jeff@ruraladvantage.org
linda@ruraladvantage.org

***Feel free to forward this brochure along to any interested parties if you will be unable to attend this year or received a duplicate copy. ***

The University of Minnesota Extension, is an equal opportunity educator and employer.

August 18 **U of M Open House – Rosemount Research and Outreach Center**
4:00pm—8:00pm UMORE Park - 1605 160th St. W. - Rosemount, MN
Contact: Dawn Seibert, University of Minnesota - UMORE Park 651-423-2455

September 12 **Soil Quality Workshop**
8:00am—5:00pm WCROC - 46352 State Hwy 329 - Morris, MN
Soil quality experts from Minnesota and other midwestern states will discuss management strategies that will improve the health of your soil. Some of the topics include: how to build your soil carbon, cover corps, conservation tillage, and crop rotation. There will also be hands-on field demonstrations. 7.5 CEU's in Soil and Water will be available.
Registration Fee
Contacts: Liz Stahl, UMN Extension stah0012@umn.edu 507-372-3912
Jodi DeJong-Hughes, UMN Extension dejon003@umn.edu 507-337-2816

September 13 **Soil Quality Workshop**
8:00am—5:00pm SROC - 35838 120th Street - Waseca, MN
Soil quality experts from Minnesota and other midwestern states will discuss management strategies that will improve the health of your soil. Some of the topics include: how to build your soil carbon, cover corps, conservation tillage, and crop rotation. There will also be hands-on field demonstrations. 7.5 CEU's in Soil and Water will be available.
Registration Fee
Contacts: Liz Stahl, UMN Extension stah0012@umn.edu 507-372-3912
Jodi DeJong-Hughes, UMN Extension dejon003@umn.edu 507-337-2816

September 15 **U of M Open House - Southern Research and Outreach Center**
4:00pm-8:00pm SROC - Hwy 14 and Co Rd 57 - Waseca, MN
10th Annual SROC Open House. Visit the Rural Advantage booth to learn about 3rd Crops!
Contact: Deanne Nelson, University of Minnesota - SROC 507-835-3620

Rural Advantage
Promoting the Interconnection of Agriculture, the Environment & Rural Communities

University of Minnesota EXTENSION

Other Events and Field Days

TBA **Annual Summer Grass Seed Field Tour**
5:00pm—8:00pm Magnusson Research Farm - Roseau, MN
Contact: Don Wyse, Univ. of Minn. wysex001@umn.edu

July 15 **EcoSun Prairie Farm - Open House**
1:30pm-4:00pm 46786 232nd St. - Colman, SD (nearest farm to field day site)
EcoSun has leased a private, working farm ("The Prairie Farm") for the purpose of demonstrating how to make a sustained and earned living from restored grassland and grass products while protecting and enhancing the natural environment. Discussion will include: grazing, haying, seed production, grassland as bioenergy feedstock, etc.
Sponsors: EcoSun Prairie Farms and South Dakota State University
Contact: Dr. Carter Johnson, SDSU Carter.Johnson@sdstate.edu 605-688-4729

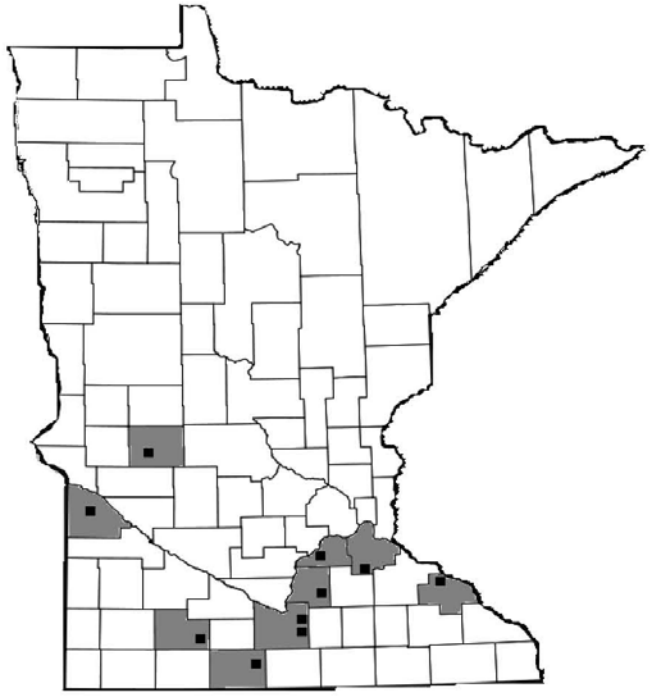
July 16 **SFA South Central Chapter - Festival of Farms Tour**
10:30am—3:30pm Wells, MN area (starting at: 56360 200th St. - Wells, MN)
The tour will start at the Lutteke organic dairy farm; it also includes the Yokiel farm and Klunder farm. There is no cost to attend. Lunch will be provided (a small donation is appreciated). Other Festival of Farms Tours will be held throughout the state this day (some of those may have participation fees) .
Sponsors: South Central Chapter of the Sustainable Farming Association (SFA)
Contact: SFA website for information (http://www.sfa-mn.org/festival-of-farms/)
Jim Tjepkema, South Central SFA 507-256-4876

August 2-4 **Farmfest**
8:00am—5:00pm Gilfillan Estates - 28366 Co. Hwy. 13 - Morgan, MN
Visit the Rural Advantage booth! Learn about 3rd crops, the Madelia Model, cover crops, 3rd generation biofuels, and more.
Entrance Fee

August 5 **Strip Tillage Expo**
8:30am—4:00pm University Center - Owatonna MN
The day will include: educational sessions, vendor and education booths, field demonstrations, and a farmer panel over the noon hour. The morning session will be repeated in the afternoon.
Contact: Brad Carlson, UMN Extension bcarlson@umn.edu 507-389-6745

The University of Minnesota Extension, is an equal opportunity educator and employer.

Walk-n-Talk Map



June 23 - Le Sueur County
June 27 - Blue Earth County
July 21 - Martin County
August 18 - Pope County
August 22 - Lac qui Parle County
August 23 - Blue Earth County
August 30 - Scott County
September 7 - Dakota County
October 1 - Wabasha County
October 13 - Cottonwood County

Le Sueur County Wheat Day

Thursday, June 23, 2011
Lunch @ 12:15pm
Field Day @ 1:00pm—4:00pm

Jim Stangler Farm
45116 151st Avenue
Kilkenny, MN 56052

Please join the Southern Minnesota Wheat Growers Group, University of Minnesota Extension, and Rural Advantage for an afternoon focused entirely on small grains.

Doug Holen, University of Minnesota Extension, will be discussing small grain diseases, crop staging and input timing, general production, as well as taking a look at samples brought by attendees. Holen will also be available to answer questions while in the field. Brad Carlson with University of Minnesota Extension will be speaking on soil fertility issues and techniques/tips. Dick Stangler, producer and member of Southern Minnesota Wheat Growers Group, will be hosting the event as well as sharing his experiences with growing wheat and other small grains. Attendees will end the day with a driving tour of area small grain fields.

Attendees are encouraged to bring plant samples of their small grains. Whether concerned about a pest, fertility, or just want to show-off, feel free to bring a sample of what you are seeing in any of your small grain fields.

Lunch will be provided by the **Southern Minnesota Wheat Growers Group**. Please join us at 12:15pm for sandwiches and soda before the tour.

Contacts for this event:
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449
Diane DeWitte, UMN Extension—Le Sueur/Blue Earth Counties, 507-380-6098

DIRECTIONS:
From the South—At the intersection of Hwy 60 and Hwy 13, turn northwest onto Hwy 13, travel ¾ mi, then turn straight north onto 151st Avenue / Co Rd 3. Travel 5 miles north to the Jim Stangler farm on the west side of the road.

From the North—At the intersection of Hwy 13 and Co Rd 2, turn east and travel 1.5 miles. Turn south on Co Rd 3 to the "Y". Follow the "Y" to the left (151st Avenue/Co Rd 3) 1/8 mile to the Jim Stangler farm site on west side of the road.

FREE EVENT!

Season Extension with High Tunnels and Quick Hoops

Thursday, October 13, 2011
1:00pm—3:00pm

Jubilee Fruits and Vegetables
1310 Mountain Lake Road
Mountain Lake, MN 56159

Fruit and vegetable production in Minnesota has been extended to nearly the entire year with the use of high tunnels and quick hoops. Jubilee Fruits and Vegetables of Mountain Lake, Minnesota, has found success with harvests beginning in March and extending through December with the use of conventional gardens, movable high tunnels, and quick hoops. Rotating crops, windrow composting, improving soil health and growing new varieties of cold-hardy crops are few of the additional variables Jubilee Fruits and Vegetables use during the season.

Join UMN Extension, Rural Advantage, and the Harder family (owners and operators of Jubilee Fruits and Vegetables) as the Harders share their experiences with season extension and give a tour of their production plots. See quick hoops in action; walk through the two movable high tunnels. Take part in discussions on season extension, fruit and vegetable production, community supported agriculture (CSA), and the local Farm To School / Farm To Cafeteria movement. The field day will also be highlighting Jubilee Fruits and Vegetables' grant-funded on-farm research on Asian and Latino vegetables. The research project is funded through Minnesota Department of Agriculture Sustainable Agriculture Grant Program.

Contact for this event:
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449

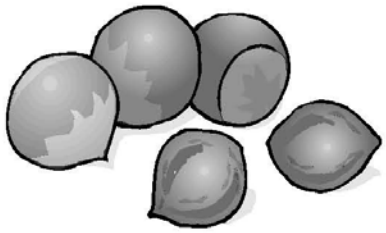
DIRECTIONS
Via MN Highway 60: At the city of Mountain Lake, turn North onto Co. Hwy. 1. Travel approximately 1/4 mile and turn West (left) onto Mountain Lake Road. Jubilee Fruits and Vegetables will be the first place on the South side of the road. Please park in the street.

FREE EVENT!

2011 Hazelnut Field Day

October 1, 2011
10:00am—4:00pm
(Potluck Lunch—bring dish to pass)

1186 W. Lakewood Avenue
Lake City, MN 55041



This annual hazelnut field day is sure to have something for everyone. Presentations in the morning will be focused on the latest research and what's new with hazelnuts. Field tours will be in the afternoon with a brief Hazelnut 101 course, as well as processing demonstrations with the cracker, sorter, and aspirator.

A potluck lunch is planned. Be sure to bring your favorite dish-to-pass and table service. We will also be having a contest for the best baked hazelnut treat. Judging will take place over the noon hour with the winner receiving a prize, so start trying out your favorite recipes for baked goods that include hazelnuts.

The annual meeting of the Minnesota Hazelnut Foundation will take place from 9:00 a.m. – 10:00 a.m. with the field day to follow. Be sure to dress appropriately for the outdoors. The field day will be held rain or shine.

Contact for this event:
Jeff Jensen, Rural Advantage, 507-238-5449

DIRECTIONS

MN Hwy 63 from Rochester: As entering Lake City, look for St. Johns Cemetery. Directly after cemetery turn right on S. Cross St. At T-intersection, turn right onto W. Lakewood Ave/Co Rd 9. Hazel field will be on right after elementary school.

MN Hwy 61 from Winona: As entering Lake City, look for marina. Turn left onto W. Lakewood Ave./Co Rd 9. Travel about 1.0 mile. Look for hazel field on right after elementary school.

FREE EVENT!

Blue Earth County Wheat Day

Monday, June 27, 2011
9:00am—12:00pm

Lucas Lindeland Farm
62535 137th Street
Mapleton, MN 56065

University of Minnesota Extension and Rural Advantage are happy to announce the first Blue Earth County Wheat Day. This field day is a partner to the annual Wheat Day held in Le Sueur County.

Doug Holen, University of Minnesota Extension, will be discussing small grain diseases, crop staging and input timing, general production, as well as taking a look at samples brought by attendees. Holen will also be available to answer questions while in the field. Brad Carlson with University of Minnesota Extension will be speaking on soil fertility issues and techniques/tips. Carlson is the newest Regional Extension Educator in Crops and is based out of the Mankato Regional Office; he is a former Local Extension Educator in Rice and Steele Counties. A spring wheat field will also be available for viewing.

Attendees are encouraged to bring plant samples of their small grains. Whether concerned about a pest, fertility, or just want to show-off, feel free to bring a sample of what you are seeing in any of your small grain fields.

Contacts for this event:
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449
Diane DeWitte, UMN Extension—Le Sueur/Blue Earth Counties, 507-380-6098

UNIVERSITY OF MINNESOTA | EXTENSION

DIRECTIONS:

From Pemberton: Drive straight South out of Pemberton on Co. Rd. 161. Turn West (right) at Co. Rd. 21 / 137th Street (cattle lot on the corner). Wheat field is located just West of the cattle lot on the North side of Co. Rd. 21 / 137th Street.

From Mapleton: Drive east of Mapleton on Co. Rd. 21 / 129th Street. Co. Rd. 21 will curve North. Turn East (right) onto Co. Rd. 21 / 132nd Street. Turn North (left) on Co. Rd. 14 / 615th Avenue. Turn East (right) onto Co. Rd. 21 / 137th Street and travel roughly 2 miles. Wheat field is located just West of the cattle lot on the North side of Co. Rd. 21/137th Street.

FREE EVENT!

Elm Creek Riparian Perennial Plantings

Thursday, July 21, 2011
1:00pm—4:00pm

Roberts Research Plot
1838 260th Avenue
Granada, MN 56039

The last few years have brought flooding to southern Minnesota as well as high petroleum prices to the nation. Researchers have been busy looking at crops able to successfully be planted in floodplain areas that will help mitigate soil erosion and chemical runoff. Many of these crops have the potential to be excellent bio-fuel feedstocks.

Please join Rural Advantage, UMN Extension, and University of Minnesota at this walk-n-talk that will be highlighting research being conducted in Martin County. The research is being done at multiple sites along Elm Creek and the walk-n-talk will be focusing on the Roberts site near Granada, Minnesota.

Attendees will hear explanations on the multiple research projects being conducted. These include: alley cropping with hybrid willow and hybrid poplar rows separated by herbaceous plant species (all possible bio-fuel feedstocks), cover crops in hybrid willow / hybrid poplar rows, oil-seed crops, and cover crops in general. Attendees will also be able to walk among the research plots and get an up-close look at the species being used.

Contact for this event:
Jill Sackett, UMN Extension / Rural Advantage,
507-238-5449

DIRECTIONS
From the Granada Exit off Interstate 90: Travel North on 260th Avenue / Co. Rd. 53 for 6.2 miles. The field day site will be North of the farm driveway and South of 190th Street about 1/4 mile. The site will be on East side of the road. Carpooling is suggested.

FREE EVENT!

Rural Enterprise Center's Experimental Farm

Wednesday, September 7, 2011
2:00pm—5:00pm

Experimental Farm / Finca Mirasol
4597 315th Street West
Northfield, MN 55057

A Sustainable Food, Agriculture, and Natural Resource Management System That Makes It Possible for Rural Latino Farmers to Succeed

Join UMN Extension and Rural Advantage for a tour of the Rural Enterprise Center's experimental farm just north of Northfield. Attendees will learn how the farming system combines poultry production and agriforestry/perennial cropping for a more sustainable, successful agriculture operation. The tour includes a presentation on the Rural Enterprise Center's efforts to create a sustainable agricultural system compatible with the challenges and strengths of aspiring Latino farmers or agripreneurs.

The Rural Enterprise Center is a program of Main Street Project.

PRE-REGISTRATION IS REQUIRED.
sacke032@umn.edu or 507-238-5449

Contacts for this event:
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449

Main Street Project

DIRECTIONS
From Northfield: Follow MN Hwy 3 North about 2.0 miles. Turn left (East) onto 315th St. W. In less than 1.0 mile, the experimental farm will be on the right (North) side of road. Look for the sign announcing, "Finca Mirasol".

FREE EVENT!

Pollinators: Concerns and Credits

Tuesday, August 30, 2011
4:00pm—6:00pm

Seven Story Farm
22285 Delaware Avenue
Belle Plaine, MN 56011

Bees and other pollinators are at the base of the food chain, providing pollination services for the majority of the foods we eat. As important as they are to society, we have seen steep declines of managed and native bees throughout the world, resulting in renewed focus on the causes and solutions to these declines.

Join the American Honey Princess Allison Adams, Seven Story Farm proprietor Heidi Morlock , and Jeff Jensen with Rural Advantage, and a local beekeeper to learn more about the issues involved in bee and other pollinator reductions as well as possible solutions to these issues. Attendees will also hear about one novel approach to pay producers for providing high quality bee habitat through the Rural Advantage ECoPayPack Pollinator Credit. A demonstration site for Rural Advantage's ECoPayPack Pollinator Credits is located on Seven Story Farm and will be available for viewing.

ECoPayPack
Ecological Commodity Payment Package

Contact for this event:
Jeff Jensen, Rural Advantage
507-238-5449

DIRECTIONS

From South: From State Hwy 169. Turn right (East) on Co Rd 64 exit in Belle Plaine. At the T Intersection with Co Rd 59 (Delaware Ave), take a left (North). Third place on right (East). Fire # 2285. Look for wind generator.

From North: From State Hwy 169. Continue traveling South past Jordan stop light for about 2.0 miles. Take left (East) onto Co Rd 59 (Delaware Ave.) at the OK Corral restaurant. Travel about 2.0 miles. Farm on left. Fire # 2285. Look for wind generator.

FREE EVENT!

Utilizing Sustainable Crop Production Principles to Establish Perennial Grasses for Bio-Energy Production

Thursday, August 18, 2011
1:45pm—3:15pm

Prairie Horizons Farm
29731 302nd Street
Starbuck, MN 56381

Rural Advantage and UMN Extension are with Prairie Horizons Farm and the USDA-ARS Soils Lab to host an afternoon of discussion on using perennial grasses for bio-energy production. Attendees will be able to hear about the work being done by the USDA-ARS Soils Lab, Prairie Horizons Farm, and Rural Advantage. A tour of the grasslands and pasture at the farm will also be available.

Prairie Horizons Farm and USDA-ARS are working on a research project comparing cropland, grassland, and pasture systems. Specifically they are looking at the Nitrogen cycle and availability under the different ag systems and developing and evaluating cropping systems for optimal biomass production. Rural Advantage has been working on establishing markets for perennial third crops; one potential market is 3rd generation biofuels.

Optional Additional Tour: North Central Soil Conservation Research Lab's Annual Swan Lake Field Day (803 Iowa Avenue - Morris, MN). This year's theme is "Sustainable Landscapes: Food, Feed, Fuel and the Future." The event is from 9am-1pm with a complimentary lunch. The Land Stewardship Project will be offering buses to take people to Prairie Horizons Farm. Buses will leave the Soils Lab at 1pm and return at 4pm. Contact Beth Burmeister for more information on the Swan Lake Field Day (320-589-3411 Beth.Burmeister@ars.usda.gov).

Directions are below, but note that the meeting place for the field day may change. Look for the press release for finalized directions, speakers, and topics.

Contacts for this event:
Sharon Weyers, USDA-ARS, 320-589-3411 Sharon.Weyers@ars.usda.gov
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449

DIRECTIONS

From Starbuck: Head South on MN-29 for roughly 10.0 miles. Turn left (East) onto 302nd St. / T-21 (gravel) for roughly 1.2 miles. Prairie Horizons Farm will be on the right (South) side of the road.

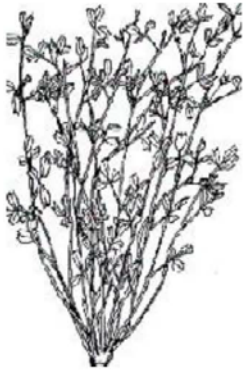
From Benson: Head North on MN-29 for roughly 11.0 miles. Turn right (East) onto 302nd St. / T-21 for roughly 1.2 miles. Prairie Horizons Farm will be on the right (South) side of the road.

FREE EVENT!

Cover Crops and Alfalfa Mulch

Monday, August 22, 2011
1:00pm—3:00pm

2484 Hwy 40
Madison, MN 56256



Crops need soils with adequate nutrients, especially nitrogen, phosphorus, and potassium (N-P-K). But how do you ensure your crops are getting enough nutrients if you do not use chemical fertilizers and do not have access to manure? Organic producer Carmen Fernholz is attempting to answer that very question.

With funding from the Minnesota Department of Agriculture and some assistance from researchers at the University of Minnesota, Fernholz will be conducting his second year of on-farm research. He will be looking at obtaining enough nitrogen from alfalfa mulch and cover crops to grow a healthy, high yielding corn crop.

Attendees will hear an explanation of Fernholz's alfalfa mulch research and will learn about utilizing various cover crops in organic or conventional agriculture systems. Cover crops have many benefits including: increasing soil organic matter, suppressing weeds and pests, and decreasing soil erosion from wind and precipitation. Fernholz has used cover crops for many years and was a cooperator on Rural Advantage's NCR-SARE cover crop project which has funds for cost-sharing cover crop acres. A tour of the mulch and cover crop acres will be given. Attendees will be able to view the machinery Fernholz uses to apply the alfalfa mulch and plant the cover crops.

Contact for this event:
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449

DIRECTIONS
From Madison: Travel East on Hwy 40 for 1 mile. You will see an A-frame house on the North (left) side of the road; this is the Fernholz farm.

FREE EVENT!

Grapes: Production and Mechanized Harvest

Tuesday, August 23, 2011
1:00pm—3:00pm

Winterhaven Vineyard and Nursery
18103 628th Avenue
Janesville, MN 56048

Join UMN Extension, Rural Advantage, and Winterhaven Vineyard and Nursery for a field day on grape production and mechanized harvest. Ray Winter and family, owners and operator s of Winterhaven and Indian Island Winery, will be leading the tour.

Winterhaven Vineyard was established in the spring of 2000. The vineyard currently covers over 12 acres with over 6000 vines, and growing. They have 17 different varieties at this time and focus on cold hardy varieties. The harvest season of 2009 brought a mechanized grape harvester to the operation.

Winterhaven Nursery was established during 2001. For two years the nursery plants were grown indoors. These plants were potted, live growing plants. In the spring of 2003, nursery stock began to be grown outdoors in nursery beds. Winterhaven now sells many bare-root grape vines. A greenhouse is being utilized in order to supply new varieties sooner as potted plants.

Indian Island Winery, a natural extension to the vineyard and nursery, opened in 2010.

Contact for this event:
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449

DIRECTIONS
From Mankato: State Highway 14 East to Smiths Mill. Turn right onto Blue Earth Co Rd 37. Travel South 4 miles to 1st stop sign. Turn right onto Blue Earth Co Ro 15 (blacktop). Travel 1/2 mile on Blue Earth Co 15. Take 1st gravel road on left. First place on the LEFT about 1 mile.

From Janesville: State Highway 14 West to Smiths Mill. Turn left onto Blue Earth Co Rd 37. Travel South 4 miles to 1st stop sign. Turn right onto Blue Earth Co Rd 15 (blacktop). Travel 1/2 mile on Blue Earth Co 15. Take 1st gravel road on left. First place on the LEFT about 1 mile.

FREE EVENT!

Rural Advantage

Promoting the Interconnection of Agriculture, the Environment & Rural Communities

www.ruraladvantage.org

Directions:

From South - State Hwy 15:
After railroad tracks—take first left @ Militelllo Motors (10th St.). Knights of Columbus Hall is 1 block West, South side of street.

From I-90:
Take Exit 102 - FAIRMONT and follow directions below

From North - State Hwy 15:
Starting at Interstate 90 overpass, travel South through 2 stoplights. Take next right @ Militello Motors (10th St.). Knights of Columbus Hall is 1 block West, South side of street.

Contact person:
Jill Sackett, UMN Extension
507-238-5449
sacke032@umn.edu

If interested in **carpooling** from St. Paul contact:
Minnesota Institute for Sustainable Agriculture (MISA)
misamail@umn.edu
800-909-6472 or 612-625-8235
A van is scheduled for each of the 4 dates.

Funding for this project was made possible by the McKnight Foundation, NCR-Sustainable Agriculture Research and Education, USDA/MDA Specialty Crop Grant, and USDA Conservation Innovation Grant/ Minnesota River Board.

Welcome to our 7th annual Third Crop Producer Meetings!

We have once again put together a strong slate of topics and speakers to increase the knowledge base of landowners and others about production and emerging issues around third crops. We hope you will be able to join us for at least one of the four meetings. As always, if you need information regarding third crops or market opportunities please contact our office at 507-238-5449.

I look forward to seeing you in Fairmont.

Linda Meschke, President
Rural Advantage

2011
Third Crop Producer Meetings

Monday, February 14
Local Foods

Monday, February 28
Renewable Energy Today

Monday, March 14
Importance of Ecological Services

Monday, March 28
Practices for Reducing Nutrient Loss

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Rural Advantage
Promoting the Interconnection of Agriculture, the Environment & Rural Communities

Rural Advantage
1343 Lake Ave, Suite 222
Fairmont, MN 56031

3rd Crops
Growing Our Communities
Economically
Socially
Environmentally

Rural Advantage
Promoting the Interconnection of Agriculture, the Environment & Rural Communities

Presents

2011 Third Crop Producer Meetings

2011 Dates
February 14th
February 28th
March 14th
March 28th

Time: 10:00 - 3:30

No Charge!
Lunch On Your Own

Knights of Columbus Hall
920 E. 10th St.
Fairmont, MN
56031

Monday, February 14th
Local Foods

9:30 Registration and Coffee

10:00 Farm2Cafeteria Network - Martin County
Jeff Jensen, Rural Advantage
Fairmont, Minnesota

10:15 Value Added Panel
Guldan Family Farm
New Ulm, Minnesota
Harbo Cider
North Mankato, Minnesota
Harris Honey Company
Madelia, Minnesota

10:45 Terra Madre
Heidi Morlock, Seven Story Farm
Belle Plaine, Minnesota
Jane Rosemarin, Slow Food MN
Minneapolis, Minnesota

11:15 Can You Make It Pay? Financial Planning for Your Project
Chuck Schwartau, UMN Extension
Rochester, Minnesota

11:50 NRCS High Tunnel Cost-Share
Betsy Norland, NRCS
Fairmont, Minnesota

12:00 LUNCH (on your own)

1:00 Improving Food Quality Through Soil Health
Jon Frank, International Ag. Labs
Fairmont, Minnesota

3:00 Further Discussion and Q/A

Monday, February 28th
Renewable Energy Today

9:30 Registration and Coffee

10:00 Biomass Crop Assistance Program
Gary Wyatt, UMN Extension
Mankato, Minnesota

10:30 Biomass Fertility and Yield Trials at UMN
Dr. Craig Sheaffer, Univ. Of Minne.
St. Paul, Minnesota

11:15 Biomass Production Economics
Dr. Bill Lazarus, Univ. of Minne.
St. Paul, Minnesota

12:00 LUNCH (on your own)

1:00 Economics of Torrefaction: Costs of Production and Value to Power Utilities
Doug Tiffany, UMN Extension
St. Paul, Minnesota

1:50 Minneapolis Biomass Exchange Update
Kevin Triemstra, Minneapolis Biomass Exchange
Minneapolis, Minnesota

2:30 Prairie Biomass Harvest Project
Jake Jungers, UMN Grad Student
St. Paul, Minnesota

3:00 Madelia Model Update
Linda Meschke, Rural Advantage
Fairmont, Minnesota

3:30 Further Discussion and Q/A

Monday, March 14th
Importance of Ecological Services

9:30 Registration and Coffee

10:00 A Discussion on Carbon
Dr. Dean Current, UMN CINRAM
St. Paul, Minnesota

10:30 Climate Change Legislation
Jim Kleinschmit, IATP
Minneapolis, Minnesota

11:15 Water Quality Trading 101
Bruce Henningsgaard, MPCA
St. Paul, Minnesota

12:00 LUNCH (on your own)

1:00 Conservation Marketplace of Minnesota and GBERBA's Role
Brooke Hacker, GBERBA
Mankato, Minnesota

1:30 Cold Spring Wellhead Protection Area
Carrie Raber, Stearns SWCD
Waite Park, Minnesota

2:00 Pollinator Credits
Jeff Jensen, Rural Advantage
Fairmont, Minnesota

2:30 Bee Production
Elaine Evans, UMN Ph.D. Student
St. Paul, Minnesota

3:00 Further Discussion and Q/A

Monday, March 28th
Practices for Reducing Nutrient Loss

9:30 Registration and Coffee

10:00 Controlled Drainage and Wetland Systems
Dr. Jeff Strock, UMN SWROC
Lamberton, Minnesota

10:30 2-Stage/Multi-Stage Ditches
Joe Magner, MPCA
St. Paul, Minnesota

11:30 Reconsider Alfalfa: Smaller Nitrogen Losses and Reliable Nitrogen Supply
Dr. Michael Russelle, USDA-ARS
St. Paul, Minnesota

12:15 LUNCH (on your own)

1:15 Cropping Systems Cover Crop Experiences
Carmen Fernholz, Producer
Madison, Minnesota

1:55 MN Cover Crop Decision Tool
Jill Sackett, UMN Extension
Fairmont, Minnesota

2:15 Improved Soil Productivity From Cover Crops
Mark Zumwinkle, MDA
St. Paul, Minnesota

3:00 Cover Crop Farmer Panel
Carl Luhmann, Martin County
Mark Querna, Waseca County
Bill Yock, Watonwan County

3:30 Further Discussion and Q/A

Welcome to the 8th annual
Third Crop Producer Meetings!

It is our hope that the topics and speakers of the 2012 Third Crop Producer Meetings will increase your interest and knowledge of third crops. We hope you will be able to join us for at least one of the four meetings.

As always, if you need information regarding third crops or market opportunities, please contact our office at 507-238-5449.

We look forward to seeing you in Fairmont!

2012
Third Crop Producer Meetings

Monday, February 6
Cover Crops Research & Experiences

Monday, February 27
Local Foods and 3rd Crops

Monday, March 12
Marketing 3rd Crops

Monday, April 2
Bioenergy from Perennials

For Weather Related Cancelations, contact:
UMN Extension Farm Information Line
1-800-232-9077

Rural Advantage
Promoting the Interconnection of Agriculture, the Environment & Rural Communities

CLEAN WATER LAND & LEGACY AMENDMENT

Contact person:
Jill Sackett, UMN Extension
507-238-5449
sacke032@umn.edu

Directions:

From South - State Hwy 15:
After railroad tracks—take first left @ Militello Motors (10th St.). Knights of Columbus Hall is 1 block West, South side of street.

From I-90:
Take Exit 102 - FAIRMONT and follow directions below

From North - State Hwy 15:
Starting at Interstate 90 overpass, travel South through 2 stoplights. Take next right @ Militello Motors (10th St.). Knights of Columbus Hall is 1 block West, South side of street.

If interested in **carpooling** from the St. Paul UMN campus, contact:

Minnesota Institute for Sustainable Agriculture (MISA)
misamail@umn.edu
800-909-6472 or 612-625-8235

A van can be scheduled for each of the four dates if there is enough interest.

Funding for this project was made possible by: the McKnight Foundation, North Central Region -Sustainable Agriculture Research and Education, USDA/MDA Specialty Crop Grant, Greater Blue Earth River Basin Alliance via the Clean Water Fund, and Rural Advantage.

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3rd Crops
Growing Our Communities
Economically
Socially
& Environmentally

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Promoting the Interconnection of Agriculture, the Environment & Rural Communities

2012 Third Crop Producer Meetings

2012 Dates:
February 6th
February 27th
March 12th
April 2nd

10:00am - 3:00pm

FREE of Charge!
Lunch On Your Own

Knights of Columbus Hall
920 E. 10th St.
Fairmont, MN 56031

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Monday, February 6th
Cover Crops Research and Experiences

9:30 Registration and Coffee

10:00 Minnesota Cover Crop Decision Tool
Jill Sackett
UMN Extension - Fairmont

10:40 University of Minnesota Tillage Radish Research
Miriam Gieske
University of Minnesota - St. Paul

11:20 Winter Rye BMPs to Reduce Loads of Sediment and Nutrients to Minnesota Surface Waters
Adam Herges
University of Minnesota - St. Paul

12:00 LUNCH (on your own)

1:00 Cover Crops and Soil Biology
Dr. Michael Lehman
USDA-ARS - Brookings, SD

1:40 Experiences with Cover Crops and Alfalfa Mulch
Carmen Fernholz
Producer/SWROC - Madison

2:20 Grower Panel
Carmen Fernholz
Producer/SWROC - Madison
Bill Yock
Producer - St. James
Ray Yokiel
Producer/Pilot - Wells
Jerry Ackermann
Producer - Lakefield

Monday, February 27th
Local Foods and 3rd Crops

9:30 Registration and Coffee

10:00 Martin County Farm2Cafeteria
Jeff Jensen
Rural Advantage - Fairmont

10:20 High Tunnels, Quick Hoops, Composting, CSAs and More
Judy Harder
Jubilee Fruits and Vegetables - Mountain Lake

11:00 What's New in the UMN Fruit Breeding Program
Dr. James Luby
University of Minnesota and Minnesota Landscape Arboretum - Chaska

12:00 LUNCH (on your own)

1:00 Grass-Fed Meat Production
Dan and Terese Hall
Growers - Butterfield

1:40 Five Years of Grape Production: The Good, the Bad, and the Ugly
Bob Lau
Grower - Janesville

2:20 Hybrid Hazelnut Update
Jeff Jensen
Rural Advantage - Fairmont

Additional speakers on apple production and neutraceuticals may be added, schedules permitting

Monday, March 12th
Marketing 3rd Crops

9:30 Registration and Coffee

10:00 Financial Risk Management
Dave Bau
UMN Extension - Worthington

10:45 Doing Business Online
Bruce Schwartau
UMN Extension - Rochester

11:45 Non-Insured Crop Disaster Assistance Program (NAP)
Nicki Miranowski
Farm Service Agency - Faribault and Martin Counties

12:00 LUNCH (on your own)

1:00 Record Keeping Tips and Techniques
Kent Janssen
Farm Business Management—Minnesota West College - Truman

1:40 Local Food Producers Market Association
Jennifer McCauley Oftelie
Local Food Producers Market Association - Albert Lea

2:20 Experiences from the Trenches
Gordy Toupal
Center Creek Orchard - Fairmont

Monday, April 2nd
Bioenergy from Perennials

9:30 Registration and Coffee

10:00 Madelia Model Update
Linda Meschke
Rural Advantage - Fairmont

10:30 Minnesota Renewable Energy Policy
Jim Kleinschmit
Institute for Agriculture and Trade Policy - Minneapolis

11:15 International Renewable Energy Technology Institute of Minnesota (IRETI) Update
John Frey
IRETI - Mankato

12:00 LUNCH (on your own)

1:00 Harvesting Restored Grasslands in Minnesota: Ecology and Management of Biomass and Energy
Jacob Junger
University of Minnesota - St. Paul

1:40 University of Minnesota Southern Research and Outreach Center Biomass Research
Dr. Gregg Johnson
UMN Southern Research and Outreach Center - Waseca

2:20 Ecosystem Services from Perennial Plantings
Jim Eckberg
University of Minnesota - St. Paul

3:00 What to do with Expiring CRP?
Gary Wyatt
UMN Extension - Mankato

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3rd Crops
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Environmentally

Other Events and Field Days

3 Dates **2012 Scott-Le Sueur Dairy Series**
12:00pm-2:00pm Scott and Le Sueur Counties
*The 2012 Summer Dairy Series features three on-farm tours and sessions on Tuesdays **July 10, July 31**, and **August 14** from 12-2pm with lunch provided. There will be presentations from the guest speaker(s) and overview of the farm from the hosts. This series is offered free of charge. For more information, see brochure: http://z.umn.edu/slsds*
Contact: Laura Kieser, UMN Extension torb0022@umn.edu 952-492-5386

July 10 **Southeast Minnesota Forage Council and Midwest Forage Association Summer Field Day**
5:00pm Capelle Farm - 31155 785th Avenue - Racine, MN
Forage experts will be sharing information and updates on forages and cover crops. This event is free to the public. A meal will be provided. Pre-registration is requested.
Contact: Chelsea Russell, MFA mfa@midwestforage.org 651-484-3888

July 14 **South Central Chapter of the Sustainable Farming Association - Festival of Farms Tour**
10:00am-4:00pm 50277 130th St. - Lyle, MN
Day long demonstrations of alternative energy on the farm. Cedar River Logging and MyBachAchers Farm will be the host farms. Attendees are asked to donate $5 to help with cost. Pre-registration is needed.
Contact: South Central SFA: mybackachers@gmail.com 507-589-5256
Directions: Take 105 south out of Austin and stay on it until you get to River Bend Camp Ground. 130th Street is just south of the campground. Go down 130th Street until you see the yellow barn. Parking is in the field.

July 14 **Small Farm U – Getting Started with Beef**
9:00am–12:00pm UMORE Park - 1605 160th St. W. - Rosemount, MN
Attendees will be able to take part in discussions on: Introduction to Beef Cattle Production and Management Calendar, Nutrition Basics, Health Management Basics, and a participate in a Pasture Walk. Pre-registration is preferred. Cost is $25.
Contact: Betsy Wieland, UMN Extension - eliza003@umn.edu 612-596-1175

August 3 **EcoSun Prairie Farm - Open House**
1:30pm 46786 232nd St. - Colman, SD (nearest farm to field day site)
EcoSun has leased a private, working farm ("The Prairie Farm") for the purpose of demonstrating how to make a sustained and earned living from restored grassland and grass products while protecting and enhancing the natural environment. Discussion will include: grazing, haying, seed production, grassland as bioenergy feedstock, etc.
Sponsors: EcoSun Prairie Farms and South Dakota State University
Contact: Dr. Carter Johnson, SDSU Carter.Johnson@sdstate.edu 605-688-4729

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2012 Third Crop Walk-n-Talks

3rd Crops are a variety of alternative crops that provide economic return and when placed strategically on the landscape, can build soil health, sequester carbon (increase soil organic matter), retain water and nutrients, and improve the overall sustainability of agricultural production. They can also improve rural vitality and supply food, fiber, and fuel in a diversified agroecosystem.

We would like to thank our 3rd Crop Initiative programming funders: The McKnight Foundation, North Central Region - Sustainable Agriculture Research and Education, Practical Farmers of Iowa, Minnesota Department of Agriculture, and the Greater Blue Earth River Basin Alliance [via Board of Water and Soil Resources - Clean Water Legacy funding].

CLEAN WATER LAND & LEGACY AMENDMENT

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The Third Crop Walk-n-Talks are outdoor events. Please dress accordingly.

For more information about the 3rd Crop Walk-n-Talks, please contact the Rural Advantage office.

Rural Advantage
1243 Lake Avenue, Suite 222
Fairmont, MN, 56031
Email: sacke032@umn.edu
linda@ruraladvantage.org

The University of Minnesota Extension is an equal opportunity educator and employer.

Who is Rural Advantage?

Rural Advantage is a Nonprofit Corporation formed under MN Statutes, Chapter 317A on November 13, 2003. Rural Advantage has 501[c][3] status with the IRS. Rural Advantage continues to advance the 3rd Crop Initiative and other forward thinking environmental initiatives to address agricultural nonpoint source pollution.

Rural Advantage's mission is to promote the connections between agriculture, the environment, and rural communities in order to improve ecological health, economic viability and rural vitality. Objectives include:

- Advance landscape diversification to improve ecological health, rural vitality and farm profitability.
- Cultivate a more sustainable approach to agriculture that is diverse, resilient and responsible; and supports natural and agricultural 'systems' thinking.
- Foster rural economic development that supports rural families and local communities.
- Promote increased stewardship through education, demonstration and implementation.

Rural Advantage has four core program areas: 3rd Crop Initiative, the Madelia Model, ECoPayPack [Ecological Commodity Payment Package], and Farm2Cafeteria program.

3rd Crop Initiative

Farm2CafeteriaNetwork
Martin County

Madelia Model
Renewable Energy and Sustainable Rural Communities

ECoPayPack
Ecological Commodity Payment Package

August 7-9 **Farmfest**
8:00am–5:00pm Gilfillan Estates - 28366 Co. Hwy. 13 - Morgan, MN
Visit the Rural Advantage booth! Learn about 3rd crops, Local Foods, the Madelia Model, cover crops, 3rd generation biofuels, and more. *Entrance Fee*

August 14 **4th Annual Twin Cities Urban Agriculture Bus Tour**
9:00am-3:00pm University of Minnesota - St. Paul Campus
The tour will visit a variety of types of farm gardens in the Frogtown neighborhood of St. Paul to help the twin cities community better understand urban agriculture. Cost is $15 and registration is required at www.misa.umn.edu .
Sponsors: UMN Extension, MISA, and SARE
Contact: Betsy Wieland, UMN Extension and NCR-SARE
eliza003@umn.edu 612-596-1175

August 21-22 **Tri-State Conservation Grazing Workshop**
8:00am-4:30pm Hankinson, ND - Dakota Magic Casino
On August 21, participants will learn about the current opportunities, information, and challenges of managing grassland habitats and achieving conservation objectives with livestock. On August 22, the workshop will consist of a field tour and on-site discussions about livestock grazing for conservation objectives.
Registration: $50
Contact: http://www.ag.ndsu.edu/2012conservationgrazingworkshop
(800) 627-0326 extension 456

September 21 **Restoring Soil Health: *Insuring* for Resiliency and Profit**
8:00am-4:00pm Morris, MN
Multiple partners will be hosting a soil health workshop focusing on techniques for improving soil health, and therefore, productivity. The day will include presentations from soil specialists, researchers, and farmers. The main site is Morris, MN, but video conference sites are available at Lamberton, Crookston, Staples, Cloquet, St. Paul, and Rochester.
Registration: $45
Contact: Julia Ahlers-Ness, Land Stewardship Project
janess@landstewardshipproject.org 320-269-2105

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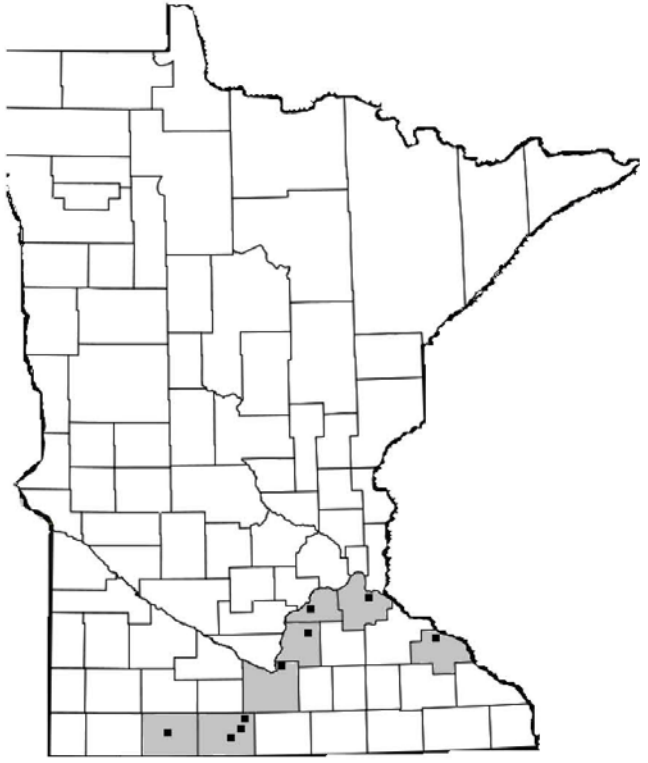
Walk-n-Talk Map



June 22 - Le Sueur County
July 26 - Dakota County
August 1 - Martin County
August 21 - Martin County
August 30 - Scott County
September 6 - Blue Earth County
September 13 - Martin County
October 6 - Wabasha County
November 7 - Jackson County

Helicopters and Cover Crops

Wednesday, November 7, 2012
1:00pm—3:00pm

Jerry and Nancy Ackermann Farm
39750 820th Street
Lakefield, MN 56150

Heron Lake Watershed District Cover Crop Demonstration Project

Join event partners for an afternoon of cover crop discussion at the Ackermann Farm west of Lakefield. Heron Lake Watershed District and Jerry and Nancy Ackermann have been awarded a North Central Region Sustainable Agriculture Research and Education (NCR-SARE) Farmer/Rancher grant to continue their work with cover crops that they started in2011.

They will be using a helicopter to aerially apply winter cereal rye, purple top turnip, and tillage radish into a 37 acre field of soybeans. Aerial application allows for the cover crop seed to germinate before the cash crop is harvested which allows for a longer cover crop growing season.

Attendees will learn about cover crops, hear the details of the Ackermann project, and get a chance to view the rye-turnip-radish cover crop mixture in the field.

Event Partners:
Jerry and Nancy Ackermann
Extended Ag
Heron Lake Watershed District
Rural Advantage
University of Minnesota Extension

Contacts for this event:
Jan Voit, Heron Lake Watershed District, 507-793-2462
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449

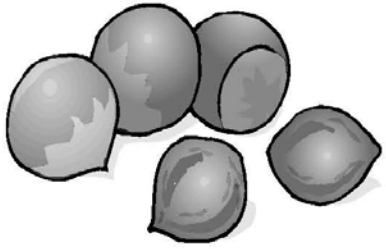
DIRECTIONS
From Interstate 90: Take Exit 64 for MN Hwy 86 and Lakefield. Travel north for about 2.5 miles. Turn west onto Mill Rd. W. / 820th St. / Co Rd 14 and travel about 5.5 miles. The Ackermann farmstead will be on the north side of the road.

FREE EVENT!

2012 Hazelnut Field Day

October 6, 2012
10:00am—4:00pm
(Potluck Lunch—bring dish to pass)

Norm Erickson Farm
1186 W. Lakewood Avenue
Lake City, MN 55041



This annual hazelnut field day is sure to have something for everyone. Presentations in the morning will be focused on the latest research and what's new with hazelnuts. Field tours will be in the afternoon with a brief Hazelnut 101 course, as well as processing demonstrations with the cracker, sorter, and aspirator.

A potluck lunch is planned. Be sure to bring your favorite dish-to-pass and table service. We will also be having a contest for the best baked hazelnut treat. Judging will take place over the noon hour with the winner receiving a prize, so start trying out your favorite recipes for baked goods that include hazelnuts.

The annual meeting of the Minnesota Hazelnut Foundation will take place from 9:00 a.m. – 10:00 a.m. with the field day to follow. Be sure to dress appropriately for the outdoors. The field day will be held rain or shine.

Contacts for this event:
Jeff Jensen, Minnesota Hazelnut Foundation, 515-320-2635
Jill Sackett, UMN Extension / Rural Advantage, 507-238-5449

DIRECTIONS

MN Hwy 63 from Rochester: As entering Lake City, look for St. Johns Cemetery. Directly after cemetery turn right on S. Cross St. At T-intersection, turn right onto W. Lakewood Ave/Co Rd 9. Hazel field will be on right after elementary school.

MN Hwy 61 from Winona: As entering Lake City, look for marina. Turn left onto W. Lakewood Ave./Co Rd 9. Travel about 1.0 mile. Look for hazel field on right after elementary school.

FREE EVENT!

Southern Minnesota Wheat Day

Friday, July 22, 2012
11:00am– 3:00pm

Hoefs Farmstead
20676 340th Street
Le Center, MN

Join us for an afternoon of small grain highlights, assessment of the progress of this season's spring and winter wheat, and a tour of the Minnesota Association of Wheat Growers Le Sueur County research plot.

The Minnesota Association of Wheat Growers has funded research in two southern counties, Swift and Le Sueur, for the 2012 season. Ruth Hoefs & Ron Pomije are hosting the spring wheat research plot in Le Sueur County. Forty different spring wheat varieties were planted on March 30 in addition to five different seed treatments. The purpose of the research is to identify which varieties grow best in southern Minnesota, and to track pest and disease issues. Minnesota wheat check-off dollars are funding this research conducted by Jochum Wiersma and Doug Holen of University of Minnesota Extension.

Attendees are encouraged to bring plant samples of their small grains.

AGENDA:
11:00am-Program Start and Introductions
11:05am-Diseases and Agronomy Factors - Grain Sample Show & Tell
12:30pm-Lunch
1:00pm-Local wheat group discussion
1:20pm-Go to Wheat Plot
1:30pm-Research Efforts and Plot Arrangements
2:30pm-Discussion, Q & A
3:00pm-Adjourn

Contacts for this event:
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449
Diane DeWitte, UMN Extension—Le Sueur/Blue Earth Counties, 507-380-6098

DIRECTIONS:
The Wheat Plot is at the corner of Co. Rd. 26 and 201st Ave. Approximately 7.0 miles east and north of Le Center and 4.5 miles west of Montgomery.

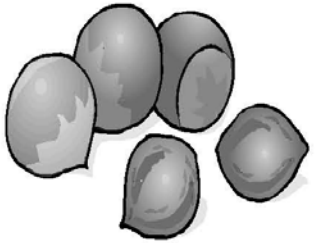
Meet at the Hoefs Farmstead (20676 340th Street—Le Center, MN) to start. From the Wheat Plot, travel 0.5 mile north on 201st Ave., then 0.5 mile west on

FREE EVENT!

Hybrid Hazelnut Research Update

Thursday, July 26, 2012
2:00pm– 4:00pm

Rosemount UMore Park
1605 160th Street West
Rosemount, MN 55068



Join University of Minnesota Researchers and University of Minnesota Extension for an afternoon on the on-going hybrid hazelnut research being conducted at the Rosemount Research and Outreach Center at UMore Park. The walk-n-talk will be led by University of Minnesota researcher Lois Braun.

Attendees will see mature 13 year old seedling hazelnut bushes. Some of these bushes are being used in a pruning and coppicing trial and some are being used in a potassium fertilization trial. Research is also looking at using mound layering with the hybrid hazelnuts. Mound layering is a type of propagation that has been successful in the research trials. It allows for researchers to 'clone' the hybrid hazelnuts that show the desired characteristics. There are first, second, and third year mound layered bushes to view. The two-year old, mound layered hazelnuts are planted in rows by genotype, which makes observations of genotypic differences more obvious.

Contact for this event:
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449

DIRECTIONS:
From the Rosemount ROC's office on Co Rd 46 / 160th Street West: Travel a few 100 yards west to Station Trail Road (gravel) and turn north. Veer north (left) onto 154th Street (gravel). You will be headed towards white turkey barns tucked into a windbreak . Turn right/east before the windbreak. The road curves around the windbreak. The hazelnuts will be along the east side of the windbreak.

There will be a sign saying, "Poultry Research – Authorized Personnel Only." This sign can be ignored unless you have been in recent contact with diseased poultry.

FREE EVENT!

Elm Creek Mair Research Site

Thursday, September 13, 2012
3:00pm—5:00pm

North of the Jeff Mathiason Farm
1849 300th Avenue
Winnebago, MN 56098

New Ways to Think About Streams and Floodplains

Research along Elm Creek has been occurring at the Mair Site in Center Creek Township for a number of years. Join the walk-n-talk partners for an afternoon of research updates and an opportunity to see what has been done. Attendees will learn about the oxbow re-connection, Elm Creek bank stabilization with the use of wood, cattle/grazing management along the waterway, and how these practices have increased the plant and animal life in that stretch of Elm Creek.

Carpooling is encouraged.

Event Partners:
Martin Soil and Water Conservation District
Minnesota Pollution Control Agency
Rural Advantage
University of Minnesota
University of Minnesota Extension

Contact for this event:
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449

DIRECTIONS
From Winnebago (Highway 169): Travel west on Co Rd 12 / 1st Ave. NW (this will eventually turn into Co Rd 44 / 200th St) for roughly 3.5 miles. Turn south (left) onto 300th Ave (gravel) and travel about 1.5 miles

From Fairmont (Walmart corner on Highway 15): Travel north on MN Hwy 15 approximately 3.5 miles. Turn east (right) onto Co Rd 38 / 170th St and travel 8.0 miles. Turn north (left) onto 300th Ave (gravel) and travel about 1.5 miles.

FREE EVENT!

Payments for Ecological Services in Southern Minnesota

Thursday, September 6, 2012
1:00pm—3:00pm

Vonderharr Residence
23940 570th Avenue
Mankato, MN 56001

Conservation Marketplace of Minnesota (CMM) was created in 2008 to establish new economic opportunities to advance conservation efforts. CMM offers a market-driven approach to assist landowners and agricultural producers in their efforts to implement conservation practices through the generation of environmental credits. These credits can be sold in local, regional, or national markets, thereby making conservation practices more economically effective.

This walk-n-talk will highlight the efforts that CMM has been doing since 2008 and will continue to do in the future. Attendees will learn about CMM's efforts on pollinator habitat credits and view a recently planted restored prairie site. Other information will include work done with nitrate levels in wellhead protection areas and the review of the computerized Nutrient Trading Tool which is meant to help measure the impact of various conservation efforts.

Contacts for this event:
Susie Carlin, Minnesota River Board, 507-389-6279
Jill Sackett, UMN Extension/Rural Advantage, 507-238-5449

DIRECTIONS
From U.S. Highway 14 in Mankato: Take the Co. Rd. 5 / 3rd Avenue exit and travel north approximately 2.5 miles. When you reach Meadowbrook Stables, turn left onto 238th Street and travel approximately 0.5 mile. Take the first right onto 570th Avenue.

FREE EVENT!

Tips for Increasing Garden Productivity

Wednesday, August 1, 2012
5:30pm– 7:30pm

Heritage Acres
Community Gardens
Lake Avenue
Fairmont, MN 56031

Whether a novice or a seasoned expert, gardeners are concerned about growing healthy plants that produce abundant and flavorful fruits and vegetables. Join Rural Advantage and International Ag Labs for an evening of gardening tips at the Community Gardens located at Heritage Acres in Fairmont, Minnesota.

Growing good tasting and nutrient dense produce starts with good soil. Jon Frank with International Ag Labs will be giving tips and techniques for increasing soil health in order to increase your garden productivity. Attendees are encouraged to bring your questions! Learn about the importance of soil testing, what to do for nutrient deficiencies, how to increase the soil organic matter, and much more. During this walk-n-talk, Jon will also demonstrate how to measure soil energy using a conductivity meter. This simple meter will let you know when to fertilize and when not to. The evening will also include a walk-through of the plots at the Community Gardens.

Those with Community Garden plots are encouraged to attend. All interested community members are welcome also!

Contact for this event:
Jill Sackett, UMN Extension / Rural Advantage, 507-238-5449

DIRECTIONS
From Interstate 90: Take Exit 102 for Fairmont. Travel south on State Hwy 15 / State Street for about 2.0 miles. Travel west (right) on Blue Earth Avenue (which will turn into Lake Avenue) for about 1.5 miles. Heritage Acres will be on the south side of the road. Drive all the way to the back of Heritage Acres, past the red outbuildings and the white house. The Community Gardens will be on the west side.

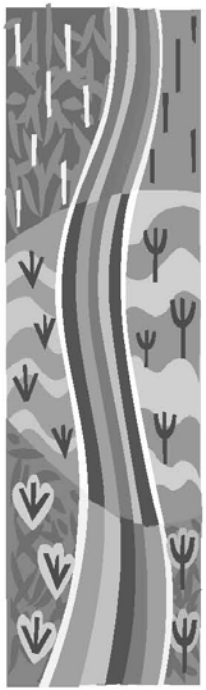
FREE EVENT!

Elm Creek Research: Perennials and Nurse Crops

Tuesday, August 21, 2012
1:00pm—3:00pm

Roberts Research Plot
1838 260th Avenue
Granada, MN 56039

Please join Rural Advantage, UMN Extension, and University of Minnesota at this walk-n-talk that will be highlighting research being conducted in Martin County. The research is being done at two sites along Elm Creek and the walk-n-talk will be focusing on the Roberts site near Granada, Minnesota.



Attendees will hear explanations on the multiple research projects being conducted. Researchers will be discussing alley cropping systems with combined tree and grass crops for bioenergy feedstock production. Alley cropping involves planting perennial crops between blocks of willow or poplar and is considered a good alternative to monocultures, especially in riparian areas. Species include hybrid willow and hybrid poplar as well as native grasses and flowers. A second research project at the site is looking at using nurse crops (also called cover crops) to help with the establishment of native plants for biofuel grasslands. The use of nurse crops may inhibit weed growth and change soil microbial communities so that native plants are established more successfully. Attendees will be able to walk among the research plots and get an up-close look at the species being used.

Contact for this event:
Jill Sackett, UMN Extension / Rural Advantage,
507-238-5449

DIRECTIONS
From the Granada Exit off Interstate 90: Travel North on 260th Avenue / Co. Rd. 53 for 6.2 miles. The field day site will be North of the farm driveway and South of 190th Street about 1/4 mile. The site will be on East side of the road. Carpooling is suggested.

FREE EVENT!

Farm Tour: Small Fruits, Grazing, and More

Thursday, August 30, 2012
5:30pm—7:30pm

Seven Story Farm
22285 Delaware Avenue
Belle Plaine, MN 56011

Join Rural Advantage and Seven Story Farm for a farm tour near Belle Plaine, Minnesota. Seven Story Farm is a small, diversified operation owned and operated by Heidi Morlock and her family. All those interested in learning about small-scale farm production are invited!

Attendees of the walk-n-talk will hear the history of Seven Story Farm and be given a tour of the farm's small fruits, hazelnuts, woody decorative florals, and gardens. The farm is also utilizing rotational grazing methods to raise cattle, sheep, and hogs. Free-range chicken production is part of the day-to-day operation as well.

With the mix of products being raised at Seven Story Farm, there is something for everybody!

Contact for this event:
Jill Sackett, UMN Extension/Rural Advantage,
507-238-5449

DIRECTIONS
From South: From State Hwy 169. Turn right (East) on Co Rd 64 exit in Belle Plaine. At the T Intersection with Co Rd 59 (Delaware Ave), take a left (North). Third place on right (East). Fire # 2285. Look for wind generator.

From North: From State Hwy 169. Continue traveling South past Jordan stop light for about 2.0 miles. Take left (East) onto Co Rd 59 (Delaware Ave.) at the OK Corral restaurant. Travel about 2.0 miles. Farm on left. Fire # 2285. Look for wind generator.

FREE EVENT!

Woody Ornamental Enterprise – A Case Study,

1

Growing Woody Decorative Florals in South Central Minnesota

Abstract

3rd crops are characterized as crops other than corn or soybeans with a focus on perennials (although not limited to perennials). 3rd crops are not one single crop but a wide range of crops that can be selected and grown on environmentally sensitive acres or areas that are not conducive to row-crop production. Examples of 3rd crops include native grasses, forage and legume crops like alfalfa and clover, small grains like oats, wheat, and barley, or even non-crop 3rd crops like agritourism. Agroforestry crops like poplar and willow for renewable energy production, hazelnuts for food and fuel, and woody decorative florals for ornamental arrangements, are also great examples of 3rd crops. Reasons for growing 3rd crops vary from farm to farm and across geographic regions but often involve maximizing ecological and economic benefit. By targeting 3rd crops to marginal acres, increased ecological benefits as well as higher economic returns to the farm family are possible.

Marketing

Woody decorative florals (WDF) are an underutilized 3rd crop with market potential. They are characterized as woody stems or vines with decorative appeal. Colors, shape, bud, leaf, and fruit are all potential attributes of WDF's. As a smaller subset of the floral industry less information is available on sales and volumes. Meyer et al. provide an estimate of the size of the woody floral market at $8 million annually in the central and eastern U.S. in their 2007 Grower's Guide to Producing Woody Floral Stems publication. They go on to say that this is most certainly an underestimate.

Various channels are available to market your WDF stems, vines, and branches, including farmers markets, wholesale flower distributors, retail flower florists, craft stores, interior decorators, grocery stores, restaurants, specialty gift shops, nurseries, internet, pick-your-own, value added arrangements and more. One or all of these options may be available to you but each will require a carefully thought-out marketing plan to ensure success. Size, scale, and location will be a significant factor in determining which channels to enter and focus on.

In south central Minnesota, market research was conducted to determine the most promising marketing channels to pursue and expand. Almost a dozen farmers markets were contacted to identify growers that may be marketing WDF through this outlet. Only one farmers market had a grower selling a single species (curly willow) at a farmers market. However, virtually all the farmers markets advised that they would welcome a grower having WDF to sell at the market.

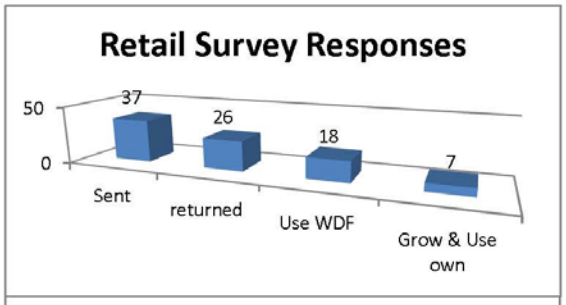
Eight craft/hobby stores were contacted to inquire about their interest of Minnesota grown decorative stems. Three stores were no longer in business, three stores replied that they don't carry WDF stems or that they carry only plastic (one store) and two other stores responded that they are required to purchase from their corporate warehouse.

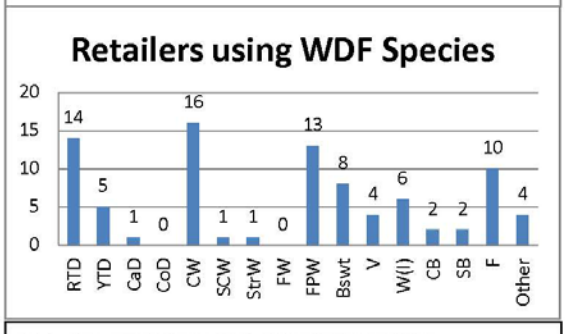
Regional wholesalers were investigated next. The goal was to determine who was using WDF in arrangements or selling stems, as well as determining what species they were selling, prices paid, volumes used, quality issues that were important to them, and their openness to using Minnesota grown stems. Surveys were developed and sent to eight floral wholesalers in Minneapolis/St. Paul and Sioux Falls SD to gather feedback from the industry and estimate demand in the Midwest. No responses were received. Subsequent follow up phone calls revealed that one major wholesaler discontinued the wholesale business to focus on their core business. Two other wholesalers directed me to the grower in WI they primarily deal with. The remaining wholesalers replied that they do not share financial or market data.

Retail florists (39) were then investigated in the South Central region roughly corresponding to New Ulm and Mankato to the North, Jackson to the West and Albert Lea to the East. Phone calls were made to determine whether identified outlets actually used or sold WDF stems.

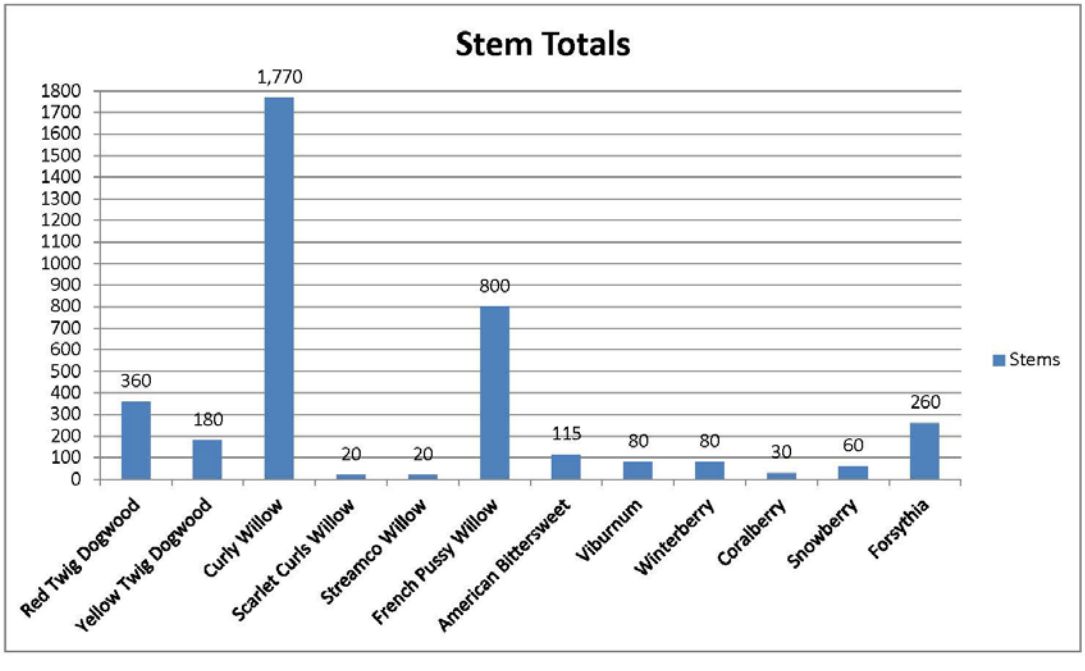
Approximately 37 surveys were sent to retail florists responding that they used WDF in their arrangements or sold stems. 26 (5-24-11) surveys were returned with feedback, a response rate of 70%. Follow-up phone calls were made to the remaining outlets that did not respond. Responses ranged from "no time to help you with the project" to "we have to order from our corporate account." The single greatest response was "we grow and use our own stock."

Responses and feedback from retailers were consolidated. Many surveys were incomplete and few reported any prices. In a few cases no survey was returned and information - on what they use and how much - was solicited over the phone. Based on the survey responses and subsequent phone calls the species most used by retail florists are shown in the graph to the right.





RTD = Red Twig Dogwood, YTD = Yellow Twig Dogwood, CaD = Cardinal Dogwood, CoD = Colorado Dogwood, CW = Curly Willow, SCW = Scarlet Curls Willow, StrW = Streamco Willow, FW = Flame Willow, FPW = French Pussy Willow, Bswt = Bittersweet, V = Viburnum, CB =Coralberry, SB = Snowberry, F = Forsythia



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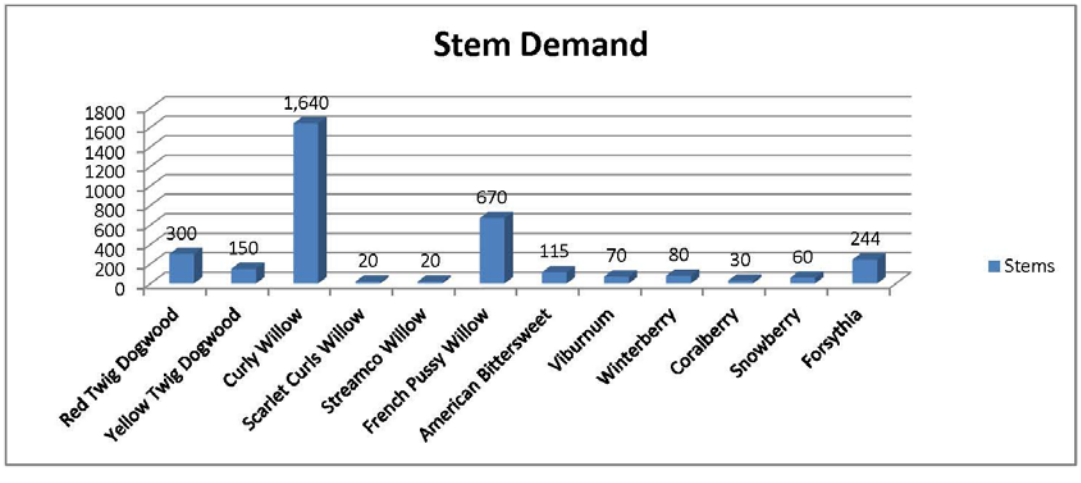
The graph titled "Retailers using WDF Species" indicates that dogwoods (especially red), curly willow, pussy willow, bittersweet, winterberry, and forsythia are all species used by at least one quarter of local retail florists. Thus, these species represent a starting point for species selection.

Adding volume figures to the range of species being used by retail florists yields more specific data that can be used to refine your marketing plan. Again using data from returned surveys and follow up calls we see from the chart titled "Stem Totals" that curly willow and pussy willow are by far the highest in demand with red dogwood a distinct third and forsythia, yellow dogwood, and American bittersweet tailing off. Scarlet curls willow and streamco willow were used sparingly, as was coralberry.

A surprising fact from the survey responses was the number of retailers that are already sourcing locally grown stems from family friends, and neighbors or growing the plants themselves. In a couple of cases the bulk of all the woody decorative florals that they already purchase comes from their own farms or from local growers. Removing the portion of stems that are already being supplied locally provides a snapshot to the actual stem demand that could potentially be filled by a local grower or growers. The chart titled "Stem Demand" shows these figures.

Survey feedback further revealed that virtually all the species are highly seasonal in their use with only curly willow being used year round consistently. The dogwoods, winterberry, coral and snowberry, viburnum, as well as bittersweet were all utilized primarily in the fall and winter corresponding to the holiday season of Thanksgiving and Christmas. After that timeframe demand seriously wanes. Pussy willow and forsythia were primarily utilized in the springtime.

Quality issues reported by retailers include pliable/bendable stems that don't break (curly willow, dogwoods), good color on colored stems (dogwoods, scarlet curls), berries that don't fall off (winterberry, bittersweet, coralberry, viburnum, etc.), buds the full length of the stem (pussy willow), and no black tips (several species).



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Species Selection

Determining what you want to grow and market can be challenging and requires forethought for success. Wholesalers, retailers, and the final customer are looking for good color, shape and unique characteristics, basically something that makes it attractive on its own or with other plants. Typically the deeper the color, more twisted the stems, or the more number of berries still intact the more desirable to florists and end consumer.

Dogwoods[1, 2, 4]

Dogwoods are grown for their bright colored stems typically red or yellow and are very popular in fall and early winter (corresponding to Thanksgiving and Christmas) in planter boxes or with winter greenery.

While preferring moist wet soils many of the dogwoods can handle a range of soils. Full sun is recommended for best color. Propagation from cuttings is common and the stems should root readily provided good moist soil.

Plant spacing is usually 4-5 ft or more depending on suckering and management practices. Stems are cut in fall, preferably after a hard frost to get the best color. Current year's growth should result in long straight stems, older stems are less colorful and more branched, thus annual harvest and coppicing to 6-10 inches. Most varieties are hardy to zone 4 or more. Various species, varieties, and cultivars can be grown depending on location and season.

Red Osier Dogwood – *Cornus Sericea* or *Cornus stolonifera*

This common species contains many varieties (Colorado) and cultivars (Cheyenne, Cardinal, Bailey, and Flaviramea), is broad forming, and can sucker out to a size of 6 ft tall and 10 ft wide. Color can range from red-brown (Colorado & Bailey) to bright red (Cardinal & Cheyenne) to deep burgundy red (Red Osier) and even yellow (Flaviramea).

Bloodtwig Dogwood – *Cornus sanguine*

The list below contains many of the species grown as woody decorative florals (WDF)

- Red Dogwood
  - Bloodtwig Dogwood
  - Red Osier Dogwood
  - Colorado Dogwood
  - Cardinal Dogwood
- Yellow Dogwood
- Curly Willow
- Scarlet Curls Willow
- Streamco Willow
- Flame Willow
- Bittersweet
- Viburnum
- Winterberry
- Coralberry
- Snowberry
- Forsythia

Bloodtwig dogwood is a large and heavy suckering species with several cultivars. The two most likely to be used for decorative stems are 'Midwinter Fire' and 'Winter Beauty'. Although similar, 'Midwinter Fire' is a prolific grower suckering readily and has a winter stem color that ranges from yellow to orange; 'Midwinter Beauty' however, is slower to grow with less suckering and a redder stem color.

Insect & Disease Problems

Insect and disease problems include but are not limited to Stem Canker, Dogwood Anthracnose, Spot Anthracnose, Septoria Leaf Spot, Powdery Mildew, and Dogwood Borer.

Willows[2, 4, 10]

Willows traditionally fall into one of two categories for woody decorative floral production, stems or catkins. Stems provide color and interesting height and texture to floral arrangements or on their own. The showy catkins on pussy willow stems are a favorite in early spring especially around Easter.

Pussy Willows

Dioecious, the male is usually grown for the catkins. Growing conditions vary with ideal conditions being well drained moist soils. However the adaptive nature of the species mean it can grow virtually anywhere in almost any condition; an attractive option to growers with "marginal" areas looking for added income. pH between 5 and 6.5 is preferred.

Like most willows, cuttings root easily and plants can be propagated readily from either soft or hard wood stems almost anytime of the year. For best results take cuttings in the spring prior to bud break. Rooting hormone can be used but is not needed as willows root well.

Spacing in plantings ranges from as close as 1 ft between plants to 6 ft. As with any spacing scheme, tradeoffs are made between stem size, overall production, and ease of harvesting. Annual growth ranges from 6-8 ft and up to 10 ft or more if not harvested.

Full production can be expected in 3 years with some production sooner. Yields will vary by species, spacing, management techniques, etc. Estimates of 40 stems per mature bush are reported. Catkins form on last years growth so coppicing or a technique known as pollarding is used to rejuvenate new stems.

Harvest in northern climates occurs in early spring or late winter depending on the season, after bud swell but before opening. Harvesting stems early and forcing buds is a strategy used by some growers to capitalize on early spring markets but should be done with caution. Improper forcing will result in catkins that fall off and inferior quality stems. Post harvest storage is accomplished dry at 29F and high humidity for months or several weeks in a preservative solution.

Several well known species and cultivars are listed below:

Pussy Willow - *Salix discolor*
This pussy willow grows native across much of the Eastern 2/3rd of the U.S. including most of the Midwest. It grows as a shrub or small tree and is primarily used for flower arrangements. The male catkins are showy and look like the ends of Q-tips™. Stem color is typically brown and fairly plain.

French Pussy Willow – *Salix caprea*
Sometimes known as goat willow, grows to 20+ ft and is hardy to zone 4. Somewhat colorful stems can range from red to purple and catkins often have a pink hue making them really attractive. Larger and more showy then *S. discolor*, when purchasing pussy willows this is typically the variety sold.

Black Pussy Willow – *Salix gracilistyla* 'Melanostachys'
This 6 to 10 ft tall shrub can have deep purple to black stems in the winter developing deep purple-black catkins in the early spring. Brightly colored red anthers protrude from the catkins making a very beautiful specimen. Hardy to zone 4, black pussy willow should be considered as a species to include because of its contrasting color and unique catkins.

Dirr in Manual of Woody Landscape Plants lists a multitude of disease and insect considerations including: bacterial twig blight, crown gall, leaf blight, black canker, cytospora canker, anthracnose, gray scab, leaf spots, powdery mildew, rust, tar spot, aphids, willow leaf beetle, willow lace bug, will borer, and more. A stem gall called willow beaked gall midge (which affects Salix caprea more so then others) can also be a problem. Other pests such as deer rubbing on stems and critters chewing on plants are typical for any woody bush. Overall few diseases and pest issues are present.

Stem Willows

Similar to the pussy willows, stem type willows grow virtually anywhere, across conditions, thriving in moist soils. Full sun is recommended for best stem color development. Propagation from soft or hardwood cuttings is standard and occurs year round. Spacing options are identical to the pussy willows with the same issues of soil depletion, disease pressures, and ease of harvesting the paramount concerns.

Annual growth of 6-8 ft or more is common. Colored stems are harvested annually because color

is best on new stems. Curly varieties are traditionally harvested every 2 years since the second year growth is where most of the "curling" happens. The exception is with 'Scarlet Curls' and 'Golden Curls' which have been selected for color and early curling, meaning they are harvested annually.

Harvesting is done throughout the fall and winter. Color is best after hard frost coinciding with leaf drop and colder temperatures. Like the dogwoods, colored and curly stems are part of the fall rush to market stems as part of the holiday season. Unlike the dogwoods, curly stems are in demand all year round. Yields, while wide ranging depending on species and management, are higher than other woody decorative species. Estimates range from 10-20 for species such as 'Scarlet Curls' or Flame willow to 35+ for some of the *Salix alba* species. High humidity and temperatures of 29F or 30F will keep cut stems for up to six months in a dry state.

Several well known species and cultivars are listed below:

Peking Willow - *Salix matsudana* 'Tortuosa'
Sometimes referred to as the Hankow Willow, this is the traditional curly or corkscrew willow of green or yellow color. It can grow quite large (up to 20+ ft) and is perhaps the most common woody decorative floral stem used in flower arrangements providing character, color, and height. Hardy to zone 5 it has been grown successfully in parts of zone 4.

Salix matsudana 'Snake'
A curling willow similar to 'Tortuosa' with red or purple hued tips, is hardy to zone 2 and a beautiful selection offering something different but great curly character. Grows approximately 10+ ft or more and may be more canker resistant than other willow varieties.

Golden Curly Willow - *Salix matsudana* 'Golden Curls'
A contorted curly willow with very bright blond color, otherwise very similar to 'Tortuosa' Best color from young stems.

Scarlet Curls Willow - *Salix matsudana* 'Scarlet Curls'
Similar to Golden Curly Willow, highly contorted with twisting stems but a great red or corral color. Best color on youngest stems but best curling on older stems, otherwise very similar to 'Tortuosa'.

Salix sachalinensis 'Sekka'
The Japanese fantail willow is a unique specimen that is sure to pique curiosity. Still referenced as *Salix udensis* in some circles, it is twisted and a dark red or brown color with white/grey catkins that can grow to 15 ft. It is hardy to zone 4 and a certain percentage of plants will produce flattened stems making it even more unique thus desirable. Can grow to a height of 10-15 ft and spread widely if not managed; a definite species to consider for woody decorative floral production and marketing.

Salix alba
This species has many cultivars of different colors, productivity, and range. Most are prolific growers although somewhat short-lived. However with the ability to readily root via stem cuttings maintaining a productive planting is possible. 'Britzensis', 'Cardinalis', 'Chermesina', and 'Chrysostela' are all red or orange stemmed cultivars with varying intensities of color. 'Vitellina' is a yellow stemmed cultivar that can be quite bright yellow. All are hardy to at least zone 4 with some of the red ones hardy to zone 2.

Salix 'Flame'
A willow discovered in Minnesota, the flame willow has brightly colored red stems and can produce large numbers of good stems due to its dense branching characteristics. Flame willow is a large shrub that can grow 15-20 ft and in many ways is similar to the red dogwoods.

Insect and disease pressures are minimal and include the range of pests like deer and rabbits but also defoliators like leaf eating beetles. Most pest and disease issues arise from stressed plants. Adequate fertilization to replace nutrients lost in removal of stems and leaves should be practiced to maintain plant health. Because of the constant harvest of the bushes they often "wear out" and new bushes propagated.

Bittersweet[3, 4]

American bittersweet (*Celastrus scandens*) is in the Celastraceae family and is found across the Eastern two thirds of the U.S. This woody vine is prized for its unique form and attractive fruits that stay attached to the vine. Plants are dioecious and recommended female to male ratios for adequate pollination is 10:1 - 15:1. Plants can be purchased as male or female but typically are sold in bunches with some of each.

American Bittersweet thrives in full sun and across a range of soil types from deep loams to rocky or gravely sights typically in disturbed areas. Both soft and hardwood stem cuttings can be used to propagate new plants. Plant spacing ranges from 3-6 ft. As a vine it will grow up trees, shrubs, and other natural vegetation. For the woody decorative grower a trellis should be used to facilitate growing vines. Spiraling stems can be trained around a large piece of conduit, pipe, or other tube.

Annual growth is roughly 3-6 ft with mature plantings (un-harvested) reaching an upper limit of around 20 ft. Harvesting can occur in as little as three years after planting but significant production typically does not occur until year 5. Harvesting in the fall occurs just before leaf drop and before fruit capsules open. Fresh cut sales do occur in fall but most is dried for arrangements and wreaths.

In addition to *Celastrus scandens* (American Bittersweet), *Celastrus orbiculatus* (Oriental bittersweet) is widely used in the woody decorative floral industry and sometimes even more so than the American bittersweet. These two species are similar enough that hybridization is thought to occur yet very different in how they grow, with the oriental being extremely vigorous to the point of damaging existing trees and shrubs. Oriental bittersweet is listed as a prohibited noxious weed in Minnesota on the eradicate list (MN dept. of Ag. website http://www.mda.state.mn.us/plants/badplants/noxiouslist.aspx)

Eradicate List: Prohibited noxious weeds that are listed to be eradicated are plants that are not currently known to be present in Minnesota or are not widely established. These species must be eradicated, meaning all of the above and below ground parts of the plant must be destroyed, as required by Minnesota Statutes, Section 18.78. Additionally, no transportation, propagation, or sale of these plants is allowed. Measures must also be taken to prevent and exclude these species from being introduced into Minnesota.

Because identification can be difficult, the United States Geological Survey (USGS) has developed a handy fact and I.D. sheet found at http://www.fs.fed.us/r9/hoosier/docs/plants/Bittersweet.pdf

Disease and insect pressures are minimal with powdery mildew, leaf spot, aphids and leaf hoppers being reported to do some damage from time to time.

Winterberry [4, 5, 6, 10]

Winterberry (*Ilex verticillata*) is a deciduous holly with large fruit that grows as a multi-stemmed bush up to 15 ft. Its use in the woody decorative market is for the branches and fruits that can range in color from red to orange to yellow. It is particularly suited to capitalize on the holiday markets of Thanksgiving and Christmas.

Winterberry is hardy to zone 3 and requires moist to very moist soil, lots of organic matter, slightly acidic pH and full sun. Both softwood and semi-hardwood cuttings have been used successfully to propagate new plants, alternatively new suckers can also be dug in the fall for transplant. Plants are dioecious and recommended female to male ratios for adequate pollination is 10:1 - 20:1. Spacing is 4 to 6 ft, recommendations for distance between males and females is no more than 40 ft. Often specific male and female cultivars are stated for adequate pollination and fruit set.

Stems and branches are harvested in fall before a hard frost, thus leaves are usually removed by sweating or hand removal for small bunches. Full production generally occurs in year 4 with a pruning or coppicing regime used for harvests. Fruit grows on second year wood, thus pruning allows for annual harvests and coppicing results in every other

year harvests. Stem yields have been reported in the 15-20+ per plant range. Once cut, stems can be stored in cold storage (32F -36F) for weeks or longer.

Several Northern Type varieties grown for woody decorative markets include:

'Stop Light' 'Shaver' 'Cacapon'
'Winter Red' 'Maryland Beauty'

'Jim Dandy' – Pollinates northern types due to its early and long flowering period

Birds can be a problem feeding on berries. Like many other woody shrubs, stems can be destroyed by deer rubbing their antlers. Tar spot, anthracnose, powdery mildew, and leaf spot have all been reported as potentially affecting winterberry.

Do not eat the holly berries or leaves as they are toxic

Viburnum [4, 5, 9]

The highbush cranberry (*Viburnum opulus* var. americanum; formerly *Viburnum trilobum*) is native to North America and belongs to the honeysuckle family (Caprifoliaceae). It is primarily grown for its bright red glossy berries, which are edible in addition to decorative. It is hardy to zone 2 and grows up to 13 ft.

Highbush cranberry is very adaptable across a range of conditions but thrives in moist well drained soils. Softwood cuttings can be taken June through July. Layering, root crown division, and hardwood cuttings can also be used to propagate new plants. Plant spacing ranges from 2 ft up to 6 ft. Flowers occur on the previous years growth so selective pruning is desired to manage plant.

Stems are harvested when berries are at appropriate color and traditionally coincide with the Thanksgiving and Christmas holidays. Berries will persist throughout much of the winter.

Insect & Disease Problems

Viburnum beetle is a leaf eater that can devastate several viburnum cultivars. According to the Minnesota Department of Agriculture, http://www.mda.state.mn.us/plants/insects/virburnum-leaf-beetle.aspx the viburnum leaf beetle has been confirmed in Illinois and Wisconsin but not yet in Minnesota. The Viburnum Beetle Citizen Science Project, http://www.hort.cornell.edu/vlb/news/2003report.pdf lists highbush cranberry as the most susceptible to the beetle.

Viburnum Borer[8] (*Synanthedon viburni* & *Synanthedon fatifera)* infest stressed or damaged bushes by boring into the stem causing cankers and scarring. Infected stems should be removed reducing yields and potentially killing the bush.

Sudden oak death can infect viburnums but is rare, other possible diseases include powdery mildew, downy mildew, and Botryosphaeria canker.

Coralberry/Snowberry[4, 10]

Coralberry (*Symphoricarpos orbiculatus*) and Snowberry (Symphoricarpos alba) are both members of the honeysuckle family (Caprifoliaceae) along with viburnum. Coralberry produces pink berries while Snowberry produces white berries along drooping stems that provides great color to fall arrangements.

Each is native across much of the Midwest and east, hardy to zone 3. Plants grow to around 2 ft and as wide as 4 ft. Propagation from new suckers is possible and softwood cuttings root readily. Plants do well in full sun to partial shade; plant spacing is close at 2-3 ft. Harvest early to avoid off colored fruit (Aug. – Sept.). Plants can be coppiced for annual harvest or selectively pruned.

Anthracnose (leaf and fruit), powdery mildew, and other leaf spots have all been documented on coralberry and snowberry.

Forsythia[4]

Forsythia x intermedia and its many varieties, along with *Forsythia ovata* show some of the earliest spring color due to the early bloom period. Yellow

flowers are visible before leaves and it provides a warm hue of springtime. Combined with its easy forcing ability and simple propagation of softwood cuttings; it makes a good addition to most woody decorative plantings.

Shrubs grow up to 10+ ft with a wide splayed form. Adaptable to various soil conditions full sun is recommended. Softwood cuttings will root easily but even hardwood cuttings should root well. Plant spacing is various but given the wide splayed form at least 4 ft should be allocated per plant.

Cutting stems while buds are tight allows for storage of weeks or maybe months and later forcing. One, two, or even three year old branches can be taken. Forsythia will grow back so plants can be coppiced annually or selectively pruned for harvest. Stem yield per plant varies with variety. Up to 80 stems have been reported with Lynwood and as few as three with another variety; 11 to 50 were the most common ranges.

Few disease or pest issues are reported for forsythia

Production

Getting Started

Planning and forethought before establishing your WDF planting will pay large dividends down the road and can reduce problems encountered after establishment. The following are a series of key questions that should be answered at the early stages of planning your WDF planting.

What is the goal of the planting?
Are you interested in making money from your planting or to provide some much needed winter color in your backyard landscape? Perhaps the goal is different, reducing lawn space to shorten mowing duties? Whatever the goals and objectives understanding what you want out of the planting will bring some focus to the decisions you will need to make. If the idea is to generate income then decisions should be geared towards production and providing everything that particular species needs to thrive and provide the yields needed to generate revenues. Higher quality and larger plant material may be purchased to get a jump start on production while a planting for aesthetic purposes may use rooted cuttings that take a little longer to establish. Similarly, a backyard planting may require closer spacing to other trees or shrubs to minimize grass and highlight color schemes. Of course the single biggest difference between a planting for revenue generation and one for aesthetic beauty is harvesting and marketing the plants in one system while merely pruning for maintenance in the other.

What specific species do I want to grow and market?
This may be the single most important question you need to answer and often takes some time to come to a complete answer. For instance, research should be conducted to determine what species are selling in the marketplace and where an opportunity exists for you to provide that species. Many WDF species can grow in a wide array of soil and climate conditions but still do best under certain ideal environmental parameters. Ensuring that you have the correct soil and climate for re-growth every year is a crucial element that can not be overlooked. In conversations with several growers, this issue came up over and over again. They advised that getting good grow-back from coppiced or pollarded plants was the single biggest determinant of success. This may mean selecting just a few plants to get started and testing them out on your farm to confirm they will be able to grow back for harvest every year.

Do I have the right soil type and adequate fertility to be successful?
As previously stated, many WDF species can grow in a wide range of conditions, however to maximize quality and production the grower should take the necessary time to match soil type and location with the species to be grown. Willows, dogwoods, and viburnums will thrive in moist soil conditions while something like winterberry prefers slightly acidic conditions. Take the time to conduct a soil test and amend the soil before establishing your planting. Some nutrients can be very immobile and will

require incorporation into the soil for proper distribution. A typical 10-10-10 garden fertilizer is often used for fertility but again a soil test will reveal needed nutrition and most appropriate fertilizer rates depending on your growing regime.

Do I have time to grow Woody Decorative Florals? As perennials, the time and labor considerations are favorable for growers. Weed control is typically via chemical application and mowing. Landscape fabric and mulch can also be used but add considerable cost and often still require some level of chemical treatment or hand weeding. Planting, maintaining, and even harvesting plants is very straightforward and requires little time. However the sorting, trimming, bundling, marketing, and delivery can be labor intensive. Budget worksheets provide some information on time requirements for specific species.

Another issue to contemplate is the time of the year for harvest. Species like the dogwoods, colored stem willows, coral/snowberry, and bittersweet are harvested in late fall and in many instances are done for the season. However some curly willows, forsythia (to force), dogwoods, and viburnum may require harvesting in waist deep snow and cold temperatures. The grower should be aware and even expect harvesting in these conditions.

Growing WDF

WDF are typically grown in long rows with adequate spacing between rows to facilitate equipment needed for field operations. A tractor and trailer are often used when harvesting to place buckets of cold water with which to hold the stems as they are harvested. Grass, legumes, or a combination of both is grown between the rows to keep down weeds and provide ground cover. Spacing between plants varies with the species but consideration for space needed to harvest should be evaluated when planning your planting. Table 1 provides some examples of plant spacing for different species.

Table 1

Species	Spacing
Dogwoods	4-5 ft
Willows	2-6 ft
Bittersweet	3-6 ft
Winterberry	4-6 ft
Viburnum	2-6 ft
Coral/Snowberry	2-3 ft
Forsythia	4 ft +

Establishment into existing sod or grass will minimize ground disturbance but can be challenging if nutrients or soil amendments are needed, which often require incorporation. This can be achieved by digging a hole 2-3 times larger than what is needed; then working amendments into the soil around where the new plant will be placed. The advantages of planting this way include little disturbance to already established surrounding vegetation, targeted chemical application (if desired), weeds and other competition removed within several feet of the new plant, cheaper but more labor intensive.

Establishing WDF plants using full tillage allows for easier incorporation of soil amendments if needed. It will also provide a worked seed bed conducive to planting with a mechanical tree planter and good for the subsequent cover crop seeding. Full tillage may be limited to areas of relatively flat ground or slightly sloping. Moderate to steep sloped sites could result in heavy soil losses when exposed to rain and wind.

Some species are more long lived than others. Species like dogwoods, some of the willows, and forsythia are easy to propagate and grow and with yearly harvesting can "burn out." Other species like bittersweet or winterberry take considerable time before first harvest and should be well cared for to achieve sustained yields. For those species that will be propagated, sufficient space is needed to establish new rows of material for harvesting while current plants are on the decline.

Financial Analysis

Information on WDF as a subset of the much larger floral industry is lacking, although some limited information is available. Scott Josiah and

colleagues at the Nebraska Forest Service, a part of the University of Nebraska, have done good work investigating woody decorative florals as an income generating enterprise. Josiah et al (2004) provided a framework by which to evaluate the economic potential of various WDF species. Building from that work, Meyer et al (2007) developed A Grower's Guide to Producing Woody Floral Stems which provides excellent introduction to new or beginning growers on the what, how, and why of growing WDF.

Using the framework outlined by Josiah et al, a 10-year pro forma financial analysis has been prepared for each WDF species in order to better understand profitability for inclusion into the farming system (Appendix A). In addition, a worksheet has been developed that provides the default data used to generate the pro forma which can also be used by growers to compare their specific situation and values (Appendix B).

Assumptions
The assumptions used for the worksheet are as follows:

- Rows are 100 ft long and spacing within rows is 5 ft between species resulting in 21 plants per row.
- All labor is figured based on $11.70 per hour (ISU Custom Rates)
- Yield per plant is derived from multiple sources (Josiah et al, individual growers, literature, NE Woody Floral Group, and industry feedback [Association of Specialty Cut Flower Growers])
- Price per stem is derived from multiple sources (Josiah et al, returned surveys, industry group feedback [Association of Specialty Cut Flower Growers], individual growers, and USDA Terminal Markets where available)
- Plant material cost per plant varies across size classes (bare root, container grown, seedlings, etc.)
- Site prep is based on Josiah et al
- Planting cost is a range based on the local SWCD custom planting rate for the (1) minimum and (2) the actual number of plants established.
- Mowing cost is an estimation of labor only and does not include cost of operating the mower or fuel, it is assumed that growers will already have a lawnmower and are already mowing their own lawn.
- Weed control is from Josiah et al and updated; the cost is for chemical only and does not include labor.
- Replacement is from Josiah et al and estimated at 20% (replacement of 5 plants per row)
- It is assumed that fertilizer (10-10-10) is provided prior to establishment and includes the cost of the fertilizer and labor to spread/incorporate. For some heavy producing species fertilizer may be needed in later years to compensate for removal rates of biomass stems and branches.
- Labor for harvesting, processing (trim/sort/bundle), and marketing is provided on a per plant basis and is from Josiah et al where available and estimated where not available.
- Establishment years are pro-rated based on yield

Table 2 shows net returns for WDF species based on the worksheet for each species. However this does not reveal the whole story. Perennials by their very nature take significant time to grow, mature, and reach full production. Thus, slow growing species, those that yield poorly, or those that are very expensive to establish are at the bottom of the list for net returns. In fact, bittersweet and winterberry are losing endeavors due to the initial cost of establishment, slow growth, and low yield.

Table 2	
Species	Worksheet Net Return
Curly Willow	$295.31 - $581.74
Forsythia	$392.08 - $482.10
Viburnum	$209.50 - $422.04
Snow-Coralberry	$205.72 - $312.84
Dogwoods	$91.31 - $216.07
Pussy Willow	$60.72 - $173.90
Bittersweet	($36.83 - $260.04)
Winterberry	$4.54 - ($350.76)

A more accurate approach is to compare species based on the 10 year average annual return. This allows for initial establishment to be spread out over many years and adjusts for slow growing or poor yielding species. To be clear, slow growing species or those that yield poorly will still not compete favorably, but do allow for a more appropriate comparison. Table 3 lists the 10 year average annual return for WDF species.

Table 3	
Species	10 yr avg. annual return
Forsythia	$405.47 - $564.35
Curly Willow	$256.50 - $586.75
Viburnum	$226.57 - $499.99
Snow-Coralberry	$229.37 - $420.10
Dogwoods	$119.71 - $343.29
Pussy Willow	$71.77 - $261.04
Bittersweet	$21.11 - $213
Winterberry	$58.81 - $80.75

Based solely on expected returns as outlined in each species worksheet and the 10 year pro forma, forsythia and curly willow should be considered highest for inclusion into the farm planting; with viburnum, snow-coralberry, and dogwoods strong possibilities. Pussy willow, bittersweet, and winterberry could also be included but are at the bottom of the profitability scale.

Conclusion

The decision on what WDF to include in the farm planting should not be made on the financial analysis alone. Marketing factors like what sort of demand is out there, how many stores are using a particular species, and location and frequency of purchases must also be include. Likewise, production factors will play a role in ultimately deciding what to grow and market. Combining all these factors in a meaningful form provides a better measure for deciding. The following discussion of each species outlines these various factors.

Dogwoods

The returned surveys indicate that dogwoods are used in at least 14 different retail floral shops representing demand for approximately 450 stems spread throughout the year but congregated heavily in the late fall timeframe corresponding to Thanksgiving and Christmas. Initial cost to establish a 100 ft row can be low if purchasing low cost cuttings instead of larger potted plants. Dogwoods grow rapidly and if growing conditions are favorable it is possible that mortality could be reduced significantly and yields increased in the first two years of establishment. Because it establishes easily new cuttings can be taken from existing stock so when the current planting begins to show signs of decreasing productivity new plants can be established in a new location conducive to high level production once again. The relatively strong demand, coupled with the low cost of production and ease of growth indicates that the dogwoods (and colored willows) should be a highly considered addition to the planting.

Dogwoods	
Expenses	
Establishment	$42.38 - $180.77
Labor & Maintenance	$27.84 - $58.69
Harvest & Marketing	$58.97
Total	$129.19 - $298.43
Total Income	$220.50 - $514.50
Net Return	$91.31 - $216.07
10 yr avg annual return	$119.71 - $343.29

Curly Willow

Returned surveys show that curly willow is both used at the most locations and has the most stem demand than any other species. 16 different retail florists reported using curly willow in arrangements, with several reporting that they use up to a bunch per week. In total curly willow demand stands at just over 1,600 stems, with most of that demand spread out through the entire year. Unlike most of the other WDF species which have spikes in
demand correlated to different seasons, the curly willows are in demand all year long. Initial cost can be low with the majority of the cost to produce coming in later years when harvesting stems. Plants are long lived and can be quite prolific producers.

Similar to the dogwoods, the strong demand combined with the low cost of initial production makes this species a great candidate and one recommended for inclusion into a planting. However this depends on realizing high productivity to achieve the outlined returns.

Curly Willow	
Expenses	
Establishment	$31.25 - $167.12
Labor & Maintenance	$23.09 - $55.44
Harvest & Marketing	$122.85 - $245.70
Total	$177.19 - $468.26
Total Income	$472.50 - $1,050
Net Return	$295.31 - $581.74
10 yr avg annual return	$256.50 - $586.75

Pussy Willow

Pussy willow showed strong demand (670 stems) with 16 different retailers using the species in arrangements. Pussy willows are highly seasonal to the spring months particularly around Easter. This makes climatic conditions very important for successfully marketing pussy willow stems. Competition can be fierce from foragers of southern states like Southern Iowa and Missouri where they can often harvest several weeks before northern climates. Forcing is one potential way to better align production with demand. Stems can be cut early and then forced to bud at the appropriate time. This practice is not without risk however. Several growers report that forcing, if not done properly, can ruin quality with the buds falling off prematurely or becoming very brittle. Like the curly willows they are fairly inexpensive to establish and grow very quickly producing lots of stems for sale. It is important to get high quality plants to establish since bud formation the entire length of the stem is one of the quality criteria that need to be present for retail florists and individual customers to purchase. This species should be viewed with a certain level of caution. If consistent demand can be found it is probably advised to consider it as part of any WDF planting, however if demand is not consistent it could be difficult to market successfully.

Pussy Willow	
Expenses	
Establishment	$31.25 - $148.22
Labor & Maintenance	$23.09 - $55.44
Harvest & Marketing	$147.44
Total	$201.78 - $351.10
Total Income	$262.50 - $525
Net Return	$60.72 - $173.90
10 yr avg annual return	$71.77 - $261.04

Bittersweet

Based on returned surveys, bittersweet is only moderately in demand. Only eight retail florists reported using it in their arrangements and mostly in the late fall and winter representing a demand of approximately 115 vines. Growing bittersweet can be challenging requiring both male and female plants for adequate pollination and fruiting. Although potentially possible to harvest within three years it typically takes up to 5 years for any significant production. Bittersweet will also require a trellis, host tree, or some other method to for the vines to grow up on. Another issue is the invasive nature of the oriental bittersweet and the difficulty in telling the American apart from the Oriental. The oriental bittersweet is listed as a MN invasive plant and should not be planted and marketed. Reducing the threat of invasive species, the slow growth and time it takes to achieve marketable vines, and the relatively low demand results in bittersweet being a marginal species for inclusion into a WDF planting.

Bittersweet	
Expenses	
Establishment	$54.56 - $561.92
Labor & Maintenance	$27.84 - $58.69
Harvest & Marketing	$164.43
Total	$246.83 - $785.04
Total Income	$210 - $525
Net Return	($36.83 - $260.04)
10 yr avg annual return	$21.11 - $213

Highbush Cranberry

Survey results indicate that highbush cranberry is in low demand (70 total stems) and only used by four retail florists. The brightly colored drupes of berries are almost exclusively used during the Christmas holiday season. Demand is low to non-existent the remainder of the year. Establishment cost is low with rapid growth and high productivity. Profitability is good with this species and it is easy to grow. Inclusion of highbush cranberry is recommended in any WDF planting provided that high productivity can be achieved.

Highbush Cranberry	
Expenses	
Establishment	$54.56 - $157.67
Labor & Maintenance	$27.84 - $58.69
Harvest & Marketing	$86.10
Total	$168.50 - $302.46
Total Income	$378 - $724.50
Net Return	$209.50 - $422.04
10 yr avg annual return	$226.57 - $499.99

Winterberry (Ilex)

Winterberry is little used and only during the winter holiday season. Demand for approximately 80 stems is spread between four different retailers. It can be a challenge to grow preferring slightly acid soils and like bittersweet a male and female plant to get berries. It is slower growing and yields are low compared to other species. Price per stem is good and local production has advantages. Many of the winterberry grown for WDF markets comes from the Pacific Northwest and quality can be poor due to shattered berries.

A local product would be much higher quality and should be easily marketed if the florist is already using it. If consistent demand can be found it warrants inclusion into the WDF planting.

Winterberry	
Expenses	
Establishment	$49.52 - $457.97
Labor & Maintenance	$27.84 - $58.69
Harvest & Marketing	$86.10
Total	$163.46 - $602.76
Total Income	$168 - $252
Net Return	$4.54 - ($350.76)
10 yr avg annual return	$58.81 - $80.75

Snow-Coralberry

Snow-Coralberry showed weak demand from the returned surveys. Only four retailers reported using it and only about 90 stems total (both species). Demand is strongest in the late fall and winter and drops off after that time period. Production can be high but variable. Full production can be achieved in three years making it a relatively rapid growing species to consider. If consistent demand can be identified it certainly warrants inclusion into a WDF planting.

Snow-Coralberry	
Expenses	
Establishment	$58.34 - $172.37
Labor & Maintenance	$27.84 - $58.69
Harvest & Marketing	$86.10
Total	$172.28 - $317.16
Total Income	$378 - $630
Net Return	$205.72 - $312.84
10 yr avg annual return	$229.37 - $420.10

Forsythia

Returned surveys indicate that Forsythia is used by at least 10 different retail florists representing demand of roughly 250 stems. Demand is exclusively in the spring when the bright yellow flowers bloom. Production can be high and prices good. However, similar to the pussy willows, climatic conditions are important. In order to capitalize on the early spring market peaks it may be necessary to cut the forsythia early and hold in cool storage until needed and then forced to achieve

the necessary effect. Without adequate cold storage the harvesting and marketing window diminishes. All things considered, on some level forsythia should be considered for inclusion into the WDF planting.

Forsythia	
Expenses	
Establishment	$94.04 - $190.22
Labor & Maintenance	$38.04 - $61.84
Harvest & Marketing	$105.84
Total	$237.92 - $357.90
Total Income	$630 - $840
Net Return	$392.08 - $482.10
10 yr avg annual return	$405.47 - $564.35

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Rural Advantage

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Cracking the Processing Nut

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Background

Hazelnuts have excellent potential as a 3rd crop providing multiple benefits including food, fuel, feed, fiber, and ecological function. The large and spreading root systems anchor soil in place reducing wind and water erosion while enhancing nutrient cycling and sequestering carbon. The multi-stemmed bushes provide wildlife habitat and food for a range of game and non-game species, and produce a marketable nut high in monounsaturated oil that can be used in a wide array of foods, products, and across industries (biodiesel).

Hundreds of innovating growers across the Midwest have planted thousands of plants for a range of purposes. From living snow-fences to research plantings for breeding, the motivations are as unique as the individuals themselves.

Grower surveys conducted by the Minnesota Hazelnut Foundation and the Upper Midwest Hazelnut Development Initiative (UMHDI) reveal that processing nuts into a raw commodity or for value added products, or simply for eating, is a significant bottleneck. More than 50% of respondents reported husking, cracking, and sorting by hand (Fischbach & Brasseur). While nut processing equipment does exist, it is scaled to large processing facilities and packing houses doing thousands of pounds per hour and costing hundreds of thousands of dollars. For context, the most recent grower survey (2010) estimates the total production in the Upper Midwest (MN, WI, IA) at between 15,000 and 25,000 pounds. Thus, identifying appropriately scaled equipment for small to medium sized growers is imperative to the development of a Midwest hazelnut industry.

To address this bottleneck, and provide options to growers requesting guidance, Rural Advantage has developed this series of processing and value added bulletins entitled "Cracking the Processing Nut." This initial bulletin provides the background of the situation and examines the various steps in the processing chain. Subsequent editions will highlight specific pieces of equipment to document efficacy and provide financial and economic data for developing tools growers can use to make decisions.

This hazelnut grower is checking their plants for nut clusters before beginning the harvest.

Cracking the Processing Nut, No. 1 January 2012

Hazelnut Processing Chain Getting hazelnut kernels from the bush to your favorite hazelnut dessert involves several distinct tasks within the processing chain; picking, husking, drying, washing, sorting, cracking, and separation. If value added products are the goal, additional processing steps may be needed including roasting, crushing for oil, or flavoring of kernels.

Picking

Picking hazelnuts means physically removing the nut cluster from the bush; this is in contrast to the method used by growers on the West Coast. In Oregon, where 99% of commercial production occurs, the nuts are allowed to fall from the trees to the ground where they are subsequently gathered into windrows with large

sweeping machines. The windrows are then sucked up by another large machine that removes any dirt, husk, sticks, etc. and consolidates the in-shell nuts into large totes or bins. These are then trucked away for further processing. This system requires level and clean ground below the trees, additional tasks Oregon growers complete simply to harvest. While this method works well for Oregon growers it is not conducive to the bush type plants and systems being developed in the Midwest. Nut clusters from bush type hazelnut plants are picked either by hand or with machines and never touch the ground, an important consideration for maintaining food safety.

Picking nuts by hand is laborious and in many cases not worth it to the producer. Several growers report not picking bushes because of the labor involved and lack of husking equipment. Currently hand harvesting is the only practical means of picking; however a highbush blueberry picker has been demonstrated on hazelnuts and appears to work moderately well. Work continues on adapting this and other small fruit harvesters to hazelnut bushes.

Drying

Once nuts have been picked they are typically dried before husking. A reliable, cheap, and easy method for drying modest volumes of nuts is to simply harness the awesome power of the sun and wind. Nut clusters can be placed in large or small onion sacks and hung in a sunny spot to dry. This method typically dries the nut clusters enough to husk within 3-5 days. It is advisable to "fluff up" the

sacks every day or so to increase air circulation. Alternatively, sacks can be laid on drying racks instead of hanging them to increase surface area exposed to the sun and speed the process. Rodent proofing drying areas is advisable to limit nut theft and predation.

Thisgrowerusesdryingrackssupportedbysomescaffolding.Therackscanbemovedfromunderthecanopyonsunny daystodryyetcoveredwhenitrains.

Husking

Removing the in-shell nuts from the cluster is referred to as husking. The current method used by many growers is to put on a good pair of leather gloves and start removing the husk by breaking it apart or picking nuts from the husk with a nut pick, tiny screwdriver, or awl. While effective, it is laborious and not practical beyond a few pounds of nuts for eating. While large-scale commercial machines are available for accomplishing this task with other nuts, and have successfully been used with hazelnuts, they are cost prohibitive. A few smaller scale options do exist and will be highlighted in future bulletins. Several growers have developed small scale machines that beat, rub, or knock the clusters apart from the in-shell

nuts. Typically built with off the shelf parts and for less than $100, these batch type systems are a low cost entry point for the beginning grower. An equally important step within this task is separating the chaff and husk material from the clean in-shell nuts. Fans, blowers, air columns and vibratory screens have all been used with some success to achieve acceptable results.

This university student uses a cake carrier (the kind your mother used to transporter cake to a potluck) mounted vertically.

Instead of a drill bit, the corded drill spins a chain flail that beats the nutclusters apart.

Washing

Washing the in-shell nuts is an important consideration for adequate food safety. However, given that most Midwestern growers pick their nuts from the tree and not from the ground, the risk of contamination is greatly reduced. Two common food sanitizers are chlorine and peroxyacetic acid (PAA). Chlorine, in all its various forms, is the most widely used sanitizer today and is typically used in concentrations of 50-150 ppm. PAA is typically used at higher concentrations of 100-200 ppm, and is highly sensitive to pH over 7. A few reasons PAA is quickly gaining ground include:

- Low corrosiveness
- Tolerance to hard water
- Effectiveness at low temperatures
- Highly biodegradable

Sizing

Once the in-shell nuts have been removed from the husk a sizing step is needed to sort nuts into size classes for the cracker. This can be accomplished in various ways and to various degrees of accuracy. Some growers simply use punched-hole screens of known size to separate into size classes. For example if using a ½ inch, 5/8 inch, and ¾ inch screen, size classes might be; 1) under half inch, 2) between ½ inch and 5/8 inch, 3) between 5/8 inch and ¾ inch, and 4) over ¾ inch. On a commercial scale roller sizers have been used in many industrial food applications to sort different fruits into various size classes. Using rollers to size gives greater accuracy and can separate into much more detailed size classes. Ultimately the level of accuracy will depend on the cracking technology used.

Cracking

Cracking the hard outer shell to get to the kernel is the goal of this step. The key is getting just enough force to crack the shell and have the kernel fall free without applying too much force that crushes the kernel inside the nut. Getting it just right so that most of your kernels come out wholly intact is improved by adequate sizing of the nuts. Although it should be noted that at least one known cracker does not require sizing prior to cracking.

In-shell hazelnuts, kernels, and shells are shown in the picture below.

Cracking the Processing Nut, No. 1 January 2012

Separation Perhaps the most important step of the entire ***Final Inspection*** processing chain is separating the shell fragments The final step on the processing line is to visually from the whole kernels and kernel pieces. This is inspect the kernels for any defects and any last absolutely critical since shell fragments are hard pieces of shell fragment. Typically done with and jagged and can cause tooth damage if eaten sorting trays or slow moving belted tables this with the kernels. Vibratory screens, air column represents the final quality control check before separators, grain fanning mills, and other methods packaging. have all been used although not documented.

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Adding Value through Husking

No. 2 Feb. 2012

Cracking the Processing Nut

This document has been produced with funds from Rural Advantage, The McKnight Foundation and the Minnesota Department of Agriculture's USDA Specialty Crop Block Grant Program.

Introduction

Removing the in-shell nuts from the nut cluster is one of the first processing steps to realizing a value-added product. Hazelnuts enter the supply chain and are sold in-shell without the husk attached. While a niche market may be available for in-shell nuts in the husk (animal food), husking will be necessary to access the larger in-shell market or even larger value-added markets for kernels and other hazelnut products.

The Upper Midwest Hazelnut Development Initiative (UMHDI) conducted a survey in 2010 to gather feedback from growers on a range of issues, including processing (Fischbach & Brasseur). More than 50% reported that they currently husk nuts by hand. This makes sense considering that virtually all growers will initially husk their nut clusters by hand when plants first start bearing and yields are low. However, as yields and volumes of nuts increase, an alternative method will be needed to accomplish this task and reduce the labor and time spent hand husking.

This bulletin will document hand husking as a baseline method for removing in-shell nuts from the nut cluster. This will be compared to a 5 gallon bucket husker used by many growers. A brief economic analysis will also be detailed in order to provide useful information for the home grower.

Methodology

Two hundred (200) clusters from each of two bushes were harvested in early-September 2011 and air-dried in onion bags. Once dried, half of the clusters (100) from each bush were weighed and either husked by hand (HH) or husked using a bucket husker (BH).
Hand husking (HH) was conducted by manually removing the husk from each in-shell nut using leather gloves and a nut pick. After 90%+ of the husk material had been removed, a final winnowing was done to separate the husked in-shell nuts from any chaff. The clean in-shell nuts were then weighed to determine husking time in lbs of in shell nuts per hour.

Whole, clean, in-shell nuts are the result of removing the husk.

Bucket husking (BH) was conducted with a batch type 5 gallon bucket husker that several growers have built. See appendix A for details. The second 100 cluster sample from bush #1 was weighed and placed into the bucket. The lid was fastened and the drill activated for 10 seconds. The lid was opened and a visual inspection was taken to determine whether additional time was needed to break the clusters apart and knock the in-shell nuts loose. Based upon the visual inspection, the drill was activated for an additional 5 seconds. A subsequent visual inspection revealed several shell pieces meaning some nuts were beginning to crack from the process. The entire mix of clean in-shell nuts, un-husked nuts, husk chaff, and larger husk pieces were dumped into the tub. The in-shell nuts were then manually sorted and any unhusked nuts were husked by hand. The cleaned in-shell nuts were weighed to determine processing time in lbs of in-shell nuts per hour. The same HH and BH procedure was repeated with nuts from bush #2.

Results & Discussion

Table 1 & 2 provide breakdowns of each individual bush using each method (HH & BH). Total weight, amount of time each procedure took, along with a breakdown of 1) clean in-shell nuts, 2) those that would not come loose from the cluster, 3) fully cracked nuts, and 4) half cracked nuts.

1 - All were cracked and all were blank 2 - After bucket husker before hand husk 3 - Final after bucket husk and hand husk 4 - All kernels were complete whole kernels

1 - All were cracked and all were blank 2 - After bucket husker before hand husk 3 - Final after bucket husk and hand husk

Table 1		
Bush #1	HH	BH
Total Time	25.2 minutes	15 minutes
Total Weight	1.79 lbs	1.41 lbs
Clean in-shell	1.32 lbs	0.95 lbs
Nuts w/ husk	2 clusters of 2 nuts 1	40 singles 2 / 4 singles 3
Half Crack	None	1 nut
Full Crack	None	16 nuts 4

Given that the actual time spent husking (time in the husker) was a mere 15 seconds for the bucket husker, it may be surprising that the total time spent per pound for bush #1 is only marginally better than husking by hand. This can be attributed to the high number of nuts that were broken apart from the larger cluster but still remained in the husk. These nuts still had to be husked by hand increasing the time and labor involved. This is in contrast to bush #2 which had very few clusters that were not husked in the bucket husker and the corresponding time to hand process those nuts was miniscule.

Table 3	Bush #1		Bush #2	
	HH	BH	HH	B
Time per cluster (seconds)	15.14	9	12.3	5.
Time per gram (seconds)	2.53	2.08	2.46	1.
Time per pound (minutes)	19	16	18	

Table 2		
Bush #2	HH	BH
Total Time	20.5 minutes	8.46 minutes
Total Weight	1.51 lbs	1.51 lbs
Clean in-shell	1.1 lbs	1.1 lbs
Nuts w/ husk	1 cluster of 4 and 5 singles	6 clusters 2 / 2 clusters 3,1
Half Crack	None	None
Full Crack	None	None

Table 3 shows time spent per cluster and time spent per gram, along with the calculated time spent to process one pound of clean in-shell nuts (the marketable product, in this case).

Based on this analysis, the variability of nut clusters between bushes is large, such that some nut clusters will hold the in-shell nuts tight while others will readily give them up. This has a direct effect on the shear force needed to break up the clusters and remove the husk from the in-shell nuts. For example, the tests conducted with the bucket husker show that for bush #1 some nuts were fully cracked while at the same time many of the nuts still had some husk left on the nut that needed to be removed by hand. Compare this to bush #2 where no nuts were cracked and virtually all the husk was removed in the bucket husker.

Several variables warrant discussion including the nut samples themselves. While we tried to select nut clusters for the 100 cluster samples that were uniform it simply was not feasible. However, to minimize bias we did exclude single nuts, thus all 100 cluster samples for each test were true clusters comprised of 2, 3, 4 or more nuts per cluster. Another consideration is the reality of husking large volumes of nuts by hand. The tedious repetitive nature of picking the nuts out of the cluster with the nut pick takes its toll on the fingers, hand, and forearm. So for bush #1, while the bucket husker may appear to be only marginally better than hand husking in our tests (three minutes faster), repeating the same tests over an extended period of time would quickly reveal a much larger gap with hand husking increasing rapidly until at some point hand husking would no longer be possible. This is in contrast to the bucket husker which will perform continually over much longer periods of time.
It should also be noted that this is a single test conducted on two individual bushes. Some bushes may be considerably more difficult to husk and some easier to husk, the point being that this range does not adequately represent a lower and upper bound range.

Finally, it is wise to keep in mind that although hand husking is laborious and time consuming it also allows the grower a level of inspection that is integrated into the process. By handling each individual nut cluster poor quality nuts can be segregated. With the bucked husker, or any other mechanical piece of equipment, some level of quality control will need to be implemented to remove poor quality nuts. The time needed to conduct this task is not reflected in this analysis or in the tests conducted.

Financial Analysis

Determining a cost specific to husking is important for comparison reasons and for further enterprise budget analysis. To determine a husking cost for each procedure (HH & BH) we calculated a labor cost and an equipment cost and made the following assumptions.

- Growers already own a nut pick, pair of leather gloves, and a container or cake pan to sort with.
- Growers already own a 5 gallon bucket and cordless 14 or 18V) drill for the bucket husker.
- Total supplies for making the bucket husker were under $15 dollars.

- Total time spent making the bucket husker is one hour.
- The useful life of the bucket husker is at least 300 lbs.
- Labor is valued at $10.00 per hour.

Labor Costs
Based on $10.00 per hour labor and the time spent to husk one pound of in-shell nuts (our marketable product) the labor cost for hand husking ranges from $3.00 to $3.16 per pound and bucket husking ranges from $1.16 to $2.66 per pound.

Equipment Costs
The total cost of materials and labor to manufacture the bucket husker is $25.00. Amortized over the estimated life of the husker the equipment cost per pound is about $0.08, which when combined with the labor cost per pound results in a total cost per pound to husk. Table 4 provides the breakdown for each bush.

Value of In-shell nuts
To determine a range of values for one pound of in-shell nuts several sources were used. The most recent survey data from growers was used as one source (Fischbach & Brasseur) and ranged from $2.75 - $5.50/lb. The local grocery store was visited and Oregon grown hazelnuts were found to be selling at $4.99/lb. Several on-line sources are selling in-shell hazelnuts including some farmers selling directly via the internet. On-line prices ranged from $3.99/lb up to $5.53/lb. Thus an average retail price of $4/lb was used for this analysis.

Subtracting the per pound cost of husking from the final sales price of the in-shell nuts reveals a return in the range of $0.84 to $1.00/lb for hand husking and $1.26 to $2.76 for bucket husking.

Table 4	Bush #1		Bush #2	
	HH	BH	HH	BH
Labor Cost/lb	$3.16	$2.66	$3.00	$1.16
Equipment Cost/lb	None	$0.08	None	$0.08
Total Cost/lb	$3.16	$2.74	$3.00	$1.24

Conclusions along with some economic data will give growers Hazelnuts are sold in the marketplace in many some valuable insight for decision making. forms starting with in-shell nuts. Hazelnut growers Based on this analysis, the bucket husker clearly in the Midwest must first husk their nuts to get to a provides an improvement over hand husking in marketable product. Many growers report hand regards to time and effort and represents a relatively husking as the method employed to achieve saleable low cost way for growers to progress from hand in-shell nuts. Other growers have made the leap to processing to more mechanized processing. the next step up the processing ladder by using a However, the bucket husker is still limited in both batch type 5 gallon bucket husker that can be made its capacity and efficacy in processing all nut cheaply and with readily available parts in about an clusters. hour. Documenting how well each method works,

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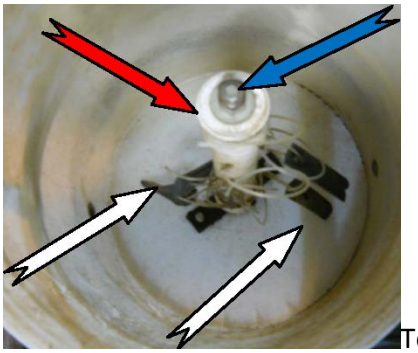
Don Price Bucket Husker

Husking hazelnuts (removing the in-shell nut from the involucre) is an important step in the process of getting hazelnuts from the field to the dinner plate. Currently

done by hand, husking is a time consuming and sometimes difficult task. Hazelnut grower Don Price of Northfield MN uses a batch-type system that was built using off the shelf parts and significantly speeds the process.

Don Price is a hazelnut grower near Northfield Minnesota. A man of many interests and a rich history, Don has built a batch-type husker using the following materials and equipment: a 5 gallon bucket, a 3/8 inch high speed corded drill, a long piece of 3/8 inch threaded rod, some pvc, a few nuts and washers, trimmer line, and cut up pieces of an old rubber tarp strap. “I wanted the husker to be economical with materials that were readily available, it had to work, and be repeatable so that others could replicate it with good results,” Don explains. The husker simply beats apart the nut cluster knocking the nuts out of the husk.



To build the husker Don drilled a hole in the bottom of a5-gallon bucket and inserted a long piece of threaded steel (3/8 inch) covered by a one inch round PVC shroud. The husker doesn’t have any bearings relying only on metal washers at the base of the spindle. The PVC shroud allows the pieces of rubber strapping to be tied to something with the trimmer line. These pieces of rubber tarp strapping are what beat the nut clusters apart releasing the nuts. To reinforce the bucket where the metal rod enters the bottom of the bucket, Don bolted a small rectangular piece of steel. For

The white arrows point to the pieces of rubber strap tied to the PVC shroud (red arrow) covering a more detailed depiction of the aspirator see appendix A. **the metal rod (blue arrow) connected to the drill.**

The bucket can be filled up almost two thirds of the way full with dried nut clusters ready to be husked. A cover is placed over the bucket to keep any flying debris safely inside. A 3/8 inch corded drill is attached to the threaded metal rod protruding from the bottom of the bucket. The drill is run for about 20 seconds spinning the spindle attached to the rubber tarp strap pieces. After the initial 20 seconds Don inspects the nut clusters to gauge how well they are macerated and how many in-shell nuts have been loosed. If needed, he will replace the cover and run the drill for another 20 seconds. If too many nuts get cracked in the process simply slow the speed of the drill. This method is a good batch-type system that allows the grower to husk individual bushes and keep good records.

Acordeddrillprovidesthepowerforthisbatch-typehusker.Thebuckethangsfreelykeepingtheangleatroughly45degrees.

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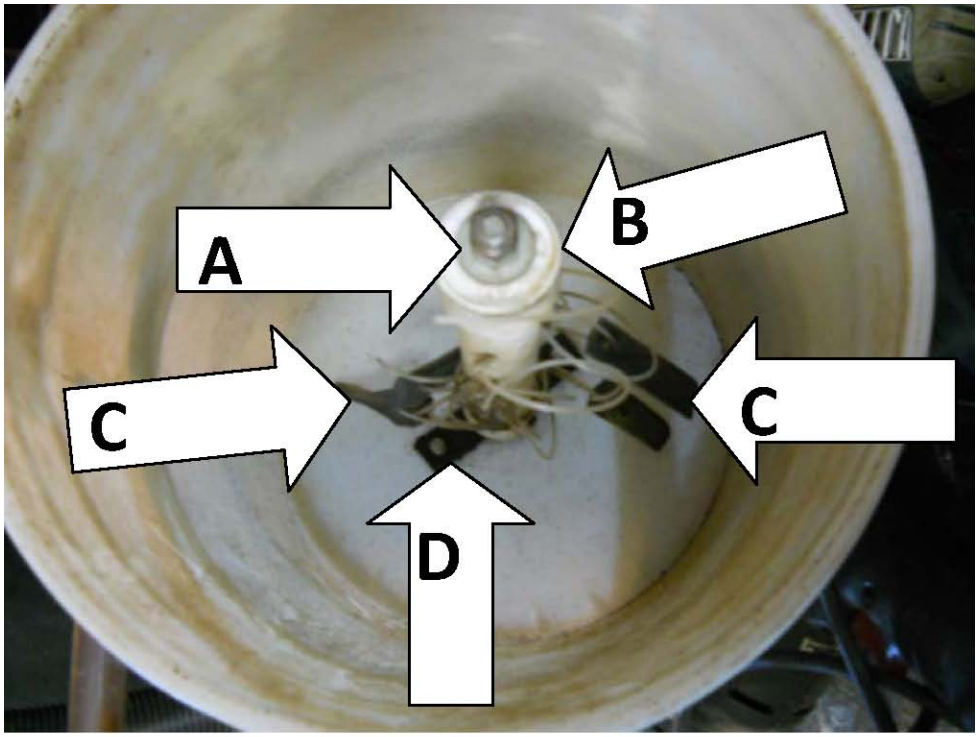

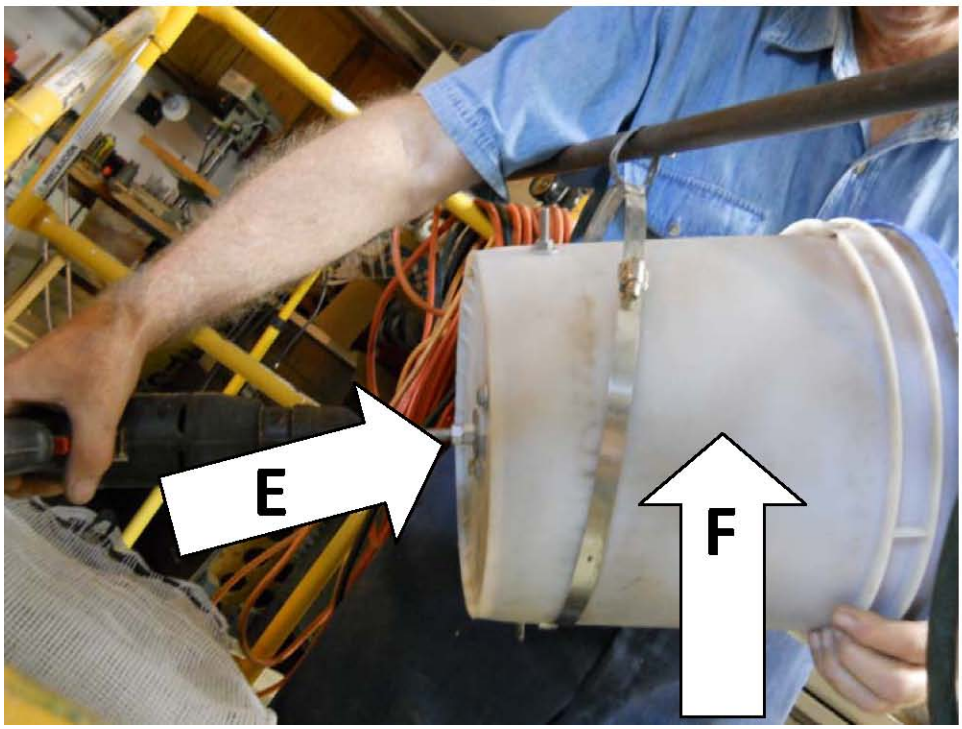

Arrow **A** – This nut and washer is attached to a long piece of 3/8 inch threaded steel that eventually attaches to a corded drill and turns the PVC spindle.

Arrow **B** – One inch diameter PVC is capped and encloses the 3/8 inch threaded steel rod. The PVC spindle provides a something solid to tie the rubber straps to.

Arrows **C** – Pieces of rubber strap are connected to trimmer line and "tied" to the PVC spindle. As the drill turns the steel rod it also turns the spindle at a high rate of speed. The rubber strap pieces tear apart the nut cluster and knock the in-shell nuts loose from the husk.

Arrow **D** – A flat piece of steel is bolted to the bottom of the bucket to provide reinforcing at the hole where the 3/8 inch threaded steel rod enters the bucket.

Arrow **E** – The bucket husker uses no bearing. A couple of washers on the bottom of the bucket and the flat piece of steel inside the bucket are all that is needed.

Arrow **F** – The angle of the bucket is important. A slight 45 degree angle keeps the nut clusters in contact with the spindle as it turns.

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HYBRID HAZELNUTS

Lois Braun[1] **& Jeff Jensen**[2] *Version 1.3, 31512*

This publication is intended to be a short introduction to growing hybrid hazelnuts. Virtually all plantings in the Upper Midwest are best described as research plantings. Ranging from conservation plantings to orchard plantings in old cow lots, the situations and circumstances are as diverse as the growers. Much of the information is based on the experiences of the authors, as well as first hand accounts and interviews with other current growers. This is not intended to be a comprehensive guide to hybrid hazelnuts but, instead, to act as an introduction.

Hybrid hazelnuts are crosses between the European hazelnut *Corylus avellana*, which was bred for large nut size and which is the basis for the commercial hazelnut industry in the Willamette Valley of Oregon and Washington, and two native American species, *Corylus americana and Corylus cornuta*, the American and beaked hazelnuts respectively, that bring winter hardiness and disease tolerance to the mix.

Unlike the European hazelnuts, these hybrids are grown as multi-stemmed bushes,

not as trees. This is important because it reduces their maintenance costs at the same time as increasing their ecological value to the landscape. These contributions include reduced soil erosion, improved water quality, improved wildlife habitat, and reduced inputs. In addition, they provide a favorable economic return to the farm family. Although still in their infancy as a commercial crop, hybrid hazelnuts have huge potential and are likely to play an important role in diversifying the landscape of the Upper Midwest.

American and beaked hazelnuts have an extensive native range, from Canada to Missouri and from the Ohio River Valley to Nebraska. Hybrid hazelnuts can be grown in many situations for a variety of reasons. Multifunctional conservation plantings such as living snowfences, riparian buffers, field windbreaks and shelterbelts provide significant ecological benefits, all while producing a crop. Because they do not require annual tillage, and because they may be grown with perennial cover between rows, hazelnuts are an ideal crop for highly erodible land. All of these situations provide much needed habitat for wildlife and increase diversity on the landscape as well as providing an economic return.

Hybrid Hazelnuts do not have the large nut size of the European Hazelnut

Uses/Markets/Commercialization

In early spring the male catkins begin to elongate to shed pollen
Photo courtesy of Roy Cerling

Currently only 20% of the hazelnuts consumed in the United States are produced in this country, so there is a large un-met market demand, which is likely to grow as new hazelnut products are developed. American consumers are most familiar with hazels as a component of gourmet party nut mixes, coffee flavoring, and in decadent chocolates, but they can also be used for cooking oil, massage oil, cosmetics, sandwich spreads similar to peanut butter, and milk substitutes. Demand is projected to grow as we become more aware of the health benefits of eating nuts: they are high in vitamins E and B-6, and in monounsaturated fatty acids, which help reduce the risk for heart disease, as well as in several phytochemicals that protect against cancer.

Hazelnuts also have potential as a bioenergy crop: with an oil content of 60%, low energetic costs of production, and a high value animal feed co-product, hazels could rival soybeans for energy produced per acre. Several current producers are growing hazelnuts for that specific purpose. They hope to produce enough oil to fuel the farm as well as provide feed to livestock for gourmet meat.

Hybrid hazelnuts have market potential but it is currently undeveloped in the Midwest. Their initial market is likely to be in oil and other processed products, because hybrids do not produce the large nuts favored for the in-shell market or for fancy nut mixes. This means that value-added processing will be required. Currently there are no commercial processors in the Midwest, but that is likely to change, however, as more people start growing them and attracting investments in processing facilities. Cooperative development of these facilities is the most promising approach.

Efforts are currently underway to commercialize hybrid hazelnuts as a 3rd crop in the Upper Midwest. To be widely adopted plants must be relatively uniform, machine plantable &

Establishment

harvestable, as well as have favorable nut characteristics. To achieve these goals research is focusing on four areas: agronomics, industry infrastructure, genetics & propagation, and harvesting & value-added processing. In addition, several growers groups are organizing to facilitate education, research and development, promotion, and to be a resource for new and existing growers.

Site Selection

Hybrid hazelnuts may be grown on marginal ground not conducive to row-crop production, such as

sites with poor soil, highly erodible slopes, or poor drainage. They have done well in soils ranging from heavy clay to sand, with pH from 5.0 to 7.5 and higher. Once established, they are capable of withstanding both drought and standing water. However, they will perform the best on deep fertile soil, and where attention can be given to their care. Targeting hazels to marginal lands, which are often the most environmentally sensitive parts of the landscape, may be a way of reaping an economic return from this land without contributing to further environmental damage. Sites that should be avoided include land that is close to woodlands, which provide habitat for marauding squirrels, and land with exceedingly compacted soils, though this can to some extent be alleviated by subsoiling before planting.

Layout

The ideal layout of a planting depends on objectives, time and money. Mature bushes may be 10 to 12 feet tall and 6 to 8 feet wide, but it takes up to eight years to attain these sizes. To develop a closed hedgerow quickly, such as is desired for living snowfences, shelterbelts, and windbreaks within-row spacing may be as close as 4 ft. between plants. Although this increases costs for planting material, it may reduce weed control costs by allowing faster canopy closure. For production plantings, a wider spacing of 6 to 9 ft is desirable to ensure access for harvest, if harvest is to be by hand, but if a mechanical harvest is planned, such as with a blueberry picker, a closer spacing of 4 to 5 feet may be better.

Between-row spacing depends on what kind of equipment will be used to mow the vegetation between rows. The width of the equipment plus an additional two to four feet to allow for bush growth is recommended. Ten feet used to be recommended, though many growers now wish they had gone with wider rows. Some growers alternate 10 or 12 ft rows with 15 or 16 ft ones to ensure access. Annual crops, such as vegetables, may be grown between rows to maximize economic returns during establishment years.

Soil Preparation

Because you can expect your hazelnut planting to live and be productive for well over fifty years, the expense of good site preparation will pay off over the long run. Several months before planting, the soil should be tested for P, K and pH, because these are most effective if incorporated into the soil and amending these is easier before planting than after. Amend soil P and K levels according to recommendations for other fruit crops, such as grapes, given in the U of M Bulletin "Nutrient Management for Commercial Fruit and Vegetable Crops in Minnesota" (BU-05886). Although hazelnuts are tolerant of low pH, it is advisable to apply lime if pH is below 5.6, using rates recommended for your state. Use dolomitic lime to supply magnesium if soils test lower than 100 ppm magnesium.

It is essential that perennial weeds, such as other woody vegetation, brambles, and quackgrass, be eliminated before planting hazelnuts, ideally the year before. This can be done with a burn-down spray of glyphosate (Roundup™), followed by plowing a few weeks later, and an additional spray of glyphosate (Roundup™). For growers who wish not to use herbicides, repetitive plowing can do the same job: plow, and then plow again when regrowth is observed. The down-side to this is that it destroys soil organic matter, may cause soil erosion, and may stimulate germination of annual weeds.

If no perennial weeds exist, plowing may be unnecessary. It is possible to simply kill sod with glyphosate (Roundup™), and plant directly into that, especially if planting will be by hand. For machine planting, however, a well-worked planting bed is essential, especially if following sod, which can interfere with the cutting disks. If the subsoil is compacted, subsoiling is recommended. The anticipated longevity of the planting justifies the cost. Two passes are recommended, one in each direction down

the planting row, followed by another operation to smooth the surface. In any case, it is never necessary to till the alleys between rows except in the case of potentially noxious perennial weeds. By leaving the alleys untilled, erosion is better controlled.

The hazel flower emerges to be pollinated; this will develop into a hazelnut cluster.

Photo courtesy of Roy Cerling

Planting Material

Currently, the only planting material available is from open pollinated seed, though research is underway to develop vegetative methods of propagation, which will mitigate the genetic variability inherent in seed stock. There are two types of seedlings currently available: "tubelings" which are 3 to 5 months old at time of transplant and which are actively growing, and "bare-root dormant", which are 10 to 14 months old when transplanted.

Tubelings can be transplanted whenever they are ready during the growing season, generally from May through early September, though planting in the searing heat of summer is not recommended. They come in sizes ranging from six to nine inches long. The larger sized seedlings generally have better developed root systems, which may confer better survival, but they may not be appropriate for machine planting.

Bare-root dormant seedlings, which are older and much more robust, must be transplanted during the early spring before they break dormancy. This leaves little time for soil preparation if it was not done the previous autumn.

Planting

Planting is best when the weather is cool and moist. If you must plant at a hot time of year, plant in the cool of the day and only if irrigation or another water source will be available immediately after planting.

Planting methods vary depending on the type of planting stock and the scale of the planting. Tubelings have very delicate root systems and should be planted with the care given to vegetable transplants: avoid breaking roots or compacting the soil too much around the newly planted seedling. Bare-root dormant seedlings are sturdier and do not need to be treated so carefully. If the seedling still has the nut attached, it is advisable to remove it before planting, because the nut is an attractant to rodents that may dig up the seedling in search of the nut.

Currently, most planting is done by hand. Simply dig a hole just a little wider than the root ball, gently pull the seedling out of the container and place it in the hole. Fill the soil back in around the roots, and water it into place. If the soil is light, or has already been worked, the only tool necessary may be a digging fork, bulb planter, or trowel. Some growers have even found that a dibble stick is adequate; for bare root dormant seedlings a "tree hoe" enables fast planting by hand. But if the soil is heavy a soil auger may be necessary for making the holes. With a dibble stick or auger, or in soils with a high clay content or which are very wet, it is important not to smear the sides of the hole, creating an impenetrable barrier for the young roots, or worse, creating a bowl in which the young seedling may drown in case of heavy rain. It is also important to plant the seedlings at the right depth. The soil-less potting mix in the

containers tends to act like a wick, drawing moisture away from the young plant if it is exposed to the air, so the seedlings must be planted deep enough to cover it with about half an inch of field soil. However, if the holes are dug too deeply, the seedlings may sink down as the soil settles. Therefore,

dig the hole just deep enough to accommodate the root ball plus half an inch, no deeper. The final step is watering to remove air pockets in the soil and to settle the soil around the roots.
For larger plantings, seedlings can be transplanted with standard vegetable transplanting machinery, such as is used for tomatoes or tobacco, but this requires a very well prepared and firm seedbed, as well as a team of workers. Bare root dormant seedlings may be planted with mechanical planters designed for other trees.

Weed Control

Research shows that young woody plants of all kinds do better with good within-row weed control. In small plantings this can be accomplished by hand, by pulling or careful hoeing of weeds. A sharp hoe that can cut through weeds at ground level is most effective and will not damage hazel roots. A weed-free area of about 1 to 1 ½ feet around each plant is desirable. Woodchip mulch and landscape fabric have been found to be beneficial by some growers, with the added benefit that they help conserve soil moisture. However, mulches can provide habitat for bark-eating mice. Landscape fabric should break down after four or five years to allow for new stems to grow through it. Black plastic mulch is not recommended. For very large plantings, mechanical weed control has been found to work, either with a regular row-crop cultivator or with specialized equipment for tree plantations, such as a Weed Badger ™. Herbicides can be used, but require extreme care to avoid getting it on the young hazelnuts.

Between rows it is desirable to either plant cover crops or allow native vegetation to grow for soil erosion control and other ecological benefits. Cool season grasses and low-growing legumes, such as clover, are best since they are less likely to compete for moisture with the hazelnuts. These can be maintained with mowing. Once the plants are well established, after about two or three years, they can compete well against weeds on their own and between-row mowing is all that should be needed.

Landscape fabric, drip tape, and mulch were used in this planting to suppress weeds and provide adequate moisture. A grass cover crop is maintained between rows.

Watering

Supplying adequate moisture to hazelnuts during the establishment year, and perhaps the year after that, is critical to their survival. Irrigation may enhance the productivity of mature bushes as well. Half an inch per week is best, if not supplied by rainfall; an inch may be needed in droughty soils. Drip hose is the most efficient way of applying water, but the most expensive. Less expensive drip tape has successfully been used by some growers. Woodchip mulch can reduce watering needs.

Fertilization

Note that these N recommendations are still under development, but they are our current best guesses.

Assuming that P and K were applied before planting, the main nutrient to be concerned about is nitrogen (N), though the N requirements of young hazelnuts are so low that fertilization is not needed in the first two years except in low organic matter soils (less than 3%). After the second year, N requirements increase with increasing size of bush according to Table 1, unless soil organic matter exceeds 4.5%, in which case apply none.

Table 1. Recommended-N rates for hybrid hazelnuts in the Upper Midwest for the first three years after transplanting.

N to Apply Year oz per plant g per plant

1 (establishment year) 0 0 2 0 to 0.18 0 to 5 3 0 to 0.36 0 to 10

• Multiply the amount needed per bush by number of plants per acre to get N application rate per acre.

For mature bushes, N recommendations are based on leaf analysis in combination with their size and observations of their vigor and yield. Low leaf N alone does not indicate N deficiency if bushes are growing and producing well. But if growth is sluggish and or leaves are pale, suspect a nitrogen deficiency and send leaf samples in to a lab for analysis. Collect 20 to 30 leaves from a bush in late July, taking the third fully expanded leaf from the tip of each of 20 to 30 stems, and apply N the following year based on Table 2:

Table 2. Recommended rate of N fertilizer to apply to established hybrid hazelnuts in the Upper Midwest based on leaf N concentrations and bush size—plants up to 7 ft in height or spread.

% leaf N		N to Apply	
		oz per cu foot of bush volume	g per cubic m of bush volume
< 1.9 %	Severely deficient	0.02 to 0.03	16 to 32
1.9 – 2.1	Slightly deficient	0.01 to 0.02	8 to 16
2.1 – 2.5	Optimal	0 to 0.01	0 to 8
> 2.5	Excessive	0	0

- Choose the lower end of the range if plants are vigorous and the higher end of the range if they are not.
- Calculate bush volume as $(\text{bush width}/2)^2 \times 3.14 \times \text{bush height}$. For large plantings, measure several bushes and average their volumes, then multiply the amount needed per bush by number of plants per acre to get N application rate per acre.

When plants reach 7 feet in height, this system of calculating N rates based on volume can lead to excessively high recommendations if the plants are slightly or severely N deficient. If more than 150 lbs of N per acre are called for, it would be best to apply only 150 lbs, then leaf sample the next July and apply more in August or the following year if deficiency is still observed.

An alternative system for figuring N rates for healthy bearing plants is to calculate the N removed with harvest and replace it. Kernels are about 4% N, but additional N is removed with husks and shells, which although not nearly as concentrated in N, comprise nearly 80% of the mass that is removed in harvest. All together, the material that is removed is about 6% N, so multiply your kernel yield (in-shell yield by shell-out rate) by 6% to determine how much N to apply; if husks and shells are returned to the planting, multiply by only 4%.

Nitrogen fertilizer is most efficiently taken up when conditions are good for growth, when the plant has most use for it. Thus it is best to apply N under conditions of good soil moisture, any time from May through August. Later applications are not harmful to the plants, but are less efficient. Apply N evenly below the plant "drip line", or at least within the row, where hazelnut roots are most likely to intercept it—no sense in fertilizing weeds between rows. Slow release forms of N fertilizer, such as tree stakes, coated urea products, or organic manures, including leguminous cover crops, are likely to increase N uptake efficiency and minimize environmental losses, though more research is needed on these.

Keep in mind that no amount of N will solve a problem caused by deficiency of other nutrients. Besides N, P, and K, other nutrients that may be deficient in hazelnuts include boron and zinc. These deficiencies can be diagnosed with leaf analysis and recommendations can be found in the Oregon nutrient management guide for hazelnuts available at:
http://extension.oregonstate.edu/catalog/pdf/em/em8786-e.pdf

Insects and Diseases

Currently hybrid hazelnuts have no insect or disease problems of sufficient concern to merit control. They have been selected at Badgersett Research Corporation to be resistant or tolerant to Eastern

Filbert Blight (EFB), the most serious disease of the European hazelnuts grown commercially in the Pacific Northwest. This disease is native to the wild hazelnut populations in this region, and thus the wild hazelnuts are naturally tolerant to it and have conferred this trait to these hybrids. They may get the disease, which appears as black cankers on older woody stems, and although it may kill an individual branch, it rarely kills the whole plant because these multi-stemmed bushes just grow replacement stems. The same is true for stem mortality caused by bronze birch borer. Big bud mite is another significant pest. This microscopic mite colonizes leaf buds, causing them to enlarge but preventing the emergence of their leaves. Genetic resistance to big bud mite is being selected for.

Other Pests

The biggest pests of hazelnuts are mammals and birds. Rabbits, deer, mice, pocket gophers, and others have all been known to nibble on hazelnut leaves, stems and roots, if only out of curiosity. Although the seedlings can tolerate a little grazing, too much can decimate a new planting. The type of protection that is best depends on what kind of animal is likely in your environment, and your own preferences. Deer fences, mesh cages, spiral tree wraps, and repellants, including a home-made egg spray, have all been found to be useful depending on the circumstances. (Details on the egg spray can be found on the Badgersett website.) Although grazing control is generally needed only through the first season or two, pocket gophers can kill pants up to five years of age and should be controlled with trapping or poison in their burrows.

Harve

At harvest time, squirrels, mice and birds, such as crows and blue jays, can be significant problems. Hawk roosts and various systems for scaring them away are necessary because they can run away with your harvest just as soon as it ripens. Timely harvest is also important, as most animals will not harvest the nuts before they are ready. Squirrels are an exception and may warrant extra control measures.

This hazelnut bush, surrounded by a clover cover crop, has some unique and beautiful purple leaves.

Hazelnut bushes will usually produce their first nuts in their fourth year, though they will not come into full nut production until year nine or later. Hazelnuts start to mature in late July in parts of Iowa; in Minnesota harvest is typically from mid-August through mid-September. Nuts should be harvested just as soon as they become loose in their husks to avoid losses to predation. In some plants this may occur when the husks are still green and moist, whereas in others it may not be until they are brown and dry. In general, if the clusters can be pulled from the bushes easily they are ready to harvest.

Currently all hazelnuts in the Midwest are harvested by hand. However, it has been found that a mechanical blueberry harvester works well on hybrid hazelnuts with no modification. This machine straddles the rows and pulls the mature nut clusters from the bushes, leaving immature ones for later harvests. As enough plantings in the region reach maturity it may be possible for growers to purchase one of these harvesters cooperatively.

Post-Harvest

If husks were still green and moist at harvest time, to avoid predation by squirrels, they need to post-ripen for a week or two in conditions of high humidity but with adequate light and air circulation. Under a sprinkler in a greenhouse or other protected location is one possibility. If the husks were starting to turn brown at harvest time they should be allowed to dry completely by spreading them out in a well-ventilated (but mouse-proof) location, hanging them in mesh onion bags, or placing them in a crop dryer at a low temperature until completely dry.

The next steps are to husk and shell the nuts. Small quantities can be husked by hand; larger quantities can be husked with a variety of home-made implements that involve beating the clusters to break the husks followed by cleaning them with an old fashioned seed cleaner. Prototypes of commercial huskers have been developed and await commercialization. The industry is waiting for a sufficient volume of production to make production of these machines worthwhile for the manufacturers. Likewise with shelling equipment, though a variety of home-scale shellers are already available.

Other Considerations

After about twelve years, hazelnut bushes will often become overly large for easy harvest, with declining yields. They can be rejuvenated by coppicing them to the ground during the winter when they are dormant. They will re-grow vigorously, and be back to full production within two or three years. Coppicing can be accomplished with a sickle-bar mower or with equipment for harvest of other woody biomass crops, such as hybrid poplar or willows. The coppiced material can be used for biomass energy. Coppicing does not have to be done on a planting all at once, but can be rotated through a planting over several years to spread out labor requirements and to ensure some harvest every year.

There are three methods of removing a hazelnut planting. Coppicing alone will not kill them, but coppicing followed by immediate application of a systemic herbicide to the stumps will kill them. A slower method is to coppice them repeatedly until they deplete their stored root reserves. Or they can be yanked out of the ground with a tractor and chain. (We hope you never really want to do this!)

References:

Olsen, J., 2001. Hazelnut Nutrient Management Guide. Oregon State University. http://extension.oregonstate.edu/catalog/pdf/em/em8786-e.pdf

Rutter, P.A. 2005. Hybrid Hazelnut Handbook. www.badgersett.com/HazHandbook1.html

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For additional information on hazelnuts and 3rd crops in general, please contact **Rural Advantage**:

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- ***Bush Foundation***
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Hybrid Hazelnut Production Timeline

	Year	Activity	When	Inputs Required
Site Preparation (Year before planting or early in planting year)	**0**	Eliminate existing vegetation	When convenient	Roundup and sprayer, or tillage equipment
		Soil test. Apply P, K and lime as needed.	When convenient	Soil test, P, K, lime and application equipment.
Establishment	**1**	Pre-plant tillage or sod burn-down	May - June or late Aug - early Sept	Roundup and sprayer, or tillage equipment
		Lay landscape fabric if planned.		Landscape fabric and landscape fabric laying machine if a large planting.
		Planting		Hand-tools (shovel, bulb planter) or mechanical transplanter.
		Watering (1/2 - 1 inch/week)	Immediately after planting into early fall.	Water wagon, drip hose, or sprinkler system.
		Within-Row Weed Control	As needed through growing season (usually 3-4 times)	Hoe, or mulch, or landscape fabric, or row-crop cultivator, or herbicides applied with a wick system or sprayer with a shield.
		Between-Row Weed Control	As needed through growing season	Mower
		Herbivore control	Immediately after planting through winter, especially in winter.	Fences or cages, repellents, bait, traps, etc.
Growing Years	**2 - 4**	Continue watering, within-row weed control, between row mowing, and herbivore control, though with diminishing intensity as plants grow and can better fend for themselves.		
	2	Leaf Sampling	Late July	Send to a lab.
	3 - 5	Fertilize	May - Aug	Fertilizer and application equipment.
Maturation	**5 – 11**	Continue mowing and fertilization as above.		
		Nut predator control	Summer	Erect hawk roosts etc.
		Harvest.	Mid-Aug.- mid-Sept	Buckets, bags, and lots of labor, or mechanical picking device.
		Dry, husk, shell and sell nuts!	When convenient (Winter)	Lots of labor or mechanical huskers, cleaners and shellers.
Coppicing	**12**	Cut bushes down.	Dormant season (Nov-March)	Sickle-bar mower, brush cutter, etc.
Regrowth	**13**	Relax! (and mow)		
	14–23 26-35 etc	Continue watering, weed control, mowing, leaf sampling, fertilizing, and harvesting as above.		

Pick-Your-Own Marketing: Right for You?

From those who know……..

Rural Advantage contacted several U-picks to gather insight into this marketing strategy. The questions we asked are below along with some of the responses.

Was your original intent to develop a PYO operation? How did it come to be?

"We started out as a CSA & added a PYO as part of the CSA package….."

"We have a PYO strawberry operation nearby but no one was doing raspberries so we decided to fill that niche……"

"We decided on a PYO because the farm we have does not have enough land for a full farm operation."

How did you decide what to grow?

"A strawberry U-pick is close to our farm and has been very successful so we decided on a raspberry PYO……"

"We decided on strawberries as there is no other field nearby. Spread out to other fruits as we saw the need for or as people asked us to supply."

"We already have a CSA and decided to start the PYO with our most labor intensive crops……."
Pick your own (PYO) is a marketing strategy that is characterized by inviting customers to the farm operation to harvest their own products, whether it be fruits, vegetables, flowers, or something else. It is often used in conjunction with the Community Supported Agriculture (CSA) model or other direct marketing strategies. It is typically used to harvest labor intensive crops like small fruits (strawberries, raspberries, etc), some vegetables (asparagus) and flowers. While a PYO option provides several benefits to the grower it also presents significant challenges. Ample research and planning should be conducted before making a decision to implement a PYO marketing strategy.

Benefits - Labor is typically the first and most obvious benefit of implementing a PYO enterprise. By having the customer come to the farm they are accomplishing the task of harvesting, sorting, and packaging their own volume. For tedious fruits and some large vegetables this can equate to substantial labor reductions for those specific tasks. However, the PYO operation will require new forms of labor. Supervision of pickers is recommended to safeguard against damage to the crop and someone to check out customers is also typical. Combined with the need for longer hours to accommodate customers it is possible that labor could be *increased* in a PYO operation with one form of labor being reduced while another is increased.

Less wasted produce or the ability to grow and market fragile foods is a less thought of benefit of U-picks. Foods like raspberries or strawberries that can "go soft" with much handling are perfect for

PYO because the customer takes it right from the farm to their kitchen within hours. Any continued handling is done by the customer in their own home.

Increased revenues can be realized with a PYO operation. This can be from reduced costs like transportation or packaging to improved prices paid for the product being marketed. Customers coming to the farm also allows for value-added revenue that could be generated from experiences offered in addition to the PYO enterprise. Animals, mazes, tours, etc. are all examples of value-added income. Likewise, t-shirts and other souvenirs can be sold to remember the "day at the farm" and enhance the experience of the visit.

What are the biggest challenges with a PYO operation?

"Our biggest challenge is signage – getting people to the correct area and making sure that nothing goes to waste."

"My biggest challenge with the PYO is patience. It takes 3 or 4 years to get blueberries & asparagus bearing & 5 or 6 years to get fruit trees bearing. The second biggest challenge is what to do with whatever doesn't get picked."

"The weather is always a challenge, but you cannot control that! The other biggest challenge is just getting people excited about coming out to pick their own fruit…..Coming out to the farm to pick takes a bit more forethought."

"The weather, specialized machinery and the cost, irrigation system, labor costs."

What suggestions would you have for someone considering getting into a PYO?

"Look at what others in the area are growing."

"Know your market and get organized."

"Do your research. Learn about the products you plan to grow. Talk to other farmers in the same field…….and talk to your customers. They don't come out to pick their own fruits/veggies to talk to a high school kid who doesn't have a clue about how things grow... they want to meet the person(s) doing the work!"

"Have a good amount of money to invest…..
…..it can be a costly hobby. Having a lot of volunteer help available helps as it requires a lot of hand labor."

Challenges - Weather is always a challenge for the grower; this is especially true with a PYO. Keep in mind that although *you* may understand that harvesting has to happen when the product is ripe, the *customer* may be thinking that harvesting happens only when it is sunny, cool, and slightly breezy – perfect conditions for any type of work. Crops with a longer harvesting window afford more margin for inclement weather; conversely a short harvesting window can be decimated by a week of rain. While you can't control the weather you can be cognizant of the affect it can have.

Another challenge is the amount of time needed before the crop comes into production; especially given that many of the crops associated with PYO's are perennials (strawberries, Christmas trees,

asparagus, raspberries, etc) and take more time than annuals to produce. Although it may not be possible to substantially speed this process, through adequate planning and proper management this time can be reduced or minimized.

Time management and long hours is another challenge for some growers. Given that the majority of homes today have two parents working, offering flexible hours in the evening, on weekends, and even holidays will be important. Even more so if you add an entertainment component to the farm visit. Customers that have to travel longer distances may want to "make a day of it" and might only be available to visit the farm on the weekend or a holiday. If you want to get their business you must plan on being open during those times.

Understanding PYO's

Pick your own operations have gone through several cycles of popularity over the decades, currently trending up in popularity along with the local food and farm2school movements. While the historical reasons for the PYO model are probably as varied as the operations in existence, the desire to purchase large quantities of fruits and vegetables for home canning and preservation are certainly at the forefront. Subsequently, as the trend for more prepared foods became prevalent and less and less time was available for canning and preserving food, PYO enterprises experienced declines in customer patronage. This move away from home canning and preserving to more prepared meals is not expected to rebound to earlier levels in the foreseeable future, however other drivers for the PYO model are present to make it a viable option for some growers.

To better understand what motivates individuals to visit PYO operations, Julie Leones, Extension Economist with the University of Arizona looked at several studies that used surveys to profile visitors from various states. The combined results shed some valuable light on several aspects of PYO operations.

It is perhaps no surprise that the predominance of women doing the shopping in the household carries through to visiting PYO's. 55% - 75% of visitors were women. Age was skewed to the under 45 age demographic and the percentage of respondents with some college education was over 60%. When asked how they learned of the PYO operation the overwhelming response was word of mouth from others. The distance traveled was also surveyed with most (75%) traveling within a 20 mile radius, although one Midwestern study showed that fully 80% were within a radius of 40 miles.

Likes and dislikes were also surveyed to gauge preferences. Common likes across studies show that quality, freshness, taste, and experience were all listed as likes and distance from home, parking, and field conditions were listed as dislikes. When asked directly what the customer wants, responses ranged from "better advertising and parking" to "better field conditions and extended service hours."

These results show that women are taking the lead in visiting PYO operations and more specifically educated women who live within a 20-40 mile radius of the farm. The word of mouth advertising reinforces the need to offer some sort of experience for the customer in order for them to be pleased and tell their friends and neighbors.

Is it right for me?

Now that you understand the benefits and challenges of PYO's and a little bit about them it is now time to ask yourself a couple of key questions to determine if a PYO option is right for you. Answering honestly will assist you in determining whether to move forward with a PYO operation.

Am I a people person? - The whole point of a PYO is to get customers to come out to your farm and participate in the labor required to consume the food they desire. This means a high level of public interaction showing customers around the farm and answering questions they may have. This is not something that all farmers are willing or cut out for. Understanding your own personality and disposition is important for success. Alternatively, some growers simply recognize this truth and manage for it. Perhaps they seek to hire individuals that have an outgoing and service oriented mentality, or rely on other workers to fill that role. In either of these cases it is prudent to remember that a customer that comes to the farm is interested in getting to know the farm and the farmer. Having someone that is not knowledgeable about the farm could turn some customers away.

Do I have the right location? - The age old saying in real estate is location, location, location. This holds particularly true with U-picks. You will need a customer base, i.e. population center, within close proximity to your farm. Although some folks are willing to drive considerable distance to access fresh fruits and vegetables, most won't. Of course there is no magic number for a minimum population to target or set distance to your farm to keep in mind. However, research results from Julie Leones, Extension Economist with the University of Arizona, who looked at several studies that profiled visitors to PYO's from various states, found that the majority (75% or greater) came from within 20 miles of the farm. In WI approximately 80% of customers came from within 40 miles of the farm.

Do I have the space? - While you will certainly need space to grow your crops, you will also need to plan for the space needed for parking, a check-out stand, bathrooms and washing stations, etc. Customers are not expecting a paved parking lot but also don't expect to be parking in mud. Reasonable accommodations should be made for parking. This could mean developing a parking area away from the fields and shuttling customers back and forth or having them park right on the farmstead. Rock and gravel are always better than grass and bare ground but individual circumstances will vary. A check out area will need to be incorporated into the PYO plan as well as restrooms and washing stations.

Getting Started

Assuming that you understand the benefits and challenges of the PYO marketing strategy, understand a little bit about how it works, and have accomplished some level of self-reflection via the above questions; a few other issues will need to be addressed before going all in.

Liability – Farm liability insurance is a crucial component protecting your farm. Accidents can and do happen no matter how careful you may be. A good first step is to simply contact your current insurance agent and talk with them about what your current coverage is. This is a good thing to do on a yearly basis, think of it as a yearly insurance review. This will allow you to update your coverage as needed while staying protected.

In general, the areas that are most pertinent to liability insurance include premise liability, employee liability, sales made at a farmers market or other location, and product liability. Your insurance agent will be able to explain each of these areas in more depth and answer specific questions you may have. In many cases additional activities can simply be added to an existing policy. In some cases a new policy or supplemental policy will be needed to be fully covered.

Pricing – Pricing your products within the PYO model can be difficult. You will need to cover costs of production at a minimum if you wish to be successful. This is an area where good record keeping really pays off. Knowing your costs of production is necessary to calculate profitability and to manage the farm. An often overlooked component of the PYO strategy is the value-added benefit or experience of coming to the farm. As a farmer you may not have a firm grasp on what this value is, and for virtually every individual it will be different. However, by allocating production costs to the value or experience component of the PYO operation you should have a better feel for what to charge. For example, if you are currently selling at a farmers market or road-side stand and wish to venture into the PYO model, the costs associated with that transition should be allocated to the experience and added value cost of developing that model. In the end, a cost of production figure can be calculated and as well as a cost of production figure for the PYO model specifically. When combined, your product pricing needs to cover the cost of both of these figures for lasting success.

References

Leones, J. (1995). Farm Outlet Customer Profiles. In Direct Farm Marketing and Tourism Handbook found at http://ag.arizona.edu/arec/pubs/dmkt/dmkt.html

Project E: Building Local Markets for Local Farmers

Mini-Markets Evaluation Table

Goal	Measure	Benchmark	Targets	Results
Increase total sales of specialty crops under the mini market project	Total specialty crops sales aggregated across all markets	$16,000 for 2008 season	$55,000	$72,600
Mini Markets provide market opportunities for a diverse group of immigrant and urban growers.	Numbers and types of farmers	18 Hmong growers; 2 beginning urban ag. growers in 2010	25- 30 growers, including additional ethnic, limited resources and	30 growers

			urban ag. growers	
New Network lead organizations have been selected through an RFP process and MOUs are established with each	Organizations selected and MOUs established		Four motivated, effectively staff neighborhood-based lead organizations are chosen and in place	MOU in place with: Kingfield Farmers Market, Minnesota FoodShare, Northeast Minneapolis Farmers Market, and the West Broadway Coalition
Leadership of mini market Network is successfully taken by community organizations	FMNP Umbrella is effectively maintained Satisfaction among Mini Market Managers with new leadership structure.	N/A	All interested markets are able to participate in WIC. Market managers' report high levels of satisfaction with new leadership structure	Leadership has been transferred. FMNP certification has been maintained with the state. All markets were FMNP-certified in 2012. Market managers report being "satisfied" to "very satisfied" with the new leadership structure.

Evaluation Table for Farm to Childcare component

Goal	Measure	Benchmark	Targets	Results
Increase sales of locally grown specialty crops to targeted facilities	Purchases of locally grown produce	No purchases of locally grown specialty crops identified prior to project.	From inception of pilot effort in June 2012 through November 2012, total procurement of locally grown specialty crops is targeted at $12,000.	Estimated purchases of 8 Minnesota grown specialty crops was $8,500 during the pilot period. (Comparison of purchases from 2011 and 2012.) We were a bit short of our goal due to weather and distribution issues cited in the main document.
Increase offerings of a diversity of locally grown specialty crops at targeted facilities	Menuing of locally grown foods	N/A	6-8 locally grown foods are menued at 8-10 childcare locations	8 locally grown specialty crops were menued at 19 childcare locations.
Pilot curriculum interventions	Use of age-appropriate curriculum at	N/A	Curriculum for 6-8 priority foods is piloted	Curriculum was developed and piloted for 8 priority foods.

related to the 6-8 priority foods	8-10 pilot locations			
Parental outreach strategies are piloted	Use of parental outreach strategies focused on the priority foods	N/A	3-5 parental outreach strategies are piloted	Five strategies were developed and implemented. (See a list of these strategies on page 3 of the main document.)
Evaluate pilot strategies and document lessons learned	Evaluation plans are developed and implemented for the 3 interventions above. Sales of Minnesota-grown Specialty Crops are tracked.	N/A	Evaluation plans are implemented, including surveys with foodservice, teachers and parents	Evaluation completed. See a summary of activities on page 3 and a summary of quantitative results on page five of the main document.

Project G

ADDITIONAL INFORMATION

Journal publications that were a result of this project (links provided to PDF files on USDA-ARS web server):

a. Spokas, K.A., Cantrell, K.B., Novak, J.M., Archer, D.W., Ippolito, J.A., Collins, H.P., Boateng, A.A., Lima, I.M., Lamb, M.C., McAloon, A.J., Lentz, O.D., Nichols, K.A. 2012 . Biochar: A synthesis of its agronomic impact beyond carbon sequestration. Journal of Environmental Quality 41(4):973-989.
b. Spokas, K.A., Novak, J.M., Venterea, R.T. 2012. Biochar's role as an alternative N-fertilizer:Ammonia capture. Plant and Soil 350(1): 35-42.
c. Fabbri, D., C. Torri and K.A. Spokas, 2012. Analytical pyrolysis of synthetic chars derived from biomass with potential agronomic application (biochar). Relationships with impacts on microbial carbon dioxide production. Journal of Analytical & Applied Pyrolysis. 93(1): 77-84.
d. Spokas, K.A., J.M. Novak, C.E. Stewart, K.B. Cantrell, M. Uchimiya, M.G. duSaire, and K.S. Ro, 2011. Qualitative analysis of volatile organic compounds on biochar. Chemosphere 85(5): 869-882.
e. Fabbri, D., A. G. Rombolà, C. Torri and K. A. Spokas "Determination of polycyclic aromatic hydrocarbons in biochar and biochar amended soil." Journal of Analytical and Applied Pyrolysis, 2012, *In press*.

Other publications that are in preparation (no volume or page # assignments yet):

a. E. Nooker, K. Spokas, R. Weis, R. Vander Wal, 2012. Impacts of biochar additions on specialty crop germination and seedling growth. *In Preparation*

(C)

Figure A1. Illustration of (A) "Deepot" growth containers, (B) seed germination trays (288 wells) on bench in greenhouse, and (C) pots in the foreground on bench with potato seeds prior to field transplanting.

Appendix 1. Overview of biochar

The name "biochar" has been receiving increased public attention, and is being hyped as a potential game changing soil amendment (Atkinson, Fitzgerald et al. 2010, Spokas, Cantrell et al. 2012). However, there are layers of undiscovered history and science that are behind the term ***biochar***.

When one examines the Google™ trends, we see that the biochar search trend has two distinct phases (Figure A2). A pre-2008 phase, with is characterized by an insignificant number of searches being conducted, resulting in no detectable search volume (volume index = 0). Then, a late 2008-2009 spike is followed by a sustained search intensity that is continued to the current day, as represented by the continual volume of Google™ search queries (Figure A2). This sudden appearance onto the global stage for the "biochar" term occurred simultaneously with the release of an Associated Press (AP) news story summarizing the research of Christoph Steiner

(from the University of Georgia at the time) on the potential of biochar to be both a climate mitigation mechanism and a potential soil improvement agent.

A)

B)

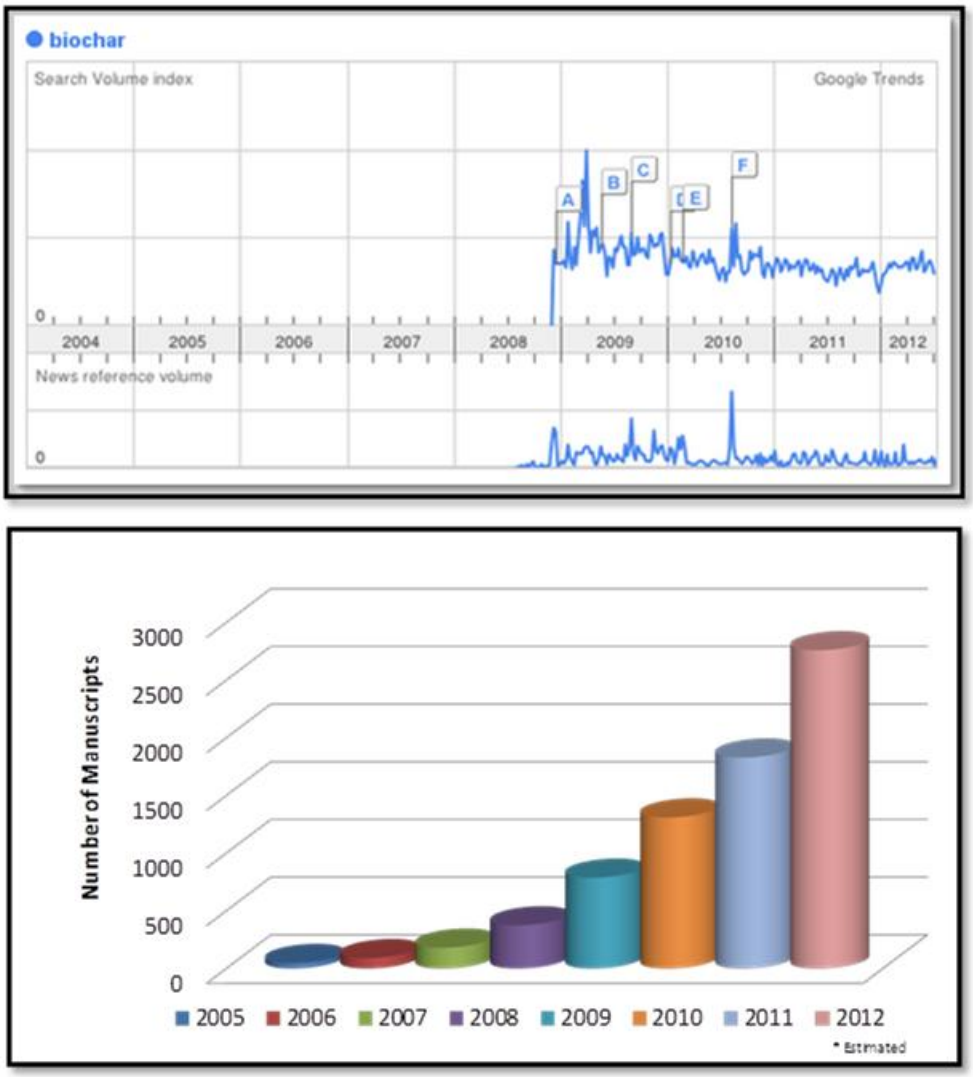

Figure A2. – a) Google™ search index trends for *biochar* and b) the number of scientific publications which include the term "*biochar*" in the recent eight years (Data from Google Scholar™).

Accompanying this growth in popular searches of biochar, have been an accompanying increase in the number of scientific publications including the term "biochar", growing from less than 10 manuscripts in 2005, to over 2700 so far in 2012 (Figure A2B, through Aug. 24, 2012; data from Google™ Scholar).

However, all of this public attention and growth of ***biochar*** has also resulted in some misinformation and confusion surrounding biochar. One example of this is in the difficulty of defining biochar. As highlighted above, biochar is the conversion of easily degradable carbon into a more stable form, or for the purpose of carbon sequestration. However, there was a study published by Abdullah and Wu (2009), that was focused on the use of *biochar as a fuel source*. Granted burning biochar is a source of renewable energy (bio-coal), but this full combustion fails to maintain the carbon sequestrating purpose since the carbon will be released and returned to the

atmosphere. Therefore, **biochar** should not be used to describe material that will eventually be used as fuel, since the focus is on the creation of a carbon sequestration benefit. Overall, biochar has generated significant interest, primarily due to three reasons:

1. Potential mitigation mechanism for combating climate change,
2. Increasing soil fertility, and
3. Bioenergy resource.

First, biochar is produced for the purpose of carbon sequestration. But unlike the graph shown in Figure A2, the use of biochar as a carbon sequestration agent did not start in 2008. This notion can be traced back in the scientific literature to the early 1980's, with the work of Goldberg (1985) and Kuhlbusch and Crutzen (1995). The hypothesis at that time was that the conversion of the biomass into a more stable product (biochar) could aid in the mitigation of increasing atmospheric CO_2 levels. This notion has been validated in the various studies on the stability of biochar (e.g. Smith, Collins et al. 2010, Zimmerman, Gao et al. 2011, Harvey, Kuo et al. 2012). However, the most important aspect of biochar is that the name refers to this carbon sequestration purpose. Therefore, the name biochar does not refer to the actual chemical composition or physical properties (Mukherjee, Zimmerman et al. 2011, Spokas, Cantrell et al. 2012), but rather to the purpose of the creation. Since different pyrolysis conditions infers different product chemical properties, different biochars are chemically unique and possessing different resistances to microbial mineralization (Spokas 2010).

Soil fertility increases have been observed following some biochar soil additions (Adams 1991, Agblevor, Beis et al. 2010, Jeffery, Verheijen et al. 2011, Vaccari, Baronti et al. 2011). Although the exact mechanisms behind these yield improvements still require study (Atkinson, Fitzgerald et al. 2010, Lehmann, Rillig et al. 2011), the observations to date support the continued examination into potential benefits from biochar, even if niche or more specialized markets need to be pursued for economic viability (Spokas, Cantrell et al. 2012).

Lastly, biochar can be a co-product of renewable bioenergy production. This does translate into lower overall conversion efficiencies for bioenergy production, since some energy is left in the solid char. There are many factors influencing the agricultural commodities market, but according to the OECD/FAO Agricultural outlook for 2012-2021,

> "*…higher oil prices are a fundamental factor behind the higher agricultural commodity price projections, affecting not only oil-related costs of production but also increasing the demand for biofuels and the agricultural feedstocks used in their production*" (OECD/FAO 2012).

This statement highlights the direct linkage of agricultural commodities and energy prices as one of the new sources of agricultural price volatility (Gouel 2012). Therefore, indicating that the price fluctuations will be tied to energy prices for the immediate future and will directly impact the economics of both specialty crop prices as well as the reuse of agricultural based co-products (e.g. biochar and bio-oil production). Therefore, we need to maximize effective strategies for agricultural production in order to meet both the food, as well as energy demands of the growing global society.

Biochar use in specialty crops production does date back to the start of modern science and

earlier (Alexander 1817). There are three major areas of past charcoal use: Specialty crop preservation, disease prevention and growth enhancements.

Some of the first documented uses of charcoal (biochar) for specialty crops was in the area of fruit and vegetable preservation. In 1865, C. Falck produced an improved "ice chest" by including charcoal filled walls (Archer 1870). This lead to both an increase in the thermal insulating property of the ice chests, but equally important was the sorption of organic vapors (smells). Charcoal also has been used in the preservation of fruit, since it was noticed that fruit and vegetables packed in charcoal could be kept for longer periods of time (Rideal 1903). Charcoal has also been used for disease prevention & non-target chemical protection. Skinner (1908) observed the increased growth of peas and lettuce in the presence of charcoal tubes. The largest increases were in poor quality, silty clay loam soils (170%). However, direct mixing of charcoal in soil did not result in the same significant increases. Durden (1849) observed that peat charcoal reduced the incidence of various root diseases in potatoes. Hitz et al. (1953) used activated charcoal for strawberry seedling protection from herbicides and this is still a use of activated charcoal today. Many of the beneficial actions of charcoal has been and still currently linked to its sorptive properties. Turner (1955) cited the sorption of "plant putrids" as a mechanism of the increase growth following charcoal additions. Weatherhead et al. (1978) successful separated and characterized some of these chemicals as plant chemical inhibitors (e.g., auxin and cytokinin) that were being sorbed by charcoal.

Appendix 2. Overview of Pyrolysis

"*Pyrolysis*" is the thermal/chemical degradation of a carbon source (biomass) in the absence of oxygen (Bridgwater, Meier et al. 1999). This alteration converts biomass into various products, which are chemically and physically different than the original material (Bridgwater, Meier et al. 1999). This process is graphically illustrated in Figure A3. These products are broadly grouped into three classifications based on their physical states:

1) Solids (biochar),

2) Liquids (bio-oil, heavy molecular weight compounds that condense when cooled down or trapped) and

3) Gaseous products (syngas, light molecular weight gases which do not condense after cooling).

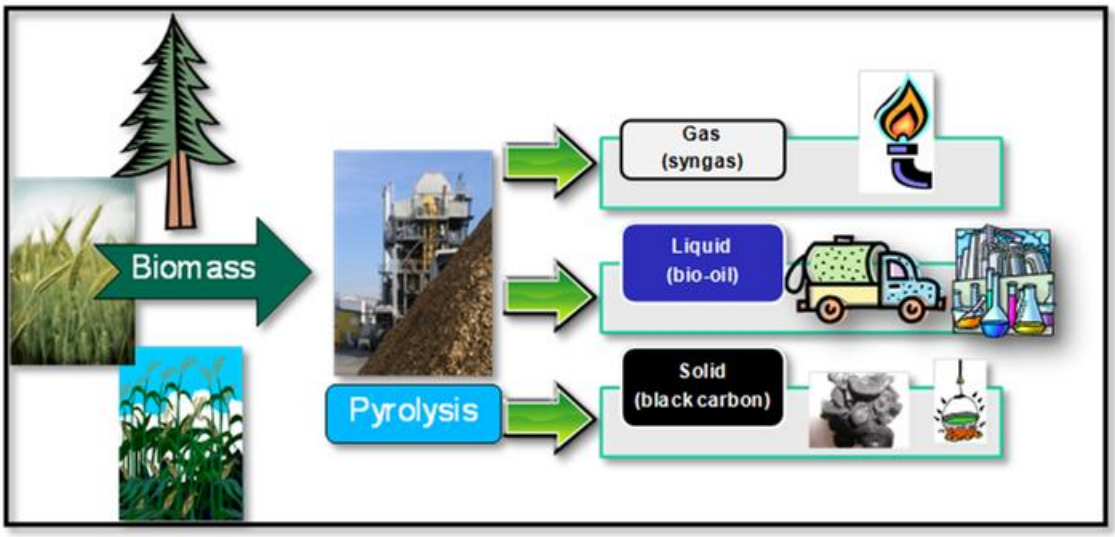

Figure A3 - Overview of biomass conversion through pyrolysis

The pyrolysis process is highly variable, which results in differences in both the chemical properties and distribution of these product groupings. These differences are both a function of the feedstock as well as the pyrolysis reactions (Shafizadeh 1968, Mok and Antal 1983, Gray, Corcoran et al. 1985, Ayache, Oberlin et al. 1990, Minkova, Razvigorova et al. 1991, Williams and Besler 1996, Butuzova, Razvigorova et al. 1998, Williams and Nugranad 2000). As of yet, there is no unified model to allow the prediction of the chemical composition or distribution of these pyrolysis products across the various platforms (i.e. Bradbury, Sakai et al. 1979, Navarro, Martínez et al. 2012). Although, advancements have occurred in lab scale units to improve the reproducibility of the pyrolysis process (e.g. Cantrell, Ro et al. 2007, Cantrell and Martin 2012, Cantrell and Martin 2012, Lin, Cho et al. 2012). Therefore, there is hope with added research to unveil the factors that influence these aspects of variability.

Even though we have utilized pyrolysis of biomass for energy from biomass in the past for energy (Hawley 1926) and there has also been reference of its use for production of a soil amendment even longer (Lefroy 1883), recent technology enhancements allows additional process control which were not possible in these past efforts. The overall renaissance in biomass pyrolysis research is largely connected to the search for renewable energy options (McKendry 2002). Biomass pyrolysis is one option which has been cited as being capable of providing future energy resources (Yaman 2004).

There are many different styles of pyrolysis which differ in the residence time of the material in the reactor. These different reactor times are given the names of slow (hours to days), fast (seconds to minutes), or flash (seconds) as indications of the relative time differences. In addition to the time in the reactor, there are differences in how heat is generated for the reactor. The traditional pyrolysis reactor utilize thermal heat, which is produced by electricity (Zhang, Chang et al. 2007). However, new advancements have also focused on utilizing microwave energy (Miura, Kaga et al. 2004, Yu, Deng et al. 2007), plasma (Shuangning, Weiming et al. 2005), or hydrothermal (Libra, Ro et al. 2011), which is a combination of steam and pressure in the reactor cell to achieve the thermal transformations. All of these methods have corresponding advantages and disadvantages (Zhang, Xu et al. 2010).

Appendix 3. PAH presence on biochar

Reformatted version of: Fabbri, D., A. G. Rombolà, C. Torri and K. A. Spokas "Determination of polycyclic aromatic hydrocarbons in biochar and biochar amended soil." Journal of Analytical and Applied Pyrolysis, 2012, *In press*.

Biochar is a co-product from biomass pyrolysis that is targeted as a material with applications in environmental and agricultural management as well as a vehicle for carbon sequestration [1]. As the interest towards biochar is steeply growing, safety procedures for ensuring human health and preservation of the environment are impelling. Polycyclic aromatic hydrocarbons (PAHs) are well known carcinogenic and persistent pollutants that are ubiquitous in the environment. PAHs are formed during the pyrolysis of biomass [2] and their occurrence in biochar [3-5] along with its possibly released into the environment need to be addressed. PAH production has also been confirmed during the production of charcoal by pyrolysis [6, 7] and wildfires [8]. Human exposure of PAHs might occur through different pathways, such as inhalation of particles during synthesis, handling and field applications of biochar, ingestion of food deriving from crops harvested in soil amended biochar. Determining the content of PAHs in biochar is of utmost importance to establish risk assessment of biochar usage.

The worldwide distribution of PAHs in soils span over five orders of magnitude and is related to source (atmospheric input) and sorption ability of soil organic matter and black carbon [9]. The inclusion of carbonaceous residues in soil could increase PAHs sorption on humic matter [10-13] and biochar [14, 15]. In this respect, soil application of biochar might represent a source and/or a sink of PAHs. All these aspects should be considered when dealing with the origin of PAHs in soil amended with biochar.

A reliable methodology of PAH analysis is a first requisite towards risk assessment. Two recent articles targeted to determine the content of PAHs in biochar have been published with the review of previous publication related to this subject [3, 4]. The reported results provided a comprehensive picture on the levels and availability of PAHs in biochar [3] as well as critical aspects of validation [4]. Both analytical methods described in these studies made use of toluene as extracting solvent. In fact, it was demonstrated that toluene is superior to other solvents for carbonaceous materials [16]. Nonetheless, extraction efficiencies are not always quantitative especially in the case of low molecular weight (LMW) PAHs in particular naphthalene, probably because of the high boiling point of toluene (111 ^{o}C) which causes the loss of semi-volatile PAHs during the preconcentration step [4].

Naphthalene is considered possibly carcinogenic to humans (IARC group 2B) and genotoxic to plants [17] and is often the most abundant PAH in biochar [3-5, 18]. Naphthalene and its isotopically labeled version are often employed in studies aimed at investigating the fate of PAHs in the environment [19-22]. In general LMW PAHs are absorbed at higher rates than HMW PAHs [21, 23], and naphthalene presence could affect the growth/response of the soil microbial community [24, 25].

Although present at lower concentrations, HMW PAHs pose the highest health and environmental hazards due to the established carcinogenic potential of this class of compounds. Because of biochar's proposed use in crops and potential human exposure of biochar PAHs through bioaccumulation in agricultural products, biochar sorbed PAH concentrations could be a matter of concern [26-28]. On the basis of their occurrence and carcinogenicity, 15 PAHs have

been identified as priority hazardous substances in food by the European Union (EU) [29] and 16 PAHs by US Environmental Protection Agency (USEPA) [30], 8 of them are shared across both lists. While studies have been reported on the occurrence of USEPA PAHs in biochar due to the widespread inclusion of these compounds in worldwide environmental legislation, very limited information is available on the occurrence of EU PAHs on biochar.

In addition, recent studies were focused on the analysis of PAHs in solely biochar, but the robustness of the solvent extraction method to extract PAHs when biochar is embedded in the soil was not fully investigated. It is important that a method developed for the analysis of pure biochar should be equally accurate for the biochar-soil matrix. In this context, the use of (cyclo)hexane/acetone mixtures as extracting solvent in PAH determination in soil is rather common (e.g. [31-33]). In fact, a relatively polar solvents like acetone is beneficial for the extraction of hydrophobic PAHs from soil [34].

The present study is aimed at developing a well characterized method for the determination of PAH in biochars and soils amended with biochar by GC-MS. To this purpose, several solvent and extraction procedures were examined using the 16 EPA PAHs as targeted PAHs on a biochar utilized in agronomic field studies [35]. The method was then applied to a set of biochars investigated as soil amendments of different origin and from different process conditions [36]. Besides the EPA PAHs, the level of EU PAHs in these biochars was investigated as well.

2. Materials and methods

2.1. Reagents and standards

Cyclohexane, acetone, acetonitrile, dichloromethane, toluene, ethyl acetate (all supra solv quality), and surrogate standard mix (for EPA 525) containing acenaphthene-d_{10}, phenanthrene-d_{10} and chrysene-d_{12} at concentrations of 500 mg l^{-1} each in acetone were purchased from Sigma-Aldrich. PAH-Mix solution containing naphthalene, acenaphtylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo[*a*]anthracene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, dibenz[*a*,*h*]anthracene, indeno[1,2,3-*cd*]pyrene and benzo[*ghi*]perylene certified at concentrations of 10 mg l^{-1} for each species in acetonitrile was purchased from Sulpeco (Belleforte, PA, USA).PAH-Mix standards in acetonitrile (10 mg l^{-1}) of EU PAHs were obtained from Dr. Ehrenstorfer GmbH (Augsburg, Germany):benzo[*a*]antracene, benzo[*b*]fluoranthene, benzo[*j*]fluoranthene, benzo[*k*]fluoranthene, benzo[*ghi*]perylene, benzo[*a*]pyrene, chrysene, cyclopenta[*c*,*d*]pyrene, dibenzo[*a*,*h*]anthracene, dibenzo[*a*,*e*]pyrene, dibenzo[*a*,*h*]pyrene, dibenzo[*a*,*i*]pyrene, dibenzo[*a*,*l*]pyrene, indeno[1,2,3-*c*,*d*]pyrene, 5-methylchrysene. Standard mix solutions containing the 15 PAHs at concentrations of 1 mg l^{-1} were prepared in acetone/cyclohexane (1:1, v/v) and stored at room temperature in the dark. A solution of 1,3,5-tri-*terz*-butylbenzene (TTB, 12.7 mg l^{-1}) in acetone:cyclohexane (1:1, v/v) was prepared by weighing the pure compound purchased from Sigma-Aldrich.

2.2 Soil and biochar samples

A natural matrix soil certified reference material ERM – CC013a (manufactured by Federal Institute for Materials Research and Testing, Berlin, Germany) containing 15 PAHs with concentrations ranging from 1.14 to 12.9 mg kg^{-1} was used for the validation of the method in

soil. An internal reference biochar sample (here named as reference biochar, or RB) was utilized for method optimization. This was a commercially available biochar from slow pyrolysis of vineyard pruning which was kindly provided by the Department of Agriculture and Environmental Sciences (DISA) University of Udine [35]. This reference biochar was homogenized mixed with an agricultural soil (dried and sieved 2 mm) at 1.16% w/w concentration level. This concentration corresponded to an application of 36 t biochar ha^{-1} (assuming a soil with 1.2 g cm^{-3} density and 0.3 m depth [5, 37] which is within the range recommended for application in agriculture (20-60 t biochar ha^{-1} [38].

Additional biochars evaluated were part of the ongoing study on the impact of biochar additions on greenhouse gas production potentials conducted by the USDA-ARS Biochar and Pyrolysis Initiative. The full characterisation of these biochars (i.e., ultimate and proximate analysis, Py-GC-MS, and microbial CO_2 production) was reported in a previous publication [36]. This group provides a cross-section of currently available biochars for agricoltural field applications.

2.3 Sample treatment

2.3.1. Optimized sample pretreatment. Soxhlet extraction and clean up

About 1 g of biochar (or 5 g soil sample) was placed into the extraction cellulose thimble, spiked with 0.1 ml of surrogate standard mix (Supelco for EPA 525 containing acenaphthene-d_{10}, phenanthrene-d_{10} and chrysene-d_{12} 5 μg ml^{-1} each in acetonitrile). The thimble was covered with cotton wool, and inserted into the Soxhlet extractor. Soxhlet extraction thimbles (and the Soxhlet apparatus) were pre-cleaned by a 4 h Soxhlet extraction with acetone/cyclohexane (1:1, v/v). Extraction was carried out with 160 ml of extraction solvents (acetone/cyclohexane (1:1, v/v)) mixture for 36 h (4 cycles h^{-1}). The Soxhlet apparatus was covered with an aluminum foil to avoid exposure to daylight, which prevents PAH photodegradation. The extraction solvent was filtered, added with 1 ml of nonane, and then carefully evaporated by rotatory vacuum evaporation at 40 °C.

The concentrated extract was collected and loaded onto a silica gel cartridge (6 ml, 1 g DSC-Si Supelco washed with ethyl acetate, dried and conditioned with 4 ml cyclohexane). After purification with 1 mL of cyclohexane, PAHs were eluted with 4 ml of acetone/cyclohexane (1:1, v/v). The obtained solution was then blown down to 10 – 50 μl under nitrogen and spiked with 10 μl of the internal standard solution (TTB at 12.7 mg l^{-1}) prior to GC-MS analysis.

2.3.2 Reflux extraction

Four different solvent systems (toluene, dichloromethane, acetone/cyclohexane 1:1 and 1:5 volume ratio) were compared by means of reflux extraction. To this purpose PAHs were extracted from the biochar (2 g reference biochar added with 0.1 ml of surrogate standard mix) by refluxing for 4 hours with 80 ml solvent. The extract was filtered and concentrated to about 100 μl by using rotary evaporator and then under nitrogen stream. The obtained solution was spiked with 10 μl of internal standard (12.7 mg l^{-1} TTB) and analyzed by GC-MS.

2.3.3 Ultrasonication extraction

Each homogenized reference biochar sample (1 g) was transferred into a Pyrex tube, and 20 ml

of acetone/cyclohexane (1:1, v/v) were added. The sample was ultrasonicated for 30 min with occasional swirling. The extraction solutions were then centrifuged and the supernatant filtered into a 50 ml beaker using a 9.0 cm GF/C glass microfibre filter (Whatman International, Maidstone, UK). The obtained solutions were reduced to 2 mL using a rotary evaporator and transferred into 4 mL vials. These solutions were further reduced using nitrogen gas, spiked with 10 µl of 12.7 mg l^{-1} TTB, and analyzed by GC-MS.

2.4. GC–MS

GC–MS analyses were performed using a 6850 Agilent HP gas chromatograph connected to a 5975 Agilent HP quadrupole mass spectrometer. Analytes were separated by a HP-5MS fused-silica capillary column (stationary phase poly[5% diphenyl/95% dimethyl]siloxane, 30 m, 0.25 mm i.d., 0.25 mm film thickness), using helium as carrier gas. Measurement solutions were injected under splitless condition with injector temperature set at 280 °C. The following thermal program was used: 50 °C to 100 °C at 20°C min^{-1}, then from 100 °C to 300 °C at 5 °C min^{-1}, then 2.5 min at 300 °C. The mass spectrometer operated under electron ionization (70 eV) and acquisition was performed on single ion monitoring (SIM) at the molecular ion of each PAH at the time windows corresponding to the elution region of the target PAH. Acenaphthene-d_{10} was utilized to quantify naphthalene, acenaphthylene, acenaphthene and fluorene; phenanthrene-d_{10} to quantify phenanthrene, anthracene, fluoranthene and pyrene; chrysene-d_{12} to quantify the remaining PAHs. Quantitation of EPA PAHs was based on the calibration curve (section 2.5), while in the case of EU PAHs a single point calibration (1 mg l^{-1}, section 2.2) was utilized.

2.5. Method Validation

The figures of merit were reported for the EPA PAHs. Recovery of surrogated PAHs were determined with respect to the internal standard TTB. The procedural blank concentrations were determined as the average of five empty thimble runs. Procedural blanks were run periodically. Precision of the procedure was determined by four replicate analyses of reference biochar sample.

Calibration was performed in the 0.0025–1.25 mg l^{-1} interval (R^2 in the 0.999–0.993 range) by serial dilutions of the 10 µg ml^{-1} EPA PAH calibration mix (Supelco). Three replicates were performed at each concentration level. Linearity was assessed using a least-squares regression line calculated from all standard concentrations and expressed by the squared correlation coefficient (R^2). Limit of detection (LOD) and limit of quantification (LOQ) were estimated for each analyte by using Eqs. (1) and (2),

Equation (1) : $LOD = 3\ s_b / a$

Equation (2) : $LOQ = 10\ s_b / a$

where s_b stands for the mean standard deviation of peak areas integrated at the retention time of the PAH from procedural blanks and a for the slope of the calibration curve. Results of LOD, LOQ and precision (%RSD) are listed in Table A1.

3. Results and discussion

3.1 Solvent selection

The choice of the extracting solvent is a crucial parameter in the analysis of PAHs in carbonised materials (soot, charcoal) because hydrophobic contaminants are tightly bound to the aromatic matrix [16]. In this study, the extraction ability of four different solvent systems was preliminary evaluated by means of reflux extraction under the same conditions. Toluene was the solvent of choice in the determination of PAHs in biochar reported in recent literature [3, 4] and therefore included in this comparison. Dichloromethane is a rather common solvent in the extraction of PAHs in several matrices, including wood chars [39]. Acetone/hexane mixtures were described in the analysis of PAHs in charcoal and soot samples [16].

The recovery of surrogate PAHs for each extraction system is reported in Table A2. Toluene is the best extracting solvent in the case of spiked d-phenanthrene and d-chrysene. This finding is in agreement with previous studies showing the strong extraction efficiency of toluene in comparison to other solvents and solvent/mixtures [4, 16]. However, in the case of spiked d-acenaphthene, dichloromethane and acetone/cyclohexane 1:1 exhibited higher extraction efficiency than toluene (83 and 80% vs. 68%). The loss of LMW PAHs in the case of toluene was caused by the analytical procedure following the extraction step, as blank analysis with toluene (resulting from solvent evaporation) confirmed a recovery of 65 ± 11% of d-acenaphthene. A similar result was reported by Hilber et al. [4], who suspected a cross-contamination by naphthalene possibly due to extended toluene removal. When examining the PAH concentrations as a function of solvent (Table A2), the detected concentrations of the low MW PAHs were the lowest with toluene (0.84 $\mu g\ g^{-1}$) and highest with acetone/cyclohexane 1/1 (1.37 $\mu g\ g^{-1}$). Therefore, the solvent mixture of acetone/cyclohexane was selected for the method optimisation, because of its superior extraction efficiency for naphthalene (the most common PAH detected on biochar; see below), its widespread use in soil analysis of PAHs, and its reduced toxicity compared to toluene and dichloromethane.

3.2 Selection of the extraction procedure

The recovery of surrogate PAHs from reflux extraction with acetone:cyclohexane 1:1 were compared with soxhlet extraction (18 hours) and ultrasonic extraction (Table A2). Ultrasonic extraction had very low recoveries (<10%) and therefore was not further investigated. As expected, the recovery of d-chrysene by soxhlet extraction increased with respect to reflux conditions. Increasing (100% v/v) or decreasing (20% v/v) the mixing ratio of acetone with respect to the 1:1 acetone:cyclohexane mixture (i.e., 50% v/v) did not significantly improve the recovery of the surrogate PAHs. Therefore, the acetone:cyclohexane mixture 1:1 was selected to investigate the effect of the extraction time on the recovery. The results, depicted in Figure A4, show that the higher recoveries were achieved with longer extraction times, which is in agreement with a previous study [4]. Interestingly, the same study showed that accelerated solvent extraction (ASE) was a less efficient than Soxhlet extraction [4]. However, prolonged extractions were problematic and did not guaranteed high recovery. We decided to focus on the behaviour of two HMW PAHs representative of five (benzo[*a*]pyrene) and six (indeno[1,2,3, *cd*]pyrene) rings as the target compounds for optimizing the extraction time (Table A2). Their concentrations increased significantly when the extraction time was increased from 18 to 36 hours, after which time the concentration remained almost constant. Thus, 36 hours of extraction were selected for the final procedure.

3.3 Final procedure applied to reference biochar and soil

The final procedure was described in detail in section 2.3.1. The EPA PAH concentrations of reference biochar are reported in Table A1 along with the relative standard deviations. A typical chromatogram is presented in Figure A5. The precision (expressed as RSD from four replicates) was rather good being within the 5 to 18% interval. The recoveries of surrogate PAHs were satisfactory (67, 77, and 88% for d-acenaphthene, d-phenenthrene, and d-chrysene, respectively, Table 2). This is considered a good result considering that PAHs are strongly associated to the aromatic carbonaceous matrix of biochar. Hilber *et al*. [4] reported 42-72% recovery range for several deuterated PAHs (from d-naphthalene to d_{12}-indeno[*1,2,3-cd*]pyrene), and similar values (56-79%) were reported by Hale *et al*. [3].

The accuracy of the method developed for biochar was tested on the certified PAH containing soil sample. The results reported in Table 3 confirm the accuracy of the method for the soil matrix. The ability of the method to analyse PAHs in the biochar once the biochar is mixed with the soil matrix was evaluated. The 1% level was selected assuming that the biochar is placed in the top 30 cm of soil and that the soil has a dry specific gravity of 1.2 g cm^{-3} and the concentration of biochar applied at the rate of 18 t ha^{-1} [37]. The obtained concentrations of PAHs in the untreated soil and in the soil amended with

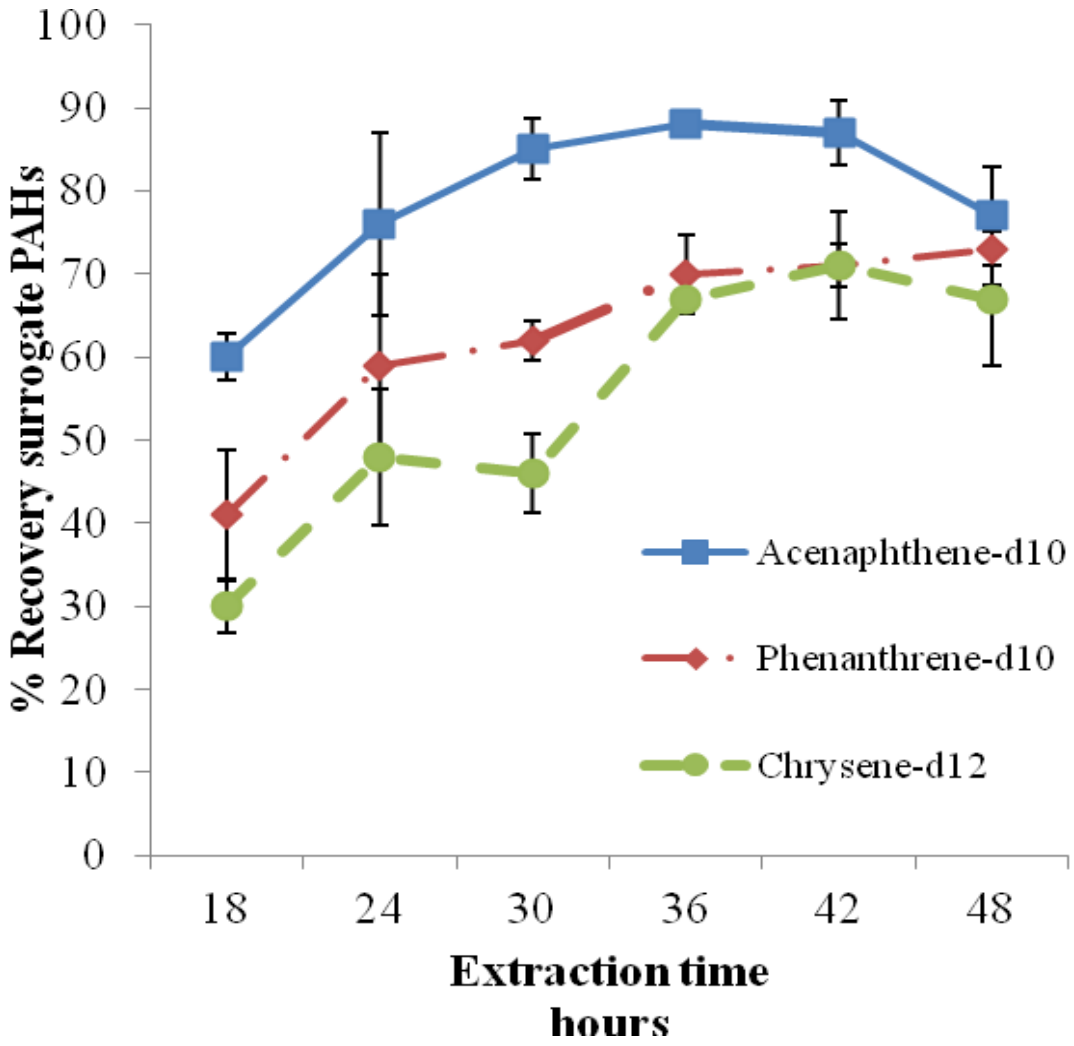

Figure A4. Recovery of perdeuterated PAHs vs. soxhlet extraction times with acetone:cyclohexane 1:1 v/v of reference biochar (mean values and 1 s.d. from three replicates).

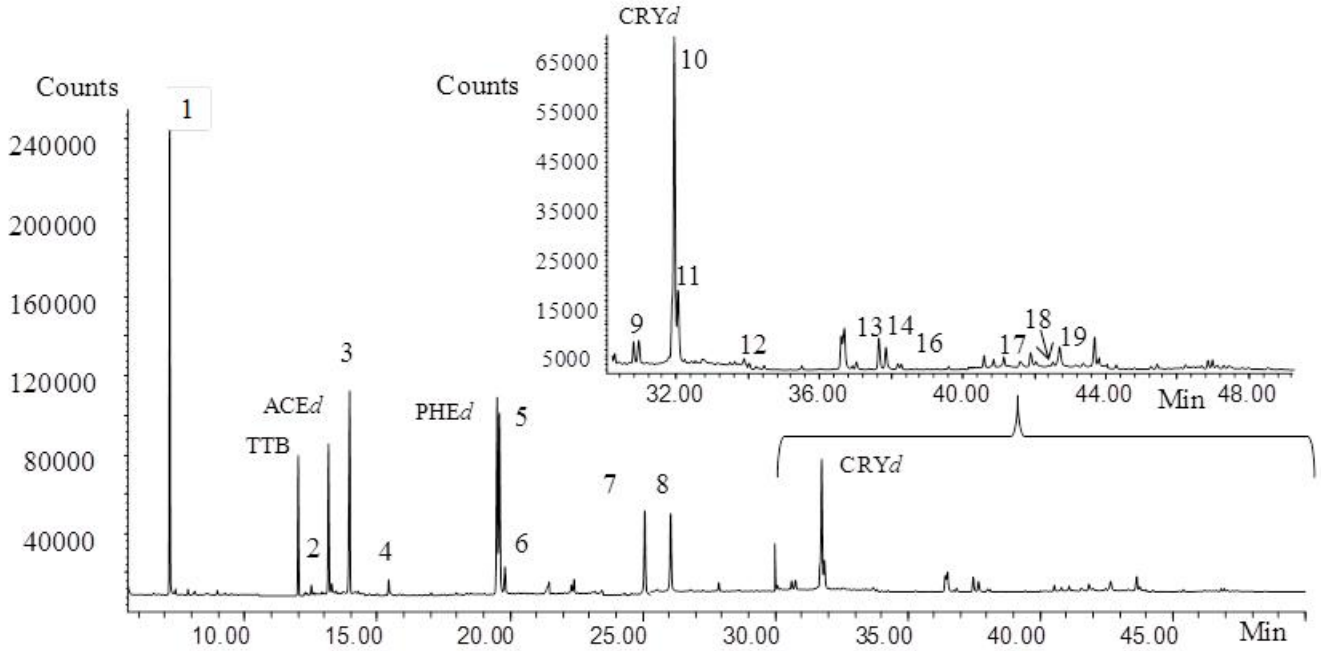

Figure A5. GC-MS (SIM) chromatogram obtained from the analysis of reference biochar. Peak numbers refers to PAHs listed in table 5.

biochar are presented in Table A4. The total PAH concentration in the amended soil is significantly higher than that in the untreated soil. In particular, the concentration of naphthalene is 0.0263 ug g^{-1} against 0.0098 ug g^{-1} in the untreated soil, a quite large difference due to naphthalene being the most abundant PAH in biochar at 1.75 ug g^{-1}. The "excess" naphthalene in the treated soil of (0.0263 – 0.0098 =) 0.0165 ug g^{-1} is slightly lower than that "expected" from the quantity of naphthalene added with biochar corresponding to (1.75*1.16% =) 0.0203 ug g^{-1}. Overall, the correspondence between the measured "excess" and "expected" is (0.0165-0.0203)/0.0203 = - 0.19 (or -19%), which is an acceptable result and a good demonstration of the accuracy of the method for low MW PAH compounds. A similar calculation was performed for the other PAHs, and the results reported in last column of Table 4 were satisfactory for the most abundant PAHs in biochar. These data support that the proposed method was capable to extract PAHs from a biochar amended soil, a PAH contaminated soil, and the original biochars.

Obviously, the effect of biochar addition in soils on the level of PAHs will depend on the background level of PAHs in the soil before treatment [40], the concentration of PAHs in the original biochar and the quantity of added biochar. Then, environmental processes (evaporation, biodegradation, or abiotic degradation) will affect the fate and levels of PAHs in amended soil. Due to the lipophilic nature of the PAHs, these compounds tend to bioaccumulate in plants [41,

42]. Leafy vegetables typically accumulate higher levels of PAHs from the soil system than companion fruit or root crops [43]. The levels of PAH observed in some of the biochars do posses levels that could be of potential health and environmental concern, depending on the application rate, original soil concentrations, and end-use for the soil.

3.4 Determination of EPA and EU PAHs in different biochar samples

The method developed in this study was applied to the determination of USEPA and EU PAHs in a suite of ten biochar investigated in a previous study [36]. With the exception of biochar S-18 and S-19 (distillers grain) and S-17 (Macadamia nut shells), all the other biochars were derived from woody biomass (Table 5). Almost all 16 USEPA PAHs were quantified in the biochars, as well as several EU PAHs, however, HMW EU PAHs were not detected. The recovery of perdeuterated PAHs ranged beween 60 to 100% (Table A3 supplementary materials) and on all-samples average 78%, 78 and 75% for d-acenaphthene, d-phenanthrene and d-chrysene, respectively, with ca. 10% RSD each.

Despite the difference in feedstock and process treatment the PAH levels were quite similar (1-18 µg g^{-1}). One sample (biochar S17) was characterised by unusual high levels of PAHs. However, the literature reports examples of biochar with much higher concentrations, some comparable to those in soot [4, 5]. A large number of biochars investigated by Hale *et al*. [3] exhibited total PAHs in the 0.07–3.27 µg g^{-1} interval when produced from slow pyrolysis from different biomass at temperatures between 250 and 900 °C, and higher values (45 µg g^{-1}) from gasification. These examples underline the variety of PAH levels that could find in biochars.

With few exceptions (S17), naphthalene was the most abundant PAH followed by phenanthrene, in accordance to previous studies [3-5]. However, it is interesting to note that benzo[*a*]pyrene was detected in all biochars analyzed here, with concentrations ranging from 0.06 to 0.19 µg g^{-1}.

Sample S-2 was biochar obtained from the fast pyrolysis of hardwood sawdust at 500 °C , while S-3 the same biochar stored 1 year in a open drum subject to climate conditions [36]. Table A3 shows that the levels of LMW PAHs did not change significantly confirming the strong sorption of PAHs to biochar. However, Hale *et al*. [3] reported that artificial aging in aqueous solutions generally increased the concentration of PAHs in biochar, probably due to the leaching of hydrophylic components leaving the more hydrophobic fraction.

Biochars S-18 and S-19 produced from the same feedstock (distiller grains) at similar pyrolysis temperatures (350 and 400 °C, respectively) exhibited significantly different PAH concentrations (total USEPA 5.0 and 2.2 µg g^{-1}) suggesting the importance of pyrolysis conditions. A general trend was observed in the literature with increasing PAH content at shorter pyrolysis times and high pyrolysis temperatures [3]. Chagger et al. [44] demonstrated through modelling that PAHs are preferentially formed in a fluidized bed reactor versus a kiln style reactor, due to unstable combustion reactions present in a fluidized bed reactor. Schimmelpfennig and Glaser have underlined the importance of the particular technological process on the sorbed PAH concentrations, with wood gasifiers associated with the highest levels of PAHs [5]. These authors proposed the naphthalene/phenanthrene ratio and the total PAHs concentrations as

factors to differentiate pyrolysis processes between biochars. These hypotheses are also supported by our data, since biochars that are created by slow pyrolysis at longer residency times in kiln style reactors possess lower sorbed amounts of PAHs compounds.

Given the values of total PAHs reported in Table A5, as well as those reported in the literature [3] for the slow pyrolysis biochars and the level of biochar applications recommended in agriculture practices, the increased levels of elevated PAHs in biochar amended soil is not of universal concern. However, as also seen in our data, some biochars do have levels of sorbed PAHs that do exceed existing guidelines for wood ash reutilization in some countries. Guidelines are emerging to establish threshold of PAHs for commercial biochar [4]. Therefore the development of validate analytical procedures for the determination of PAHs in biochar will be mandatory.

4. Conclusions

A method for the determination of PAHs in biochar was developed making use of a solvent mixture (1:1 acetone:cyclohexane) in place of more toxic and/or hazardous solvents (e.g., dichloromethane, toluene) which was appropriate for the determination of semi-volatile PAHs including naphthalene along with high molecular weight PAHs. The method was validated with a certified reference soil and demonstrated its validity for the detection of PAHs deriving from biochar in a soil matrix amended with 1% biochar. Because of the strong affinity of PAHs towards biochar, solvent and time duration of the Soxhlet extraction were crucial parameters and at least 36 hrs were necessary to obtain a satisfactory recovery with 1:1 acetone:cyclohexane. Furthermore, this method provided satisfactory recovery when applied to a wide range of biochar samples obtained at different conditions from different biomass suggesting that the acetone:cyclohexane solvent could be used across different biochar types successfully. All the biochar analysed contained the USEPA as well as some of the EU PAHs at detectable levels (ranging from 1.2 to 18.7 $\mu g\ g^{-1}$). In particular, the presence of EU PAHs on biochar could be of concern when biochars with elevated levels of PAHs are used in human food production due to the potential of contamination. However, this aspect requires further investigations.

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Table A1. Limits of detection (LOD), limits of quantification (LOD), mean concentration of EPA PAHs in reference biochar (RB) and relative standard deviations (RSD) from four replicates.

PAH	LOD ng/g	LOQ ng/g	RB µg/g	RSD %
Naphthalene	0.08	0.2	1.75	8
Acenaphtylene	0.01	0.03	0.026	13
Acenaphthene	0.03	0.1	0.034	5
Fluorene	0.03	0.1	0.071	10
Phenanthrene	0.4	1	0.71	12
Anthracene	0.03	0.1	0.13	13
Fluoranthene	0.08	0.3	0.30	11
Pyrene	0.06	0.2	0.35	11
Chrysene	0.1	0.4	0.095	9
Benzo[*a*]anthracene	0.08	0.3	0.095	9
Benzo[*b*]fluoranthene	0.2	0.5	0.13	6
Benzo[*k*]fluoranthene	0.09	0.3	0.10	18
Benzo[*a*]pyrene	0.2	0.8	0.19	14
Indeno[1,2,3-*cd*]pyrene	0.2	0.7	0.15	16
Dibenzo[*a*,*h*]anthracene	0.3	0.9	0.056	15
Benzo[*ghi*]perylene	0.1	0.4	0.15	8

Table A2. Recovery of surrogate PAHs using different extraction procedures of reference biochar.

	Acenaphthene-d_{10} recovery %	**Phenanthrene-d_{10} recovery %**	**Chrysene-d_{12} recovery %**
Reflux extraction			
Acetone/cyclohexane 1/1	80	41	7
Acetone/cyclohexane 1/5	56	38	7
Dichloromethane	83	50	11
Toluene	68	68	58
Ultrasonication extraction			
Acetone/cyclohexane 1/1	9	4	0.4
Soxhlet extraction (18 hours)			
Acetone/cyclohexane 1/1	75	66	29
Acetone/cyclohexane 5/1	76	37	10
Acetone	84	58	29
Soxhlet extraction (36 hours)			
Acetone/cyclohexane 1/1	88	77	67

Table A3. Validation of the optimized method for the soil matrix through the analysis of the certified material ERM – CC013a.

PAH	**Measured concentrationμg/g**	**Certified value μg/g**	**Relative error %**
Naphthalene	2.2 ± 0.2	2.4 ± 0.5	-9
Fluorene	1.3 ± 0.1	1.14 ± 0.11	+13
Phenanthrene	12.4 ± 0.3	12.0 ± 0.6	+2
Anthracene	2.0 ± 0.1	1.41 ± 0.22	+32
Fluoranthene	12.0 ± 0.5	12.9 ± 0.7	-9
Pyrene	8.4 ± 0.6	9.6 ± 0.3	-15
Benzo[*a*]anthracene	5.1 ± 0.3	5.6 ± 0.5	-11
Chrysene	6.3 ± 0.3	5.3 ± 0.8	+15
Benzo[*b*]fluoranthene	6.4 ± 0.4	7.1 ± 1.0	-12
Benzo[*k*]fluoranthene	4.0 ± 0.4	3.4 ± 0.4	+14
Benzo[*a*]pyrene	4.6 ± 0.4	4.9 ± 0.7	-8
Benzo[*ghi*]perylene	4.3 ± 0.7	4.6 ± 0.5	-8
Indeno[1,2,3-*cd*]pyrene	5.5 ± 0.9	5.2 ± 1.0	+3

Table A4. Concentration of PAHs in untreated soil and soil amended with 1.16% reference biochar (mean value ± 1 standard deviation from four replicates). The last column reports the concordance between the measured and expected value (the expected value is the concentration in soil calculated from the PAH concentration in biochar, table 1) expressed as percentage ((measured-expected)/expected).

PAHs	**Soil µg g^{-1}**	**Soil + biochar µg g^{-1}**	**concordance %**
Naphthalene	0.0098 ± 0.0002	0.0263 ± 0.0046	-19
Acenaphtylene	n.d.	n.d.	n.d.
Acenaphthene	n.d.	n.d.	n.d.
Fluorene	0.0023 ± 0.0008	0.0033 ± 0.0006	+13
Phenanthrene	0.0118 ± 0.0036	0.0212 ± 0.0063	+15
Anthracene	0.0003 ± 0.0002	0.0014 ± 0.0014	-24
Fluoranthene	0.0035 ± 0.0010	0.0075 ± 0.0030	+15
Pyrene	0.0031 ± 0.0007	0.0069 ± 0.0020	-6
Chrysene	0.0007 ± 0.0003	0.0014 ± 0.0010	-31
Benzo[*a*]anthracene	0.0039 ± 0.0007	0.0057 ± 0.0009	+60
Benzo[*b*]fluoranthene	0.0067 ± 0.0014	0.0091 ± 0.0029	+32
Benzo[*k*]fluoranthene	0.0005 ± 0.0001	0.0014 ± 0.0003	-51
Benzo[*a*]pyrene	0.0001 ± 0.0002	0.0019 ± 0.0009	-21
Indeno[1,2,3-*cd*]pyrene	0.0023 ± 0.0008	0.0040 ± 0.0022	-9
Dibenzo[*a,h*]anthracene	0.0009 ± 0.0002	0.0014 ± 0.0004	-18
Benzo[*ghi*]perylene	0.0046 ± 0.0011	0.0070 ± 0.0013	+36
Total	**0.0506 ± 0.017**	**0.0986 ± 0.019**	**-2**

Table A5. Concentrations of the 16 EPA PAHs and 15 EU (#) PAHs (µg g^{-1} mean of two duplicates). (RB reference biochar; characteristics of biochars from S-2 to S-20 were published elsewhere [36].

Nr.	Sample Id. / PAHs	RB	S-2	S-3	S-4	S-5	S-15	S-16	S-17	S-18	S-19	S-20
1	Naphthalene	1.75	1.57	1.71	2.39	0.44	0.47	0.93	2.58	0.78	0.49	3.36
2	Acenaphtylene	0.03	0.50	0.30	0.04	0.01	0.02	0.12	0.71	0.10	0.05	0.10
3	Acenaphthene	0.03	0.62	0.31	0.05	0.01	0.07	0.08	0.28	0.24	0.22	0.11
4	Fluorene	0.07	0.25	0.16	0.10	0.05	0.08	0.04	0.92	0.59	0.26	1.13
5	Phenanthrene	0.71	0.25	0.30	0.56	0.31	0.27	0.36	3.88	0.49	0.33	2.70
6	Anthracene	0.13	0.03	0.04	0.07	0.03	0.03	0.04	0.65	0.19	0.12	0.33
7	Fluoranthene	0.3	0.14	0.08	0.11	0.08	0.11	0.05	2.46	0.10	0.09	0.21
8	Pyrene	0.35	0.07	0.07	0.08	0.08	0.12	0.04	2.58	0.16	0.07	0.10
9	Cyclopenta[*c*,*d*]pyrene#	0.001	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.04	n.d.	0.03
10	Chrysene#	0.09	0.05	0.02	0.02	0.02	0.03	0.02	0.92	0.42	0.17	0.09
11	Benzo[*a*]anthracene#	0.09	0.04	0.02	0.05	0.04	0.04	0.02	0.83	0.46	0.08	0.17
12	5-methylchrysene#	0.01	0.11	0.04	0.02	0.02	0.02	0.09	0.27	0.21	n.d.	0.21
13	Benzo[*b*]fluoranthene#	0.13	0.02	0.05	0.04	0.04	0.05	0.02	0.70	0.29	0.05	0.07
14	Benzo[*k*]fluoranthene#	0.1	0.02	0.01	0.04	0.02	0.02	0.01	0.43	0.39	0.07	0.06
15	Benzo[*j*]fluoranthene#	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
16	Benzo[*a*]pyrene#	0.19	0.02	0.02	0.10	0.01	0.05	0.02	0.67	0.32	0.06	0.22
17	Indeno[1,2,3-*cd*]pyrene#	0.15	0.02	0.01	0.13	n.d.	0.02	0.01	0.50	0.27	n.d.	0.03
18	Dibenzo[*a*,*h*]anthracene#	0.06	0.02	0.01	0.01	0.01	0.01	0.01	0.08	0.21	0.19	0.06
19	Benzo[*ghi*]perylene#	0.15	0.01	0.01	0.01	0.01	0.02	0.01	0.53	n.d.	n.d.	0.08
20	Dibenzo[*a*,*e*]pyrene#	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
21	Dibenzo[*a*,*h*]pyrene#	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
22	Dibenzo[*a*,*i*]pyrene#	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
23	Dibenzo[*a*,*l*]pyrene#	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
	Σ 16 EPA PAHs	**4.3**	**3.6**	**3.1**	**3.8**	**1.2**	**1.4**	**1.8**	**19**	**5.0**	**2.2**	**8.8**
	# Σ 15 EU PAHs	**0.97**	**0.32**	**0.2**	**0.43**	**0.18**	**0.27**	**0.22**	**5.0**	**2.6**	**0.62**	**1.0**

Appendix 4. Sorbed Organics on Biochar

Reformatted version of: Spokas, K. A., J. M. Novak, C. E. Stewart, K. B. Cantrell, M. Uchimiya, M. G. duSaire and K. S. Ro (2011). "Qualitative analysis of volatile organic compounds on biochar." Chemosphere 85(5): 869-882.

The presence of individual volatile organic compounds (VOCs) in the soil system can have mechanistic effects by triggering various plant and microbial responses or "*soil volatilomics*" (Insam and Seewald, 2010). VOCs produced in the rhizosphere can regulate plant growth (Simms and Rausher, 1987; Ryu et al., 2003; Kloepper et al., 2004; Baldwin et al., 2006; Zhang et al., 2007) as well as microbial processes (Klinke et al., 2004; Almeida et al., 2009; Graber et al., 2010). These studies have shown that even low VOC concentrations (μg m^{-3}) can have a significant impact on the well-being of plants, impacting seed germination, herbivore resistance, invasive plant responses, and nutrient uptake. VOCs also control the ability of soil micro- and macro-organisms to participate in abiotic and biotic reactions known to influence soil quality (Insam and Seewald, 2010).

During biochar production, VOCs are produced regardless of the process used (Olsson et al., 2003; Olsson et al., 2004; Chouchene et al., 2010; Mun and Ku, 2010; Song and Peng, 2010). These VOCs are formed during pyrolysis by the breakdown or rearrangement of the original biomass chemical structures (Demirbas, 2000; Zeng et al., 2011). Pyrazines, pyridines, pyrroles and furans were the typical classes of volatile compounds observed during the pyrolysis of chitosan (Zeng et al., 2011) and glucosamine (Chen and Ho, 1988). These volatile compounds are typically trapped and condensed into the liquid fraction (bio-oil) product (Boateng et al., 2007; Yu et al., 2007). In bio-oil, the most frequent compounds observed include: methanol, acetic acid, acetone, methyl acetone, acetaldehyde, furan, furfural, and volatile organic acids (Mullen et al., 2010; Tiilikkala et al., 2010). Other studies have confirmed the presence of these compounds in wood vinegar (condensates of wood smoke from pyrolysis), which historically is used for its herbicide and pesticide properties (Orihashi et al., 2001; Yatagai et al., 2002). VOCs re-condensed as liquids during the pyrolysis process are known to cause mixed impacts on plant growth as a function of production conditions and application amount (Mu et al., 2004; Mu et al., 2006). In particular, phenols present in these liquid distillates are speculated to be responsible for these negative plant-growth impacts (Mun and Ku, 2010).

Although VOCs from biochar have the potential to mediate profound changes in the soil gas atmosphere, very few studies have examined the chemical nature of VOCs associated with biochar. Previous chemical characterizations of biochar have primarily used pyrolysis with generated vapors swept into a GC/MS (Py-GC/MS) to monitor the degree of solid alteration occurring (Galipo et al., 1998). However, since high temperatures (550-800 ^{o}C) are used, this analytical technique further thermally alters the sample (Kaal and Rumpel, 2009). Therefore, it is difficult to distinguish whether the compounds observed are break-down products due to the analytical pyrolysis conditions or sorbed originally to the material, which complicates the quantitative nature of this technique (Kaal et al., 2008; Kaal and Rumpel, 2009). Despite these limitations, Py-GC/MS has confirmed the presence of polyaromatic hydrocarbons (PAHs) on biochar (Rumpel et al., 2007).

Some of the VOCs released from biochar potentially can both stimulate and reduce plant productivity (Deenik et al., 2010) and microbial processes (Graber et al., 2010; Khodadad et al., 2011), due to VOC chemical composition. Clough et al. (2010) observed acetaldehydye, α-

pinene, β-pinene, and trans-pinocarveol using an automated headspace solid-phase micro-extraction (SPME) gas chromatography-mass spectrometry (GC/MS) analysis of a slow pyrolysis wood biochar. Graber et al. (2010) hypothesized that sorbed VOCs were capable of disease suppression in pepper and tomato plants in soilless media treated with biochar. Spokas et al. (2010) quantified varying ethylene production rates originating from different biochars. The authors speculated that this ethylene could be involved in both the plant responses (fine root hair development) and soil microbial responses observed from biochar additions. Furthermore, both ethylene (McCarty and Bremner, 1991) and α-pinene (Clough et al., 2010) can act as nitrification inhibitors. Sorbed VOCs on biochar have also been implicated in negative impacts on plant germination and growth (Vantsis and Bond, 1950; Turner, 1955; Kadota and Niimi, 2004; Deenik et al., 2010; Free et al., 2010). Even though these studies focused on different VOC compounds and soil processes, the overall conclusions suggest a mixed role of VOCs in the plant-soil system; with individual compounds serving as inhibitors or stimulants to biological systems following biochar amendments.

It has been well established that biochar chemistry and yields varies considerably with production process conditions (Novak et al., 2009; Keiluweit et al., 2010; Lee et al., 2010) and surface oxidation (i.e., activation, aging, weathering) (Boehm et al., 2004; Yao et al., 2010). The yield of biochar is particularly influenced by the feedstock's initial moisture content, ash content, and elemental composition (Gray et al., 1985). Previously, attention to VOC contents has been focused on the bio-oil because of its influence on marketability and post-collection processing (Bridgwater et al., 1999; Mohan et al., 2006; Boateng et al., 2010; Shuping et al., 2010).

The linkage between VOC associated with biochar to microbial and plant responses is agriculturally and environmentally important. Unfortunately, there is limited information on the impact of various feedstocks, production conditions and different pyrolysis technologies on the chemical characteristics of sorbed VOCs associated with these biochars. Moreover, this could be an important consequence when selecting biochar to improve soil quality (Lehmann, 2007; Laird, 2008; Novak and Busscher, 2011). Therefore, our objectives were to evaluate the effects of feedstock, pyrolysis technology, and pyrolysis temperatures on the qualitative properties of sorbed VOCs on biochar.

2.0 Material and Methods

2.1 Biochar production processes

Biochars were obtained from a variety of commercial and research sources[3] because it was postulated that VOC profiles associated with the biochars would correspondingly be diverse. The biochars were manufactured under an array of production levels, including homemade, laboratory, and pilot scale pyrolysis equipment. Exact production parameters were not known for all biochars, due to the fact that some of the biochars were created in pyrolysis units lacking industrial process monitoring equipment. Nevertheless, these biochars were included among the employed suite to capture irregularity in the types of biochar currently available. There were a total of 77 different biochars evaluated in this study (Table 1). All biochars were evaluated as received from the various suppliers. Each supplier, or pyrolysis unit, is designated in the unit column, with similar labels designating the same pyrolysis unit. To produce the biochars, an assortment of conversion technologies were used, including; fast pyrolysis (3), slow pyrolysis (46), traditional methods (4), gasification (5), wood fired boilers (6), microwave assisted

[3] - Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

pyrolysis (4), hydrothermal carbonization (4), and activated carbons (5). The two types of traditional pyrolysis (fast and slow) biochars were both created in some type of engineered unit, typically under anaerobic conditions by an inert gas purge. These biochars were further divided based on the residence time of the material in the reactor chamber, with fast designating less than 15 min and slow greater than 15 min (Table 1). Traditional soil kiln methods were biochars that were created in the absence of an engineered unit, such as a soil mound or soil pit. Gasifier biochars were those produced under elevated temperatures with no efforts to exclude oxygen from the reaction chamber (i.e., no inert gas purge). Wood boiler biochars are a special sub-set of gasifier biochars, since these were all created in wood fired boilers, which are common in the paper and pulp industry (Etiégni and Campbell, 1991). Microwave assisted pyrolysis biochars were those created with microwave energy for pyrolysis heating (Wan et al., 2009). Hydrothermal carbonization (HTC) biochars were produced under lower temperatures (200 - 250 ^{o}C) and elevated steam/water pressures to carbonize the biomass material (Cao et al., 2011; Libra et al., 2011). Select activated carbons were included as examples of biochar that underwent further chemical and/or thermal processing after production (Azargohar and Dalai, 2006; Ippolito et al., 2011).

Biochar pH was determined in a 1:5 (1 g biochar to 5 mL distilled water) slurry. Proximate (ASTM D121/ D5142/D7582) and ultimate analyses (ASTM D5373/D3176) were performed by Hazen Research (Golden, CO) and N_2 BET surface area (Brunauer et al., 1938) analyses were performed by the USGS (D. Rutherford, Boulder, CO) and Material Synergy (Oxnard, CA), if equivalent data was not available for the particular biochar. Not all biochars were fully characterized due to lack of material needed for these assessments.

2.2 Headspace Thermal Desorption- Gas Chromatographic-Mass Spectrometer System

The use of headspace instrumentation is common for the analysis of sorbed compounds on charcoal sample tubes (Canela and Muehleisen, 1986; Gan et al., 1994; Risholm-Sundman et al., 1998; Kusch and Knupp, 2004). Therefore, headspace instrumentation would be an ideal tool for the analysis of sorbed VOCs on biochar, and has been used in one existing study (Bernardo et al., 2010).

To analyze the chemical composition of sorbed VOCs associated with biochars, a headspace sampler (HP-7694; Agilent, Santa Clara, CA) was modified through the use of a 10-port diaphragm valve (DV22-2110; Valco Instruments Co., Inc.; Houston, TX) to allow the introduction of two simultaneous gas samples from a single headspace venting to two different analytical GC columns. The effluent from one of the columns [RTX-624 (60 m × 0.32 mm ID), Restek Corp.; Bellefonte, PA] was directed to a mass spectrometer (MS) detector (Clarus P600; Perkin-Elmer; Waltham, MA) and the other column's effluent [Porapak Q (6.4 mm × 1.8 m); Restek Corp.; Bellefonte, PA] was connected directly to a thermal conductivity detector (TCD), which was in series with a flame ionization detector (FID). The GC and MS instruments were controlled through TurboMass software (Perkin-Elmer; Waltham, MA), and the TCD and FID signals were collected via a interface box (Perkin-Elmer 900; Perkin-Elmer, Waltham, MA) using TotalChrom software (ver. 2.2; Perkin-Elmer; Waltham, MA). In this fashion, the carbon dioxide (CO_2) evolved during heating and the corresponding light weight volatiles (C_1 – C_4 compounds) could be quantified that would otherwise be lost in the air/water peak on the MS. The VOCs analyzed in this study were desorbed thermally from the biochars, we did not use any solvents on the biochars to extract VOCs. The overall settings and conditions of the system are provided in Table S1 (Supplementary material).

Typically, 0.5 g biochar samples were placed into a 10 mL headspace vial (#5182-0838, Agilent, Santa Clara, CA) and sealed with Teflon-lined high-temperature silicone septa (#22831, Restek Corp.; Bellefonte, PA). For headspace methods, vial temperature and equilibration time are the most vital for method development (Friant and Suffet, 1979; Penton, 1992). For the analysis here, biochar samples were thermally heated to 150 ^{o}C for 10 min in a sealed headspace vial prior to injection. These conditions were selected based on preliminary experiments across several biochars. However, there was no single optimum desorption temperature for all biochars. To collect data that would be universal across all biochars (i.e., compounds that are thermally desorbed under set conditions), a fixed thermal desorption temperature of 150 ^{o}C was selected, which is similar to other studies using headspace methods for charcoal desorption (e.g., Markelov and Bershevits 2001; Candole et al., 2007). Furthermore, a desorption time of 10 min was used to minimize the pressure build up in the vial resulting from the variable water content of the biochars, which is a significant difficulty in headspace analyses (Novotny et al., 1974; Bicchi et al., 2008).

Qualitative peak identification was conducted by comparing the collected ion spectra to the reference spectral library (NIST; Perkin-Elmer; Waltham, MA). Peak retention times and library spectral identification was confirmed with external liquid standards (AccuStandard; New Haven, CT), which were injected as a liquid (<5 µL) into a sealed headspace vial and analyzed under the same conditions (Table S1, Supplementary material). Only qualitative analyses were conducted, due to the high number of identified peaks that lead to overlapping and co-eluting interferences. In addition, extraction efficiency of VOCs from charcoal (biochar) was known to be a function of the compound and biochar (Raguso and Pellmyr, 1998), which leads to dissimilar extraction efficiencies for various biochars. Therefore, further refinement in the analytical technique is needed before accurate quantification can be accomplished by headspace methodology. An 85% level of certainty in the spectral match criteria was used as a cut-off for spectral identification.

Samples vials were run with corresponding air blank vials to avoid cross-contamination and establish laboratory VOC baselines. If the biochar's integrated compound area was significantly greater than the corresponding compound in the air blank sample, the resulting identified peak was retained in the table. On the other hand, if the integrated area was not significantly different than the air blank control, these compounds were flagged as not-detected. In this fashion, potential VOCs present in the laboratory air or septa contamination were accounted for.

Chemical data were averaged across biochar production styles. These means were compared utilizing a one-way analysis of variance (InStat, GraphPad Software) to determine if statistical ($P < 0.05$) differences existed in chemical properties as a function of pyrolysis production technique.

3.0 Results

3.1 Chemical and physical biochar analyses

There was an assortment in the chemical analyses of the biochars evaluated here. The biochars possessed a range of 1 to 95% total carbon, 0.5 to 43.9% volatile matter content, 0.3 to 96% ash, 0.1 to 7.4% nitrogen, <0.1 to 1661 m^2 g^{-1} BET surface areas, 0-63% moisture, and a range of pyrolysis temperatures from 200 to >800 ^{o}C (Table 1). Overall, pH values ranged from 3.3 to 10, with significant differences among production styles ($P<0.05$). Gasifier biochars were typically alkaline, hydrothermal biochars were acidic, fast pyrolysis biochars were near neutral pH values, and the slow pyrolysis biochars ranged from acidic to alkaline (pH 4 to 10) (Table 1).

There were also significant differences in the total residual carbon as a function of the type of pyrolysis ($P<0.05$). Biochars produced through gasification had low carbon contents, which would indicate oxygen presence during the heating allowing for combustion to CO_2. As expected, the activated carbons consistently possessed the highest total carbon contents (90.7 ± 5.1%) and surface areas (1130 ± 360 m^2 g^{-1}). The most common technique used to produce the biochars here was slow pyrolysis, which also was the technique with the highest variability in all assessments, resulting in no clear distinction in chemical characteristics for the slow pyrolysis biochars.

3.2 Biochar headspace desorption VOC profiles

The only consistently identified contaminant on the GC/MS scans was 1,1,1,5,5,5-hexamethyl-3-(trimethylsilyl) trisiloxane, which originated from the septa (silicone). This peak showed up in all samples in varying amounts (retention time = 28.3 min). Atmospheric methane was also a contaminant in all samples due to its presence in lab air. However, the value for methane in the control lab air blanks was subtracted from the biochar area to correct for its interference. Occasional peaks for ethanol, methanol, and dichloromethane (solvents in use in the lab building) were identified in the air samples. However, no correction was required, since the focus was on qualitative detection, with detected biochar compounds typically exceeding these background levels by an order of magnitude.

We observed differences in VOC profiles from biochars created from different pyrolysis production units with equivalent feedstock and pyrolysis temperatures. There were 77 compounds positively identified in this study (Table S2, Supplementary material), with the remainder of the chromatographic peaks insufficiently characterized through a mass spectral match to positively identify the target compounds. Figure 1 illustrates the differences in the GC/MS thermal desorption total ion chromatograms (TIC) obtained from a similar feedstock (oak hardwood) across five pyrolysis production platforms, ranging from slow (BC21; 538 ^{o}C; Fig. 1A), slow (BC42; 550 ^{o}C; Fig. 1B), fast (BC2; 500 ^{o}C; Fig. 1C), limited oxygen supply gasifier (BC54; unknown; Fig. 1D) and traditional soil mound (BC50; 400-600 ^{o}C; Fig. 1E). The corresponding retention times (RT) of the identified compounds are listed in Table S2 (Supplemental Information). Even though quantitative analysis was not conducted, the differences in the peak height would be proportional to thermally desorbed concentrations for equivalent compounds. Samples BC21 (Fig. 1A) and BC2 (Fig. 1C) possessed a high number of sorbed VOCs of differing amounts. Both of these pyrolysis units utilized an inert gas stream purging the reaction chamber during production and equivalent final production temperatures (540-550 ^{o}C). For BC21, the most prevalent VOC identified was acetone (9.7 min), followed by methyl ethyl ketone (14.2 min; Fig. 1A); whereas for sample BC2, methyl acetate (10.8 min) occurred in the highest abundance followed by acetone (9.7 min; Fig. 1C). On the other hand, samples BC42 (Fig. 1B), BC54 (Fig. 1D), and BC50 (Fig. 1E) had significantly lower sorbed volatiles than the fast (Fig. 1A) and other slow pyrolysis unit (Fig. 1C). The most prevalent VOCs in samples BC54 and BC50 were acetone (9.7 min) and benzene (16.3 min). Both benzene (16.3 min) and trichloroethene (17.9 min) were most abundant in BC42, with all compounds being significantly lower than BC21 and BC2 (Fig. 1). Due to the unknown production temperature (lack of process monitoring equipment), the differences observed in BC54 and BC50 could be attributed to pyrolysis temperature differences rather than solely residence time. However, these results do suggest that feedstock is probably not the primary determining factor for sorbed VOCs profiles in this dataset.

The presence of oxygen in the pyrolysis unit appears to be a controlling factor in the

number and amount of sorbed volatiles. Increasing oxygen presence during pyrolysis (B21, B2; both with inert gas purging) to gasification (B54; higher oxygen presence) resulted in a decrease in sorbed VOCs (Fig. 1). The oxygen level similarly influenced the sorbed VOCs characteristics for slow pyrolysis biochars compared to the traditional soil kiln biochar (produced for a period of time

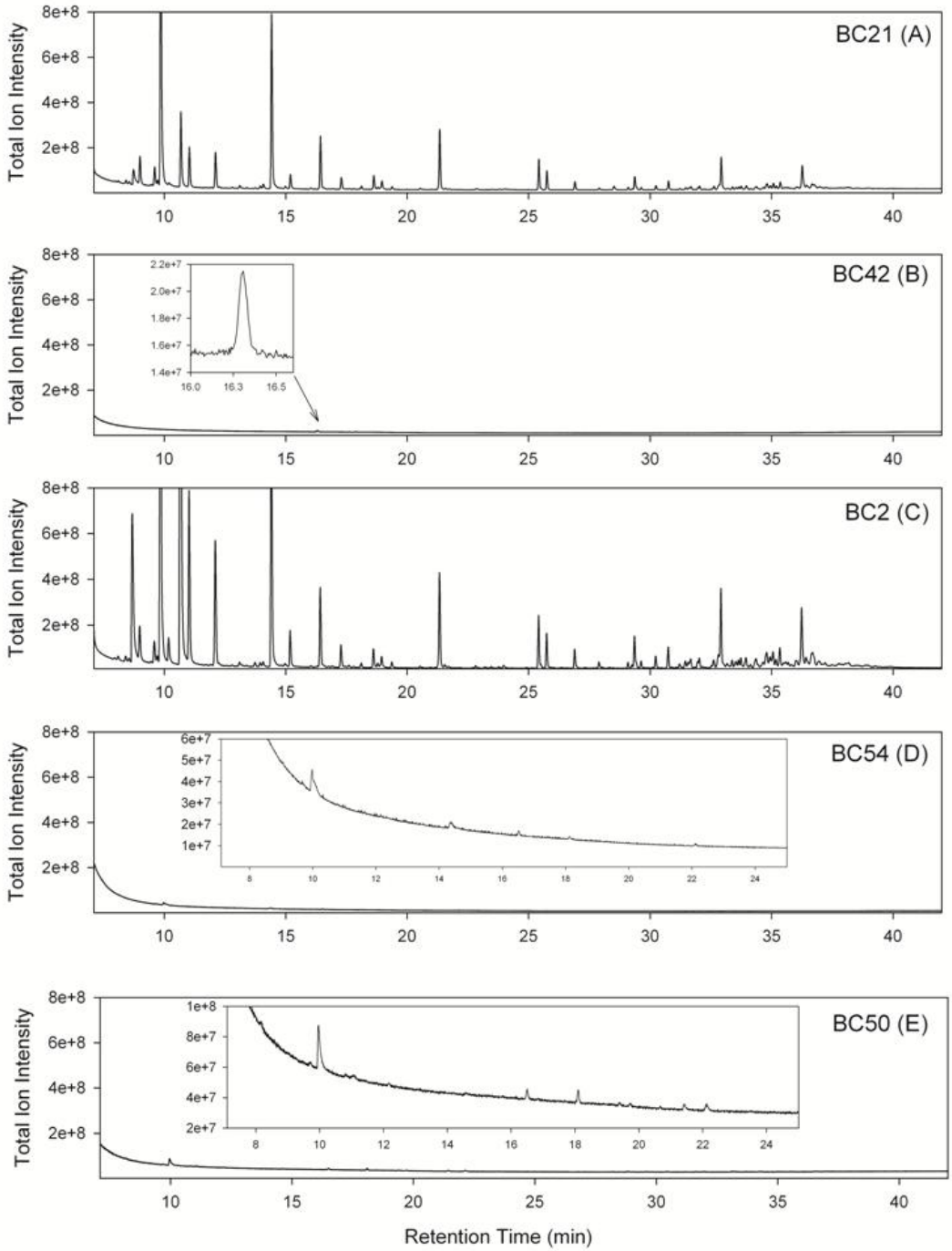

Figure 1. Images of the total ion chromatograms from the thermal desorption GC/MS analysis of five different oak hardwood biochars: (A) Slow pyrolysis (BC21), (B) Slow pyrolysis (BC42), (C) Fast pyrolysis (BC2), (D) Gasifier (BC54), and (E) Tradition soil mound kiln (BC50) production methods. All chromatograms are scaled equally, with the inset chromatograms showing the rescaled chromatogram. All pyrolysis techniques had nearly equivalent production temperatures in oxygen presence, prior to burial). However, detailed data on the oxygen content during pyrolysis was not directly collected during the production of the various biochars used here.

Despite equivalent feedstock and pyrolysis conditions, we observed substantially different biochar sorbed VOCs from the diverse pyrolysis facilities. Figure 2 illustrates the differences in sorbed volatiles on corn stover biochar from four different slow pyrolysis facilities (BC 4, 7, 8, and 11), produced at nearly equivalent temperatures (410-515 ^{o}C). These four corn stover biochars possessed drastically different concentration and distribution of sorbed VOCs as a function of the pyrolysis facility, which was similar to the observations for the two slow pyrolysis biochars of oak hardwood (Fig. 1B and 1C). These differences exist despite the fact that pyrolysis conditions were similar for these biochars (Table 1). Sample BC4 contained the most abundant sorbed volatiles, which were dominated by furan (8.8 min), acetone (9.7 min), and methyl acetate (10.8 min), which was produced at the highest temperature (515 ^{o}C). In contrast, sample BC7 was lower in total sorbed species, with benzene (16.3 min), toluene (21.1 min), and acetone (9.7 min) being the most prevalent. Likewise, sample BC8 had acetone (9.7 min) in the greatest abundance followed by 1-dodecane (36.1 min). BC11 had extremely low VOC levels, which were characterized by benzene (16.3 min) and methyl acetate (10.8 min) being the largest peaks. These results illustrate the striking dissimilarity in VOC compositional chemistry among the four biochars made from the same feedstock and pyrolysis conditions.

There was also substantial variability in VOC profiles between pyrolysis temperatures using a single feedstock on the same pyrolysis unit. Figure 3 illustrates the TIC chromatograms for waste cottonseed hull (containing both hull and cottonseed) pyrolyzed at 800, 650, 500, 350, and 200 ^{o}C for 4 h under a nitrogen flow (BC 44-48), on the same slow pyrolysis unit. The biochar with the highest sorbed content of VOCs was the biochar produced at the lowest temperature (BC44; 200 ^{o}C; Fig. 3E). This biochar was characterized by high proportions of short-chain aldehydes and furans, with the three most dominant compounds being 2-propanal (9.2 min), ethyl acetate (12.5 min), and 2-hexenal (26.5 min). The next temperature step (350 ^{o}C; BC45), showed overall decreases in the amount of longer (6-7 carbon) chain aldehydes to shorter chain aldehydes and ketones, with propanal (9.4 min), acetone (9.7 min), and methyl ethyl ketone (14.2 min) comprising the most dominant peaks. At 500 ^{o}C (BC46), the three most abundant compounds were dodecane (36.1 min), toluene (21.1 min), and benzylaldehyde (31.2 min). At 650 ^{o}C (BC47) the overall quantities of sorbed volatiles decreased due to the reduced peak magnitude observed in the TIC (Fig. 3B). The largest three peaks at this temperature were unidentifiable compounds. Background spectra subtraction did not aid in their identification, suggesting co-eluting compounds impacting the spectral comparisons. At 800 ^{o}C (BC48), the biochar had very low quantities of sorbed volatiles, as indicated by reduced peak magnitudes (Fig. 3A). The three VOCs that had the highest peak areas were toluene (21.1 min), octanal (31.6 min), and potentially 4-methyloctane (R^2=78%; 34 min).

Although there were substantial variability between pyrolysis units and feedstock (Fig. 1-2), there were some trends in sorbed VOC compounds as a function of production temperature from the same feedstock with the same pyrolysis unit. Figure 4 illustrates the abundance trends (relative TIC peak areas) for a few select compounds for cottonseed hull (containing both hull and cottonseed) pyrolyzed at 200, 350, 500, 650, and 800 ^{o}C. The abundance of sorbed toluene (21.1 min) (Fig. 4a) was maximum at the lowest temperature (BC44; 200 ^{o}C), and decreased with increasing temperature to 800 ^{o}C (BC48). However, not all VOCs follow this decreasing trend as a function of production temperatures. For instance, the initial detection of benzene

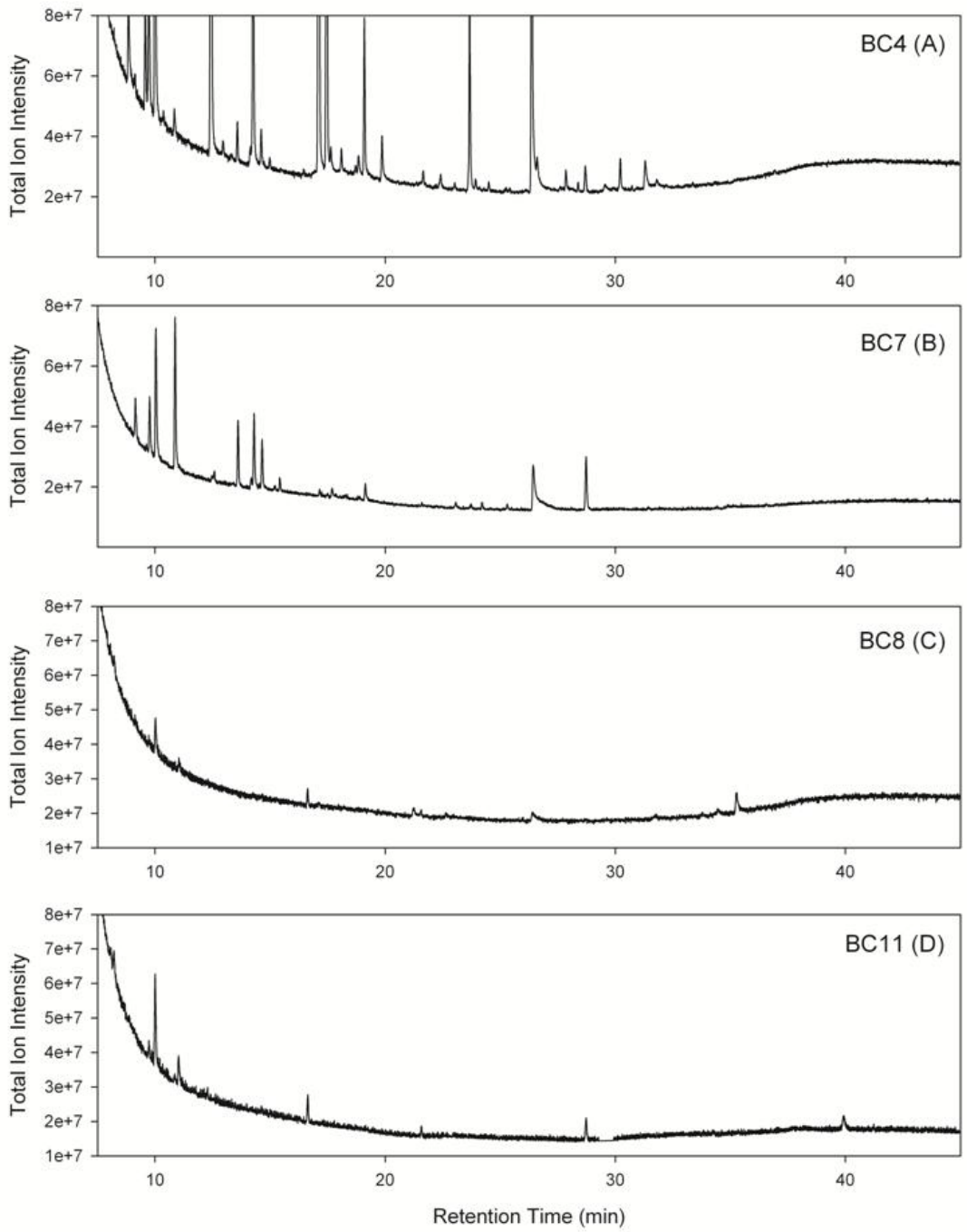

Figure 2. Illustrations of the headspace thermal desorption GC/MS total ion chromatograms for corn stover biochar produced by four different slow pyrolysis units: (A) BC4, (B) BC7, (C) BC8, and (D) BC11. All chromatograms are scaled equally and had nearly equivalent production temperatures.

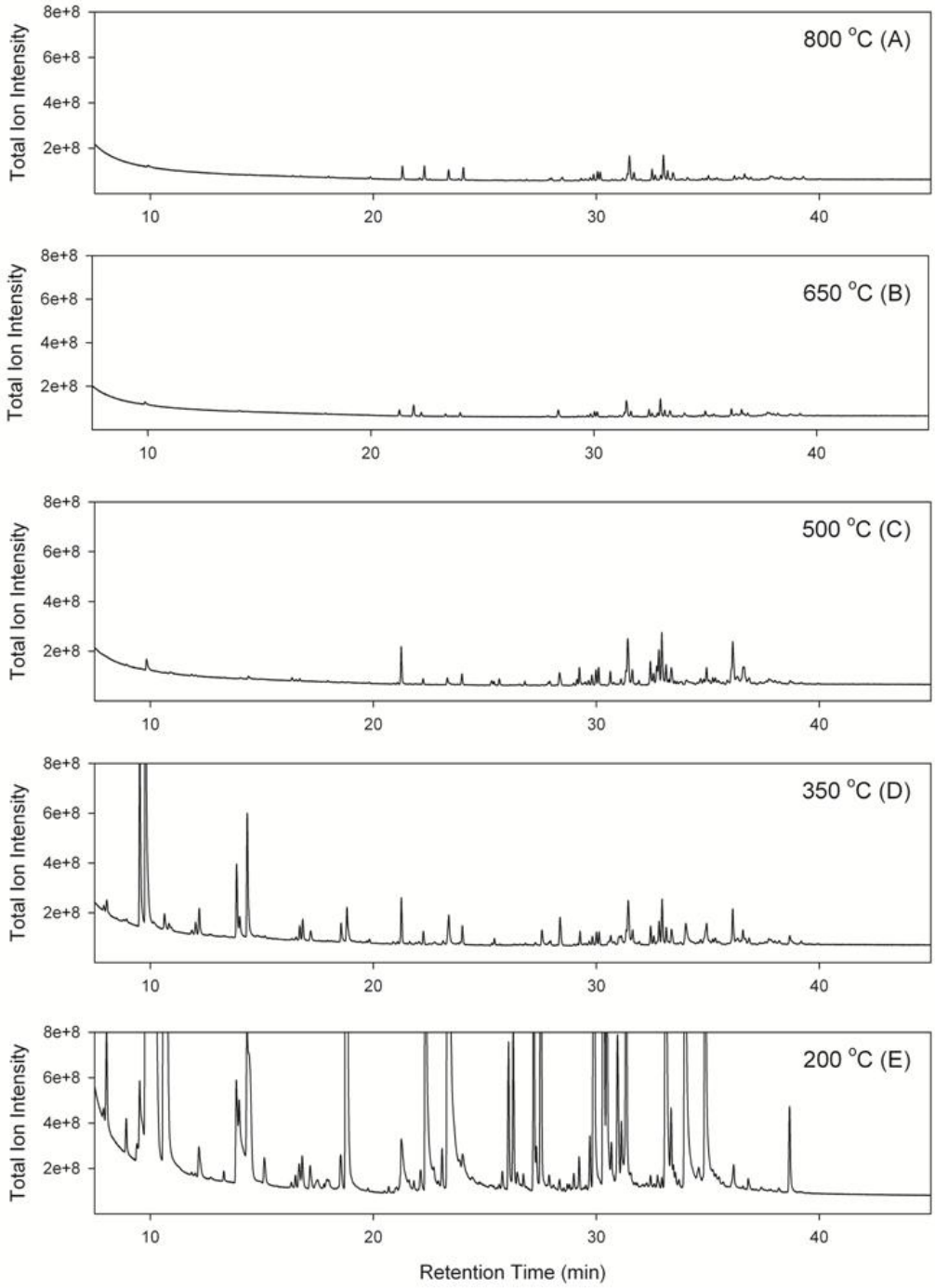

Figure 3. Total ion chromatograms for the analysis of cottonseed hull biochar pyrolyzed at (A) 800, (B) 650, (C) 500, (D) 350, and (E) 200 ^{o}C for 4 h under 1600 mL min^{-1} N_2 flow. All chromatograms are scaled equally.

(16.3 min) on these biochars was made at 350 ^{o}C (BC45), and then the quantity of sorbed

benzene decreased with increasing production temperature, with the highest amount of sorbed benzene being present on the 350 ^{o}C biochar (Fig 4B). The amount of sorbed methane (Fig. 4C), ethylene/acetylene (Fig. 4D) and ethanol (Fig. 4E) also peaked with the observed benzene maximum (BC45; 350 ^{o}C). All of these shorter chain hydrocarbons decreased with further increases in pyrolysis temperature from 350-800 ^{o}C. Ethanol, ethylene, and methane were still detectable even at the highest temperatures (BC48; 800 ^{o}C). There was a general decrease in the magnitude of the aldehyde, furan and ketone peaks with increasing production temperature (Fig. 3). Furthermore, aromatic species (e.g., benzene, toluene, phenol, etc.) and branched species became the more dominant compound class sorbed, even though the total concentrations of sorbed species were lower at elevated temperatures (Fig. 3). This trend can be seen visually on the TIC chromatograms, with the shift in the appearance of the peaks from earlier eluting times (Fig. 3E) (typically short carbon chain compounds) to higher molecular weight compounds, typically possessing a benzene ring that appear at later elution times (typically after 20 min; Fig. 3A).

The sum of all detected peaks from the GC/MS for each biochar is presented in Figure S1 (Supplementary material). The conservative estimate was that the ranges of sorbed volatiles on biochar spanned at least 6 orders of magnitude (from ng kg^{-1} to mg kg^{-1} levels), although this was not confirmed in this study. Despite the graphical appearance, there was no significant relationship between total TIC peak area and production temperature (Fig. S2, Supplementary material; $R^2 = 0.23$) or volatile matter content ($R^2 < 0.1$).

The frequencies of VOC identification on biochar by GC/MS are given in Table 2 and for the FID/TCD in Table 3. The top ten most frequently observed compounds by GC/MS in biochar samples were: acetone, benzene, methylethyl ketone, toluene, methyl acetate, propanal, octanal, 2,3-butadiene, pentanal, and 3-methylbutanal (Table 2). From the TCD/FID data, carbon dioxide, methane, ethylene/acetylene, and ethanol were detected in all of the sampled biochars (Table 3).

4.0 Discussion

4.1 Implications of feedstock, pyrolysis unit, and pyrolysis type

There were over 150 individual VOCs identified that were sorbed to biochars, not to mention the semi-volatiles and non-volatiles that still require investigation. There was a visual grouping of the total sorbed VOCs on biochar by some pyrolysis techniques (Fig. S2, Supplementary material). Biochars made using hydrothermal carbonization, fast pyrolysis and gasification clustered in the regions shown, on the other hand, slow pyrolysis biochars were highly scattered indicating no clear clustering (Fig. S2, Supplementary material). However, these relationships could also be an artifact of our uneven sample size of production techniques, with 46 biochars from slow pyrolysis and only 3 biochars from fast pyrolysis, 4 from hydrothermal carbonization, and 11 from gasification methods (Table 1). In addition, since thermal desorption only analyzed those VOC's which are released and not the total sorbed concentrations, further elucidation of VOC relationship with the production styles needs to wait for the total sorbed concentrations to be known.

These results are in agreement with past literature on identified compounds present in wood smoke (gases) and wood vinegars (liquids) (Asita and Campbell, 1990; Guillén and Manzanos, 2002; Olsson et al., 2004; Blake et al., 2009; Estrellan and Iino, 2010; Mun and Ku, 2010). Woody materials have low ash contents (<1%) and contain variable amounts of other organic compounds (e.g., terpenes, phenols, quinones, and tannins; (Umezawa and Higuchi,

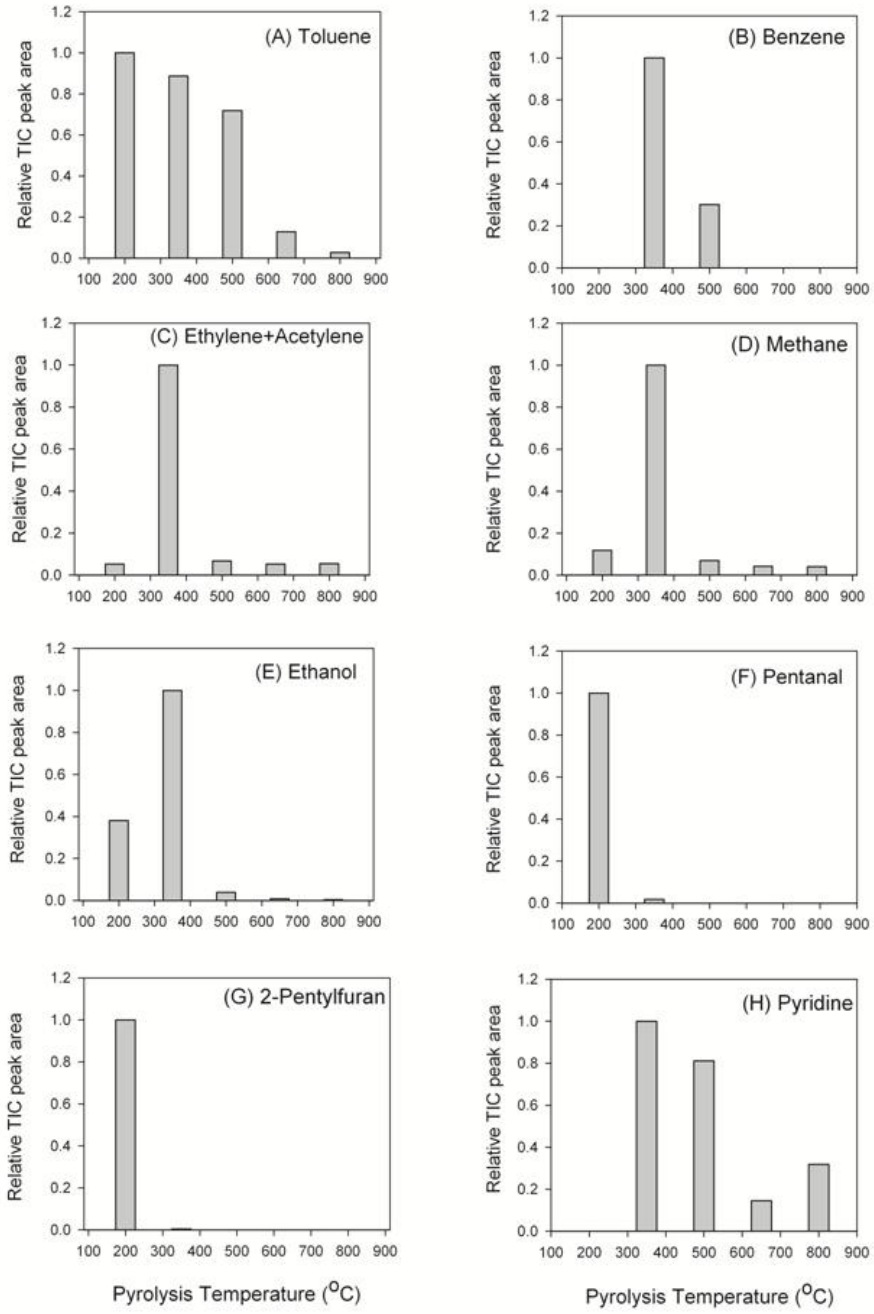

Figure 4. Illustration of trends in relative peak areas for (A) toluene, (B) benzene, (C) ethylene-acetylene, (D) methane, (E) ethanol, (F) pentanal, (G) 2-pentylfuran, and (H) pyridine detected in cottonseed hull biochars as a function of pyrolysis temperature.

1991). The VOCs desorbed from non-charred wood samples typically contain acetaldehyde, methanol, 2-pentylfuran, acetic acid and hexanal for deciduous trees and α-pinene, 3-carene,

hexanal, and other terpenes for confier species as the major components (Risholm-Sundman et al., 1998). Some of these compounds were still observed sorbed to the wood biochar (Table 2).

The observed shifts in desorbed VOCs components and peak magnitude at 300-500 ^{o}C (Fig. 3-4) for the cotton seed hull biochar are in agreement with the greatest changes in VM content (Table 1), BET surface area (Keiluweit et al., 2010), aromatic peaks using solid-state ^{13}C NMR (Sharma et al., 2002), and Fourier transform infrared (FTIR) spectroscopy (Uchimiya et al., 2011) within this temperature range for biochars. It should be noted that the occurrence of the lighter weight volatiles (C_1 – C_4) were more frequently observed on biochar than heavier VOC compounds observed in the GC/MS data. For instance, acetone was the most prevalent VOC identified by GC/MS, which only had a 67% frequency compared to the lighter weight compounds by TCD/FID having above 80% detection frequencies (Table 2 and 3). The atmospheric air and water vapor peaks from the biochar headspace gas sample interfered with the detection of these earlier eluding VOC peaks on the GC/MS. The probabilities of these VOC being present are typical for this suite of biochars tested; the VOC probabilities for other biochars will more than likely vary accordingly.

Elemental composition of the feedstock appears to influence some of the VOC species identified in our biochar sample pool. The relatively high chlorine content of agricultural biomass lowers burn efficiencies by forming scales and causing other corrosion issues in gasifiers (Hansen et al., 1998; Spliethoff and Hein, 1998). Obernberger et al. (2006) attribute these corrosion problems to the high concentrations of nitrogen, chlorine and sulfur in straws, cereals, grasses, grains and fruit residues when compared to other biomass sources. Furthermore, Vierle et al. (1999) attributed these elevated chlorine levels to the observations of chlorinated VOCs from burning biomass derived pellets. Therefore, it is possible that these variable chlorine levels in biomass sources could explain the presence of some chlorinated species sorbed to the biochars analyzed here (Table 2). However, there was not a clear division between feedstock type in the presence of chlorinated species, with tetrachlorethylene observed in a variety of feedstocks including hardwood, manure, corn stover, pine, and macadamia nut shells across a variety of pyrolysis types and conditions. Plants in the *Cyperaceae* (e.g., switch grass) and *Poaceae* (e.g., sugarcane) families are known to possess relatively high amounts of silica in their plant tissues (Hodson and Evans, 1995), which correspondingly could be the source for the unidentified siloxane compounds in the switch grass and sugar cane biochars. Sulfur contents of feedstock and pyrolysis products are similar, often at low concentrations in biomass feedstocks (Di Blasi et al., 1999). Other studies on pyrolysis oils and gases have observed various nitrogen compounds (ammonia, aliphatic amines; pyridine; aniline; pyrroles; indoles; quinolines and benzothiazoles), which were predominately observed with feedstocks with high nitrogen contents (Mirmiran et al., 1992; Hansson et al., 2004). However, the chemical complexity of the resulting isomers and possible ring substitutions require improvements in the mass spectral database and up-front analytical separation to improve compound identification, particularly from biomass (Overton and Manura, 1995; McLafferty et al., 1999).

The elevated sorbed volatiles on HTC biochar could potentially be due to contact with the liquid phase, which includes products of hydrolysis during biochar production (Kruse and Gawlik, 2002; Funke and Ziegler, 2010). This condition could result in higher concentrations of sorbed volatiles, unless the biochar is rinsed or otherwise processed (Hoekman et al., 2011; Libra et al., 2011). For instance, if biochar was activated (i.e. steam, acid, or base chemical activation) (Lima and Marshall, 2005; Langley and Fairbrother, 2007), this process removed sorbed surface

volatiles and a corresponding increase in the effective surface area was typically observed (Azargohar and Dalai, 2006, 2008). Bernardo et al. (2010) observed over a 2-3 order reduction in the concentration of various organic compounds in leachates from chars following dichloromethane rinsing. This was also seen in the activated carbons possessing lowest total sorbed VOCs of the suite of biochars analyzed here. This condition implies that the elapsed time from production and post-production processing of the biochar would impact the distribution of sorbed volatiles. Thereby, one can conceptualize how different concentrations can be sorbed to the biochar as a function of the pyrolysis conditions as well as the cooling rate of the biochar, and whether it was in contact with the pyrolysis gases or liquids, water, and oxygen during cooling. Our results have shown that post-production processing reduces the amount of sorbed VOCs on biochar (Fig. S1, Supplementary material).

Despite individual compound differences, the overall trend associated with an increase in pyrolysis temperature within the same unit was a net decrease in total sorbed VOCs with an increasing proportion of aromatic compounds. These temperature relationships were not observed when biochar was sampled across different pyrolysis units, despite the similarities in design and production parameters (Figure 2). The lack of clear relationships with production temperature and feedstock, indicate that the production method and post production handling and storage of the biochar could be the dominant factor controlling the variability in the VOC profile. In this study, not only were differences observed as a function of pyrolysis unit, feedstock, and temperature; but there were also differences imposed by the post-production processing (activation) of the biochar.

Lastly, biochars that possessed the lowest levels of sorbed volatiles were produced under partial aerobic conditions (i.e., hog fuel boilers, fire pits or soil kilns; pyrolysis processes without an inert gas purge or temperature regulation) or that underwent secondary activation (treatments). Incidentally, wood ash from aerobic gasifiers has been shown to be low in sorbed VOC content (Someshwar, 1996). These data suggests that the presence of oxygen during the pyrolysis reaction reduces the amounts of sorbed volatiles, potentially through oxidation or allowing more complete combustion (Jenkins et al., 1998; Simoneit, 2002), which could be a desired biochar characteristic for soil fertility improvements (Brewer et al., 2011).

4.2 Sorbed VOC implications

Historically, both positive and negative effects on plant and microbial systems of soil applied charcoal have been attributed to specific compounds entrained within or emitted from the charcoal (Vantsis and Bond, 1950; Nutman, 1952; Turner, 1955). Benzene and ethylene are the dominate products of oxidative pyrolysis during glowing combustion of charcoal (Olsson et al., 2003; Olsson et al., 2004) and can inhibit microbial responses in soils (Smith, 1976; Prosen et al., 1993; Nunes-Halldorson et al., 2004).

Methoxyphenols and phenols have been observed as a product of pyrolysis of hemicelluloses and lignin (Faix et al., 1991; McDonald et al., 2000; Lingens et al., 2005). These compounds, along with carboxylic acids, ketones, and furans are also known microbial inhibitors (Klinke et al., 2004; Mu et al., 2006; Mun and Ku, 2010). Moreover, these compounds even possess nematicidal qualities (Ali et al., 2002). The presence of these inhibitory compounds on biochar could be optimized for pathogenic control (Graber et al., 2010).

In addition to suppressing microbial activity, polyphenols have been observed to shift the dominant pathway of N-cycling from mineral to organic N-forms (Palm and Sanchez, 1990; Northup et al., 1998; Tian et al., 2001). These microbial responses are already known to vary as a function of ecosystem (Shneour, 1966; Spokas and Reicosky, 2009). Additionally,

polyphenols are known to be effective in repelling other soil fauna and anthropods (Bottimer, 1929). Therefore, given the fact that some of the biochar analyzed here possess these components (Table 2), these VOCs released from biochar could trigger an array of microbial, animal, and plant responses (Ryu et al., 2003). Incidentally, a possible explanation for the historical observations of biochar losing its agronomic benefit with storage could be if these beneficial VOCs were lost with time following production (e.g., Lefroy, 1883). More importantly, we corroborate that sorbed VOCs can be removed from biochar by further post-production treatment, such as chemical, thermal, or microbial (composting). The conditions and duration of these post-production treatments still require investigation.

Biochars will sorb not only pyrolysis gases generated during production (Olsson et al., 2003; Olsson et al., 2004; Chouchene et al., 2010; Mun and Ku, 2010; Song and Peng, 2010), but they could also absorb other volatile compounds directly from the environment (Masclet et al., 1987). These sorbed volatiles could influence sorption behavior of other inorganic species (Uchimiya et al., 2011) as well as organic contaminants such as naphthalene, nitrobenzenene (Cheng et al., 2008), and benzene (Chun et al., 2004) possessing structural similarity to VOCs and other volatile components of biochars.

Since the analysis here was solely volatile headspace gases, semi-volatile compounds were not adequately assessed (Wei and Jen, 2003). However, the observation of naphthalene in 20% of the biochars evaluated here does confirm polyaromatic hydrocarbon presence on some biochars, as reported by others (e.g., Rey-Salgueiro et al., 2004; Rumpel et al., 2007). However, the frequency and potential impacts of these polyaromatic compounds require additional studies, with particular attention devoted to the quantification of all sorbed compounds.

5.0 Conclusions

The diverse range of sorbed VOCs moieties between individual biochars could be partially responsible for the noted variance in soil and plant responses after biochar additions. Differences in the chemical composition of the sorbed VOCs from the same pyrolysis type, temperature, and feedstock suggests that even biochars created under similar pyrolysis conditions and equivalent feedstocks can result in biochars with sorbed VOCs that are chemically diverse. Clear influences of production conditions, especially the presence of O_2, pyrolysis temperature, post-production conditions and activation were observed, but with very little consistent effect of feedstock. The post-production handling of the biochar controls the quantities of sorbed volatiles that remain on the biochar, with further thermal and chemical processing virtually removing all sorbed VOCs. Variability in the sorbed VOC profiles could be linked to other structural features of biochar, but these were not examined here. The complexity and distribution of VOCs on biochar still warrants supplementary investigation, which will require further analytical method improvements, in order to adequately compare biochar impacts across various studies. However, these results indicate that the VOC composition of biochar contained within this study have been linked by others with both stimulative or inhibitive effects in plant and microbial systems. It is important that the presence of individual VOC compounds and that the combined effects of these compounds be elucidated because their presence may cause diverse responses from biochar additions to soils or other growth media.

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Table 1. List of biochars examined in this study and accompanying characterization and production parameters that were known. Units with the same designations were made on the same pyrolysis unit.

BC#	Parent Material	Unit	PT (°C)	pH	SA ($m^2 g^{-1}$)	C	N	O	H	H_2O	VM	Ash
						(% dry weight)						
				Fast Pyrolysis Biochar								
1	Macadamia shells	F1	n/a	6.2	6.9	84.3	0.6	1.5	2.3	9.5	15.2	1.7
2	Oak hardwood sawdust	F2	500	8.0	46	61.8	0.21	2.3	0.6	80.7	5.0	15.8
3	Macadamia shells	F3	650	6.9	0.45	71.0	0.88	1.2	2.5	5.0	19.5	20.4
				Slow Pyrolysis Biochar								
4	Corn stover	SP1	515	9.5	4.4	45.0	0.5	1.0	1.7	11.5	30.9	55.0
5	Pine wood chip	SP2	465	6.8	0.1	75.0	0.3	9.0	3.4	55.0	34.9	6.0
6	Peanut hulls	SP2	481	8.0	1.0	59.0	2.7	12.0	2.3	72.0	5.3	15.0
7	Corn stover	SP3	500	8.9	4.2	25.0	0.6	5.0	1.1	9.1	41.3	69.0
8	Corn stover	SP2	410	n/a	2.2	42.0	1.0	11.0	1.8	4.1	n/a	54.0
9	Pine wood chip	SP2	465	6.8	0.2	71.0	0.2	11.0	3.3	12.0	72.3	9.0
10	Peanut hulls	SP2	481	5.1	286	60.0	0.9	10	1.1	5.2	n/a	15.0
11	Corn stover	SP4	505	10.0	17.3	46.0	1.2	4.0	1.5	28.0	13.8	54.0
12	Coconut shell	SP1	550	8.9	15.1	80.1	0.5	2.5	n/a	12.4	8.7	n/a
13	Distillers grain	SP5	350	6.8	0.3	67.4	7.4	6.5	4.7	1.8	43.9	11.3
14	Distillers grain	SP5	400	6.9	0.3	68.1	7.3	5.9	4.2	2.0	36.9	11.7
15	Corn cob	SP5	350	8.7	<0.1	76.5	0.7	12.9	4.2	2.9	32.2	2.8
16	Corn cob	SP5	400	9.0	<0.1	80.1	0.6	8.8	3.7	3.1	24	3.7
17	Wood waste	SP6	400	6.9	3.5	76.9	0.8	11.5	3.6	3.7	25.8	3.5
18	Wood waste	SP6	450	8.4	26.8	77.9	0.7	11	3.1	3.6	22.8	3.6
19	Wood Waste + Composting	SP7	465	8.6	63.5	43.0	2.2	n/a	n/a	11.4	32.3	n/a
20	Wood chip (pellet)	SP8	650	9.8	177.2	69.3	0.2	17.7	1.2	5.6	11.7	6.0
21	Oak hardwood	SP9	538	9.8	33.7	53.4	0.4	9.8	2.6	6.3	32.5	27.1
22	Wood Waste	SP10	500	5	66.3	68.7	0.1	19.9	3.3	3.3	33.6	4.6
23	Oak hardwood	SP11	540	6.6	n/a	73.3	0.3	n/a	n/a	1.7	n/a	2.4
24	Oak hardwood	SP12	n/a	8.5	106.3	90.1	0.3	4.5	2.8	1.3	15	1.0
25	Pine wood chip	SP13	500	7.2	n/a	87.2	0.43	6.44	3.6	3.24	45.8	2.3
26	Sugar Cane Bagasse	SP15	350	5.0	n/a	75.2	0.66	15.8	4.6	3.42	39.2	3.6
27	Pine wood chip	SP15	350	4.6	n/a	74.7	0.45	18.4	5.0	2.74	45.2	1.5
28	Swine Manure	SP15	350	8.1	0.92	50.8	3.74	6.64	5.0	2.31	46.2	32.3
29	Switchgrass	SP15	250	6.2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
30	Poultry litter	SP16	400	10.3	n/a	42.3	4.2	n/a	n/a	n/a	n/a	n/a
31	Pine chips	SP16	500	7.3	n/a	73.3	0.2	n/a	n/a	n/a	n/a	n/a
32	Wood wastes	SP17	n/a	8.4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
33	Wood waste	SP18	n/a	9.1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34	Wood pellets	SP19	n/a	5.5	78.3	77.3	0.4	3.9	1.6	6.8	14.1	10.1
35	Wood pellets	SP19	n/a	10.8	4	73.9	0.4	10.8	2.8	4.8	26.3	7.3
36	Wood pellets	SP19	n/a	6.7	n/a	76.4	0.4	11.7	2.7	5.1	27.3	3.7

Table 1 (Continued)

BC#	Parent Material	Unit	PT (°C)	pH	SA ($m^2 g^{-1}$)	C	N	O	H	H_2O	VM	Ash
						(% dry weight)						
			Slow Pyrolysis Biochar (continued)									
37	Wood pellets	SP19	n/a	6.8	1.7	77.2	0.3	12.5	2.9	5.1	28.6	1.9
38	Wood ash + Fertilizer	SP20	n/a	8.3	n/a	68.0	1.53	n/a	n/a	58.1	n/a	8.1
39	Oak hardwood	SP20	n/a	10.2	n/a	59.8	0.6	n/a	n/a	n/a	n/a	n/a
40	Mixed hardwood	SP20	n/a	8.8	n/a	76.9	0.5	n/a	n/a	2.2	n/a	11.6
41	Mixed wood	SP21	n/a	4.7	n/a	60.8	0.44	n/a	n/a	6.8	n/a	n/a
42	Oak hardwood	SP22	550	10.2	134.8	52	0.2	3.9	0.6	n/a	4.3	43.4
43	Oak hardwood	SP22	550	10.5	116.8	56	0.2	0.7	0.9	n/a	4.4	42.2
44	Cottonseed hull	SP23	200	3.7	n/a	48.2	5.6	37.7	5.6	5.3	69.3	3.1
45	Cottonseed hull	SP23	350	6.6	4.7	71.5	4.2	14.6	4.2	6.8	34.9	5.7
46	Cottonseed hull	SP23	500	8.5	<0.1	78.7	2.5	6.9	2.5	6.5	18.6	7.9
47	Cottonseed hull	SP23	650	8.6	34	84.4	1.2	5.5	1.2	8.2	13.3	8.3
48	Cottonseed hull	SP23	800	7.7	322	84.3	0.6	6.6	0.6	9.9	11.4	9.2
49	Coal + wood pellets	SP24	900	5.5	5.0	6.8	0.2	n/a	0.10	1	1.8	86.4
			Traditional Kiln Biochar (e.g. Soil mound, pits)									
50	Oak hardwood	K1	400-600	8.9	n/a	72.4	0.4	n/a	n/a	n/a	n/a	n/a
51	Oak hardwood (possible?)	K2	n/a	6.5	n/a	83.8	0.3	n/a	n/a	0.8	n/a	1.7
52	Hardwood	K3	n/a	6.8	19.2	69.0	0.7	9	2.4	10.0	69.9	14
53	Hardwood	K4	n/a	7.4	n/a	77.4	0.3	n/a	n/a	n/a	n/a	n/a
			Gasifier Biochar (e.g. ashes)									
54	Oak Hardwood	G1	n/a	11.2	33.5	31.5	0.3	n/a	0.6	0.6	20.3	66.6
55	Mixed waste wood	G2	>600 °C	11.8	144.0	27.2	0.3	n/a	0.3	0.9	18.8	72.2
56	Turkey manure & wood chips	G3	850	10.9	4.8	1.0	0.1	3	0.5	5.0	22.2	89
57	Wood ash	G4	n/a	11.8	n/a	<0.1	0.01	n/a	n/a	16.5	0.6	82.9
58	Corn stover	G5	815	10.1	9.9	31.0	1	0	0.9	14.0	33.0	74
			Wood Fire Boiler Biochar (Wood Ash)									
59	Wood Ash	WB1	n/a	9.1	176.7	16.0	0.2	2.1	0.1	32.3	6.8	49.3
60	Wood Ash	WB2	n/a	8.4	193.5	15.9	0.2	2.5	0.1	41.9	9	39.3
61	Wood ash	WB3	n/a	8.7	57	4.6	0.09	1.3	0.04	41.7	5.2	52.1
62	Wood ash	WB4	n/a	8.6	335.9	20.9	0.1	1.5	0.2	67.3	4	10
63	Wood ash	WB5	n/a	5.8	63.1	10.1	0.1	1.7	0.4	65.6	3.1	22.1
64	Wood ash	WB6	n/a	10.3	n/a	89.6	1.01	<0.01	n/a	0.1	5.8	5.2
			Activated Charcoals									
65	Coconut shells (activated)	AC1	500 °C steam activated 900 °C	7.6	1200	83.1	0.4	<0.01	0.06	5.5	1.7	12.3
66	Coconut shells (activated)	AC2	900 °C activation (steam)	6.8	922	90.2	1.72	3.08	0.38	3	0.5	15
67	Hardwood	AC3	n/a	5.8	1661	89.4	0.4	0.6	2.1	3.4	7.8	4.1

Table 1 (Continued)

BC#	Parent Material	Unit	PT	pH	SA	C	N	O	H	H_2O	VM	Ash
			(°C)		($m^2 g^{-1}$)			(% dry weight)				
			Activated Charcoals (continued)									
68	Bituminous coal	AC4	Activated at 800 °C	9.4	988	94.9	1.27	2.49	0.7	1.6	1.8	0.3
69	Hardwood	AC5	Phosphorus acid activated 600 °C	3.8	877	95.8	0.2	1.0	0.6	5.0	0.5	0.2
			Hydrothermal Biochars									
70	Algae	HT1	250	3.3	0.1	48.9	7.9	16.5	9.1	10.2	n/a	0.2
71	Swine manure + sugar beet	HT2	200-250	4.4	2.5	50.7	2.3	25.4	5.0	4.1	63.2	12.2
72	Swine manure + pine bark	HT3	200-250	4.0	6.5	56.0	0.7	23.7	4.4	5.6	55.2	29.7
73	Algae	HT4	200	3.9	<0.1	66.3	7.3	18.0	7.9	9.2	n/a	0.3
			Microwave Assisted Pyrolysis Biochar									
74	Chicken feathers	MAP1	Not measured (n/a)	9.2	n/a	33.6	3.1	n/a	n/a	n/a	n/a	n/a
75	Swine manure + bedding	MAP2	Not measured (n/a)	9.8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
76	Distiller grain	MAP3	Not measured (n/a)	10.1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
77	Corn stover	MAP4	600	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Notes Compositional values are weight percentages related to dry mass; VM=volatile matter; SA=surface area; PT= pyrolysis temperature; H_2O = moisture content; and n/a = data not available.

Table 2 – Frequency of detection of VOCs sorbed to various biochars by GC/MS.

Compound	% of biochars containing	Compound	% of biochars containing
ACETONE	67	1,4 DIMETHYL BENZENE	17
BENZENE	65	1,3 DIMETHYL BENZENE	17
METHYL ETHYL KETONE	60	CYCLOHEXANE	16
TOLUENE	60	3 PENTANONE	14
METHYL ACETATE	52	2-HEXENAL	12
PROPANAL	50	ETHANOL	11
OCTANAL	48	2 METHOXY 2 METHYL PROPANE	11
2,3 BUTANEDIONE	45	DICHLOROMETHANE	10
PENTANAL	45	CARBON TETRACHLORIDE	9
3-METHYL-BUTANAL	43	2-BUTANOL	7
ETHYLBENZENE	43	METHYLCYCLOHEXANE	7
1-DODECANE	42	1,2 DICHLOROETHENE (Z)	6
TETRACHLOROETHENE	40	1,2,4 TRICHLOROBENZENE	5
BUTANAL	39	1,2,3-TRICHLOROBENZENE	4
CYCLO PENTANONE	38	1,1 DICHLOROETHANE	3
FURAN	37	TRICHLOROMETHANE	3
HEPTANAL	37	1,2-DIBROMO 3-CHLOROPROPANE	3
2-PENTANONE	35	1,1,2 TRICHLORO 1,2,2 –TRIFLUORO ETHANE	2
HEXANAL	35	1,1 DICHLOROETHENE	2
HEXANE	34	ETHYL ACETATE	2
BENZALDEHYDE	34	TRIMETHYL ESTER BORIC ACID	2
1,2,3-TRIMETHYLBENZENE	34	TRANS 1,2 DICHLOROETHENE	2
METHYL PROPANAL	31	1,1,1 TRICHLOROETHANE	2
HEXENE	31	1,2 DICHLOROETHANE	2
CARBON DISULFIDE	30	1,2 DICHLOROPROPANE	2
2-HEXANONE 5-METHYL	28	BROMODICHLOROMETHANE	2
TRICHLOROETHENE	27	1,3 DICHLOROPROPENE (Z)	2
FURFURAL	27	1,3 DICHLOROPROPENE (E)	2
1 METHYLETHYL BENZENE	26	1,1,2 TRICHLOROETHANE	2
2-PROPENAL	25	DIBROMOCHLORMETHANE	2
2-HEPTANONE	25	1,2 DIBROMOETHANE	2
2-METHYL-2-CYCLOPENTEN-1-ONE	22	CHLOROBENZENE	2
2 METHYL FURAN	20	TRIBROMOMETHANE	2
NAPHTHALENE	20	1,1,2,2-TETRACHLOROETHANE	2
STYRENE	18	1,3-DICHLOROBENZENE	2
PENTANE 2-METHYL	17	1,4- DICHLOROBENZENE	2
1,2 DIMETHYLBENZENE	17	1,2-DICHLOROBENZENE	2
SILOXANES (UNIDENTIFIED)	17		

Table 3 – Frequency of detection of various compounds sorbed to biochars by TCD-FID analyses.

Compound	% of biochars containing
Carbon dioxide	100
Methane	100
Ethylene/Acetylene [1]	97
Ethane	95
Propylene	99
Propane	95
Butane	93
Methanol	81
Ethanol	100

Notes: [1]- Ethylene and acetylene co-elute on the packed Porapak Q column.

Table S1: GC Conditions for the headspace thermal desorption analyses

Gas Chromatograph Settings	
Mass Spectrometer (MS) Detector	
Column	Restek RTX-624 (0.22 µm × 30 m)
Flow Rate	He – 2.0 mL min^{-1}
Mode:	Scan
Scan Range (m/z)	5 – 250
Transfer line Temperature (°C)	200
Source Temperature (°C)	200
Electron Energy (eV)	70
Solvent Delay (min)	5
TCD-FID Detectors	
Column	Porapak Q (3.2 mm × 1.82 m)
Flow Rate	He - 30 mL min^{-1}
TCD Temperature (°C)	200
Reference Flow	30 mL min^{-1}
Attenuation	1 (40 mA current TCD)
FID Temperature (°C)	200
Oven Temperature Program	36 °C (hold 5 min) Ramp to 200 °C at 5 ° min^{-1} Hold 10 min
Headspace Conditions	
Vial Temperature (°C)	150
Vial Equilibration Time (min)	10
Loop Fill (min)	0.7
Loop Fill Equilibration Time (min)	0.5
Injection Time (min)	2.0
Sample Loop Size	250 µL (GC/MS column) 500 µL (TCD-FID column)
Vial Pressurization (kPa)	180 kPa

Table S2. List of identified compounds and their retention times (RT) in the headspace thermal desorption –GC/MS method

#	NAME	RT	CAS NUMBER	#	NAME	RT	CAS NUMBER
1	ETHANOL	8.3	64-17-5	**41**	TOLUENE	21.1	108-88-3
2	FURAN	8.8	110-00-9	**42**	1,3 DICHLOROPROPENE (E)	21.9	10061-02-6
3	2-PROPENAL	9.2	25314-61-8	**43**	1,1,2 TRICHLOROETHANE	22.4	79-00-5
4	1,1,2 TRICHLORO 1,2,2 TRIFLUORO ETHANE	9.3	76-13-1	**44**	TETRACHLOROETHENE	22.5	127-18-4
5	1,1 DICHLOROETHENE	9.4	75-35-4	**45**	HEXANAL	23.3	66-25-1
6	PROPANAL	9.4	123-38-6	**46**	DIBROMOCHLORMETHANE	23.4	124-48-1
7	ACETONE	9.7	67-64-1	**47**	HEXENE	23.5	592-41-6
8	CARBON DISULFIDE	10	75-15-0	**48**	1,2 DIBROMOETHANE	23.8	106-93-4
9	PENTANE 2-METHYL	10.7	107-83-5	**49**	CYCLOPENTANONE	23.8	120-92-3
10	METHYL ACETATE	10.8	79-20-9	**50**	CHLOROBENZENE	25	108-90-7
11	DICHLOROMETHANE	10.9	75-09-2	**51**	ETHYLBENZENE	25.2	100-41-4
12	2 METHOXY 2 METHYL PROPANE	11.4	1634-04-4	**55**	1,2 DIMETHYLBENZENE	26	95-47-6
13	1,2 DICHLOROETHENE (Z)	11.5	156-59-2	**52**	1,4 DIMETHYL BENZENE	26.1	106-42-3
14	HEXANE	12	110-54-3	**53**	1,3 DIMETHYL BENZENE	26.1	108-38-3
15	METHYL PROPANAL	12.1	78-84-2	**57**	2-HEXANONE 5-METHYL	26.1	110-12-3
16	ETHYL ACETATE	12.5	141-78-6	**56**	FURFURAL	26.3	98-01-1
17	1,1 DICHLOROETHANE	12.7	75-34-3	**54**	2-HEXENAL	26.5	6728-26-3
18	TRIMETHYL ESTER BORIC ACID	13.2	121-43-7	**58**	STYRENE	26.8	100-42-5
19	2 METHYL FURAN	13.2	534-22-5	**59**	2-HEPTANONE	27.4	110-43-0
20	BUTANAL	13.8	123-72-8	**60**	TRIBROMOMETHANE	27.4	75-25-2
21	2,3 BUTANEDIONE	13.9	431-03-8	**61**	1 METHYLETHYL BENZENE	27.7	98-82-8
22	TRANS 1,2 DICHLOROETHENE	14.2	156-60-5	**62**	HEPTANAL	27.7	111-71-7
23	METHYL ETHYL KETONE	14.2	78-93-3	**63**	HEXAMETHYL TRISILOXANE	28.3	139347-50-5
24	TRICHLOROMETHANE	14.5	67-66-3	**64**	1,1,2,2-TETRACHLOROETHANE	28.8	79-34-5
25	2-BUTANOL	14.8	78-92-2	**65**	2-METHYL-2-CYCLOPENTEN-1-ONE	28.9	1120-73-6
26	CYCLOHEXANE	15.3	110-82-7	**66**	BENZALDEHYDE	31.2	100-52-7
27	1,1,1 TRICHLOROETHANE	15.3	71-55-6	**67**	1,3-DICHLOROBENZENE	31.5	541-73-1
28	CARBON TETRACHLORIDE	15.6	56-23-5	**68**	OCTANAL	31.6	124-13-0
29	BENZENE	16.3	71-43-2	**69**	1,4- DICHLOROBENZENE	31.7	106-46-7
30	1,2 DICHLOROETHANE	16.5	107-06-2	**70**	1,2,3-TRIMETHYLBENZENE	32.8	526-73-8
32	3-METHYL-BUTANAL	17	563-80-4	**71**	1,2-DICHLOROBENZENE	32.9	95-50-1
33	2-PENTANONE	17.1	107-87-9	**72**	1,2-DIBROMO 3-CHLOROPROPANE	35.3	96-12-8
34	TRICHLOROETHENE	17.9	79-01-6	**73**	1-DODECANE	36.1	112-40-3
35	METHYLCYCLOHEXANE	18.2	108-87-2	**74**	1,2,4-TRICHLOROBENZENE	37.7	120-82-1
36	1,2 DICHLOROPROPANE	18.6	78-87-5	**75**	HEXACHLOROBUTADIENE	38.2	87-68-3
37	3 PENTANONE	18.8	96-22-0	**76**	NAPHTHALENE	39	835-31-4
38	PENTANAL	19	110-62-3	**77**	1,2,3 TRICHLOROBENZENE	39.6	87-61-6
39	BROMODICHLOROMETHANE	19.2	75-27-4				
40	1,3 DICHLOROPROPENE (Z)	20.4	10061-01-5				

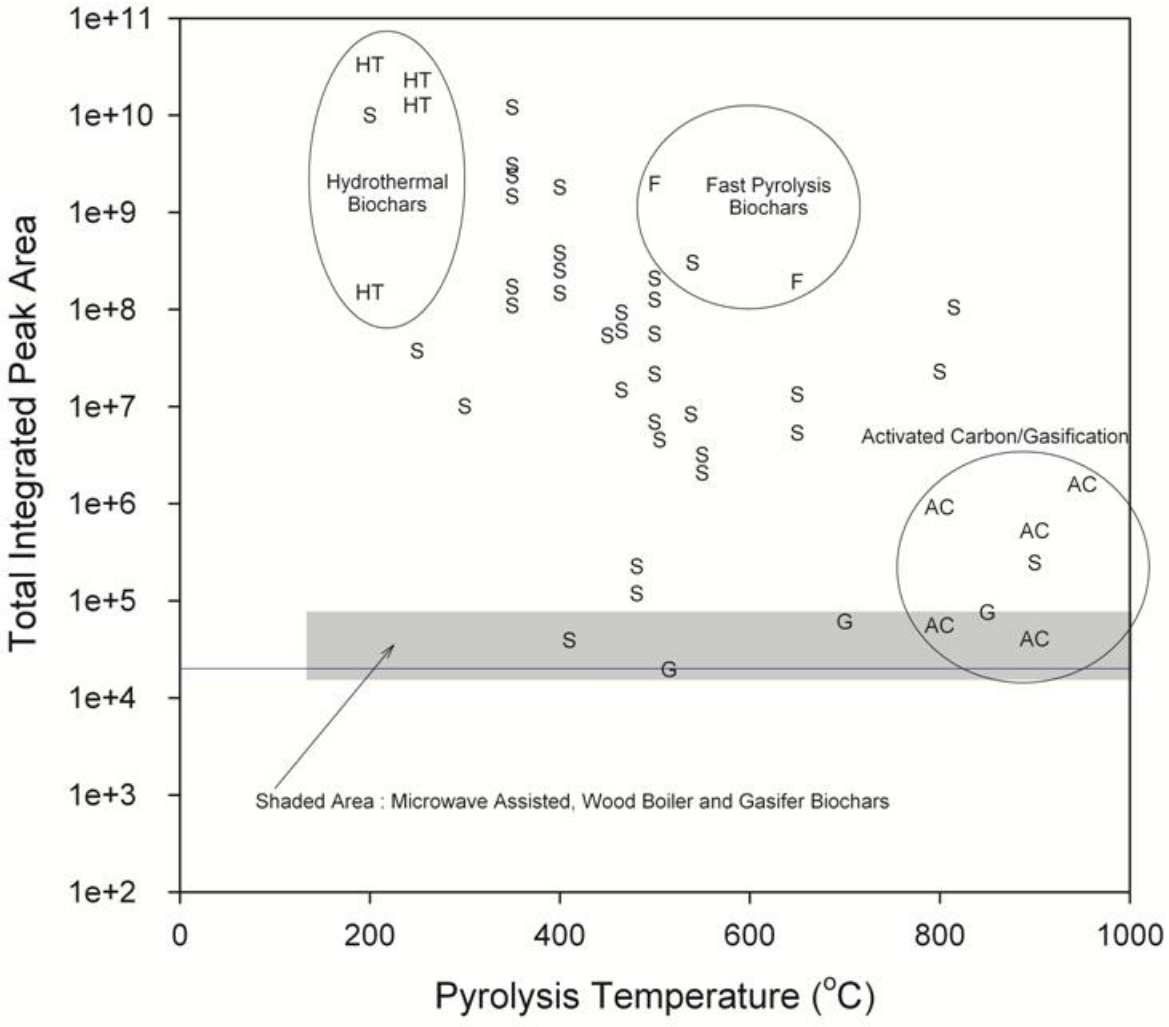
Total Integrated Peak Area
Pyrolysis Temperature (°C)
Hydrothermal Biochars
Fast Pyrolysis Biochars
Activated Carbon/Gasification
Shaded Area : Microwave Assisted, Wood Boiler and Gasifer Biochars

Figure S1:

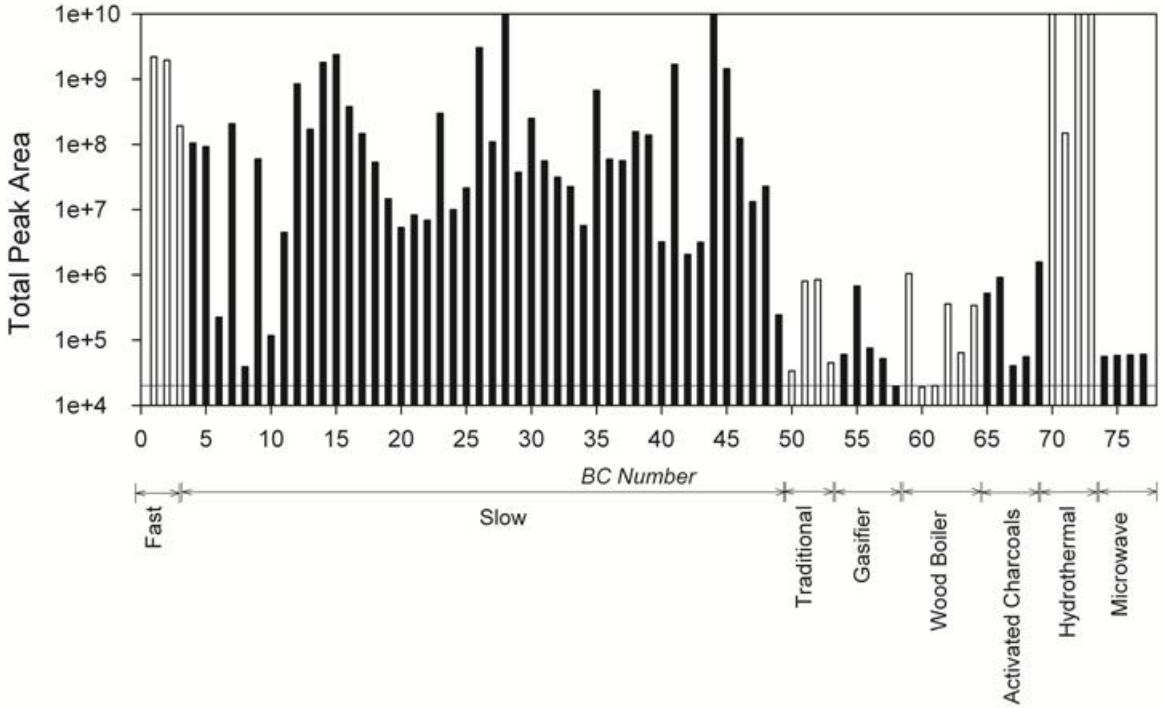
Total Peak Area
1e+10
1e+9
1e+8
1e+7
1e+6
1e+5
1e+4
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
BC Number
Fast
Slow
Traditional
Gasifier
Wood Boiler
Activated Charcoals
Hydrothermal
Microwave

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Figure S2:

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Project H

Development of Nitrogen Management Practices in MN & ND

Additional Information

Table 1. Clone means across nitrogen rates for sucrose, glucose and acrylamide levels following storage at 0, 3, 6, and 9 months storage at 45 ˚F. The mean value is followed by significance (* = significant, ** = highly significant, ns = not significant) for clone.

Storage Time	Clone	Sucrose	Glucose	Acrylamide
		mg/g	mg/g	ng/g
0 Time	Alpine Russet	1.90	0.27	204.8
	Dakota Trailblazer	1.34	0.48	211.8
	Ivory Crisp	1.50	0.19	2682.2
	Russet Burbank	1.03	0.53	424.1
	Snowden	1.38	0.07	2131.4
	Mean	1.43**	0.31**	1138.0**
	LSD (α = 0.05)	0.17	0.09	324.2
3 Months	Alpine Russet	1.77	0.36	304.1
	Dakota Trailblazer	0.77	0.96	613.2
	Ivory Crisp	0.72	0.17	1808.6
	Russet Burbank	0.90	0.92	736.6
	Snowden	0.91	0.60	820.6
	Mean	1.02**	0.49**	856.6**
	LSD (α = 0.05)	0.11	0.22	272.6
6 Months	Alpine Russet	0.99	0.28	304.1
	Dakota Trailblazer	0.33	0.40	296.9
	Ivory Crisp	0.68	0.06	980.5
	Russet Burbank	0.78	0.55	666.0
	Snowden	0.98	0.04	1357.5
	Mean	0.75**	0.26**	725.3**
	LSD (α = 0.05)	0.12	0.18	74.1
9 Months	Alpine Russet	0.88	0.47	208.3
	Dakota Trailblazer	0.34	0.71	325.5
	Ivory Crisp	0.96	0.27	811.9
	Russet Burbank	0.59	0.72	404.3
	Snowden	1.78	0.98	3716.9
	Mean	0.91**	0.63**	1093.3**
	LSD (α = 0.05)	0.31	0.32	605.7

Table 2. Effect of nitrogen rate across clones on sucrose, glucose and acrylamide levels following storage at 0, 3, 6, and 9 months storage at 45 ˚F. The mean value is followed by significance (* = significant, ** = highly significant, ns = not significant) for nitrogen rate.

Storage Time	Nitrogen Rate	Sucrose	Glucose	Acrylamide
		mg/g	mg/g	ng/g
0 Time	0	1.38	0.24	1159.2
	90	1.45	0.26	979.9
	150	1.44	0.37	1118.9
	210	1.44	0.37	1254.6
	270	1.45	0.32	1178.4
	Mean	1.43 ns	0.31**	1138.0 ns
	LSD (α = 0.05)	0.22	0.05	256.6
3 Months	0	1.00	0.42	584.9
	90	1.13	0.39	832.9
	150	1.07	0.56	769.5
	210	0.93	0.44	1036.6
	270	0.95	0.65	1059.2
	Mean	1.02 ns	0.49 ns	856.6*
	LSD (α = 0.05)	0.23	0.24	270.8
6 Months	0	0.75	0.19	691.7
	90	0.68	0.23	688.2
	150	0.77	0.23	768.9
	210	0.70	0.32	688.9
	270	0.87	0.36	791.0
	Mean	0.75 ns	0.26 ns	725.3 ns
	LSD (α = 0.05)	0.15	0.17	100.5
9 Months	0	0.83	0.61	1038.9
	90	0.94	0.55	1096.8
	150	0.87	0.62	1019.1
	210	0.81	0.51	1212.3
	270	1.094	0.86	1099.8
	Mean	0.91 ns	0.63 ns	1093.3 ns
	LSD (α = 0.05)	0.27	0.22	320.4

Table 3. Effect of nitrogen rate on sucrose, glucose and acrylamide level of five potato cultivars, Inkster, ND, 2011.

		suc0*	glu0	acryl0	suc3	glu3	acryl3	suc6	glu6	acryl6	suc9	glu9	acryl9
Clone	**N Rate**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
Alpine Russet	**0**	2.06	0.14	86.5	2.04	0.24	125.4	1.10	0.10	281.9	1.04	0.21	86.8
	90	1.84	0.24	251.0	2.00	0.29	293.8	0.86	0.16	333.4	0.80	0.55	250.4
	150	1.60	0.32	248.7	1.78	0.53	386.6	0.90	0.36	349.7	0.66	0.40	190.4
	210	2.22	0.44	232.4	1.59	0.23	410.9	0.91	0.10	286.6	0.80	0.39	319.7
	270	1.78	0.22	205.3	1.45	0.52	303.8	1.19	0.66	269.1	1.11	0.79	194.2
Dakota Trailblazer	**0**	1.24	0.42	105.3	0.81	0.88	642.0	0.46	0.39	201.0	0.19	1.31	281.2
	90	1.47	0.32	137.9	0.94	0.59	753.0	0.39	0.26	161.6	0.54	0.28	360.7
	150	1.67	0.62	273.5	0.97	1.04	662.9	0.40	0.20	279.4	0.45	0.59	258.5
	210	1.29	0.64	280.8	0.51	1.14	371.3	0.17	0.74	353.7	0.25	0.68	385.2
	270	1.05	0.42	261.3	0.64	1.16	636.9	0.24	0.40	484.3	0.25	0.72	341.7
Ivory Crisp	**0**	1.31	0.20	2907.6	0.58	0.06	902.7	0.56	0.02	1000.6	0.51	0.16	602.3
	90	1.54	0.13	1898.0	0.78	0.07	1218.5	0.62	0.03	935.7	0.86	0.05	660.8
	150	1.55	0.17	2362.1	0.68	0.19	1330.5	0.76	0.03	955.8	0.91	0.16	922.6
	210	1.46	0.29	3206.6	0.70	0.11	2982.3	0.86	0.07	1050.6	0.78	0.19	993.3
	270	1.66	0.20	3036.7	0.86	0.41	2609.3	1.10	0.13	960.1	1.66	0.80	880.5
Russet Burbank	**0**	1.10	0.40	438.3	0.88	0.88	463.8	0.55	0.41	657.1	0.82	0.64	424.4
	90	1.05	0.59	528.8	0.81	0.97	1077.8	0.57	0.65	845.5	0.45	1.07	529.2
	150	1.05	0.66	371.8	0.98	0.98	575.4	0.76	0.49	641.4	0.54	0.60	447.0
	210	0.88	0.40	354.5	0.93	0.64	782.2	0.74	0.65	465.7	0.60	0.68	287.5
	270	1.08	0.63	430.7	0.91	1.11	783.8	0.81	0.56	720.3	0.55	0.61	333.3
Snowden	**0**	1.21	0.04	2078.1	0.71	0.06	790.5	1.09	0.05	1318.0	1.58	0.72	3799.8
	90	1.34	0.04	2083.7	1.12	0.04	821.4	0.96	0.03	1164.8	2.04	0.81	3683.1
	150	1.33	0.06	2338.6	0.94	0.04	892.4	1.04	0.06	1495.7	1.77	1.35	3276.9
	210	1.34	0.09	2198.9	0.90	0.09	636.3	0.83	0.03	1287.8	1.60	0.63	4075.8
	270	1.67	0.13	1957.9	0.89	0.07	962.2	0.99	0.03	1521.2	1.91	1.39	3749.2

*Sucrose abbreviated as suc (mg/g), glucose as glu (mg/g), acrylamide levels (ng/g) as acryl for 0, 3, 6 and 9 months storage times.

Table 4: Significance results of ANOVAs for each dependent variable as a function of nitrogen treatment, potato variety, and their interaction, for Becker, MN[1].

Dependent Variable	All varieties			Chipping varieties only			Frying varieties only		
	Treatment	Variety	Trt * Var	Treatment	Variety	Trt * Var	Treatment	Variety	Trt * Var
Plant % stand	NS	**	NS						
Stems/plant	NS	**	NS						
Petiole nitrate, June 20	**	**	NS						
Petiole nitrate, June 28	**	*	NS						
Petiole nitrate, July 11	**	**	++						
Petiole nitrate, July 26	**	**	++						
Yield, 0-3 oz	NS	**	**						
Yield, 3-6 oz	**	**	NS						
Yield, 6-10 oz	**	**	*						
Yield, 10-14 oz	**	**	++						
Yield, > 14 oz	**	**	++						
Yield, Total	**	**	NS						
Yield, #1s	**	**	NS						
Yield, #2s	NS	**	**						
Yield, Marketable	**	**	NS						
Yield, % > 6 oz	**	**	NS						
Yield, % > 10 oz	**	**	NS						
Hollow heart	**	**	**						
Brown center	**	**	**						
Scab	NS	**	NS						
Specific gravity	++	**	NS						
Dry matter	**	**	*						
AGT score, harvest				NS	NS	NS			
AGT score, 3 months				NS	NS	NS			
AGT score, 6 months				NS	*	NS			
AGT score, 9 months				*	**	NS			
Chip color, harvest				NS	NS	NS			
Chip color, 3 months				NS	NS	NS			
Chip color, 6 months				NS	*	NS			
Chip color, 9 months				**	**	NS			
Tuber nitrogen	**	**	**	**	++	**	**	**	++
Glucose, harvest	**	**	**	**	NS	++	**	**	**
Glucose, 3 months	**	**	*	**	NS	NS	**	**	++
Glucose, 6 months	**	**	*	NS	NS	NS	*	**	*
Glucose, 9 months	**	**	*	NS	**	NS	**	**	**
Sucrose, harvest	NS	**	NS	NS	**	++	NS	**	NS
Sucrose, 3 months	NS	**	NS	NS	**	**	**	**	NS
Sucrose, 6 months	NS	**	NS	NS	**	NS	NS	**	NS
Sucrose, 9 months	NS	**	NS	++	**	**	NS	**	NS
Acrylamide, harvest				NS	++	NS	**	**	**
Acrylamide, 3 months				*	**	++	NS	**	NS
Acrylamide, 6 months				NS	*	NS	**	**	NS
Acrylamide, 9 months				**	**	*	++	**	NS

NS: not significant. ++: $0.05 \le P < 0.10$. *: $0.01 \le P < 0.05$. **: $P < 0.01$. Blank cell: Not anaylyzed. (Agtron score and chip color were only determined for chipping varieties.

Table 5. Effect of nitrogen rate from ESN fertilizer on plant stand, stems per plant, and petiole nitrate concentration of Alpine Russet potato plants in Becker, MN.

Nitrogen Treatments				Stand (%)	Stems per plant	Petiole NO_3-N Concentration (ppm)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]						
		lb N/ac	P, E			June 20	June 28	July 11	July 26
1	MAP + AMS	30	30, 0	61.8	3.4	10197 b	1423 c	181 d	206 c
2	MAP + AMS, ESN	120	30, 90	61.8	3.5	20449 a	10819 b	2417 c	781 c
3	MAP + AMS, ESN	180	30, 150	67.4	3.5	21559 a	12151 b	3032 c	1329 c
4	MAP + AMS, ESN	240	30, 210	63.9	3.7	21206 a	19265 a	9571 b	3834 b
5	MAP + AMS, ESN	300	30, 270	52.1	3.6	22655 a	19594 a	14510 a	9299 a
			Significance[3]	NS	NS	*	**	**	**
			LSD (0.10)	--	--	5769	5653	1369	1199

[1]MAP = monoammonium phosphate; AMS = ammonium sulfate; ESN = Environmentally Smart Nitrogen.

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 6. Effect of nitrogen rate from ESN fertilizer on plant stand, stems per plant, and petiole nitrate concentration of Dakota Trailblazer potato plants in Becker, MN.

Nitrogen Treatments				Stand (%)	Stems per plant	Petiole NO_3-N Concentration (ppm)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]						
		lb N/ac	P, E			June 20	June 28	July 11	July 26
1	MAP + AMS	30	30, 0	99.3 a	2.6	8011 c	981 d	379 e	194 d
2	MAP + AMS, ESN	120	30, 90	95.8 b	2.5	17102 b	7813 c	3301 d	1092 cd
3	MAP + AMS, ESN	180	30, 150	100.0 a	2.9	18381 ab	10133 c	7121 c	2682 c
4	MAP + AMS, ESN	240	30, 210	99.3 a	2.8	20606 a	16080 b	9954 b	5071 b
5	MAP + AMS, ESN	300	30, 270	99.3 a	2.8	21556 a	20186 a	12828 a	7515 a
			Significance[3]	++	NS	**	**	**	**
			LSD (0.10)	2.8	--	3181	3594	1081	1652

[1]MAP = monoammonium phosphate; AMS = ammonium sulfate; ESN = Environmentally Smart Nitrogen.

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 7. Effect of nitrogen rate from ESN fertilizer on plant stand, stems per plant, and petiole nitrate concentration of Russet Burbank potato plants in Becker, MN.

Nitrogen Treatments				Stand (%)	Stems per plant	Petiole NO_3-N Concentration (ppm)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]						
		lb N/ac	P, E			June 20	June 28	July 11	July 26
1	MAP + AMS	30	30, 0	100.0	5.2 a	4415 c	689 e	333 e	112 e
2	MAP + AMS, ESN	120	30, 90	100.0	4.5 ab	14864 b	5353 d	2919 d	1600 d
3	MAP + AMS, ESN	180	30, 150	99.3	4.4 b	17714 a	10181 c	7442 c	4367 c
4	MAP + AMS, ESN	240	30, 210	100.0	4.1 b	19549 a	14070 b	12438 b	6683 b
5	MAP + AMS, ESN	300	30, 270	99.3	4.3 b	19893 a	17249 a	15501 a	9377 a
			Significance[3]	NS	++	**	**	**	**
			LSD (0.10)	--	0.8	2638	2177	1776	1313

[1]MAP = monoammonium phosphate; AMS = ammonium sulfate; ESN = Environmentally Smart Nitrogen.

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 8. Effect of nitrogen rate from ESN fertilizer on plant stand, stems per plant, and petiole nitrate concentration of Ivory Crisp potato plants in Becker, MN.

Nitrogen Treatments				Stand (%)	Stems per plant	Petiole NO_3-N Concentration (ppm)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]						
		lb N/ac	P, E			June 20	June 28	July 11	July 26
1	MAP + AMS	30	30, 0	88.2	3.7 ab	4032 c	346 d	160 d	100 c
2	MAP + AMS, ESN	120	30, 90	90.3	3.5 bc	16220 b	5157 c	937 d	275 c
3	MAP + AMS, ESN	180	30, 150	86.7	4.0 a	19321 ab	9918 b	4265 c	1721 bc
4	MAP + AMS, ESN	240	30, 210	88.2	3.5 bc	21115 a	16604 a	8705 b	3536 b
5	MAP + AMS, ESN	300	30, 270	88.9	3.4 c	22467 a	16943 a	14872 a	7478 a
			Significance[3]	NS	**	**	**	**	**
			LSD (0.10)	--	0.3	3467	3370	2654	2134

[1]MAP = monoammonium phosphate; AMS = ammonium sulfate; ESN = Environmentally Smart Nitrogen.

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 9. Effect of nitrogen rate from ESN fertilizer on plant stand, stems per plant, and petiole nitrate concentration of Snowden potato plants in Becker, MN.

Nitrogen Treatments				Stand (%)	Stems per plant	Petiole NO_3-N Concentration (ppm)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]						
		lb N/ac	P, E			June 20	June 28	July 11	July 26
1	MAP + AMS	30	30, 0	100.0	5.3	3556 c	573 d	260 e	306 d
2	MAP + AMS, ESN	120	30, 90	100.0	5.0	15618 b	6535 c	2766 d	1490 c
3	MAP + AMS, ESN	180	30, 150	99.3	5.2	20797 a	11989 b	6237 c	2561 b
4	MAP + AMS, ESN	240	30, 210	100.0	4.8	22039 a	16424 a	10604 b	6679 a
5	MAP + AMS, ESN	300	30, 270	99.3	5.0	20957 a	18960 a	14041 a	7535 a
			Significance[3]	NS	NS	**	**	**	**
			LSD (0.10)	--	--	3843	2691	1907	1003

[1]MAP = monoammonium phosphate; AMS = ammonium sulfate; ESN = Environmentally Smart Nitrogen.

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 10. Effect of nitrogen rate from ESN fertilizer on Alpine Russet tuber yield and size distribution in Becker, MN.

Nitrogen Treatments				Tuber Yield										
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0-3 oz	3-6 oz	6-10 oz	10-14 oz	> 14 oz	Total	# 1 > 3 oz	# 2 > 3 oz	Total marketable	> 6 oz	> 10 oz
		lb N/ac	P, E	cwt / A						cwt / A			%	
1	MAP + AMS	30	30, 0	51.3	168.4 a	82.7 c	34.1 b	1.6 c	338.1 c	154.3 c	132.5 a	286.8 c	37.1 b	11.5 c
2	MAP + AMS, ESN	120	30, 90	42.5	150.5 a	140.1 ab	66.5 a	30.3 b	429.8 ab	293.6 ab	93.7 ab	387.3 ab	55.8 a	23.4 b
3	MAP + AMS, ESN	180	30, 150	50.7	150.3 a	154.1 a	75.7 a	42.5 b	473.3 a	339.7 a	82.9 b	422.5 a	57.8 a	25.2 b
4	MAP + AMS, ESN	240	30, 210	53.8	123.4 ab	128.8 ab	79.7 a	41.9 b	427.6 ab	286.4 b	87.4 b	373.8 ab	59.9 a	29.6 ab
5	MAP + AMS, ESN	300	30, 270	40.6	96.6 b	113.9 bc	56.5 ab	76.7 a	384.3 bc	266.7 b	77.0 b	343.7 b	64.7 a	35.1 a
			Significance[3]	NS	++	*	*	**	*	**	++	**	**	**
			LSD (0.10)	--	46.5	32.1	23.2	24.4	59.9	51.8	39.2	50.3	10.6	9.6

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 11. Effect of nitrogen rate from ESN fertilizer on Dakota Trailblazer tuber yield and size distribution in Becker, MN.

Nitrogen Treatments				Tuber Yield										
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0-3 oz	3-6 oz	6-10 oz	10-14 oz	> 14 oz	Total	# 1 > 3 oz	# 2 > 3 oz	Total marketable	> 6 oz	> 10 oz
		lb N/ac	P, E	cwt / A						cwt / A			%	
1	MAP + AMS	30	30, 0	20.6 bc	162.7 a	213.6 bc	26.1 b	0.9 c	424.0 c	399.8 c	3.6	403.3 c	56.2 c	6.1 c
2	MAP + AMS, ESN	120	30, 90	19.5 c	121.9 bc	260.3 ab	88.8 a	21.7 b	512.1 ab	491.2 ab	1.4	492.6 ab	72.4 a	21.5 b
3	MAP + AMS, ESN	180	30, 150	29.1 a	135.4 ab	272.9 a	97.3 a	12.4 bc	547.0 a	516.4 a	1.4	517.8 a	69.8 ab	19.9 b
4	MAP + AMS, ESN	240	30, 210	27.8 ab	159.6 ab	196.1 c	115.9 a	24.4 ab	523.8 ab	496.0 ab	0.0	496.0 ab	64.1 b	26.2 ab
5	MAP + AMS, ESN	300	30, 270	32.1 a	94.1 c	213.4 bc	114.7 a	44.3 a	498.7 b	465.7 b	1.0	466.6 b	74.7 a	32.0 a
			Significance[3]	*	*	++	**	*	**	**	NS	**	**	**
			LSD (0.10)	7.7	38.6	57.2	27.8	20.1	41.9	46.0	--	46.2	7.1	6.6

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 12. Effect of nitrogen rate from ESN fertilizer on Russet Burbank tuber yield and size distribution in Becker, MN.

Nitrogen Treatments				Tuber Yield										
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0-3 oz	3-6 oz	6-10 oz	10-14 oz	> 14 oz	Total	# 1 > 3 oz	# 2 > 3 oz	Total marketable	> 6 oz	> 10 oz
		lb N/ac	P, E	cwt / A						cwt / A			%	
1	MAP + AMS	30	30, 0	141.0 a	231.1	56.6	1.1 c	0.0 c	429.8 b	232.2	56.6	288.8 b	12.9 c	0.3 c
2	MAP + AMS, ESN	120	30, 90	112.2 b	234.3	135.5	7.6 c	5.0 bc	494.6 ab	320.2	62.1	382.4 a	30.2 b	2.6 c
3	MAP + AMS, ESN	180	30, 150	107.2 b	243.7	143.7	38.4 b	10.0 bc	543.0 a	363.2	72.6	435.8 a	35.4 ab	8.9 b
4	MAP + AMS, ESN	240	30, 210	102.4 bc	208.3	139.4	50.5 ab	14.4 ab	515.0 a	315.9	96.7	412.6 a	39.6 ab	12.6 b
5	MAP + AMS, ESN	300	30, 270	82.0 c	177.3	148.2	68.7 a	25.3 a	501.5 ab	304.0	115.5	419.5 a	48.1 a	19.3 a
			Significance[3]	*	NS	NS	**	*	++	NS	NS	*	**	**
			LSD (0.10)	24.8	--	--	20.7	12.7	77.2	--	--	79.1	14.3	6.3

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 13. Effect of nitrogen rate from ESN fertilizer on Ivory Crisp tuber yield and size distribution in Becker, MN.

Nitrogen Treatments				Tuber Yield										
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0 - 3 oz (0 - 2.25")	3 - 6 oz (2.25 - 2.75")	6 - 10 oz (2.75 - 3.25")	10 - 14 oz (3.25 - 3.75")	> 14 oz (> 3.75")	Total	# 1 > 3 oz	# 2 > 3 oz	Total marketable	> 6 oz	> 10 oz
		lb N/ac	P, E	cwt / A						cwt / A			%	
1	MAP + AMS	30	30, 0	41.6	147.1 a	135.6 d	36.2 c	7.6 c	368.1 c	326.4 c	0.0	326.4 c	47.8 b	11.4 c
2	MAP + AMS, ESN	120	30, 90	30.4	125.7 ab	215.4 b	80.2 bc	18.4 bc	470.1 b	438.9 b	0.8	439.7 b	66.1 a	20.0 bc
3	MAP + AMS, ESN	180	30, 150	33.6	137.2 ab	185.2 bc	108.7 ab	40.1 ab	504.8 ab	470.7 ab	0.5	471.2 ab	65.9 a	28.9 b
4	MAP + AMS, ESN	240	30, 210	26.4	118.4 bc	254.8 a	104.9 ab	41.5 ab	546.1 a	516.7 a	2.9	519.6 a	73.5 a	26.6 b
5	MAP + AMS, ESN	300	30, 270	25.5	89.9 c	176.9 c	128.6 a	67.0 a	487.9 b	461.6 ab	0.8	462.4 ab	76.3 a	40.2 a
			Significance[3]	NS	*	**	*	*	**	**	NS	**	**	**
			LSD (0.10)	--	28.7	35.3	47.4	30.6	53.3	59.6	--	59.7	11.0	10.6

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 14. Effect of nitrogen rate from ESN fertilizer on Snowden tuber yield and size distribution in Becker, MN.

Nitrogen Treatments				Tuber Yield										
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0 - 3 oz (0 - 2.25")	3 - 6 oz (2.25 - 2.75")	6 - 10 oz (2.75 - 3.25")	10 - 14 oz (3.25 - 3.75")	> 14 oz (> 3.75")	Total	# 1 > 3 oz	# 2 > 3 oz	Total marketable	> 6 oz	> 10 oz
		lb N/ac	P, E	cwt / A						cwt / A			%	
1	MAP + AMS	30	30, 0	76.1 bc	240.7	81.2 b	12.1 d	1.8 c	411.9 b	335.7 b	0.0	335.7 b	23.0 c	3.3 d
2	MAP + AMS, ESN	120	30, 90	72.8 c	275.8	164.8 a	25.2 cd	1.6 c	540.3 a	467.5 a	0.0	467.5 a	35.2 b	4.9 cd
3	MAP + AMS, ESN	180	30, 150	75.3 bc	243.8	203.2 a	32.5 c	5.1 bc	559.9 a	484.6 a	0.0	484.6 a	43.1 ab	6.7 c
4	MAP + AMS, ESN	240	30, 210	90.3 ab	231.5	181.2 a	48.3 b	13.3 ab	564.6 a	474.3 a	0.0	474.3 a	43.2 a	10.9 b
5	MAP + AMS, ESN	300	30, 270	96.4 a	210.7	173.1 a	64.9 a	16.9 a	562.0 a	464.0 a	1.6	465.6 a	44.9 a	14.5 a
			Significance[3]	*	NS	**	**	*	**	**	NS	**	**	**
			LSD (0.10)	16.0	--	47.5	14.8	8.9	53.1	53.2	--	53.5	8.0	2.6

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 15. Effect of nitrogen rate from ESN fertilizer on Alpine Russet tuber quality in Becker, MN.

Nitrogen Treatments				Hollow Heart (%)	Brown Center (%)	Scab (%)	Specific Gravity	Tuber Dry Matter (%)
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]					
		lb N/ac	P, E					
1	MAP + AMS	30	30, 0	0.0	0.0	0.0	1.0802	17.6
2	MAP + AMS, ESN	120	30, 90	0.0	0.0	0.0	1.0725	19.5
3	MAP + AMS, ESN	180	30, 150	2.0	2.0	0.0	1.0758	20.0
4	MAP + AMS, ESN	240	30, 210	2.0	2.0	0.0	1.0765	19.8
5	MAP + AMS, ESN	300	30, 270	3.3	4.3	0.0	1.0798	20.7
			Significance[3]	NS	NS	--	NS	NS
			LSD (0.10)	--	--	--	--	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 16. Effect of nitrogen rate from ESN fertilizer on Dakota Trailblazer tuber quality in Becker, MN.

Nitrogen Treatments				Hollow Heart (%)	Brown Center (%)	Scab (%)	Specific Gravity	Tuber Dry Matter (%)
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]					
		lb N/ac	P, E					
1	MAP + AMS	30	30, 0	4.3 c	4.3 c	0.0	1.0985	26.6 ab
2	MAP + AMS, ESN	120	30, 90	11.0 bc	11.0 bc	4.3	1.1074	26.3 b
3	MAP + AMS, ESN	180	30, 150	15.0 bc	15.0 bc	0.0	1.1045	27.3 a
4	MAP + AMS, ESN	240	30, 210	37.8 a	37.8 a	0.0	1.1057	26.7 ab
5	MAP + AMS, ESN	300	30, 270	22.3 b	22.3 b	0.0	1.1020	24.9 c
			Significance[3]	**	**	NS	NS	**
			LSD (0.10)	14.2	14.2	--	--	1.0

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 17. Effect of nitrogen rate from ESN fertilizer on Russet Burbank tuber quality in Becker, MN.

Nitrogen Treatments				Hollow Heart (%)	Brown Center (%)	Scab (%)	Specific Gravity	Tuber Dry Matter (%)
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]					
		lb N/ac	P, E					
1	MAP + AMS	30	30, 0	0.0 c	0.0 c	0.0	1.0758 c	20.0
2	MAP + AMS, ESN	120	30, 90	3.0 c	2.0 c	0.0	1.0839 a	19.7
3	MAP + AMS, ESN	180	30, 150	6.3 bc	6.3 bc	0.0	1.0823 ab	21.0
4	MAP + AMS, ESN	240	30, 210	19.0 a	19.0 a	3.0	1.0799 b	21.1
5	MAP + AMS, ESN	300	30, 270	18.3 ab	18.3 ab	0.0	1.0831 ab	20.8
			Significance[3]	*	++	NS	**	NS
			LSD (0.10)	12.7	12.4	--	0.0037	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 18. Effect of nitrogen rate from ESN fertilizer on Ivory Crisp tuber quality in Becker, MN.

Nitrogen Treatments				Hollow Heart (%)	Brown Center (%)	Scab (%)	Specific Gravity	Tuber Dry Matter (%)
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]					
		lb N/ac	P, E					
1	MAP + AMS	30	30, 0	0.0	0.0	18.8	1.0758 c	18.9 d
2	MAP + AMS, ESN	120	30, 90	1.0	1.0	9.0	1.0851 b	20.9 c
3	MAP + AMS, ESN	180	30, 150	1.0	1.0	20.0	1.0864 ab	21.1 bc
4	MAP + AMS, ESN	240	30, 210	1.0	2.0	17.0	1.0880 ab	22.1 ab
5	MAP + AMS, ESN	300	30, 270	1.0	1.0	18.0	1.0894 a	22.5 a
			Significance[3]	NS	NS	NS	**	**
			LSD (0.10)	--	--	--	0.0038	1.1

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 19. Effect of nitrogen rate from ESN fertilizer on Snowden tuber quality in Becker, MN.

Nitrogen Treatments				Hollow Heart (%)	Brown Center (%)	Scab (%)	Specific Gravity	Tuber Dry Matter (%)
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]					
		lb N/ac	P, E					
1	MAP + AMS	30	30, 0	0.0	0.0	1.0	1.0835	20.8 b
2	MAP + AMS, ESN	120	30, 90	0.0	0.0	12.0	1.0875	22.2 ab
3	MAP + AMS, ESN	180	30, 150	3.0	4.0	1.0	1.0893	22.8 a
4	MAP + AMS, ESN	240	30, 210	3.0	3.0	0.0	1.0871	22.4 ab
5	MAP + AMS, ESN	300	30, 270	6.0	6.0	4.3	1.0922	23.5 a
			Significance[3]	NS	NS	NS	NS	++
			LSD (0.10)	--	--	--	--	1.6

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 20. Effect of nitrogen rate from ESN fertilizer on whole-tuber nitrogen, sucrose, and glucose concentrations of Alpine Russet potato plants in Becker, MN.

Nitrogen Treatments				Tuber Nitrogen (%)	Sugar Concentration (mg/g)							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]		0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E		Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
1	MAP + AMS	30	30, 0	1.16 c	1.52	2.02 a	1.30 ab	3.11 a	1.29	2.65 a	0.39	3.76 a
2	MAP + AMS, ESN	120	30, 90	1.29 bc	1.50	1.86 ab	1.57 a	2.17 b	0.93	3.48 a	0.30	3.13 a
3	MAP + AMS, ESN	180	30, 150	1.18 c	1.46	1.50 bc	0.92 c	2.64 ab	0.98	2.99 a	0.72	3.10 a
4	MAP + AMS, ESN	240	30, 210	1.43 ab	1.34	1.24 c	1.17 bc	1.81 b	0.89	2.75 a	0.38	1.96 b
5	MAP + AMS, ESN	300	30, 270	1.54 a	1.49	0.73 d	1.48 ab	1.74 b	0.86	1.40 b	0.29	1.38 b
			Significance[3]	**	NS	**	*	++	NS	*	NS	**
			LSD (0.05)	0.17	--	0.40	0.34	0.91	--	1.09	--	0.97

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 21. Effect of nitrogen rate from ESN fertilizer on whole-tuber nitrogen, sucrose, and glucose concentrations of Dakota Trailblazer potato plants in Becker, MN.

Nitrogen Treatments				Tuber Nitrogen (%)	Sugar Concentration (mg/g)							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]		0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E		Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
1	MAP + AMS	30	30, 0	0.82 c	1.45	0.31 b	0.99 ab	0.55	0.47	0.90	0.67	0.62
2	MAP + AMS, ESN	120	30, 90	0.86 c	1.54	0.61 a	1.07 a	0.54	0.55	0.68	0.40	0.95
3	MAP + AMS, ESN	180	30, 150	0.98 b	1.39	0.41 ab	0.94 abc	0.51	0.63	0.60	0.74	0.85
4	MAP + AMS, ESN	240	30, 210	1.07 b	1.50	0.25 b	1.50 c	0.41	0.61	0.37	0.96	0.65
5	MAP + AMS, ESN	300	30, 270	1.19 a	1.38	0.48 ab	1.38 bc	0.48	0.50	0.65	0.75	0.89
			Significance[3]	**	NS	++	*	NS	NS	NS	NS	NS
			LSD (0.05)	0.12	--	0.26	0.16	--	--	--	--	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 22. Effect of nitrogen rate from ESN fertilizer on whole-tuber nitrogen, sucrose, and glucose concentrations of Russet Burbank potato plants in Becker, MN.

Nitrogen Treatments				Tuber Nitrogen (%)	Sugar Concentration (mg/g)							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]		0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E		Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
1	MAP + AMS	30	30, 0	0.79 c	0.94	2.40	1.08	3.07 a	0.48	2.42	0.23	2.61
2	MAP + AMS, ESN	120	30, 90	1.06 b	0.78	1.49	1.22	2.42 ab	0.42	1.36	0.32	2.24
3	MAP + AMS, ESN	180	30, 150	1.12 ab	0.83	1.37	1.02	1.81 bc	0.49	1.98	0.23	1.81
4	MAP + AMS, ESN	240	30, 210	1.14 ab	0.95	1.76	0.85	1.88 bc	0.42	1.68	0.29	1.50
5	MAP + AMS, ESN	300	30, 270	1.23 a	1.24	1.56	1.27	1.58 c	0.60	1.52	0.13	1.67
			Significance[3]	**	NS	NS	NS	*	NS	NS	NS	NS
			LSD (0.05)	0.18	--	--	--	0.72	--	--	--	--

Table 23. Effect of nitrogen rate from ESN fertilizer on whole-tuber nitrogen, sucrose, and glucose concentrations of Ivory Crisp potato plants in Becker, MN.

Nitrogen Treatments				Tuber Nitrogen (%)	Sugar Concentration (mg/g)							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]		0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E		Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
1	MAP + AMS	30	30, 0	0.96 d	0.37	0.61 a	0.48	0.45 a	0.55	0.98	0.33	1.10 a
2	MAP + AMS, ESN	120	30, 90	1.09 c	0.52	0.28 b	0.61	0.28 ab	0.41	0.60	0.40	1.10 a
3	MAP + AMS, ESN	180	30, 150	1.19 b	0.66	0.29 b	0.76	0.29 ab	0.95	0.66	0.40	0.72 b
4	MAP + AMS, ESN	240	30, 210	1.20 b	0.63	0.24 b	0.81	0.24 ab	0.86	0.53	0.92	0.56 b
5	MAP + AMS, ESN	300	30, 270	1.48 a	0.92	0.11 b	0.72	0.11 b	0.46	0.22	0.70	0.48 b
			Significance[3]	**	NS	*	NS	++	NS	NS	NS	**
			LSD (0.05)	0.08	--	0.21	--	0.21	--	--	--	0.30

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 24. Effect of nitrogen rate from ESN fertilizer on whole-tuber nitrogen, sucrose, and glucose concentrations of Snowden potato plants in Becker, MN.

Nitrogen Treatments				Tuber Nitrogen (%)	Sugar Concentration (mg/g)							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]		0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E		Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose	Sucrose	Glucose
1	MAP + AMS	30	30, 0	1.11	1.18 a	0.29 a	0.91 a	0.42 a	1.43	0.65	2.36 a	3.41
2	MAP + AMS, ESN	120	30, 90	1.21	1.13 ab	0.30 a	0.87 a	0.23 b	1.17	0.53	1.22 c	2.48
3	MAP + AMS, ESN	180	30, 150	1.03	0.95 bc	0.16 b	0.68 b	0.23 b	1.33	0.77	1.98 ab	2.93
4	MAP + AMS, ESN	240	30, 210	1.14	1.05 abc	0.22 ab	0.67 b	0.20 b	1.32	0.42	1.86 ab	2.57
5	MAP + AMS, ESN	300	30, 270	1.16	0.91 c	0.12 b	0.73 ab	0.10 b	0.97	0.33	1.62 bc	2.82
			Significance[3]	NS	++	++	*	**	NS	NS	*	NS
			LSD (0.05)	--	0.20	0.12	0.19	0.15	--	--	0.63	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 25. Effect of nitrogen rate from ESN fertilizer on tuber frying quality of Ivory Crisp potato tubers in Becker, MN.

Nitrogen Treatments				Frying Quality							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score
1	MAP + AMS	30	30, 0	2.3	56.0	2.0	57.3 ab	2.0	56.0	3.0 a	50.3 b
2	MAP + AMS, ESN	120	30, 90	2.0	58.5	2.0	57.8 ab	2.0	57.5	2.3 b	57.0 a
3	MAP + AMS, ESN	180	30, 150	2.0	58.0	2.3	56.0 b	2.0	59.0	2.0 b	58.8 a
4	MAP + AMS, ESN	240	30, 210	2.3	58.0	2.0	59.0 a	2.0	58.0	2.0 b	59.5 a
5	MAP + AMS, ESN	300	30, 270	2.0	58.3	2.0	59.3 a	2.0	58.3	2.3 b	58.0 a
			Significance[3]	NS	NS	NS	++	--	NS	*	*
			LSD (0.10)	--	--	--	2.4	--	--	0.5	5.5

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

[4]Chip Color Score: 1 = light and 5 = dark.

Treatments that have the same letter within a column are not significantly different from each other.

Table 26. Effect of nitrogen rate from ESN fertilizer on frying quality of Snowden potato tubers in Becker, MN.

Nitrogen Treatments				Frying Quality							
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]	0 Months		3 Months		6 Months		9 Months	
		lb N/ac	P, E	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score	Chip Color[4]	AGT Score
1	MAP + AMS	30	30, 0	2.0	58.8	2.0	58.3	2.3	53.7	3.8	42.0
2	MAP + AMS, ESN	120	30, 90	2.0	57.8	2.0	58.8	2.5	54.8	3.8	43.0
3	MAP + AMS, ESN	180	30, 150	2.0	58.3	2.0	59.0	2.5	55.3	3.5	43.0
4	MAP + AMS, ESN	240	30, 210	2.0	58.8	2.0	57.8	2.0	57.8	3.0	46.8
5	MAP + AMS, ESN	300	30, 270	2.3	59.0	2.0	58.8	2.0	58.0	3.3	44.0
			Significance[3]	NS	NS	NA	NS	NS	NS	NS	NS
			LSD (0.10)	--	--	--	--	--	--	--	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22); ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

[4]Chip Color Score: 1 = light and 5 = dark.

Treatments that have the same letter within a column are not significantly different from each other.

Table 27. Effect of nitrogen rate from ESN fertilizer on acrylamide concentration of Alpine Russet French fries in Becker, MN.

Nitrogen Treatments				Acrylamide Concentration (ppb, fresh-weight basis)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]				
		lb N/ac	P, E	0 Months	3 Months	6 Months	9 Months
1	MAP + AMS	30	30, 0	420	629	543 cd	912
2	MAP + AMS, ESN	120	30, 90	359	824	705 bc	1071
3	MAP + AMS, ESN	180	30, 150	532	525	816 ab	1104
4	MAP + AMS, ESN	240	30, 210	476	113	1010 a	1128
5	MAP + AMS, ESN	300	30, 270	403	1021	478 d	756
			Significance[3]	NS	NS	**	NS
			LSD (0.05)	--	--	225	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22);
ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 28. Effect of nitrogen rate from ESN fertilizer on acrylamide concentration of Dakota Trailblazer French fries in Becker, MN.

Nitrogen Treatments				Acrylamide Concentration (ppb, fresh-weight basis)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]				
		lb N/ac	P, E	0 Months	3 Months	6 Months	9 Months
1	MAP + AMS	30	30, 0	137	445	114	117 c
2	MAP + AMS, ESN	120	30, 90	144	254	312	192 bc
3	MAP + AMS, ESN	180	30, 150	85	126	192	449 a
4	MAP + AMS, ESN	240	30, 210	93	413	219	337 abc
5	MAP + AMS, ESN	300	30, 270	100	382	226	395 ab
			Significance[3]	NS	NS	NS	*
			LSD (0.05)	--	--	--	229

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22);
ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 29. Effect of nitrogen rate from ESN fertilizer on acrylamide concentration of Russet Burbank French fries in Becker, MN.

Nitrogen Treatments				Acrylamide Concentration (ppb, fresh-weight basis)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]				
		lb N/ac	P, E	0 Months	3 Months	6 Months	9 Months
1	MAP + AMS	30	30, 0	407 b	491	408	564
2	MAP + AMS, ESN	120	30, 90	474 b	669	845	996
3	MAP + AMS, ESN	180	30, 150	760 a	918	1118	840
4	MAP + AMS, ESN	240	30, 210	443 b	755	788	955
5	MAP + AMS, ESN	300	30, 270	826 a	745	713	1016
			Significance[3]	**	NS	NS	NS
			LSD (0.05)	186	--	--	--

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22);
ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 30. Effect of nitrogen rate from ESN fertilizer on acrylamide concentration of Ivory Crisp potato chips in Becker, MN.

Nitrogen Treatments				Acrylamide Concentration (ppb, fresh-weight basis)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]				
		lb N/ac	P, E	0 Months	3 Months	6 Months	9 Months
1	MAP + AMS	30	30, 0	3533	2929	1400	4037 a
2	MAP + AMS, ESN	120	30, 90	3031	2737	1334	2832 b
3	MAP + AMS, ESN	180	30, 150	3615	3484	1024	2194 bc
4	MAP + AMS, ESN	240	30, 210	3187	1840	1351	1555 c
5	MAP + AMS, ESN	300	30, 270	3114	2861	1376	1727 c
			Significance[3]	NS	NS	NS	**
			LSD (0.05)	--	--	--	1094

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22);
ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 31. Effect of nitrogen rate from ESN fertilizer on acrylamide concentration of Snowden potato chips in Becker, MN.

Nitrogen Treatments				Acrylamide Concentration (ppb, fresh-weight basis)			
Treatment #	Nitrogen Source[1]	Nitrogen Rate	Nitrogen Timing[2]				
		lb N/ac	P, E	0 Months	3 Months	6 Months	9 Months
1	MAP + AMS	30	30, 0	2950	1697 b	2993 a	10044 ab
2	MAP + AMS, ESN	120	30, 90	3363	3152 a	2564 ab	10881 a
3	MAP + AMS, ESN	180	30, 150	2409	1725 b	3035 a	11632 a
4	MAP + AMS, ESN	240	30, 210	2568	1291 b	1553 b	7431 bc
5	MAP + AMS, ESN	300	30, 270	2643	1587 b	1620 b	5399 c
			Significance[3]	NS	**	*	*
			LSD (0.05)	--	816	1042	3433

[1]MAP = monoammonium phosphate (11-46-0); AMS = ammonium sulfate (21-0-0-22);
ESN = Environmentally Smart Nitrogen (44-0-0).

[2]P = planting; E = emergence/hilling.

[3]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Treatments that have the same letter within a column are not significantly different from each other.

Table 32. Acrylamide contents of fries and chips vs. raw tuber sugar and nitrogen concentrations for Becker, MN[1].

	Acrylamide vs:	R^2	P	N	Direction
Alpine Russet	Sucrose, harvest	0.075	0.3223	15	0
	Sucrose, 3 months	0.099	0.2191	17	0
	Sucrose, 6 months	0.036	0.4672	17	0
	Sucrose, 9 months	0.115	0.2154	15	0
	Glucose, harvest	0.006	0.7796	15	0
	Glucose, 3 months	0.059	0.3468	17	0
	Glucose, 6 months	0.096	0.2263	17	0
	Glucose, 9 months	0.031	0.5309	15	0
	Nitrogen, harvest	<0.001	0.9887	15	0
	Nitrogen, 3 months	0.130	0.1550	17	0
	Nitrogen, 6 months	0.002	0.8725	17	0
	Nitrogen, 9 months	0.016	0.6509	15	0
Dakota Trailblazer	Sucrose, harvest	0.067	0.2994	18	0
	Sucrose, 3 months	0.183	0.1276	14	0
	Sucrose, 6 months	0.038	0.5073	14	0
	Sucrose, 9 months	0.063	0.3672	15	0
	Glucose, harvest	0.053	0.3561	18	0
	Glucose, 3 months	0.084	0.3145	14	0
	Glucose, 6 months	<0.001	0.9727	14	0
	Glucose, 9 months	<0.001	0.9564	15	0
	Nitrogen, harvest	0.055	0.3493	18	0
	Nitrogen, 3 months	<0.001	0.9492	14	0
	Nitrogen, 6 months	0.016	0.6638	14	0
	Nitrogen, 9 months	**0.321**	**0.0162**	**15**	**+**
Russet Burbank	Sucrose, harvest	0.075	0.2573	19	0
	Sucrose, 3 months	*0.229*	*0.0521*	*17*	-
	Sucrose, 6 months	0.109	0.2110	16	0
	Sucrose, 9 months	0.111	0.1768	18	0
	Glucose, harvest	0.032	0.4674	19	0
	Glucose, 3 months	0.002	0.8553	17	0
	Glucose, 6 months	0.014	0.6681	16	0
	Glucose, 9 months	0.047	0.3875	18	0
	Nitrogen, harvest	0.147	0.1050	19	0
	Nitrogen, 3 months	<0.001	0.9549	17	0
	Nitrogen, 6 months	0.029	0.5311	16	0
	Nitrogen, 9 months	*0.193*	*0.0680*	*18*	+

	Acrylamide vs:	R^2	P	N	Direction
Ivory Crisp	Sucrose, harvest	0.046	0.3936	18	0
	Sucrose, 3 months	**0.290**	**0.0470**	**14**	**+**
	Sucrose, 6 months	0.024	0.6147	13	0
	Sucrose, 9 months	0.095	0.2839	14	0
	Glucose, harvest	0.025	0.5328	18	0
	Glucose, 3 months	0.163	0.1517	14	0
	Glucose, 6 months	<0.001	0.9722	13	0
	Glucose, 9 months	*0.220*	*0.0517*	*14*	+
	Nitrogen, harvest	0.001	0.9046	18	0
	Nitrogen, 3 months	0.002	0.8971	14	0
	Nitrogen, 6 months	0.085	0.3337	13	0
	Nitrogen, 9 months	0.203	0.1059	14	-
Snowden	*Sucrose, harvest*	*0.207*	*0.0581*	*18*	+
	Sucrose, 3 months	0.094	0.2305	17	0
	Sucrose, 6 months	<0.001	0.9512	18	0
	Sucrose, 9 months	0.045	0.3993	18	0
	Glucose, harvest	**0.378**	**0.0067**	**18**	**+**
	Glucose, 3 months	0.012	0.6822	17	0
	Glucose, 6 months	**0.312**	**0.0160**	**18**	**+**
	Glucose, 9 months	0.107	0.1846	18	0
	Nitrogen, harvest	0.023	0.5450	18	0
	Nitrogen, 3 months	0.062	0.3371	17	0
	Nitrogen, 6 months	0.146	0.1179	18	0
	Nitrogen, 9 months	0.110	0.1778	18	0

[1]Linear regressions: Acrylamide content of fried potato product at each sampling period as a function of whole-tuber glucose or sucrose content in the same period or whole-tuber nitrogen content at harvest.

Table 33. Whole-tuber sugar concentrations of participating growers' potato plants in MN.

Grower	Variety	Preparation	Sugar Concentration (mg/g)							
			0 Months		3 Months		6 Months		9 Months	
			Sucrose[1]	Glucose[1]	Sucrose[1]	Glucose[1]	Sucrose[1]	Glucose[1]	Sucrose[1]	Glucose[1]
K+O	Alpine Russet	Fry	2.11 ± 0.74	0.82 ± 0.34	1.74 ± 0.44	0.97 ± 0.54	0.94 ± 0.10	0.73 ± 0.17	2.75 ± 2.74	1.90 ± 1.97
K+O	Russet Burbank	Fry	1.82 ± 0.84	0.95 ± 0.42	1.58 ± 0.57	1.05 ± 0.23	0.77 ± 0.33	0.71 ± 0.16	1.49 ± 0.85	1.22 ± 0.41
Park Rapids Bliss	Russet Burbank	Fry	0.89 ± 0.33	0.74 ± 0.30	1.03 ± 0.19	1.13 ± 0.36	0.73 ± 0.06	1.17 ± 0.21	0.90 ± 0.13	1.19 ± 0.50
Park Rapids HCBE	Russet Burbank	Fry	1.22 ± 0.12	1.02 ± 0.27	0.98 ± 0.22	1.16 ± 0.42	0.55 ± 0.08	0.91 ± 0.33	0.89 ± 0.14	0.74 ± 0.36
Perham-Karsina	Dakota Trailblazer	Fry	1.12 ± 0.15	0.58 ± 0.13	1.44 ± 0.05	0.90 ± 0.23	1.00 ± 0.28	0.57 ± 0.11	1.08 ± 0.09	0.45 ± 0.34
Perham-RDO	Ivory Crisp	Chip	1.75 ± 0.63	0.12 ± 0.04	1.28 ± 0.26	0.27 ± 0.15	0.72 ± 0.05	0.05 ± 0.03	1.66 ± 0.10	0.39 ± 0.20
Goenner	Snowden	Chip	0.81 ± 0.14	0.08 ± 0.04	0.61 ± 0.01	0.11 ± 0.03	0.83 ± 0.15	0.27 ± 0.19	2.69 ± 0.38	2.39 ± 0.78
		Significance[2]	*	**	**	**	NS	**	NS	NS
		LSD (0.10)	0.85	0.39	0.48	0.49	--	0.27	--	--

[1]Mean ± S.D.

[2]NS = non-significant; ++ = significant at 10%; * = significant at 5%; ** = significant at 1%.

Table 34. Tuber frying quality of participating growers' potato tubers in MN.

Grower	Variety	Preparation	Frying Quality							
			0 Months		3 Months		6 Months		9 Months	
			Chip Color[1,2]	AGT Score[1]	Chip Color[1,2]	AGT Score[1]	Chip Color[1,2]	AGT Score[1]	Chip Color[1,2]	AGT Score[1]
Perham-RDO	Ivory Crisp	Chip	2.0 ± 0.0	57.7 ± 3.1	2.0 ± 0.0	59.3 ± 2.1	-	-	2.0 ± 0.0	58.0 ± 1.7
Goenner	Snowden	Chip	2.0 ± 0.0	62.7 ± 1.2	2.0 ± 0.0	59.0 ± 1.0	2.0 ± 0.0	57.3 ± 1.2	3.0 ± 0.0	50.3 ± 3.2

[1]Mean ± S.D.

[2]Chip Color Score: 1 = light and 5 = dark.

Table 33. Acrylamide concentrations of French fries and chips from participating growers' potato plants in MN.

Grower	Variety	Preparation	Acrylamide Concentration[1] (ppb, fresh-weight basis)			
			0 Months	3 Months	6 Months	9 Months
K+O	Alpine Russet	Fry	409 ± 205	619 ± 34	633 ± 395	1291 ± 643
K+O	Russet Burbank	Fry	582 ± 281	802 ± 362	519 ± 219	1306 ± 249
Park Rapids Bliss	Russet Burbank	Fry	678 ± 220	717 ± 427	781 ± 91	788 ± 142
Park Rapids HCBE	Russet Burbank	Fry	493 ± 67	838 ± 321	681 ± 171	834 ± 116
Perham-Karsina	Dakota Trailblazer	Fry	554 ± 49	371 ± 243	584 ± 121	908 ± 363
Perham-RDO	Ivory Crisp	Chip	3510 ± 859	2020 ± 658	1056 ± 119	1469 ± 320
Goenner	Snowden	Chip	2197 ± 608	1311 ± 156	1908 ± 994	5930 ± 563

[1]Mean ± S.D.

Project I

Expanding sales & consumption of specialty crops at farmers markets

Farmers Market Pasta

SERVES 8

INGREDIENTS

1 pound pasta (any shape)

3 cups chopped tomatoes

6-8 cloves finely chopped garlic

¼ cup fresh parsley, chopped

1 tablespoon lemon juice

1 tablespoon olive oil

Salt and pepper to taste

Lots of assorted chopped vegetables (zucchini, green peppers, eggplant, etc.)

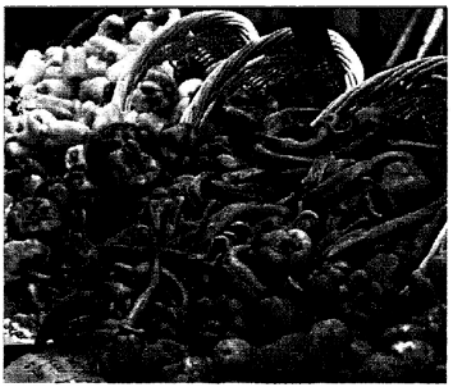
Add your favorite fully cooked meat. Heat thoroughly. (optional)

DIRECTIONS

1. Cook pasta per package directions.
2. Heat olive oil in sauté pan or skillet.
3. Add garlic and sauté until you can smell it cooking.
4. Add parsley and tomatoes and simmer for 4 minutes.
5. Add vegetables.
6. Add pasta, toss and heat thoroughly.
7. Season with salt and pepper to taste.
8. Add lemon juice just before serving.

Broiled Zucchini with Herbs

SERVES 10



INGREDIENTS

2 teaspoons olive oil

2 garlic cloves (or 2 teaspoons garlic powder)

2 tablespoons lemon juice

¼ cup chopped parsley

½ cup chopped green onions

5 cups sliced zucchini (about 1 ½ pounds)

1 tomato, chopped

Fresh herbs to taste (basil, rosemary, or thyme)

DIRECTIONS

1. Preheat broiler.
2. In a large bowl, mix the olive oil, garlic, lemon juice, parsley, onion, tomato and herbs.
3. Toss the zucchini with this mixture.
4. Place the zucchini mixture on a baking tray and broil for 8 to 10 minutes or until tender.

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Blasted Broccoli
SERVES 4-6

INGREDIENTS

1 ¼ pounds (about 8 cups) broccoli crowns

2 teaspoons olive oil

2 garlic cloves, finely chopped

(or 2 teaspoons garlic powder)

½ teaspoon of dried red pepper flakes

DIRECTIONS

1. Preheat oven to 450 °F.
2. Wash broccoli and toss it with olive oil, garlic and red pepper flakes.
3. Place on a baking sheet or oven safe baking dish.
4. Cook for about 15 minutes.

Parsley-Buttered New Potatoes
SERVES 10

INGREDIENTS

3 pounds small potatoes, unpeeled

2 tablespoons butter

2 tablespoons fresh parsley, chopped

(or 2 teaspoons of dried parsley)

Pinch of salt (optional)

DIRECTIONS

1. Wash potatoes and cut to the same size.
2. Cover potatoes with water and bring to a boil. Reduce to a simmer and cook until tender (about 20 minutes).
3. Drain and place in a baking dish.
4. Add butter and parsley, gently mix.

Fresh Apple Salsa
SERVES 4

INGREDIENTS

2 ripe apples

1 large tomato

1 clove garlic, finely chopped

¼ cup chopped onion

2 teaspoons fresh mint

1 tablespoon lemon juice or vinegar

1 tablespoon olive oil (optional)

Salt and pepper to taste

DIRECTIONS

1. Dice fresh apples.
2. Dice tomato.
3. Finely chop garlic clove.
4. Finely chop onion.
5. Chop mint leaves.
6. Mix apples, tomatoes, garlic, onion, and mint together.
7. Mix lemon juice, oil and salt together and add to the above ingredients.
8. Serve with whole-wheat pita chips, tortilla chips or crackers.

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GOOD NUTRITION AT FARMERS MARKETS

Smart Shopping for Vegetables and Fruits

It is possible to eat vegetables and fruits on any budget. Getting enough of these foods promotes health and can reduce your risk of certain diseases. There are many low-cost ways to meet your vegetable and fruit needs.

- Eat fresh vegetables and fruits that are in season. They are easy to get, have more flavor, and are usually less expensive. Your local farmers market is a great source of seasonal produce.
- Create a meal plan for the week that uses similar vegetables and fruits, prepared in different ways.
- Cook enough for several meals and freeze leftovers. Place enough food for 1-2 meals in each container.
- When trying new vegetables and fruits, buy in small amounts. Taste test before you change your grocery list.
- To make many fresh vegetables and fruits last longer, store them in the refrigerator or freezer soon after getting home from your shopping trip.
- Prepare and freeze vegetable soups, stews, or other dishes in advance. This saves time and money. Add leftover vegetables to casseroles or blend them to make soup. Overripe fruit is great for smoothies or baking.

KEEP YOUR FOOD SAFE

- Choose produce that is free of all signs of bruising and spoilage. If the skin is broken, the surface of the produce is slimy, or there are soft spots on a portion of the vegetable or fruit, it will spoil more rapidly.
- Go directly home from the market. Foods will decline in quality and perishable foods like meats and eggs can pose food safety problems if left sitting in your car.
- Wash hands with soap and warm water for at least 20 seconds before preparing produce.
- Wash produce before you use it, NOT when you bring it home. Washing produce before storage causes faster spoilage. Rinse under clean, running water just before preparing or eating. Do not use soap or detergent; it can get into produce and make you sick. Rub briskly to clean the surface. Dry with a clean cloth or paper towel.

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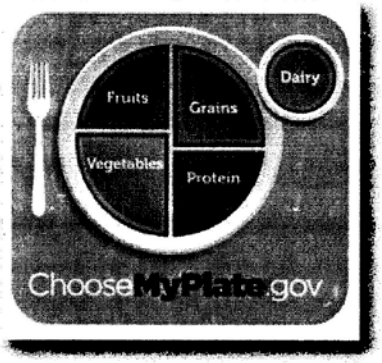
BUILD A HEALTHY PLATE

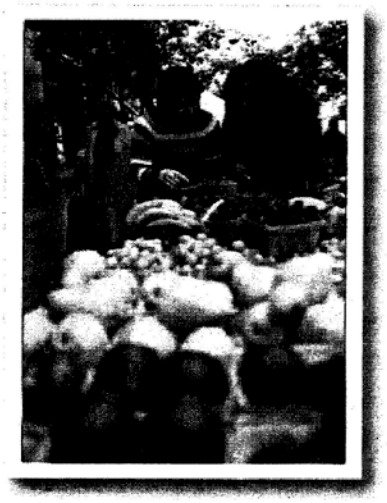
Before you eat, think about what goes on your plate or in your cup or bowl. Foods like vegetables, fruits, whole grains, low-fat dairy products, and lean protein contain the nutrients you need without too many calories. Try some of these options.



- **Make half your plate vegetables and fruits.** Eat red, orange, and dark-green vegetables like tomatoes, sweet potatoes, and broccoli, along with other vegetables for your meals. Add fruit to meals as part of main or side dishes or as dessert.
- **Switch to skim or 1% milk.** They have the same amount of calcium and other essential nutrients as whole milk but less fat and calories.
- **Make at least half your grains whole.** Choose 100% whole-grain cereals, breads, crackers, rice, and pasta.
- **Vary your protein choices.** Eat beans, which are a natural source of fiber and protein. Keep meat and poultry portions small and lean.
- **Drink water or unsweetened beverages instead of sugary drinks.** Soda, energy drinks, and sports drinks are a major source of added sugar and calories.
- **Cut back on foods high in solid fats, added sugars, and salt.**
- **Be physically active your way.** Pick activities that you like and start by doing what you can, at least 10 minutes at a time. Every bit adds up, and the health benefits increase as you spend more time being active.

SIMPLY GOOD EATING

The University of Minnesota Extension's Simply Good Eating program gives you ideas for fresh, flavorful, low-cost meals along with ways to put more activity into your life. Simply Good Eating works with you to build a simple, healthful plan that fits with your lifestyle and budget. Visit the Simply Good Eating website at www.extension.umn.edu/Nutrition



ANSWERLINE (1-800-854-1678 / ANSWER@IASTATE.EDU)

Call or email the AnswerLine to get information about safely cooking, canning, and freezing foods. Calls are answered Monday-Friday between 9 a.m.- noon and 1-4 p.m.

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Use Your EBT Card at Farmers Markets!

- It's simple to bring home fresh vegetables, fruits and other locally produced foods for you and your family!
- More and more Minnesota farmers markets accept Supplemental Nutrition Assistance Program (SNAP) benefits when you shop with your Electronic Benefit Transfer (EBT) card.
- Market Bucks coupons are an extra bonus when you shop at farmers markets with your EBT card. Spend $5 with your EBT card and receive $5 in matching Market Bucks to double your value at participating markets.
- Visit your local farmers market and look for the EBT booth to get started shopping.

FIND YOUR LOCAL FARMERS MARKET

- The number of farmers markets that accept EBT is growing! Turn this page over to see a list of 30 farmers markets that currently accept EBT and offer Market Bucks coupons.
- Use the Minnesota Grown Directory to find a complete list of almost 200 Minnesota farmers markets: www.minnesotagrown.com

USE YOUR EBT CARD AT FARMERS MARKETS!

EBT AT FARMERS MARKETS

30 Minnesota farmers markets currently accept EBT. Starred* markets also offer Market Bucks coupons. When you visit the market, look for the EBT booth where market staff will help you get started.

ALBERT LEA*
Municipal Parking Lot
N. Broadway and Fountain St
Wednesdays, 4pm - 6 pm
Saturdays, 9am - 12 pm

ALEXANDRIA*
Big Ole Central Park
Broadway and 2nd Ave
Tuesdays, 9am - 12pm
Thursdays, 3pm - 6 pm
Saturdays, 9am - 12pm

AUSTIN AREA - DOWNTOWN*
Main Street
Thursdays, 3:30pm - 6 pm

AUSTIN AREA - OAK PARK MALL*
1301 18th Avenue Northwest
Mondays, 3:30 pm – 6 pm
Saturdays 9:30 am – 11:30 am

BEMIDJI AREA*
Pamida/Subway Lot
200 Paul Bunyan Drive S.
Tuesdays, 10am - 5pm
Thursdays, 12pm - 6pm
Saturdays, 9am - 3pm
Sundays, 11am - 4pm

BLOOMINGTON*
Bloomington Civic Plaza
1800 West Old Shakopee Rd
Saturdays, 8am – 1 pm

BURNSVILLE - MARY, MOTHER OF THE CHURCH*
3333 Cliff Road
Thursdays, 12pm – 5 pm

BURNSVILLE - SENIOR CAMPUS*
200 W Burnsville Parkway
Saturdays, 8am - 1pm

CHISAGO CITY – MOBERG PARK*
10656 Railroad Ave
Fridays, 2pm – 6pm

DULUTH*
14th Ave East & 3rd St.
Wednesdays, 7am -12pm
Saturdays, 7am – 12pm

DULUTH – UMD
UMD Kirby Plaza Bus Hub
Wednesdays, 1:30pm - 4:30pm

FOSSTON – MELLAND PARK
East Polk Heritage Center Lawn
Highway 2 East
Saturdays, 8am – 12pm

GRAND RAPIDS*
104 NW 4th St
Mondays, 2pm – 6 pm
Wednesdays, 8am – 1pm
Saturdays, 8am – 1 pm

MANKATO FARMERS MARKET
Madison East Center Lot
1400 Madison Avenue
Tuesdays, 3:30pm – 6pm
Saturdays, 8am – 12pm

MAPLEWOOD - ALDRICH ARENA*
1850 White Bear Avenue N
Wednesdays, 8 am - 12 pm

MINNEAPOLIS - AUGSBURG*
701 22nd Avenue S.
Tuesdays, 2pm – 5pm

MINNEAPOLIS - BRIAN COYLE*
420 15th Ave S
Tuesdays, 11am – 1pm

MINNEAPOLIS – FULTON*
4901 Chowen Ave S.
Saturdays, 8:30am – 1 pm

MINNEAPOLIS - KINGFIELD*
4310 Nicollet Avenue
Sundays, 8:30am – 1 pm

MINNEAPOLIS - MIDTOWN *
2225 East Lake Street
Saturdays, 8am – 1pm
Tuesdays, 3pm – 7 pm

MINNEAPOLIS – MUNICIPAL FARMERS MARKET*
312 East Lyndale Avenue N
Thursdays-Fridays, 9am – 12pm
Saturdays-Sundays, 7am – 1pm

MINNEAPOLIS- NORTHEAST*
St Boniface Church Lot
7th Ave NE and University Ave NE
Saturdays, 9am – 1pm

MINNEAPOLIS -WEST BROADWAY*
900 West Broadway Avenue
Fridays, 3pm – 7pm

NORTHFIELD
Cannon River Riverwalk
2nd-5th Street – Downtown
Saturdays, 9am – 1pm

RICHFIELD - CHURCH OF ASSUMPTION*
305 E. 77th Street at 2nd Ave S.
Wednesdays, 2pm – 7pm

RICHFIELD - VETERAN'S MEMORIAL PARK*
64th Street and Portland Ave S
Saturdays, 7am – 12pm

ROCHESTER - DOWNTOWN*
4th Street SE and 4th Avenue SE
Saturdays, 7:30am – 12pm

ROCHESTER- KMART PARKING LOT*
202 9th St SE
Wednesdays, 2pm – 6pm

SAINT PAUL - DOWNTOWN *
290 5th Street East
Saturdays, 6am - 1pm
Sundays, 8 am - 1pm

WEST SAINT PAUL – SIGNAL HILLS MALL*
1201 South Robert Street
Fridays, 8:00am – 12:00pm

This material was developed with help from the Minnesota Department of Human Services, the Minnesota Farmers Market Association, local farmers markets, and Saint Paul - Ramsey County Public Health and the Minneapolis Department of Health and Family Support and its Statewide Health Improvement Program, funded by the Minnesota Department of Health. Funding for Market Bucks is provided by Blue Cross® and Blue Shield® of Minnesota, a nonprofit independent licensee of the Blue Cross and Blue Shield Association. Funding for this mailing and material is provided through University of Minnesota Extension. This material is funded in part by USDA's Supplemental Nutrition Assistance Program (SNAP). SNAP provides nutrition assistance to people with low income.

Project J

Appendix A:

Pictures from workshops:

Image 1: Brett Olson, Renewing the Countryside introducing speaker Stephanie March, *Mpls. St Paul Magazine,* who spoke on the "Value of Local Food and Public Perception.

Image 2: Dayna Burtress, *Laughing Loon Farm* and Benjamin Jacoby, *The Craftsman* speaking about a "Successful Farmer/Chef Direct Marketing Relationship"

Images 3-6: Participants networking

HELLO

Project K

Increasing GAP adoption through regional grower training

ADDITIONAL INFORMATION

Cost Estimates for Major GAPs Related Cost Categories

The following estimates are based on the costs for a small, 2-3 acre farm with 2-4 employees. The farms that we interviewed varied from 1 to about 100 acres. Only one farm (Harmony Valley) was 100 acres. The others were about 2-5 acres. When estimating costs, we assumed an average size farm in Minnesota, with about 2-5 acres and about 2-3 employees. Many costs are fixed and are not farm size-dependent, such as the cost of renting a port a potty or building a portable hand washing station.

Assumptions: Season is 6 months long, 3 employees, and an average labor dollar equivalent of $9.00/hour.

Logs/recordkeeping

- 3-ring binders and log sheets – $5.00 each
- Brackets to hand logs in packing house – $5.00 each
- Storage boxes for keeping logs/records – $2.00 each
- Labor to fill out logs (cooler temps, cleaning, vehicle, restocking) – 2 hours/week
- Labor to replace full logs and store in boxes – 1 hour/month

Labor plus fixed costs: $498 for the season

Restrooms/hand washing

- Weekly cleaning and restocking supplies of bathroom – .5 hour/week
- Rental cost of toilets – $85/month (includes weekly maintenance and supplies)
- Hand washing stations – (materials, using reclaimed lumber and new water tank) $ 20
- Small garbage cans by hand washing station $ 5.00
- Single Use Paper hand towels - $50.00/season
- Liquid Soap – $15.00/season

Labor plus fixed costs: $1095 for the season

Postharvest Food Safety

- Water sanitizer – (Bleach $20.00) (Tsunami $300.00)/season
- Chlorine concentration test strips – $20.00/season
- Labor to clean and sanitize tools after each harvest day - 3 hours/week
- Labor to clean and sanitize storage coolers – 6 hours/season

Labor plus fixed costs: $778 (assuming bleach is used) for the season

Employee training

- One 1 hour training that includes food safety in English/Hmong- $29.00/video
- Labor time to have employees watch video – 1 hour

Labor time plus fixed costs: $56 for the season

Traceability

- Stickers – 2.7 cents/each

Water Testing

- 2 times/year for nitrites, nitrates, coliforms - $30.00/each test

Rodents and Pests

- Maintenance and inspection of mice traps in greenhouses and packing sheds and maintenance of logs recording inspections and actions taken - 1 hour/week

Animal Exclusions

- Maintenance and inspection of field perimeter and fences to ensure no excessive animal activity. Burn/remove brush from field border if necessary - 1 hour/week
- Deer safe fencing – $250.00+/acre

Vehicles and Transportation

- Visual inspection of produce transport vehicles and maintenance of logs - .5 hours/day

Packing shed Safety and Sanitation

- Shatterproof lights - $150
- Time to sanitize and clean packing shed - .5 hour/day
- Weekly cleaning of drains – 1.5 hours/week for 4 drains

Summary of Cost Findings

We are excluding major start-up costs such as building a new packing shed or purchasing and installing a storage cooler. These costs will vary so greatly that estimating a cost is not useful.

Using these figures and cost estimates, we will direct outreach efforts to reduce grower's costs, and to encourage them to adopt the practices that have the greatest "bang for their buck" to reduce microbial contamination. We have developed a list of the 5 most important practices that we recommend farmers start with if they currently have no food safety plan or history or practice with GAPs.

These "biggest bang for the buck" practices include:

- Sanitize produce rinse water using bleach or another chemical alternative.
- Get water tested annually.
- Do not use raw manure on farm. If you do, use only in the fall.
- Check cooler temperatures daily using a digital thermometer, and log these temps on a log sheet.
- Sanitize all tools daily, all harvest containers weekly or as needed.

As a part of the outreach based on this research, a GAPs equipment and resources list was posted to the UMN Food Safety website for farmers to reference. This page contains links and resources for purchasing items such as traceability labels and guns, used coolers and cold storage, paper towels, thermometers and water sanitizer. The UMN Food Safety website is currently undergoing substantial revisions and cost information will be available again when those revisions are completed.