Global Food Ventures MnDRIVE Mid-term Grant Reports

Reinventing Year-Round Local Food Production in Minnesota

Principal Investigator(s):

John Erwin, Joanne Slavin, Carl Rosen, and Greg Schweser.

1. Describe progress on grant objectives

Progress on each objective is outlined below. We are on track to complete all work outlined in the proposal plus additional work (see below) at or below budget on time. We are doing additional sampling with labor and travel savings (elaborated on below).

Grant Objectives:

1) Identify 5 'high opportunity' vegetable/fruit/herb crops to sell at local grocery stores, Coops, restaurants and farmers markets that can be produced in MN greenhouses, (whole group)
   a. Owners of 8 restaurants, 4 food coops, 4 grocery store, and >150 existing greenhouse growers were contacted, and information was solicited on what crops they believed could be sold in greater volume that they had demand for. After soliciting information from a broad cross section across the state, a meeting was held at Bachman's (Lyndale Ave.; July 24, 2014) where attendees (representatives from 10 businesses; including Lund's/Byerly's produce manager) selected 5 crops based on input from the broad group survey (July 1-July 23, 2014). Selected crops were kale, mesclun mix (mizuna, arugula, red giant mustard), spinach, strawberry and mini cucumber. Appropriate cultivars/varieties were selected and plant material was acquired/ordered in August to start growing crops October 1, 2014 for installation at the end of October, 2014.

2) Determine how environment and production system affects crop growth and yield (Erwin/Rosen),
   a. Strawberries, kale and spinach (currently in growth chambers) were growth under different day/night temperature combinations in environmental growth chambers

(plants moved among 5 chambers at 800 and 1600HR daily to achieve 25 day/night temperature combinations). Growth chamber temperatures are/were 10, 15, 20, 25, and 30 °C based on plant leaf temperature. Data were collected on photosynthetic responses to irradiance (0-1200 *u*mol m^{-2} s^{-1}), CO_2 (50 – 1200 ppm) and temperature (10-30 ^{o}C) from plants grown in each day/night temperature combination to determine how growing environments affect photosynthetic capacity. Leaf number (to determine leaf unfolding rate), and leaf dimensions were recorded, and leaves were harvested for vitamin C determination (and fiber in some cases), ICP analysis (15 nutrients), leaf fresh weight, and leaf dry weight were also collected. Photographs of whole plants and individual leaves were also taken.

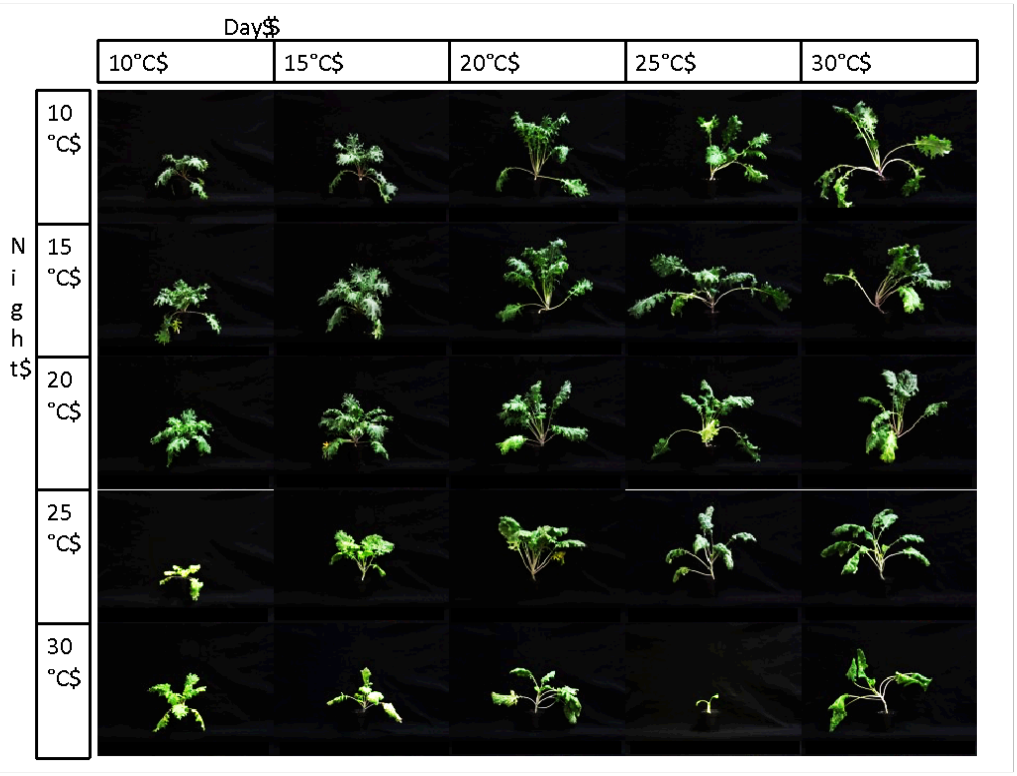

Figure 1. Effect of day and night temperature on kale growth after 60 days.

Photosynthetic response curves will allow growers to determine the benefits of increasing day/night temperature, irradiance (light intensity), and carbon dioxide levels (in general, dry weight gain is directly proportional to photosynthetic rate). The sample photosynthetic response curves to increasing irradiance is shown in Figure 2 below.

b. Plant material was sown and grown in 5 different fertility treatments at the U of MN St. Paul Campus to assess the effects of conventional versus organic fertilizers on yield and nutritional value of mesclun mix (arugula, mizuna, and red giant mustard), spinach, and strawberries. Some of these media/fertilizers are currently used in commercial deep winter greenhouses and conventional greenhouses. Edible plant tissue (leaves on

spinach and mesclun and fruit on strawberry) was collected for vitamin C and nutrient analysis via ICP testing. Media samples were also collected to determine plant available nutrients and microbial activity (in conjunction with Grossman Lab).

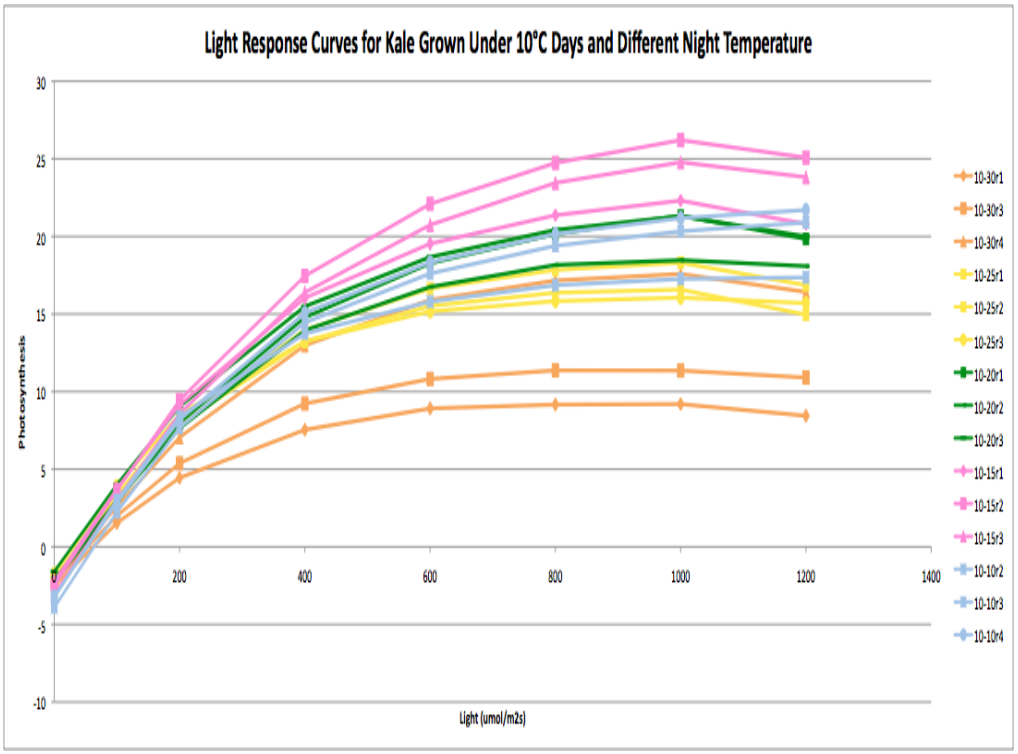

Figure 2. Photosynthetic responses of kale to increasing irradiance on 5 of the 25 day/night temperature treatments.

c. Experiment areas were set up in 3 deep winter and 6 conventional greenhouses (November 1, 2014) at Engwalls Greenhouse (Duluth), Bergen's Greenhouse (Detroit Lakes), Pork and Plants (Altura), Tangletown Garden (Plato), Garden Goddess (Milan), Paradox Farm (Ashby), Lida Farm (Pelican Rapids), Bachman's Greenhouses (Farmington), and at the U of MN St. Paul Campus. Experimental setups included planting the 5 identified crops in pots and gutter systems at each facility, setting up an internal weather station to collect environmental data (temperature, instantaneous and cumulative daily light integral, humidity, etc.), and reviewing sampling protocols with growers. Yield data, environmental conditions, and tissue samples have been collected over time to identify differences in yield, conditions, and nutritional value of crops growth at each facility. During visits on or around February 5, 2015, photosynthetic data were collected on responses of each crop in each facility to increasing light intensity and CO_2. Sites will be visited again in March for final sampling and removal of plant material, growing systems, and equipment.

d. Additional experimentation not part of the original proposal completed so far includes growing kale and strawberry under 8 different lighting treatments (short days, and long days with increasing irradiance (4 levels)). Leaf samples were collected from kale for vitamin C and fiber determination. In contrast, flowering, yield over time, and vitamin C content (fruit) is being collected on strawberry plants.

3) Determine how environment, and production system affect nutritive value of selected crops, and whether the nutritive value of locally produced produce differs from imported produce (Slavin),

Based on the first half of the MnDRIVE project we have found some significant results from the Red Giant Mustard and Mizuna plants grown in different fertility media. From plants grown in the St. Paul Plant Growth Facilities we have observed a relationship between the fertility treatments used and their corresponding vitamin C content. There were five fertility options analyzed: conventional comparison (CC), CalMag 15-5-15; Poultry Litter (PL), Sustane 8-4-4; Fish Emulsion (FE), 2-5-0.2; All in One (AO), Purple Cow Potting Mix, 0.5-0.2-0.4; Carol's Mix (CM), a blend of peat/vermiculite/compost/bloodmeal/greensand/rock phosphate/lime.

All plants were analyzed as frozen tissue samples, following the same handling techniques between all treatments. As seen in the IQR figure above (Figure 3) the poultry litter has been shown to be the most successful fertility treatment for corresponding vitamin C content in the frozen tissue samples. The poultry litter provided significantly more vitamin C than any of the other four treatments, measuring at 16mg/100g for mizuna and 20.8mg/100g for Red Giant Mustard ($p<0.05$). The treatment differences played a significant impact on the corresponding vitamin C levels in both the Red Giant Mustard and the Mizuna plants analyzed.

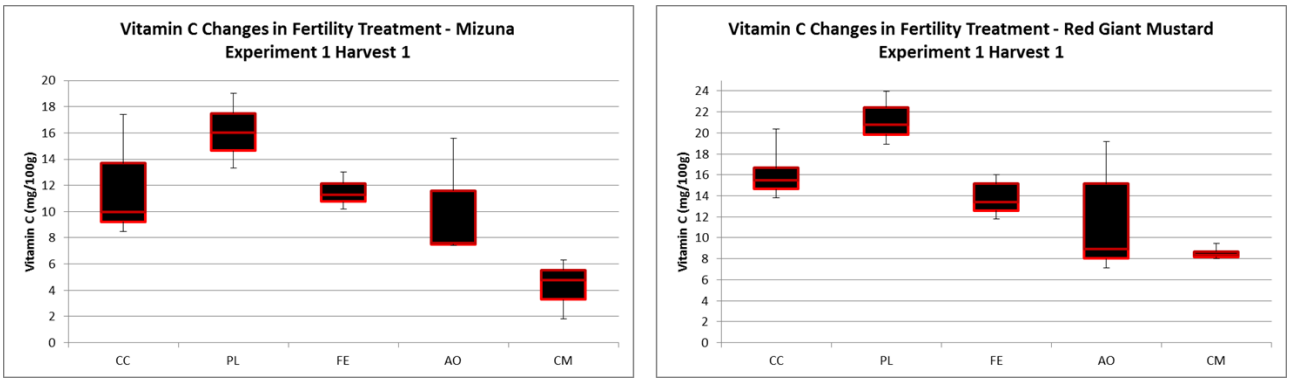

Figure 3. Vitamin C Changes For Mizuna and Red Giant Mustard Between Fertility Treatments

Additional Work Completed: Vitamin C loss curves were developed for Mizuna and Red Giant Mustard at both refrigeration (4C) and at -80C. Those data show vitamin C levels were maintained for the first 5 days only at 4C, and for 10-12 days at -80C; vitamin C levels depleting quickly thereafter (Figure 4). These data suggest plants should be consumed as close to the time of harvest as possible for higher vitamin C levels for both refrigerated and frozen material. Therefore, material imported to grocery stores (likely

over 5 days from harvest) has little, or no vitamin C. These data can be used to support the need for local foods for grocery store, and restaurant sales.

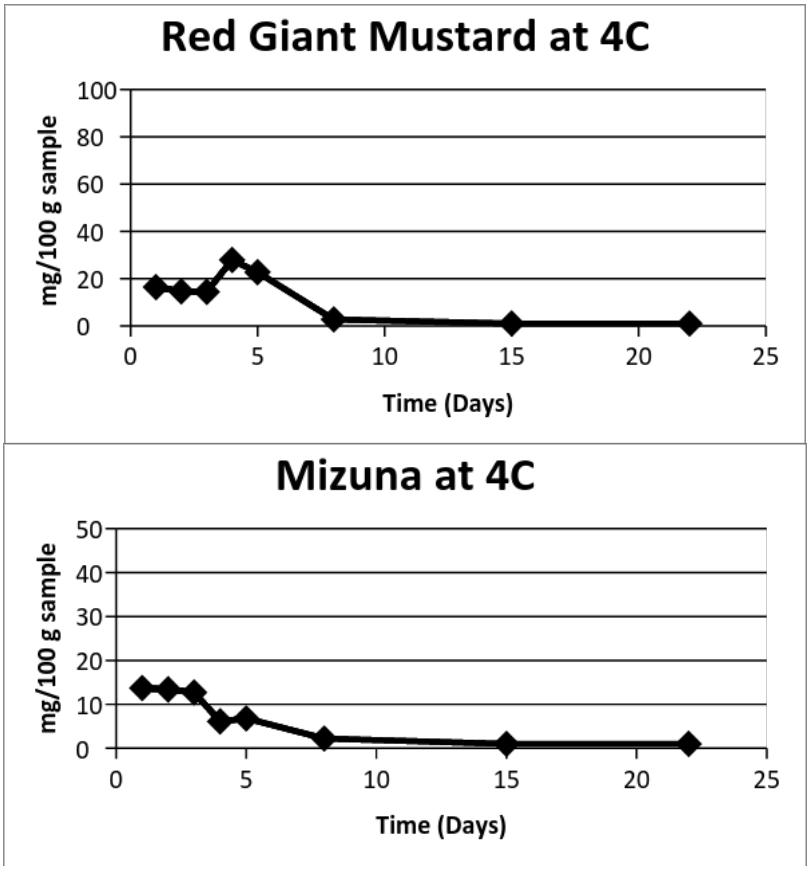

Figure 4. Vitamin C loss curves over time in mustard and mizuna leaf tissue.

4) Conduct an economic analysis of deep winter greenhouse production of selected crops (Schweser),

We are currently documenting cost and revenue data from deep winter greenhouse operators to create a profile of their financial performance as well as tracking comparable winter green pricing to inform a basic market analysis.

Although there is a lot of attention on winter greenhouse production, no financial benchmarks currently exist. Many prospective greenhouse builders would like to know the potential revenue that a winter greenhouse could provide or at least get some sense potential of deep winter enterprises. To meet this need, we are compiling annual direct costs and revenues from eight greenhouses now raising greens and cool season crops in the winter to create a basis enterprise analysis. Also documenting capital costs, we will be able to calculate the return growers are receiving on their investment. These benchmarks will be helpful to current greenhouse operators as well as prospective ones.

The second part of the economic analysis is a market analysis to discover the size and extent of the market which local deep winter greenhouse could fill. Focused on winter greens such as mesclun mix and arugula, we are documenting prices of the most

comparable products. This should inform winter producers not only in their pricing, but in identifying the market potential for the winter greens market in non-direct market channels such as grocery stores. We expect to complete the greenhouse financial documentation in February, although the price data collection will continue through March.

5) Reach out to growers to maximize their success and establish an advisory committee (Schweser).

We organized a group that consists of 38 individuals who are active in small to medium-scale fruit and vegetable production in all regions of Minnesota as well as portions of Wisconsin, North Dakota. Additional members of this group include Extension support staff, staff of the Regional Sustainable Development Partnerships, and Johnny's Selected Seeds in Maine to act as an advisory committee. We communicated with the group three times during the project so far to introduce and describe the research at various stages. Additional communication will be released as research results are completed. The audience for this group consists of individuals interested in both conventional production methods and Deep Winter Greenhouse technology. This group will also guide future research questions that they believe will facilitate the success of their businesses.

To stimulate a dialogue among those interested in Deep Winter Greenhouse technology, a separate list serve has been created. The Sustainable Farming Association of Minnesota has recently formed a special interest chapter of producers who operate, or are interested in becoming operators, of Deep Winter Greenhouse technology. This group will form the initial membership for the listserv that will act to serve as a crowd-sourced information sharing platform. In addition to this listserv, Facebook will be used as a platform for communication and information sharing among researchers and those interested in Deep Winter Greenhouse technology. These communication platforms will be operational in March-April and will also be used to develop future areas of research to support this rapidly growing local industry.

2. How has your grant addressed the following MnDRIVE goals?

a. Advances Minnesota's economy

Our project aims to capture consumer interest in fresh, local produce by supporting the revival of the local, year-round fresh vegetable/fruit/herb greenhouse production industry. The project facilitates the growth of new and existing MN businesses and provides residents with increasingly healthy and safe fresh food options.

New passive solar 'deep winter greenhouses' are 'catching on' as a low-cost, low-input method of production that is capable of supplying fresh greens in areas where access to high quality, fresh produce is limited (some out-state areas and some inner city areas). Existing conventional greenhouses (currently producing flowering/bedding crops) have the potential to expand to provide large amounts of produce for local food system streams during times of the year when growing ornamental crops is not profitable.

Aside from production, of particular interest to small and large-scale food marketers (grocers and restaurants) is a comparison between local versus imported produce with respect to nutritional value. Should locally sourced foods have higher nutritional value, this would be of

great interest to producers, grocers, and restaurant owners to promote local produce. Such a promotion of locally sourced crops would likely supplant imported produce thereby increasing local economies throughout MN, as well as the entire greenhouse industry.

Early results (see above) already show this is the case with vitamin C! We expect that Lund's/Byerly's will be very interested in these data as they would prefer to purchase locally produced food and believe advertising nutritional data would allow them to offer a price premium for local foods that consumers would be willing to pay (stated at the meeting in July, 2014). That price premium would likely be transferred to the growers to some extent.

b. Seizes opportunities to leverage MN's strengths and comparative advantages

Minnesota is uniquely suited to year round greenhouse/controlled environment food production as we have a generally cooler climate that many parts of the US; high temperatures in much of the country limit greenhouse production of food during much of the year. Aside from this, results on vitamin C degradation above suggests that local growers are at a competitive advantage as they are close to the consumer and will, therefore, be far more likely to produce crops with higher nutritive value. Lastly, MN residents (especially the Twin Cities) are uniquely interested in local sourcing of foods and/or organic production. The green house industries are uniquely equipped to provide both during most of the year in MN.

c. Improves Minnesotans' health and quality of life

This project facilitates the accessibility of local food. Aside from accessibility, local foods may have a higher nutritive value compared to imported food. In fact, early results already show that the time from harvest to sale dramatically affects vitamin C content; vitamin C levels dropped to non-detectable levels after 5-7 days of refrigeration (4C). Therefore, most imported material likely has little of no vitamin C; we are testing vitamin C levels in grocery stores at this time. We also are currently testing at least 15 other nutrients.

Aside from increased accessibility and nutritive value, local foods offer greater food safety. This is in part due to less concentrated more diversified food chain in sourcing of food. Lastly, local food sourcing increases the potential employment opportunities in many communities.

d. Advances the capacity and competitiveness of Minnesota industries

This proposal is an interdisciplinary project that addresses all three MN Global Food Venture desired areas. The project conducts research on a new and innovative project with great potential for growth, it advances early and mid-stage projects with a very high probability of commercialization, and involves workforce development and educational programs through extension, on and offsite employee training, and online resources.

The project aligns with all MN-DRIVE objectives and is a collaborative project between the Departments of Horticultural Science, Soil Water and Climate, and Food Science and Nutrition, and the UMN Regional Sustainable Development Partnerships and the UMN Extension Community Vitality.

With respect to research, the project is already resulting in new collaborations between faculty that is resulting in possibilities for new external funding. This is especially the case with respect to how media/fertility and environment affect the nutritive value of crops. In addition, the project is bringing together faculty to support this new and growing sector of agriculture in MN resulting in a new core competency group to support the industry.

With respect to commercialization, the crops we are growing are already being grown in 9 greenhouse facilities throughout MN. Information is being communicated in each region using a variety of tools including listserv, the Minnesota, Nursery and Landscape Association bulletins, and conference presentations. A statewide conference will be organized and we are building this information to all the other existing vegetable, nursery and greenhouse related conferences.

With respect to workforce development, we are educating growers on site, and providing information in a variety of ways (see above) to reach the largest possible number of interested parties. This will include current and prospective growers. The project is also exciting possible marketers of the products we are teaching growers to produce.

e. Positions our state as a national leader

This project positions MN to be a leader in production, and research related to production factors related to nutritive value. Minnesota was a leader in greenhouse food production in the past. For instance, all major greenhouse companies produced fruits and vegetables until the interstate highway system was developed in the 1960's. Recent interest in locally sourced food is allowing us to be a leader again as consumers are open to paying higher prices for locally sourced food for social and nutritive reasons. Given we can control the greenhouse environment more than growers in the southern producers indoors and outdoors, it allows us to increase the nutritive value of foods by either environmental manipulation and/or using media that can enrich those vegetables/fruit that we grow.

Little work is being conducted on the link between the environment and media and nutritive value. Research initiated here already shows great potential for research in this area. I/we suspect that the project will open doors to possible federal funding opportunities. Lastly, there may be the potential to produce branded foods from MN growers that have elevated nutritive value.

3. List any publications, presentations, patents, or intellectual property associated with your grant.

As data is just now starting to come in, we are just beginning to present results to the industry and publishing early findings.

Publications to date:

Before documented communications via advisory group/listserv

MNLA Scoop – New directions in greenhouse production – Year-round local foods! (in Press; March/April)

MNLA Green Expo – poster presentation

MOSES Organic Farming Conference - Poster Presentation Feb 26-28

We anticipate a number of scientific publications.

Conference Presentations:

Minnesota Fruit and Vegetable Growers Assoc. – "Soil Fertility for Brassicas – Not just Cole and Cabbage (included summary of MN-DRIVE Project) (St. Cloud, MN)

Minnesota Statewide High Tunnel Conference - "Reinventing Year-Round Local Food Production in Minnesota", Alexandria, MN (February 17, 2015)

Greenhouse Food Production – Landsberg Greenhouse and Nursery (Brainerd, MN), April 28, 2015.

Statewide Greenhouse Food Production (Midland Hills Country Club, Roseville, MN) – proposed for the end of August/early September, 2015.

There are several additional conferences planned including 2 regional conferences to present research results. Dates have yet to be determined.

4. Did your project or MnDRIVE area create any new programs, degree areas, or courses/seminars?

As the project is quite young, we are just starting to develop new seminars. There is great interest in this project and we are already receiving requests for information.

To respond to these requests we are building website content adding content to an existing U of MN website (http://www.extension.umn.edu/rsdp/community-and-local-food/), presenting work to date at the before-organized conferences throughout the state (see above), and are planning the first statewide conference on greenhouse food production to be held during the beginning of September, 2015 at Midland Hills Country Club (Roseville, MN) this year. IN addition, we will be organizing 2 regional conferences in northwest and west central MN.

Aside from these, this project opens the possibility of a more coordinated, organized center for controlled environment agriculture in which there is a great deal of interest!

5. List the names of all faculty, post docs, graduate students, and non-faculty staff contributing to grant.

John Erwin (Professor, Department of Horticultural Science)
Joanne Slavin (professor, Department of Food Science and Nutrition)
Carl Rosen (Professor and Department Head, Department of Soil, Water and Climate)
Julie Grossman (Assistant Professor, Department of Horticultural Science)
Mary Rogers (Assistant Professor, Department of Horticultural Science)
Greg Schweser (UMN Regional Sustainable Development Partnership)
Ryan Pesch (Associate Extension Professor, Extension Center for Community Vitality)
Justin Carlson (PhD Graduate Research Assistant, Department of Food Science and Nutrition)
Liz Perkus (Technician, Department of Horticultural Science)
Esther Gesick (Technician, Department of Horticultural Science)
Sonora Nolan-Rapitz (undergraduate student, Applied Plant Sciences)
Jared Rubenstein (undergraduate student, Applied Plant Sciences)
Michael Laskowski (undergraduate student, Applied Plant Sciences)
Sam Voss (undergraduate student, Applied Plant Sciences)

Lindsey Miller (undergraduate student, Applied Plant Sciences)
Julian Esparza (undergraduate student, Animal Science)

6. List external partners and specific contributions they have made to the grant.

Pork and Plants (Altura, MN) – host site and crop selection
Garden Goddess Enterprises (Milan, MN) – host site (DWG) and crop selection
Susan Wika (Fergus Falls, MN) – host site and crop selection
Seward Coop (Minneapolis, MN) – crop selection
Lund's/Byerly's – (Edina, MN) – crop selection
Kim Barton (Owner Red Stag, Bread and Pickle, Barbettes, Bryant Lake Bowl, Gigis, etc.) – crop selection
Dean Engleman (C-Owner Wiseacres Farm and restaurant (Plato and Minneapolis, MN) – host site and crop selection
Engleman's Greenhouse (Duluth, MN) – test site and crop selection
Bergen's Greenhouse (Detroit Lakes and Forest Lake, MN) – test site and crop selection
Bachman's Greenhouse (Lakeville, MN) – test site and crop selection
Len Busch Roses, Inc. (Plymouth, MN) – crop selection
Lida Farm (Pelican Rapids, MN) - test site

7. Submit a current financial report to include unspent grant balance and spending plan for next 4 months (see below).

We are on track to complete the Objectives 1-3 of the project at, or below budget, by June 1. In addition, we will be completing more work than what was proposed in the project through cost savings (see below). All data and information will be collected for Objectives 4 and 5 by the end of the project, however, there will be some lag in analysis and printing of those results.

Early indications are that we will have cost savings through salary/labor savings in the Departments of Horticultural Science, and Food Science and Nutrition. Labor cost savings will be re-budgeted to allow us to do more nutritional analysis of additional material. We are projected to have an additional $17,000 in Food Science and Nutrition and $20,000 in Horticultural Science. Savings are occurring because of a lag in hiring after initiation of the grant, travel savings using overnight mail delivery, and negotiated reduced costs for vitamin sampling.

All the additional savings in Food Science and Nutrition will be dedicated to additional vitamin C and fiber analysis. In Horticultural Science, $10,000 of the additional savings will be allocated to additional tissue/media analysis in Soil Water and Climate, and $10,000 for additional undergraduate student hours.

Delays in billing of testing/lab analysis are due in part to a lag in billing from a third party for conducting analysis. This is the case for vitamin C, fiber, and ICP analysis. Regardless, samples are getting collected, submitted and analysis has begun. A specific breakdown of those expenditures that have been billed/encumbered are shown in the attached financial report.