Specialty Crop Block Grant Program—Farm Bill

CFDA: 10.170

AMS Agreement #14-SCBGP-MN-0027

Minnesota Department of Agriculture

Agricultural Marketing and Development Division

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2017 Final Report for Federal Fiscal Year 2014 Projects

Original Submission: December 27, 2017
Accepted Date: March 12, 2018

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Project 1

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

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PROJECT TITLE

Producing Strawberries Throughout the Growing Season With a Small Environmental Footprint

PROJECT SUMMARY

Minnesota farmers need an environmentally acceptable system for producing annual strawberries to increase the supply of this high-value specialty crop. Despite growing consumer interest in local foods, the supply of Minnesota-grown strawberries is extremely limited due to the short growing season and perishability of June-bearing cultivars. Our annual strawberry system produces higher yields with excellent fruit quality while extending the harvest the season into October.

Our recent survey of regional rural and urban farmers offered convincing evidence that there is great interest in extended season annual strawberry production. In our survey of 200 farmers, 73% want to learn to grow annual strawberries, and 64% want to learn about low tunnels for season extension. Based on responses, we were able to characterize our primary beneficiaries as rural and urban smaller acreage farmers (under 20 acres) who already grow a wide range of specialty crops. This group of producers expressed the greatest interest in learning about our extended season annual strawberry system, therefore we continued to target this group as our primary community of interest.

Our project continues to build on our 2013-2014 previously funded SCBGP research with organic production systems for day neutral strawberries to extend the season using plasticulture with and without low tunnels. Comparative field trials were established in 2015-2016 on organic-certified land at the University of Minnesota West Central Research and Outreach Center (WCROC), Morris, MN and the University of Minnesota St. Paul Campus (UMTC). We examined nutrient requirements and pest management strategies for this system. Low tunnel systems were also installed and planted at three grower cooperator sites in 2015-2016. These growers worked with us to develop and refine the system in this project, and to assist in educating other growers. Our project has developed recommendations for organic strawberry plasticulture with and without low tunnels to extend the harvest season and provide fruit for a longer period of the year. Long-term outcomes were focused on enhancing profits and improving environmental sustainability for specialty crop growers.

PROJECT APPROACH

In 2015-2016 we established day-neutral strawberry cultivar Albion on raised beds with plastic mulch in a low tunnel system compared to a non-low tunnel system. All treatments were managed under organic certification standards.

Objectives

1. To continue development of our innovative strawberry production systems, we developed recommendations for
    - nitrogen and other nutrient requirements.
    - irrigation practices.
    - pest management strategies.
2. To increase supply of locally produced organic strawberries and encourage environmental stewardship, we educated our stakeholders through:
    - frequent online research updates.
    - face-to-face educational events.

In order to determine optimal nitrogen rates for our annual, day-neutral strawberry production project, we tested five different nitrogen rates:

- 0 lb N/acre/week (0x)
- 2.5 lb N/acre/week (0.5x)
- 5 lb N/acre/week (1x)
- 7.5 lb N/acre/week (1.5x)
- 5 lb N/acre/week only until first harvest, then 0 lb N/acre/week for the rest of the season (1-0x).

These treatments helped us answer these questions:

1. Which nitrogen rate is optimal for annual, day-neutral strawberry production in the Upper Midwest?
2. Are there noticeable effects of too much or too little nitrogen in the system?
3. Is there a point where additional nitrogen incorporation will not lead to higher yields?

A continuing objective from previous research was to determine if the use of a low tunnel system with day- neutral strawberries could provide adequate yields. Traditional June bearing strawberry varieties in Minnesota have a baseline yield of 5,500 pounds/A. As shown below in the 2015-2016 summaries from both Morris and St. Paul trials, yield of Albion in the low tunnel and non-low tunnel surpassed this baseline.

Table 1. Summary of yield and berry weight of Albion at Morris and St. Paul, 2015 and 2016. Letters indicate statistical differences by column groupings, i.e. values that share letters within groupings are NOT statistically different. If a grouping has no letters, there are no statistical differences between any of the values in that group. As mentioned above, the x in

fertility rate is a multiplier that equals 5 lbs N/acre/week. 1-0x received 1x until first harvest, then 0x for the rest of the season.

Morris 2015*

		Tissue % N		Avg. Yield/Plant (lb)		Average Yield/Acre (lb)		Avg. Berry Weight (g)		Brix	
Low Tunnel Coverings	0x	1.92		1	ab	18450	-	11.4	ab	9.4	a
	0.5x	1.76		0.75	c	13710	-	9.2	c	10.14	a
	1x	1.69		0.82	bc	14991	-	9.8	bc	8.72	a
	1.5x	2.03		1.12	a	20446	-	11.9	a	8.69	a
	1-0x	1.94		0.94	abc	17228	-	10.5	abc	9.61	a
No Low Tunnels	0x	1.93		0.95	a	17278	-	10.1	a	8.42	a
	0.5x	2.09		0.86	a	15687	-	10.1	a	9.22	a
	1x	2.13		1	a	18414	-	10.3	a	9.31	a
	1.5x	2.36		0.92	a	16828	-	9.7	a	9.09	a
	1-0x	2.23		0.9	a	16467	-	9.4	a	8.67	a

* Due to a miscommunication only 1 rep of each % N treatment was taken from Morris in 2015, so pairwise comparisons could not be performed

Morris 2016

		Tissue % N		Avg. Yield/Plant (lb)		Average Yield/Acre (lb)		Avg. Berry Weight (g)		Brix	
Low Tunnel Coverings	0x	1.94	a	0.99	a	14325	-	10.56	a	9.48	a
	0.5x	1.86	a	1	a	14546	-	11.34	a	9.67	a
	1x	1.91	a	1.02	a	14939	-	11.88	a	9.56	a
	1.5x	1.89	a	1.01	a	14701	-	11.58	a	10.04	a
	1-0x	1.75	a	0.87	a	12639	-	9.53	a	11.07	a
No Low Tunnels	0x	1.85	a	1.13	a	16369	-	11.96	a	9.96	a
	0.5x	1.94	a	0.82	a	14702	-	10.25	a	10.41	a
	1x	1.95	a	1.25	a	18195	-	13.29	a	9.67	a
	1.5x	1.96	a	1.05	a	15183	-	11.81	a	10.07	a
	1-0x	1.97	a	1.28	a	18531	-	13.06	a	9.78	a

St Paul 2015

	Fertility	Tissue % N		Avg. Yield/Plant (lb)		Average Yield/Acre (lb)		Avg. Berry Weight (g)		Brix	
Low Tunnel Coverings	0x	1.81	b	0.78	a	13263	-	10.1	a	7.51	a
	0.5x	1.89	ab	0.76	a	13933	-	10.9	a	8.18	a
	1x	1.93	ab	0.71	a	12991	-	8.8	a	7.80	a
	1.5x	2.04	a	0.79	a	14393	-	10.7	a	7.26	a
	1-0x	2.01	ab	0.91	a	15493	-	9.6	a	7.50	a
No Low Tunnels	0x	1.82	a	0.55	b	9933	-	10.3	a	7.47	a
	0.5x	1.93	a	0.79	ab	14330	-	10.4	a	7.44	a
	1x	1.99	a	0.61	ab	11081	-	9.7	a	7.96	a
	1.5x	1.91	a	0.61	ab	11164	-	9.6	a	7.67	a

St. Paul 2016												
		Tissue % N		Avg. Yield/Plant (lb)		Average Yield/Acre (lb)		Avg. Berry Weight (g)		Brix	
Low Tunnel Coverings	0x	2.36	a	1.38	a	20014	-	13.71	a	8.06	a
	0.5x	2.28	a	1.36	a	19798	-	15.03	a	8.29	a
	1x	2.24	a	1.37	a	19926	-	14.33	a	7.26	a
	1.5x	2.38	a	1.42	a	20641	-	14.20	a	7.7	a
	1-0x	2.32	a	1.48	a	21467	-	13.47	a	7.56	a
No Low Tunnels	0x	2.42	a	1.02	a	14774	-	13.73	a	7.87	a
	0.5x	2.32	a	1.36	a	13769	-	13.83	a	7.58	a
	1x	2.18	a	1.37	a	14224	-	12.16	a	8.06	a
	1.5x	2.30	a	1.42	a	14804	-	13.39	a	7.64	a
	1-0x	2.22	a	1.48	a	15059	-	13.09	a	7.77	a

Similar to our previous findings, day neutral production resulted in excellent yields regardless of fertility practice or low tunnel use. In 2015 and 2016 we did not find any significant differences that affected average yield per plant, average yield per acre, average berry weight, between fertility treatments for % leaf nitrogen and brix values at either Morris or St. Paul research sites as can be seen in Table 1. The cells are formatted to better visualize the values for each treatment (color scale from red to green going from lowest value to highest value).

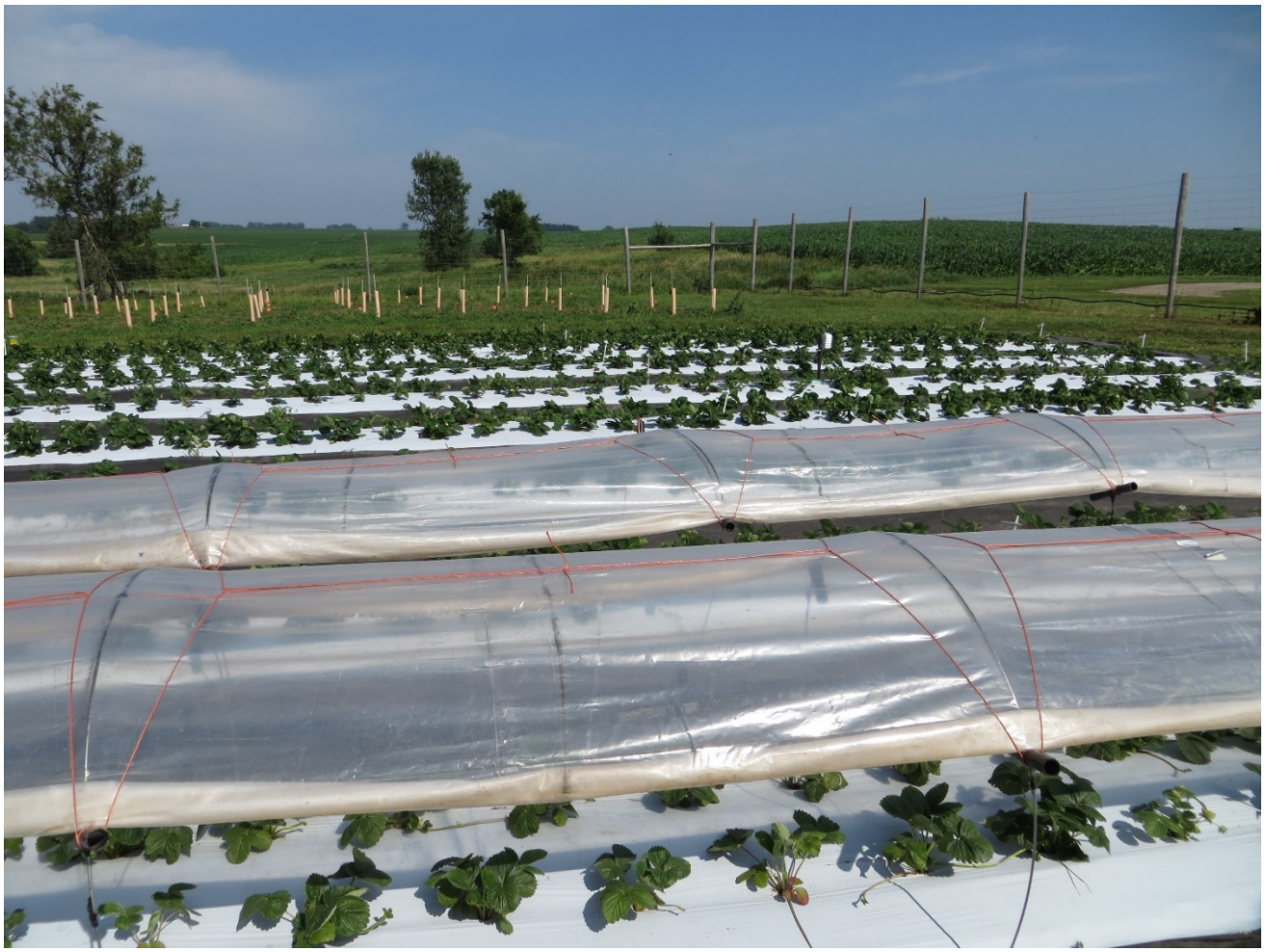
Since day neutral cultivars in this production system are treated as annuals, growers can enjoy the added economic benefit of yield in the first year, rather than the typical no yield 'establishment year' common to in June-bearing systems. Similarly, labor and other management costs are saved by eliminating the need to overwinter the plants. Day neutral cultivars managed with an annual system can be incorporated into crop rotations, reducing the potential buildup of soil pathogens.

Hourly temperature were recorded at the WCROC site in 2015-2016 using WatchDog A-Series data loggers in the low tunnel and non-low tunnel beds. The data loggers were suspended 12 inches above both beds and recorded temperatures from May- October in 2015-2016. Observations from data loggers (Table 2) showed average temperatures in the low tunnel were slightly higher than non-low tunnel temperatures. 2015 data shows average temperatures to be only a 1.1 degree average increase under tunnels and in 2016 only a 1.8

degree higher increase as compared to non-low tunnel. The benefit of higher average temperatures is that it increases plant respiration, which typically results in more photosynthesis and potentially higher yields. Also, the tunnel provides a physical barrier that keeps standing water from accumulating on the leaves during rainfall events. This in turn reduces fungal pressure, as fungal spores often need standing water in order to germinate.

Table 2 2015 temperature at WCROC 2016 temperature at WCROC

Low tunnel	67.3	62.6
Non-low tunnel	66.2	60.8



Principal investigator, Steve Poppe, was manager of the project at WCROC with specific duties of planning, installation and planting at two University sites and 3 grower cooperator sites. Co-investigator, Emily Hoover, assisted with project management, project evaluation, and coordinating with U of MN graduate assistants Nathan Hecht and Jared Rubenstein who coordinated efforts at the St. Paul site and overall data analysis. Emily Tepe and Esther Jordan oversaw communications and outreach primarily through maintaining the research section of our website and blog http://fruit.cfans.umn.edu/category/strawberries/low-tunnel-strawberry/

Our grower cooperators were:

- Mary Jo and Laverne Forbord, Owner/Operator Prairie Horizon Farm, Starbuck, MN.
- Ron Branch, Owner/Operator Berry Ridge Farm, Alexandria, MN.
- David Macgregor/Marsha Anklam, Owners/Operators Fairhaven Farm, South Haven, MN.

They assisted with planting, cultural practices, harvest and have interest in continuing to develop and refine the low tunnel day-neutral strawberry systems, and to share their experience with other growers.

Numerous site visits to our three grower cooperators took place during 2015-2016 growing seasons. Here are the comments or notes from those interviews.

Prairie Horizon Farm: Strawberry plants appeared to be very healthy right before first harvest. A continued problem, which took place in 2015-2016 were the plants being weak at the soil line. Are the plants not planted deep enough or is the white on black plastic mulch creating an injury or too much wind? The farm is located in a windy site. They would normally spray insecticide for Tarnished Plant Bug (TPB) around mid-August. No apparent injury on fruit from TPB for the remainder of the 2015-2016 picking season. Total yield in 2016 was about half of what it was in 2015. They figured a lot of excessive rainfall in 2016 created yield reduction. They think the Dubois retractable low tunnel system is an improved system. When the plastic cover did slide off they were always able to put back up with no damage to system. Final comment: They would grow June-bearing strawberries instead of the low tunnel day-neutral strawberry system.

Berry Ridge Farm: The Albion day-neutral strawberry cultivar grew well in 2015 but lacked vigor in the early 2016 season and never did recover. Deer moved in and continually browsed on strawberry plants in 2016. Low tunnel plastic slid off several times but easy to put back with no damage in 2016. The fruit they harvested was nice and took to farmers market in both years. 2016 yield was down compared to 2015. Final comment: They would rather grow day-neutrals in a high tunnel.

Fairhaven Farm: They learned from 2015 experience to keep low tunnel sides down as much as possible in 2016 to avoid deer browsing. They indicated that water needs are not high for these strawberry plants under these low tunnel growing conditions. Normally sprayed insecticide from July to early August for control of TPB and Spotted Wing Drosophila. 2015-2016 productivity was excellent from late August to early November. Sold everything at market each week. Thinking of a You-pick strawberries with this system in 2017. Using a whole different mind-set for those people who just want a couple of pints and will pay the higher price.

This project was supported by Sodexo, the food service provider for University of Minnesota Morris, They indicated a strong alignment of this project’s goals with their organization's’ commitments to increasing the supply of locally grown fruit in the community, They received all the strawberries that were picked from the WCROC site from late August until mid-October. They were very happy with the nice size and excellent flavor. They commented how well they held up for fresh eating from lunch through the dinner hour. During September, 2016 they we not able to get additional strawberries from their regional food distributor because of environmental issues. They were very happy they had quality strawberries from us during this shortage of strawberries.

GOALS AND OUTCOMES ACHIEVED

Goals	Outcomes Achieved
Develop recommendations for nitrogen and other nutrient requirements. (Project goal, short-term outcome.)	Similar to our previous findings, day neutral production resulted in excellent yields regardless of fertility practice. In 2015 and 2016 we did not find any significant differences in yield or berry weight, between fertility treatments for % leaf nitrogen and brix values at either Morris or St. Paul research sites. See Table 1.
Extend the harvest season and increase yields. (Short-term outcome.)	In 2015-2016 summaries from both Morris and St. Paul trials, yield of Albion in the low tunnel and non-low tunnel surpassed the baseline for June bearing strawberries. We extended the normal harvest season into mid to late October with this low tunnel day-neutral system. See Table 1 for yield data.
Develop recommendations for pest management strategies (Project goal, short-term outcome.)	Three of the five research sites are on organic land, so synthetic pesticides were eliminated. Organic approved pesticides were used to control insects. With the installation of white on black plastic mulch on the strawberry raised beds, weed pressure has been substantially reduced as compared to a June bearing matted row system.
Educate stakeholders through frequent online research updates and face-to-face educational events. (Project goal and medium-term outcome.)	The project team regularly communicates to stakeholders via our research blogs, newsletter articles, media, and educational conferences, all with the purpose of educating current and potential growers about new strawberry production methods. The project team posts regular updates on research and related information on our research blog at http://fruit.cfans.umn.edu/category/strawberries/low-tunnel-strawberry/. During the project, we wrote 21 blog posts with timely updates on our research. Some of these posts included grower-cooperator perspectives, event announcements, and information about related research. Website analytics can be found below in #9. In 2015-2016 we emphasized in-person events to help stakeholders fully understand the details of the system. During this period, we reached approximately 200 stakeholders at in-person events. Our research team presented our findings to 65 strawberry growers at the Upper Midwest Regional Fruit and Vegetable Growers Conference on January 14, 2016 at the St. Cloud, MN Convention Center. We presented basic day neutral strawberry management, fertility management, irrigation, pest management, and projected profits of this production system. On July 28, 2016, we held a “Build a Strawberry Low Tunnel” program at the WCROC Horticulture Night. Forty-five (45) growers and other stakeholders participated in this hands-on workshop to construct a

	strawberry low tunnel based on our research, using the same equipment and methods we use in our field trials and on-farm plantings. Two field days held at the U of MN St. Paul campus featured our research plantings. In July, 25 participants toured the planting and learned management practices from project team members. A similar event in September had 30 participants. In 2017, as a continuation of our project our project team participated in a forum hosted by the UM Regional Sustainable Development Partnership. This forum, held at the St. Paul campus, focused on building specialty crops markets and highlighted the University's new and innovative crops research. The event provided an opportunity to reach a broader audience. The 40 participants included UM faculty and staff, sustainable food systems professionals, farmers, culinary professionals, MDA/MN Grown representatives, UM Extension professionals, and media. The project team led a panel highlighting our day-neutral strawberries research, which also included a grower and a culinary professional who is using the fruit produced by our research.
Evaluate our success at increasing strawberry growers, production, demand and profits in the Upper Midwest.	

The measureable short- and medium-term outcomes of this project were achieved and detailed above. This project has also made progress towards achieving 3 longer-term outcomes:

- **Improve profits for local specialty crop growers.** In our trials, this strawberry production has produced high yields of exceptional quality fruit. Because this system facilitates organic production, a high price point is possible. This project has helped refine the system by focusing on specific nutrient and pest management details. This project has also provided the opportunity to refine the construction of the system. We continue to streamline the labor and materials needed for installation. Combine all of this with the extended growing season, and it is possible for a grower to see increased profits by implementing this system.
- **Establish expectation that locally grown strawberries are available from June to October.** Through our partnership with our grower cooperators, who sell the fruit from this project to consumers at farmers markets, we are establishing the expectation that local strawberries should be available for a several-month period. Similarly, our partnership with Sodexo is having a similar impact. Sodexo serves the University of Minnesota Morris community through their dining services. This community is made aware that the strawberries they consume are produced locally, which is also contributing to an expectation among

consumers that Minnesota-grown strawberries can and should be available from June to October.

- **Improve soil health and environmental sustainability of specialty crop operations.** This project has succeeded in refining nutrient recommendations for day neutral strawberry production systems. This, along with pest management strategies is contributing to our efforts in improving soil health and environmental sustainability of specialty crop operations.

Education is an important component of this project. Our research team presented the system to grower participants at the Upper Midwest Regional Fruit and Vegetable Growers Conference on January 14, 2016 at the St. Cloud, MN Convention Center. While there is an expressed interest in having greater access to locally grown strawberries, lack of knowledge regarding innovative production systems and new cultivars has limited growers from being able to fulfill this need in our region. We shared our findings to this grower group from the past two years of research with organic production systems for day neutral strawberries to extend the season using plasticulture with and without low tunnels.

During our WCROC July 28, 2016 Horticulture Night we shared our day-neutral low tunnel project during a "Build a Strawberry Low Tunnel" program. We demonstrated to specialty crop growers and interested individuals a hands on field demonstration. All necessary machinery and components were used to interact with the participants from start to finish.

Project-specific content on http://fruit.cfans.umn.edu/category/strawberries/low-tunnel-strawberry/ had over 5800 page views from April 2013-November 2016. In addition to the increased traffic on the website, there has also been increased interest in the project in media which leads us to believe that the work we are doing is of great interest to the greater community. Since 2014 the project has been featured in multiple publications including the Midwest Organic & Sustainable Education Service (MOSES) Organic Broadcaster newspaper, North American Strawberry Growers Association Newsletter, Nourse Farm Professional Growers Newsletter, Ontario Berry Grower Newsletter, College of Food Agriculture and Natural Resources Science in the News, Twig Bender (Department of Horticultural Science e-newsletter), the Grand Forks Herald, the Fargo Forum, the Morris Sun Tribune, Northern Gardener magazine, and The Land magazine. Our interactive eBook, Cold Climate Strawberry Farming, and the corresponding Facebook page experienced increased traffic in the past year. Facebook likes have grown from 60 in May 2015 to 103 in November 2016. In addition 592 views on the YouTube video advertising the eBook, 1.360 clicks on the short link to view the eBook, and 32 Twitter followers. Feedback has indicated the need for recommendations on nutrient needs and irrigation management, along with a clearer picture of this system's insect and disease complex and management strategies.

BENEFICIARIES

Our grower cooperators were:

- Mary Jo and Laverne Forbord, Owner/Operator Prairie Horizon Farm, Starbuck, MN.
- Ron Branch, Owner/Operator Berry Ridge Farm, Alexandria, MN.
- David Macgregor/Marsha Anklam, Owners/Operators Fairhaven Farm, South Haven, MN.

Our three grower cooperators benefitted from the completion of this project in such that they now have first-hand experience with the system and have been able to determine adjustments to make it suitable for their farms. These growers are able to share their experience with other growers, and provide advice on many aspects of establishment, management, and marketing.

We reached our goal of engaging 200 stakeholders, face-to-face, with information about this production system. Of course, the group we always hope to engage with and impact the most is specialty crop growers. During this project, we were able to get many growers out to the plantings to see them first-hand and to practice with the materials and processes. We anticipate that this type of experience will have a great impact on adoption of the system. We have also been successful in expanding our reach to stakeholders that support specialty crop production: consumers and food distributors. Our partnership with Sodexo has impacted how these groups perceive locally grown strawberries. Sodexo's participation in outreach efforts is helping spread this impact throughout the greater food distributor and culinary professional community. Finally, through our participation in events with broader

audiences, we are expanding our reach and thus impact among the regional sustainable agriculture and food community.

Since this projected was completed, we have begun new partnerships with two specialty crop growers that are demonstrating our strawberry system on their farms. Little Hill Berry Farm is located in Northfield, MN and Tangletown Gardens Farm located in Plato, MN. Both have commented that they like using the day-neutral strawberry system and plan on growing even more day neutral strawberries next year. These two growers will help us expand the project's reach to a new region and a new set of growers and consumers.

Expenses and projected profit from the low tunnel day-neutral strawberry system. Data collected during the 2015-2016 growing season.

Variable costs	**Total low tunnel Treatment**		per 100'
Fertilizer	$70		$11.67
Pesticides	$17		$2.78
Plants	$125/1000 (w/o shipping)	approx. 17,500 plants/acre	$25.00
Irrigation - drip tape	$13/acre		$2.22
Mulch - Plastic (white on black)	$112.00/2400' of row		$5.00
1.5 mil Clear Film Roll	$176.00/1640"		$11.00
Galvanized Steel Hoops placed every 5" (Quantity: 20)	$3.98		$79.60
Straw (for walkways)	$56.00		$9.33
Hoops for beginning and end of each row, anchor pipe, steel stakes to anchor hoops and elastic bungee			53.44
Tractor Fuel (tillage, bed prep, plastic laying)	approx. 1 gallon/hour	approx. 20 hours per acre, $3.50/gallon	$3.50
1 lb. plastic qt. containers	$0.05	approx. 1 lb per plant & 200 plants per 100' row	$10.00

Total costs (variable + fixed)			$213.54

Projected profit based on 2016 data	
Average total yield/plant (based on low tunnel yields at the St. Paul and Morris site)	1.19 pounds
Estimated marketable yield/plant (15% loss)	1.011 pounds
Average marketable yield/100' row	202.3 pounds
Average selling price/pound	X $5.00
Gross profit/100' row	**=$1,011**
10 hrs labor to pick 100' row x $9.50/hr	- $95.00
10 hours labor for all details to maintain and grow this system per 100' row for one growing season x $9.50/hr.	-$95.00
Total costs (variable and fixed, from above table)	$213.54
Net profit/100' row	**= $607.46**
1 acre (660' x 66')	≈ 72.6 100' rows*
Net profit/acre	**$44,101.60**

LESSONS LEARNED

Insect pest and disease pressures posed significant challenges in 2015, at both the Morris and St. Paul sites. One of the first insects we encountered was the spider mite. While unsightly, spider mites don't cause much damage to the fruit themselves and can be controlled easily, even with organic measures. Another insect at both sites in 2015-2016 proved to be a much bigger problem – *Lygus lineolaris*, commonly known as the tarnished plant bug (TPB). TPB damage occurs when the insects use their sucking mouth parts to "drink" the sugars out of developing fruit. This results in distorted, cat-faced berries at maturity. TPB pressure was noticeably higher in 2015 than our 2013 or 2014 projects. Starting in late July, 2015 we noticed minimal-to-severe TPB damage on our fruit leading a reduction in total and marketable yields. TPB was present in both the low tunnel and non-low tunnel treatments, however the damage was markedly more severe in the non-low tunnel plants at the beginning of the season. At both sites in 2015-2016 a variety of organic insecticide sprays were applied to both low tunnel and non-low tunnel day-neutral strawberry plants. Weekly insecticide applications starting in early July through the end of

September including organic approved tank mixes of either Pure Spray Green (Horticulture Spray Oil), Conserve (Spinosad), PyGanic, (Pyrethrin based) and Oxidate (Hydrogen Dioxide).

The St. Paul site in 2015 experienced minimal pressure from the fungus *Phytophthora cactorum*, commonly known as leather rot. This was likely due to increased precipitation along with a silty clay soil. Once the soil dried, the disease pressure diminished. The St. Paul site also experienced in 2015 the arrival of the spotted wing drosophila (SWD). SWD damage is obvious – sunken, soft flesh. While yield loss was minimal, the presence of SWD required constant monitoring.

At the Morris site, SWD was not detected in trap cups or in ripe fruit in 2015-2016. The trap cups are clear plastic quart-size cups, with lids. Small 3/16" holes are drilled all the way around the cup. A wire handle inserted into the sides of the cup allows hanging the cup. A mixture of water, sugar, dry yeast, apple cider vinegar and whole wheat flour is used as bait in the cups, and yellow sticky traps are placed inside the lid using twist ties. The yellow sticky traps were removed each week and observed for SWD using a 10x magnifying glass. More detailed information about these trap cups can be found on our website http://fruit.cfans.umn.edu/spotted-wing-drosophila/.

At the Morris site in 2015 we experienced leaf spot disease on the plants. Leaf spot disease was more prevalent on the non low-tunnel plant leaves versus the low tunnel. We also saw rhizoctonia, or black root rot in 2015. We first noticed some strawberry plants wilting, then the underside of the leaves turned purplish and curled up. Eventually, the crown of the plants died. In order to properly diagnose, we collected plant and soil samples and sent into the U of MN Plant Disease Clinic. The results showed the disease rhizoctonia in both the plant roots and crown tissue. This disease significantly stunted fruit production in certain areas of our strawberry planting.

Late in the 2016 picking season, around early to mid-September we noticed some strawberry plants in our WCROC trial that started to look unhealthy and appeared to be dying. These dying plants were noticed under the plastic low tunnel in treated and non-treated fertilizer treatments. No unhealthy plants were visibly noticed in the non-low tunnel treatment. These low tunnel unhealthy plants were removed once symptoms were noticed to avoid possible spread of disease. One dying plant was dug and removed from each of the five different fertility treatments in the low tunnel system and sent to University of Minnesota Plant Disease Clinic for testing.

Results from that plant disease report found no pathogens present. But, according to their interpretation many of the salinity levels found in the soil around the plant roots were higher than optimal for strawberry plants. In another test we had a soil test lab take an analysis of the soil where our day-neutral strawberry plot was located. The soil pH report came back at 7.8 and the soluble salts levels came back low. We know that this level of pH in the soil is not the preferred soil for growing strawberries. We believe the combination of the high pH soil and the higher than normal salinity levels found in the soil created the dead strawberry plants. We assume if the plastic low tunnel would have been removed the rains

would have leached the salts from the soil and the plants would have looked healthy as the non-low tunnel plants did. With this high pH issue and growing day-neutral strawberries we would suggest or look into the soil incorporation of elemental sulfur at 600 lbs. per acre to hopefully reduce the high soil pH levels.
Previously, at one of our grower sites we observed iron chlorosis in the day neutral cultivars due to high soil pH. Iron chlorosis is a yellowing of foliage when high soil pH prevents plants from the uptake of iron present in the soil. Yellow foliage indicates a lack of chlorophyll, the green pigment responsible for photosynthesis (sugar production) in plants. Any reduction in chlorophyll during the growing season can reduce plant growth and vigor. Chlorotic plants often produce smaller fruits of poor quality with bitter flavor. In order to avoid this issue again we took soil tests from three different planting locations at this grower site. The planting sites that had previous iron chlorosis on strawberries measured 7.5 soil pH. The site we selected for planting in 2015 had a soil pH of 7.3. This 7.3 pH site had no symptoms of iron chlorosis on the strawberry plants in 2015. Consequently, we suggest a grower should select sites that have a pH level of 7.3 or lower to successfully grow these newer day- neutral strawberry cultivars.

One of the major challenges confronting us in the past was wind damage to the tunnels. Our original low tunnel system was very labor intensive to construct, and highly prone to wind damage. In 2015 we purchased a retractable tunnel system, called the Tunnel Flex Retractable Low Tunnel System, from Dubois Agrinovation (www.duboisag.com) of Quebec, Canada. This system offered a simpler, labor-efficient solution to our original system. This new system withstood any major damage from higher than normal winds, however we did observe a difference when the temperatures dropped near freezing. With our old system, the 4 mm thick plastic sheeting provided enough heat retention that our harvest season was extended by three weeks in 2014. In 2015, however, the 1 mm plastic sheeting provided with the Tunnel Flex system provided little if any heat retention. The low tunnel plants froze the first night of freezing temperatures.

Our original objectives stated these questions below.

1. Which nitrogen rate is optimal for annual, day-neutral strawberry production in the Upper Midwest?
2. Are there noticeable effects of too much or too little nitrogen in the system?
3. Is there a point where additional nitrogen incorporation will not lead to higher yields?

Similar to our previous findings, day neutral production resulted in excellent yields regardless of fertility practice or low tunnel use. In 2015 and 2016 we did not find any significant differences that affected average yield per plant, average yield per acre, average berry weight, between fertility treatments for % leaf nitrogen and brix values at either Morris or St. Paul research sites as can be seen in table 1.

ADDITIONAL INFORMATION

Outreach components were shared in Goals and Outcomes Achieved section. Photographs are included and incorporated into report.

Project 2

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Contact: Angela Orshinsky

Organization: Regents of the University of Minnesota

Contact information: aorshins@umn.edu, 612-625-9274

PROJECT TITLE

Survival, Biology, and Management of Leaf Mold on High Tunnel Tomatoes Grown in Minnesota

PROJECT SUMMARY

In 2013, the Minnesota Specialty Crop Block program funded The Minnesota High Tunnel Network project to survey diseases of tomatoes grown in Minnesota high tunnels. To date, 50 % of submitted samples were diagnosed with leaf mold, caused by the fungal pathogen *Passalora fulva*. A questionnaire administered to Minnesota high tunnel growers indicated that 64% of growers have experienced leaf mold in the past and 36% experience leaf mold disease every year. Additionally, 43 % of respondents grow tomatoes every year without rotation and 45% of growers rotate out of tomatoes for one year at a time, demonstrating the importance of tomatoes to high tunnel growers.
P. fulva infects leaves, stems, blossoms and fruit of tomatoes. Infection of leaves is the most common, causing upper leaves to develop irregular, yellow blotches. Velvety, olive-green fungal spores are produced on the lower leaf surface. Eventually, leaves turn brown and die. Infection typically starts on the lower leaves and moves rapidly up the plant, resulting in significant loss of foliage. In severe cases, blossoms may be killed and fruit can develop a black, leathery rot at the stem end. The disease is unique to areas of high humidity since the pathogen needs 85 % humidity for spore germination. Consequently, most leaf mold research is done in the southeastern United States or in greenhouse production areas of Europe. Little is known about how *P. fulva* survives, spreads and causes disease in Minnesota high tunnels, preventing extension specialists from making relevant management recommendations. The purpose of this project was to determine more about the epidemiology of MN leaf mold in high tunnels including methods of introduction.

The estimated revenue of Minnesota high tunnels is over $25 million. Most high tunnel growers that will be impacted by this study are small to middle-sized farms operated by growers with minimal experience required to effectively manage disease. The project

proposed here will establish the knowledge that we need to help educate growers in the region on effective management of leaf mold disease. By understanding the biology of the fungus, we aim to improve recommendations for reducing build up and survival of the leaf mold pathogen populations. Recommendations for cultural management of the disease will reduce the need for and frequency of fungicide applications and improve the efficacy of fungicide applications that are made. By improving the productivity of Minnesota high tunnel tomatoes, we will decrease reliance on imported tomatoes and provide a steady source of local grown produce to Minnesotans during an extended season.

This project has specific objectives that are based on observations made during the course of the previously funded, Project 7: Minnesota Hightunnel Network. Leaf mold was identified as the most prevalent pathogen. High tunnels with high levels of leaf mold had noticeably higher levels of necrotrophic pathogens (ie. gray mold) than those without leaf mold. One hypothesis is that the degradation of tomato tissue by leaf mold increases susceptibility to invasion by pathogens that thrive when the plant tissue is weakened or dead. This is the first work to study the genetics, epidemiology and biology of leaf mold in high tunnels in MN and USA.

PROJECT APPROACH

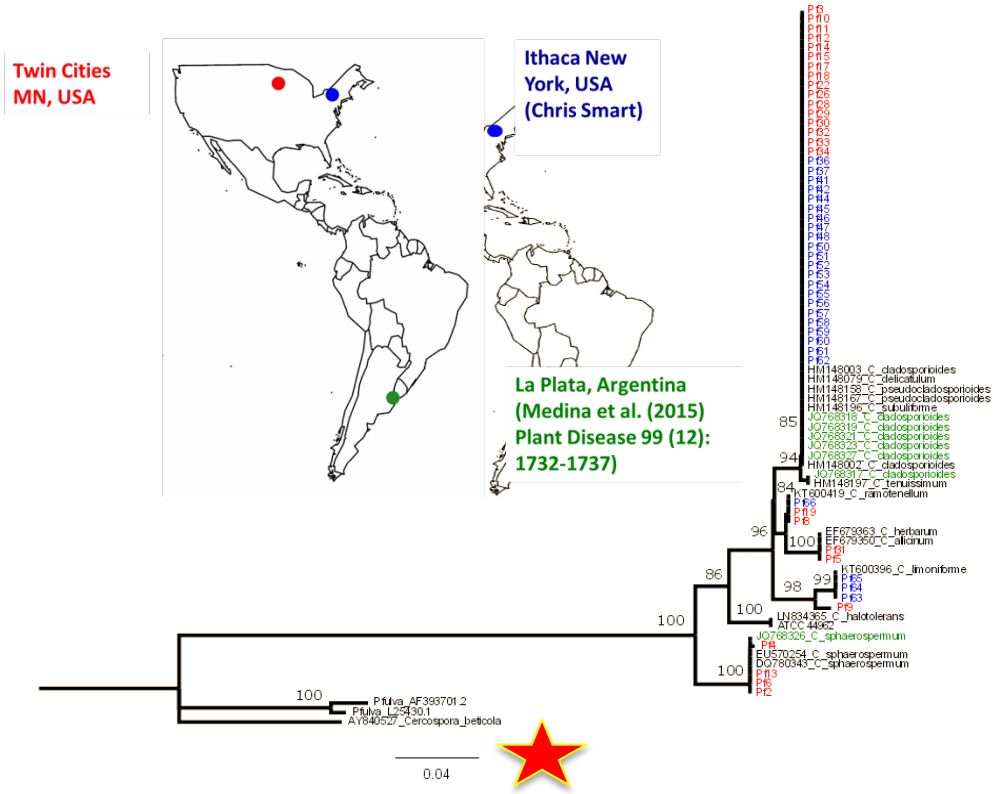
Goal 1. Define the conditions for survival of P. fulva conidia, mycelia, and other fungal propagules over winter.

Air samples were taken at intervals of 1 month to determine the presence of *P. fulva* conidia throughout the season. We also have collected environmental data on temperature and humidity throughout the year in 5 high tunnels at 2" below the soil, at the soil line, and 2 feet above ground. We will use this information to develop an epidemiological model for leaf mold disease and *P. fulva* survival. We are still awaiting the survival and optimal growth data to complete this work. Portions of this goal was supplemented by a Rapid Agricultural Response Fund project: specifically it provided funding for the software and environmental monitoring data. Please read through to the challenges portion of this report for an explanation of why this experiment is still on going.

***Goal 2. Assess the potential host range of* P. fulva**

Obtaining a pure culture of *P. fulva* was more difficult than we projected. We obtained two isolates of *P. fulva* from the American Type Culture Collection, but one was misrepresented and turned out to be *Cladosporium halotolerans*. The other isolate did not grow well and was lost. This attenuation phenomenon is common in fungi stored for too long without reculturing. Other researchers have also stumbled across this issue including Dr. Christine Smart at Cornell University and a group of leaf mold researchers in Argentina (Figure 1a, 1b).

Figure 1a: Locations reporting isolation of *Cladosporium* spp. from leaf mold lesions. The isolates in NY and MN were identified using ITS region sequences by our lab. We downloaded the sequences from *Cladosporium* spp. reported in Argentina for phylogenetic comparison. **1b:** Most isolates (location is color coded) recovered from leaf mold lesions are *Cladosporium cladosporioides, C. pseudocladosporioides,* and *C. sphaerospermum*. *P. fulva* is represented at the branch with the red and yellow star.



We eventually discovered that a majority of the spores on infected leaves are from *Cladosporium* spp. – not *Passalora* spp. To isolate pure cultures of *Passalora fulva* required diluting spores from a leaf to 100 spores per 100 µl and spread plating 100 spores onto water agar containing streptomycin at 300 mg/L and amoxicillin to 100 mg/L. After two days we used a dissecting microscope to pick out germinated conidia of *P. fulva*, which were rare relative to the *Cladosporium* spp. spores. The conidia look very similar, but the *P. fulva* spores can be identified by their larger size and faster growth (figure 2).

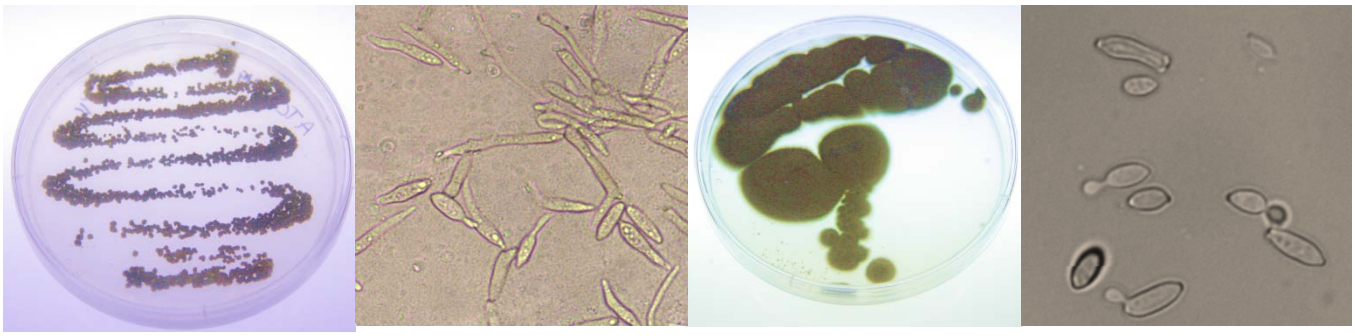


Figure 2: Left to right: *Passalora fulva* colonies after 3 days growth on PDA; Conidia are cylindrical to straight and 16–40 µm × 5–7 µm; *Cladosporium* spp. after 3 days growth on PDA, *Cladosporium* spp. spores are lemon shaped and 4–14 µm × 2.5–4 µm

These single spore isolates of *P. fulva* have been run through a tomato plant in growth chambers and again isolated using single spores to ensure purity. These isolates were used for all *P. fulva* experiments in the lab.

Goal 3. Determine the ability of P. fulva to infect and be dispersed on seeds

We used seed from 3 sources: Johnny's Seed Company, Seed Savers' cooperative, Eden Brothers. We used 2 varieties from each source: Brandywine and Black Krim. We also tested seed from 2 MN farms with severe leaf mold. Seeds were surface sterilized in 10 % bleach for 3 min then rinsed three times in sterile water for 1 minute each. Two thousand seeds from each lot in total were used. Surface sterilized seed was plated onto 1/8 strength potato dextrose agar with 300 µg/ml streptomycin. Fungi growing from seeds were isolated into pure culture and identified by their ITS regions. 81 isolates were collected. There were no differences in the number of fungi isolated from seeds based on location or cultivar. *P. fulva* was not isolated, but since it grows slower, we may have simply missed it as other faster-growing fungi came out. Fungi isolated from inside the seeds included *Chaetomium* spp. (common endophyte and mycoparasite), *Cladosporium* spp. and *Alternaria* spp.

Goal 4. Determine the races of* P. fulva *present in Minnesota

As planned, we used primers for avirulence genes in *P. fulva* to detect mutations. Mutations in these genes would are important as they would allow *P. fulva* to overcome resistance genes deployed to reduce leaf mold in the tomato plants used by growers. Mutations found are as follows: deletions in one isolate for AVR2; one mutation from G to T in one isolate for AVR4; one isolate has T to C, and 2 from C to T for AVR4E; all isolates relative to reference have A to G, T to C, A to C changes in AVR9. These mutations may or may not be functional – that is, conferring ability to infect plants with the corresponding resistance genes in plants. We are still race-typing our *P. fulva* collection with differential tomato sets to determine if mutations are assisting in overcoming resistance. This is being funded by nonsponsored program funds because our initial issues with isolating *P. fulva* have resulted in a delay in these experiments.
Briefly, to determine races and functionality of avirulence gene mutations, each isolate is sprayed onto a set of tomatoes with differential sets of resistance genes at the two-leaf stage. Race-typing will be determined by the quantitative and qualitative assessment of disease symptoms on each of the differentials including a susceptible control containing no resistance genes.

Goal 5: Develop research based cultural control recommendation for management of leaf mold

We have worked extensively with growers to encourage better pruning of plants to promote ventilation and reduce humidity in the canopy and to avoid early planting of tomatoes when conditions do not favor growth.

In summer of 2016, we conducted a variety trial of leaf mold resistant tomatoes both in a high tunnel and in the field. None of the cultivars tested exhibited leaf mold symptoms, but they may have been escapes as we did not inoculate the experiment. The best cultivars of

the tested set of tomato cultivars were -Golden Sweet, Sweet Hearts, Sweet treats, Sakura, Trust, Geronimo, Favorita, Toronjina, St. Clemon - based on yield.

We tested 11 fungicide programs at three farms, collecting disease severity data, marketable and unmarketable yield data. Half of the programs were applied preventatively (prior to disease appearance at two weeks after transplant), and the other half were applied in mid-June, when leaf mold made an appearance. There was a marginal increase in marketable yield between the treatments at location 1 and 3, but no difference in treatments at location 2. When we tried to accound for the difference, we observed that the canopy at location 2 was a great deal thicker. In all locations, plants were trained using a Florida weave method. At location 1 and 3, plants were trimmed back at regular intervals but still had pretty thick canopies. At location 2, plant branches were stuffed into the weave instead of pruning, leading to very packed canopy. We hypothesize that the fungicide coverage was not adequate inside the canopies. This would explain a lack of significant differences between treatments and the controls. Clearly we will need to assess fungicide sensitivity in the lab and in the greenhouse/growth chamber to ascertain efficacy of fungicides when adequate plant coverage is attained.

These activities include results of both SCBG Project 2 and of a separate grant that was obtained by leveraging results of Project 2.
We encountered a great deal of difficulty with the study initially as methods described in the literature for isolating *P. fulva* were far from adequate. We followed multiple protocols and were only able to isolate *Cladosporium* spp. We obtained isolates reported to be *P. fulva* from the ATCC and they turned out to be *Cladosporium halotolerans*. We obtained over 60 isolates from a collaborator in New York who claimed they were *P. fulva* and they were all either *C. cladosporioides* and *C. pseudocladosporioides*. In 2015, a study conducted in Argentina reported isolation of a high proportion of *Cladosporium* spp. in relation to *P. fulva.* We spent all of 2014 and 2015 trying to develop a method for isolating *P. fulva* from mixed populations of *Cladosporium* spp. and *P. fulva*. *Cladosporium* spp. grow very quickly, making it difficult to use spore dilutions.
Therefore, our greatest accomplishment in 2014 and 2015 was uncovering the misidentification of large culture collections of *P. fulva* and developing a method for isolating *P. fulva* from complex fungal mixtures.
Due to our delay in being able to isolate pure cultures of *P. fulva*, we were unable to conduct the objective to investigate overwintering of *P. fulva* in soil, on stakes, and strings. We will attempt to conduct the studies in the future now that we have *P. fulva* cultures.
We did collect data to determine several of the goals originally outlined in the original study. They are reported under Goals and Outcomes Achieved.

Angela Orshinsky has provided two to three Extension talks on leaf mold management to high tunnel and vegetable growers in Minnesota and the Midwest every year including an invited lecture in Ohio. She has also co-authored a general high tunnel disease management booklet as part of a separate grant: 2013 Project 7: The Minnesota High Tunnel Network. Dr. Orshinsky assisted in troubleshooting experiments including obtaining pure cultures of *P.*

fulva from complex spore mixtures and amplification and sequencing of genetic markers and avirulence genes.

The graduate student (Lillian Garber) employed by this project has given both an oral presentation at the North Central American Phytopathological Society (NC-APS) in June 2016 and a poster presentation of the diversity of fungi associated with leaf mold symptoms at the national APS meeting in August 2016 in Tampa Bay Florida. Lillian has also been trained in Extension work and has given several field presentations at horticultural field days and with individual growers.

Four undergraduate students worked on this project at various points giving them the opportunity to work in a lab making media, isolating and culturing fungi and bacteria, growing tomatoes, and conducting molecular biology assays. These students were funded either by this grant, the leveraged funds from the UMN grant in aid program, the rapid agricultural response funds and foundational funds (donations).

GOALS AND OUTCOMES ACHIEVED

We conducted surveys (turning point) in each year of the project to assess learning and knowledge. We conducted Turning Point assessments of grower learning at MN Hightunnel conferences, and Upper Midwest Fruit and Vegetable Conference in 2014-2018.
At each presentation in 2015, 2016, and 2017, growers rated the presentations as an average of 4.5 to 4.8 out of 5 for usefulness of information.

Due to the challenges with this project, our goals of decreasing disease related tomato losses in MN tomato production has become a long term goal. To date, we have provided in person guidance, fact sheets, and presentations to encourage growers to engage in appropriate practices that will improve growth. We have no measure of this across the state, but anecdotally, one major tomato producer has initiated heavy pruning early in the season to improve canopy ventilation. Others have installed fans into their high tunnels. We will attempt to assess this progress in quantitative terms over the course of the next year.

The following 5 goals are included in the original project proposal:

- Define the conditions for survival of P. fulva conidia, mycelia, and other fungal propagules over winter.
  We were unable to conduct this assay due to the delay in obtaining *P. fulva.* However, we will work towards obtaining this data as it is important information for cultural management across the Midwest USA.

- Assess the potential host range of P. fulva

  We were unable to conduct this assay due to the delay in obtaining *P. fulva*.

- Determine the ability of P. fulva to infect and be dispersed on seeds

  We tested 6 seed lots for *P. fulva*. We tested seeds of Black Krim and Brandywine cultivars from Johnny's seeds (high quality commercial seed), Seed Savers (cooperative seed supplier from multiple farm sources), and Eden Brothers (commercial high quality organic seed). There were visual differences in the cleanliness and consistency of seed from each supplier. Johnny's seeds and Eden Brothers seed supplies were very clean and had little visible contamination on the seed coat exterior. Seed from the Seed Savers' lots were visibly dirty, many seeds were shriveled and debris was found in all lots.

  We surface sterilized seed to obtain only those fungi inside the seed coat. We plated 1000 surface-sterilized seeds per trial onto PDA with streptomycin to inhibit bacterial growth. Fungi growing from seed were put into pure culture and identified using ITS sequencing procedures.

  Johnny's seed lots from both cultivars contained high numbers of *Cladosporium* spp. and *Chaetomium* spp. fungi in both cultivars in the first trial. In the second round, *Alternaria alternata* was also isolated from the seeds. Seed Savers seed contained high levels of *Cladosporium* spp., *Chaetomium* spp., *Alternaria* spp., and *Mucor* spp. Eden Brothers' seed contained only *Aspergillus* spp. and *Chaetomium* spp.

  Finding *Cladosporium* spp. and *Chaetomium* spp. was not surprising since both are known to be endophytes of multiple plants. There were no significant differences in the number of seeds with fungi inside between sources and cultivars; however, the type of fungus isolated from the seed was dependent upon the supplier. *Alternaria* spp. is a pathogen of tomato plants and other Solanaceae and its presence was not entirely unexpected. We did not expect to find *Aspergillus* spp.

  Cladosporium spp. colonization of seeds may help to understand why we had such a problem isolating *P. fulva*. More experiments will be required, but our hypothesis is that *Cladsporium* spp. grow asymptomatically inside the plant until *P. fulva* causes senescent leaf tissue that the *Cladosporium* spp. can grow on quite easily. To this end, we tested colonization of *P. fulva* and *Cladosporium* spp. over time and looked at the inoculated tomato leaves over time. At 18 days post inoculation, *P. fulva* had infected and colonized the leaves and begun to produce spores. The *Cladosporium* spp. were only able to penetrate local intracellular spaces around stomata and produced only small, visually imperceptible colonies on the underside of the leaf. More testing is required. We didn't isolate *P. fulva* from the seed; however, since the pathogen grows so slowly in relation to the other fungi it is possible that *P. fulva* was present but obscured by the growth of the other fungi.

- Determine the races of P. fulva present in Minnesota

  This objective consisted of two separate experiments: screening isolates for the ability to infect plants with specific resistance genes and amplifying and sequencing fungal avirulence genes to determine if there are functional mutations in these genes (creating new races).

We have completed screening the avirulence genes of our MN isolates and identified mutations in Mutations found are as follows: deletions in one isolate for AVR2; one mutation from G to T in one isolate for AVR4; one isolate has T to C, and 2 from C to T for AVR4E; all isolates relative to reference have A to G, T to C, A to C changes in AVR9.

However, we are still working on screening various cultivars for resistance to our isolates to determine both race and the function of the listed mutations. The delay in our ability to produce pure cultures of *P. fulva* put off our ability to begin screening. It also took longer than expected to produce enough seed of the required genotypes (acquired from the genotype resource collection in California). This screening is taking place using unsponsored funds. We will persist in pursuing this very important information.

- Develop research based cultural control recommendation for management of leaf mold
  Each year, we presented our data at the Upper Midwest Vegetable Production Conference in St. Cloud, MN. We also made approximately 60 visits per year to various high tunnel operations to investigate the leaf mold pathosystem. At each location and presentation we advised growers to avoid intercropping to reduce humidity and to allow for application of preventative fungicides when the temperatures are optimal for *P. fulva* growth (20-25 °C as per our experiments). MN *P. fulva* isolates grow optimally at 20-25 °C and don't grow at all at 30 °C or 4°C. In contrast, *Cladosporium* spp. grew quickly at 4°C and 30 °C. We were able to convince many growers to move from 18 inch spacing to 24 inch spacing and to prune early in the season to avoid heavy canopies. Two growers even installed fans to improve ventilation under my advisement. Reduction in leaf mold at one of these two tunnels was noticeable at one location.
  All of these recommendations are found on the UMN Extension website as a fact sheet. We are not making cultivar recommendations at this point. We will wait until we know more from our race typing experiments to do this.

  We encountered major challenges in isolating *P. fulva*. However, this is incredibly important because it seems that we are not the first to encounter co-colonization of tomato leaves by specific species of *Cladosporium* spp. In fact, we hypothesize that leaf mold may be a disease complex whereby *P. fulva* initiates weakening of the tissues and *Cladosporium* spp. ultimately take over the weakened tissue. Isolation of *Cladosporium* spp. from surface disinfested seeds indicates that the "contaminant" may in fact colonize the tomato plants early during the growth stages. We will attempt to find funding to test this important epidemiological hypothesis. Despite the delay, we consider the grant a success because we have learned about the interactions between the tomato, *P. fulva*, and *Cladosporium* spp.

  Baseline data has been acquired from surveys conducted in 2015, 2016, and 2017. However, as the project will not be completed until 2018 (race typing and survival data), we will need to wait until this information has been dispensed to the growers to assess final outcomes.

BENEFICIARIES

Individual tomato growers benefited from our project. We worked with over 15 individual operations to complete this study. The Minnesota Fruit and Vegetable Growers' Association benefited from this project as Dr. Orshinsky provided free presentations every year to update the membership on the progress of the grant. Finally, the research community is going to benefit as we are conducting studies that have never been conceived of with regards to how *P. fulva* acts in concert with other fungi and in a high tunnel situation. Most work on *P. fulva* has been at the molecular level and in greenhouses. High tunnels present more challenges in regulating the environment and reducing overwintering pathogens on plant debris in the exposed soil.

High tunnel vegetable production in Minnesota has become a major source of fresh vegetables and fruit over the past decade with the advent of the high tunnel program supported by the USDA Natural Resources Conservation Service. Minnesota is a national leader in high tunnel use for local food production with over 1,500 tunnels in production. Tomatoes are the highest value high tunnel crop. Forty three percent of growers plant tomatoes every year with no rotation of crops and 45% of growers rotate out of tomatoes for one year at a time, demonstrating the importance of tomatoes to high tunnel growers. Each 2100 sq ft high tunnel can provide each grower with an average income of $12,000. Thus, high tunnel tomato production is a substantial part of many small farmer incomes and contributes up to an estimated $18,000,000 to Minnesota's economy each year (based on high tunnel numbers and average revenue per high tunnel). Nationally, the United States is world leader in tomato production with fresh market tomatoes earning $2 billion annually [1]. Table 1 demonstrates the impact of small yield losses on profit for small farmers. Even a modest three pound reduction in yield over the course of a year can impact the income of a small farmer by several thousand dollars.

Table 1: The effect of yield on profit per high tunnel under a series of market values.
(Source: Karl Foord, UMN Extension Educator, based on a 2880 sq ft tunnel, 64 plants/ row x 7 rows = 448 plants)

Yield		**Price per lb ($)**				
lb/plant	**lb/tunnel**	**$1.50**	**$2.00**	**$2.50**	**$3.00**	**$3.50**
7	3136	$1,758	$3,326	$4,894	$6,462	$8,030
10	4480	$3,347	$5,587	$7,827	$10,067	$12,307
14	6272	$5,591	$8,727	$11,863	$14,999	$18,135
17	7616	$7,144	$10,952	$14,760	$18,568	$22,376

Over the past three years, the horticultural plant pathology program in the Department of Plant Pathology has conducted a disease assessment survey to determine the most important diseases to high tunnel solanaceous crops in Minnesota. Results of the survey demonstrated that tomato leaf mold is one of the most important tomato diseases in Minnesota high tunnel tomato production (Fig. 1b). Leaf mold disease was found at every single high tunnel tomato operation surveyed in 2014 and 2015 (100 % incidence of 18 high tunnel locations surveyed).

LESSONS LEARNED

The most important lesson learned is that other scientists have been failing to report isolation of *Cladosporium* spp. in association with *P. fulva*. This may be due to the confusion over the taxonomy and lack of training in differentiating the two fungal genera. Due to the prevalence of this phenomenon, we decided not to ignore the secondary pathogen and will explore the role of each fungus in the leaf mold pathosystem. However, this issue did cause major delays in obtaining purified isolates of *P. fulva* and as a result our research goals were delayed. However, because of our ability to resolve the initial issue, we have gained a more detailed understanding of the leaf mold system. We will need to find additional funding to explore the leaf mold pathosystem in high tunnels further. The presence of another group of fungi associated with the leaf mold disease in various locations of the world means that it may be necessary to control both fungi with different means to reduce disease.

The other unfortunate issue is that all of the fully resistant tomato cultivars are indeterminate. This has been an issue because high tunnel growers tend to prefer determinate tomato cultivars. We may attempt to create determinate cultivars of fully resistant tomatoes in collaboration with a breeder in the future. This would give high tunnel growers more options for successfully managing leaf mold without chemical fungicide application.

ADDITIONAL INFORMATION

Orshinsky, A.M. 2017. Tomato leaf mold research update on cultural and chemical management. Midwest fruit and Vegetable conference. St. Cloud, MN.

Orshinsky, A.M. 2017. Leaf Mold: It's Complicated. Ohio Produce Growers and Marketing Association. Sandusky, OH.

Garber, L., Le Blanc, N., **Orshinsky, A. M.** and Smart, C. D. 2016. Characterization of fungi associated with tomato leaf mold in the United States. Phytopathology. 106: S4.36 (Abstract from national presentation)

Project 3

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Contact: Robert Olson

Organization: Minnesota Grape Growers Association

Contact information: bolson@cdsus.coop, 651-265-3682

PROJECT TITLE

Expanding knowledge of vineyard best management practices

PROJECT SUMMARY

Growers of all experiences are eager to learn proven grape-growing strategies that have accumulated to the research scientists and early adopters. With limited research staff and virtually no dedicated Extension resources, the educational outreach of commercial grape growing in Minnesota is being led by the MGGA. This project's written and video products will aid the dissemination of knowledge to a wide audience eager to learn.

Interest in commercial grape production is expanding rapidly among a diverse group of persons including many new to agriculture. Everyone, in effect, was new to commercial grape culture as recently as the mid '70's when the state's first vineyard and corresponding winery were established. Since them, the knowledge base has been dramatically expanded due to the establishment of dedicated University of Minnesota breeding programs and the determination of early viticulturists.

The commercialization of grapes in Minnesota is a recent phenomenon; the first commercial-scale vineyards were planted in the mid 1970's with limited success due to the crops' inability to overwinter. Since that time, through on-going legislative outreach by the MGGA for the behalf of the industry, the University of Minnesota grape breeding program (and subsequent enology program) has developed cold-hardy varieties that have formed the backbone of the entire cold climate grape industry. To realize the benefits of these improved varieties in an economically and environmentally sustainable method, however, required rigorous vineyard management and adherence to new techniques which yield high quality fruit. These new techniques, in concurrence to new cold hard varieties will be taught and illustrated via the products of this SCBG.

PROJECT APPROACH

The project involved two main activities:

Work plan Activity 1:

Revise/update/modify ‘Growing Grapes in Minnesota’ (MGGA 2006) to address Vineyard Best Management Practices. Print/distribute 800 copies.

The content for GGIM was provided by retired professor of Horticulture, Paul Demoto. Dr Demoto was tasked with updating GGIM as well as generating new material content. Having Dr Demoto as the sole author proved wise; he was totally in charge of the content and style of writing which we anticipate would have been more challenging if numerous content specialists had been involved. The proofing of Dr Demoto’s materials was provided by MGGA members including Dr Gary Gardner, former Horticulture Department Chair at the University of Minnesota.

While Dr Demoto’s work and timeliness was stellar, the breadth of text, images, and graphics went far beyond what MGGA was anticipating, thus leading to a much larger than expected deliverable. The additional content, although welcome, meant costs for layout and printing became an issue. An internal MGGA member was tasked with layout and print duties, but personal time commitments and other MGGA administrative duties resulted in production delays including missing the Annual Meeting deliverable. In the end, however, the layout and printing resulted in a breathtakingly beautiful and functional 166 page, spiral-bound publication,

The initial printing (800 copies) were virtually exhausted by fall, 2017 with only 10 copies in inventory as of September, 2017. The MGGA Board is evaluating whether to invest in a second printing.

Work plan Activity 2:
Produce, narrate and edit ‘Vineyard Best Management Practices’ videos for website postings. Nine videos produced for YouTube format.

The content and production of the videos was originally assigned to two private contractors. The primary contractor, John Thule, resulted in the production of 9 videos. The second contractor, however, rescinded his bid for services due to scheduling issues with his regular work assignments. The cost savings in his videos facilitated covering cost over-runs for the printed GGIM.

Subsequent to the SCBG project, MGGA has self-funded 5 additional videos, bringing the total to 14. The video series has proven to be a very popular and educational activity. The series is played on a continuous loop at major MGGA events including the 11 day Minnesota State Fair.

This project has largely been accomplished by paid contractors. Supervision of work and deliverables has been provided by MGGA President Irv Geary. The University of Minnesota’s Department of Horticulture and Extension faculty will provide valuable distribution of the manuals for work with growers and hobbyists throughout the state.

GOALS AND OUTCOMES ACHIEVED

Work plan Activity 1:
Revise/update/modify 'Growing Grapes in Minnesota' (MGGA 2006) to address Vineyard Best Management Practices.
This workplan is completed, resulting in a 166 page, coil bound color manual (attached). The writing of the manual was completed by December 2016, but layout services and subsequent printing was delayed. As a result, we missed the opportunity to roll out the manuals at the Cold Climate Conference held in February 2016 as planned. Layout services and printing were completed in September, 2016. Within two days of printing, 200 manuals were distributed at an open house hosted by the University of Minnesota Grape Breeding and Enology project. The primary audience were commercial vineyard/winery operators and aspiring commercial growers.
Distribution of the complimentary manuals includes University of Minnesota Extension and research/teaching faculty with horticulture responsibilities. Major distribution will occur February 16-18, 2017 concurring with the MGGA's Cold Climate Conference.
In addition to printed copies of the manual, all chapters will be posted as PDF files for viewing/downloading from the MGGA website. The website will track "clicks and downloads" from viewers.

Work plan Activity 2:
Produce, narrate and edit 'Vineyard Best Management Practices' videos for website postings. Nine videos produced for You Tube format.
Contractor John Thull produced and edited 9 videos including:

A. Balanced Pruning
B. Tying
C. Planting New Vines
D. De-Suckering
E. Shoot Thinning
F. Shoot Positioning and Trimming
G. Leaf Pulling
H. Crop Adjustments
I. Harvesting

These videos will be available for viewing as YouTube videos linked to the MGGA website. The website will track 'clicks and downloads' from viewers.
One notable departure from our planned deliverables was the inability of contractor Brian Nelson to develop the five videos related to pest control and management. MGGA did not, therefore, request all of the SCBG funds that were awarded.
Access to the printed GGIM has been astounding; the first-run printing of 800 copies have all been distributed (2 years earlier than anticipated).

Web access to GGIM and the video series is beyond expectations. In the 6 month period April to September 2017, the MGGA website tracked 788 downloads of the digital GGIM. In that same time-period the website tracked 5,112 "clicks" to the digital GGIM and 3,935

views/clicks for the video series. The website access is expected to continue for the foreseeable future.

	# of Downloads (2017)						
	April	May	June	July	Aug	Sep	Total
Growing Grapes in Minnesota Manual	87	133	212	92	155	109	**788**
Chapters	# of Clicks (2017)						
Chapter 1 Growing Grapes in Minnesota	4	0	0	0	0	0	**4**
Chapter 2 Considering Growing Grapes	55	54	58	51	7	66	**291**
Chapter 3 Vineyard Economics	49	33	66	46	34	33	**261**
Chapter 3 Tables	24	23	37	32	18	22	**156**
Chapter 4 Grape Cultivars for Minnesota	61	81	107	71	122	76	**518**
Chapter 5 Starting the Vineyard	51	65	78	60	36	43	**333**
Chapter 6 Care of Established Vineyards	37	46	83	62	68	39	**335**
Chapter 7 Pruning	38	48	75	54	37	37	**289**
Chapter 8 Canopy Management	32	44	76	58	31	22	**263**
Chapter 9 Fertilization and Nutrition	30	42	72	50	32	63	**289**
Chapter 10 Weed Control and Vineyard Floor Management	76	79	83	48	52	31	**369**
Chapter 11 Winter Protection for Tender Cultivars	36	30	46	42	20	19	**193**
Chapter 12 Vineyard Pest Management	28	36	61	48	23	28	**224**
Chapter 13 Insects Pests of Grapes	50	56	85	98	96	79	**464**
Chapter 14 Wildlife Pests of Grapes	32	49	58	57	35	49	**280**
Chapter 15 Grape Maturation	40	51	62	56	77	88	**374**
Chapter 16 Resources	35	47	60	52	25	25	**244**
Chapter 17 Growing Grapes in Minnesota Tables	30	32	55	45	31	32	**225**
Total	**708**	**816**	**1,162**	**930**	**744**	**752**	**5,112**
Best Practice Videos	# of Views/Clicks (2017)						
Planting New Vines Prep	30	15	30	10	49	25	**159**
Training Young Vines	19	11	51	100	479	305	**965**
De Suckering Young Vines	7	9	24	12	102	10	**164**
De Suckering Older Vines	7	4	21	16	67	60	**175**
Balanced Pruning High Cordon Labrusca	10	8	19	12	40	21	**110**
Shoot Thinning High Cordon	7	17	34	118	495	570	**1241**
Shoot Position and Trim HCV	9	7	24	6	31	22	**99**
Balanced VSP Pruning	15	10	20	7	125	91	**268**
Shoot Thinning VSP Vines	9	17	31	37	145	87	**326**
Shoot Positioning VSP	12	6	14	17	69	33	**151**
Shoot Trimming Hedging VSP	9	5	17	4	33	25	**93**
Leaf Pulling VSP and High C	4	4	12	5	9	2	**36**
Crop Adjustment for Grapes	3	6	13	5	16	15	**58**
Harvesting Grapes	3	7	12	9	36	23	**90**
Total	**144**	**126**	**322**	**358**	**1,696**	**1,289**	**3,935**

Our outcome is to improve the viticultural best management practices of cold climate grape growers. Our goal is that commercial grape growers, and those aspiring to be, will learn Vineyard Best Management Practices. To measure whether the goal and outcome has been achieved, we will be capturing metadata from the MGGA website (http://www.mngrapes.org/) related to number of 'clicks' of the manuals chapter and/or the individual videos posted. At this time we are finalizing our linkages to the website and soon will begin tracking 'clicks and downloads'. We are maintaining control of distribution for the printed manuals, with approximately 200 already distributed and an additional 400 planned for first quarter 2017.

For work activity 1 (printed manual) we intended to write and print 800 copies for complimentary distribution. We have fully achieved this accomplishment.

For work activity 2 (videos) we intended to develop 14 videos. In actuality we developed 9 of the 14 chapters. The independent contractor for the remaining 5 videos was unable to accomplish his task. MGGA did not seek reimbursement for this portion of the workplan/budget.

Outcome: Improve the viticultural best management practices of cold climate grape growers.
Goal: Commercial grape growers, and those aspiring to be, will learn Vineyard Best Management Practices.
Performance Measure: Number of 'click-throughs' to MGGA and other vineyard best management practice information, illustrating that the viewer has interest in the topic and is actively learning.
Benchmark: website measures and print distribution for the manual and videos (not yet developed) were zero at the beginning of this project.
Target: We anticipated that 50 percent of the average viewers (at least 500) will click through to MGGA and other vineyard best practice information.
Progress toward achieving targets: The manual is completely written and individual chapters are being readied for website viewing as PDF files. The nine videos are being readied for website viewing as YouTube files. We feel attainment of 500 'clicks' is likely.
The "Growing Grapes in Minnesota Manual" can be accessed at:
http://www.mngrapes.org/page/GrowingGrapes

The Best Practices videos can be accessed at:https://mngrapegrowers.site-ym.com/general/custom.asp?page=BestPracticeVideos

Measures of clicks/downloads will be on-going. A good time to assess their access will be in September, 2017 prior to harvest.

BENEFICIARIES

Groups benefiting include:
Commercial grape growers;
Aspiring commercial grape growers;
Hobby grape growers;
University of Minnesota Extension staff;
University of Minnesota Research/Teaching faculty;
University of Minnesota viticulture students;
Cold climate state grape associations

From an economic base of zero in 1976, Minnesota's commercial grape industry has grown to represent >$59 million in e3conomic activity by 2011. Of this, $16.4 million was generated by vineyards, $22.1 million by wineries, and $20.5 million by winery tourists. The grape growing and winery industries reported 3,250 employees in Minnesota with $19.7 million in labor payments (Vineyards and Wineries in Minnesota: A Status and Economic Contributions Report, 2014, UM).
As of March 1, 2017 approximately 500 copies of the manual have been distributed (MGGA maintains a list of growers who have received copies). The Best Practices videos were running throughout the Cold Climate Conference February 16-18 to the 500+ attendees and commercial vendors.

LESSONS LEARNED

The bulk of the tasks for this project were performed by independent contractors who occasionally failed to meet project deadlines. For the project staff this means we should have been more explicit about deadlines in our contracts.

We are overly pleased with the content, look, and functionality of 'Growing Grapes in Minnesota'. The publication became larger (more robust) in narration and photographs than originally conceived. The additional time required for layout services was unexpectedly large, delaying final printing. The end product, however, has surpassed our expectations.

We were disappointed by the inability of one of our video contractors to deliver as promised. By the time we were informed of his withdrawal from the project it was too late to capture in-season videos applicable for the pest management phase of our video series. In hindsight we should have been more thorough in our selection of that particular contractor and should have maintained on-going communications to monitor his progress.

ADDITIONAL INFORMATION

Guide to growing grapes in Minnesota is attached separately to the e-mail submission of Minnesota's Final Performance Report. The entire manual, as well as links to each chapter and a best practices video, is on the MGGA website at: http://www.mngrapes.org/page/GrowingGrapes

Project 4

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Contact: Angela Orshinsky

Organization: Regents of the University of Minnesota

Contact information: aorshins@umn.edu, 612-625-9274

PROJECT TITLE

Diseases of Hops in Minnesota

PROJECT SUMMARY

The major disease impacting hop production east of the Rocky Mountains is likely to be downy mildew. Though Wisconsin and New York were major hop-growing states in the late 19th and early 20th century, any remaining production was wiped out by a combination of market forces, including prohibition, and the appearance of downy mildew in Wisconsin in 1909. The actual distribution and prevalence of this disease in modern cultivars in the region is unknown. Downy mildew is less problematic in the major production areas of Washington State because of the dry climate (< 25 cm annual precipitation), but thrives in the moist spring weather common to eastern Minnesota and across the upper Midwest.
In Oregon, an average of 6 to 10 fungicide sprays are made annually to control downy mildew; however, a degree day model and risk index were found to be effective at reducing downy mildew with fewer applications. These measures may be effective in Minnesota, but the model needs to be validated in our climate. In addition, chemical control products need to be evaluated for production systems in Minnesota.
Other diseases detected in Minnesota hop production areas include a host of aphid-transmitted viruses including American Hop Latent Virus, Hops Latent Virus, and Hops Mosaic Virus as well as another unidentified virus (Lockhart and Rohwer, unpublished results). Hop viruses are particularly important as hops are propagated through cuttings, which will contain viruses from parent plants. Virus-free propagative material is exceedingly expensive due to product demand. A single virus-free plant can cost as much as $300. Reduction in hop yield due to viruses can vary from 20 to 70 % depending on the virus and cultivar host. Characterization of viruses present in Minnesota is an important part of developing recommendations for hops cultivars for local growers and for developing management strategies to reduce the impact of these pathogens on hop yield and vigor.

As the hop growing industry expands in Minnesota, it will be crucial to catalogue hop pathogens occurring in the region and to provide educational resources and outreach to growers to reduce the impact of these diseases on their operations. As such, the objectives of this project are to characterize the occurrence and distribution of pathogens in Minnesota hop growing operations, identify chemical and cultural management strategies for managing

downy mildew of hops, including options compatible with organic production practices, build a collection of P. humuli isolates and characterize the Minnesota P. humuli population including disease responses by different cultivars, fungicide sensitivity, and genetic variability, and to educate hop growers in the upper Midwest on identification and management of hop diseases found in the survey.

A resurgence in hop production, concomitant with an increase in the popularity of craft brewing, is occurring in regions of the US that have not grown hops commercially in more than 50 years. US production of hops has been centered in Washington, Oregon, and Idaho since the 1960's due to the devastation caused elsewhere by hop downy mildew, caused by Pseudoperonospora humuli. However, production in the upper Midwestern US is growing to meet demand from craft brewers. Expansion in Minnesota is evidenced by the formation of the Minnesota Hop Growers Association in 2012.

The timeliness of the project was key as the number of acres of harvested hops increased from 2015 to 2016 by 180 % (Hop Growers of America Statistical Report, 2016). However, Mighty Axe Farms increased their planted acreage to over 200 acres in 2017, more than double the total production of the state. This was accompanied by a harvest and processing facility to provide dried and pelletized hops to local breweries. Clearly the industry is growing and support is needed to encourage safe and effective management of hop diseases as well as insects and soil fertility.

PROJECT APPROACH

a) Characterize the occurrence and distribution of viral, fungal, and oomycete pathogens in Minnesota hop growing operations

Graduate student, Joshua Havil, travelled to a minimum of 16 farms two to three times per growing season in 2015 and 2016. The presence of hop pathogens and symptoms were documented at each time. Viruses were noted based on visual symptoms and when necessary we used Reverse transcription polymerase chain reaction. However, viruses are often latent in the hop plant and without conducting a proper survey of each hop yard (sampling multiple plants per row), which would have been exceedingly expensive. For this reason, it is impossible to say how widely the viruses and viroids are distributed. We detected Hop Mosaic Virus (HpMV) and hop latent viroid (HpLVd) from almost all samples of hop plants that were ordered from Michigan for our own testing purposes. Among these plants we also detected American Hop Latent Viroid (AHpLVd) and Hop Stunt Viroid (HpSVd). Plants ordered from major suppliers also demonstrated signs and symptoms of hop downy mildew and hop powdery mildew. Most Minnesota growers obtain their plants from these major suppliers in MI and it can be expected that these pathogens will be spread throughout MN if MN growers continue to order from these same suppliers.

Early Season Disease Survey (April - June)		
County	**Diseases found 2015**	**Diseases found 2016**
Anoka	ND	Downy mildew
Chisago	ND	Downy mildew
Dakota	Downy mildew	Downy mildew
Fillmore 1	Fusarium bine wilt Downy mildew unidentified virus/viroid	Fusarium bine wilt Downy mildew unidentified virus/viroid
Fillmore 2	Fusarium bine wilt Downy mildew	Fusarium bine wilt Downy mildew
Hennepin 1	Downy mildew	Downy mildew
Hennepin 2	Downy mildew	Downy mildew
Hennepin 3	Downy mildew unidentified virus/viroid	Downy mildew unidentified virus/viroid
Hennepin 4	Downy mildew	Downy mildew
Houston	Alternaria leaf spot Fusarium bine wilt	Downy mildew Fusarium bine wilt
Le Seuer 1	Alternaria leaf spot Downy mildew	Downy mildew
Le Seuer 2	Downy mildew	Downy mildew
Rice	Downy mildew	Downy mildew
Scott	ND	Downy mildew
Sherburne	ND	ND
Washington 1	Downy mildew	Downy mildew
Washington 2	Downy mildew	Downy mildew

Late Season Disease Survey (August)		
County	**Diagnosis 2015**	**Diagnosis 2016**
Anoka	Downy mildew	Downy mildew Fusarium bine wilt
Blue Earth	ND	Downy mildew Fusarium bine wilt
Chisago	Downy mildew	Downy mildew
Dakota	Downy mildew Fusarium bine wilt	Fusarium bine wilt Alternaria leaf spot Downy mildew
Fillmore 1	Downy mildew	Downy mildew Fusarium bine wilt
Fillmore 2	Downy mildew	Downy mildew
Hennepin 1	Downy mildew	Downy mildew

		Alternaria leaf spot Fusarium bine wilt
Hennepin 2	Alternaria cone disorder Downy mildew	Fusarium bine wilt Downy mildew
Hennepin 3	Alternaria cone disorder Fusarium bine wilt	Fusarium bine wilt
Hennepin 4	Powdery mildew	Powdery mildew
Houston	Alternaria leaf spot Alternaria leaf spot	Fusarium bine wilt Downy mildew
Lake	ND	Downy mildew
Le Seuer 1	Alternaria leaf spot Downy mildew	Downy mildew
Le Seuer 2	Fusarium bine wilt Powdery mildew	Powdery mildew
Rice	ND	Downy mildew
Scott	Alternaria leaf spot unidentified virus/viroids	ND
Sherburne	ND	Alternaria leaf spot Fusarium bine wilt Apple Mosaic Virus
Washington 1	Alternaria cone disorder Downy mildew Fusarium bine wilt Gray mold	Fusarium bine wilt Downy mildew
Washington 2	Alternaria cone disorder Downy mildew Gray mold	Downy mildew

ND = no disease found

(b) Identify chemical and cultural management strategies for managing downy mildew of hops, including testing of potential chemical controls that would be compatible with organic production practices

Our research conducted several studies on the cultural and chemical management of downy mildew of hops. Nitrogen source and timing was conducted at grower locations in Shakopee, Ham Lake, and Stillwater. Field trials of fungicides were conducted at UMN research and outreach centers in Grand Rapids, Waseca, and Rosemount. We also developed an *in vitro* assessment to determine fungicide efficacy against downy mildew of hops that was conducted in the Orshinsky lab on the St. Paul campus.

i. Field and *in vitro* trials of fungicides

In July 2014, three 0.10 acre hopyards were established at University of Minnesota Research and Outreach Centers (Grand Rapids, 47.246 °N, -93.494 °W; Rosemount, 44.715 °N, -93.098 °W; Waseca, 44.076 °N, -93.523 °W). Prior to planting, the fields were disced and leveled. The trellis was constructed with three 100 ft rows with 15 ft between each row and a trellis height of 16 ft. Two hop cultivars were selected for transplanting, cvs. Brewer's Gold and Columbus, based on their differential susceptibility. Plants were arranged with three replications using a split-plot treatment design. Whole plots were designated as cultivars and sub-plots as fungicide treatments. Replicated whole plots (cultivars) were 50 ft in length and each replicated sub-plot (fungicide treatment) contained two plants that were 3 ft apart with 4.5 ft between plots. The fields were hand-weeded as necessary. Nitrogen was applied at a rate of 160 lbs N/acre in both 2015 and 2016. Nitrogen was applied as three granular fertilizer applications and incorporated into the top 6 inches of soil. In Grand Rapids, nitrogen was applied as calcium nitrate (15.5-0-0 NPK). In Rosemount and Waseca, nitrogen was applied as urea (46-0-0 NPK).

In both 2015 and 2016, individual plants were trained on single strings of coir with 4 – 8 bines per plant. In 2015, single transplants of a susceptible experimental breeding line were planted at both ends of each row at all locations. Prior to transplanting, these plants were inoculated with a composite mixture of *P. humuli* sporangia derived from multiple basal spikes recovered from hopyards within Minnesota. Inoculations were performed by rinsing heavily sporulating basal spikes with sterile distilled water and standardizing inoculum to 50,000 sporangia/mL. The plants were placed into plastic bags for a period of 24 h following inoculation before being removed and transplanted into the field.

Field experiment 1. In 2015, scouting was initiated in mid-April at Rosemount and Waseca whereas scouting did not begin for Grand Rapids until mid-May. Fungicide applications began in May, with starting dates varying depending on location. Fungicide treatments (Table 1) consisted of a single, tank-mixed, or pre-mixed fungicide compounds applied at the highest rate allowable throughout the entire season and at recommended application intervals based on manufacturer instructions. Treatments included a non-treated control; extract of Reynoutria sachlianensis (Regalia®, Marrone Bio Innovations, Davis, CA) and copper hydroxide (Kocide® 3000, DuPont Crop Protection, Wilmington, DE); boscalid and pyraclostrobin (Pristine®, BASF Ag Products, Research Triangle Park, NC); copper hydroxide (Kocide® 3000, DuPont Crop Protection, Wilmington, DE); phosphorous acid (Agri-Fos®, AgriChem, Queensland, AU); or mefenoxam (Ridomil® Gold SL, Syngenta Crop Protection, Greensboro, NC) and copper hydroxide (Kocide® 3000, DuPont Crop Protection, Wilmington, DE). Fungicide applications and visual disease ratings were taken at 7 – 28 day intervals at all three locations. Disease ratings were assessed on a whole plant basis using a 0 – 5 scale where 0 = no disease, 1 = 1-25% foliar disease, 2 = 26-50% foliar disease, 3 = 51-75% foliar disease, 4 = 76-100% foliar disease, 5 = dead plant. Visual disease ratings were averaged across two plants (sub-samples) within a plot for each replicate. By late July, fungicide applications ended due to lack of disease in all plots. Additional hop downy mildew

inoculations were initiated in mid-August through early September to improve chances of disease in the following year.

Field experiment 2. In 2016, scouting was initiated in early April at Rosemount and Waseca whereas scouting did not initiate until early May in Grand Rapids. Fungicide applications did not begin until May, with starting dates varying by location. Fungicide treatments (Table 2) consisted of a series of single, tank-mixed, or pre-mixed fungicides applied at varying rates throughout the season based on crop development with a fixed-interval schedule of 14 days between applications. Visual disease ratings were taken bi-weekly throughout the growing season from mid-May until early September. Visual disease ratings were assessed on a whole plant basis using a 0 – 5 scale where 0 = no disease, 1 = 1-25% foliar disease, 2 = 26-50% foliar disease, 3 = 51-75% foliar disease, 4 = 76-100% foliar disease, 5 = dead plant. Disease ratings were averaged across two plants (sub-samples) within a plot for each replicate.

Statistical analysis*.* Data from the field experiment in 2015 were not analyzed due to inadequate disease incidence. Data from the field experiment conducted in 2016 were analyzed in a mixed effect model with a balanced dataset. Locations, fungicide treatments, and cultivars, were considered fixed effects and replicates nested within locations were treated as a random effect. The area under the disease progress curve (AUDPC) value was calculated and used as the response variable to determine treatment effects.

In vitro fungicide study. Fungicides registered for use in hop production were evaluated for control of hop downy mildew. Eleven different fungicides were evaluated including copper hydroxide (Kocide® 3000, DuPont Crop Protection, Wilmington, DE), cymoxanil (Curzate® 60DF, DuPont Crop Protection, Wilmington, DE), cymoxanil and famoxadone (Tanos®, DuPont Crop Protection, Wilmington, DE), extract of Reynoutria sachalinensis (Regalia®, Marrone Bio Innovations, Davis, CA), fluopicolide (Presidio®, Valent USA LLC Agricultural Products, Walnut Creek, CA), fosetyl-Al (Aliette® 50WDG, Bayer CropScience, Research Triangle Park, NC), mandipropamid (Revus®, Syngenta Crop Protection, Greensboro, NC), mefenoxam (Ridomil® Gold SL, Syngenta Crop Protection, Greensboro, NC), phosphorous acid (Agri-Fos®, AgriChem, Queensland, AU), pyraclostrobin and boscalid (Pristine®, BASF Ag Products, Research Triangle Park, NC), trifloxystrobin (Flint®, Bayer CropScience, Research Triangle Park, NC), and a water-treated control.
Three-week old rooted-cuttings of cv. Pacific Gem were maintained in a greenhouse with a 16 h photoperiod, with temperatures ranging from 22.6 – 25.7 °C. Twenty-four hours pre-inoculation, fungicide treatments were applied to single rooted-cuttings at the highest recommended rate as a foliar application assuming a total spray volume of 280 L/ha. Twenty-four hours post-treatment, five healthy leaves were selected from three to five nodes below the apical meristem and placed individually with the abaxial surface facing upwards in a 90 mm Petri dish containing a single sterile paper towel treated with 1.5 mL of sterile water. Approximately 1 mL of *P. humuli* inoculum at 50,000 sporangia/ml was applied to the fungicide treated leaves using a handheld spray bottle (US Plastics, Lima, OH) and the leaves were then placed in a growth chamber (Model #E15, Controlled Environments Ltd., Winnipeg, MB, Canada) for a period of seven days at 20 °C with a 14 h photoperiod. Seven

days post-inoculation (DPI) the leaves were removed from the growth chamber and images were collected using a CanoScan 110 LiDE scanner (Cannon USA, Melville, NY) using the default settings on a white background. Images were imported into ASSESS v2.0 (American Phytopathological Society, St. Paul, MN) and were evaluated for the total percent diseased leaf area using the default settings. This experiment was arranged in a randomized complete block design with ten replicates.

Field experiment 1. In 2015 there were no results reported between treatments or locations, due to inadequate disease incidence and severity across locations.
Field experiment 2. In 2016 overall disease severity was different between all locations (P = <0.0001), Grand Rapids had an absence of disease, Waseca had moderate disease severity, and Rosemount had high disease severity. There was a significant interaction between cultivars and fungicide (P = 0.0011) and location by cultivar by treatment (P = 0.0005).

In Rosemount, a significant reduction in disease severity between the non-treated cv. Brewer's Gold and cv. Brewer's Gold treated with Pristine or Curzate. Cultivar 'Columbus' treated with Regalia had less disease than the untreated control.

In Waseca, all fungicide and cultivar treatment combinations significantly reduced disease severity compared to non-treated plots.

Unfortunately, due to the variability between locations, general fungicide recommendations cannot be made.

Table 2: Spray program for 2016 field season focused on downy mildew suppression in early season. As the risk of fungicide resistance, environmental impact quotient (EIQ) and cost are all of importance to growers deciding on a program, we calculated this data for comparison.

ram	Spray Order	Trade Name	Active Ingredient	Rate (Units)	Total # MOA	FRAC Code	Risk	Total Field Use EIQ	Total Cost ($)/ Acre	Cost ($)/Poun Dried H
	NA	Non-treated control	NA	N/A	0	0	NA	0	0.00	0.00
	1, 3, 5, 7, 8	Kocide 3000*, Regalia**	copper hydroxide, plant extract	1.5 lbs and 2, 2, 4, 4, 4 qts		M, P5	Low			
	2, 6	Sonata***	*Bacillus pumilis* Strain QST 2808	3.2, 7 qts	4	M	Low	115.5	193.61	0.13
	4	Actinovate AG\\	*Streptomyces lydicus* WYEC 108	10 oz		M	Low			
	1, 4, 6	Agri-Fos††	phosphorous acid	1.5, 3.9, 5.25 fl oz		33	Low			
	2, 5, 7	Flint***	trifloxystrobin	3, 4, 4 oz	5	11	High	125.4	249.67	0.17
	3	Kocide 3000, Ridomil Gold SL‡	copper hydroxide, mefenoxam	1.5 lbs and 0.5 pts		M, 4	Low to High			
	8	Revus‡	mandipropamid	8 fl oz		40	Low to Medium			
	1, 4, 6	Agri-Fos	phosphorous acid	1.5, 3.9, 5.25 fl oz		33	Low			
	2, 5, 7	Pristine†	boscalid + pyraclostrobin	14, 21, 28 oz	5	7, 11	Medium to High	152.0	311.42	0.21
	3	Kocide 3000, Ridomil Gold SL	copper hydroxide, mefenoxam	1.5 lbs and 0.5 pts		M, 4	Low to High			
	8	Revus	mandipropamid	8 fl oz		40	Low to Medium			
	1, 4, 6	Agri-Fos	phosphorous acid	1.5, 3.9, 5.25 fl oz		33	Low			
	2, 5, 7	Kocide 3000, Curzate*	copper hydroxide, cymoxanil	1.5 lbs and 3.2 oz	5	M, 27	Low to Medium	197.4	187.67	0.13
	3	Kocide 3000, Ridomil Gold SL	copper hydroxide, mefenoxam	1.5 lbs and 0.5 pts		M, 4	Low to High			
	8	Revus	mandipropamid	8 fl oz		40	Low to Medium			
	1, 4, 6	Agri-Fos	phosphorous acid	1.5, 3.9, 5.25 fl oz		33	Low			
	2, 5, 7	Kocide 3000, Tanos*	copper hydroxide, cymoxanil + famoxadone	1.5 lbs and 8 oz	5	M, 11, 27	Low to High	201.6	223.67	0.15
	3	Kocide 3000, Ridomil Gold SL	copper hydroxide, mefenoxam	1.5 lbs and 0.5 pts		M, 4	Low to High			
	8	Revus	mandipropamid	8 fl oz		40	Low to Medium			

* = Manufactured by DuPont Crop Protection, Wilmington, DE
** = Manufactured by Marrone Bio Innovations, Davis, CA
*** = Manufactured by Bayer Crop Science, Research Triangle Park, NC
\\ = Manufactured by Novozymes BioAg, Franklinton, NC
† = Manufactured by BASF Ag Products, Research Triangle Park, NC
†† = Manufactured by Agri-Chem, Yatala, QLD, Australia
‡ = Manufactured by Syngenta Crop Protection, Greensboro, NC

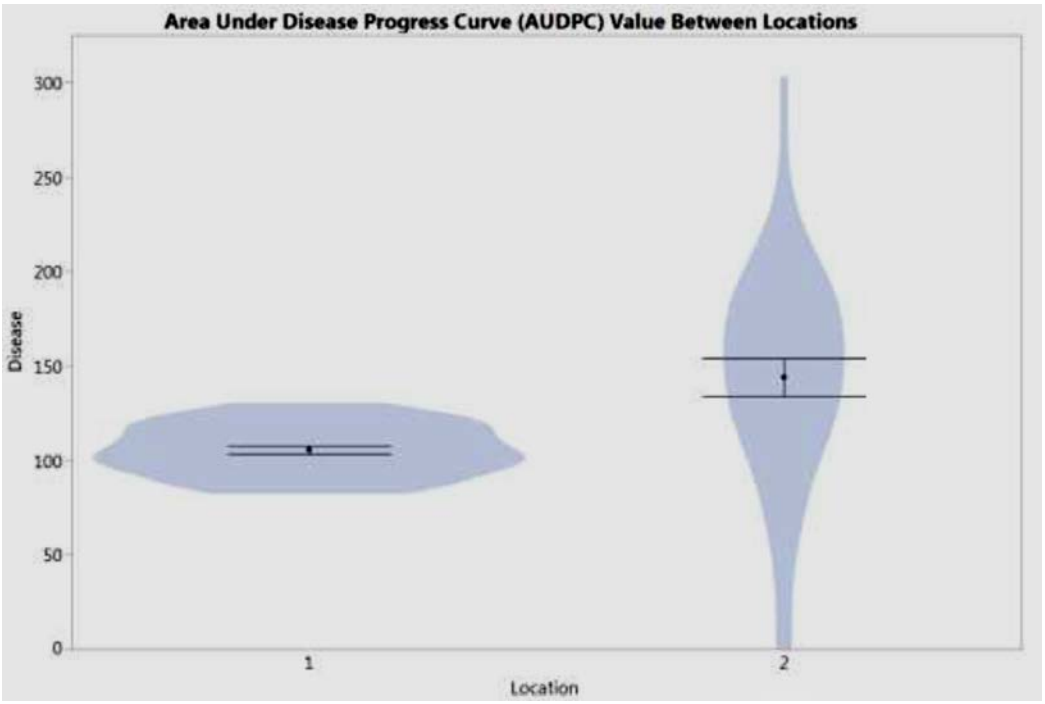


Figure: there was a great degree of variation between fungicide study locations. Location 1 indicates the disease level at Waseca, Location 2 indicates the disease severity at Rosemount. Grand Rapids is not pictured due to a complete lack of disease at this location despite inoculation.

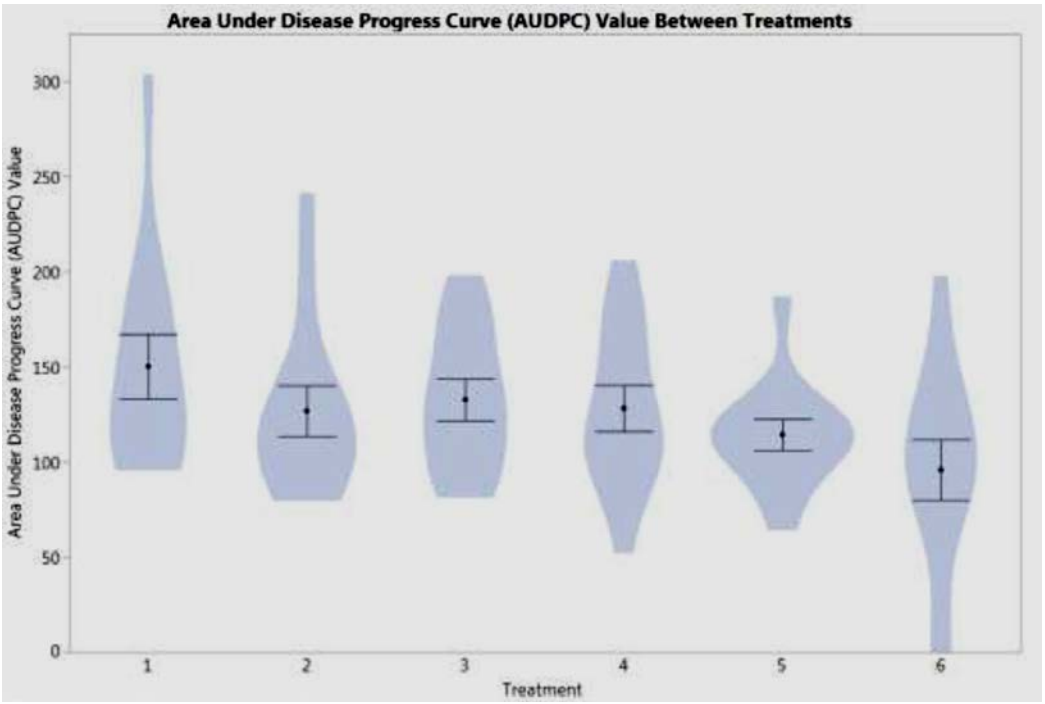


Figure: AUDPC of treatments at both Rosemount and Waseca. All fungicide treatments worked relative to the mock treated controls. Treatments 5 and 6 appear to be the most efficacious, although more study would be required to say this with absolute certainty.

In vitro fungicide study. The total percent reduction in disease on detached leaves varied depending on the fungicide (F = 1.969, P = 0.0459). Interestingly, only fluopicolide performed significantly better than the biological fungicide, Regalia, as indicated by pairwise comparisons (P = 0.0281). Unfortunately, at the current time fluopicolide is not registered for use in commercial hop production though its efficacy in the field has recently been demonstrated (Gent, 2017).

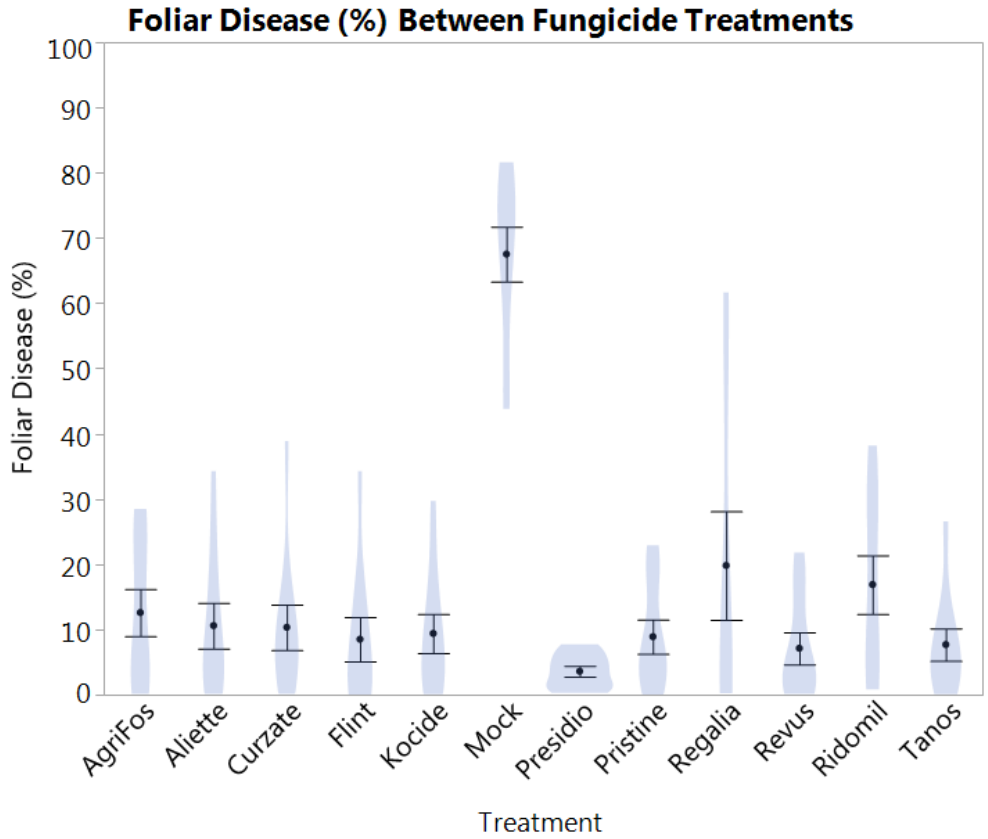


Figure: All fungicide treatments had less disease than the water-treated control. Presidio (fluopicolide) worked the best at reducing disease.

Previous research has demonstrated that fungicide insensitivity to metalaxyl (and mefenoxam) and fosetyl-Al exists in certain hop production regions, which has major implications in newer production regions where registration of fewer fungicidal compounds is present for hop, thereby further limiting selection of effective controls (Gent et al., 2008; Hellwig et al., 1991; Klein, 1994; Nelson et al., 2004). Additionally, insensitivity to fosetyl-Al may pose threats to other phosphonate fungicides which are commonly used in hop production for control of hop downy mildew. While these experiments demonstrated that mefenoxam and fosetyl-Al did increase disease control, even when mefenoxam was applied individually, it would be worthwhile to assay multiple pathogen isolates for sensitivity in newer production regions where these fungicides have seen limited use.

Nitrogen type and amount applied as a granular fertilizer. This study was done with funds and in kind donations leveraged with this grant from the Minnesota Hop Growers' Association, Sustane, and other private sources.

The results are quite variable and indicate that yield was improved at only the Elysian location by the various nitrogen treatments relative to the control. This was a first year

planting relative to the other locations that were in their second year. Thus, it is possible that the nitrogen variables investigated here was significant in increasing yields in newly established plants. The timing of the application did not seem to make a difference at any location. Despite a lack of differences, an important conclusion from this study is that the more expensive poly-coated urea did not outperform urea, which is a cheaper source of nitrogen but is more prone to volatilization and leaching. Similarly, Sustane, an organic fertilizer composed of composted turkey litter worked well in newly established yards and was not outperformed by the urea or poly-coated urea.

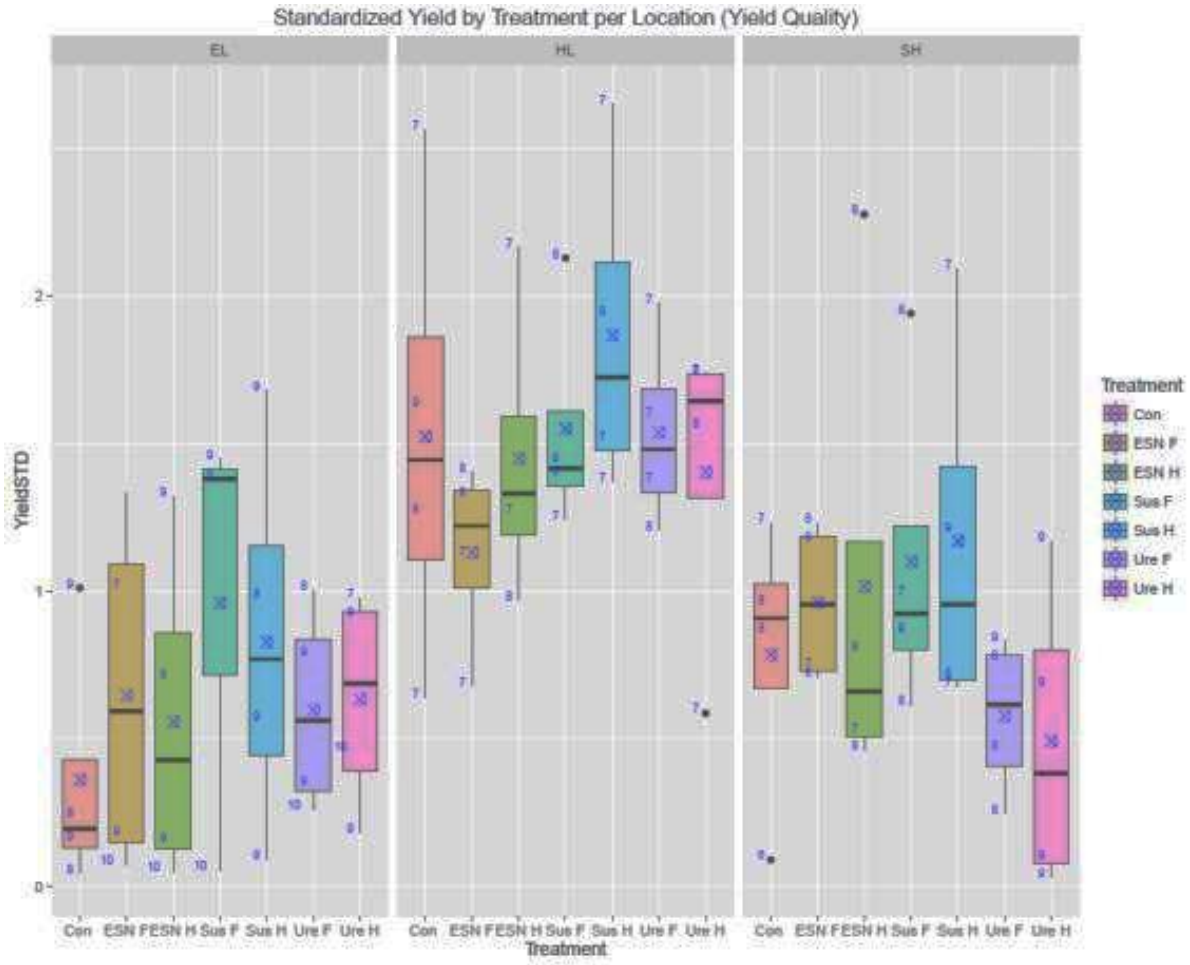


Figure: Box and whisker plot of standardized yield (8% moisture) separated by treatments and locations. Treatments included zero nitrogen (control), two 70 lbs N/acre, or one 140 lbs N/acre with nitrogen originating from urea (Ure), poly-coated urea (ESN), or Sustane® (Sus).
The split application of nitrogen was made five weeks apart.

Cultivar selection for resistance to P. humuli *in the Midwest*

We randomly-selected a single genotype from each of three hop botanical varieties, *Humulus l*. var. *lupuloides*, var. *lupulus*, and var. *neomexicanus*, and the related annual species Japanese hops (*H. japonicus*) for resistance screening (Table 3.3). A single replicate of five leaves from each plant was collected in the early morning and each leaf was placed individually abaxial surface up onto a sterile paper towel inside of a 90 mm Petri dish wetted with 1.5 mL sterile water. The abaxial leaf surface was misted using a handheld

spray bottle with approximately 1 mL of inoculum (US Plastics, Lima, OH). Plates were then placed in a growth chamber (Model #E15, Controlled Environments Ltd., Winnipeg, MB, Canada) at 20 °C with a 14 h photoperiod and incubated for seven days post inoculation (DPI). The leaves were then 56 digitally scanned using a Cannon LiDE 1100 flatbed scanner (Cannon USA, Melville, NY) using default settings on a white background. Images were uploaded into APS ASSESS v2.0 (American Phytopathological Society, St. Paul, MN) and the percent diseased leaf area was determined using standard settings. This experiment was arranged in a randomized-complete block design and repeated six times. Based on our preliminary results a subsequent experiment was carried out on 112 randomly selected genotypes. This experiment was conducted 8 times.

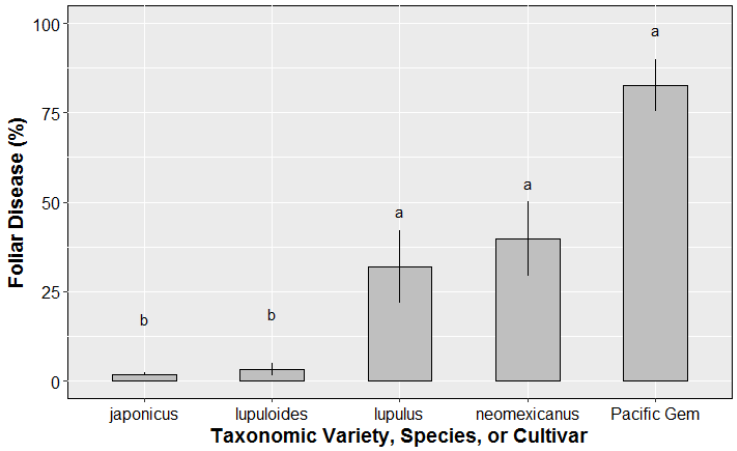


Figure: Pacific Gem serving as the susceptible control, this figure illustrates the relative sensitivity of various *H. lupulus* varieties to *P. humuli*.

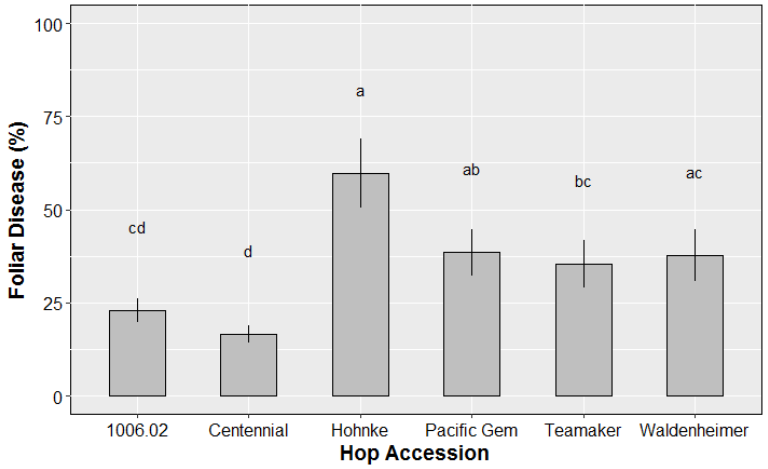


Figure: Percent disease of several known sensitive (Pacific Gem) and resistant (Teamaker, Centennial) cultivars as well as several wild hop plants collected in MN and MI. We found that most of the current cultivars were sensitive to downy mildew, but that several wild cultivars may offer some resistance for future breeding programs.

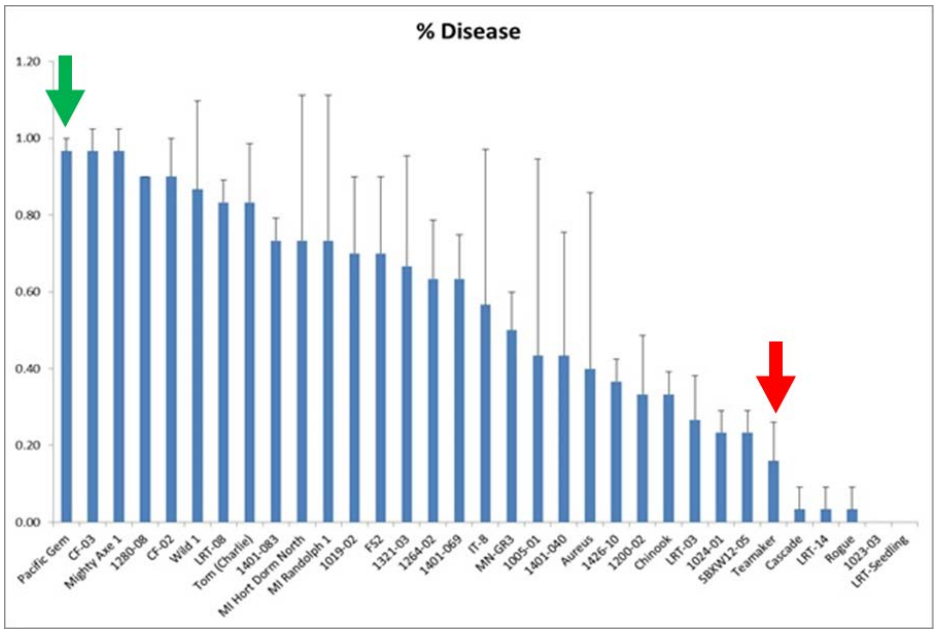


Figure: Screening cultivars and accessions to establish which are most resistant to *P. humuli* in MN. Green arrow marks Pacific Gem (susceptible), red arrow marks Teamaker (resistant).

(c) To build a collection of *P. humuli* isolates and characterize the Minnesota *P. humuli* using genetic markers.

We were able to build a collection of *P. humuli* isolates; however, due to an underestimation of the time and funding required for the field work, we were unable to do a population genetics study on MN isolates.

(d) Educate hop growers, especially beginning growers, in the upper Midwest on identification and management of hop diseases found in the survey.

Each year of the study, either the principle investigator (Dr. Orshinsky) or Joshua Havil (MS student) presented on the results of the disease survey and how to manage diseases at the Minnesota Hop Growers' Association meetings in March of 2014, 2015, 2016 and 2017. Additionally, Dr. Orshinsky organized a hop disease management conference at the University of Minnesota in St. Paul in October of 2015 to focus on getting information on the laws surrounding pesticide application in Minnesota and how to properly apply fungicides to hops and manage other non-fungal diseases. The conference included a presentation by Clarissa Levi on when and what type of licenses are required for pesticide use on commercial crops in MN, Dean Herzfeld on how to properly read a pesticide label, and two presentations by Dr. Orshinsky on how to recognize hop diseases and how to properly select and apply fungicides on hops.

Although we proposed handing out copies of a new hop disease manual for MN only, we provided hard copies of a more comprehensive guide to pest management for hops put together by hop researchers around the country and published by the Hop Growers of America free of charge to all that attended MHGA meetings in 2015 and 2016.

Dr. Orshinsky guided the research objectives and assisted in trouble shooting project experiments for this project. She participated in harvesting hops, surveying hop yards, and diagnosing hop disease. She organized and participated in hop grower educational forums

as described in 4(d). She also coordinated with other state hop researchers to disperse information and collaborate on grants and projects regarding hop disease.

Joshua Havil conducted the research and hop disease survey for this project. He completed the analysis of all data and assisted in disseminating data at hop growers' conferences, at the American Phytopathological Society meetings in St. Paul and Tampa Bay, FL, at the University of Florida, and at North Central IPM hop working group meetings.

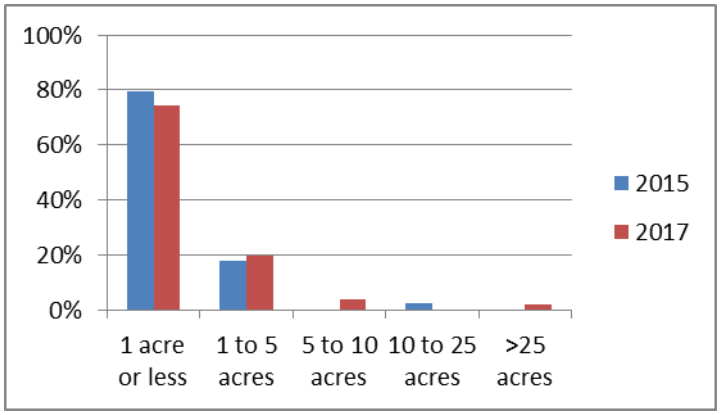
Charlie Rohwer provided trellis space in Waseca and invaluable advice regarding hop experiments throughout the project. He assisted in providing advice to Joshua Havil on research design and analyses.

Four undergraduate students obtained experience in hop research for this project. They assisted in making media, measuring disease in the field and in the lab, and scanning thousands of leaves for disease response in the cultivar and fungicide in vitro studies.

GOALS AND OUTCOMES ACHIEVED

At the beginning of the project at the end of the project, we conducted a Qualtrics survey to assess potential outcomes and impacts of this project.

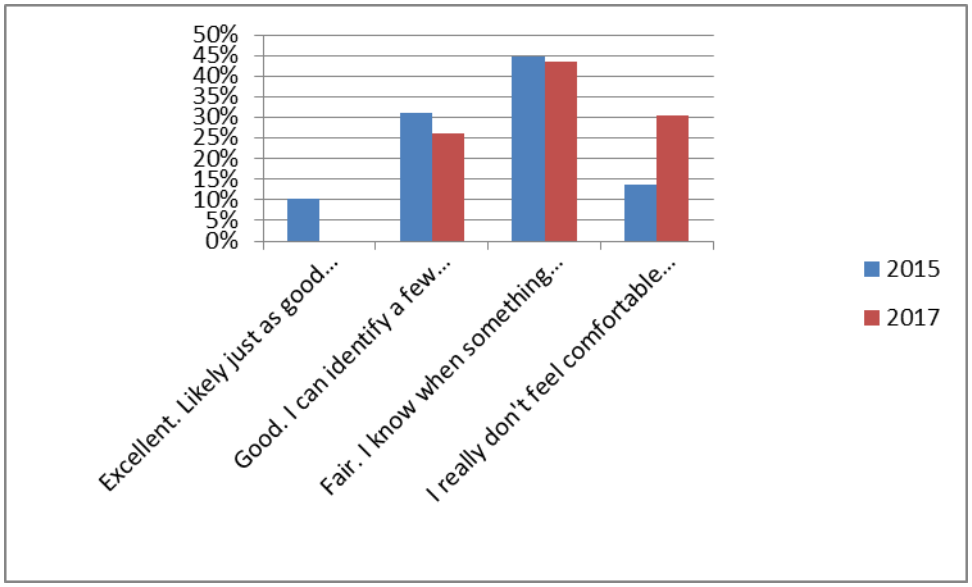
The number of hop growers in MN has increased from 2015 to 2017 (180 % based on Hop Growers of America Data); however, the acreage has increased as well with one grower exceeding 200 acres in 2017. In general, as growers gain knowledge and access to processing equipment, the number of acres per grower is increasing.



Michigan continues to be the leading supplier of hop transplant material with 30% of plant material ordered and 44 % of plant material ordered in 2015 vs. 2017, respectively. This may become an issue as MI has more confirmed cases of viruses, viroids, powdery mildew and downy mildew than MN. Additionally, after testing plant material from three different suppliers from MI, we found viruses and viroids, downy mildew, and powdery mildew in material from hop plant suppliers. This poses a threat to MN production by less experienced growers.

Importantly, more growers are beginning to understand the difficulty in diagnosing plant disease. Although we want to educate growers about plant disease towards making self

evaluations, we really tried to help them understand the value of a professional diagnosis during our education campaign. This is because many growers were observed to be making mistakes in the first year of the project. Hop grower appreciation of expert opinion is demonstrated by the survey question "How comfortable are you with making your own hop disease diagnosis?"



Clearly we were able to make an impact on the occurrence of pesticide application without a license. In 2015, 48 % of growers were applying fungicide but only 33% had a license. In 2017, 28 % of growers applied fungicide and 33 % of growers had a license. During the 2016 pesticide workshop, 31 % of growers applied pesticides but only 17 % had a license (Turning point survey). However, the proportion of growers with a private versus commercial license went up – which could be a result of our pesticide outreach efforts. Growers understood what kind of licensing was required.

A turning point survey during the 2016 presentations indicated that 77 % of growers felt that they learned a lot from the presentation and the same number reported that they would use all of the information they had learned. This demonstrates that our programming was well selected and needed by the industry. The growers in both years indicate that their primary need for future outreach is how to select pesticides and how to use the equipment for applying pesticides safely and accurately. It is my assessment that more outreach is needed to support the educational requirements of the hop industry in MN.

Outcome measures included an increase in the number of growers and an increase in the acreage of hop production in MN. Both of these have been achieved and are described in the answer for 5 and 6.

Goal: Determine the diseases most common to MN using a survey.
Accomplishment: Downy mildew and Fusarium bine wilt are the most common diseases in MN. Downy mildew is entering via transplants and likely via rain. Fusarium bine wilt is likely a result of the high proportion of growers using mechanical methods for trimming

the first flush of growth from hop plants combined with excess moisture, lack of cultural controls.

Goal: Determine the genetic diversity of downy mildew pathogen in MN.
Accomplishment: We did not have enough money to do this objective and we elected to slash it from our priorities as it would provide the least amount of relevant information to MN hop growers and to our own knowledge.

Goal: Determine the efficacy of various fungicides for MN hops. Determine if there is resistance to fungicides in MN hop populations.
Accomplishsment: We used a composite mixture of *P. humuli* isolates to test fungicides in vitro and found that there was no resistance to fungicides and that Pristine, Presidio, Revus and Tanos were the most effective against downy mildew in vitro. In the field, treatments 5 and 6 – both containing at least one phosphorous acid, one mefenoxam, one cymoxanil, one mandipromamid and several copper hydroxide applications were the most effective. Treatments 5 and 6 did better than those where cymoxanil was replaced with a strobilurin fungicide (Treatments 3 and 4).

Goal: Determine the sensitivity of hop cultivars to *P. humuli* in MN.
Accomplishment: Over 100 genotypes and cultivars of hops were screened in vitro for *P. humuli* sensitivity. In general, cultivars reported to be resistant in the Pacific Northwest were also resistant to *P. humuli* during in vitro studies. However, only foliar resistance was tested. It was not feasible to test crown rot resistance of so many plants. We did demonstrate a correlation between foliar resistance and crown rot in other studies, but these studies were conducted in different growing environments. We identified resistance in wild genotypes of hop that might lead to the development of new varieties of hop in MN (funded by NC-SARE funds that were obtained by leveraging data from this project).

Goal: Educate MN hop growers about diseases of hops and to contribute to new scientific knowledge about downy mildew and hops in the Midwest.
Accomplishement: We presented information at three years of hop conferences, through popular press articles (The Growler, Star Tribune, UMN Source, UMN Solutions). We distributed over 200 Hop IPM manuals (Hop Growers of America) to hop growers from MN and WI. We presented new scientific information at the North Central American Phyopathological Society (NC-APS; St. Paul), APS (Tampa Bay, FL), and the NC-IPM Hop Working group.

Comparisons of baseline data to end point data for the project are given above. More data is available by request.

BENEFICIARIES

Groups that benefited from the accomplishments are primarily Minnesota hop growers, Minnesota Extension service, and other hop growers and hop groups across the Midwest. Local brewing companies are a secondary beneficiary of this research and outreach project as they are the primary users of locally produced hops.

The primary and secondary beneficiaries of this research project are the Minnesota hop growers and Minnesota Breweries. Hops are worth approximately $1500 per acre dried and $21,000 per acre pelletized (Estimated Costs of Producing Hops in Michigan; Michigan Extension Service, 2014) depending on the quality of the hops, cultivar, and acid/oil profile. When the project started in 2015, the MN hop industry had approximately 70 acres of hops sold as dry or wet hops for approximately $105,000 gross per year. Currently, there are approximately 180 acres in MN, with one grower producing approximately 85 acres of pelletized hops. This is a total gross value of over 2 million dollars. Clearly the industry is growing. The craft brewers in MN (largest user of MN produced hops) has grown from 35 to 112 from 2011 to 2016 (Craft Brewers Association, www.brewersassociation.org) and is valued at $2 billion impact for the state. Minnesota ranks 7th in the country for dollar impact of craft brewers per capita ($509 per capita). The benefits of this project were to increase the awareness of hop diseases and cultural and chemical management in Minnesota. Specific quantitative impact is demonstrated in answers to question 6.

LESSONS LEARNED

This project was invaluable to development and success of the horticultural pathology laboratory at the UMN. This program is overseen by tenure-track assistant professor Dr. Angela Orshinsky and the hop project funded by the MDA was critical to leveraging funding from North Central SARE Graduate Education ($10,000), the Minnesota Hop Growers' Assocation ($2500). We also received in kind contributions from Sustane Inc., Syngenta, and Bayer.

The project made it possible for Dr. Orshinsky to oversee training of several undergraduate researchers and one MS student under her supervision. The positive lessons learned in this context were project management and student supervision by Dr. ORshinksy and scientific research lessons by the student.

A couple of negative results were that the cost of genotyping *P. humuli* and finishing the rest of the study were underestimated. This is primarily due to the amount of travel costs for the survey and fungicide trials was underestimated. Also, the harvest time of hops was a serious impediment to obtaining data on the yield for fungicide studies in all years. We learned that hops take approximately 1 hour per person per bine to harvest. With thousands of bines per location, it was impossible to determine yield without a mechanical, portable harvester. Having access to such an implement will be necessary if future studies are to be continued by the UMN hop research group.

Two unexpected outcomes from this project are very important. First, we discovered (in collaboration with University of Oregon) that hop powdery mildew is transmissible by seed. This was due to observation of the fungus on seed collected from wild hops in MN. Since hop seeds are not currently regulated by quarantine in the Midwest (all other propagative parts are quarantined to stay out of Oregon, Washington and Idaho due to powdery mildew), this important finding may impact the regulation of hop seed

movement within the USA and internationally. This discovery resulted in a publication in Plant Disease (Claasen et al., 2017, Infestation of hop seed (*Humulus lupulus*) by chasmothecia of the powdery mildew fungus, *Podosphaera macularis*, Plant Disease, https://doi.org/10.1094/PDIS-03-17-0328-PDN.)

The second unexpected outcome was that during testing of propagative material ordered from MI for this project, we found that nearly all hop transplants contained a virus or viroid and several were infested with downy mildew and powdery mildew. This is an important red flag as the MI industry is much larger and older and will likely have different races of powdery mildew that have overcome the currently used resistance genes and may even contain isolates of *P. humuli* that are resistant to mefenoxam, a commonly used fungicide in hop yards.

All goals were achieved and exceeded expectations except for the goal of genotyping the *P. humuli* population of MN. This was in part due to lack of disease in the first season but also to the underestimation of travel and labor costs for other parts of this project. The principle investigator now has a better idea of the costs and time involved in hop research and will not be likely to make the same mistake again.

ADDITIONAL INFORMATION

Claasen et al., 2017, Infestation of hop seed (*Humulus lupulus*) by chasmothecia of the powdery mildew fungus, *Podosphaera macularis*, Plant Disease, https://doi.org/10.1094/PDIS-03-17-0328-PDN

There will be fact sheets put onto the Extension Website as possible. Other information available can be found at:

https://plpa.cfans.umn.edu/minnesota-hops-grow

http://hortpathology.cfans.umn.edu/extension

Project 5

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Contact: Anim Steel

Organization: Third Sector New England for Real Food Challenge

Contact information: anim@realfoodchallenge.org, 617-835-8961

PROJECT TITLE

The Good, The Bad and The Ugly: Cosmetically Imperfect Produce Seconds.

Please note that in the implementation of this project, we adopted a shorter name, "Beyond Beauty," which you will see reflected in this report and in the public reports on our research.

PROJECT SUMMARY

A stunning 50% of the fruits and vegetables grown in the U.S. goes uneaten. Of these enormous losses, roughly half occur at the "farm end" of the supply chain in the form of produce that is rejected in the packing shed or never harvested. Produce grading standards that prioritize very specific cosmetic attributes are a key contributor to these losses. Produce grown for the fresh market that is too large, small or misshapen to meet USDA Grade A standards often goes unsold for lack of a market. Given the time, labor and inputs invested by farmers, these cosmetically imperfect "seconds" are a significant drag on farm profitability. At the same time, most foodservice buyers pay for Grade A product even though they do not need produce that looks beautiful in un-cut form. This project was designed to explore the potential to increase financial returns to farmers while reducing costs for institutional buyers through the development of a market for cosmetically imperfect "seconds". We intended to do this through in-depth research with Minnesota fruit and vegetable growers and fresh-cut processors, and market testing with area colleges and universities.

There are over 3000 fruit and vegetable growers in Minnesota – and it's likely that not one of them doesn't have cosmetically imperfect seconds that they would rather sell than plow under. Many specialty crop growers feel themselves fortunate if their proceeds for the year exceed their costs by even a few percentage points. Even if unsold CI seconds represent a conservative 20% of production in the average year, it is clear that the costs farmers incur to grow these crops have a significant negative effect on farm profitability and cash flow. The development of a market for CI seconds could be an important step in strengthening farm profitability. This project will provide the "proof of concept" for that possibility. In particular, growers would benefit from the new insights gained through the proposed research on these critical questions:

- What volume of CI seconds are growers now producing and what do they do with them?
- What are the key factors that influence the supply of CI seconds?

• How do unsold CI seconds currently impact growers' bottom line?
• What aspirations and concerns do growers have about a potential market for CI seconds?
• What pricing, labor and market conditions would growers need for selling seconds to benefit their business?
• What are the pros and cons from the perspective of distributors, fresh-cut processors and collegiate foodservice buyers?
• What crops have the strongest market potential as seconds?
• To what degree could growers realize a financial benefit while also reducing costs for collegiate foodservice buyers? Can this be an economic win-win for both farmers and buyers?

PROJECT APPROACH

Outcome #1: Attitudes and experiences with cosmetically imperfect fruits and vegetables among Minnesota specialty crop growers are assessed and documented, leading to greater understanding of specialty crop growers' perceptions of this issue. We have:

· Conducted an electronic survey with Minnesota fruit and vegetable growers, generating quantitative input from 138 farmers across the state (relative to our goal of 40 responses).
· Conducted in-depth one-on-one interviews with 16 farmers (relative to our goal of 15), prioritizing those with mid-size operations that sell into wholesale markets.
· We found the combination of survey work and interviews to be particularly effective given that the former generated quantitative data and the latter provided an abundance of nuanced insight into farmers' thinking processes, attitudes, assumptions and experiences with imperfect produce. Our research methodology subsequently informed similar research conducted with farmers in New York State and recent research work among a selection of California growers by UC-Davis.

Outcome #2: The potential institutional market for Minnesota specialty crop farmers' cosmetically imperfect fruit and vegetable seconds is evaluated through research with potential supply chain partners and an on-the-ground procurement pilot with collegiate partner institutions. Relative to this outcome, we:

· Secured partnerships with the foodservice management companies that serve key colleges and universities in Minnesota. These included Bon Appetit Management Company (including three of their collegiate accounts in Minnesota), Sodexo (at University of Minnesota-Morris campus) and Aramark (University of Minnesota-Twin Cities campus).
· Collaborated with them to clarify their purchasing protocols and supply chains for Minnesota-grown fresh produce, identified imperfect products that are of interest, and interviewed their culinary staff to identify their aspirations and concerns about the use of imperfect product in their operations.
· Identified imperfect products that are viewed by these foodservice professionals as viable from an operational point of view and identified key dynamics around supply chain management, procurement, product specifications and other factors that would influence the feasibility of expanded use of these products.

· Engaged the distributors and fresh-cut processors that supply locally grown produce to our collegiate foodservice partners to clarify purchasing practices with local growers and product specifications. Identified processing, inventory, sourcing and other considerations related to use of imperfect produce from 4 produce distributors/fresh-cut processing companies and one broadliner serving institutional accounts in Minnesota.
· Conducted research on use of imperfect produce by Minnesota's foodbank community and identified relevant lessons learned.

Outcome #3: Through dissemination of research findings, knowledge of farmers' perspective on specialty crop seconds and the feasibility of selling cosmetically imperfect fruits and vegetables into the college/university market is expanded among (key) stakeholders.

· Prepared reports covering the electronic farmer survey results (May 2015) and our qualitative assessment based on the farmer interviews (October 2015), both well ahead of schedule.
· Produced written reports capturing the findings from collaboration with foodservice management partners, distributors / fresh cut processors and foodbanks. (All released in the first half of 2016.)
· Held webinar with the Wallace Center at Winrock International and collaborated with organizations in the sustainable agriculture, local foods, non-profit, foodservice, government and other sectors to disseminate the research nationally (largely well ahead of our goal of sharing the research in April 2016). Secure a "home" for our "Beyond Beauty" research results on the Wallace Center / National Good Food Network website, a well-recognized national resource for information on food hubs, regional food systems, food entrepreneurship and related topics.

GOALS AND OUTCOMES ACHIEVED

This project was focused on conducting research, not on generating market sales that would demonstrate economic impact. We note that this might have been possible had the project run for an additional year so that market building activities could have been conducted in the growing season that followed completion of the research and the grant period. That said, the institutional foodservice markets for imperfect produce have clearly expanded in the period since our research was conducted. For examples, see here for progress by Bon Appetit, one of the foodservice partners in our project. http://www.bamco.com/timeline/imperfectly-delicious-produce/. Bon Appetit's parent company, Compass Group USA is the largest foodservice management company in the US and has ramped up its Imperfectly Delicious Produce from a handful of states in 2014 to 30 states (including Minnesota). To date they have procured more than 3 million pounds of imperfect produce nation-wide, spanning more than 50 types of fruits and vegetables. Compass Group was an active player in the advisory group for the Beyond Beauty research and was integral to the conduct of the research. It would be inappropriate to claim that our research in Minnesota fueled this expansion, but we believe it's fair to say that the research informed its progress.

Goal #1: Increase knowledge about specialty crop growers' experiences with and aspirations for their CI seconds.

--Target #1: These issues are thoroughly researched through in-depth interviews with 15 Minnesota specialty crop growers and 40 farmers that participate in a written/electronic survey.

We achieved the goal by exceeding our targets: we conducted in-depth one-on-one interviews with 16 farmers (relative to our goal of 15) and conducted and generated quantitative input from 138 farmers across the state (relative to our target of 40 responses).

Goal #2: Increase knowledge about the feasibility of a new market for CI seconds among selected colleges and universities, distributors and fresh-cut operators.

--Target #2: Two colleges/university partners will pilot the procurement and use of three specialty crops of their choosing during the grant period.

Overall, we accomplished this goal by securing partnerships with three university foodservice operations (relative to our target of 2). Through these partnerships, we identified key dynamics around supply chain management, procurement, product specifications and other factors that would influence the feasibility of expanded use of these products. All three university partners experimented with a variety of imperfect Minnesota-grown specialty crops during the grant period. These include misshapen watermelon and cantaloupe, over-sized cabbage, bent carrots, over and undersized potatoes, bent and over-sized zucchini, double-hearted onions, and off-spec apples.

Goal #3: Information about the above issues will be captured and shared, leading to greater knowledge among specialty crop growers and other industry stakeholders.

--Target #3: By April 30, 2016, a well-written and well-substantiated report will be released and a webinar will be held that shares project findings and outcomes. Both will be disseminated in Minnesota and nationally through the Sustag list-serve, the national Comfood list-serve, Real Food Challenge's national network of collegiate partners, youth leaders and concerned stakeholders, newsletters and websites of farm advocacy groups in the region and nationally, and will be provided to trade publications and the media.

All the targets for this goal were accomplished:

(1) Our series of reports were all completed and released by the first half of 2016 and shared through Real Food Challenge's national network of collegiate partners, youth leaders and concerned stakeholders. It was also shared widely with organizations such as the National Farmer Union, Land Stewardship Project, Institute for Agriculture & Trade Policy, the Wallace Center for Sustainable Agriculture, agriculture-oriented media in Minnesota as well as numerous universities, state departments of agriculture and extension departments arounds the country.

(2) We presented the research results in a webinar in partnership with the Wallace Center at Winrock International.

(3) We secure a "home" for our "Beyond Beauty" research results on the Wallace Center / National Good Food Network website, a well-recognized national resource for information on food hubs, regional food systems, food entrepreneurship and related topics.

We have accomplished what we hoped through this project. We were especially pleased by the depth of insight we were able to gather from participating farmers given the complexity of this issue and the potential for disparate impacts given potential market implications and the operating circumstances of particular farms. This is a nuanced story

and we worked hard to do justify to that nuance in our work (see especially our report summarizing findings from the farm interviews).

We were pleasantly surprised to identify a very wide range of crops and specifications that were viewed as viable by farmers, distributors and foodservice alike. While we had anticipated at the outset of the project that the list of viable options might be fairly short, what we learned was that considerably broader aesthetic standards were viewed as acceptable by all three major parties in the supply chain.

This seems to bode well for expanded acceptance of imperfects in college foodservice markets. That said, given that "seconds" have historically had only limited markets and sold at steep discounts, farmers will need to make the high quality of such products known, particularly for those imperfects that function at the same level of culinary performance as standard "#1" products.

We completed all expected deliverables for the project and captured our results and findings in a widely disseminated collection of reports. All five reports are available here: http://ngfn.org/beyondbeauty These include:

Report No. 1: Survey data gathered from Minnesota fresh-market fruit and vegetable growers, including baseline data for rates of product imperfection for 20+ crops, causes of imperfection, uses of imperfect product, barriers to sale and interest in expanded markets for imperfects.

Report No. 2: Lessons from farmer interviews. This report delves deeper into current rates and causes of imperfection, analysis of the role of imperfect product on farm sales and profitability, supply dynamics, implications of harvesting and post-harvest handling methods on product viability, pricing needs, strategies for maximizing the efficiency with which imperfect product could be brought to market and potential interactions between the sale of imperfects and existing markets for "#1" product.

Report No. 3: Lessons from Produce Distributors and Fresh-cut Processors. This report captured insights such as current barriers to greater use of imperfects, market development dynamics for imperfects, the potential impact of imperfect product on processing costs, equipment and labor, the interplay between the sale of #1 product and imperfects, potential impacts on inventory management, client education and marketing, and a detailed assessment of the specific types of imperfections that could be workable for nearly 20 Minnesota-grown fruits and vegetables.

Report No. 4: Lessons from Minnesota Hunger Relief Community. This report captured insights from Minnesota's "Farm to Foodshelf Program, "Harvest for the Hungry" and the work of the Minnesota-based Produce Capture Institute, all of which handle donation and distribution of a range of #1 and imperfect Minnesota grown fruits and vegetables.

Report No. 5: Lessons from Foodservice Management. This report shared the results and insights from our work with three of the largest foodservice management companies in the country through their operations on Minnesota college and university campuses. This included current uses of imperfects, drivers toward greater use of imperfects, perceived

barriers, implications for culinary operations, labor costs and staff training, and identification of acceptable imperfections for Minnesota-grown fruits and vegetables.

Report No. 6: Lastly, we produced a summary report capturing findings and results from the entire initiative. Please see this summary for a full review of the insights and results from our work.

We also conducted a webinar highlighting results from our farm-related research including rates and causes of cosmetic imperfection, current uses of imperfect products, barriers to sale, grower aspirations and concerns about expanded market opportunities for seconds, and strategies for bringing such product to market in ways that minimize costs for growers. The webinar is available here: http://ngfn.org/resources/ngfn-cluster-calls/beyond-beauty

BENEFICIARIES

Fruit and vegetable growers:
The research delved deeply into the perspective of Minnesota fruit and vegetable growers on the role of imperfect produce in their operations and the potential pros and cons of expanded opportunities to market those products in college foodservice contexts. We believe that Beyond Beauty's effort to document and share these growers' views was unprecedented and is important given that growers' perspectives are often either overlooked or false assumptions are made by others operating in agricultural supply chains about how growers of different sizes and operating environments view emerging marketing opportunities.
134 Minnesota fruit and vegetable growers benefited by the opportunity afforded by the research to share their perspective on cosmetically imperfect produce.

The research also fostered more transparency about the view of distributors and fresh-cut processors, which are often not clearly conveyed to their major foodservice management customers. Similarly, the research highlighted the perspective of several major foodservice companies, highlighting the widespread interest in these products.

The project was focused on research, not on generating market sales that would demonstrate economic impact. (This might have been possible had the project run for an additional year so that another growing season could be included.)

LESSONS LEARNED

If we had it to do over again, we would likely have proposed a 2.5 year grant period (rather than 1.5 year period) so that we would have had a second growing season to develop the market and facilitate increased purchases of these products. A second season would have enabled us to do more follow-up with the foodservice buyers to have them articulate demand for specific products to the distributors, and in turn position the distributors to get into conversation with their farmers about making those imperfect products available during the harvest season at the end of the second year. That said, a 1.5 year grant period

worked well for completion of all the research and market exploration that we had planned to address.

In addition to participating in "Beyond Beauty", a regional distributor/fresh-cut processor that serves all three participating management companies' collegiate accounts in Minnesota instituted a new program for purchasing "Imperfectly Delicious Produce" for Compass Group USA / Bon Appetit accounts in Summer 2015. In its first year of operation in Minnesota, the program included Minnesota-grown imperfect green beans, as well as various other products sourced from other states. Compass Group and Bon Appetit have since expanded the Imperfectly Delicious Program to 30 states and have sourced more than one million pounds of imperfect produce since the program's inception.

Further, all of our foodservice partners experimented with a wide variety of imperfect product during the 2015 harvest season through their purchases either directly from Minnesota farmers or from their student-run farms. (Note that the grant period ended before the 2016 harvest season began.)

We believe that our objectives have largely been fulfilled. We were able to finalize and release the results of our electronic farm survey and farm interviews in May and October 2015, well in advance of our target date of April 2016. Other deliverables were completed on schedule.

Project 6

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Contact: Dr. Ian MacRae

Organization: Regents of the University of Minnesota

Contact information: imacrae@umn.edu, 218-281-8611

PROJECT TITLE

Remote Sensing of Potato Virus Y.

PROJECT SUMMARY

Potato virus Y (PVY) is a yield and quality limiting disease of potatoes; it is vectored by aphids and the virus is non-persistent, (acquired and immediately transmitted to plants by aphids in a matter of minutes). Historically a problem in seed potato production, new strains of the virus now cause Potato Tuber Necrotic Ringspot disease, causing problems in commercial production. Because the virus is acquired and transmitted so quickly, PVY

cannot be controlled by insecticide. Consequently, within season identification and removal of infected plants, called roguing, is an established technique to limit disease spread. Unfortunately, many new varieties of potato are visually asymptomatic. Spectral reflectance (the amount of light in specific wavelengths an object reflects) has been used to identify and measure plant stress (i.e. disease). Our preliminary data indicate spectral reflectance may provide a rapid and accurate method of identifying infected plants. We will use NIR imagery and spectral reflectance data to identify the wavelengths and vegetative indices that can best differentiate between infected and noninfected plants.

PROJECT APPROACH

2104/2015 - 6 varieties of potatoes were obtained from Dr Asunta Thompson, Potato Breeder at North Dakota State University. These varieties included Dakota Pearl, Dakota Ruby, ND7132-1R, ND8305-1, Red Lasoda, Red Norland, and Russet Burbank. These were evaluated in replicated greenhouse plots, half of which were infected with PVY positive plant sap using the carborundum method. ELISA analysis indicated this method of transmission was effective. Post emergence, leaf reflectance was measured from all plants using a leaf-clip sampler attached to an Ocean Optics hyperspectral radiometer (measuring reflectance of wavelengths in individual bandwidths of 1nm from 350nm (ultarViolet, UV) through 1150nm (NearInfrared, NIR). The leaf clip sampler contains its own light source which transmits light on all wavelengths tested; this negates the necessity of natural sunlight and facilitates the collection of data in greenhouses where glass or plastic roofing can filter certain wavelengths of sunlight. All plants also had leaf chlorophyll measured using a Nikon Spadmeter 502. Greenhouse data was taken on 3 dates. Replicated field plots were established at the Potato Research Farm in Grand Forks North Dakota in the growing season of 2015. Plots had a similar replicated design of 5 varieties that were infected with 3 different PVY treatments (control plots, PVY^O, and PVY^N inoculated plants) via the carborundum inoculation method. Attempts were made to exclude aphid vectors through repeated applications of crop oils and anti-feedant insecticides. Plots were again assessed for reflectance using the hyperspectral radiometer and for leaf chlorophyll content with the Nikon Spadmeter 502. In field plots, however, reflectance was measured both with a leaf clip and with a sensor held over the canopy that measures the overall canopy reflectance of natural sunlight. In addition, field plots were photographed with a Near-Infrared camera to obtain multi-spectral imagery. These images were analyzed to assess plots with Normalized Difference Vegetative Indices. Field plots were examined at 7-14 d intervals depending on growth stage and status of plants (for a total of 7 sample dates) through the growing season of 2015.

Results – Analyses of greenhouse data from the winter of 2015 indicated that there may be a varietal effect on reflectance. Some varieties seemed to have lower reflectance values. Statistical analyses did not indicate a significant difference, however, but greenhouse trials for 2016 were amended to address this issue. Analyses of chlorophyll and reflectance data indicated that in field plots, both PVY^O and PVY^N inoculated plants had significantly lowered chlorophyll levels, but that there was no significant difference in their impact ($P < 0.0001$, fig. one). It was noted, however that by mid-season, when rows had closed, the amount of vegetation present started to drown out differences in NDVI.

This is not surprising given that NDVI was developed as a measure of biomass rather than purely to assess plant health. Consequently, we concluded that NDVI may have limitations as a diagnostic tool.

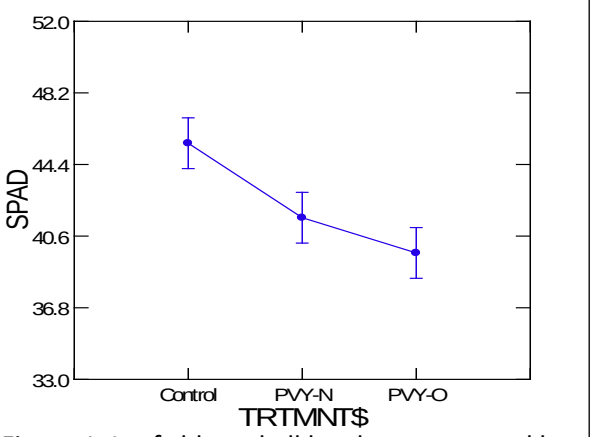


Figure 1. Leaf chlorophyll levels as measured by a Nikon SPAD 5000 vs PVY infection. Vertical bars are 95% CI. Note that while chlorophyll levels in both PVY^O and PVY^N infected plants is significantly lower than that of non-inoculated plants, there is no significant difference in the levels of chlorophyll in plants inoculated with either strain of virus.

2015/2016 - High levels of rain in the Red River Valley in the growing season of 2016 created difficulties in the plots at the Potato research Farm in Grand Forks. The excessive soil moisture prevented the application of Aphoil to manage the transmission of PVY into control plots by naturally occurring aphid populations. This was an important management tactic given the presence of numerous infected plots. As a result, control plots were also infected with PVY, making differentiation between infected and non-infected plants impossible. Field data was available from plots located at the UMN-NWROC but these plots were also subject to Colorado Potato Beetle feeding (again the result of difficulties in getting into the plots to apply pesticide) and consequently whole canopy reflection was influenced by missing leaves. Leaf clip data was, however available.

Greenhouse work continued and we obtained data from 7 different varieties (Dakota Trailblazer was added to the same 6 used in 2014) to assess varietal influence on reflectance and added an additional trial to assess the impact on reflectance of spraying crop oils on plants to reduce aphid probing (a common treatment to prevent PVY transmission).

Results – Complete canopy datasets were unavailable for comparison, however, field and greenhouse leaf clip data indicate there is a varietal influence in the effect on spectral response due to PVY infection. Several varieties did not show significant differences between infected and non-infected plants (Fig 2). While there was a significant difference in the reflectance values in non-infect, PVY^O infected and/or PVY^N infected plants, this was not universal across all 10 varieties tested, Several varieties do not show a spectral response to infection, some which are varieties that do not show visible symptoms of PVY. Varieties that showed a response included Dakota Pearl, Dakota Trailblazer, ND1321IR, ND83051 and Russet Burbank. The fact that Russet Burbank shows a significant effect is beneficial given it is the most widely grown variety in the U.S.

The application of Aphoil had a significant impact on reflectance. This was highly significant during the first 24 hrs but decreased over time. We recommend not using

reflectance for evaluating / scouting PVY infection within 24 hrs of treating with Aphoil. Some investigations into using oil so suggest that oils are absorbed into the leaf cells and this means there may be a potential long term effect.

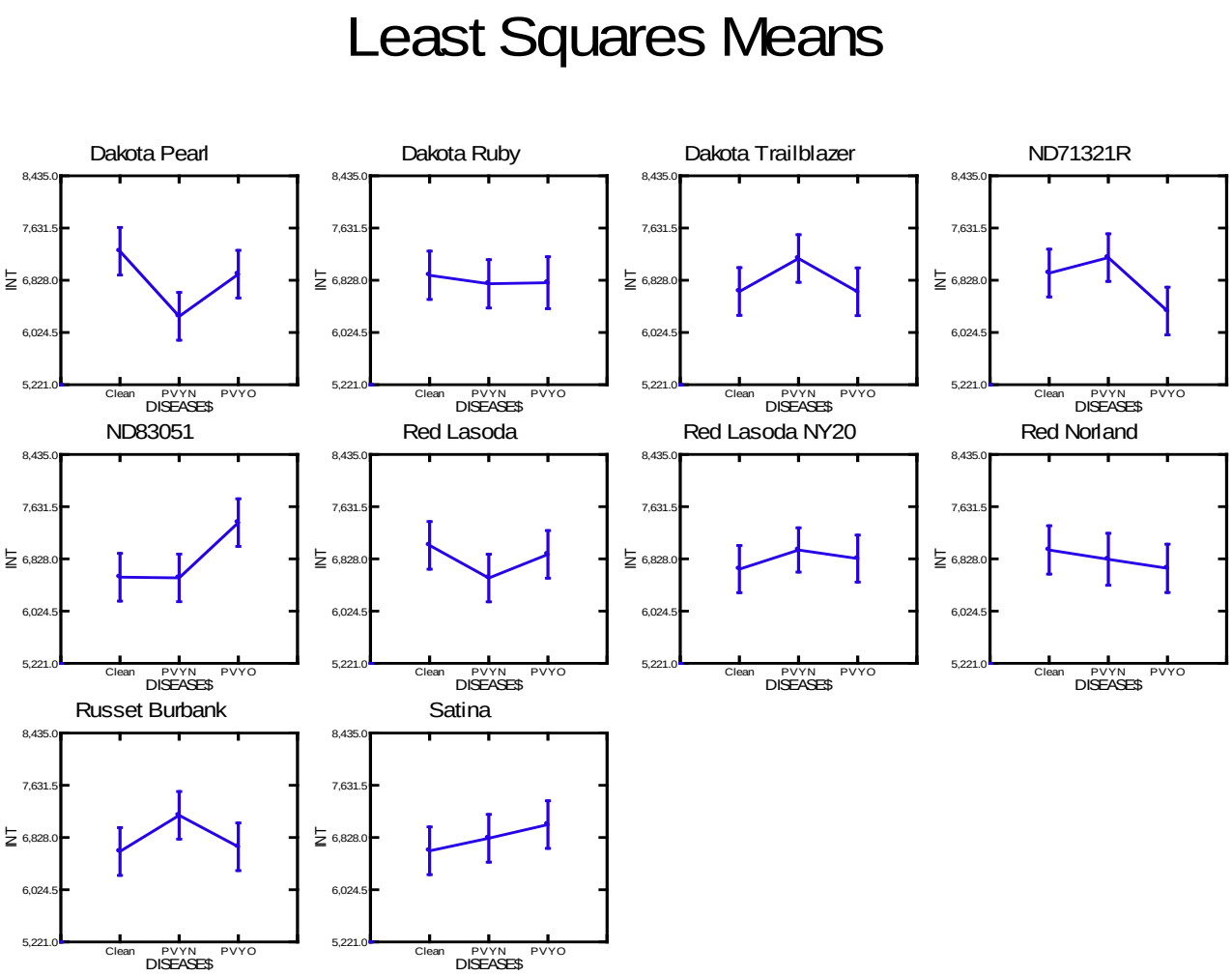


Figure 2. Multiple ANOVA results from greenhouse trials in 2016 indicating varietal influence on reflectance differences between infected and non-infected potatoes (vertical bars represent range of data). While there was a significant effect of disease on reflectance (P=0.11) the effect was only seen in Dakota Pearl, Dakota Trailblazer, ND1321IR, ND83051 and Russet Burbank. Other varieties in this trial showed no significant difference between non-infected, PVY^O or PVY^N infected plants.

2016/2017 – Analysis of greenhouse trials again confirmed the strong varietal effect on reflectance of PVY infection. These data clearly indicated that infection has no impact on a number of varieties (Fig 3). These results are beneficial in a number of ways; we know that PVY cannot be remotely sensed in certain varieties, and fortunately there are a number of varieties for which PVY infection can be sensed using this technology, including Russet Burbank, by far the most widely grown variety in the United States.

Although field plots in 2017 were established at both the Potato research Farm in Grand Forks and at the UMN-NWROC in Crookston, data on canopy reflection was not available. None of the three inoculation techniques attempted in 2017 were successful in transmitting PVY. It is unknown if this was a technique problem or if there was something wrong with the inoculum. The 2017 PVY inoculum was tested for activity with ELISA and

positive results were obtained. In addition, the same successful method that was used in 2016 was repeated in 2017 but did not work.

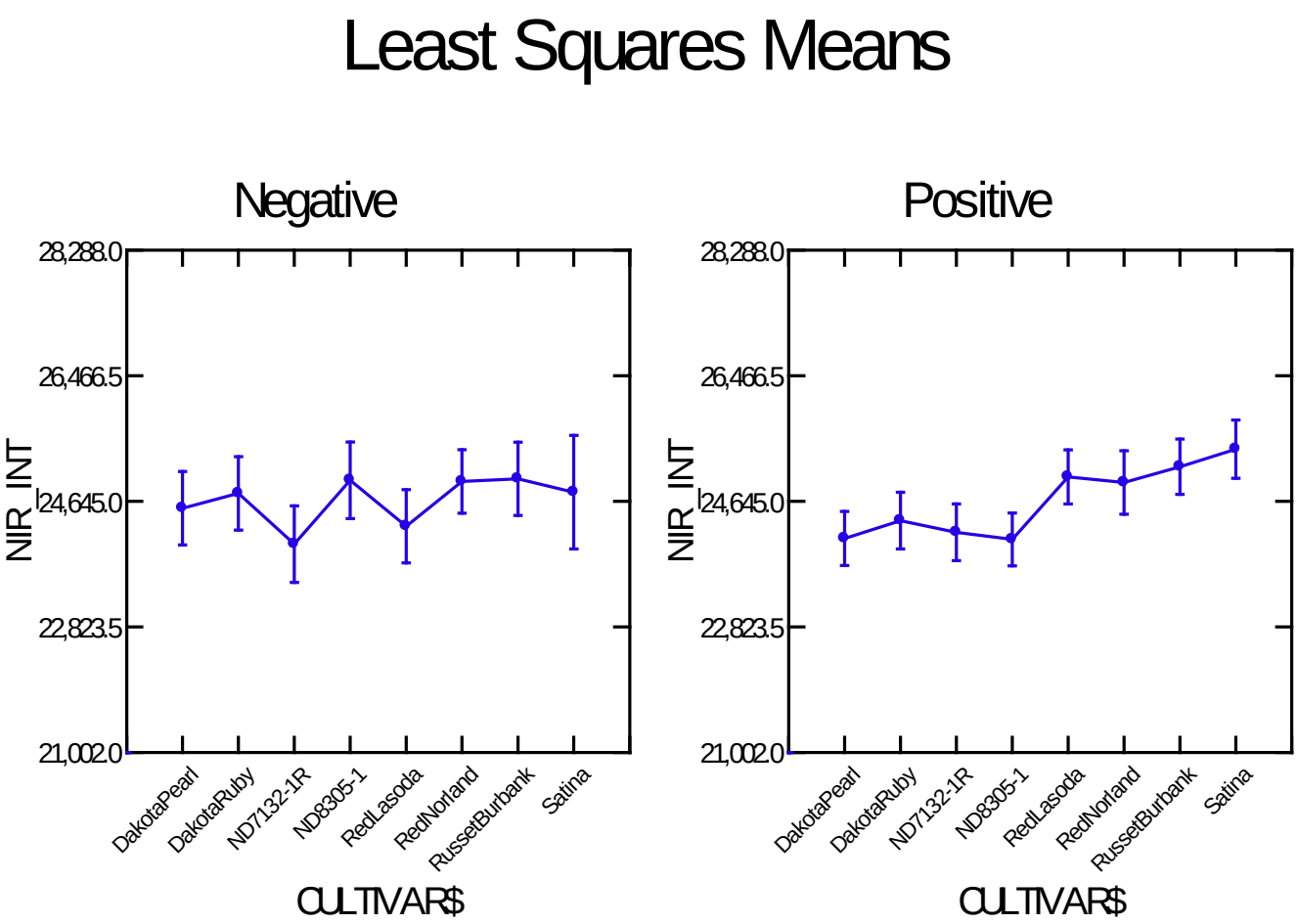


Figure 3. Results of General Linear Model ANOVA, comparing the integrals of the spectral curves of potato plants infected with PVY and those that are clean of virus. ANOVA results indicate Cultivar (P=0.001) and the Cultivar X Infection Status interaction (P=0.028) are both significant effects. This indicates that the cultivar of potato significant influences the spectral reflection of the plant (i.e. not all varieties reflect the same) and that the presence of disease has an interactive effect with cultivar on spectral reflectance (i.e. the reflectance of infected plants depends on the variety).

Continued work with APHOIL applications in 2017 supported the findings in 2015/2016' Aphoil application does affect the spectral reflectance of potato leaves but the activity is time limited and lasts not longer than 24 hours.

Overall Analyses – Databases were constructed from all data in the project based on collection methods. Canopy reflectance data from field trials was not successfully collected and therefore results all come from leaf clip readings. This is actually less limiting than canopy readings; the leaf clip collector has an integrated light source that emits on all the wavelengths being sampled. It is, therefore, not reliant on adequate ambient sunlight to illuminate the plant, readings could, theoretically, be taken at night or in darkness if the lack of sunlight did not affect the plant being sampled. The datasets obtained with the leaf

clip tend to be more conservative and therefore more likely to show real differences in spectral response.

Multiple regression and Akaike Information Criteria analyses were conducted on individual wavelengths from leafclip data taken in the replicated greenhouse and field trials. Data was pooled within location but not across (data was not pooled across these trials) and Relative Likelihood analyses were conducted on the AIC values. Relative Likelihood results of the trials provided slightly different results; field data indicate that a 20nm wide block of wavelengths centered around 687nm was most closely associated with PVY infection, greenhouse trials indicated a block of wavelengths approximately 20nm wide centered around 759nm was most closely associated with PVY (fig 4). This means that the Normalized Difference Vegetative Index (NDVI), which is based on the ratio of red to NIR, is less effective in finding PVY than are those blocks of wavelengths in the NIR.

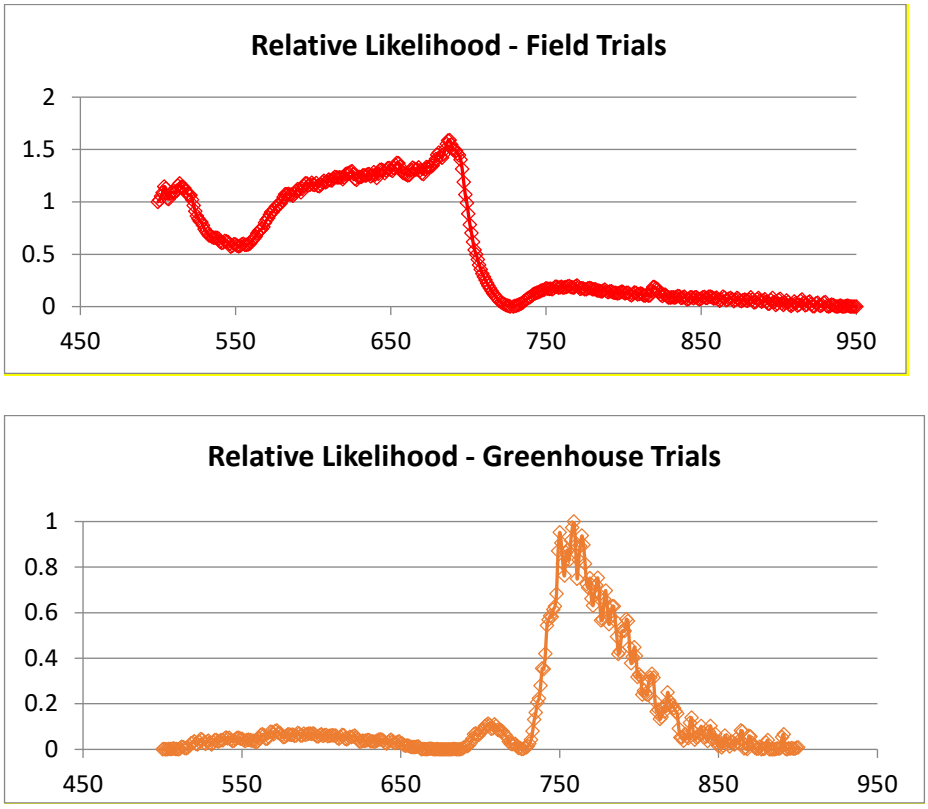


Figure 4. Relative likelihood of wavelengths being associated with PVY infection. In both field and greenhouse trials, a 20nm band was found to be most closely associated with PVY infection, but the center in field trials was ~80nm lower than that found in greenhouse trials. It should be noted that greenhouse trials had greater replication and experimental plants and potential confounding factors.

Response to the different strains of virus was also interesting. PVY^O had a much more pronounced influence on the reflectance of infected plants than did PVY^N (Fig 5). It also went against our hypothesis that infection would decrease reflection in the NIR wavelengths, instead we saw a net increase in NIR reflectance in infected plants compared to clean plants. This is biologically possible, however. Many plant diseases, PVY included, have been reported as having a greening effect, keeping infected plants greener for longer periods of time. This would make infected plants easier for vectors to see and increase the

probability of an infected plant being probed and the virus acquired and moved by a vector to a new host.

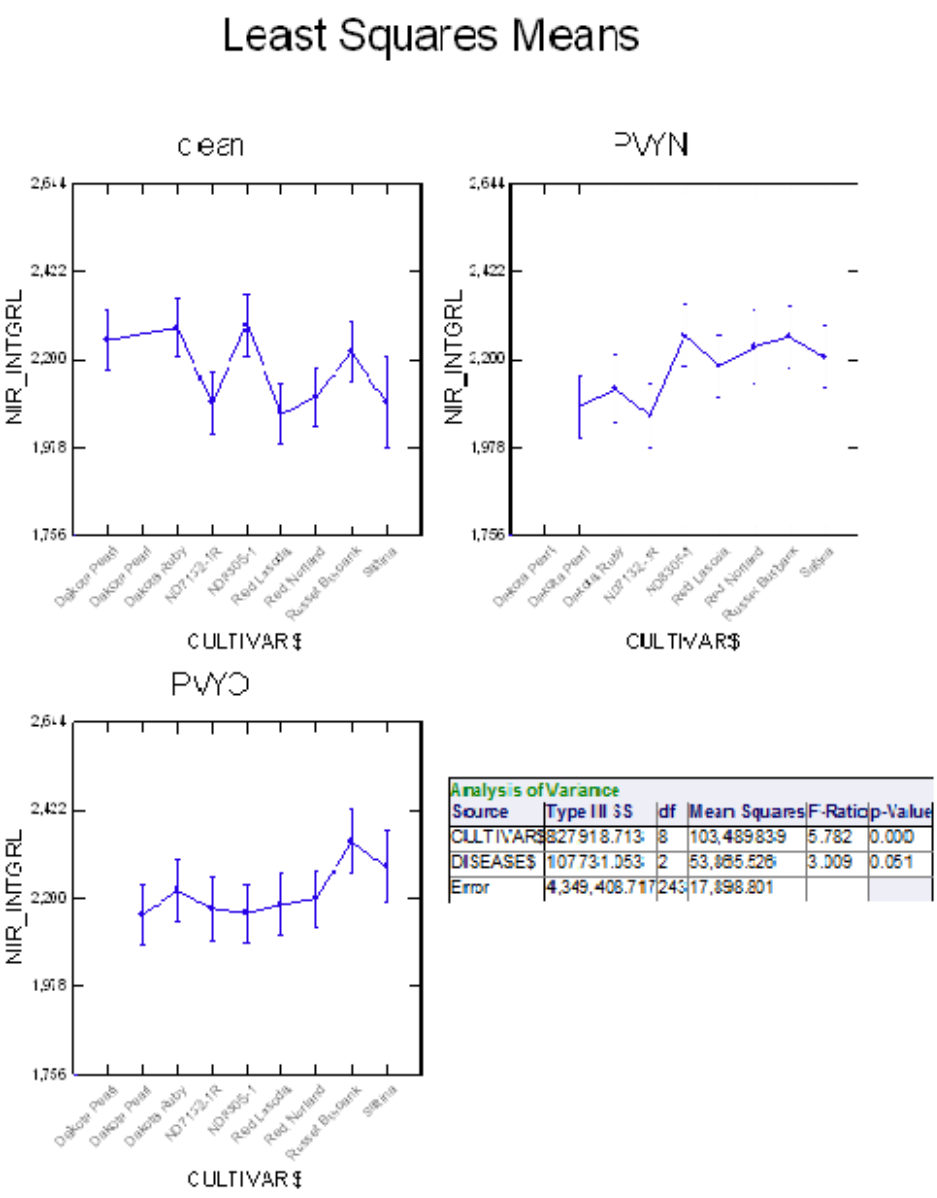


Figure 5. Mean integrals of spectral curves (from 680nm – 900 nm) of the 6 varieties tested in all project years. Note integrals of reflectance curves of non-infected plants (upper left); the integrals of infected responsive plants are higher than the uninfected plants.

Conclusions – the data indicate that PVY can be used to scout for PVY with the following caveats:

- It is possible only certain varieties of potato we tested, fortunately Russet Burbank is included in these.
- In our trials, NDVI as a scouting tool was less effective than the block of Visible and NIR wavelengths from 680 – 900 nm
- The application of management chemicals, especially oils to decrease virus transmission, will interfere with spectral readings for up to 24hr post-application.

GOALS AND OUTCOMES ACHIEVED

1. Recommendations on the techniques for remotely scouting PVY within field were developed (although some refinement is still necessary. Blocks of NIR wavelengths have been identified which are associated with PYV infection in some varieties, including Russet Burbank, the most common potato variety grown in the U.S. In addition, some current management tactics were identified as possibly confounding the technique; remote sensing of PVY should not be attempted within 24 hours of oil application.

   Research will be continuing beyond the period of the project. We have recently acquired a Forward Looking InfraRed (FLIR) Thermal sensor, capable of measuring canopy temperature. We will be deploying this sensor with aerial visible / NIR camera arrays to further refine diagnostic algorythms.

2. Peer reviewed publications are currently being prepared for submission from which UMN Extension publications will be prepared (see Additional Information below). Continued presentations and publications will be developed and disseminated. In addition, a series of hands-on workshops is currently in development for delivery to agricultural professionals. Results from this project will figure prominently in those presentations.

Videos are also currently in development.

BENEFICIARIES

Original thoughts were that this information would initially benefit the 97 seed potato producers in ND and MN (and seed potato producers in other areas after this). However, our results may well have a wider impact. Discussions with stakeholders indicate that most producers report, that while they see this tool as valuable, they prefer a consultant (or other ag professional) conduct the data collection and analyses and supply management recommendations based on the results. The primary audience for our findings, therefore, may more likely be agricultural professionals serving those growers than the growers themselves (although the producers remain a primary beneficiary). The techniques developed here will play a part in facilitating the adoption of remote sensing into professional crop scouting. There are approximately 50 Certified Crop Advisors in the potato production areas of ND and MN; similar numbers are unavailable for agronomists and other agricultural professionals who may be associated with Co-operatives, elevator operations and other businesses advising potato producers. It is safe to say that most of these entities will eventually adopt aerial remote scouting when it is demonstrated to be fast, reliable, and easily incorporated into contracted services. This adoption will facilitate industries developing and selling aerial remote sensing products and services in the region. Some publications, e.g. Tenkorang F., & J. Lowenberg-DoBoer, 2008. J. Terres. Obs (a review of 12 remote sensing economic studies) have indicated the use of remote sensing to improve management decisions has the potential to improve farm profits by as much as $31.74/ha depending on the crop. Even if only half of that increase was realized in seed potatoes, the annual increase in profits on the current 9800 ha of seed potatoes in the two states alone would be approximately $154,000. As technology that increases profitability is rapidly adopted by other regions, other states would soon see a similar return. Another beneficiary will undoubtedly be the state government agencies conducting seed quality inspections and certifications. This technique can be used to more rapidly identify infected plants within field during the growing season and during winter grow-out trials

conducted for seed certification. We will be attempting to work with several of these agencies to further develop and implement within field, real-time PVY diagnostic techniques.

LESSONS LEARNED

The confounding influence of varieties on spectral response was unexpected and, at first, discouraging, until it became apparent that the technique could still be applied to several varieties, including Russet Burbank. There is still a wide potential for application of this technique in the identification and management of PVY within season. We foresee using aerial imagery to rogue infected plants and as a tool for identifying infection in seed potato winter grow out sites.

The discovery that the application of Aphoil can interfere with the appropriate interpretation of remotely sensed data is, upon reflection, not surprising. However, it is beneficial to have this information prior to the widespread application of the techniques.

ADDITIONAL INFORMATION

Preliminary results have been presented at several venues.

Extension Presentations

MN Seed Potato Growers Lunch Meeting. E. Grand Forks, MN July 16, 2014.

UAS eXtension User Community Meeting (teleconference). Oct 14, 2014.

MacRae, I.V. 2015. Apprehending aphids and bagging beetles. Northern Plains Potato Growers Assoc. Research Report, Feb 17, 2015.

MacRae, I.V. 2015. Apprehending aphids and bagging beetles. MN Area II Potato Growers Assoc. Research Report, Feb 17, 2015.

MN Seed Potato Growers Summer Meet. East Grand Forks, MN. Jul 07, 2015.

UMN-NWROC Field Day. Crookston, MN Jul 15, 2015.

NPPGA Field Day. NDSU & UMN Extension, Grand Forks, ND. Aug 20, 2015.

MacRae, I.V. 2015. Potato insect management – current research report. Cavendish Farms Research Update. Fargo, ND. Dec 08, 2015.

MacRae, I. 2016. UAS in agriculture. MN Crop Improvement Assoc. Fergus Falls, Jan 12-13, 2016.

MacRae, I. 2016. All the bug news that's fit to print. Ag. Prof. Research Update. Crookston MN Jan 14, 2016.

MN Seed Potato Growers Meeting, Barnesville, MN Feb 04, 2016

MacRae, I. Aphids, beetles and drones! Oh my!. NPPGA Potato Research Report. Grand Forks, ND Feb 16, 2016.

MacRae, I. Aphids, beetles and drones! Oh my!. Area II Potato Growers Research Reports. Duelm MN Mar 01, 2016.

Centrol Crop Consultants Round Table Fargo, ND. Mar 24, 2016.

MN Seed Potato Growers Summer Meet. East Grand Forks, MN. Jul 07, 2015.

RD Offutt Co. Scout School. Park Rapids, MN. Jun 10, 2016.

UMN Sand Plains Research Farm Field Day. Becker, MN. Jul 19, 2016.

UMN-NWROC Field Day. Crookston, MN Jul 20, 2016.

NPPGA Field Day. NDSU & UMN Extension, Grand Forks, ND. Aug 25, 2016.

Scientific Presentations

MacRae, I, M. Smith, A. Chanda, T. Baker. Remote scouting for plant disease with drones – the highs and lows. Am. Phytopath Socity NC Branch Meeting. Minneapolis, MN. Jun2 08, 2016

MacRae, I., R. Koch, T. Baker, & Z. Marston. 2016. Remote sensing of insects in agricultural systems. Ent. Soc. America National Meeting & Int. Congress of Entomology, Orlando, FL. Sept. 24-30, 2016.

MacRae, I., T. Baker, & R. Koch. 2016. The view from above – Unmanned Aerial Systems and Remote Scouting. Great Lakes Fruit Vegetable & Farm Expo, Grand Rapids, MI. Dec 6-8, 2016.

MacRae, I. T. Baker, & R. Koch. The view from here is great! Remote sensing and drones in pest management. Manitoba Agronomists Conference. Winnipeg MB Can, Dec 14-15, 2016.

Project 7

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Contact: Greg Schweser

Organization: Regents of the University of Minnesota

Contact information: schwe233@umn.edu, 612-625-9706

PROJECT TITLE

Retail Produce Handling Education for Rural Grocers and Specialty Crop Farmers

PROJECT SUMMARY

Produce upkeep and sales are frequently an area of concern for rural grocers, many of whom do not have dedicated produce managers. These grocers face issues around maintaining the quality of fresh produce in aging equipment, stocking produce in an appealing way, clearly displaying the name and cost of produce, in addition to other issues. Stores with less frequent produce purchasing often have lower product quality, limiting the appeal of purchasing healthy foods among customers. Additionally, grocers may be unable or unsure of purchasing from other produce vendors - like local farmers - resulting in a lost market opportunity for fresh produce growers in the surrounding area.

This project was designed to address the issues above by providing store owners and managers with simple, easy-to-use produce storage and handling guides. Additionally, on-site trainings were designed and implemented to provide in-person knowledge and skills on maximizing produce quality, freshness, and appearance. Local specialty crop farmers were invited to these workshops to network with grocers. This allowed both grocers and farmers to understand each other's needs in a farm-to-grocery business relationship. The Fresh Produce Toolkit is the end result of this work, highlighting key storage, handling, and marketing information, including information relevant to locally grown fresh produce: **http://z.umn.edu/rsdprg**

Produce aisles of grocery stores can be catalysts for increased business.

Produce coolers stocked to medium capacity with disheveled wilted produce sets an overall tone for the store. On the other hand, produce coolers packed to the brim with bright colorful fresh fruits and vegetables entices customers to buy and can encourage new customer visits and return visits from existing customers. In this sense, produce sections can be the key to retail profitability even if overall produce sales are a small percentage of a store's total receipts.

The ability of a store to effectively market and sell fresh produce is a necessary precursor to creating a viable outlet for locally grown produce. Local growers looking to expand beyond direct marketing opportunities need to have confidence that retailers can effectively market their products in order for farmers to earn an income from their produce. Over time, as rural grocery stores build the capacity to handle and sell fruits and vegetables, local farmers will have a consistent outlet for their product leading to long-term market stability.
Once rural grocery stores are able to maintain quality and well stocked produce coolers, rural residents that rely on rural grocery stores for the bulk of their food supply will have better access to healthier fresh fruits and vegetables from both locally grown farms and traditional distributors.

With increased capacity to participate in local food systems in addition to possessing the skills required to effectively handle and merchandize produce, rural grocery stores are better positioned to succeed in a difficult retail environment. Rural grocery stores often suffer from small margins, low population service areas, and competition from distant big box stores. Strengthening the viability of rural grocery stores can ensure that rural areas have access to healthy food options, prevent more food deserts from emerging, and support local specialty crop farmers.

PROJECT APPROACH

Initial activities included a series of kickoff meetings and identification of existing materials currently available for produce handling education. The project was launched when the project team traveled to a USDA designated food desert and met with two rural grocery owners in western Minnesota. The team asked grocers to share their experiences and challenges, toured the store, and had a chance to ask about and examine the coolers and fresh produce at each site. Both grocers provided valuable input and offered to be on the advisory group for this project.

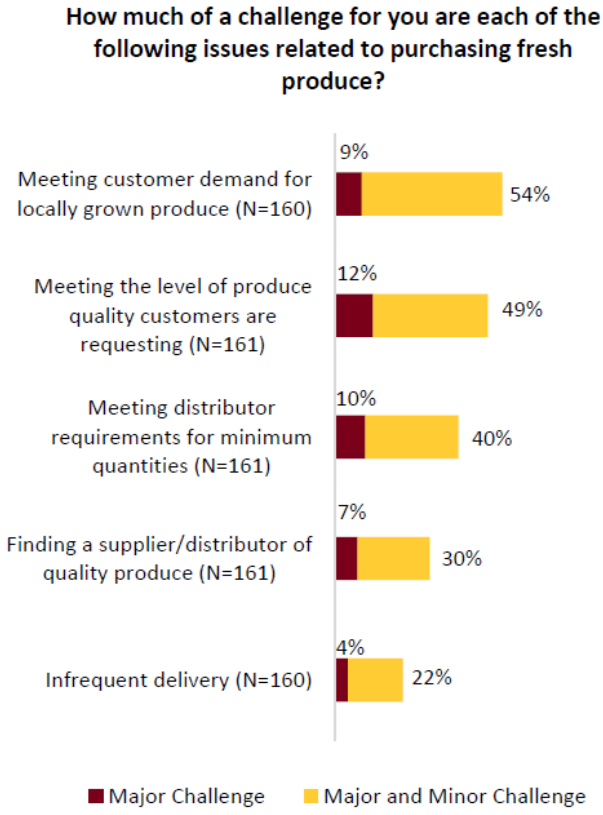
Survey of Rural Grocers

While assembling an advisory committee to give input into toolkit materials and rural grocery fresh produce handling needs, the project team realized there was an opportunity to do a statewide survey of rural grocer issues and their concerns. Survey results would be used to inform the creation of a fresh produce toolkit, and additional questions on business characteristics and energy usage were added to give a comprehensive picture of rural grocery needs. The survey was sent out to more than 250 rural grocery stores in

towns with populations under 2500, with 175 returning the survey for a 69% response rate.

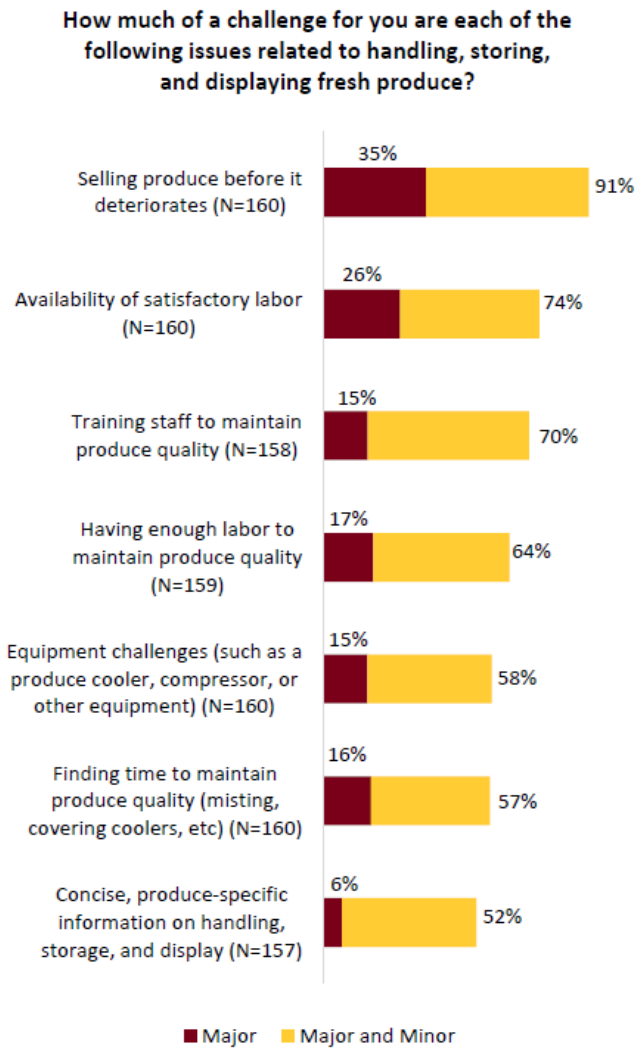
Almost all stores surveyed (92%) sold fresh produce in-store, and of those, 54% noted that meeting customer demand for locally grown produce was a challenge (Fig. 1). Second to that challenge was meeting the level of produce quality customers are requesting. When asked about challenges to selling fresh produce, 91% of respondents indicated selling produce before it deteriorates was a challenge (Fig. 2). These results and others reinforced the potential benefits of a toolkit and demonstrations on fresh produce storage, handling, and marketing.
Additional survey results can be found at http://z.umn.edu/rsdprg

Figure 1: Challenges purchasing fresh produce



Note: 92% of respondents indicated they sell fresh produce (N=175). Chart reflects only that group.

Figure 2: Challenges around Handling, Storing, and Display



Note: 92% of respondents indicated they sell fresh produce (N=175). Chart reflects only that group.

In addition to surveying rural grocers around the state, Karen Lanthier attended a Mason Brothers Distributors meeting with rural grocers in Proctor, Minnesota and in Mankato, Minnesota to meet with rural grocery owners and better understand their challenges. At this meeting Karen connected with the owner of the Hoyt Lakes IGA who addressed produce handling issues in an innovative way by storing produce in French door refrigerator units, thus saving energy compared to his previous open produce coolers that become inefficient with relatively infrequent use. The grocer suspects that the French door style produce coolers not only save energy, but also enable produce to stay fresh longer as there is less variability in produce temperature throughout the day. These meetings helped further inform toolkit resources.

Assembling Advisory Committee

One of the first project activities was to assemble an advisory committee comprised of both rural grocers and produce managers to provide feedback on the project and the types of information that would be most useful in a rural setting. The four grocers that were a part of the advisory committee were store owners in southwest, southeast, northeast, and central Minnesota. Three produce managers who were on the committee included a

produce manager from a food co-op in northwest Minnesota, a produce manager from a Twin Cities food co-op, and a representative from a wholesale distributor of fresh produce.

Topics to be covered by the toolkit

Initially the advisory committee was asked to identify major topics that should not be missed in the produce storage, handling, and marketing toolkit. One example suggestion was to have a separate handout for a few, especially difficult produce items, including bananas, avocados, and tomatoes. Another piece of feedback was to keep the toolkit simple enough that it could be applicable to many stores, but have many photos and examples from which to draw inspiration. Merchandising best practices can vary by store and situation, for example, but basic best practices and examples could serve as a starting point.

Critical feedback on the "Quick-Reference Guide"

Figure 3: Quick-reference Guide

A second major task of the advisory committee was to critique a guide (**Fig. 3**) that could hang from produce coolers and be quickly referenced by store employees stocking the cooler shelves. This guide would note ideal storage temperature, number of days of peak quality, and any additional helpful notes for common fruits and vegetables sold in-store. The advisory committee provided important feedback, including that both temperature ranges and specific ideal temperatures were important to show since some grocers had equipment that could be more exact than others. Members of the committee also thought that misting information for humidity control would also be important to include. Dr. Cindy Tong was able to use this feedback and feedback from the survey of rural grocers to hone the information for this guide.

Identification of Demonstration Host Sites and Demonstration Planning

In addition to creating a comprehensive toolkit, this project hosted in-store demonstrations across five stores in Greater Minnesota. The first hour of the event was a presentation on key information and topics in the toolkit materials, and the second hour of the event was a hands-on discussion in the host store about the tips and tricks learned during the presentation. The project team worked with two presenters, Ryan Pesch (U of M Extension and local producer) and Matt Olson (Produce Manager at Mississippi Market), to lead the presentation portions of the in-store demonstrations.

Ryan Pesch talking with demonstration participants (Photo Credit: Karen Lanthier)

The 5 sites where located in rural communities as evenly spread around Greater Minnesota as possible to reduce travel time and costs for participants. Together, the RSDP regions cover all Greater Minnesota, and each of the Regions provided travel reimbursement for those grocer and small producer participants who needed it. Regional Executive Directors provided valuable assistance in identifying potential host stores in their regions.

In January of 2016, project team members met with Ryan Pesch and Matt Olson to finalize demonstration layout, presentation information, and review drafted toolkit resource materials. The project team decided to give out the Quick-reference Guide to each participant and use feedback from the demonstrations to hone the other toolkit materials. During that same time period, Lanthier contacted potential host stores, determined dates and times for the demonstration that worked for interested store owners, established an off-site location for the presentation portion of the demonstration if needed, and coordinated other pre-demonstration activities. In February 2016, postcards were sent to approximately 260 grocers statewide about the demonstration events in addition to electronic outreach through related partner organizations, including a wholesale grocery provider, Minnesota Institute on Sustainable Agriculture, Extension SNAP-Ed networks, and more.

Demonstrations were held at Bergen's Prairie Market in Milan, MN; Kiester Market in Kiester, MN; TJ's Country Corner in Mahtowa, MN; Pierz Foods in Pierz, MN; and KC's Market in Badger, MN. The demonstrations varied in attendance (**Fig. 4**) but were well received by attendees at each site.

Figure 4: Attendance at In-store Demonstrations

	Milan	Pierz	Mahtowa	Kiester	Badger	Subtotals
Grocers	3	9	5	3	3	23
Local Farmers	3	4	1		2	10
Other related stakeholders	2	4	1	2	3	12
					TOTAL:	45

Finalization of Toolkit Components

Toolkit resources (**Fig. 5**) included guides on: 1) high maintenance produce, 2) produce merchandising for fresh and locally grown produce, 3) unique considerations in purchasing locally grown produce, 4) a guide to storing and handling fresh produce, 5) an example grocery policy and application for local food vendors, 6) a quick reference guide on produce handling and maintenance, and 7) a guide on culling undesirable produce. Dr. Cindy Tong provided postharvest handling horticultural expertise throughout the production of these materials while Schweser and Lanthier provided expertise around local produce procurement.

Physical copies of these resources, along with produce cooler thermometers, were mailed to all rural grocers who were surveyed by RSDP in Summer 2015. Additional physical toolkits were made available at conferences in winter 2017, including the Minnesota Organic Conference. Information on accessing the digital version of the toolkit was shared via multiple organizations, including the Minnesota Department of Ag, Minnesota Department of Health, Extension SNAP-Ed program, and others. The link to the digital toolkit was also shared on the Sustainable Agriculture listserv, hosted by MISA.

Figure 5: Toolkit Components

1. High Maintenance Produce

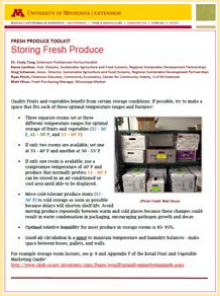
2) Produce Merchandising

3) Locally Grown Produce

4) Storing and Handling

5) Example store policy & application for local produce

6) Quick Reference Guide



7) Culling Fresh Produce

Grocery wholesalers Mason Brothers and SuperValu have expressed interest in the Produce Handling toolkit for the stores they serve. SuperValu is interested in providing the Toolkit to their stores in North and South Dakota. The project team is currently working through how these materials can be shared with other states.

The Fresh Produce Toolkit - posted on the Rural Grocery Resources page of RSDP's website (**http://z.umn.edu/rsdprg**) - had 491 unique page views between 12/12/16 and 01/11/2017. One of two large spikes in page viewership occurred on and for a few days following December 19th, the day communications about the new resource went out. A second, unexpected spike occurred between January 4th-6th and may have been the result of delayed page opens from e-mail hyperlinks due to the holidays. Between 12/12/16 and 01/25/2017, there were 469 downloads of PDFs and Word documents from the Rural Grocery Resources page on which the toolkit is posted. Page visitation for January 2017 was higher than at any other month in 2016.

Greg Schweser: Schweser served as project PI. Schweser scheduled all events, wrote project reports, and coordinated with project team members to ensure activities were completed on schedule. Schweser coordinated and wrote project reports and contributed to outreach efforts to ensure successful contributions and participation from rural grocers, farmers, and project team members.

Dr. Cindy Tong: Dr. Tong provided expertise and contributed content to produce handling and storage workshops and educational materials.

Karen Lanthier. Lanthier worked with Dr. Tong, educators, and rural grocers to coordinate the design and content of produce handling toolkit materials. Lanthier also contributed to general project management.

Dr. Kathryn Draeger. Dr. Draeger contributed to outreach efforts to significantly increase the visibility of this project and to the plight of rural grocery stores across Minnesota. Dr.

Dreager also imitated and conducted a large survey of rural grocery stores, the results of which greatly influenced the content of workshop educational events and toolkit materials.

Ryan Pesch. Pesch delivered three produce handling workshops in his role as an expert produce handling professional.

Matt Olson. Olson delivered three produce handling workshops in his role as an expert produce handling professional.

Brett Olson. Olson contributed to graphic design of produce handling toolkit materials.

GOALS AND OUTCOMES ACHIEVED

- Completion of extensive survey of rural grocery stores to identify pressing needs facing rural grocers in Minnesota. Survey was sent to all grocery stores in Minnesota in towns of under 2,500 people.
- Advisory committee convened to help refine content for Produce Handling Toolkit materials
- Development of produce handling toolkit consisting of: Quick Produce Reference Guide; Storing and Handling Fresh Produce; Produce Merchandizing Techniques; Purchasing Locally Grown Produce; Example Grocery Store Policy and Application for Local Producers; High Maintenance Produce; Culling Fresh Produce; and Produce Aisle Checklist. Produce toolkit was mailed to all rural grocery stores in Minnesota in towns of less than 2,500 people.
- Five produce handling workshops convened in rural grocery stores throughout Minnesota (in each of the five RSDP service regions) targeting rural grocers and local producers
- Produce aisle audits conducted before and after workshops in each participating store
- Participant evaluations conducted at each workshop
- Survey of participating grocery stores to determine increases in produce sales and local produce sales
- Rural Grocery Store website created to house all project materials, project presentations, and other rural grocery store resources

While the project activities are expected to have long term outcomes in that they are expected to help rural grocery stores and rural farmers both develop the capacity to sell more produce items and further develop local food systems as part of the rural landscape, visual results on-the-ground will take years to realize. Despite the long-term outlook, some important inroads have been made as a results of this project. Directly, relationships have been established between local producers and rural grocery stores that have participated in the produce handling workshops. Grampa G's Farm in Pillager, the Local Harvest Market Food Hub, Gosch's Grocery, and TJ's Country Corner Grocery and Farm/Street Market have all made efforts to sell and incorporate more local foods into the offerings in the produce isle.

Furthermore, dramatic inroads have been made to raise awareness of the plight of rural grocery stores as a direct result of this project. Considerable media attention in outlets such as the Star Tribune, MPR News, West Central Tribune, MinnPost, and Minnesota Alumni Magazine have brought elevated the attention of the project activities to a broad statewide audience. Additional projects have been funded that build upon this work to identify opportunities to further intertwine rural grocery stores within the local food system. A grant funded by the USDA AFRI program will contribute to work that will identify opportunities for rural grocery stores to serve as important hubs for local food producers looking to access wholesale markets through backhaul arrangements with distributors. Research will determine the feasibility of backhauling garlic, strawberries, and organic potatoes thereby providing more markets to local farmers while providing rural grocery stores with additional revenue streams and access to locally grown product.

All of the project activity goals set forth were achieved.

- GOAL 1: Develop a Fresh Fruit and Vegetable Handling Toolkit
  - Produce sales increase in participating stores from between 10 and 20% on the year following demonstrations.

The Produce Handling Toolkit was completed and disseminated. Of the five stores that hosted produce handling trainings, the changes in produce sales varied. In Pierz, produce sales increased between 10 and 20%; in Badger, produce sales increased by more than 20%; the store in Mahtowa had slightly decreased produce sales; and two stores (Kiester and Milan) were unable to tell the changes in produce sales due to the lack of sophisticated sales tracking data.

- GOAL 2: Develop a Local Food Buying Guide
  - Each participating demonstration store will sell locally produced specialty crop products throughout the growing season in its produce department. Those products will be handled appropriately, and marketed effectively as locally produced. Demonstration stores will have a minimum of 3 local vendors from whom they regularly purchase product.

A Local Food Buying Guide was completed as part of the overall Toolkit.
The participating demonstration stores had varying numbers of local farmers that they were able to support. Since the demonstration, one store (Pierz) sold product grown by between 5-10 local farmers. The store in Mahtowa began selling farm produce from between 3-5 producers in addition to local eggs. In Milan, they started selling produce from between 3-5 farmers in addition to local eggs. The store in Kiester began hosting a regular farmers market in their parking lot with between 3-5 local vendors. In Badger, they did not yet include products from local farmers, but have plans to start a farmers market in their parking lot and experiment with an onsite greenhouse to produce locally grown products for sale in the store.

- Goal 3: Provide in-store fresh fruit and vegetable handling demonstrations
  - Target audience of 3-5 neighboring rural grocery store personnel and 3-5 local farmers attend each event, attendees fill out evaluation forms that indicate they learned a significant amount of important information and that they are more likely to make changes in their produce handling practices, and purchase more fruits and vegetables from local producers.

Follow-up surveys will determine if training demonstrations led to business relationships among farmers and rural grocery stores.

In-store produce handling demonstrations were conducted by established produce handling professionals. There were an average of 3.6 rural grocery store personnel attending each demonstration and an average of 3 farmers in attendance at each demonstration. The rural grocery stores that hosted demonstrations began business relationships with 25 farmers. Other grocery store personnel that attended demonstrations likely also began business relationships as a result of the training sessions in addition to the 25 reported relationships.

- GOAL 4: Develop informational tool kits consisting of fact sheets, tips, and regulatory information to encourage specialty crop farmers to initiate business relationships to sell fruit and vegetable products to rural grocery stores
  - Tool kits are distributed to 50 farmers and at least 50 online toolkit downloads are achieved by the end of the project period.

Toolkits are available online and are distributed at farmer conferences. Online downloads have exceeded project goal targets of 50 downloads by a factor of three (157 downloads). Toolkits have been distributed at conferences to a minimum of 125 farmers in Minnesota and North Dakota.

Additional outcomes consisted of an overarching survey of rural grocery stores; and a Rural Grocery Store Resource website. The following are results of surveys and evaluations that were conducted to determine the effectiveness of the project activities:

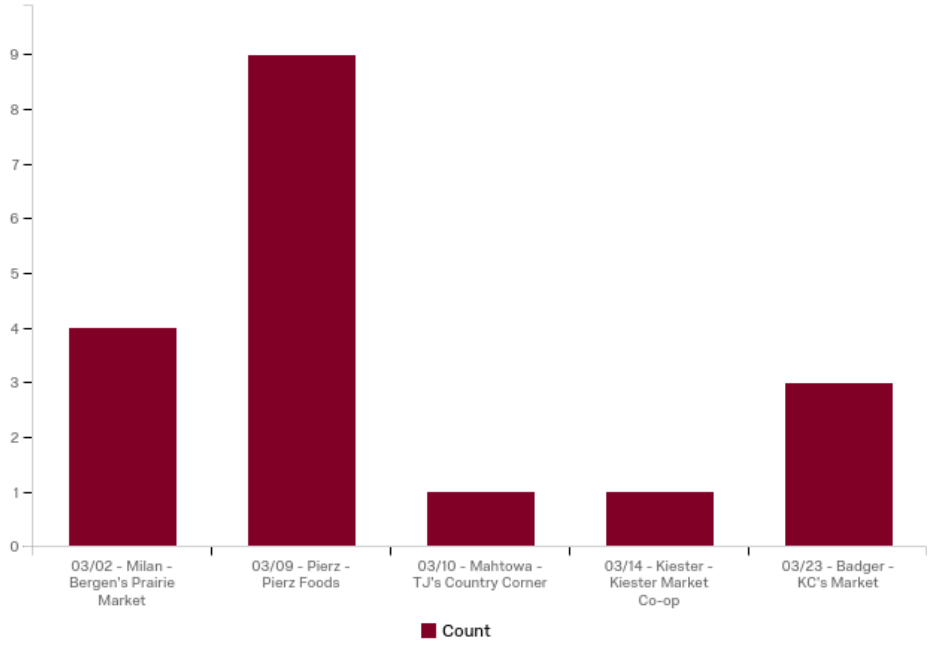
Analysis of Demonstration Attendee Feedback

Survey Responses

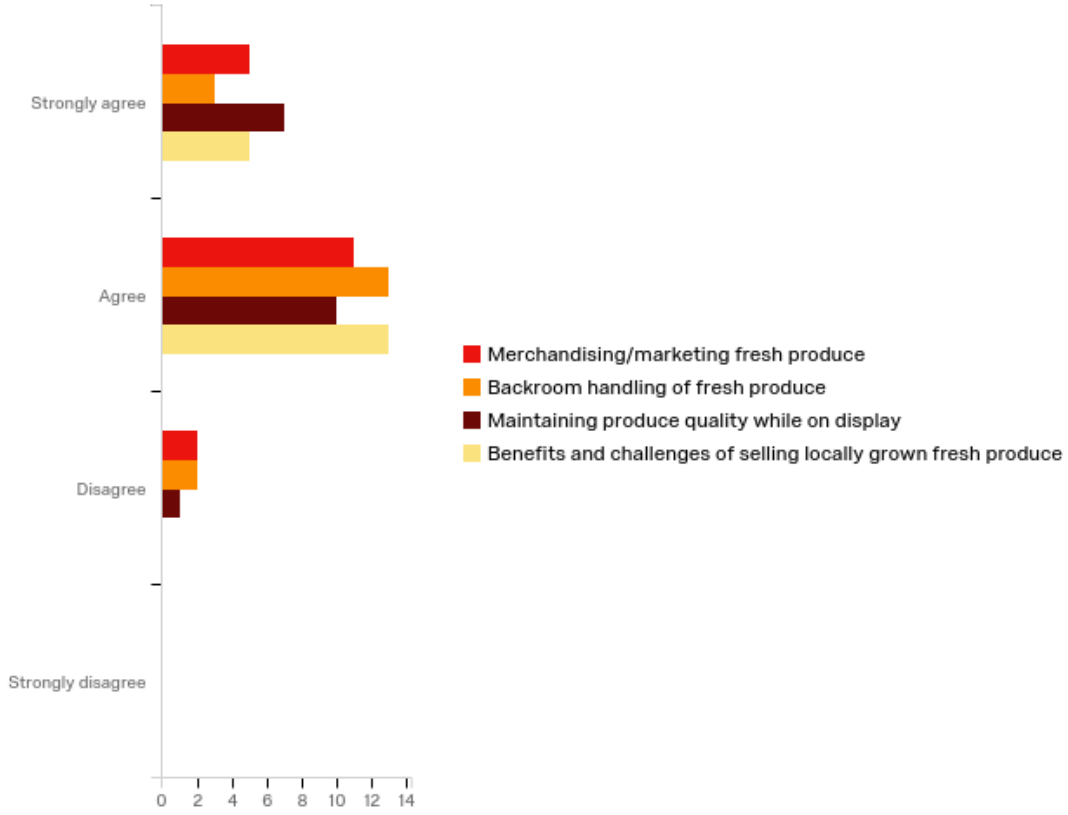
The project team surveyed and analyzed survey results from demonstration attendees. Some of the most informative responses are highlighted here with all responses given in **Appendix A**. Responses were captured from every demonstration site with those sites that had greater attendance also seeing greater survey response:

Question 1 - Which produce handling demonstration did you attend?

A majority of survey respondents felt they had a better understanding of the four main topics covered (1. Merchandising/marketing fresh produce, 2. Backroom handling of fresh produce, 3. Maintaining produce quality while on display, and 4. Benefits and challenges of selling locally grown fresh produce)



Question 2 - Overall, as a result of attending the demonstration, I have a better understanding of...



Overall the majority of respondents (83%) were satisfied with the demonstrations. Questions 8, 9, and 11 provided opportunities for participants to give open responses, and a selection of the most informative responses are given below.

Question 8 - How will you use information learned at the Produce Handling and Marketing Demonstration in your work?

"Suggesting to grocers different methods of marketing and displaying produce, as well as sharing storage info."

"My produce manager is using some of the display items already, and we are talking to the school to be their CSA point for pick-up."

"We will spend more time to merchandise the produce. I would also like to work with more local farmers to bring produce in."

Question 9 - What changes to your business have you made or will be likely to make after attending the Produce Handling and Marketing Demonstration?
"Making sure everyone knows the proper storage temps and are able to inspect for fresher produce and quality."

"We have already started to implement some of the merchandising techniques. We are hoping to be in contact with more of the local farmers and bring more produce in."

"We already have very good relationships with local farmers and suppliers and strive to incorporate more and more local products in our store. I think mostly the demo stoked the fire inside me to continue to promote and support our neighbors ever more and the commitment to doing things that help our community thrive from the inside out. Exciting stuff!"

Question 10 - Overall, how satisfied were you with the Produce Handling and Marketing Demonstration?

Question 11 - Do you have any suggestions if an event like this were to be hosted again?
"More info on how wholesalers can help in offering variety to small grocers, less local info, as that is only pertinent to 5 months of the year on selected items, and more info on financial resources to keep local grocers above water."

"When giving advice to the grocery store owner on how to better display produce, there were too many cooks in the kitchen giving advice. This should have been a 1:1 conversation between the grocery and presenter just due to sensitive of his family business."

"Recipe cards to print off a website"

"I would have like to know more details on the produce handling itself, but I am very new to this, so others may have already know some of the basics"

Anecdotal Responses

Anecdotal positive outcomes were also seen. During the southwest Minnesota demonstration in Milan, host store owner Bergen Standahl and a store manager in Morris, Minnesota had a chance to kick around ideas of working with a local CSA farmer, who normally travels between Milan and Morris, to haul split product orders between their stores. This splitting of product orders would better fit the small amounts of product needed at each store, potentially save money at each store by having less product go bad before it can be purchased, and open an opportunity to work more closely with a local farm.

Additionally, the West Central Tribune out of Willmar was in attendance at the Milan demonstration to cover the event. The result was a positive article about the demonstration, local foods, and the role rural grocery stores play in Milan and around Greater Minnesota (see article URL in Broader Project Reach/Publication section). After the article's publication, store owner Bergen Standahl reported to Lanthier that he had seen a noticeable uptick in phone calls from interested residents around the Willmar area who wanted to know more about the specialty products he carried.

Lastly, a Gosch's Grocery representative in attendance at the Pierz, MN demonstration had a chance to connect with the owners of Grampa G's Farm who farm near Randall, MN where the store is located. In summer of 2016, the grocer and farmer began limited sales of locally grown produce in Gosch's Grocery and plan on evaluating a more extensive sales arrangement for 2017. More about Gosch's Grocery and Grampa G's experiences in exploring "farm-to-grocery" partnerships can be found in case studies posted on the RSDP Rural Grocery webpage: **http://z.umn.edu/rsdprg**

Partnership between Grampa G's and Gosch's Grocery fostered by demonstration networking (Photo Credit: Claire Stoscheck)

Local Foods Interest Questions

All host demonstration sites were asked a series of four questions (with sub-questions) on their interest and experience carrying locally grown fresh fruits and vegetables (**Appendix B**). Each site was asked these questions before and after the in-store demonstration events

except Kiester Market in Kiester, Minnesota. The primary manager at Kiester Market changed in Fall of 2016 and the new manager was unavailable for response.
Changes in responses to the four questions on locally grown fresh produce were minimal pre-demonstration and post-demonstration. Those changes that did occur were slight variations in what products were purchased by grocers if they were already buying from local producers. Those who weren't purchasing from local farmers still were not purchasing from them when the post-demonstration questions were asked, and those who had already been working with local farmers continued those relationships. Below are highlights from the responses:

Question 1 – Do you know of local farmers who grow and sell fruits and vegetables in your area?
All five of the host sites for the in-store demonstration knew of local fruit and vegetable producers in their area.

Question 2 – Are you concerned that there are regulatory barriers to purchasing fresh produce directly from a local farmer?

Participant responses to this question stayed the same pre- and post-demonstration. Two grocers answered "Yes" and indicated that this was because they were unsure if there were barriers or how liability would be handled if a food safety issue arose. Two grocers indicated "No" and these were grocers who already had business relationships with one or more local producers (Question 3). The fifth grocer did not indicate whether or not they were concerned about regulatory barriers but said that they believed there was overregulation in government in general

Question 3 – Did you purchase locally produced fruits, vegetables, or herbs within the past year?

Three out of the five grocers purchased local fruits or vegetables. Some of the produce purchased included apples, herbs, salad mixes, and decorative pumpkins. Number of

producers supplying these items varied between one and three. One store estimated that they made "a couple hundred" in locally grown produce sales within the past year, while another store estimated $1,000. The third store had no estimation specific to just sales of locally grown produce but estimated sales of other local products (including meat, eggs, dairy, maple syrup, and wild rice) in combination with these totaled around $5,000

Question 4 – Do you have any additional comments?
"In our hearts, we strongly believe this is the correct way to farm and sell produce. If you look at the gas that goes into one head of lettuce it's ridiculous... If we have someone local who's dedicated AND can make a decent living on it, we will try to buy it, but we need the WHOLE supply chain to be able to make a profit from that model."

"Just training customers how to use [local produce] and difference between it and regular [produce] will help. The Little Falls radio station runs ads on buying local. When [a person] spends $100 at locally owned business, $74 will stay in community."

"In theory it's a great thing; in practice it's tough because small producers aren't always able to meet demand instantaneously. This is the main issue I run into. I enjoy having [local] product but it's frustrating when I have to do [additional] marketing within store. It's bad for my customers if we have product and then it's not available soon after. When run out of stock it's frustrating."

Broader project reach
Ongoing Rural Grocery Conversation
Beyond producing a physical resource and providing in-person training, a key outcome of this project has been informing and energizing a broader conversation about rural grocery challenges and potential solutions to address these challenges. Below are a collection of rural grocery publications from 2016 that cover the opportunities and challenges facing rural grocery stores. These conversations stemmed from the new information gleaned from the 2015 Rural Grocery Survey - a piece that was developed in part to address the deliverables of this grant project. The first, West Central Tribune article specifically covers one of the in-store demonstrations held as part of this project and the broader landscape of rural grocery issues.

- "Grocery store thrives in tiny Milan", Tom Cherveny, West Central Tribune, 03/06/2016, link to story is no longer available.
- "Rural Minnesota dies a little when small grocers close", Bob Collins, MPR News, 03/15/2016, http://blogs.mprnews.org/newscut/2016/03/when-grocery-stores-close-rural-minnesota-loses-the-heart-of-a-community/
- "How can rural grocery stores survive?", Greg Breining, Minnesota Alumni Magazine, Summer 2016, https://umnalumni.org/UMAA-stories/How-Can-Rural-Grocery-Stores-Survive
- "As local groceries close, more rural areas in Minnesota may become 'food deserts'", Susan Perry, MinnPost, 03/18/2016, https://www.minnpost.com/second-opinion/2016/03/local-groceries-close-more-rural-areas-minnesota-may-become-food-deserts
- "U study: Rural areas could have shortage of groceries in decade", Mike Hughlett, Star Tribune, 03/15/2016, http://www.startribune.com/u-of-m-study-rural-areas-could-have-shortage-of-groceries-in-decade/372002781/

Analysis of Host Store Changes

Changes in produce handling practices at stores that hosted demonstrations were analyzed as part of the project. To do this, a "produce aisle audit" was developed to measure quality of produce storage, handling, and marketing conditions. (See Appendix B). Pre- and post-demonstration produce aisle audits were conducted at each site. A set of questions on interest in local foods was also conducted pre- and post-demonstration. The project team analyzed these responses and examined whether changes in the host stores could be noted before and after hosting the demonstration events.

The project team had hoped to also compare sales of fresh produce in each store pre- and post-demonstration, but an unforeseen limitation to conducting this analysis was that each host site grocer used different sales measurements, and few stores were able to separate produce sales from general sales. Although this was a limitation, the project team was still able to note interesting results through changes between produce aisle audits changes and local food interest questions.

Produce Aisle Audit (Pre- and Post-Demonstration)

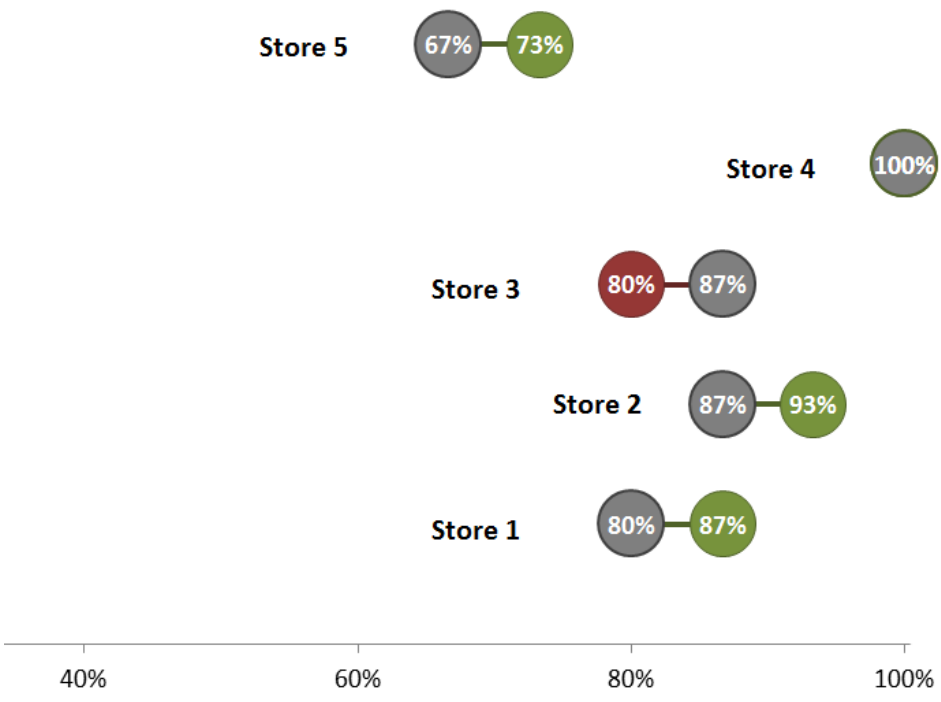
Project staff examined and noted results around produce quality, merchandising, and signage at each of the host demonstration sites. Results of the 15 questions filled-in by each of these staff were averaged and used to study any measurable changes at the sites post-demonstration. To visualize overall improvement or regression at each site and compare better across sites, an Overall Quality value was measured for all stores, both pre- and post- demonstration. For our purposes, Overall Quality = (# neutral or positive scores) / (# total evaluation questions), and this value was expressed as a percentage. For example, one store had an Overall Quality of 80% pre-demonstration because 12 out of the 15 total questions were either neutral or positively rated. Detailed rankings for each question, both pre- and post- demonstration are given in Appendix C and separated by store.

Figure 4: Produce **before demonstration** at a host store lacks fullness and a separation of like-colors (e.g. reds and purples) from each other (color breaks).

Figure 5: Produce **after demonstration** at a host store shows use of color breaks and false bottoms to create fullness.

Upon analysis of these results, we could see that stores improved overall between the demonstration and the surprise follow-up visit, regardless of the initial overall quality at each store site. In the graph below (**Fig. 8**), **grey** indicates the starting overall quality value, and **green** or **red** values indicate improvement or regression in overall quality score, respectively, on the follow-up visit. The two exceptions to this were Store 4, which scored highly in all areas both before the demonstration and during the surprise follow-up, and Store 3, which had an initial overall quality score the same as Store 2 but had slipped in overall quality on the follow-up visit.

Figure 6: **Overall, stores improved produce quality/merchandising/signage after hosting demonstration**



BENEFICIARIES

Primary stakeholders included rural grocers and local farmers. The following chart shows the number of participants of each that attended the produce handling workshops:

Figure 7: Attendance at In-store Demonstrations

	Milan	Pierz	Mahtowa	Kiester	Badger	Subtotals
Grocers	3	9	5	3	3	23
Local Farmers	3	4	1		2	10
Other related stakeholders	2	4	1	2	3	12
					TOTAL:	45

Additionally, once complete, the project team mailed produce handling toolkits to over **250 rural grocery stores** throughout Greater Minnesota.

There have been a total of 1119 unique downloads of the materials created for the Rural Grocery Toolkit as part of this project from the UMN RSDP Rural Grocery website. This includes 154 unique downloads of the Purchasing Locally Grown manual. This figure is more than half of those rural grocery stores that were surveyed in Minnesota. As our body of rural grocery store work continues to grow, this connecting of rural grocers to rural farmers will continue to grow. Our primary concern with this project is providing rural grocers with the tools needed to properly handle fresh produce. With that competency, rural grocers will be able to continue to build relationships with rural farmers and increase the capacity of rural grocery stores to sell locally grown food. While the number of 154 downloads is not necessarily inactive of that number of rural grocery relationships with local farmers, it does represent that there is some interest in this area. Should rural grocery stores choose this avenue to differentiate themselves from competition, the number of business relationships between rural grocery stores and small farmers will continue to increase. These parties now have the tools available to help facilitate successful business relationships.

LESSONS LEARNED

While rural grocers were enthusiastic about participating in the project, the overall attendance in workshops from rural grocers was not as high as we had anticipated. We identify two main reasons for this. 1) Workshops were held in rural communities that are far from each other. Travel to workshops is a limiting factor for attendance. 2) Rural grocery stores owners are often very busy, and often have limited help. In this scenario, attending events far from the grocery store is a hardship. That said, there was a minimum of three grocers attending each workshop, with one workshop attracting 9 grocers. Overall 23 grocers attended produce handling workshops.

The largest unexpected outcome of the project was the dramatic response that was received to the rural grocery survey. 69 percent of grocery stores in rural Minnesota responded (175 out of 254 eligible grocery stores) to a long exhaustive survey. The project team believes that this dramatic response rate is indicative that rural grocers feel that their plight and difficulties surviving as a rural business model are ignored. Rural grocers were very willing to work with the project team, despite their busy schedules. It is also clear that a large number of rural grocers are interested in supplying locally grown produce. 68 percent of survey respondents already sell locally grown produce, while a sizable minority (52 stores, or 30%) were interested in getting help in finding connections with local producers. While it is clear that connecting with local farmers isn't optimal for ALL grocery stores, for some it is an opportunity to differentiate product and supply high quality locally grown food.

Grocers are very interested in learning from each other. During workshops, analyzing produce departments gave grocers the opportunity to discuss their strategies for selling produce including processing and repackaging items, selling local product, product placement, merchandizing techniques, and cross-merchandizing produce with other items. Rural grocery networking is clearly an under-recognized opportunity to increase knowledge.

ADDITIONAL INFORMATION

See attached:
Rural Grocery Survey

Report: Stocking Freshness and Abundance

See link to RSDP Rural Grocery Store Website:
https://www.extension.umn.edu/rsdp/statewide/rural-grocery-stores/

	Pre-Demonstration	Post-Demonstration	"Pre" Dot Spacing	"Post" Dot Spacing	Growth
Store 1	80%	87%	1	1	7%
Store 2	87%	93%	2	2	7%
Store 3	87%	80%	3	3	-7%
Store 4	100%	100%	4	4	0%
Store 5	67%	73%	5	5	7%

Project Photos:

Rural grocers talk produce with project staff in Kiester, MN.


A conversation during a produce presentation in Mahtowa, MN

Discussing the produce cooler in Milan, MN

Farmers and grocers watch produce handling presentation in Pierz, MN.

STORE LOCATION: _____
DATE: _____
AUDITOR NAME: _____

Produce Aisle Checklist

Developed for the project: *Retail Produce Handling Education for Rural Grocers and Specialty Crop Farmers,* Funded by MDA Specialty Crop Grant

Directions: Fill out the following questions as accurately as possible. Before or after, **take pictures** of the area being studied and attach to completed form. Provide any notes needed for clarity.

PRODUCE QUALITY:

1. Is there opportunity for air circulation (space between boxes, pallets and walls) in storage areas?

   YES NO N/A _____

2. Are products that need special care (e.g. “Asparagus - keep upright in chilled water”) being kept in the manner as noted on the retail display quick-reference guide?

   YES NO N/A _____

3. Do products that require misting show signs of being misted?

   YES NO N/A _____

4. Are products that prefer temperatures of **32 to 35.6 F** and **44.6 to 50 F** kept in refrigerated display cases?

   YES NO N/A _____

5. Are cold-loving produce (**32 to 35.6 F**) kept near the coldest parts of the cooler (e.g. low shelves, toward the back)?

   YES NO N/A _____

6. Are cool-loving produce (**44.5 to 50 F**) kept near warmer parts of the cooler (e.g. high shelves, toward the front)?

   YES NO N/A _____

STORE LOCATION: _____
DATE:_____
AUDITOR NAME:_____

7. Are any fruits and vegetables visibly rotting, wilting, or undergoing other forms of deterioration? (1 = very unappealing with most produce items in a state of deterioration, 5 = very appealing with no visible signs of produce deterioration)

1	**2**	**3**	**4**	**5**
(Highly visible deterioration on most product)		(Some deterioration on some product)		(Near perfect produce quality on most product)

8. Is there a discount bin for produce needing to be sold quickly?

YES NO N/A or Other _____

9. What is the overall appearance of the produce on a scale of 1 to 5?

1	**2**	**3**	**4**	**5**
(Very unappealing)		(Somewhat appealing)		(Very appealing)

10. Do produce coolers and display areas appear clean?

YES NO N/A or Other _____

MERCHANDIZING:

11. Is there adequate space so that vents are not blocked in the cooler?

YES NO N/A or Other _____

12. Do color breaks between produce exist so that produce of different colors are placed near each other? (1 = very unappealing with like colors together, containers greater than half-empty, and large amounts of unused space. 5 = very appealing with color breaks, full containers, and no gaps in produce other than what is needed for adequate ventilation)

1	**2**	**3**	**4**	**5**
(No color breaks, nearly empty		(Some color breaks, most containers full,		(Appealing use of color, full containers,

STORE LOCATION: _____
DATE:_____
AUDITOR NAME:_____

containers, unused space)	some space well used)	no gaps except for ventilation)

SIGNAGE:

13. Are there signs with the name and price for at least 90% of the fresh produce on display?

YES NO N/A or Other _____

14. Do signs adequately convey and promote the product? (1 = signage not present for most products, 3 = signs are available for almost all products but not easy to read, 5 = signs are present for every product and easy to read)

1	**2**	**3**	**4**	**5**
(Very little/ no signage)		(Signs posted but difficult to read)		(Signs present/ easy to read)

15. Is there signage indicating locally grown produce? (e.g. Minnesota Grown sticker)

YES NO N/A or Other _____

STORE LOCATION: _____
DATE:_____
AUDITOR NAME:_____

Local Foods Questions

1. Do you know of local farmers who grow and sell fruits and vegetables in your area?

YES NO N/A or Other _____

2. Are you concerned that there are regulatory barriers to purchasing fresh produce directly from a local farmer?

YES NO N/A or Other _____

If yes, what are those barriers?

3. Did you purchase locally produced fruits, vegetables, or herbs within the past year?

YES **NO** N/A or Other _____

If **yes**, what were these products?

If **yes**, how many different producers did you work with in the pastyear? _____

If **yes**, what is your best estimate of your total sales of local product?$_____

If **no**, are you interested in purchasing from local fruit and vegetable producers in the future?

YES NO N/A or Other _____

Why or why not?

4. Do you any additional comments?

Project 8

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Contact: Terrance T. Nennich

Organization: Minnesota Fruit & Vegetable Growers Association

Contact information: mfvga@msn.com , 218-280-7713

PROJECT TITLE

Intensive Production & Management Training for Beginning Specialty Crop Farmers

PROJECT SUMMARY

In recent years, there has been an increase in demand for locally grown fruits and vegetables at farmers' markets, community supported agriculture (CSAs), farm-to-school programs and local food co-ops. Meanwhile, many established producers were looking towards retirement. This created, and still presents, many opportunities for beginning fruit and vegetable growers.

In spite of high numbers of people interested in starting their own fruit or vegetable operations in Minnesota, some beginning growers face serious challenges. A survey conducted by the Sustainable Farming Association revealed that many new farmers were entering farming with unrealistic expectations for potential income and commitments for labor and time. The majority of them had no business plan and those that did have a business plan reported those plans did not accurately predict their farming experience. Many had over-estimated yields and income while under-estimating labor requirements.

Most fruits and vegetables are technically challenging to produce. Beginning growers often face a series of challenges like frosts, insect pressure or soil nutrient deficiencies that stunt plants. Many growers quit after a few years and those who do continue are not producing enough to supply the growing market.

Without clear plans, realistic expectations and expert guidance, new growers often struggle, become frustrated and discouraged, and fail.

Because of the rapidly growing market for locally grown fruits and vegetables and the increased interest in fruit and vegetable production, many people wanted to be part of the local foods movement. Many of them, however, were new to farming or were returning to farming after a long absence. At the same time, established growers who could meet an increasing demand for local foods were planning to decrease production or retire.

This project set out to provide new specialty crop producers with the tools needed for individual success using group meetings, individualized on-farm instruction and field days over a two-year period.

The goal was to provide intensive production and management training for beginning fruit and vegetable producers who would not be able to afford the regular Specialty Crop Management Program tuition at Central Lakes College. The project helped new growers address a variety of planning, recordkeeping, production and marketing issues.

The Minnesota Fruit and Vegetable Growers Association had provided day-long intensive workshops for beginning growers for several years prior to this program. Some of those were funded through Specialty Crop Block Grant Programs. This project greatly expanded those programs to address individual needs by providing on-farm training that specifically addressed individual needs and situations. This project also included a series of group meetings and field days where growers could interact and discuss issues with each other and form a network of producers able to support each other.

PROJECT APPROACH

This project included individualized instruction for beginning specialty crop growers over a two-year period. The instructor met with every enrolled producer 4-6 times during the growing season. During the first meeting, the producer discussed production goals, financial goals and plans for the upcoming growing season. In many cases, growers changed goals or production plans with the input of the instructor. Beginning growers often struggle to estimate their yields, and many appreciated having a second opinion. Beginning growers were just as likely to underestimate their yields as overestimate their yields. As the season progressed, the instructor taught growers how to identify and control different insect pests and diseases. As harvest approached, the instructor and growers discussed the best time to start and end harvest. In late summer, the main topic was soil and plant nutrition, and the instructor and producer took soil tests and tissue analyses to help plan a fertilization program.

In May 2016, a widespread frost hit most of the state, and the instructor visited each participating farm to estimate yield losses. In most cases, the growers overestimated the damage, and the instructor assured the producers not to change their marketing plans. Many growers had other emergencies that arose during the season, and they contacted the instructor each time.

Instruction also included two fall field days (2015 and 2016), four group meetings and a full-day workshop for people interested in starting a commercial berry farm. Topics included in the group meetings and field day included:

1) Compliance with the Food Safety and Modernization Act
2) Changes to the Worker Protection Standards
3) Pesticide safety and regulations
4) Advertising and social media for pick-your-own fruit growers
5) Post-harvest physiology
6) Economics of direct market fruit and vegetable production
7) New technologies for fruit producers
8) Record keeping
9) How to read soil and tissue analyses

Twenty-one farms participated in the program in the first year. Nineteen of those farms continued into the second year. An additional 13 farms were added to the program in the second year.

Thaddeus McCamant, Specialty Crops Management Instructor with Central Lakes College, helped identify and recruit participating farms. He also conducted the on-farm instruction, helped organize the Field Day and assisted in scheduling and organizing the group meetings. Marilyn Johnson provided project oversight, coordinated promotional material and helped identify and recruit participating farms. She drafted the initial assessment and helped coordinate the field days. Both McCamant and Johnson are involved in compiling information and preparing required reports.

GOALS AND OUTCOMES ACHIEVED

Goal 1: Increase availability of locally produced fruits and vegetables and improve profitability for beginning growers through comprehensive production and management training for low income beginning fruit and vegetable producers. Improved skills will include identification and management of pests and diseases and improved harvest and post-harvest handling.
Individualized instruction was given to beginning specialty crop producers. Twenty-one farms participated in the program in the first year. Twenty-six farms were enrolled at the beginning of the second year. An additional six farms enrolled during the second year. Beginning growers were at different stages. Two growers had not planted, and wanted help in preparing and designing their site for apple or blueberry production. Six growers had already planted but had not started harvesting and selling their produce. The rest of the participants had already started producing and selling, but were still considered beginning growers. The beginning growers also had different educational backgrounds and experiences. Instruction was tailored to the farms and addressed specific specialty crops being produced, the owner's business and financial goals, unique weed and pest pressures and soil types for the location, etc. Instruction also included marketing, disease and pest identification, fertility, IPM, picking and post-harvest handling, various production practices, time management, farm management, and profitability.

Fall field days were held each year hosted by experienced specialty crop producers who shared information on their production and marketing practices. Beginning growers were able to tour the fields, see equipment and ask questions of the hosts and other tour participants.

Group meetings for just the beginning growers were held in the late fall. Structured discussion included general topics that applied to all of the growers such as labor management, insurance, and social media marketing. Group meetings held in the spring combined the beginning grower group with experienced growers for discussions on the challenges and successes of the past growing season as well as preparations for the coming season. Facilitated discussion included more general topics as well such as disease identification.

Goal 2: Add information to the FinBin database to make information more relevant for small and medium sized farms primarily growing specialty crops with gross farm sales under $50,000.
Fifteen Finpack analyses were submitted to the FinBin database for the 2015 and 2016 growing seasons (www.finbin.umn.edu). Over ten of those analyses were of people who were receiving scholarships from the Specialty Crops Block Grant. In addition, two growers started the process of doing an analysis and completed a balance sheet. Overall, 20 specialty crop farms had their finances submitted to the FinBin database in 2015 and 19 in 2016. The Summary Report of whole-farm finances generated in FinBin currently gives a realistic view of specialty crops farms in Minnesota: smaller

acreage farms with moderate incomes. In addition to the whole farm data, growers who received scholarships submitted enterprise analyses for assorted vegetables, pumpkins, blueberries, apples and strawberries. Beginning growers and growers wishing to expand their operations regularly use this data to help planning.

The goal of this program was to establish a strong foundation for success by giving growers the tools to make management decisions on their own as their businesses mature. All participating growers reported increasing their knowledge on many different topics from pest control to fertility management. The full impact will not be realized for another five years or more as the businesses develop and mature.

	Target – Participating Farms	Actual Participation	Average Increase in farm revenue
Year 1 - 2015	20 farms	21 farms	20%
Year 2 – 2016-2017	20 Farms	32 farms	20-24%

In 2016, the majority of farms had an increase in revenue over the previous year in spite of the May frost. 13 farms had an increase in revenue and 3 had a decrease in revenue, while the remaining 5 farms were either not producing or were harvesting for the first time. In 2017, four farms had no sales because they were planting, and another 4 farms held their first commercial harvest. Of the remaining farms, 3 had a decrease in revenue from the previous year, and the rest had an increase in revenue. The increase varied from a 10% increase in total sales to a doubling of sales from 2016 to 2017.

In addition, 50 people attended the field day in 2015 and 50 people registered for the field day in 2016. Heavy rain prevented a few of the people from attending the 2016 field day.

This project also included a one-day workshop for beginning berry growers. Twenty-two people attended that workshop on January 18, 2017. That workshop gave a general overview of what growers should know before starting a berry farm, basics of strawberry, raspberry and blueberry production, an overview of marketing strategies and information on organizing and starting a business venture. Some of those who attended the workshop also enrolled in the Specialty Crops Management Program and received additional individualized instruction.

At the beginning of this project the FinBin database included information from 48 farms classified as specialty crops, but many of them included other enterprises. At the end of this project 17 specialty crop farms were included in the database and all of them primarily produce specialty crops.

BENEFICIARIES

Groups benefitting from this project included the beginning growers as well as experienced growers who were able to participate in some of the group discussions. Pertinent information from observations during on-farm visits with the beginning growers was shared by the instructor with a larger specialty crop audience through an on-line IPM newsletter and conversations with other growers. Central Lakes College received increased exposure of and support for the Specialty Crops Management Program. The Minnesota Fruit and Vegetable Growers Association strengthened relationships with existing members and established relationships with new growers. Long-term

benefits should also accrue to institutions and consumers who will be able to purchase a continuing supply of local foods.

Financial information submitted to the University of Minnesota FinBin database helps to provide growers with realistic financial information that they can use and compare with their operations. Adding more information from farms that primarily grow specialty crops will provide better benchmark data for all of Minnesota's specialty crop operations and provide better comparative data for both beginning and established specialty crop producers.

Over the course of three growing seasons, 34 beginning farmers received scholarships that allowed them to enroll in the Specialty Crops program. Two of those growers only participated the first year of the program. In 2017, the 32 participating beginning farmers will have an approximate gross farm income of $651,500. Several producers are just planting this year and will have no income, while the largest farm will have an expected gross income of $95,000. Two of the beginning growers bought existing farm businesses, and their incomes should rise slowly over the next three years. The rest of the farms are start-ups, whose yearly sales should increase dramatically in the next three years as they increase their acreage, have a normal increase in sales, and as their blueberry, stone fruit or apple trees come into production. In three years, the same group could have approximately $950,000 in sales. Specialty crops are labor intensive, and the average producer spends 25% of their gross sales on labor. Therefore this year, the group will spend $162,875 on labor, which primarily will go to local high school and college students. In a few years, nearly $250,000 will be spent on labor.

Like all locally owned businesses, specialty crop producers benefit the local economy, and many of these businesses are in poor rural areas. Helping these growers succeed and increase production and sales helps the local economy.

LESSONS LEARNED

This program has been instrumental in keeping several of the beginning growers in business. Weather patterns and unexpected pest pressures can create tense situations for any grower. That anxiety is magnified for someone who has never experienced similar situations. For growers in this program, access to the instructor went beyond the on-farm visits. When faced with an unexpected situation like a hard freeze in May, they were able to contact the instructor for guidance. They followed practical, calm, and sound advice from the instructor and didn't lose the crop.

As one participant stated: "Books and internet can only go so far in solving real world challenges and having an instructor who will make on-site visits to help optimize our farming operation [is invaluable]." He went on to say "This program trains new farmers and helps to ensure the future of agriculture. We really don't know what we would have done without the Specialty Crops Program." "We can make decisions with confidence, knowing that even though our own experience is limited, experienced advice is available to us."

Another participant said "We have read many publications and books on specialty crops, but to have a specialist available to come to the farm and help custom tailor a plan has been the extra bump we needed to be successful. The instructor is a wealth of knowledge that has helped us avoid potential costly mistakes in our first few years farming strawberries and raspberries."

Because this program addresses the specific needs of individual farms and the instructor has multiple on-farm visits, the instructor is keenly aware of the farm's situation and the owner's ability to adapt and respond to given situations.

Even though the main emphasis was tailored on-farm instruction, we knew that the field days and networking would be important components of this program. Comments from growers included the following:

- It is helpful in building a network of fellow growers who we can interact with about similar challenges. In addition, field days allow us to actually meet at a feature grower's field and look over the operation, see their equipment and set up, and ask questions that can improve our own operation.
- We enjoy attending the field days. Going to other farms and hearing first hand from the farmer what works for them and what doesn't is priceless. It shapes what we want to attempt on our own farm, and what we would rather not. We went to a strawberry farm that uses high school kids for labor and heard from the farmer how he handles the kids, and now use high school students for labor on our farm and we have loyal, honest helpers that often stick around for several years taking ownership in our farm.
- To be able to meet with other growers in the same stages of farming, as well as those that have been growing similar crops for many years, is a huge benefit to us. We are able to make valuable connections with those in similar situations, help each other, and learn from others' experiences.
- This program has helped us immensely, not only providing someone to come to our farm and help us, but with providing so many learning opportunities that you cannot find elsewhere.

Goals for the number of farms participating in the beginning grower program were exceeded with very positive comments from participants. As the project neared its end, there was more interest in the program than scholarships available.

Project 9

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Submitted by: Angie Ambourn and Mark Abrahamson

Organization: Minnesota Department of Agriculture, Plant Protection Division

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PROJECT TITLE

Accelerating Integrated Pest Management Research & Extension to Fruit Producers: The Invasive Spotted Winged Drosophila

PROJECT SUMMARY

Spotted Wing Drosophila (SWD), an invasive pest throughout much of the U.S. fruit growing region, was first detected in Minnesota in 2012. As a result, producers of the state's soft fruit crops were faced with unexpectedly high damage levels and/or substantial increases in insecticide inputs and costs relative to pre-2012 production. To provide relief from this situation, we proposed applied studies with an aim toward improving management options for SWD within an integrated pest management (IPM) framework, specifically to: (1) determine the phenology (timing) and damage potential of SWD in soft fruit (e.g., raspberry, grapes) through trapping and fruit collections; (2) evaluation of a) treatment timing of foliar insecticides for SWD, and (b) sub-lethal effects on SWD when using organic insecticides; (3) determining economic losses associated with SWD infestation in treated and untreated fruit; and (4) timely Extension of research-based results, tailored to Minnesota producers. The primary focus was raspberries and grapes, although the results are generally applicable to all SW D-susceptible small fruits.

This project expanded on seed funds for an SWD trapping program provided to UMN by the UMN Rapid Agricultural Response Fund, North Central IPM Center (USDA), and USDA-NIFA (both in the Extension IPM Coordination and Support). None of the previous funds, however, support coordination of the program with MDA activities; this collaboration is essential for success, particularly in reaching the vast majority of MN growers via the MN Grown Program, the Organic growers of MN, and the Pest Alert program.

PROJECT APPROACH

Determine SWD phenology which will provide robust information regarding the distribution and abundance of SWD across Minnesota and specifically in relation to fall bearing raspberry during the growing season of each proposal year (GOAL). Current knowledge is lacking regarding when SWD is present in Minnesota and how this relates to infestation timing in specific crops (BENCHMARK). We will continue the collection of statewide trapping data via MDA field survey and conduct trapping and berry collections from 2 crops associated with SWD infestation, raspberry and grape, in Rosemount, and Hastings MN (TARGET) to generate standardized, quantitative measures of SWD distribution and abundance in Minnesota and related infestation levels of raspberry and grape (PERFORMANCE MEASURE).

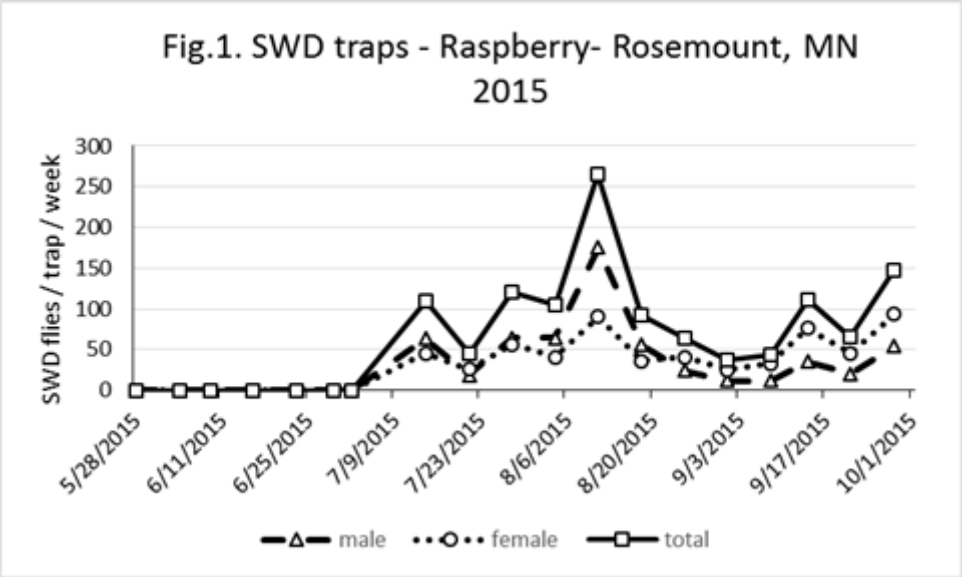
Address deficiencies in current pest management knowledge, by collecting high quality scientific data on SWD in Minnesota via scientific studies replicated during each proposal year (GOAL). Current management recommendations chiefly derive from experiences with other states (e.g., Michigan), with the majority of control options restricted to broad-spectrum insecticides and currently no established thresholds for making treatment decisions. Collectively, this indicates a lack of knowledge to make informed recommendations specific to our target beneficiary – Minnesota soft fruit growers (BENCHMARK). We will conduct replicated field trials in fall raspberries at the Rosemount Research and Outreach Center examining treatment timing using foliar insecticides relative to trap catches and phenological growth stages of fall bearing raspberry. The efficacy of tested insecticides against SWD will be evaluated, as well that of the application timing. In addition, yield data will be collected to provide estimates of economic loss/gain under various scenarios (TARGET). The economic benefits of

these treatments will be compared using yield estimates and costs of control (PERFORMANCE MEASURE).

Communicate project results and increase grower awareness through a variety of outlets (GOAL). Due to the short time that SWD has been in Minnesota, many growers are not very familiar with this pest and its impacts (BENCHMARK). Communications will include: (1) website updates (both through the SWD profiles on UMN's FruitEdge and the MDA main site), and (2) the Minnesota Fruit and Vegetable Growers Association and MDA's Fruit Growers Newsletters (and email lists) (TARGET). In addition, the resulting data was presented to the scientific community in the form of (1) at least one article published in a peer-reviewed scientific journal (e.g., Journal of Economic Entomology) (PERFORMANCE MEASURE).

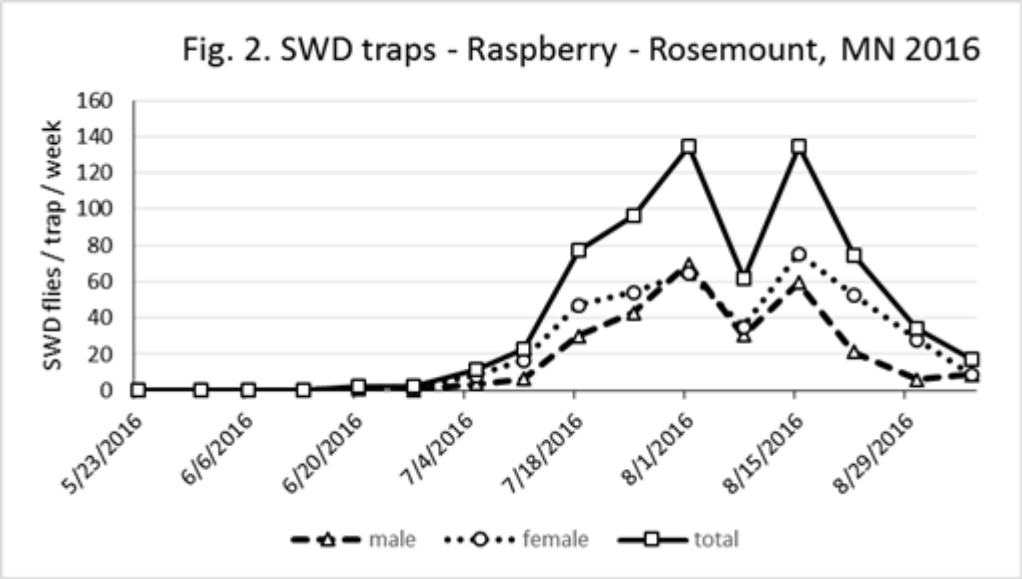
Significant results and conclusions:

1. The University of Minnesota maintained and serviced SWD traps in 5 locations across the Twin Cities metro in 2015 and 2016. Traps consisted of Pherocon Trece traps with a high specificity lure and apple cider vinegar bait with a drop of soap in the bottom of the trap. Traps were placed in a variety of fruit crops including summer and fall bearing raspberries, June bearing strawberries, day-neutral strawberries, blueberries, and grapes. Traps were emptied weekly and apple cider vinegar was replenished. Trap contents were returned to the lab and SWD flies were counted under a dissecting microscope. Data were recorded for the number of male and female SWD flies. Weekly trap catch updates were provided on the FruitEdge website (http://www.fruitedge.umn.edu/) along with pest management update articles. In 2015, fruit collections to assess SWD infestation were done as a part of objective 2 to maintain consistency with regards to whether fruit was sprayed or unsprayed. Traps were monitored from May 27 until Sep. 1, 2015 at most locations and continued until Sep. 28, 2015 at the Rosemount location (see Fig 1).



In 2016, fruit collections were done at most trapping locations to determine infestation rates of various fruit crops. In 2016, fruit collections indicated that peak infestation in June bearing strawberries occurred at 70% on July 5, blueberries occurred at 60% on July 25, and for summer raspberry occurred at 100% on July 18 in untreated raspberries and at 32% on July 25 in insecticide treated raspberries. Traps were monitored from May 23 through Sep. 6, 2016 (see Fig 2). Trap data indicated SWD was

present in all crops in both years. First trap catch occurred on June 23 and June 13 in 2015 and 2016, respectively. Peak trap catches occurred in most crops in early to mid-August except in 2015 for grapes and strawberries where peaks occurred 1-2 weeks later and earlier, respectively, than other fruit crops. Based on first trap catch dates and crop phenology, different fruit crops will potentially be at risk each season.



2. The University of Minnesota also conducted insecticide trials 2015 and 2016. In 2015 and 2016, 4 treatments with 4 replications were established in a 3 and 4 year old stand of 'Heritage' raspberry, respectively, at the Rosemount Research and Outreach Center. Treatments consisted of an untreated check, weekly sprays beginning at green berry stage, weekly sprays beginning at yellow berry stage, and weekly sprays beginning at ripe berry stage. Insecticide sprays consisted of Mustang Maxx (4 oz/ac) alternated with Delegate (3.9 oz/ac). In 2015 and 2016, respectively, Insecticide sprays were initiated for the green berry treatment on Aug. 5 and July 28, yellow berry treatment on Aug. 19 and Aug. 10, and ripe berry treatment on Aug. 24 and Aug. 16. Total sprays for each treatment in both years were green berry = 8, yellow berry = 6, and ripe berry = 5. Berry harvest began on Aug. 27 and Aug. 19 in 2015 and 2016, respectively, and harvests were conducted twice per week until Sep. 24 for a total of 9 harvest in 2015 and Sep. 9 for a total of 7 harvests in 2016. For each harvest date, 1 meter of row was harvested in each plot and the data collected at harvest included berry weight and berry marketability (Tables 1 and 2). Unmarketable fruit was described as the presence of discoloration, damaged druplets caused by disease, insect feeding, crumbly berries (pollination related), and water soaked appearance that is related to SWD larval feeding. Once per week during harvests, 10 berries were collected from each plot to assess the SWD infestation rate in each plot. SWD traps were placed in 3 replicates of the untreated check plots and all indicated a constant presence of SWD flies even after initiation of spraying (Figs 1 and 2). For both years there doesn't appear to be any advantage to spraying insecticide treatments regardless of the timing of initiation with no significant differences between the untreated check and insecticide treated plots for any of the variables measured (Tables 1 and 2).

Table 1. Impact of growth stage specific insecticide application programs on marketability of raspberries, associated loss, and infestation from SWD, Rosemount, MN 2015

Treatment[1]	Cumulative Proportion Marketable	Unmarketable	SWD infested berries	Total Weight (gr)	Total value/ac ($)[2]	Unmarketable loss/ac ($)[3]	Insecticide cost/ac ($)[4]
Green berry (5 applications)	0.75	0.25	0.72	170.22	4,733.27	1,195.40	239.06
Yellow berry (6 applications)	0.77	0.23	0.75	191.65	5,329.31	1,225.78	179.30
Ripe berry (8 applications)	0.72	0.28	0.66	186.40	5,183.28	1,353.06	164.05
Untreated Check	0.68	0.32	0.77	164.55	4,575.62	1,302.49	0.00
	NS	NS	NS	NS	NS	NS	

Means within columns followed by the same letter are not significantly different ($P > 0.05$), Protected Least significant difference Test (LSD). Mean proportion marketability berries infested data were transformed using the arcsine transformation to obtain mean separations using LSD (P=0.05); untransformed means are presented.
NS = not significant.
[1]Insecticide sprays initiated at the specified growth stages. Insecticides applied included Mustang Maxx at 4 oz/ac and Delegate at 3.9 oz/ac. Products were alternated to minimize insecticide resistance development.
[2]The value for raspberries was set at an average of $4.50/pint for pre-picked berries based on information from the 2015 NARBA Pricing Survey, http://www.raspberryblackberry.com/wp-content/uploads/2015BerryPricingSurveySummary.pdf.
[3]Unmarketable berry loss/ac is calculated using the proportion of unmarketable berries only and includes berries that are unmarketable based on visual defects but likely includes defects related to SWD larval feeding; however, it is not based on the proportion of SWD infested berries because SWD infestation at time of harvest is difficult to assess.
[4]Insecticide costs were obtained from a local supplier and were $1.31/oz for Mustang Maxx and $8.85/oz for Delegate; an application cost of $10/ac per application was assumed for fuel, tractor, spray equipment, labor, etc. Insecticide cost data were not subjected to statistical analysis.

Table 2. Impact of growth stage specific insecticide application programs on marketability of raspberries, associated loss, and infestation from SWD, Rosemount, MN 2016

Treatment[1]	Cumulative Proportion Marketable	Unmarketable	SWD infested berries	Total Weight (gr)	Total value/ac ($)[2]	Unmarketable loss/ac ($)[3]	Insecticide cost/ac ($)[4]
Green berry (5 applications)	0.66	0.34	0.51 b	123.12 a	3,423.64 a	1,448.07	209.80
Yellow berry (6 applications)	0.63	0.37	0.50 b	78.56 b	2,184.60 b	861.93	150.03
Ripe berry (8 applications)	0.63	0.37	0.40 b	62.21 b	1,729.83 b	813.03	134.78
Untreated check	0.66	0.34	0.85 a	95.10 ab	2,644.52 ab	1,033.44	0.00
	NS	NS				NS	

Means within columns followed by the same letter are not significantly different ($P > 0.05$), Protected Least significant difference Test (LSD). Mean proportion marketability berries infested data were transformed using the arcsine transformation to obtain mean separations using LSD (P=0.05); untransformed means are presented.
NS = not significant.
[1]Insecticide sprays initiated at the specified growth stages. Insecticides applied included Mustang Maxx at 4 oz/ac and Delegate at 3.9 oz/ac. Products were alternated to minimize insecticide resistance development.
[2]The value for raspberries was set at an average of $4.50/pint for pre-picked berries based on information from the 2015 NARBA Pricing Survey, http://www.raspberryblackberry.com/wp-content/uploads/2015BerryPricingSurveySummary.pdf.
[3]Unmarketable berry loss/ac is calculated using the proportion of unmarketable berries only and includes berries that are unmarketable based on visual defects but likely includes defects related to SWD larval feeding; however, it is not based on the proportion of SWD infested berries because SWD infestation at time of harvest is difficult to assess.
[4]Insecticide costs were obtained from a local supplier and were $1.31/oz for Mustang Maxx and $8.85/oz for Delegate; an application cost of $10/ac per application was assumed for fuel, tractor, spray equipment, labor, etc. Insecticide cost data were not subjected to statistical analysis.

b) On April 27, 2015, the efficacy of residual exposure of SWD to insecticides was tested by spraying a 35x10mm petri dish (both top and bottom of petri dishes were treated with insecticides) and allowing the dishes to dry for 30-60 minutes. Insecticides were sprayed at a rate of 50 gallons of water per acre. After dishes were dry a 0.5 ml piece of SWD diet was added to each dish to provide flies food and moisture. Exposure to residue was for 24 hours at which time all flies (dead and alive) were transferred to a clean vial with 5mls of diet until the trial was completed (17 days). Each replicate of each treatment had 5 male and 5 female SWD flies that were ~3 days old. Adult fly mortality was assessed at 1 DAT (4/28), 3 DAT (4/30), 7 DAT (5/4). Final numbers of adult SWD that emerged from the diet were measured 17 DAT (5/14). The trial consisted of 5 treatments and 6 replicates. Treatments consisted of the conventional insecticides Mustang Maxx (4 oz/ac) and Delegate (4.5 oz/ac) and the organic insecticides Pyganic 1.4 II EC (64 oz/ac) and Azera (56 oz/ac). An untreated check treatment was also included in the trial. Both Mustang Maxx and Delegate provide significantly higher mortality levels compared with the untreated check on all 3 evaluation dates (Table 3). Neither Pyganic nor Azera provided significantly higher mortality compared with the untreated check on any evaluation date. Because both Mustang Maxx and Delegate had 100% mortality of insecticide exposed flies, fly production after exposure was significantly less than the untreated check (Table 4). Azera had similar fly production to the untreated check while Pyganic had significantly greater fly production than the untreated check. Two noteworthy pieces of information to be derived from this trial include the presence of an emerged fly in the Mustang Maxx treatment (Table 4), a treatment that had resulted in 100% mortality of adult flies after initial exposure (Table 3), and the Pyganic treatment resulted in a significantly higher level of fly production after exposure to the insecticide than the untreated check with more than 1.5 times more flies produced (Table 4).

Table 3. Mean proportion of dead *Drosophila suzukii* (SWD) flies* exposed to residue in insecticide treated petri dishes.

		Mortality (proportion of dead flies)		
Treatment	Rate	Male	Female	Total
*1DAT***				
Mustang Maxx	4 oz / ac	1.00 a	1.00 a	1.00 a
Pyganic 1.4II EC	64 oz / ac	0.00 c	0.03 c	0.02 c
Azera	56 oz / ac	0.07 b	0.03 c	0.05 c
Delegate	4.5 oz / ac	1.00 a	1.00 a	1.00 a
Untreated Check	--	0.00 c	0.00 c	0.00 c
*3DAT***				
Mustang Maxx	4 oz / ac	1.00 a	1.00 a	1.00 a
Pyganic 1.4II EC	64 oz / ac	0.00 b	0.03 b	0.02 b
Azera	56 oz / ac	0.07 b	0.07 b	0.07 b
Delegate	4.5 oz / ac	1.00 a	1.00 a	1.00 a
Untreated Check	--	0.03 b	0.03 b	0.03 b
*7DAT***				
Mustang Maxx	4 oz / ac	1.00 a	1.00 a	1.00 a
Pyganic 1.4II EC	64 oz / ac	0.00 c	0.03 b	0.02 c
Azera	56 oz / ac	0.10 b	0.07 b	0.08 b
Delegate	4.5 oz / ac	1.00 a	1.00 a	1.00 a
Untreated Check	--	0.03 bc	0.03 b	0.03 bc

Means within columns followed by the same letter are not significantly different ($P > 0.05$), Protected Least significant difference Test (LSD). Mean proportion mortality data were transformed using the arcsine transformation to obtain mean separations using LSD (P=0.05); untransformed means are presented.

*Five male and five female flies were simultaneously exposed to dry insecticide residue in petri dishes for 24hrs with a total of 6 replicates for each treatment. After 24hrs all flies dead and alive were moved to clean vials with 5mls of artificial diet for an additional 17 days.
**DAT = days after treatment.

Table 4. Mean number of *Drosophila suzukii* (SWD) flies* emerged from artificial diet 17 days after an initial 24 hour exposure of adult flies to residue in insecticide treated petri dishes.

Treatment	Rate	Mean number of flies emerged from diet after 17 days Male	Female	Flies / Female
Mustang Maxx	4 oz / ac	0.00 c	0.17 c	0.03 c
Pyganic 1.4II EC	64 oz / ac	14.33 a	18.67 a	6.60 a
Azera	56 oz / ac	4.83 b	8.67 b	2.70 b
Delegate	4.5 oz / ac	0.00 c	0.00 c	0.00 c
Untreated Check	--	7.50 b	11.33 ab	3.77 b

Means within columns followed by the same letter are not significantly different ($P > 0.05$), Protected Least significant difference Test (LSD). Mean number of emerged fly data were transformed using the square root transformation to obtain mean separations using LSD (P=0.05); untransformed means are presented.
*Five male and five female flies were simultaneously exposed to dry insecticide residue in petri dishes for 24hrs with a total of 6 replicates for each treatment. After 24hrs all flies, dead and alive, were moved to clean vials with 5mls of artificial diet for an additional 17 days.
**DAT = days after treatment.

3. The University also determined the economic losses associated with treated and untreated plots. An average price / pint of raspberries for Minnesota was determined to be $4.50 / pint based on a pricing survey in 2015 from the North American Raspberry and Blackberry Association (NARBA) (http://www.raspberryblackberry.com/wp-content/uploads/2015BerryPricingSurveySummary.pdf). One meter subplot data were used to generate estimates of total value of raspberries per acre, and is based on the number of harvests conducted for each season. The number of pints per subplot was calculated based on subsamples of harvested raspberries using a paper pint container to obtain an equivalent weight of 217.50 grams / pint. Loss / acre was based on unmarketable berries as described in Obj. 2 (Tables 1 and 2). Data are also presented for the proportion of berries found to be infested with SWD larvae; however, these data are not incorporated into the economic calculations as these berries can visually appear uninfested or undamaged. How to calculate direct losses based on a particular level of infestation in the berries is a point that needs further investigation. In 2015, value / acre and loss / acre were not significantly different for insecticide treatments when compared with the untreated check, regardless of the growth stage at which applications began. Loss / acre was roughly 25-30% of the total crop value (Tables 1). Cost of insecticide applications would further increase losses but were not included in the loss calculation. In 2016, loss / acre was approximately 40-45% of total value and yields were lower than in 2015, likely due to excessive rains that shortened the harvest season by 2 harvests. As in 2015, there were no significant differences in marketability of berries compared with the untreated check but berry infestation levels for all insecticide treatment regimes were significantly lower compared to the untreated check (Table 2). Similar to 2015, the insecticide treatments did not provide significant increases in total value / acre but the green berry treatment did have significantly higher value / acre compared to the yellow and ripe berry treatments (Table 2).

4. As data were generated from Objs. 1-3, extension materials and updates were produced to use in making management recommendations at grower meetings and on the FruitEdge website (http://www.fruitedge.umn.edu/) . Trapping data (http://www.fruitedge.umn.edu/swdtrap) and pest updates during the summer were made available on the FruitEdge website. In addition to online updates and recommendations, an info-graphic fact sheet was developed to inform home / small scale growers in the Twin Cities Metro area about the potential impact of SWD and this document is currently being translated to Spanish, Hmong, and Somali languages. The English version of the info graphic fact sheet is under Objective 4 of question #7.

5. MDA and UMN worked jointly work to develop and maintain a grower/volunteer based trapping network for SWD with MDA taking the lead on that work. Commercial and hobby growers were solicited for monitoring a trap or traps and sharing data with the network. Most of the network organization will occur in the late winter and spring of each proposal year (January - May). Participants in the network were provided supplies or instructions on how to construct traps as well as technical support for maintaining the traps and identifying captures. Data from the network was used to create regularly updated maps throughout the growing season to help anticipate where SWD problems may develop in each proposal year (May - October). This component also provided a benefit to the individual monitors who are now better positioned to anticipate problems developing in their own crops than if they were not monitoring for SWD. As more individuals become familiar with monitoring for this pest, there is the potential for the monitoring network to function beyond the lifetime of this project.
This was conducted for 3 field seasons. Each year volunteers were recruited, traps kits were mailed to them with instructions for monitoring and reporting SWD. Contact (weekly updates, questions and timely newly developments shared) was maintained weekly with all growers which enforced the importance of yearly early detection.

1. *Present the significant contributions and role of project partners in the project.*

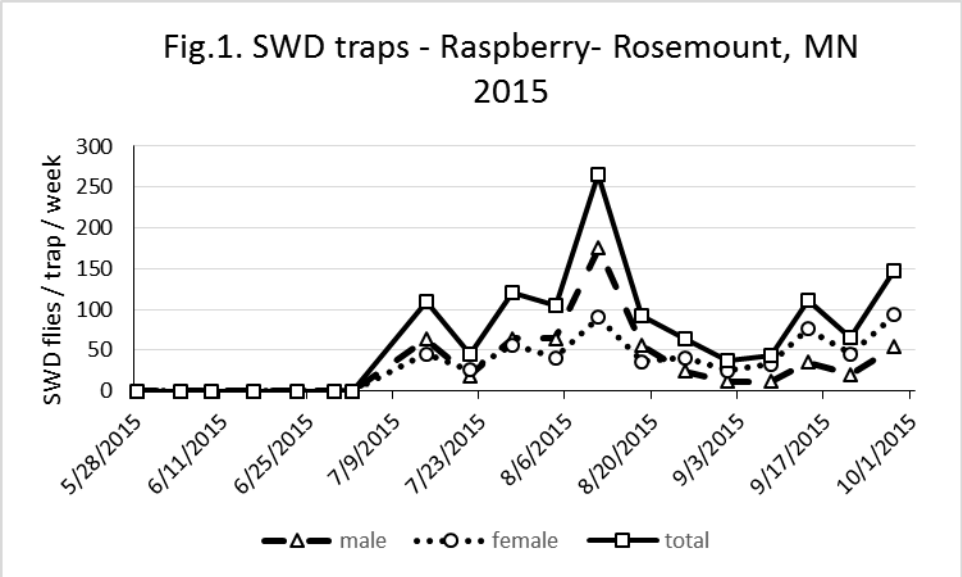
University of Minnesota
The University of Minnesota contributed phenology data that was in addition to MDA's volunteer monitoring network detections (see results above) to inform soft berry growers across the state as to when they should be on the lookout for SWD to show up in their crops.

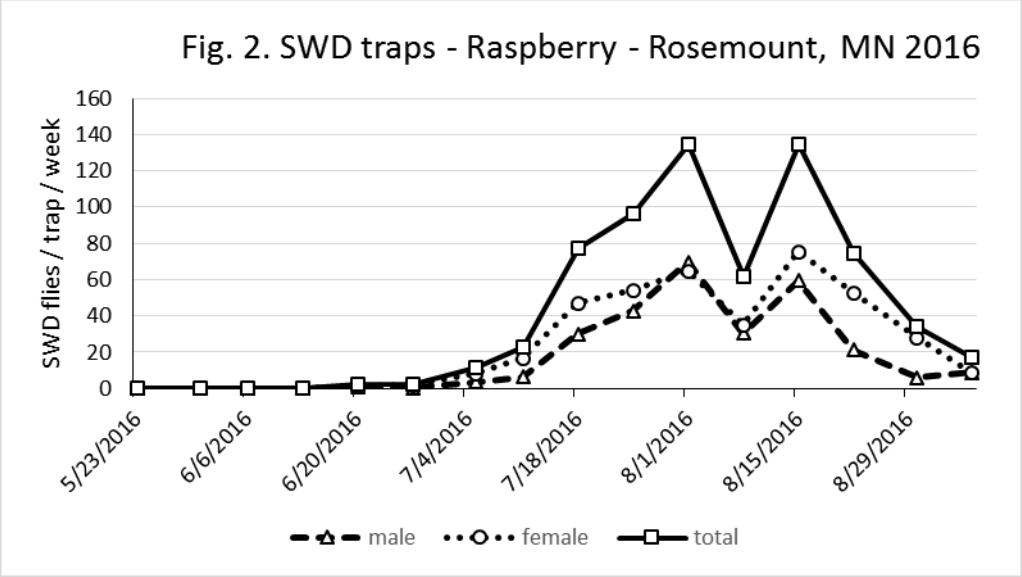
The University of Minnesota used established raspberry and grape crops in Rosemount and Hastings, respectively, for SWD phenology and treatment timing research and conduct field trials during the growing seasons of both project years.
They also conducted insecticide trials (see results above) to improve chemical recommendations for chemical control of SWD and determined economic losses associated with chemically treating SWD plots vs no treatment (see results above). The University also produced and informational handout in multiple languages with identification and management recommendations (see above). The University also maintained and update their FruitEdge website weekly throughout field seasons during the project.

The University of Minnesota took the lead on producing a scientific journal article presenting research results.

Objective 1 - Determine phenology and damage potential of SWD in soft fruit through trapping and fruit collection:

The University of Minnesota maintained and serviced SWD traps in 5 locations across the Twin Cities metro in 2015 and 2016. Traps consisted of Pherocon Trece traps with a high specificity lure and apple cider vinegar bait with a drop of soap in the bottom of the trap. Traps were placed in a variety of fruit crops including summer and fall bearing raspberries, June bearing strawberries, day-neutral strawberries, blueberries, and grapes. Traps were emptied weekly and apple cider vinegar was replenished. Trap contents were returned to the lab and SWD flies were counted under a dissecting microscope. Data were recorded for the number of male and female SWD flies. Weekly trap catch updates were provided on the FruitEdge website (http://www.fruitedge.umn.edu/) along with pest management update articles. In 2015, fruit collections to assess SWD infestation were done as a part of objective 2 to maintain consistency with regards to whether fruit was sprayed or unsprayed. Traps were monitored from May 27 until Sep. 1, 2015 at most locations and continued until Sep. 28, 2015 at the Rosemount location (see Fig 1). In 2016, fruit collections were done at most trapping locations to determine infestation rates of various fruit crops. In 2016, fruit collections indicated that peak infestation in June bearing strawberries occurred at 70% on July 5, blueberries occurred at 60% on July 25, and for summer raspberry occurred at 100% on July 18 in untreated raspberries and at 32% on July 25 in insecticide treated raspberries. Traps were monitored from May 23 through Sep. 6, 2016 (see Fig 2). Trap data indicated SWD was present in all crops in both years. First trap catch occurred on June 23 and June 13 in 2015 and 2016, respectively. Peak trap catches occurred in most crops in early to mid-August except in 2015 for grapes and strawberries where peaks occurred 1-2 weeks later and earlier, respectively, than other fruit crops. Based on first trap catch dates and crop phenology, different fruit crops will potentially be at risk each season.





Objective 2 – Evaluate a) treatment timing for management of SWD using foliar insecticides, b)sub-lethal effects of organic insecticide on SWD:

a) In 2015 and 2016, 4 treatments with 4 replications were established in a 3 and 4 year old stand of 'Heritage' raspberry, respectively, at the Rosemount Research and Outreach Center. Treatments consisted of an untreated check, weekly sprays beginning at green berry stage, weekly sprays beginning at yellow berry stage, and weekly sprays beginning at ripe berry stage. Insecticide sprays consisted of Mustang Maxx (4 oz/ac) alternated with Delegate (3.9 oz/ac). In 2015 and 2016, respectively, Insecticide sprays were initiated for the green berry treatment on Aug. 5 and July 28, yellow berry treatment on Aug. 19 and Aug. 10, and ripe berry treatment on Aug. 24 and Aug. 16. Total sprays for each treatment in both years were green berry = 8, yellow berry = 6, and ripe berry = 5. Berry harvest began on Aug. 27 and Aug. 19 in 2015 and 2016, respectively, and harvests were conducted twice per week until Sep. 24 for a total of 9 harvest in 2015 and Sep. 9 for a total of 7 harvests in 2016. For each harvest date, 1 meter of row was harvested in each plot and the data collected at harvest included berry weight and berry marketability (Tables 1 and 2). Unmarketable fruit was described as the presence of discoloration, damaged druplets caused by disease, insect feeding, crumbly berries (pollination related), and water soaked appearance that is related to SWD larval feeding. Once per week during harvests, 10 berries were collected from each plot to assess the SWD infestation rate in each plot. SWD traps were placed in 3 replicates of the untreated check plots and all indicated a constant presence of SWD flies even after initiation of spraying (Figs 1 and 2). For both years there doesn't appear to be any advantage to spraying insecticide treatments regardless of the timing of initiation with no significant differences between the untreated check and insecticide treated plots for any of the variables measured (Tables 1 and 2).

Table 1. Impact of growth stage specific insecticide application programs on marketability of raspberries, associated loss, and infestation from SWD, Rosemount, MN 2015

Treatment[1]	Cumulative Proportion			Total Weight (gr)	Total value/ac ($)[2]	Unmarketable loss/ac ($)[3]	Insecticide cost/ac ($)[4]
	Marketable	Unmarketable	SWD infested berries				
Green berry (5 applications)	0.75	0.25	0.72	170.22	4,733.27	1,195.40	239.06
Yellow berry (6 applications)	0.77	0.23	0.75	191.65	5,329.31	1,225.78	179.30
Ripe berry (8 applications)	0.72	0.28	0.66	186.40	5,183.28	1,353.06	164.05
Untreated Check	0.68	0.32	0.77	164.55	4,575.62	1,302.49	0.00
	NS	NS	NS	NS	NS	NS	

Means within columns followed by the same letter are not significantly different ($P > 0.05$), Protected Least significant difference Test (LSD). Mean proportion marketability berries infested data were transformed using the arcsine transformation to obtain mean separations using LSD (P=0.05); untransformed means are presented.
NS = not significant.
[1]Insecticide sprays initiated at the specified growth stages. Insecticides applied included Mustang Maxx at 4 oz/ac and Delegate at 3.9 oz/ac. Products were alternated to minimize insecticide resistance development.
[2]The value for raspberries was set at an average of $4.50/pint for pre-picked berries based on information from the 2015 NARBA Pricing Survey, http://www.raspberryblackberry.com/wp-content/uploads/2015BerryPricingSurveySummary.pdf.
[3]Unmarketable berry loss/ac is calculated using the proportion of unmarketable berries only and includes berries that are unmarketable based on visual defects but likely includes defects related to SWD larval feeding; however, it is not based on the proportion of SWD infested berries because SWD infestation at time of harvest is difficult to assess.
[4]Insecticide costs were obtained from a local supplier and were $1.31/oz for Mustang Maxx and $8.85/oz for Delegate; an application cost of $10/ac per application was assumed for fuel, tractor, spray equipment, labor, etc. Insecticide cost data were not subjected to statistical analysis.

Table 2. Impact of growth stage specific insecticide application programs on marketability of raspberries, associated loss, and infestation from SWD, Rosemount, MN 2016

Treatment[1]	Cumulative Proportion		SWD infested berries	Total Weight (gr)	Total value/ac ($)[2]	Unmarketable loss/ac ($)[3]	Insecticide cost/ac ($)[4]
	Marketable	Unmarketable					
Green berry (5 applications)	0.66	0.34	0.51 b	123.12 a	3,423.64 a	1,448.07	209.80
Yellow berry (6 applications)	0.63	0.37	0.50 b	78.56 b	2,184.60 b	861.93	150.03
Ripe berry (8 applications)	0.63	0.37	0.40 b	62.21 b	1,729.83 b	813.03	134.78
Untreated check	0.66	0.34	0.85 a	95.10 ab	2,644.52 ab	1,033.44	0.00
	NS	NS				NS	

Means within columns followed by the same letter are not significantly different ($P > 0.05$), Protected Least significant difference Test (LSD). Mean proportion marketability berries infested data were transformed using the arcsine transformation to obtain mean separations using LSD (P=0.05); untransformed means are presented.
NS = not significant.
[1]Insecticide sprays initiated at the specified growth stages. Insecticides applied included Mustang Maxx at 4 oz/ac and Delegate at 3.9 oz/ac. Products were alternated to minimize insecticide resistance development.
[2]The value for raspberries was set at an average of $4.50/pint for pre-picked berries based on information from the 2015 NARBA Pricing Survey, http://www.raspberryblackberry.com/wp-content/uploads/2015BerryPricingSurveySummary.pdf.

[3]Unmarketable berry loss/ac is calculated using the proportion of unmarketable berries only and includes berries that are unmarketable based on visual defects but likely includes defects related to SWD larval feeding; however, it is not based on the proportion of SWD infested berries because SWD infestation at time of harvest is difficult to assess.
[4]Insecticide costs were obtained from a local supplier and were $1.31/oz for Mustang Maxx and $8.85/oz for Delegate; an application cost of $10/ac per application was assumed for fuel, tractor, spray equipment, labor, etc. Insecticide cost data were not subjected to statistical analysis.

b) On April 27, 2015, the efficacy of residual exposure of SWD to insecticides was tested by spraying a 35x10mm petri dish (both top and bottom of petri dishes were treated with insecticides) and allowing the dishes to dry for 30-60 minutes. Insecticides were sprayed at a rate of 50 gallons of water per acre. After dishes were dry a 0.5 ml piece of SWD diet was added to each dish to provide flies food and moisture. Exposure to residue was for 24 hours at which time all flies (dead and alive) were transferred to a clean vial with 5mls of diet until the trial was completed (17 days). Each replicate of each treatment had 5 male and 5 female SWD flies that were ~3 days old. Adult fly mortality was assessed at 1 DAT (4/28), 3 DAT (4/30), 7 DAT (5/4). Final numbers of adult SWD that emerged from the diet were measured 17 DAT (5/14). The trial consisted of 5 treatments and 6 replicates. Treatments consisted of the conventional insecticides Mustang Maxx (4 oz/ac) and Delegate (4.5 oz/ac) and the organic insecticides Pyganic 1.4 II EC (64 oz/ac) and Azera (56 oz/ac). An untreated check treatment was also included in the trial. Both Mustang Maxx and Delegate provide significantly higher mortality levels compared with the untreated check on all 3 evaluation dates (Table 3). Neither Pyganic nor Azera provided significantly higher mortality compared with the untreated check on any evaluation date. Because both Mustang Maxx and Delegate had 100% mortality of insecticide exposed flies, fly production after exposure was significantly less than the untreated check (Table 4). Azera had similar fly production to the untreated check while Pyganic had significantly greater fly production than the untreated check. Two noteworthy pieces of information to be derived from this trial include the presence of an emerged fly in the Mustang Maxx treatment (Table 4), a treatment that had resulted in 100% mortality of adult flies after initial exposure (Table 3), and the Pyganic treatment resulted in a significantly higher level of fly production after exposure to the insecticide than the untreated check with more than 1.5 times more flies produced (Table 4).

Table 3. Mean proportion of dead *Drosophila suzukii* (SWD) flies* exposed to residue in insecticide treated petri dishes.

		Mortality (proportion of dead flies)		
Treatment	Rate	Male	Female	Total
*1DAT**				
Mustang Maxx	4 oz / ac	1.00 a	1.00 a	1.00 a
Pyganic 1.4II EC	64 oz / ac	0.00 c	0.03 c	0.02 c
Azera	56 oz / ac	0.07 b	0.03 c	0.05 c
Delegate	4.5 oz / ac	1.00 a	1.00 a	1.00 a
Untreated Check	--	0.00 c	0.00 c	0.00 c
*3DAT**				
Mustang Maxx	4 oz / ac	1.00 a	1.00 a	1.00 a
Pyganic 1.4II EC	64 oz / ac	0.00 b	0.03 b	0.02 b
Azera	56 oz / ac	0.07 b	0.07 b	0.07 b
Delegate	4.5 oz / ac	1.00 a	1.00 a	1.00 a
Untreated Check	--	0.03 b	0.03 b	0.03 b
*7DAT**				

Mustang Maxx	4 oz / ac	1.00 a	1.00 a	1.00 a
Pyganic 1.4II EC	64 oz / ac	0.00 c	0.03 b	0.02 c
Azera	56 oz / ac	0.10 b	0.07 b	0.08 b
Delegate	4.5 oz / ac	1.00 a	1.00 a	1.00 a
Untreated Check	--	0.03 bc	0.03 b	0.03 bc

Means within columns followed by the same letter are not significantly different ($P > 0.05$), Protected Least significant difference Test (LSD). Mean proportion mortality data were transformed using the arcsine transformation to obtain mean separations using LSD (P=0.05); untransformed means are presented.
*Five male and five female flies were simultaneously exposed to dry insecticide residue in petri dishes for 24hrs with a total of 6 replicates for each treatment. After 24hrs all flies dead and alive were moved to clean vials with 5mls of artificial diet for an additional 17 days.
**DAT = days after treatment.

Table 4. Mean number of *Drosophila suzukii* (SWD) flies* emerged from artificial diet 17 days after an initial 24 hour exposure of adult flies to residue in insecticide treated petri dishes.

		Mean number of flies emerged from diet after 17 days		
Treatment	Rate	Male	Female	Flies / Female
Mustang Maxx	4 oz / ac	0.00 c	0.17 c	0.03 c
Pyganic 1.4II EC	64 oz / ac	14.33 a	18.67 a	6.60 a
Azera	56 oz / ac	4.83 b	8.67 b	2.70 b
Delegate	4.5 oz / ac	0.00 c	0.00 c	0.00 c
Untreated Check	--	7.50 b	11.33 ab	3.77 b

Means within columns followed by the same letter are not significantly different ($P > 0.05$), Protected Least significant difference Test (LSD). Mean number of emerged fly data were transformed using the square root transformation to obtain mean separations using LSD (P=0.05); untransformed means are presented.
*Five male and five female flies were simultaneously exposed to dry insecticide residue in petri dishes for 24hrs with a total of 6 replicates for each treatment. After 24hrs all flies, dead and alive, were moved to clean vials with 5mls of artificial diet for an additional 17 days.
**DAT = days after treatment.

Objective 3 – Determine economic losses associated with SWD infestation in treated and untreated fruit:

Data for berry yield and marketability from Obj. 2 were used to determine the economic losses associated with treated and untreated plots. An average price / pint of raspberries for Minnesota was determined to be $4.50 / pint based on a pricing survey in 2015 from the North American Raspberry and Blackberry Association (NARBA) (http://www.raspberryblackberry.com/wp-content/uploads/2015BerryPricingSurveySummary.pdf). One meter subplot data were used to generate estimates of total value of raspberries per acre, and is based on the number of harvests conducted for each season. The number of pints per subplot was calculated based on subsamples of harvested raspberries using a paper pint container to obtain an equivalent weight of 217.50 grams / pint. Loss / acre was based on unmarketable berries as described in Obj. 2 (Tables 1 and 2). Data are also presented for the proportion of berries found to be infested with SWD larvae; however, these data are not incorporated into the economic calculations as these berries can visually appear uninfested or undamaged. How to calculate direct losses based on a particular level of infestation in the berries is a point that needs further investigation. In 2015, value / acre and loss / acre were not significantly different for insecticide treatments when compared with the untreated check, regardless of the growth stage at which applications began. Loss / acre was roughly 25-30% of the total crop value (Tables 1). Cost of insecticide applications would further increase losses but were not included in the loss calculation. In 2016, loss / acre was approximately 40-45% of total value and yields were lower

than in 2015, likely due to excessive rains that shortened the harvest season by 2 harvests. As in 2015, there were no significant differences in marketability of berries compared with the untreated check but berry infestation levels for all insecticide treatment regimes were significantly lower compared to the untreated check (Table 2). Similar to 2015, the insecticide treatments did not provide significant increases in total value / acre but the green berry treatment did have significantly higher value / acre compared to the yellow and ripe berry treatments (Table 2).

Objective 4 – Disseminate research information and management recommendations to Minnesota soft fruit producers across production scales and socioeconomic boundaries (e.g., through translation of Extension materials into Spanish and Hmong).

As data have been generated from Objs. 1-3, extension materials and updates have been produced to use in making management recommendations at grower meetings and on the FruitEdge website (http://www.fruitedge.umn.edu/) . Trapping data (http://www.fruitedge.umn.edu/swdtrap) and pest updates during the summer were made available on the FruitEdge website. In addition to online updates and recommendations, an info-graphic fact sheet was developed to inform home / small scale growers in the Twin Cities Metro area about the potential impact of SWD and this document is currently being translated to Spanish, Hmong, and Somali languages. The English version of the info graphic fact sheet is attached.

Spotted Wing Drosophila

Drosophila suzukii (SWD)

UNIVERSITY OF MINNESOTA

Help MN! If you think you have found Spotted Wing Drosophila contact the Minnesota Department of Agriculture at arrest.the.pest@state.mn.us

Key Facts

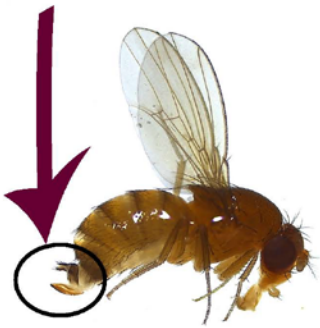
~While SWD is a Vinegar Fly, it is similar in appearance to common fruit flies in MN
~Attacks MANY fruit crops: strawberries, raspberries, blueberries
~Potential to infest UNDAMAGED, RIPENING OR RIPE fruit, where common fruit fly infests only rotting fruit

Not native to the United States

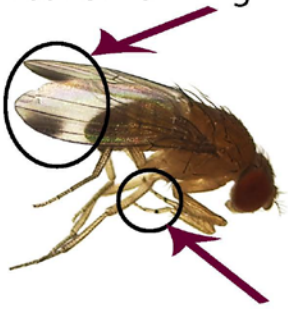
~Originated in SE Asia
~Found in California in 2008
~First detected in MN in 2012
~As of 2013 most U.S. States infested

Similar to the common fruit fly but...

Females have large ovipositor



Males have black spots on first vein of wing



And two black bands on each foreleg

2013 United States Infestation Map

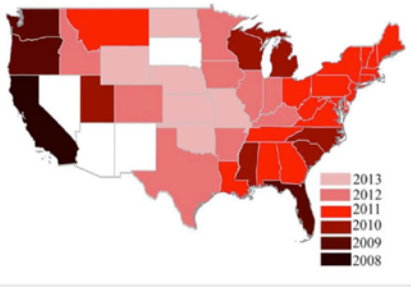
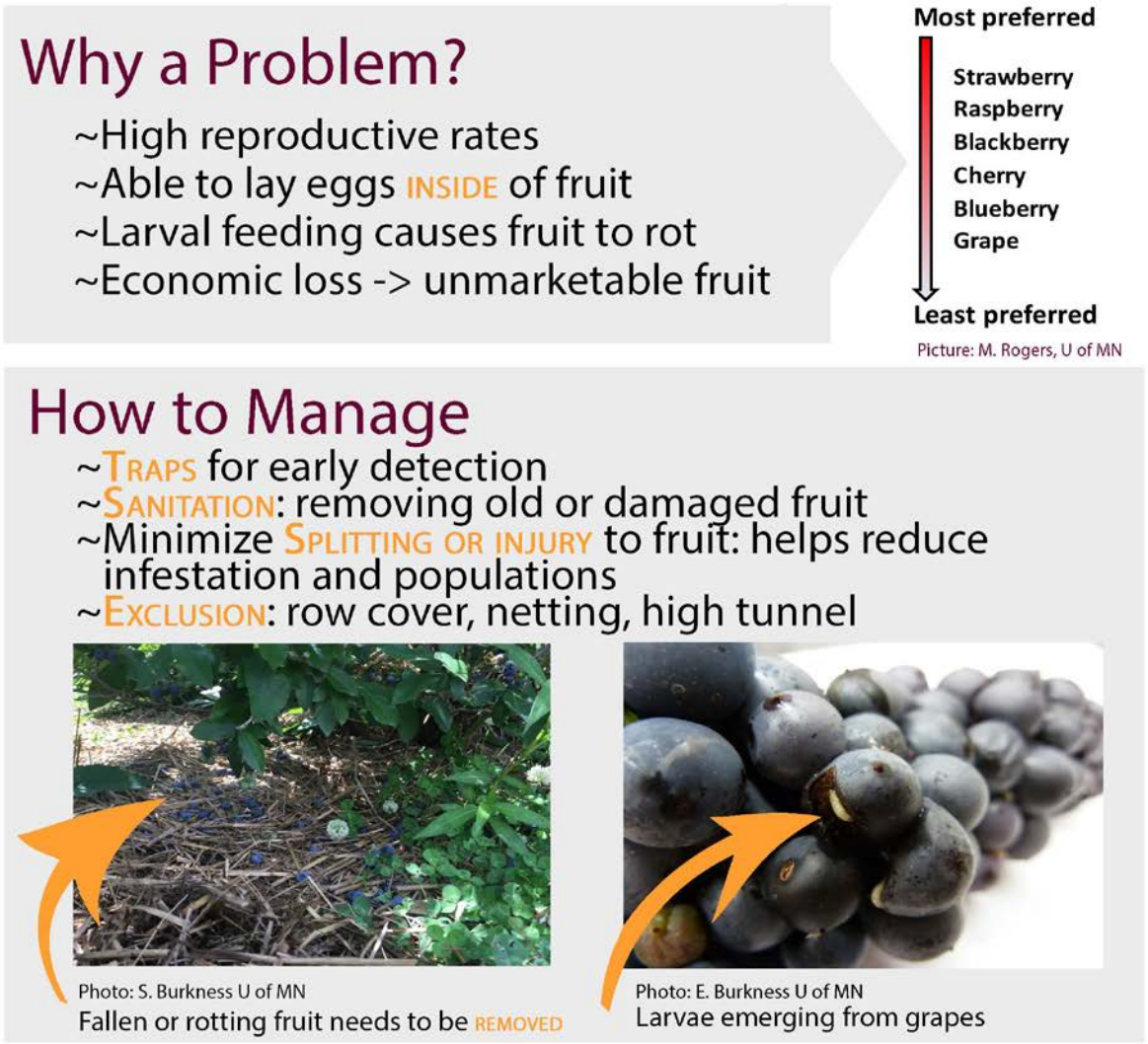


Figure from H. Burrack, NC State University

Most counties in MN have confirmed presence of SWD



Goal: Communicate with cooperators (growers, volunteers) regarding SWD monitoring. Assemble and send supplies to same.

Progress:

Year 1 Completed:
U of M: Five trapping locations were established in the Twin Cities metro with fruit growers and on the University of Minnesota Research and Outreach Center in Rosemount, MN.
MDA: We initiated a volunteer network of growers to monitor for SWD. Potential cooperators were identified from soft fruit growers via a variety of sources such as Minnesota Grown Directory, other growers we have worked with in the past, nursery and county agriculture inspectors and the University of Minnesota extension offices. Requests for volunteer participants were also sent out in a newsletter to master gardeners and in the Plant Pest Insider (monthly MDA newsletter). Volunteers were contacted by phone and/or email early spring 2015. Trap supplies were purchased and assembled during this same time period. Most traps and directions were mailed out to the growers by early June 2015 however, others were mailed out periodically throughout the season as we recruited new volunteers in counties we were missing. Traps used were the same as those described in Objective 1.

Year 2 Completed:
U of M: In 2016, 5 trapping locations were established in the Twin Cities metro with fruit growers and on the University of Minnesota Research and Outreach Center in Rosemount, MN. Trap data was collected weekly to establish SWD phenology in several different fruit crops and fruit collections were made to assess SWD infestation levels throughout the fruiting period of each crop.
MDA: In year two of the volunteer SWD survey, growers who participated in year one and some new growers were contacted by phone and/or email in early spring. We used the same sources to find new growers as in 2015. Requests for volunteer participants were also sent out in a newsletter to master gardeners and in the MDA Plant Pest Insider. Trap supplies were purchased and assembled during this same time period. Most traps and directions were mailed out to the growers by the end of May 2016 so that growers could get an earlier start on their monitoring compared to 2015. Other traps were mailed out periodically throughout the season as we recruited new volunteers in counties we were missing. Traps used were the same as those described in Objective 1.

Year 3 (Final) Completed:
UMN: All work was complete in 2016
MDA: In the final year of the volunteer SWD survey, growers who participated in year one and some new growers were contacted by phone and/or email in early spring. We used the same sources to find new growers as in 2015 and 2016. Requests for volunteer participants were also sent out in a newsletter to master gardeners and in the MDA Plant Pest Insider. Trap supplies were purchased and assembled during this same time period. Most traps and directions were mailed out to the growers by the end of May 2016 so that growers could get an early start on their monitoring. Other traps were mailed out periodically throughout the season as we recruited new volunteers in counties we were missing. Traps used were the same as those described in Objective 1.

Goal: Work with cooperators to obtain regular data from traps and update web-based maps.
Progress:
Year 1 Completed:
U of M: Trap data was collected from 5 trap locations in the Twin Cities metro on a weekly basis and data were summarized and presented on the FruitEdge website (http://www.fruitedge.umn.edu/).
MDA: Cooperators were asked to monitor the traps each week and report back to MDA either by email if the traps were empty or they had a digital photo of an adult to submit or by sending in the yellow sticky cards for confirmation. Minnesota Department of Agriculture staff updated the SWD web page and on-line county map weekly. Growers were sent a weekly email update from June 8, 2015 thru

September 3, 2015. To protect privacy the MDA online map only shows a positive find at the county level; growers were contacted individually to notify them if they were infested with SWD. The MDA map can be found here http://www.mda.state.mn.us/en/plants/insects/swd/swdsurvey.aspx.

Summary from 2015:
63 volunteers from 44 counties participated in the SWD survey during 2015. These volunteers were responsible for confirmation of SWD activity in 13 counties. SWD activity in an additional 3 counties was confirmed through other survey work and 7 counties were confirmed through reports to "Arrest the Pest". SWD activity was reported in an additional 8 counties but could not be confirmed by the MDA. The first confirmation of the summer was made by the University of Minnesota in Dakota and Washington Counties during the week of June 23. Rock County was also reported around this same time. The latest confirmation of the year was during the week of August 19 from Houston County.

Year 2 Completed:
U of M: Trap data was collected from 5 trap locations in the Twin Cities metro on a weekly basis and data were summarized and presented on the FruitEdge website (http://www.fruitedge.umn.edu/).

MDA: In 2016, cooperators were again asked to monitor the traps weekly and report back either by email if the traps were empty or they had a digital photo of an adult to submit or by sending in the yellow sticky cards for confirmation. Minnesota Department of Agriculture staff updated the SWD web page and on-line county map weekly. Growers were sent a weekly email update from early June 2016 through the end of August 2016. Growers were also given the University of Minnesota's IPM weekly newsletter which gave them additional information. To protect privacy the MDA online map only shows a positive find at the county level; growers were contacted individually to notify them if they were infested with SWD. The MDA map can be found here http://www.mda.state.mn.us/en/plants/insects/swd/swdsurvey.aspx.

2016 updates published online:

- Update for the week of June 10: A few traps have come in to MDA, no SWD have been detected as of yet.
- Update for the week of June 17: The University of Minnesota confirmed spotted wing drosophila activity this week in Waverly (Wright County), Rosemount (Dakota County), Forest Lake (Washington County) and Northfield (Rice County). This is about 10 days earlier than the first finds in 2015.
- Update for the week of June 24: SWD has been confirmed in Houston County in addition to the four counties reported last week. SWD was also reported in Sherburne and Ramsey Counties. The U of M reports significant increases in catches at some sites including Houston, Dakota and Wright Counties.
- Update for the week of July 1: SWD was confirmed in Douglas, Murray, Rock and Stearns Counties this week. Also, the U of M reports significant increases in catches again this week at sites in Anoka, Dakota, Houston and Washington Counties.
- Update for the week of July 8: SWD numbers continue to increase and activity was confirmed in the following counties this week: Hennepin, Meeker, Olmsted, Pipestone, Ramsey, Scott and Sherburne
- Update for the week of July 15: SWD activity was confirmed in the following counties this week: Aitkin, Cass and Winona.

- Update for the week of July 22: SWD activity was confirmed in the following counties this week: Carver, Clearwater, Crow Wing, Isanti, McLeod, Mille Lacs, Olmsted, Roseau and St Louis.
- Update for the week of July 29: SWD activity was confirmed in the following counties this week: Benton, Carlton and Fillmore.
- Update for the week of August 5: SWD activity was not confirmed in any new counties this week.
- Update for the week of August 12: SWD activity was confirmed in Pine County this week.
- Update for the week of August 19: SWD activity was not found in any new counties this week.

Year 3 Complete
U of M: Completed in 2016
MDA: In 2017, cooperators were again asked to monitor the traps weekly and report back either by email if the traps were empty or they had a digital photo of an adult to submit or by sending in the yellow sticky cards for confirmation. Minnesota Department of Agriculture staff updated the SWD web page and on-line county map weekly. Growers were sent a weekly email update from early June 2016 through the end of August 2016. Growers were also given the University of Minnesota's IPM weekly newsletter which gave them additional information. To protect privacy the MDA online map only shows a positive find at the county level; growers were contacted individually to notify them if they were infested with SWD. The MDA map can be found here
http://www.mda.state.mn.us/en/plants/insects/swd/swdsurvey.aspx

2017 updates published online:

- Week of August 28 - SWD captured in Carver and Clearwater Counties.
- Week of August 14 - SWD captured in Todd County.
- Week of July 31 - SWD captured in Benson and Goodhue Counties.
- Week of July 24 - SWD captured in Cass, Cook, Douglas and Marshall Counties.
- Week of July 17 - SWD captured in Anoka and Itasca Counties.
- Week of July 10 - SWD captured in Aitkin, Pipestone and Sherburne Counties.
- Week of July 3 - SWD captured in Meeker and Mille Lacs Counties.
- Week of June 26 - Spotted wing drosophila captured in Goodhue County.
- Week of June 19 - Spotted wing drosophila captured in Anoka, Dakota, Douglas, Washington and Watonwan Counties.
- A total of 33 sites in 26 counties are now being monitored with traps by volunteers this year.

Goal: Establish experimental plots in fall bearing raspberries and grapes for field based phenology experiments.
Progress:

- Year 1 - Plots were established in 3 year old 'Heritage' raspberry and the trial was initiated on August 5, 2015.
- Year 2 - Plots were established in 4 year old 'Heritage' raspberry and the trial was initiated on July 28, 2016.

Goal: Conduct insecticide timing and efficacy trials to develop informed control strategies for SWD.
Progress: Trials completed in 2015 and 2016 and recommendations based on results have been developed, see results described in objectives 1-3.

Goal: Conduct sub-lethal effects trials (in lab) using organic insecticides.
Progress: Completed - trials completed in 2015 on the St. Paul campus of the University of Minnesota. Data have been analyzed and summarized – see objective 2 for more details.

Goal: Analyze data and prepare peer-reviewed scientific journal articles / Extension publications
Progress: Data entry and analysis is complete and data has been summarized. Data is being reviewed for preparation of a peer reviewed journal article.

Expected outcomes for this project and progress to date:
Outcome: Determine SWD phenology and provide robust information regarding the distribution and abundance of SWD across Minnesota specifically in relation to fall bearing raspberry during the growing season of each proposal year. Collect statewide trapping data via MDA field survey and conduct trapping and berry collections from 2 crops associated with SWD infestation, raspberry and grape, in Rosemount, and Hastings MN to generate standardized, quantitative measures of SWD distribution and abundance in Minnesota and related infestation levels of raspberry and grape.

Progress:
U of M: Traps were deployed in both years of the project and checked weekly. Trapping locations in the Twin Cities metro (Obj.1) and data were relayed to cooperators and growers through the FruitEdge website in both years. Fruit collections were conducted as a part of Obj. 2 to provide consistency with regards to insecticide application in year 1 of the project and collected from various fruit crops throughout the fruiting period in year 2.

MDA: The MDA was able to recruit 63 volunteers from 44 counties to monitor for SWD in the 2015 field season. From this survey, we were able to confirm the presence of SWD in 13 counties. Our earliest confirmation came from the Rosemount research center in Dakota County and Washington County the week of June 23. Rock County was also reported around this same time. Our latest positive confirmation came the week of August 19 from a grower in Houston County. This grower had been reporting all season long and this was the first time all season that they had detected it.

In 2016, the MDA was able to recruit 79 volunteers from 36 counties to monitor for SWD in the 2016 field season. This year we were able to confirm SWD in 34 counties. That is up from 23 counties in 2015. Our earliest confirmation came from the University of Minnesota research plots in Dakota, Wright, Washington and Rice Counties the week of June 13, 2016. That is approximately 10 days earlier than in 2015. Our latest positive confirmation came the week August 8 from two growers in Cass and Roseau Counties. These growers had been reporting all season long and this was the first time all season that they had detected it.

In 2017, the MDA was able to recruit 32 volunteers from 26 counties. Our earliest confirmation came from SWD of the season at the University of Minnesota's Rosemount research station on June 12, 2017. This is the same time frame as in 2016. Our latest positive confirmation came the week of July 31 which is about a week earlier than in 2016. Many of the growers in 2017 expressed that overall the infestation levels seemed less compared to 2016.

Outcome: Address deficiencies in current pest management knowledge, and collect high quality scientific data on SWD in Minnesota via scientific studies replicated during each proposal year. (GOAL). Conduct replicated field trials in fall raspberries at the Rosemount Research and Outreach Center

examining treatment timing using foliar insecticides relative to trap catches and phenological growth stages of fall bearing raspberry. Evaluate the efficacy of tested insecticides against SWD and the application timing. Collect yield data to provide estimates of economic loss/gain under various scenarios and compare the economic benefits of these treatments using yield estimates and costs of control.

Progress: Replicated field trials were conducted by U of M in year 1 and 2 with yield data collected in both years. Data entry is complete and economic analysis of costs of control and loss / acre are complete.

Outcome: Communicate project results and increase grower awareness through a variety of outlets. Communications will include: (1) website updates (both through the SWD profiles on UMN's FruitEdge and the MDA main site), and (2) the Minnesota Fruit and Vegetable Growers Association and MDA's Fruit Growers Newsletters (and email lists) (TARGET). Present to the scientific community in the form of (1) at least one article published in a peer-reviewed scientific journal (e.g., Journal of Economic Entomology).

Progress:
U of M: Year 1 and Year 2 trapping results and pest updates were made available on the FruitEdge website and MDA's fruit growers newsletters. Preparation of articles for publication are underway.

MDA:
Year 1 - The Minnesota Department of Agriculture's main site website and map was updated weekly from June 8, 2015 through September 3, 2015 with updates from all participants in the monitoring study. Growers were also contacted weekly through the projects weekly email update. Growers were directed to UMN's Fruit Edge site for the most up to date research and management guidelines. The map was also updated whenever we received and confirmed SWD in a county through other means such as public reports to MDA's Arrest the Pest hotline and University of Minnesota cooperators.

Information on this project was also communicated to growers in the following ways:

- Information on Spotted Wing Drosophila was exhibited to growers at the Minnesota Organic Gardener Conference January 9-10, 2015 in St. Cloud Minnesota.
- Spotted Wing Drosophila information will be presented to participants of the Minnesota Naturalist Association Conference at the Long Lake Conservation Center in Palisades, MN November 15, 2015.
- All growers and volunteers were mailed a hard copy of the USDA, Regional IPM Center and National Institute of Food and Agriculture's Spotted Wing Drosophila National Pest Alert.
- This project was described and volunteers were solicited in the MDA Plant Pest Insider May 2015 issue.
- This project was described and volunteers were solicited in the University of Minnesota Master Gardener's newsletter.

Year 2 - The Minnesota Department of Agriculture's main site website and map was updated weekly from June 10, 2016 through August 19, 2016 with updates from all participants in the monitoring study. Growers were also contacted weekly through the projects weekly email update. Growers were directed to UMN's Fruit Edge site for the most up to date research and management guidelines. The

map was also updated whenever we received and confirmed SWD in a county through other means such as public reports to MDA's Arrest the Pest hotline and University of Minnesota cooperators.

Information on this project was also communicated to growers in the following ways:

- This project was described and volunteers were solicited in the MDA Plant Pest Insider June 2016 issue.
- Project updates were reported in the July 2016 issue of the MDA Plant Pest Insider.
- Results were sent out weekly throughout the summer of 2016 in the University of Minnesota's IPM Newsletter.
- This project was described and volunteers were solicited in the University of Minnesota Master Gardener's newsletter
- All growers and volunteers will have the new MDA spotted wing drosophila laminated identification card made available to them.

Due to our efficient use of funds and time, in year 2 we will be able to offer a third year of monitoring for our participants. We followed the same protocol as in year 1 and 2 with focus on those people who have participated regularly and again tried to obtain volunteers in some of the underrepresented counties. Having a 3rd year of monitoring help provide our volunteers with a better understanding of SWD phenology and drove home the importance of monitoring in their management plans.

Year 3

U of M: During this project it became more apparent that SWD could also be a significant pest of Minnesota strawberries, particularly day-neutrals. In 2017, Dr. Bill Hutchison, agreed to present our SWD research at a North American Strawberry Growers Assoc. (NASGA) field day (~ 55 growers and industry participants) at The Berry Patch Farm (Forest Lake, MN) on August 15, 2017. Timely updates on SWD adult trap catches continued in 2017, and are also available at https://www.fruitedge.umn.edu

The Minnesota Department of Agriculture's main site website and map was updated weekly from June 8, 2017 through September 7, 2017 with updates from all participants in the monitoring study. Growers were also contacted weekly through the projects weekly email update. Growers were directed to UMN's Fruit Edge site for the most up to date research and management guidelines. The map was also updated whenever we received and confirmed SWD in a county through other means such as public reports to MDA's Arrest the Pest hotline and University of Minnesota cooperators.

Information on this project was also communicated to growers in the following ways:

- This project was described and volunteers were solicited in the MDA Plant Pest Insider April 2017 issue.
- Project updates were reported in the June 2017 issue of the MDA Plant Pest Insider.
- The online map for detections of SWD was updated as new county finds were reported https://www.mda.state.mn.us/plants/insects/swd.aspx

Upon completion of the monitoring season, the MDA sent the 2017 volunteers (many of whom have participated since the beginning a survey to assess the value of this monitoring. Nine of 32 people responded to the final survey.

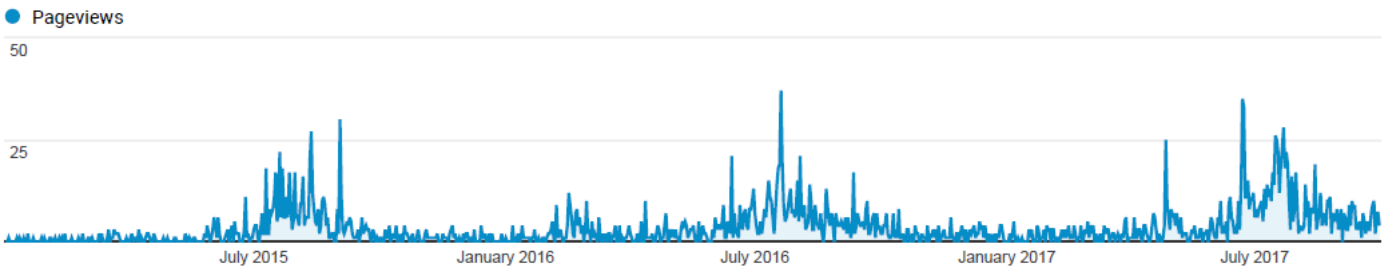
- Participant break down was as follows: 55% of our growers were commercial and 45% were hobby.

- 66% grew raspberries
- 45% found SWD frequently and 34% occasionally
- 78% said they found trapping/monitoring easy
- 67% found the volunteer network useful
- 100% said they were likely to continue to monitor for SWD on their own as part of their management strategy for this pest
- Many of the growers would like more updates on the latest IPM and control methods

BENEFICIARIES

The number of beneficiaries affected by the projects outcome:

- In 2017, Dr. Bill Hutchison, agreed to present our SWD research at a North American Strawberry Growers Assoc. (NASGA) field day (~ **55** growers and industry participants) at The Berry Patch Farm (Forest Lake, MN) on August 15, 2017
- The MDA discussed this project with updates and calls for volunteers in our Plant Pest Insider. This goes out to **6500** stakeholders.
- Information on Spotted Wing Drosophila was exhibited to growers at the Minnesota Organic Gardener Conference January 9-10, 2015 in St. Cloud Minnesota. **~500 people**
- The MDA monitoring network yearly engaged on average **~ 60** soft berry growers across the state and engaged them in actively monitoring for SWD presence. Note: this is an average of the total.
- The MDA's SWD website reached a total of **3,455** interested stakeholder over the course of the project with most of the hits coming during the berry growing season. See website analytics below. Each person spent an average of about 3 minutes on the page.



- The University of Minnesota webpage reached over **8,000** stakeholders. Between 1/1/2015 and 12/31/2016, FruitEdge generated 8,167 unique pageviews (11,177 total pageviews). The top three pages viewed were the home page, SWD page, and SWD Management Recommendations.

Beneficiaries of this work include Minnesota fruit producers, both commercial and hobby. Quantitative information on SWD phenology gleaned from this project has been made available to both the private and public sector via MN's FruitEdge and the MDA main website. We have also been able to reach people through the Minnesota Fruit and Vegetable Growers Association and MDA's Fruit Growers Newsletters (and email lists). Management recommendations based on data from this project are available on the MN's FruitEdge webpage https://www.fruitedge.umn.edu/swd. Data will also reach the scientific community through reviewed journal articles and contribute to an overall better understanding of biology and management of this invasive pest.

LESSONS LEARNED

Year 1 - Not all growers who signed up and received traps as part of the volunteer survey coordinated by MDA ended up participating in the study. We sent out traps to 63 representatives in 44 counties (some counties had more than one volunteer as we did not want to turn away anyone that was interested) and only received reports from 13 counties. The weekly emails did prompt people to respond sometimes but we would like more regular responses from participants. We had approximately 29/63 growers actually respond throughout the course of the study some responded regularly and some did not. Thirty four volunteers never responded at all.

We were also getting reports from growers that they were seeing SWD in their crops but they were not getting them in the traps, or the flies were in down in the vinegar but not on the sticky cards. There is no clear reason as to why this was occurring and so we will work hard next field season to make sure that the trapping protocol is very clear and concise so traps are set up properly and in the correct place.

Year 2 - In 2016 we encountered fewer challenges with cooperators than in 2015. Overall volunteers were very engaged and many of them made personal phone calls to give their insights throughout the survey. Also many of them contacted MDA at the end of the season to thank us for the traps and information we sent them and expressed this was a valuable project for them. We mailed traps to 79 people, 40 responded regularly and 39 never responded. This was about the same return rate as in 2015 but overall we were able to confirm the presence of SWD in more counties. We also updated the survey protocol so that directions were clearer for participants.

Project 10

MN Specialty Crop Block Grant- Federal Fiscal Year 2014
FINAL PERFORMANCE REPORT

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PROJECT TITLE

Accelerating Success for Specialty Crop Producers

PROJECT SUMMARY

Demand for locally-grown food continues to grow in Minnesota among a range of buyers: individual consumers, schools, grocery stores, health care institutions, child care providers, and restaurants. Edible specialty crops are of particular demand because they are at the intersection of the heightened interest in local foods and increased interest in healthy eating.

In response to this demand, we see current and aspiring producers interested in growing more specialty crops. In surveys with "local foods" producers in Dodge and surrounding counties, most respondents indicated they would be interested in increasing their production if they could find fairly priced, dependable markets for their crops.

While one might think the forces of supply and demand would magically snap into place, the reality is that getting from point A to point B is a much more complicated endeavor. There are a variety of issues that prevent an easy supply/demand flow of goods. Pests, disease, climate, food safety, regulations, processing, marketing, distribution, financing – these are just some of the factors that specialty crop producers must manage. It is not surprising that most producers are not experts in all of these areas.

The specific objectives of this project were to:
1) increase supply and sales of edible specialty crops by local producers;
2) increase the profitability and sustainability of these producers; and
3) expand awareness and support for locally-grown, edible specialty crops in southern Minnesota.

There has been a rising tide among our farmer constituents voicing a clear need for more information and technical support that would allow them to safely and efficiently increase their sales of specialty crops. The demand for local food continues to grow quickly, so time is of the essence to get the expertise to the farmers so they can capitalize on the expanded market opportunity, and play a critical role in improving the health and connectivity of citizens in their community.

This project did build on past work and on current initiatives. It included providing post-harvest handling training to current and aspiring specialty crop farmers and putting specialty crop enhancement teams in place to work with producers and specialty crop entrepreneurs.

First, this project built on the work of the Minnesota Institute for Sustainable Agriculture and FamilyFarmed.org in creating a new edition of the Wholesale Success post-harvest handling manual, and of MISA in developing additional teaching materials on post-harvest handling of fruits and vegetables. The manual was distributed to 250 farmers in MN through four RMA-funded workshops offered in 2012-2013. MISA went on to develop open-access workshop presentations that are available to any organization, and assembling an advisory committee for that project that served as the start of a working group for additional efforts in post-harvest handling education.

Second, this project borrowed a page from the Minnesota Department of Agriculture's Dairy Profitability and Enhancement Teams. Those teams have proven to be effective means of improving the profitability of dairy farmers in Minnesota. We proposed adapting that model to specialty crop farmers growing edible crops. By matching specialty crop farmers with a team of professionals – we sought to accelerate producer's ability to expand production and increase sales.

Finally, this project built on the work of the FEAST Local Foods Network—a partnership of many organizations, businesses, and individuals committed to growing a sustainable, local and regional food system that encourages innovation. FEAST's goal is help current food businesses flourish and new businesses get established. In the four years since the inception of FEAST, this group has worked together to create and implement a plan of action which included the launching of a Local Foods

Festival and Tradeshow in the Fall of 2014 (partially funded by a 2013 SCBG) and the development of a Finance Network.

Finally, this project built on Renewing the Countryside's work to expand local foods markets. RTC has over a decade of experience working with farm and food entrepreneurs. We have conducted over 30 farmer/buyer networking workshops throughout the state which have resulted in increased sales for farmers and helped broaden interest in local foods. We have also collaborated with MOSES to develop the New Organic Stewards Program, which continues to provide training and assistance to new farmers in the Upper Midwest. Finally, we have a long record of promoting specialty crops through events (e.g. Healthy Local Foods at the EcoExperience), publications (Minnesota Homegrown Cookbook), and media (Local Food Hero Radio show).

PROJECT APPROACH

Details on the **Post Harvest Handling Workshop** component of the project, which occurred in 2015, were included in that year's report. We met and exceeded our goal for number of attendees by 300.

The short workshops included a total of 314 participants. The breakdown includes:

Minnesota Organic Conference: St. Cloud, MN, 38 participants.
Minnesota Fruit and Vegetable Growers Association Conference: St. Cloud, MN, 60 participants.
Immigrant and Minority Farmer Conference: St. Paul, MN, 33 participants.
Sustainable Farming Association Conference: St. Joseph, MN, 58 participants.
Minnesota Farmers Market Association Conference: Monticello, MN, 125 participants.

The full-day workshops included 85 participants. The breakdown includes:

St. Charles, MN, 16 participants.
Fairmont, MN, 17 participants.
Little Falls, MN, 30 participants.
Cannon Falls, MN, 22 participants.

Through our pre- and post-survey evaluations we found that the majority of workshop participants were vegetable farmers with 10 + years of farming experience. This was followed by farmers with 4-10 years farming experience. All participants were asked to rate their knowledge level (beginner, moderate, expert) prior to the workshop in various topics. Post evaluation, we asked them to rate their knowledge again. We averaged all the scores and every topic received a higher score. Likewise, we had participants rate the overall workshop, from presenter to workshop content (1-low to 5-high). Each location had an average score of 4.0 and higher.
All participants were asked to rate their knowledge level (beginner, moderate, expert) on various topics prior to the workshop, and then again post-workshop. We averaged all the scores and every topic received a higher score post-workshop. Likewise, we had participants rate the overall workshop, from presenter to workshop content (1-low to 5-high). Each location had an average score of 4.0 and higher.

Our focus in 2016-2017 has been on **Specialty Crop Enhancement Teams**.

- We did the groundwork for this in 2015, getting input from our advisory committee, developing a process, developing outreach materials, and promoting the program. At the end of our first year we had worked with 15 specialty crop producers.
- We hired two additional part-time staff in 2016 (who are also farmers) to help with outreach and work with clients and teams because the original process of reaching farmers and having them actively engage with the programs was moving slower than we had hoped. The group of coordinators (4 in total) made further revisions and adaptions to the process to improve it.
- In 2016, we conducted outreach for this service at: Minnesota Organic Conference, Sustainable Farming Association Annual Conference, MOSES Organic Conference, and by reaching out to farmers' market managers and local extension agents. We also used local listservs focused on the southeast and south central Minnesota sustainable farming community to get the word out.
- In 2016, we added to our list of people with specialized expertise willing serve on the Enhancement Teams.
- When we brought on additional staff, Renewing the Countryside staff member Grace Brogan began facilitating bi-weekly coordinator check-ins to ensure coordinators were sharing knowledge and resources, and moving forward toward goals according to the work plan. Check-ins and tracking documents have helped guide the project's direction, cohesion, and clarity.

By the end of the project, we facilitated 49 farms completely through the enhancement team process, exceeding our goal by 9. The farms were quite different, and the issues they are struggling with differed. From disease outbreak, to questions about regulatory standards, to finding wholesale contacts and developing branding, farmers came with a variety of questions and issues. We worked hard to connect them with experts who could help them overcome barriers that limit their production and sales of edible specialty crops. Of those who responded to our follow-up survey, 27% indicated an increase in specialty crop sales within the 2-18 months we had been working with them, and among those who did not, the majority did foresee those changes ahead (and credited the expected increase to the assistance provided by the enhancement teams).

Qualitative feedback from farms who worked with enhancement team included:

- "I received access to an expert on solar power and other renewable energy options that could be deployed on my farm. The person I worked with has helped me figure out the best path forward."
- "This was exactly what our farm needed! We have been 'treading water' for the last 5-6 years with our goal to start an on-farm beverage business and now we have steps laid out for us to move forward. Consulting with the people we did helped us to focus on specific [specialty] crops for beverages and look at other possible value-added beverages we were not even considering. We are currently in the process of applying for our federal licenses to get the process moving forward."
- "My farm mentor was always available to answer my questions thoughtfully and fully. He was able to quickly size up my operation and give me sound advice right on the spot about how I could make things run more efficiently and cost-effectively."

A number of other organizations have assisted this project either by serving on the Advisory Committee, helping to identify farmers who would benefit from these services, serving on enhancement teams, or helping to identify enhancement team members. These include Southern

Minnesota Initiative Foundation, Farm Business Management at Riverland Community College, several departments at the University of Minnesota, University of Minnesota Extension, Minnesota Institute for Sustainable Agriculture, Minnesota Farmers Market Association, Midwest Organic and Sustainable Education Services, and the Sustainable Farming Association. A number of individuals (e.g. experienced specialty crop farmers) have also served on the enhancement teams.

GOALS AND OUTCOMES ACHIEVED

Post-Harvest Handling Workshops
We partnered with the University of Minnesota's Minnesota Institute for Sustainable Agriculture (MISA) to conduct four post-harvest handling workshops. We also conducted five short workshops in 2015 at various venues and key conferences that are popular among specialty crop farmers. These workshops also served as outreach mechanisms to promote the availability of Specialty Crop Enhancement Teams.

Specialty Crop Enhancement Teams
We originally based our process on an adaption of Dairy Profitability and Enhancement teams, but made additional modifications as we continued given the differences regarding topic and audience we learned along the way.

We developed an application form that gathers basic information from specialty crop producers about their operations and the top obstacles they face in expanding production and sales. We also developed eligibility criteria, e.g. currently raising edible specialty crops; being located in the 20 county southeast region of Minnesota; interested in increasing sales of specialty crops; being willing to share information and take advice.

The program was publicized through various networks in the region including U of M Extension, Minnesota Grown, Southeast Regional Sustainable Development Partnership, Minnesota Farmers Market Association, Sustainable Farming Association, local non-profits, and the FEAST Local Foods Network.

Producers and specialty crop entrepreneurs completed the application form. The project coordinators then reviewed applications and one of them conducted a phone or in person interview to gather additional information. If an applicant met the criteria, they moved forward to receive assistance.

The coordinating team worked with producer applicants, staff, advisors, and the FEAST Network to identify team members with the necessary expertise. Depending on needs, the teams varied widely. Team members spanned from specialists in production (vegetables, berries, hazelnuts, grapes…), marketing, logistics, season extension, food safety, financial management, and financing. Some of these specialists were successful producers who are willing and able to serve as advisors. Others were staff from organizations like U of M Extension, Farm Service Agency, or Farm Business Management. And others were from the private sector (marketing professionals, bankers, co-op buyers, etc.). The size of the team varied, and in some cases a single mentor was deemed the best option for the need identified.

Once the team was formed, the project coordinators facilitated meetings and ongoing communications so that the specialists could meet with the producer, see the operation, and discuss the obstacles that are preventing increased sales. At that point, the trajectory went multiple directions as needed to navigate barriers. This is also the point at which we continued to modify, and when common barriers arose, we organized groups around specialists to be more efficient with limited time and resources.

It is likely that the effects of the workshop trainings and enhancement team technical support will be felt most strongly in the 1-3 years following the assistance when the changes take place and have the opportunity to significantly increase the sales of specialty crops. For instance, the farmer quoted above wants to do a value added beverage business that uses specialty crops from their farm. While their team was able to get them moving in the right direction, the "fruit" of this work won't blossom for a couple years.

As noted earlier in this report, we exceed the goal of number of farmers reached by our post-harvest handling workshops by nearly 300, and our enhancement teams by 9. All responding participants indicated an increase in knowledge after attending the workshops, and over 25% indicated an increase in sales after working with enhancement teams.

BENEFICIARIES

The primary beneficiaries of this project are edible specialty crop producers in the 20 county region of southeast Minnesota. (This region is bordered on the north by Sibley, LeSeuer, Rice and Goodhue counties, on the west by Brown, Watonwan and Martin counties, on the south by Iowa and on the east by Wisconsin.)

Producers indicated increased understanding about post-harvest handling. 49 farms navigated barriers to increasing specialty crops sales. 25% of responding farms who received enhancement team support indicated an increase in specialty crop sales.

LESSONS LEARNED

The strengths of our work have been the collaboration of numerous organizations to plan and accomplish the post-harvest handling workshops, and among our coordination team in finding creative ways to reach out to farmers and modify our efforts to meet the needs and realities as they are on the ground. Our areas to improve included making the program attractive and clear to farmers, and continuing to inform more organizations and individuals about the Specialty Crop Enhancement Team program.

We have learned through this experience that it is challenging to reach and encourage our goal number of farms to actively respond and participate in the program, and to align timelines and communication between farms and enhancement team members when everyone is very busy. That is why we continued to make adjustments, including putting additional staff time toward outreach and coordination.

We also have discovered that the Enhancement Team model as used with dairy farms (and which we modeled this program off of) – did not translate smoothly to specialty crop farms. For instance, where

dairy farmers often have trusted professionals that they interact with regularly (veterinarians, feed suppliers, etc.) and who understand their business – that isn't the case with many specialty crop producers – at least in the southeast part of the state, and we expect most places in Minnesota. This was an issue both because many of these farmers weren't use to working with assistance providers, and so we had to build enough trust from them to do this. It was also sometimes challenging to find the right people to serve on the enhancement teams. While some producers had very specific issues they needed assistance with, others wanted a more holistic look at their operation and assistance in improving it overall. That second request was most difficult to find people to help with, because it was so complex.

Overall, we ended up making major shifts in our plans and expectations in order to be of service to farmers. In many cases we deemed it better to bring in a couple of experts to help address a specific problem, or linked up a farmer to a more experienced farmer who could serve as a mentor. As part of this learning process, we modified how we connected farmers and experts with a more direct line of need and expertise during the extension time into 2017. We identified a handful of common needs by farmers in the region (based on conversations with farmers), and held a series of mini, on-farm workshops led by farmer experts. These workshops included High & Low Tunnel Greenhouse Growing, Soil Health for Specialty Crops, Fruit Tree Grafting, & Produce Packing and FSA Funding. We limited attendance to 8 and asked that only those who were raising and selling specialty crops to attend. The workshops started with a farm tour and presentation by the farmer expert, then moved a discussion session where attendees could share their plans and where they needed assistance. They attendees also then had access to the farmer expert for personalized assistance after the workshop.

The main unexpected outcome was the strengthening of relationships with others working with specialty crop farmers. Because we needed these folks to be on enhancement teams – we had to better understand who was working in this arena, what their area of expertise was, what their capacity was, and how to best engage them.

It was challenging to get robust response in follow up surveys. Also challenging is marking significant economic change for processes and projects that take time to implement. This is especially the case as we looked at assistance for specialty crop producers that are implementing projects that have a longer time frame. For instance – assistance to someone with an orchard or vineyard, who is just getting that established, will not see any increase in sales within the time of the project. Same thing with someone who is putting in a hoop house, or deep-winter greenhouse.

Project 11

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Contact: Rachel Armstrong

Organization: Farm Commons

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PROJECT TITLE

Increasing the Stability and Resiliency of Minnesota Fresh Fruit and Vegetable Sales through Sales Agreement Education

PROJECT SUMMARY

In a study of 60 Midwestern farmers with at least three years of experience selling directly to grocery stores, institutional buyers or distributors, 30% of the farmers had experienced a buyer cancel an order after the product had already been prepared for the individual. For all but one farmer, product was sold at a loss or could not be sold at all. Why does this happen? One clue lies in a 2009 report by AURI, Minnesota Farmers Union, Cooperative Development Services, grocery retailers and other wholesale buyers consistently cite communication as a barrier to success when buying from local farmers. Successful farmers in the same study cite effective communication as key, along with trust and a mutual understanding of expectations.

Food safety is a serious concern for both farmers and wholesale buyers. Farmers who sell wholesale need to be immediately ready to communicate their food safety practices, and their compliance with new federal regulations scheduled to be announced by the end of 2014. To do that, farmers first need detailed education in exactly what the new laws will require and how they will demonstrate compliance.

Although it may not be intuitive, the background and problems presented above provide the perfect opportunity for a written sales agreement. The process of writing down the terms of a sale is essentially the process of communicating mutual needs and arriving at a mutually beneficial decision. A solid sales agreement prevents problems and creates clear pathways for resolution when cancelation is necessary. But, despite the clear opportunity to foster strong communication through written documents, few farmers write down sales agreements. In part, it's a lack of legal access within the farming community. Where 78% of U.S. small business owners have used an attorney in the past three years, about 16% of farmers have ever used an attorney at all. Buyers may have more access to legal education and services, but may not have the time for each farmer. On the plus side, farmers are very receptive to legal education. Yet, very little exists. Farm Commons has hosted one webinar and has a single resource on the subject, but much more is needed.

This project addresses these problems and positions wholesale specialty crop relationships for long-term success. First, we disseminate educational resources that help farmers and buyers understand the

issues that should be memorialized in a written agreement. Second, we build the confidence and practical ability of farmers and buyers to use that education helping them write their own agreements using models, with a group of peers. Last, we create peer networks that will strengthen the institutional knowledge of the local food community over time, and allow individuals to be flexible as new relationships emerge.

PROJECT APPROACH

In the first quarter, we solidified our plan, held interviews, and began research. IN the second quarter, we made significant progress in the research portion of the project. We have explored sticky legal issues that needed research and drafted potential formatting and design options for our model contracts. In the third quarter, we began planning for our winter outreach program in earnest. We have set up our workshops and tutorials, scheduled follow up sessions for attendees, and crafted the marketing plan for the program. We've also worked on our web capabilities to deliver/distribute programming this fall and winter. In the fourth quarter, did outreach and advertising on the tutorials and handled registration. Then, we delivered our tutorials. We also planned and delivered our workshops. Over the fourth and fifth quarter, we finalized our print resources on sales laws, had them reviewed, and finalized versions. The fifth quarter tasks accomplished included publishing and distributing our resources, plus conducting evaluation. We issued and analyzed evaluation forms from online tutorials, in-person workshop, and online print resource access.

Our partners assisted with review of the print documents. They provided valuable feedback that improved our final product. Outside reviewers help us see our resources objectively, including ways to improve. The Sustainable Farming Association gave us space at their annual conference for our workshop, allowing us to reach many more farmers than if we had done outreach separately.

GOALS AND OUTCOMES ACHIEVED

The activities for the project were as follows:

a. Researched laws, interviewed farmers and buyers, wrote guides and models
b. Drafted guide and had reviewed
c. Set up webinar registration and did outreach on events
d. Planned and hosted webinars.
e. Planned and hosted workshop.
f. Developed final versions of resources
g. Did outreach on resources
h. Evaluated program success.

As for our project activities, there was no difference between the established goals and the accomplished goals. We completed all activities.

Our project goals also including increasing knowledge and changing behaviors. We identified several specific elements for both, listed below:

INCREASING KNOWLEDGE

Our goal was to reach 400 farmers, and see 75% of them increase their knowledge and change specific behaviors. Specifically, 300 Farmers/Buyers will increase their knowledge of all the following:
1. How farmers and buyers are currently addressing communication and sales agreement issues
2. Best practices and methods for addressing communication and sales agreement issues
3. Techniques for negotiating on sticking points within the sales relationship
4. The type of wholesale relationship ideal for their operation
5. Insurance options available to protect against food safety risks
6. The new regulations for wholesaling fresh specialty crops under the Food Safety Modernization Act.

300 Farmers/Buyers will change their operations in one of the following ways:
7. Implement written sales agreements, formally or informally
8. Negotiate sales terms that are more accommodating of their specific needs
9. Choose more appropriate buyers to their specific needs
10. Buy or change their insurance coverage to accommodate the unique risks of wholesaling fresh produce
11. Put a plan in place to comply with the new regulations for produce wholesaling under the Food Safety Modernization Act.

We reached a total of 388 farmers, just 12 shy of our goal. But more importantly, we had a higher percentage of farmers gain new knowledge than we anticipated. 78% or 304 of farmers reached increased their knowledge on the points listed above. We exceeded our goal by an even wider margin on the changed behaviors. The most significant thing learned was that the FSMA Produce Rule applies when farms sell more than $25,000 worth of produce normally consumed raw.

94% of the farmers reached, or 365 total, changed their operation or planned to change their operation in the near future on the points listed above. The most popular change farmers indicated they had or would do was, “Write down our agreement with buyer(s).”

We collected baseline data about farmers’ knowledge prior to using our resources and their current behaviors regarding sales agreements. We asked specifically if farmers had known specific legal facts about availability sheets and invoices as written contracts for specialty crop products, insurance coverage for indemnification of specialty crops, and the FSMA Produce Rule. This is how we know that 78% of respondents achieved an increase in knowledge. 218 farmers did not know that insurance was available to cover damages if they became responsible under contract indemnification. The same number of farmers also did not know that FSMA Produce Rule applies when they sell more than $25,000 worth of produce normally eaten raw. We also asked farmers which specific behavior changes they made on their farm, based on the resource. Each survey question was written such that farmers were indicating behavior changes- practices they were not already performing. The options included 1) talk with buyer(s) about our agreement, 2) Write down our agreement with buyer(s), 3) Explore FSMA obligations, 4) Explore my insurance policy coverage options.

BENEFICIARIES

Specialty crop producers benefited from this project's accomplishments. Our partner Sustainable Farming Association of Minnesota benefited by being able to offer a popular workshop at their annual conference.

388 specialty crop producers benefited from this project. 94%, or 365 specialty crop producers made a specific risk-reducing change that increased the legal resiliency of their business. These changes have an economic impact over time. For example, 129 producers had a conversation with their buyer about the agreement. These conversations lead to greater stability of the relationship. If we estimate the sales relationship lasts one year longer because each party's goals are met for that much longer, we have a large economic impact over time, depending on the overall size of the farm business. The users of our resources tend to be small operations averaging $25,000 in farm revenue. If we expand this by just 1% for 129 users, we have protected $32,250 worth of specialty crop sales. 260 specialty crop producers wrote down their agreement with their buyer. This means those producers have the legal authority to enforce those sales. Although legal enforcement is unlikely, this motivates more stable, sales relationships between compatible buyers and sellers (rather than fly-by-night buyers who do not intend to follow through on purchasing intentions). If we estimate 260 farmers' sales (averaging $25,00 in revenue) are protected using the modest 1% rate, that's an economic impact of $65,000. Combined we estimate the total economic benefit to be $97,250.00.

LESSONS LEARNED

These are some of the positive quotes evaluation respondents left in response to the question, "What did you like best about the workshop/webinar/resource?"

- wonderful
- presenter stayed on topic and focused on a subject that applies to farmers: selling product
- all of this was valuable
- this was incredibly informative. We are just getting started and we are glad that Farm Commons is an available resource
- quality information. It was like Business Law For Farmers 101
- Easy to understand, not difficult legal jargon. Thank you
- a wealth of good information

As for negative conclusions, we found it difficult to get interviews with grocery and wholesale buyers in the early stages of the project. We had gotten commitment before the project began for interviews from several subjects. We had even written honorariums into the budget to motivate follow through from our subjects. But, things kept coming up for producers, we saw personnel changes at the grocery distributor business, and others simply didn't respond. This was a very unfortunate part of the project. Although we feel confident in the end result of our guides and tutorials, we know they could have been better with interviews beforehand.

We had anticipated creating a single comprehensive guide regarding sales contracting. But, we decided it was better to create two separate guides- this makes it easier to attract farmers because we can advertise them in a more targeted, rather than general, manner.

ADDITIONAL INFORMATION

Please find the project resources at the following web links. I will happily send paper copies upon request, as well.

Solidifying Wholesale Sales with Written Agreements: A Workbook
Wholesale sales - such as to grocery stores, distributors, or even large institutions - can be a valuable market channel for small farmers. However, selling into these markets can take a bit of foresight and preparation. Often it involves a substantially higher volume along with quality specifications, specific handling and packing standards, fulfillment timeframes, and so on. In this workbook, farmers will walk through the process of wholesale sales. This includes brainstorming and negotiating the terms as well as solidifying the deal in a written agreement. The workbook includes a basic guide, a checklist for creating a wholesale sales agreement, and 2 model agreements for reference.
https://farmcommons.org/resources/solidifying-wholesale-sales-written-agreements-workbook

Choosing the Best Market Channel for Your Farm's Success and Your Happiness: Legal and Practical Considerations
Your farm's success and your happiness hinge on what market channel you sell into. There are a lot of factors that go into this important strategic decision. Some are personal, such as financial situation and aspiration, your skill set, your personal preferences, and what opportunities you already have in place. Some are legal considerations, e.g., the liability risks of each channel, employment and food safety regulations, and sales contracts. This guide will help you navigate the benefits, challenges, and legal considerations of the most popular market channels for small farmers: Community Supported Agriculture (CSA), Farmers Markets, Restaurants, Grocery Stores and Co-op Markets, and Distributors.
https://farmcommons.org/resources/choosing-best-market-channel-your-farms-success-and-your-happiness-legal-and-practical

Project 12

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

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Organization: North Dakota State University

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PROJECT TITLE

Managing blemish problems to improve marketing of fresh potatoes

PROJECT SUMMARY

This project was initiated to evaluate methods to reduce unsaleable potatoes because of blemishes. The biggest challenge of providing a high-quality potato is to produce tubers free from blemishes, because consumer will "buy with their eyes" as they naturally gravitate to tubers free from blemishes. Fresh market potato growers will cull 20% or more of their crop because of tuber blemishes. Blemishes can be defined as any flaw or imperfection that spoils the appearance of the tuber, thus making it unmarketable. Smooth-skinned tubers (red, white, and yellow) in particular are especially vulnerable to blemishes because they are easily observed. The primary blemishes fresh market potato growers face today include silver scurf, black dot, scab, unattractive skin color, malformed tubers and other unknown blemish problems.

This project was motivated by the anecdotal evidence of growers continually reaching out to the University of Minnesota Extension for ways to reduce blemishes of potatoes. After some more conversations, it was determined that more funding was needed to perform an in-depth study of this issue.

PROJECT APPROACH

In 2015 there were 11 samples taken from 8 different fresh pack sheds to be evaluated for blemishes. There were seven red-skinned cultivars, three yellow-skinned cultivars, and one white-skinned cultivar. The most prevent blemishes by percent were external bruise (36%), lenticel spot (33%), superficial common scab (25%), and black dot (22%). Other blemished found were skin netting (13%), silver scurf (9%), enlarged lenticels (7%), black heart (5%), greening/sunburn (5%), pitted common scab (2%), growth crack/secondary growth (2%), hollow heart (2%), wirework (2%), and soft rot (1%). These data are interesting because it gives insight on where to focus efforts to improve the quality of fresh market potatoes. Blemishes such as external bruise, lenticel spot, and sunburn can be controlled through cultural management practices. These may include being more careful when handling potatoes, planting potato shallower and allowing potatoes to dry rapidly after washing, and ensuring complete soil coverage or tubers.

The field trials were established that consisted of testing fungicides and fumigants, plant growth regulators, and a cultivar trial at Becker, MN. These trials were planted in May and harvested in August and September. In the fungicide trial, there was no difference in yield of Red Norland across treatments and in Yukon Gold across treatments. There was a difference in percent blemish from treatments. In the Red Norland and Yukon Gold Maxim 4FS reduced the percent blemish when blemishes were evaluated 90 days after harvest (Table 1 and 2). For the Red Norland Emesto Silver and Nubark Mancozeb + Moncut 70 DF had a numerically low blemish percentage.

Table 1. Percent blemish of Red Norland potato tubers 90 days after harvest when grown in Becker, MN in 2015.

Treatment		Rate	Schedule	Blemish %
1	Non-treated	-	-	68.5
2	Moncut 70 DF	1.1 lb / a	In-furrow	67.8
3	Moncut 70 DF +	1.1 lb / a +	In-furrow	66.2
	Serenade	6.0 qt / a	In-furrow	
4	Quadris	11.6 fl oz / a	In-furrow	50.0
5	Vertisan	23 fl oz / a	In-furrow	65.3
6	Priaxor	8.1 fl oz / a	In-furrow	67.3
7	Nubark Mancozeb +	1.0 lb / cwt	Seed	41.3
	Moncut 70 DF	1.1 lb / a	In-furrow	
8	Emesto Silver	0.31 fl oz / cwt	Seed	37.4
9	Omega 500F	3.0 pt / a	In-furrow	69.0
10	Luna Tranquility	11.2 fl oz / a	In-furrow	66.8
11	Regalia	8.8 fl oz / 1000 row ft	In-furrow	66.6
12	Maxim 4FS	0.08 fl oz / cwt	Seed	33.4
	LSD $_{p>0.05}$			7.90

Table 2. Percent blemish of Yukon Gold potato tubers 90 days after harvest when grown in Becker, MN in 2015.

Treatment		Rate	Schedule	Blemish %
1	Non-treated	-	-	48.8
2	Moncut 70 DF	1.1 lb / a	In-furrow	61.9
3	Moncut 70 DF +	1.1 lb / a +	In-furrow	46.4
	Serenade	6.0 qt / a	In-furrow	
4	Quadris	11.6 fl oz / a	In-furrow	43.9
5	Vertisan	23 fl oz / a	In-furrow	51.5
6	Priaxor	8.1 fl oz / a	In-furrow	55.2
7	Nubark Mancozeb	1.0 lb / cwt	Seed	41.5
	Moncut 70 DF	1.1 lb / a	In-furrow	
8	Emesto Silver	0.31 fl oz / cwt	Seed	41.2
9	Omega 500F	3.0 pt / a	In-furrow	62.5
10	Luna Tranquility	11.2 fl oz / a	In-furrow	65.3
11	Regalia	8.8 fl oz / 1000 row ft	In-furrow	55.2
12	Maxim 4FS	0.08 fl oz / cwt	Seed	35.4
LSD $_{p>0.05}$				6.70

In 2015 the plant growth regulators did not affect the yield or most blemishes measured. There was a difference found in the amount of skin netting from treatments. Ethylene reduced the amount of netting to 1.3% compared to 41% for the non-treated. When 2,4-D was applied it tended to cause epinasty of the leaves while ethylene caused a reduction in plant biomass. When comparing this to previous research, the application timing was later than previous work. The plant growth regulator trial and the variety trial yield were graded on a mechanical graded and the data became corrupted at some step in the process and was not recovered. Thus, we do not have data to share on these studies.

The plant growth regulator trial in 2016 revealed no differences in total yield. There were some small differences in graded yield. In general, the ethelene treatment reduced overall tuber size, causing more C- and B-sized tubers and fewer A-sized tubers. Skin-netting was somewhat opposite of 2015, with the ethylene treatment increasing skin netting and the non-treated have a reduced amount of skin-netting. An important finding is that 2,4-D treatments did not increase surface blemishes in either 2015 or 2016. Plant growth regulators can often

react wildly to environmental conditions; thus, it makes them difficult to work with in a field setting to get consistent results.

The 2016 field trial testing seed and/or in-furrow treatments had many products that reduced blemishes (Table 3). The most promising products were Quadirs and Moncut 70 DF + Serenade. Although the data varied by 2015 and 2016, the results seen in 2016 may have been from different environmental conditions.

Table 3. Percent blemish Red Norland potato tubers 90 days after harvest when grown in Big Lake, MN in 2016.

Treatment		Rate	Schedule	Blemish %
1	Non-treated	-	-	43.5
2	Moncut 70 DF	1.1 lb / a	In-furrow	43.7
3	Moncut 70 DF +	1.1 lb / a +	In-furrow	25.8
	Serenade	6.0 qt / a	In-furrow	
4	Quadris	11.6 fl oz / a	In-furrow	20.4
5	Vertisan	23 fl oz / a	In-furrow	32.0
6	Priaxor	8.1 fl oz / a	In-furrow	32.8
7	Nubark Mancozeb	1.0 lb / cwt	Seed	36.7
	Moncut 70 DF	1.1 lb / a	In-furrow	
8	Emesto Silver	0.31 fl oz / cwt	Seed	30.9
9	Omega 500F	3.0 pt / a	In-furrow	52.8
10	Luna Tranquility	11.2 fl oz / a	In-furrow	37.7
11	Regalia	8.8 fl oz / 1000 row ft	In-furrow	47.2
12	Maxim 4FS	0.08 fl oz / cwt	Seed	30.6
13	Vibrance	0.08 fl oz / cwt	Seed	31.6
14	Nubark Mancozeb	1.0 lb / cwt	Seed	33.6
15	Emesto Silver	0.31 fl oz / cwt	Seed	32.0
	Luna Tranquility	11.2 fl oz / a	In-furrow	
LSD $_{p>0.05}$				5.8

In 2016 the variety trial was conducted to identify traits of various cultivars and advanced selections on blemishes. There were 20 red-skinned cultivars and 6 yellow-skinned cultivars evaluated in Big Lake, MN. Plots were established in a commercial, irrigated potato field. A randomized complete block design was utilized with four replicates. Seed tubers were hand cut to 2-ounce seed pieces and suberized for approximately 5 to 10 days at 55 F and 95% relative humidity prior to planting. Tubers were planted on April 21, 2016 at a 9-inch within-row spacing; rows were spaced 36 inches apart. Plots were single rows; measuring 25 feet long, or 33 seed tubers per plot were planted.

Agronomic practices were typical of Minnesota irrigated production. After harvest, potatoes were stored at about 55 °F until graded. The tuber size profile distribution was determined by sorting potatoes into C size (<1.875 inches), B size (1.875 to 2.25 inches), A size (2.25 to 3.5 inches), and Chef size (>3.5 inches).

The agronomic data presented in Tables 4-7 are from the replicated research plots using experimental designs enabling the use of statistical analysis. These analyses allow the reader to ascertain, at a predetermined level of confidence, if the differences observed among cultivars/selections are reliable,

or if they might be due to error inherent in the experimental process. The LSD (least significant difference) values beneath the columns in the tables are derived from these statistical analyses and apply only to the numbers in the column in which they appear. If the difference between two cultivars/selections exceeds the LSD value at 0.05 or 0.10 it means that with 95 or 90 percent confidence, respectively, the higher-yielding cultivar/selection has a significant yield advantage. When the difference between two cultivars/selections is less than the LSD value, no significant difference was found between the two under these growing conditions. The CV stands for coefficient of variation, and is expressed as a percentage. The CV is a measure of variability in the trial. Large CVs mean a large amount of variation that could not be attributed to differences in the cultivars/selections.

The most common, or standard potato cultivar grown for the fresh market in Minnesota is Red Norland. The yield data supports this as it was the highest yielding cultivar. Red Norland tended to have roughly an average number of blemishes when compared with other cultivars. It was one the high end of skin netting. These defects reduced the number of tubers that can be marketed. Red Endeaver, Dark Red Norland, and W8890-1R seem to have good characteristics such as high yield and average or lower blemishes. These cultivars could be considered when trying to reduce blemish in fresh market potatoes. Of the yellow-skinned cultivar, Satina was the highest yielding, but tended to have a greater amount of problems with scab. Promising advanced selections were CO05037-3W/Y and NDA081451CB-1CY which had less blemish problems.

Overall, this project was successful. The survey found that some of the marketability problems growers face can be reduced by handling. Further work needs to be conducted to educate growers on potato handling to reduce skinning and bruising. Additionally, this work was able to delineate the effects of various fungicides and plant growth regulators on blemishes of fresh market tubers. This data will help potato growers in Minnesota have improved management of potato blemishes. The cultivar trial data is also important for potato growers as they look to select different cultivars to grow, they have some data from Minnesota to reference that will help them make decisions on the cultivars that could perform with the least number of blemishes.

Table 4. Red-skinned potato cultivar/selection trial graded yield from study conducted at Big Lake, MN in 2016.

Cultivar/Selection	Plants	Stems/plant	Tubers	Vine vigor[1]	A	B	C	Chef	Total yield
	Number				cwt/a				
AND00272	30	3.7	259	2.7	274	106	7	7	394
CO00277-2R	27	4.0	374	4.0	163	154	71	0	389
CO98012-5R	28	2.4	293	4.0	133	166	12	1	314
CO99076-6R	26	2.2	247	2.3	183	125	6	7	322
Crimson Red	26	2.1	185	2.7	268	73	1	29	371
Dakota Ruby	29	2.6	270	2.3	178	127	22	6	334
Dark Red Norland	23	2.2	215	2.7	275	84	2	19	380
MN10002PLWR-06R	23	3.8	201	1.3	227	79	9	5	319
MN13097PLWR-02R	26	2.8	277	1.0	155	142	22	6	325
ND-7982-1R	28	4.8	358	3.0	89	171	51	0	311
ND4659-5R	29	2.5	300	2.0	223	150	9	5	387
ND6002-1R	30	2.3	268	2.0	248	115	9	4	376
ND7132-1R	29	1.8	251	3.0	226	118	8	7	359
NDA7985-1R	27	2.4	246	3.0	267	95	11	9	382
NDCO81655-1R	30	3.4	386	3.0	99	192	57	0	348
Red Endeaver	26	3.6	293	4.3	190	179	5	3	377
Red Norland	31	2.9	224	5.0	381	54	2	29	466
Runestone Gold	26	3.5	272	4.0	261	128	6	5	399
Sangre	26	1.6	238	1.0	151	109	24	2	285
W8890-1R	27	4.1	326	4.3	213	157	82	4	456
Mean	27	3	274	3	209	129	20	7	366
CV %	10	12	25	20.0	40	33	154	123	22
LSD 0.10	4	0.5	93	0.8	115	58	42	12	112
LSD 0.05	4	0.6	111	1.0	138	70	51	15	134

[1]Vigor evaluation was completed eight weeks after planting. Rating compared with Red Norland; 1 indicates least vigor and 5 greatest vigor

Table 5. Potato variety trial blemish survey from 20 red-skinned cultivar or advanced selections grown in Big Lake, MN in 2016.

Cultivar	Black dot silver scurf	Early blight	Powdery Scab	Pitted common scab	Superficial common scab	Late blight	Soft rot	Dry rot	Lenticel spot	Growth crack/secondary growth	Skin netting	Greening browning
											%	
AND00272	15	17	13	8	20	0	0	12	0	3	0	3
CO00277-2R	43	5	8	0	13	0	0	0	0	0	27	3
CO98012-5R	77	5	5	0	0	0	0	7	0	2	10	5
CO99076-6R	42	7	10	0	17	0	0	3	0	5	22	2
Crimson Red	33	28	5	8	10	0	0	7	0	3	0	3
Dakota Ruby	45	35	5	2	18	0	0	5	2	2	45	2
Dark Red Norland	33	7	18	17	13	0	0	3	5	6	0	5
MN10002PLWR-06R	50	60	2	2	9	0	0	14	4	2	13	2
MN13097PLWR-02R	28	5	8	3	17	0	0	0	0	3	42	3
ND-7982-1R	20	43	3	7	7	0	0	12	0	0	0	2
ND4659-5R	42	7	5	3	7	0	0	5	0	2	17	5
ND6002-1R	42	27	10	0	23	0	0	3	0	0	10	0
ND7132-1R	17	40	7	3	12	0	0	2	0	7	70	3
NDA7985-1R	18	2	2	2	15	0	0	3	0	0	20	3
NDCO81655-1R	22	38	8	3	8	0	0	18	0	7	5	3
Red Endeaver	35	12	8	2	8	0	0	3	0	3	0	2
Red Norland	33	5	0	0	10	0	0	5	0	0	35	3
Runestone Gold	28	18	20	7	8	2	0	13	0	5	27	3
Sangre	42	25	0	0	8	0	0	7	0	8	32	2
W8890-1R	10	22	7	2	20	0	0	0	0	0	0	0
Mean	33	20	7	3	13	0	0	6	0	3	18	3

Table 6. Yellow-skinned potato cultivar/selection trial graded yield from study conducted at Big Lake, MN in 2016.

Cultivar	Plants	Stems/plant	Tubers	Vine vigor[1]	A	B	C	Chef	Total yield
	Number				cwt/a				
A05182-7Y	29	3.0	415	4.8	163	188	52	3	405
CO05037-3W/Y	28	4.6	363	4.3	143	219	23	0	384
MN02586	27	3.7	361	5.0	160	177	26	0	363
MN13041PLWR-03	26	3.6	205	3.5	116	110	11	2	239
NDA081451CB-1CY	27	4.5	426	4.8	66	225	60	0	351
Satina	27	3.0	317	5.0	290	135	12	1	437
Mean	27	4	348	5	156	176	31	1	363
CV %	10	18.7	13	9.4	13	29	21	239	13
LSD 0.10	ns[2]	0.9	56	0.5	55	46	23	ns	59
LSD 0.05	ns	1	67	0.6	67	55	27	ns	71

[1]Vigor evaluation was completed eight weeks after planting. Rating compared with Satina; 1 indicates least vigor and 5 greatest vigor.
[2]ns indicates the data was not significant.

Table 7. Potato variety trial blemish survey from 20 red-skinned cultivar or advanced selections grown in Big Lake, MN in 2016.

Cultivar	Black Dot Silver Scurf	Early blight	Powdery Scab	Pitted common scab	Superficial common scab	Late blight	Soft rot	Dry rot	Lenticel spot	Growth crack/secondary growth	Skin netting	Greening /browning
A05182-7Y	33	0	0	0	13	0	0	3	0	0	0	0
CO05037-3W/Y	29	4	3	0	11	1	0	3	3	1	0	3
MN02586	49	5	0	0	25	0	0	0	0	0	7	0
MN13041PLWR-NDA081451CB-	46	3	4	1	46	0	0	6	0	0	0	0
Satina	23	0	0	0	10	0	0	1	0	0	6	8
Mean	39	0	0	10	28	0	0	5	0	8	0	4
	36	2	1	2	22	0	0	3	0	1	2	2

The survey portion of this project was done by Dr. Robinson and Dr. Secor. Dr Robinson gathered samples from the potato growers and took the sample to Dr. Secor. Thereafter, Dr. Secor's lab was able to evaluate the tubers for blemishes. Dr. Robinson took the lead in presenting this information at the Potato Extension webpage, Valley Potato Grower, at the NPPGA Research Reporting Conference, and incorporated images into an Extension bulletin.

Field trials were completed by Dr. Robinson and Dr. Secor. Dr. Secor studied the effects of various in-furrow fungicides. Dr. Robinson evaluated cultivars and conducted the growth regulator trial.

Dr. Robinson and Dr. Secor have reported the data from these projects at Minnesota Area II Potato Growers meeting, on the NDSU/U of M Potato Extension webpage, Valley Potato Grower, and at the NPPGA Research Reporting Conference.

GOALS AND OUTCOMES ACHIEVED

To identifying the major blemish problems fresh market potato growers currently face we conducted a survey. The survey was successful as described in section 4.

Quantifying what agriculture production managements practices will reduced these major blemish problems was evaluated by four field trials. The in-furrow study and the growth regulator study completed in 2015 and 2016.

Identifying new cultivars that show resistance to blemish complexes was done through the cultivar trials completed in 2015 and 2016.

Our initial target was to reduce culls 15-20% in near future and to 5% long term.
However, after getting into this project we realized that cull numbers vary each year because of environmental conditions. Additionally, there were no new cultivars that we tested that provide this 15-20% reduction in culls. Unfortunately, we were not able to meet this goal. However, we did learn that bruising and skinning occurs to a large percentage of tubers. This is a cultural management practice that could be improved over time by educating potato growers on handling of potatoes and could potentially reduce culls.

Target: All the information gathered will be posted immediately after the report is finished on the NDSU/U of M Potato Extension webpage.
Information on this project was shared on the NDSU / U of M Potato Extension webpage throughout the project as updates for the potato growers. These can be found at: https://www.ag.ndsu.edu/potatoextension/identifying-surface-blemishes-on-potatoes
https://www.ag.ndsu.edu/potatoextension/documents/UnderstandingBlemishProblemstoImproveMarketingofFreshPotatoes.pdf
https://www.ag.ndsu.edu/potatoextension/understanding-and-managing-blemish-problems-in-fresh-market-potato
https://www.ag.ndsu.edu/potatoextension/BlemishofRedandYellowskinnedpotatoes.pdf

Target: Data will be shared with potato growers and industry at meetings/conferences.
Data from this project were presented at the Potato Association of America meeting from 31 July to 4 August 2016; Minnesota Area II Potato Council meeting on 1 March 2016; International Crop Expo on 18 February 2016. We are in the process of putting together a manuscript to submit to the American Journal of Potato Research.

In general, the outcomes were short term and data has been shared with the potato growers so they can implement what was learned. The most difficult thing to determine is the reduction the blemishes, because there is so much year-to-year variability on blemishes caused by pathogens or from physiological stresses.

BENEFICIARIES

Those who benefitted from this research primarily are the fresh market potato growers in Minnesota. This data would also be transferable to neighboring states, such as North Dakota or Wisconsin and to other types of potatoes such as seed or process potato production.

As example of the economic impact could be calculated as such. If the price of fresh red-skinned potatoes were $20/cwt for US#1 and $15/cwt for us#2 and the yield was 400 cwt/a and you grew 500 acres of potatoes. If you were to reduce bruising and skinning by 10% by slowing down when harvesting and handling the potatoes more carefully. This would be going from 36% to 26% bruising and skinning, then you could sell 40 cwt/a more potatoes as US #1 for an extra $5/cwt. This would equate to $200 more per acre and over 500 acres that would equal $100,000.

LESSONS LEARNED

The project was a good opportunity to help a specific grower issue. Every time we shared results there was a great interest from those in attendance. One caution, would be to break up a project like this into smaller projects where more focus can be taken.

We did not expect that bruising and skinning were one of the most prevalent blemishes. This is important, because this can be managed through handling of potatoes and it is not something that must be controlled in the soil or plant.

We accomplished our goals. We were not able to get a specific number in reduction of blemishes.

ADDITIONAL INFORMATION

We are working on a publication to be published in a peer-reviewed journal, such as the American Journal of Potato Research.

Extension article: Northern Plains Fresh Market Potato Cultivar/Selection Trial Results for 2016
https://www.ag.ndsu.edu/publications/crops/northern-plains-fresh-market-potato-cultivar-selection-trial-results-for-2016/a1834.pdf

Extension article: Potato Production Problems
https://www.ag.ndsu.edu/publications/crops/potato-production-problems/a1817.pdf

Valley Potato Grower magazine link from March 2015 issue:
http://www.valleypotatogrower.com/flipbookMarch2016Mag/flipbook/

Image of the growth regulator trial taken August 12, 2015.

Russeting or road-mapping on a red-skinned potato.

Skinning of a yellow potato.

Thumbnail bruise of red-skinned potato.

Black dot of potato.

Project 13

MN Specialty Crop Block Grant – Federal Fiscal Year 14

Project Title

Potato Production Sustainability in Midwest: Validation of Biochemical Markers to Predict Sugar End Development under Field Conditions

Project pulled by University of Minnesota

Project 14

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Contact: Bob Olson

Organization: Cooperative Development Services

Contact information: bolson@cdsus.coop, 651-265-3682

PROJECT TITLE

Assessing Financial Metrics of Regional Specialty Crop-based Food Hubs that serve Small Farm Operators

PROJECT SUMMARY

Specialty crop operators are seeking access to perceived markets for specialty crops in retail, institutional and independent restaurant venues as an extension to sales in farmers markets, CSA's and other direct marketing ventures. To accomplish efficiencies and product standardization, producers are exploring aggregation and distribution through food hubs that serve as intermediaries.

Based on our direct experience with fledging food hubs, coupled with scores or research reports, we believe that almost all specialty crop-based food hubs are operating below a break-even size. Most, however, aspire to achieve break-even, pay fair wages, pay producers fair prices, and to make their products available to consumers of all income categories. While there is much useful information in the generic reports currently available, they do not clearly show the scope of this challenge in standard financial format. Understandable, existing food hubs do not make their financial statements widely available.

To address the lack of financial benchmarking and decision making, CDS developed generic financial templates which were based on real data and vetted by food hub managers. The result are comprehensive financial tools to enable specialty crop-based food hub managers to properly plan and proactively address the financial challenges ahead. We also addressed how smaller food hubs (earlier stage) use a mix of volunteers, in-kind support, grants and donation and just "making do and going without" to achieve their goals.

In the last 3 years, at least 6 new specialty crop-based food hubs have begun operations in Minnesota; further, at least 5 additional hubs are in the pre-start-up phase. It was our belief that the specialty crop producers who are/will be supplying theses food hubs are unfamiliar with the financial challenges associated with aggregating, selling, and distributing fresh produce to institutions and other wholesale markets. These producers (and the community sponsors/organizations who often manage them) would benefit from knowing what level of sales and margins will be required before these business entities reach a self-sustaining size.

PROJECT APPROACH

The collection of financial benchmarks and operational characteristics of existing specialty crop-based food hubs was the initial focus of this project. Several food hubs exist in Minnesota, the Midwest, or scattered across the US (some for a few years, others for decades or more). Useful data and financial metrics were gleaned from these specialty crop-based food hubs, serving as benchmarks for aspiring enterprises. By the same token, we identified miss-steps which were equally useful to aspiring food hubs, learning from the experiences of those that preceded them. The data collection was obtained from prior CDS case studies, literature review of appropriate academic studies, targeted interviews with regional specialty crop-based food hubs, and travel to selected regional specialty crop-based food hubs.

Understanding the motivations of Minnesota specialty crop-based food hub participants represented the second focus of this project. Meeting with diverse producers seeking aggregation strategies helped establish the context for why specialty crop producers were interested in food hubs. CDS conducted surveys of specialty crop producers at the on-set of the SCBG project (January, 2015) and at the end-point of the SCBG project (January, 2016). These surveys were conducted at the Minnesota Fruit and Vegetable Growers Association (MFVGA) annual meeting and convention. In addition, we relied upon surveys obtained by the Institute of Agriculture and Trade Policy (IATP), who collaborated with Renewing the Countryside and Sustainable Farmers Association to collect data from specialty crop producers seeking access to institutional markets. In addition, the Lakes Country Service cooperative, operator of the Fresh Connect Food Hub, contributed insights from their own survey of specialty crop producers obtained in summer of 2015.

The third focus of this project was to develop specialty crop-based food hub financial proforma templates. Applying the learning from existing food hubs, coupled with the motivations of aspiring Minnesota specialty crop-based food hub participants, served as basis for various food hub development strategies. CDS developed financial proforma templates for 3 types of specialty crop-based food hubs (full service aggregator/distributor; aggregator/packhouse-only; and broker-only). In addition, each of these types of food hubs were modeled at 3 scales of development: artisanal/community-sponsored scale (annual sales of $100k, $250k, $500k); transitioning to break-even scale (annual sales of $1M, $2M); and break-even scale (annual sales >$5 million).

The final focus of this project was disseminating findings, tools, and recommendations to specialty crop producers. The findings and implications (as well as facilitated 'next steps') was presented at the Minnesota Fruit and Vegetable Growers Association's Annual Conference and Tradeshow on January 15, 2016. Printed copies of the presentation are being assembled by MFVGA for direct-mailing to their 200+ membership base and/or conference attendees. Further, CDS has been providing electronic copies of the presentation and (monitored) distribution of the proforma templates to interested groups seeking further information.

We were pleased to utilize excellent surveys of specialty crop producers conducted by: Institute for Agriculture and Trade Policy (in collaboration with Renewing the Countryside and Sustainable Farming Association); and Lake Country Service Cooperative, operator of the Fresh Connect food hub. We are also grateful for the cooperation of the Minnesota Fruit and Vegetable Growers

Association who provided a forum for our project's introductory survey and the project's culmination one year hence.

GOALS AND OUTCOMES ACHIEVED

Activities included:

- Questionnaire development
- Identification of survey participants (MFVGA members)
- Administering survey (at MFVGA annual conference, 2015)
- Collecting appropriate survey data from contributors (Institute of Ag and Trade Policy/RTC/SFA; Lakes Country Service Cooperative)
- Summarizing survey data re: specialty crop producer attitudes/motivations for food hub participation
- Development of food hub proformas
- Vetting of food hub proformas with food hub managers (Minnesota/Regionally/nationally)
- Development of food hub visual presentation modules
- Presentation of project findings and post-presentation assessment (MFVGA annual conference 2016).
- On-going one-to-one post seminar follow-ups

Our primary outcome measure was assessing the degree to which specialty crop producers increased knowledge of food hub financial metrics. We found that at the onset of the program less than 10% of specialty crop producers were aware of the fundamentals associated with developing financial proformas; further, virtually none of the producers were aware of the hub's scale (measured by annual sales of specialty crops) required to achieve financial sustainability. Following our presentation at the MFVGA conference, the discussion period validated that participants had gained a much greater understanding about the primary determinants of financial sustainability: annual hub sales, gross margin, and estimated operational costs.

We have accomplished the goals established for the project, and have exceeded what we intended regarding the proforma development. AS we surveyed specialty crop producers and interviewed food hub managers it became apparent that the current scale of >50% of the producers interested in food hubs were <$10,000 in annual sales. In addition, virtually all of the regional specialty crop-based food hubs interviewed were 'start-ups' with <4 years of operations and selling well under $500k/year. That said, we had to down-size the scale of our generic proformas in order to accommodate these small businesses. To that end, we detailed likely financial scenarios for food hubs as small as $100k in sales, with incremental growth to what we believe is a realistic break-even sales level of just over $5M/year.

Our goal was to see 75% of specialty crop producers improve their knowledge of food hub financials. Our facilitated post-seminar discussions evidenced that 100% of our attendees had gained considerable knowledge compared to their pre-level competencies.

BENEFICIARIES

The primary beneficiaries are the specialty crop producers interested in food hubs. These producers were of paramount importance to our project. A secondary beneficiary group are the nonprofit organizations and community sponsors of food hubs in the region. It is our observation that the specialty crop producers are very appreciative for learning the intricacies and financial challenges of food hubs. The nonprofit organizations and community sponsors, however, are much less appreciative of our assessment regarding the market challenges and sales levels required for financial self sufficiency. In general, many nonprofit groups feel threatened by our assertions of market challenges, operational costs, and the gross margins reflected in our generic proformas.

The primary finding of our assessment of food hub financial metrics is, “What level of sales is necessary to achieve break-even”. Using our generic, ‘estimated’ proformas which have been vetted by established food hub managers, the break-even sales for a full scale distributor model (aggregated, sells, distributes) is approximately $5.2M at an industry standard 20% gross margin. This sales level drops to $4.1M, $3.2M, and $2.6M for gross margins of 25%, 30%, and 40%, respectively.

For specialty crop based food hubs with expectations of breaking even with $300k in sales (or even $1.5M in sales), our financial estimates are extremely sobering. To that end, our proformas identify ways in which small scale hubs can sustain themselves. Those ‘support and subsidy’ line items include: ‘doing without’; ‘doing with volunteers’; doing with in-kind facilities and/or sponsorships’; and ‘doing with grants/donations’. For full distributor models, the total of these ‘support and subsidy’ line items under a 20% gross margin scenario totaled approximately $191,000, $226,000, $192,000, $332,000, and $247,000 for hubs with sales levels of $100k, $250k, $500k, $1M, and $2M, respectively.

What this means for the food hub with a sales target of, say $500k/year, is that they are likely to require on-going ‘support and subsidies’ totaling $192,000/year to cover all costs. As we have interviewed small-scale food hubs, many believe this level of support is achievable so long as grant funds continue to be available, and/or community support remains strong. For the food hub manager this becomes an on-going, difficult task.

LESSONS LEARNED

We are struck by the passion and energy of specialty crop producers seeking access to wholesale markets via food hubs. Our producer surveys validate that in many respects, the type of producer most interested in aggregation strategies for wholesale markets is, in our estimation, the least likely to succeed. Our survey respondents are overwhelmingly small scale (measured by acreage and/or specialty crop sales) and relatively inexperienced as specialty crop producers (half of the respondents have <10 years of farming experience and few have any experience selling into wholesale markets). These characteristics bring financial and logistical challenges for the food hub business, which competes in a highly-competitive, low-margin marketplace.

We are pleased to report that this project will play a major role to inform the Minnesota Legislature about the status of food hubs. CDS was awarded a contract by the Minnesota Department of Agriculture to research the status of Minnesota food hubs and to identify means to overcome barriers to their success. Our findings and proforma templates will be utilized to address challenges and to suggest potential public policy actions by decision-makers.
We affirm that NO lobbying activities of any kind took place in conducting research on food hub issues. Similarly we affirm that NO SCBGP funds were used for lobbying at all. Subsequent to and independent from the federally funded SCBGP project, the Minnesota Legislature commissioned the MN Dept. of Agriculture (MDA) to create a study to assess the status of food hubs in MN. The MDA issued a competitive RFP to accomplish that task, and Cooperative Development Services (CDS) was one entity that responded to that RFP. After review of all submissions, the MDA selected the CDS project proposal for funding. No lobbying was involved in this process.

While we believe that specialty crop producers are much better informed about the financial metrics of food hubs, there continues to be on-going community activism and nonprofit encouragement for these businesses with little regard for realistic financial planning. These groups and organizations, in our opinion, grossly underestimate the financial, market, and logistical challenges ahead.

ADDITIONAL INFORMATION

-We have provided a copy of our presentation to the MFVGA conference below.
-In addition, we have provided our generic proformas (3 types of food hub models; each with a range of sales goals) (attached to the e-mail submission of Minnesota's final progress report). Please Note: The generic proformas are not meant for public distribution. They provide a template for use by trained financial advisors to guide food hub managers using the unique attributes and nuances of individual hubs and their producers. (Project 14.Generic Proformas of 3 Types of Food Hub Models)

Understanding Food Hub Financials

What does it take to reach break-even?

Bob Olson
Joan Stockinger

CDS Cooperative Development Services
Where cooperation is at work, communities prosper

"Assessing the Financial Metrics of Regional, Specialty Crop-Based Food Hubs"

- Specialty Crop Block Grant
  - Federal USDA funds
  - Administered by Minnesota Department of Ag

"The Status of Minnesota Food Hubs"

- Minnesota Department of Agriculture contract
- Report to Minnesota Legislature
- February 29, 2016

A Food Hub is....

- "... a centrally located facility with a business management structure facilitating the aggregation, storage, processing, distribution, and/or marketing of locally/regionally produced food products." *USDA*
- *However, great variability in:*
  - *Size/scale*
  - *Business organization (non-profit vs for-profit)*
  - *Markets served*
  - *Years of operation*
  - *Activities performed*
  - *Definitions of Local*

Values & Goals

- Markets for small farmers
- Healthy, sustainable food
- Fewer food miles
- Local jobs
- Food security
- Food justice
- Consumer education
- Farmer networking
- Other
- ~~Financial viability~~

Public goods ??

Minnesota Grower Surveys

- CDS Survey
  - 2015 MFVGA Annual Convention
  - *Food Hub Questionnaire*
- IATP Survey (Sustainable Farming Association and Renewing The Countryside)
  - 2015 Report; 2014 data
  - *Building Minnesota's Farm to Institution Markets*

Producer Survey:

Size and Experience

- Respondents are small scale
  - Sales
    - most <$40,000/year;
    - 17% < $5,000/year
  - Acreage
    - 50% < 50 acres;
    - 24% < 3 acres
- Respondents are less-experienced
  - Approximately 50% < 10 years; 40% < 5 years

Producer Survey:

Interests in Aggregation

- > 50% interested in aggregation strategies
- >75% interested in selling to institutions
  - K-12
  - Universities
  - Hospitals
- Also interested in
  - Retail
  - Direct-to-Consumer

Producer Survey:

Concerns with Aggregation

- **Wholesale Price Points**
- Minimum volume requirements
- Seasonality of production vs customer demand
- Product specs and packaging
- Others

Producer Survey:

Motivations for Hubs

- **Increase sales**
- **Make more money**
- Support small farmers
- Support local economy
- No preference for serving low or high income households

The Food Hub is a Business

- Do your homework
  - The hub leadership needs to 'Go Deep'
- Food hubs must be prepared for marketplace realities
- Financial sustainability must be achieved

Food Hub Metrics

- Food Industry Context
- Ways Food Gets from Producer to Consumer
  - Definition(s) of Food Hubs
- Food Hub Financial Metrics Summary
  - Artisanal vs Commercial Scale Concept
  - Three Hub Types
    - Full Service Distributor
    - Aggregate/Pack House
    - Broker Only
- Summary, Final Thoughts

Context Food Industry

- We have a food system in USA
  - Characteristics include: mature; full (supply meets demands); consolidated; efficient; intensely price competitive; utilizes technologies; globalizing; many externalities
- Many externalities
  - Include environmental costs to soil, water, bio-diversity; health costs of poor quality food; social costs of poor paying jobs; rural community decline from consolidation; limited access for lower income people
- Three channels
  - Direct to Consumer; Wholesale to Retailers; Wholesale to Food Service/Institution

Context Food Industry

- Many values/goals of alternative food systems
  - Support small / family farms
  - Rural economic development
  - Care for environment
  - Better health through healthy food
  - "Food justice" with access for those of limited means
  - Build community around food and sustainable living
  - Financial Viability

(Inevitable) Values Tensions

Challenge of Managing a Fair, Healthy, Sustainable, Local Food System

Context for Food Hub: How food gets from producer to consumer

Farm Direct to Consumer

(benchmark)


$1

- Farmstand or Farmstore
- Farmers' Market
- CSA
- Order/direct deliver

$1
Includes any price premiums*

**Price Premiums include: organic, local, family-farmed, grass-based, sustainable, quality, freshness, taste, local fair trade, natural, other?*

Farm Direct to Retailers

For a "friendly" retailer



65c | 35c | $1 *(premium price)*

Farm to Distributor to Retailers

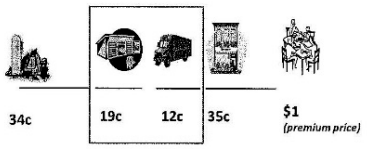
For a "friendly" retailer & distributor




53c* | 12c | 35c | $1 *(premium price)*

**Farm-retail price spread for fresh vegetables 27%*
For processed fruits and vegetables 17%
(USDA ERS 2013)

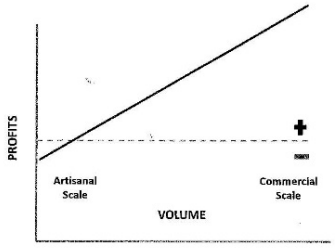
Farm to Packhouse (Aggregator)
to Distributor to Retailers
with scale & efficiencies in pack/distribution; friendly throughout



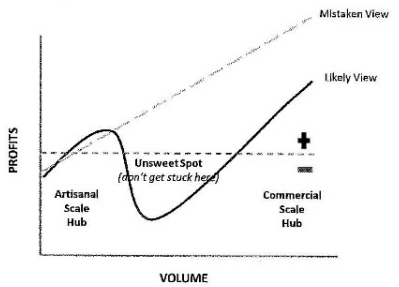
*Farm-retail price spread for fresh vegetables 27%
For processed fruits and vegetables 17%
(USDA ERS 2013)

Relationship of Profit vs Scale

Mistaken View:



Likely View:



Food Hub Financial Metrics and Proformas

- For Three Hub Types:
  1. Full Service Distributor (sells, packs, trucks)
  2. Aggregator/Packhouse (sells, packs, arranges trucking)
  3. Broker Only (sells, arranges aggregation & trucking)
- Modeled Artisanal Scale, Commercial Scale (B/E) and Transition

Detailed multi-level pro formas for each, based on regional and national models. Reviewed with experienced hub managers.

Full Service Distributor (Sells, Packs, Trucks)

- Most common type
- What most of us think a hub does
- Addresses producers desire to farm and not sell, pack and truck
- Characteristics of successful distributors
  - High volume, low margin (2% net profit)
  - Year round supply
  - Efficient systems; professional manager/staff
  - Capital intensive (trucks, warehouses, coolers, inventory)
  - Customer focused - organized around customer demand (not producer)
  - Specialized by market channel, product
  - Certifications for handling; insurance
  - Long term customer relationships

Distributor Pro Forma
Key Numbers

	Artisinal/Community Sponsored			Transition to B/E		Break Even
	Year A1	Year A2	Year A3	Year B1	Year B2	Year C1
Total sales	**$100,000**	**$250,000**	**$500,000**	**$1,000,000**	**$2,000,000**	**$5,175,000**
Sales growth yr over yr	-	*150%*	*100%*	*100%*	*100%*	*159%*
Gross margin %	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
Weeks operating	26	26	26	52	52	52
Avg sales per week	*$3,846*	*$9,615*	*$19,231*	*$19,231*	*$38,462*	*$99,519*
Est weekly delivery runs	*2*	*4*	*4*	*5*	*6*	*10*
Avg sales per delivery run	*$1,923*	*$2,404*	*$4,808*	*$3,846*	*$6,410*	*$9,952*
Employees (fte)	*2.262*	*3.224*	*3.224*	*6.63*	*8.372*	*12.22*
Labor (all) as % sales	*81%*	*45%*	*23%*	*23%*	*14%*	*8.5%*
Sales per fte employee	*$44,203*	*$77,543*	*$155,047*	*$150,830*	*$238,882*	*$423,486*
Square Feet Warehouse	*5,000*	*5,000*	*5,000*	*10,000*	*10,000*	*15,000*
Cost per square foot	*$6.5*	*$6.5*	*$6.5*	*$6.5*	*$6.5*	*$6.5*

Distributor Pro Forma
Capital Investment (Equipment, Leasehold)

	Artisinal/Community Sponsored			Transition to B/E		Break Even
	Year A1	Year A2	Year A3	Year B1	Year B2	Year C1
Equipment & Leasehold Improvement						
Start-up (1)	$254,475	$254,475	$254,475	$254,475	$254,475	$254,475
Additional purchases (2)	$0	$25,000	$25,000	$50,000	$50,000	$50,000
Total Equip/Lease	**$254,475**	**$279,475**	**$304,475**	**$354,475**	**$404,475**	**$454,475**

(1) Start-up Capital includes $40k office, computer, phone, software, website, legal, accounting investment; $210k coolers, leasehold improvements, warehouse equipment and supplies. Trucks are assumed to be leased.

(2) Ongoing additional equipment estimated at $25k - $50k per year. Likely low.

Distributor Pro Forma
Profit & Loss Statement - Income

	Year A1	Year A2	Year A3	Year B1	Year B2	Year C1
Income						
Total Sales	**$100,000**	**$250,000**	**$500,000**	**$1,000,000**	**$2,000,000**	**$5,175,000**
Sales growth yr over yr	-	*150%*	*100%*	*100%*	*100%*	*159%*
Cost of Goods (COGS)(80%)	$80,000	$200,000	$400,000	$800,000	$1,600,000	$4,140,000
Shrinkage (.5% sales)	$500	$1,250	$2,500	$5,000	$10,000	$25,875
Total COGS	$80,500	$201,250	$402,500	$805,000	$1,610,000	$4,165,875
Gross Margin (gross profit)	**$19,500**	**$48,750**	**$97,500**	**$195,000**	**$390,000**	**$1,009,125**
GM as % of Sales	*19.5%*	*19.5%*	*19.5%*	*19.5%*	*19.5%*	*19.5%*

Distributor Pro Forma
Profit & Loss Statement - Expense

	Artisinal/Community Sponsored			Transition to B/E		Break Even
	Year A1	Year A2	Year A3	Year B1	Year B2	Year C1
Expense						
Total Sales Expense	$13,046	$17,354	$17,354	$34,788	$59,140	$78,853
% of sales	*13.0%*	*7.0%*	*3.5%*	*3.5%*	*3.0%*	*1.5%*
Total Aggregation Expense	$56,701	$71,177	$74,677	$161,029	$187,705	$326,030
% of sales	*56.7%*	*28.5%*	*14.9%*	*16.1%*	*9.4%*	*6.3%*
Total Distribution Expense	$37,116	$72,273	$72,273	$164,682	$188,818	$336,322
% of sales	*37.1%*	*28.9%*	*14.5%*	*16.5%*	*9.4%*	*6.5%*
Gross Margin After Cost of Sales	-$87,383	-$112,093	-$66,843	-$165,499	-$45,663	$267,921
% of sales	*-87.4%*	*-44.8%*	*-13.4%*	*-16.5%*	*-2.3%*	*5.2%*
Total Overhead Expense	$62,424	$68,304	$75,382	$108,353	$135,087	$186,604
% of sales	*62.4%*	*27.3%*	*15.1%*	*10.8%*	*6.8%*	*3.6%*
Net Operating Income (ebitda)	**-$149,807**	**-$180,397**	**-$142,225**	**-$273,852**	**-$180,750**	**$81,316**
% of sales	*-149.8%*	*-72.2%*	*-28.4%*	*-27.4%*	*-9.0%*	*1.6%*

Distributor Pro Forma
Profit & Loss Statement – Other Expense

	Artisinal/Community Sponsored			Transition to B/E		Break Even
	Year A1	Year A2	Year A3	Year B1	Year B2	Year C1
Other Expense						
Depreciation Expense	$41,562	$45,728	$49,895	$58,228	$66,562	$74,895
Taxes Estimate	$0	$0	$0	$0	$0	$0
PRODUCER Support Services	$0	$0	$0	$0	$0	$0
Subtotal Other Expense	$41,562	$45,728	$49,895	$58,228	$66,562	$74,895
Net Income before Support	**-$191,369**	**-$226,125**	**-$192,120**	**-$332,080**	**-$247,312**	**$6,421**
net margin	*-191%*	*-90%*	*-38%*	*-33%*	*-12%*	*0%*

Distributor Pro Forma
Profit & Loss Statement - Other Sources of Support

Other	Year A1	Year A2	Year A3	Year B1	Year B2	Year C1
*Support & Subsidy**						
In Kind ($)	$0	$0	$0	$0	$0	$0
Volunteer ($)	$0	$0	$0	$0	$0	$0
In-Kind ($) Sponsorships	$0	$0	$0	$0	$0	$0
Grant / Donation ($)	$0	$0	$0	$0	$0	$0
Grant / Donation ($)	$0	$0	$0	$0	$0	$0
Total Community Support	$0	$0	$0	$0	$0	$0
Net Income After Support/Grants	**-$191,369**	**-$226,125**	**-$192,120**	**-$332,080**	**-$247,312**	**$6,421**
net margin with grant income	*-191%*	*-90%*	*-38%*	*-33%*	*-12%*	*0%*

*Equity Investment and Debt/Loans are additional sources of capital/cash. They are reported on the Balance Sheet and not P&L.

Distributor Pro Forma
Sources & Uses Start Up Budget (example)

EXAMPLE ONLY	Start-Up
Uses of Capital ($)	
Purchase Equipment/Leasehold	
Office and Start-up	$40,000
Warehouse Improvements & Equip	$180,000
Distribution Equipment	$25,000
Working Capital (op loss yr 1)	$149,807
Working Capital (op loss yr 2)	$180,397
Misc	$20,000
Total	$595,204
Sources of Capital ($)	
Do Without	$50,000
Volunteer Labor	$60,000
In Kind Use	$25,000
In Kind Sponsorships	$150,000
Grants/Donations #1	$100,000
Grants/Donations #2	$100,000
Loan #1 Line of Credit	$0
Loan #2	$0
Member Equity	$50,000
Investor Equity	$0
Total	$535,000
Gap	$60,204

Key Points Re: Break even

- Break even is a function of:
  sales volume, gross margin and costs
  - At 20% GM (80% sales$ to farmers) B/E est $5.2 M
  - At 25% GM (75% sales$ to farmers) B/E est $4.1 M
  - At 30% GM (70% sales$ to farmers) B/E est $3.2 M
  - At 40% GM (60% sales$ to farmers) B/E est $2.6 M

Key Points Re Other Hub Models

- CDS has complete pro forma for other models
  - Aggregator/Packhouse with B/E Est $3.2M with 18% GM
  - Broker Only with B/E Est. $1.4M with 15% GM
- Many varieties of hubs – many are hybrids of distribution types
- Challenges of finding financial data

Summary Points/Take Aways

- Food hubs are separate and real business
- Two very different levels were evaluated:
  - Artisanal (limited, sponsored and supported collaboration for public good)
  - Commercial scale hub

Food Hub Challenges

- **Sales price resistance** (especially institutions)
- Finding adequate markets (at the right price)
- Aggregating from small growers (complex and costly)
- Inadequate local supply (related to pay price)
- Matching producers to markets (wholesale growers)
- Volunteer burn-out
- Under-capitalization
- Cost control (need efficiencies to compete)
- Access to sales/management professionals
- Produce-only hubs (seasonal unless non-local sources)

Advice/Key Success Factors

- Develop realistic plans
- Hire knowledgeable distribution/sales professionals
- Use existing infrastructure whenever possible
- Serve higher-margin markets
  - Direct to Consumer (CSA)
  - Retail
- Target population centers vs rural-only
- Year-round operations; non-local during winter
- Source from wholesale-ready producers

Wholesale Grower Characteristics

Transition from Direct Selling to Wholesale Requires Real Changes

- Coordinate/cooperate with others
- Understand wholesale price constraints
- Understand cost of production per product
- Focus their wholesale production to a limited number of crops
- Grow to order/contracts
- Follow through on commitments. No 'selling around the hub'
- Understand uniform packing requirements
- GAP, Insurance, FSMA
- Have investments in infrastructure

For more Information

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CDS | Cooperative Development Services
When cooperation is at work, communities prosper

145 University Avenue, Suite 450
St Paul, MN 55103

End

Slides after this are extras for possible incorporation.

Distributor Pro Forma
Profit & Loss Statement -Detail

	Artisinal/Community Sponsored			Transition to B/E		Break Even
	Year A1	Year A2	Year A3	Year B1	Year B2	Year C1
Overhead Expenses						
Advertising: Promotion	$1,500	$1,500	$2,000	$2,500	$5,000	$7,500
Salary/Wages Admin (Mgr, Asst)	$45,224	$44,703	$52,182	$74,831	$85,087	$118,279
Employee Benefits (health)	$0	$0	$0	$0	$0	$0
Employee Training	$500	$1,000	$1,000	$1,000	$1,000	$1,000
Office: Rent (in Warehouse)	$0	$0	$0	$0	$0	$0
Office: Computer & Internet	$2,400	$2,400	$2,400	$2,400	$2,400	$4,000
Office: Telephone	$2,400	$2,500	$2,700	$3,000	$3,000	$4,000
Office Misc: Admin (supplies, printing, postage, misc)	$1,000	$1,000	$1,200	$1,500	$2,000	$2,500
Credit Cd Fee (@2.5% x 20% sls)	$500	$1,250	$2,500	$5,000	$10,000	$25,875
Liabil Ty Insurance (.2% sales)	$200	$500	$1,000	$2,000	$4,000	$10,350
Travel: mileage, lodging	$1,000	$1,000	$1,000	$2,000	$2,000	$2,000
Travel: meals, entertaining	$500	$750	$1,200	$1,200	$1,200	$1,200
Membership & Conference Fees	$500	$500	$500	$500	$500	$500
Total Payroll Expenses	$0	$0	$0	$0	$0	$0
Professional: Accounting	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
Professional: Legal	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
Other/Misc (Rebrish, Detail	$500	$1,000	$1,500	$2,000	$2,500	$3,000
Total Overhead	$62,424	$68,303	$75,382	$108,353	$135,087	$186,604
Net Operating Income (ebi	-$149,887	-$180,397	-$142,225	-$273,852	-$180,750	$81,316

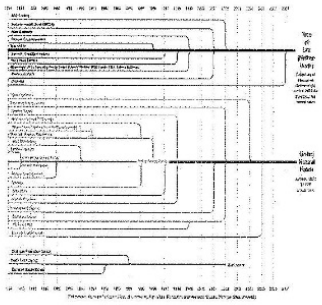
Distributor Pro Forma
Profit & Loss Statement - Detail

	Artisinal/Community Sponsored			Transition to B/E		Break Even
	Year A1	Year A2	Year A3	Year B1	Year B2	Year C1
Cost of Selling						
Salary/Wages/Fringe	$13,046	$17,394	$17,394	$34,788	$39,143	$78,853
Other	$0	$0	$0	$0	$0	$0
Total Cost of Selling	$13,046	$17,394	$17,394	$34,788	$39,143	$78,853
% of sales	13.0%	7.0%	3.5%	3.5%	3.0%	1.5%
Cost of Warehouse/Aggregation						
Salary/Wages	$12,175	$24,352	$24,352	$60,879	$73,055	$130,455
Building & Equipment	$44,525	$46,825	$50,325	$100,150	$114,650	$195,575
Total Cost of Aggregation	$56,701	$71,177	$74,677	$161,029	$187,705	$326,030
% of sales	56.7%	28.5%	14.9%	16.1%	9.4%	6.3%
Cost of Distribution						
Salary/Wages	$10,436	$20,873	$20,873	$52,182	$62,618	$111,322
Vehicles /Equipment	$26,700	$51,400	$51,400	$112,500	$126,200	$225,000
Total Cost of Distribution	$37,136	$72,273	$72,273	$164,682	$188,818	$336,322
% of sales	37.1%	28.9%	14.5%	16.5%	9.4%	6.5%
Gross Margin After Cost of Sales	-$87,383	-$142,093	-$66,843	-$165,499	-$45,665	$267,821
% of sales	-87.4%	-44.8%	-13.4%	-16.5%	-2.3%	5.2%

Distributor Pro Forma
Profit & Loss Statement - Detail

	Artisinal/Community Sponsored			Transition to B/E		Break Even
	Year A1	Year A2	Year A3	Year B1	Year B2	Year C1
Interest Income	$0	$0	$0	$0	$0	$0
Other Income	$0	$0	$0	$0	$0	$0
Subtotal Other Income	$0	$0	$0	$0	$0	$0
Other Expense						
Interest Expense	$0	$0	$0	$0	$0	$0
Depreciation Expense	$41,562	$45,728	$49,895	$58,228	$66,562	$74,895
Taxes Estimate	$0	$0	$0	$0	$0	$0
PRODUCER Support Services	$0	$0	$0	$0	$0	$0
Subtotal Other Expense	$41,562	$45,728	$49,895	$58,228	$66,562	$74,895
Net Other Income/Expense	-$41,562	-$45,728	-$49,895	-$58,228	-$66,562	-$74,895
Net Income before subsidies	-$191,369	-$226,125	-$192,120	-$332,080	-$247,312	$6,421

Organic Industry Structure: Distributor Acquisitions and Mergers, 1984-2007



Characteristics of Retailers

- Retail gross margin varies – 35% - 45% (specialty)
- Very friendly retailer might take less
- Retailer grocers are high volume/low margin
- Typical retail net margin 2-4%
- Rest of margin goes to real costs
- Need year round supply and quality
- Capturing the price premium requires retailer participate in farm story & sell values
- Many will not deal direct with small producer
- "Friendliest" markets may be "full" with local product

Characteristics of Aggregation/Packhouse

- Real costs: miles; handling; facilities; spoilage; selling; invoicing; overhead, pre-season contracting, trouble shooting management; etc.
- Value-added in marketing and sales; access to larger markets; certification and insurance
- Volume/throughput driven
- Have one way hauling
- Can't fix seasonality in fully local model
- Must be able to communicate and sell the premiums to escape commodity price squeeze
- Risk to growers to weaken brand and brand premiums

Full Service Distributors (Sells, Packs, Trucks)

- What Most of us Think a Hub Does
- Low margin (15-20%); driven by volume
- Minimize costs through efficient handling and consolidated delivery and services
- Compete on price, reliability, quality
- Understand 'Terminal Pricing'
- Need year round, consistent supply
- Driven by their customers' business preferences
- Many will not deal directly with small producer
- Long term, repeat, multi-product relationships
- Require certification (GAP) and liability insurance

Food Hubs: Measuring Success

1. Support local / family farms

   Metrics: growth in local sales $; improved farm gate income and profitability; increased acreage in local crops; # farmers participating in local sales; evidence of farmers "scaling up" (measure in total and per producer participating); # of new farmers

2. Local economic development

   Metrics: # new jobs; fair wages for new food system workers; growth local payroll; secondary business creation (processing, services); multiplier estimates

Food Hubs: Measuring Success (con't)

3. Care for Environment

   Metrics: acres impacted by sustainable practices; acres in new rotations such as perennials or continuous cover; acres in wetland/habitat and wildlife impacts; ests carbon sequestered; soil quality measures; water quality measures

4. Better health through better diet

   Metrics: # pounds/$ local fresh food sold; expanded # outlets for healthy local food; # such meals served in institutions; ests reduced exposure to harmful chemicals (organic or like);

Food Hubs: Measuring Success (con't)

5. Access for those of limited means (affordable = food justice) Metrics: Fair prices to farmers; fair wages to workers in food system; affordable for all / those of limited means

6. Build community around food and sustainable living
   Metrics: Challenge to measure "soft but real" benefits; new connections between farmers, "eaters" and others? impact on living, eating, well-being?
   # participating in education programs around food; attendance at farmers markets; attendance at other community events addressing food

Food Hubs: Measuring Success (con't)

7. Achieve financial viability for hub
   Metrics: Achieve break/even operations within timeframe of resources available; ability to attract start-up and working capital needed to achieve viability; ability to find and secure sufficient markets paying price needed to stimulate supply growth

Factors identified in reports on hubs that have failed

- Did not do adequate planning to understand business
- Needed more capital to get through start-up to b/e
- Big transition from direct selling to wholesale markets
- Did not have knowledgeable distribution/professional manager(s)
- Did not fullyl understand producer goals and desires (small producers were interested but then do not want to scale up)
- Better match producers to markets served
- Use existing infrastructure where possible

Project 15

MN Specialty Crop Block Grant
FINAL PERFORMANCE REPORT 2014 SCBG Projects

Contact: Paul Hugunin

Organization: Minnesota Grown Promotion Group, Inc.

Contact information: paul.hugunin@state.mn.us, 651-201-6510

PROJECT TITLE

Statewide Marketing of Minnesota Grown Specialty Crops

PROJECT SUMMARY

This project enhanced the competitiveness of all Minnesota specialty crop producers by improving marketing efficiency for growers and by making it easy for consumers to locate and purchase directly from growers. A major advantage of this proposal is the strength of the Minnesota Grown Program, a public/private partnership that is the statewide umbrella marketing program for specialty crop producers. By coordinating SCBG funds with the state's Minnesota Grown Program, this project avoided duplication and maximized the impact of federal and state resources.

This proposal included new initiatives, including creating new customized promotional materials for squash; creating greater demand for locally grown produce by creating a new advertising campaign in greater Minnesota; and the development of new billboards and television ads for Christmas trees, apples and berries.

Consumer demand for locally grown produce is increasing each year. Consumers want to know where their food comes from, who grows it and they want to proudly (and publicly) demonstrate the ways in which they are supporting the local foods movement. With this increase in demand, specialty crop growers need assistance developing marketing tools that facilitate their connection to these consumers.

This proposal built on previous SCBG investments that demonstrated the value of pay-per-click advertising as a way to connect consumers who are searching for fresh produce with Minnesota growers via the online Directory. We are built on previous efforts that included adding specialty crop specific advertising to the printed Minnesota Grown Directory.

PROJECT APPROACH

Activity 1: Build on our previous expertise with pay per click advertising to link consumers with growers via the online Minnesota Grown Directory. The primary component of this activity

included sponsored search ads on Google and Bing search engines that resulted in the following results.

Apples	*26,184 clicks (16,959 Google, 9,225* Bing*)*
Christmas trees:	*18,470 clicks (15,803 Google, 2,667 Bing)*
Berry farms:	*14,869 clicks (12,546 Google, 2,323 Bing)*
CSA:	*3,571 clicks (1,884 Google, 1,687 Bing)*
Farm wineries:	*24,043 clicks (18.927 Google, 5,116 Bing)*
Pumpkin patches:	*13,408 clicks (11,022 Google, 2,386 Bing)*
Honey:	*4,538 clicks (3,974 Google, 564 Bing)*

We also used "boosted posts" on Facebook that reached over 325,000 Minnesotans and resulted in 8,377 interactions, including link clicks to our online Directory, page likes, post likes, comments and post shares.

Activity 2. Develop, print and distribute new point of sale materials for specialty crops.
New cards were designed and printed to promote the four most common varieties of squash grown in Minnesota. We printed a total of 5,000 cards (1,250 of each variety). The designs were included with previous annual reports.

Activity 3. Increase awareness of locally grown produce through a new advertising campaign in greater Minnesota.
The new television ads were aired on cable television networks that reach targeted cities in greater Minnesota. The two networks are Spectrum Reach (a cable TV network serving regional centers such as Duluth, Willmar, St. Cloud, Owatonna, Mankato and more) as well as Cable One (a cable TV network specifically chosen to reach the Fargo/Moorhead area).

Lamar, based in St. Cloud, Minnesota, designed and posted our outdoor billboards promoting Minnesota specialty crops. Produce ads were displayed 9 locations in greater Minnesota during September and October of 2016. An additional 4 billboards promoting locally grown Christmas trees were displayed in four locations in greater Minnesota in November and December of 2016.

Activity 4. Increase effectiveness of advertising by developing new creative for apples, Christmas trees and berries.
Each new TV ad featured Minnesota Grown spokesperson Carrie Tollefson. The ads for Christmas trees and berries also include her two young children.

Activity 5. Increase usage of specific specialty crops through the Minnesota Grown Directory.

The 2015 Minnesota Grown Directory was successfully printed distributed statewide from April, 2015 to February of 2016. Approximately 155,000 copies were distributed statewide.

The primary partner in this project was the Minnesota Department of Agriculture's Minnesota Grown Program. They provided staff time to administer the project and ensured that the activities align with the MDA's Minnesota Grown Program activities. This ensured that we avoided duplication and that this project supplements rather than supplants existing activities.

KARE-11 Television was a significant partner, providing filming and editing of the new ads.

LAMAR was our vendor providing design and installation of our specialty crop billboards in greater Minnesota.

We worked closely with the Minnesota Fruit and Vegetable Growers Association on the design of the new squash cards. The Minnesota Fruit and Vegetable Growers Association invited the Minnesota Grown Program to attend and exhibit at their annual conference to gather input and promote the new marketing materials.

GOALS AND OUTCOMES ACHIEVED

Activity 1. Use pay per click advertising (sponsored search advertising) to link consumers with growers via the online Minnesota Grown Directory. We updated all of our campaigns and monitored progress throughout the grant period.

Activity 2. Develop, print and distribute new point of sale materials for specialty crops. With help from the MN Fruit and Vegetable Growers Association and individual member farmers, we created a series of new promotional materials promoting the four most common varieties of squash grown in Minnesota.

Activity 3. Increase awareness of locally grown produce through a new advertising campaign in greater Minnesota. Working with media partners Lamar Outdoor, Cable One TV and Spectrum Reach, we posted new billboards as well as aired 3 new television ads in greater Minnesota.

Activity 4. Increase effectiveness of advertising by developing new creative for apples, Christmas trees and berries. We created three new television ads and a new outdoor billboard during this grant period.

Activity 5. Increase usage of specific specialty crops through the Minnesota Grown Directory. We designed and printed seven full pages devoted to specialty crops including 2 full pages dedicated to Christmas trees, 2 full pages for strawberries, 1 full page for farm wineries, 1 full page for CSA farms, and ½ page ads for carrots, garlic, rhubarb and honey. We committed to seven pages but were able to deliver more than 8-1/2 pages to promote these specialty crops.

The activities conducted in this project all contribute toward the State of Minnesota's long term goal of increasing the demand for locally grown specialty crops and increasing the diversification of Minnesota agriculture by creating more profitable markets for specialty crop producers.

Measurable Outcome #1
GOAL: To increase the number of consumers who purchase Minnesota Grown specialty crops as a result of their visit to the Minnesota Grown Directory. Surveys of both participating growers as well as of consumers purchasing from them clearly show that the Minnesota Grown Directory is directly responsible for sales of specialty crops.

PERFORMANCE MEASURE: We measured the number of unique visitors to www.minnesotagrown.com. We measured the source of visitors to identify how many arrived from PPC, unpaid search engine results, links from other sites and using the direct link.

BENCHMARK: In calendar year 2013, we received 265,000 unique visitors.

TARGET: Our goal was to have a 5% increase in the number of unique visitors to a total of at least 278,000 unique visitors annually. Increasing our unique visitors will parallel an increase in sales for specialty crop growers.

ACTUAL: In calendar year 2014, we received 286,170 unique visitors, an increase of just over 21,000 unique visitors. This represents an increase of 8%, exceeding the original goal of at least a 5% increase.

Measurable Outcome #2
GOAL: To increase the competitiveness of Minnesota Specialty crop producers by providing them with effective promotional materials to increase their sales and visibility.

PERFORMANCE MEASURE: We tracked producer orders for the new squash cards. We surveyed those specialty crop producers post-order, asking questions related to the effectiveness and estimated impact on sales. Additionally we will be tracking the number of items distributed.

BENCHMARK: These are new promotional items; the benchmark is zero.

TARGET: Our goal was to have at least 75% of producers who use the new promotional items report that their sales increased because of the promotional material.

RESULT: The squash cards were printed and were well received by members who ordered them. We had 15 members order the squash cards during the grant period, with 12 of the 15 (80%) estimated that their sales increased because of the cards.

BENEFICIARIES

The Minnesota Grown Program is statewide and includes farms who sell direct to consumer and/or through wholesale markets. Farms of any size may join the program regardless of whether they are organic, sustainable, or conventional. The continued pay-per-click promotion of the online Directory of farmers who sell directly to consumers benefited the widest possible range of specialty crop producers, including Christmas tree growers, nurseries, garden centers, apple growers, berry growers, vegetable growers, CSA farms, grape growers, farm wineries & more.

There were more than 1,250 producers licensed to use the Minnesota Grown logo during this project, 80% of which raise specialty crops. More than 41% of members have been farming for less than 10 years, including 21% that have been farming for 2-4 years and 2.2% in their first year. This project also reached a large number of disadvantaged and immigrant farmers. For example, the St Paul Growers Association represents 165 vendors of which nearly 45% are Hmong growers and the

Central Minnesota Vegetable Growers Association represents over 200 members, of which 60% are minorities for whom English is their second language. The 2014 Minnesota Grown Directory of farms that sell directly to consumers included 978 producers and the Program's wholesale database included 110 farmers who sell to restaurants, schools, grocery stores and other wholesale markets.

LESSONS LEARNED

This project continued to reinforce the effectiveness of sponsored search advertising as a way of marketing specialty crops. It is targeted, measurable and scalable.

ADDITIONAL INFORMATION

Although the Minnesota Grown Program also works with farmers and farmers markets who are not allowed to benefit from USDA's SCBG program, we take the necessary steps to ensure that SCBG funds in this project only benefit eligible producers. All of the elements of this proposal only benefit producers of eligible products. For example, pay-per-click ads will only promote specialty crops, promotional materials only identify specialty crops, and the new billboards are specifically promoting specialty crops.

Project 16

MN Specialty Crop Block Grant
FINAL PERFORMANCE REPORT 2014 SCBG Projects

Contact: Theresa Keaveny

Organization: Sustainable Farming Association of Minnesota

Contact information: theresa@sfa-mn.org, 507-766-9159

PROJECT TITLE

Enhancing Competitiveness of Minnesota Herbs

PROJECT SUMMARY

Demand in Minnesota food cooperatives for locally produced specialty food items is growing, as evidenced by the SFA New Crops Project of 2010, and feedback from several coops. It is often difficult to obtain local y producers or processed examples of these food products, either because production expertise is lacking among Minnesota Farmers, the perceived returns are too low, or producers do not have readily available markets to get these products to consumers. Through

other ongoing work at SFA, a need had been identified among Minnesota farmers for growing and marketing unique crops with a higher than average return such as herbs. This led to the establishment of the project.

The Sustainable Farming Association of Minnesota designed "Expanding Opportunities for Minnesota Herb Growers" to 1) develop education programs to assist farmers in learning how to grow, harvest and market specialty crops, specifically herbs; 2) assist farmers, MN good coops and grocers in enhancing competitiveness of these products; and 3) educate consumers about the many benefits of alternative crops, to reach the ultimate goal of increasing both the supply and demand of locally produced specialty crops.

SFA's "adjust 2015" project has demonstrated that new farms struggle to become established and succeed long-term. Additionally, at a time when existing farms are rapidly transitioning to new operators, and new farms are getting started in greater numbers, new products which can fulfill unmet demand will enhance the competitiveness of Minnesota farmers. "Enhancing Competitiveness of Minnesota Herbs" presented an opportunity for Minnesota farmers, and a potential for Minnesota Agriculture to help new farm businesses establish and continue successfully.

Unlike other specialty crop segments in Minnesota, such as fruit and vegetable growers, herb producers have not had direct support organization similar to the MN Fruit and Vegetable Growers Association. The Minnesota Herb Society is largely inactive, and the organizations and events supporting herbs, such as the Minnesota Herbalist Festival, are not focused on producers. As the Farmer-to-Farmer Network, SFA saw a gap in industry support for herb producers, which was perceived as a reason why demand for locally-produced herbs is unmet. SFA was pushing into new territory and one vision was to see the creation of an entity that would support the emerging herb industry in Minnesota.

The project didn't build on previously funded SCBGP or SCBGP-FB work, but it did result in the creation of a more narrowly defined project related to garlic that has since been funded by SCBGP.

PROJECT APPROACH

The project began late due to a late start in finalizing the grant contract. Thus, the first growing year, 2015, was delayed and effectively didn't result in production. The project was thus extended for a year, into 2017, to enable greater public education and outreach about herb production and marketing.

Activities/outcomes 2015: Due to the timing of the funding being made available, the demonstration plot was established too late in the year to have an effective field day in 2015. This year, the plot was prepared with drip irrigation, weed control fabric and tillage in June. Seeds were started in flats in June, and transplanted into the plot in July and August. The following crops were intended to be a part of the project, but were not planted into the plot in 2015 either because the seedlings failed or because we could not obtain seed or seedlings: Anise, Rue, Artemisia, Goldenseal, Gingko Biloba. These will be attempted again in 2016. No harvest data were taken in 2015, as herbs were not harvested. The 2015 CornerPost was distributed and featured the project.

(http://www.sfa-mn.org/wp-content/uploads/2011/02/CornerPost-MAIN-2015-16-FINAL.pdf). Jason Walker contributed his communication expertise to the project, promoting it to the SFA Network.

Activities/outcomes 2016: A Blog site was developed (http://www.sfa-mn.org/category/herbs/), but less have visited the blog site than projected (32, compared to a goal of 100). SFA Connect articles were posted (http://www.sfa-mn.org/sfa-connect-archive/). A group of 32 visiting ag. professionals toured the demonstration plot in June, 2016. Because the demonstration plot was located next to a county highway, numerous people stopped and asked about the project. This provided an additional and unplanned-for level of project exposure. An herb field day was conducted on September 20, 2016. Eight participants viewed the demonstration plots and held a lengthy discussion on the potential for and issues associated with herb production. Developments: Original funding was delayed until Spring 2015, thus creating a significant obstacle in project development. Herb planting at Central Lakes College was not successful, mainly due to lack of the attention necessary for successful herb production. Our originally identified herb expert left the state, while John Mesko, original project director moved on to another NGO September, 2016. Experiences on the ground and difficulties encountered have led project partners to believe that, yes there is a market for herbs in MN, good sources of commercial production and marketing information are scarce, and for most, herb production as a viable farming enterprise will likely be an add-on to an existing enterprise where it makes sense to do so. In other words, herbs as a primary farming enterprise is may not be feasible or viable. An herb production and marketing workshop scheduled for February 2016 was postponed to 2017.

Activities/outcomes 2017: SFA contracted with herbalist Connie Karstens for a series of educational events and activities to complete the project. *Karstens (http://www.sfa-mn.org/connie-karstens-herb-specialist/). 1)* She served as an on-call advisor for producers wanting to expand their herb production and marketing, and for outlets that are seeking to connect with growers/processors and received consultation contact from 19 people. *2)* She convened a session, "*"Growing & Marketing Herbs",* at our Annual Conference on February 13th, 2017 attended by 70 people. *(http://www.sfa-mn.org/2017-annual-conference-sessions/).* Connie discussed the benefits of growing and marketing herbs throughout her PowerPoint presentation. There are many aspects when discussing growing and marketing herbs, so Connie touched on both culinary and medical herb markets. Connie pointed out multiple ideas for value-added products for herbs in Minnesota. Adding herbs to your farm production can help create a diverse enterprise and give you an advantage to the market. Connie discussed the importance of determining goals and the necessary strategies to complete the end outcomes. 3) She also coordinated a field day near Hutchinson on June 24th attended by 31 people. This free event had multiple aspects including a Marketing Herbs presentation, Growing Herbs presentation, a Medicine Garden tour, and networking with other farmers. Specific attention was on numerous creative ideas for producers to value add the herbs they are already growing. Participants were encouraged to find their personal specialty with value adding herbs and were able to have their personal questions addressed by the Herb Specialist. 4) Connie also conducted a presentation at the MN garlic festival on August 12, 2017 attended by 27 people. The presentation was done at the "Ask the Expert" stage and titled "How Herbs Can Heal." The herb specialist educated the public on the benefits of purchasing and using herbs. She used personal case studies to explain the benefits herbs and plants. Throughout the presentation Connie engaged the audience by showing

the freshly picked medicinal herbs. She went through various plants and their medicinal properties and uses. After the presentation, there was great interest about personal health issues and if specific herbs can help overcome them. 5) The Herb Specialist created an interactive exhibit for the MN Garlic Festival. This life-size board game in a 10 x 30-foot space that leads participants through a series of multiple choice questions about local herbs and their uses. Numerous medicinal herbs were freshly picked to guide the pathway for participants to learn as they roll the dice and land on different questions/scenarios. There were garlic related questions along the "game board" too. Participants could encounter the Garlic Gremlin along their journey which made them move back three spaces. Once they reached the end, they were rewarded with a prize. There was a great deal of positive feedback from the public about the interactive display. The herb specialist was there to answer any questions from festival attendees. Additionally, herbal education material and herbal products were available for purchase.

MISA, the Minnesota Institute of Sustainable Agriculture, assisted in outreach, earned and social media for project activities throughout the grant term. *The Minnesota Landscape Arboretum* was the site for an SFA annual conference, and it is the home of the Minnesota Master Gardeners. This relationship has helped SFA work with Master Gardeners who grow herbs, enabling us to recruit for attendance at some of the project activities. It also has opened the door for discussions about the establishment of a Minnesota herb network, though this wasn't accomplished as it was difficult to identify willing leadership. *Central Lakes College* was the location of the demo plot but the planting and crop failed due to extreme heat, dryness and too little moisture and attention. SFA continues to work with this partner on other programs such as soil health.

GOALS AND OUTCOMES ACHIEVED

Goal 1/outcomes: Increase the number of producers in Minnesota who are producing and marketing herb crops. SFA held several educational and outreach events and activities to achieve this goal, including a 2016 demonstration plot visit, a late 2016 field day and a series of workshops and activities in 2017. Total attendance at all of these events was 217, against a goal of 175 in the grant proposal. This was in part facilitated by strong traffic at the Herb Display at the 2017 Garlic Festival, where producers obtained information and children were able to take part in the "Walk of Herbs". SFA also created a Specialty Crops herb blog, but it didn't enjoy the projected traffic that other pages such as the Soil Health portal experiences, in that 500 blog views were projected but 89 were the actual recorded visits.
SFA met its goals in publishing information in the *SFA Connect* bi-weekly e-newsletter and the SFA *Cornerpost* publication. Attempts were made to obtain coverage in farm press.

Goal 2/outcomes: Expand and strengthen the Minnesota Herb Industry. One projected outcome was to convene a farmer-focused herb conference in Minnesota, where producers, buyers and consumers convene to learn and network. The actual outcome was a series of 3 workshops largely targeting producers to teach them how to grow and market herbs, and how to wild craft. A secondary and unexpected outcome was that garlic growers, who don't necessarily characterize garlic as an herb (or is it a vegetable) were interested in identifying a program to expand production of premium Minnesota garlic, promote the MN Department of Agriculture's "Minnesota Grown" program, and expand market links with wholesalers.

A shortcoming of the project was the failure of planned demonstration plots. The proposal included a component for planting several herbs that were selected because there was either an unmet consumer demand for them, or periodic shortages in the Upper Midwest distribution. The original project advisor moved and the growing season had begun after funding was released to purchase herbs. So herb growing didn't commence until 2016 and was done in cooperation with Central Lakes College. It resulted in a field day of the test plot with attendance of 8 agricultural professionals and an additional 13 attendees. Planting information, site selection, map layout, planting and cultivation schedules including work schedules, and data collection was submitted in John Mescoe's report. However, the crop failed due to extreme heat, lack of moisture, and inadequate attention. Therefore, SFA was not able to provide farmers with field data on this aspect of the project.

The long term goal of the project was to inform MN farmers of the demand for locally produced herbs and increase knowledge of these farmers regarding herb production. A more aspirational goal was to inspire/motivate and coach up to 50 farmers to add herb production to their operations as an income supplement. This was emphasized in the 2017 workshop series. At this time 29 attendees have expanded or incorporated herb production to their operations or have diversified production or marketing, largely through CSA offerings. A follow up survey is being conducted in early 2018 to assess impact.

A secondary goal was to form a Minnesota Herb Network. This was explored in 2015 and early 2016 when discussions were held at the MN Organic Conference, and with herbal supplement manufacturers (2), herb distributors (3) and informally with herb growers and SFA leaders. SFA identified a nucleus of prospective herb growers to be part of a network, and considered a structure similar to the Midwest Garlic Growers, a network that meets annually and hosts a day-long program and takes part in the Garlic Festival. Because no leadership emerged to convene and maintain an herb network, the nucleus will be communicated with prior to SFA's February annual conference and the January, 2018 Organic Conference to identify interest again.

Goal: Increase number of producers in MN producing and marketing herbs. Accomplishments: 217 producers/farmers attended one or more of SFA's workshops and thousands of producers were exposed to SFA's e-newsletter Connect and Cornerpost publication. Follow up data to measure how many of these people have increased herb production and marketing indicates that 29 have made changes, moreso in things they've done to diversify CSA's and expand marketing and processing, than actually expanding production. Over half of those attending did not complete the evaluation and follow up.

Goal: Inform MN Farmers of the demand for locally produced herbs and increase production knowledge regarding herb production and increase awareness of demand, production and processing options and marketing strategies. Outcome: 217 producers received more intensive information.

SFA achieved its outreach and education outcomes by exceeding the projected number of educational and outreach events, and exceeding the number of producers/farmers targeted (175 goal, 217 actual).

SFA conducted a spring 2016 field day tour, a fall 2016 field day, and a series of 3 2017 workshops during the one year grant extension. These outcomes exceeded what was listed in the grant.

Publication and online information was produced as per the plan and grant goals. Blog followers fell short substantially (goal 500, actual 89).

Field test plots weren't planted in 2015 because funds were released too late for the first year growing season. So the 2015 plan was moved to 2016, which was undertaken but crop failure occurred. The grant year was extended by 1 year to ensure educational, outreach and organizing goals would be met.

BENEFICIARIES

Two constituencies were beneficiaries, farmers and food coops and other groceries seeking locally grown Minnesota herbs. Farmers/producers (217) in attendance at SFA's educational workshops, field days and gatherings were beneficiaries in that they received information about how to raise and market herbs. SFA has also promoted, with these producers, enrollment in the Minnesota Grown program (including the directory) for enhanced marketing. The other constituency, are marketers. In terms of accessibility of MN raised herbs by food coops and groceries, SFA is reaching out to non-metro food cooperatives to discuss how best to promote Minnesota grown fruits, vegetables, meats and herbs. This process is yielding an interest on the part of coops for SFA information including content from Connect and the herb marketing table found at the end of this document for their websites and newsletters.

A total of 217 producers attended one or more of the activities and gatherings hosted by the project. A total of 29 growers modified or expanded their production and marketing, according to post-event surveys. However, data on herb growing was not gathered because of crop failures.

LESSONS LEARNED

On the positive, SFA's educational and outreach work in the area of herb production and marketing was given a meaningful boost by this project. Indeed, small vegetable growers view diversification of CSA's and herb production via deep winter greenhouses as an opportunity today where they didn't when the grant was written in 2014. SFA's structure and the enlistment of Connie Karstens in the final year of the project ensured high quality outreach and education as well as publications and exhibits. One is found at the end of this report.

But the project suffered from staff transition, in that the herb specialist initially contracted moved at a pivotal time in the life of test plots. Indeed, the research design of this project did not account for either the staff transition, or the weather. A best case scenario would have yielded at least some harvest of the herb test plots in 2016 despite drought, but the lack of cohesiveness between the specialist and Central Lakes College, coupled with his move, made it impossible to achieve a 2016 harvest.

Despite that, the benefits of herb production, processing and marketing onsite was explored very well in 2017, giving producers more specific and practical advice on how to grow, harvest, process and market herbs.

Excellent reception of Ms. Karsten's information was one unexpected result. Another unexpected outcome was the interest on the part of garlic growers attending the herb workshop in creating a garlic specific growing and marketing project.

Lesson learned #1: Communicate with grantor as necessary to modify plans. This was done well throughout the project and enabled achievement of all but one of the project outcomes. Lesson learned #2: Don't start a project with demonstration plots in the middle of a growing season. Craft a contingency plan with project staff and partners to accommodate unforeseen weather that can cause failure of demonstration plot crops. Lesson learned #3: Be more conservative in projecting the creation of a growers' group or network, as this depends upon committed leadership recruitment. The project did a good job exploring this, but lack of committed leadership prevented a group from being formed.

ADDITIONAL INFORMATION

Ways to Sell Herbs

- Starter Plants
- Fresh Herbs
- Dried Herbs
- Medicinal Plants
- Farmers' Market
    - Appearance & Quality Matter
    - Find your niche
    - Build Clientele
- Wholesale: Suppliers/Stores
- Public Markets
    - Farmer's Markets
    - Flea Markets/Fairs/Events
    - Craft Shows
- On-Farm Sales: Direct
- Herb CSA
- Farm to Table Events
- Educational Classes
- Marketing Weeds

Value Added Ideas for Herbs

- Medicinal Preparations
    - Herbal Infused Oils
    - Herbal Salves
    - Herbal Sprays
    - Herbal Extracts (tinctures)

    - Herbal Tea Blends
    - Herbal Vinegars
    - Herbal Education
- Professional Wellness Consults
- Direct Sales
    - Create Eye Catching Displays
    - Quality Products
    - Knowledgeable Staff
    - Priced to Sell
- Promote Sales with Add-On's
    - Recipes
    - Combination Sales ie. vegetables with herbs

- Herb CSA
    - 3 or 6-month options
        - Herbal tinctures
        - Salves/infused oils
        - Specialty tea blends
        - Herbal vinegars
        - Spice blends
        - Bath teas/insect repellent/liniment
        - Recipe ideas, nutritional information
        - One 30-minute health consultation

Project 17

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Contact: Dennis Emslie Drummond

Organization: Central Lakes College

Contact information: demslie@clcmn.edu, 218-894-5133

PROJECT TITLE

Minnesota Wine Quality Alliance

PROJECT SUMMARY

The need to help MN wineries expand sales into more markets, than just the seasonal sales from their own tasting rooms. There is a need to give consumers greater confidence in wines produced in Minnesota.

Increasing confidence could increase sales of wine by diversification from seasonal tasting rooms into untapped competitive markets through distributors to local liquor stores and restaurants. Also, there has been a great number of new wineries that have opened with less experience and less qualified winemakers that produce wine with variable quality. This results in negative consumer outcomes that can reflect on the Minnesota wine industry as a whole.

The wine industry is experiencing significant expansion, with many new businesses opening, and it is necessary to ensure that the quality of the wine is at the highest level, as some of the new producers have limited experience. Other wine quality programs were observed and a Minnesota program was established to give consumers an indication of wine quality, but not constrain the winery to a certain style.

PROJECT APPROACH

Activities Performed:

a. Set up a chemical analysis laboratory and sensory evaluation panel, based on the Iowa Wine Quality Alliance.
b. Advisory panel from the Minnesota Farm Winery Association were consulted on chemical parameters and the wine quality sticker design.
c. Sensory evaluators at Central Lakes College were trained in evaluating wines with faults and flaws using "Le Nez du Vin" aroma standards (previously purchased) and additives to wines to monitor their sensitivities.
d. The Minnesota Grown license was purchased to enable the quality sticker to have the trademark design.
e. Three quotes were obtained for the label production, and the lowest was chosen.
f. Protocols were established, based on the Iowa Wine Quality program, for sample submission and results.
g. The program was advertised by promotion at the 2016 and 2017 Cold Climate Conference in Minneapolis at the VESTA booth, and presentation in the Enology Series in 2016. Announcements were made to the Minnesota Grape Growers Association google group and emails to all the Minnesota Farm Winery members.

Project Partners:

a. Minnesota Farm Winery Association were helpful in the initial promoting this project, and Dennis attended most of their meetings to report on the program. There were at least five more wineries that were going to submit samples and did not follow through.
b. Minnesota Grown was going to place an article about the program in their magazine (which I am not sure if it happened, as I was not followed up on it).
c. Minnesota Grape Growers Association were not approached, as this was really a winery project. But they invited me to a board meeting and invited me to speak on the program at the Cold Climate Conference February 2016 (this was unexpected and a pleasant surprise). There were 40 people at the presentation and showed much interest.
d. Central lakes graphic design students were given the sticker design as a project, and in the end it was completed by the instructor Leon Dahlvang.

GOALS AND OUTCOMES ACHIEVED

Outcome 1: Minnesota wine producers will gain knowledge about the quality of their wine through chemical analysis

a. Wine quality benchmarks were defined by chemical levels and sensory evaluation scoring. A sweet red wine was analyzed and sent to the Midwest Grape and Wine Institute at Iowa State (ISU-MGWII), with comparable results.
(See attached Midwest grape and wine results vs. lab results: Chateau St Croix Rouge)

b. The Target was to have seven of the ten wineries would have an increase in sales of 10% by achieving certified quality status. Four wineries entered 12 wines, with 6 achieving a passing evaluation. Two of that passing group had inaccurate alcohol content, which would place them in the above 14% category and subsequent higher tax excise class (Wineries were notified of these discrepancies). One wine that failed to pass had a Total Sulfur Dioxide level that was in excess of the legal limit, and the winemaker was contacted with possible solutions. Northern Vineyards purchased 3,000 Minnesota Grown Wine Quality labels, but had not used them by the end of the grant, so there was feasible way to measure a change in sales from this program.

Outcome 2: Minnesota wineries will build a solid reputation in quality assurance. Lack of winery participation and completion of the quality program appears that they are not interested in this program. Or the cost of the program was beyond the budgets of the Minnesota wineries.

Outcome 3: Utilize survey of certification recipients to measure the program and the recipient's business performance indicators. None of participants finished the program.

Comparison of actual accomplishments with the goals established:

a. Outcome 1: Achieved goal to set up a wine analysis process to allow producers to measure wine quality.
b. Outcome 2: Goal to certify quality was established, but no impact on sales were measurable as none of the producers used the quality sticker.
c. Outcome 3: Feedback on performance survey was nullified by participants failing to complete the program.

Baseline data was not gathered due to the participant's completion rate.

BENEFICIARIES

a. Minnesota grape growers were made aware of the chemical legal limits of wine, and given some sense of sensory evaluation procedures. Minnesota Farm Wineries participated in the choice of the quality sticker and were aware of the details of the

wine quality techniques employed.

b. Participants were given feedback: Northern Vineyards (Stillwater) was advised to sweeten a wine to soften the acid bite of a wine, to a level that the sensory panel established after the original wine had failed to pass. Seven Vines winery (Dellwood) gave tank samples, which could not be awarded the sticker but were given very high marks by the evaluators. Milner Heritage winery (Kimball) had a wine with excessive sulfur dioxide, which could dangerous to sensitive individuals. Also there was a wine with an alcohol content in a higher tax class than the label statement, with possible tax consequences.
   Sovereign Estate winery (Waconia) had loose corks that appeared to have oxidized the wine, so they were advised on trying a different supplier. One Sovereign wine had an alcohol higher than the label, and were advised on the approved testing protocols.
c. The number of grape growers/participants who were included in this project:
   1. Northern Vineyards- 3 wines
   2. 7 Vines Vineyard and Winery- 2 wines
   3. Milner Heritage Vineyard and Winery- 4 wines
   4. Sovereign Estate- 3 wines

   A total of four wineries participated in this project.

LESSONS LEARNED

a. In comparing to the Iowa State University program, their program is fully funded with no charges to the participants, with free sensory training for members of the Iowa Grape Growers. The laboratory has 2 full time analysts and access to automated precise equipment well beyond the budget of this grant. Possibly this program should be done at the Land Grant/Extension University level due to the long term commitment that a quality wine program requires.
b. The program could have been more successful if the wineries that were verbally backers of the MNWQA had followed through with sending samples to be analyzed. Input into the sticker label design was weak from the MNFWA committee, and substitute members were elusive or/and tended to be domineering.

Unexpected results:

a. There was an unexpected yearly license to use the Minnesota Grown logo for the sticker.
b. Speaking at the Cold Climate Conference was unexpected, plus the invitation to the MGGA board meeting was very helpful.
c. As mentioned before, wineries were advised on laboratory analysis techniques for accuracy and problem solving wine making solutions.

ADDITIONAL INFORMATION

a. Attached power point from the Cold Climate Conference.

b. Midwest grape and wine results vs. lab results: Chateau St Croix Rouge (Minnesota Wine Quality Alliance power point)

Minnesota Wine Quality Alliance Central Lakes College

Chemical Analysis Results

1830 Airport Road, Staples
MN 56479

Client: Ch St Croix Report Date
5/1/2016

Sample ID Ch Rouge
Lab ID

	Analyte Name	Technique		ISU-MGWII Result		ISU-HPLC
pH	Hydrogen Ion Concentration	Electrode	3,55		3.58	
TA	Titratable Acidity (g/L)	Titration		7	6.84	
VA	Volatile Acidity (g/L)	Cash Still		0.83	0.79	0.8
EtOH	Alcohol (%)	Ebulliometer		13.8	13.37	12.9
RS	Residual Sugar (%)	Enzymatic		7.8	7.9	8.33
	Glucose (g/L)	Enzymatic				39.179
	Fructose (g/L)	Enzymatic				44.137
FSO2	Free Sulfur Dioxide (ppm)	Aeration-Oxidation		8	12.4	
TSO2	Total Sulfur Dioxide (ppm)	Aeration-Oxidation		80	52.4	

Cold Stability: White wines only
Freeze Test Visual

Sensory Score Average
tasters Range
Median

Comments:

Results:

Thank you for choosing the MNWQA

Project 18

MN Specialty Crop Block Grant – Federal Fiscal Year 14
FINAL PERFORMANCE REPORT

Contact: Danielle Daugaard

Organization: Minnesota Department of Agriculture, Marketing and Development Division

Contact information: Danielle.Daugaard@state.mn.us, 651-201-6170

PROJECT TITLE

Minnesota Honeycrisp Apple Promotion

PROJECT SUMMARY

This project increased sales and competitiveness of Minnesota developed and grown Honeycrisp apples through development and distribution of new marketing materials. Because of the variety's enormous consumer popularity, it is widely grown in apple producing states like Washington and most of Michigan. However, Honeycrisp apples grown in Washington and Michigan don't taste the same as those grown in MN. Because those states produce huge volumes of apples, they are widely available in Minnesota grocery stores and Minnesotans who buy them are left with a less than ideal impression for the variety. As a result, they are less likely to pay a premium price for Minnesota Grown Honeycrisp apples. This project differentiated and promoted Honeycrisp apples grown in Minnesota through a comprehensive marketing campaign that included television ads, digital banner ads, e-newsletters, and social media.

The timing of the campaign was such to reach consumers during peak apple buying season.

PROJECT APPROACH

Minnesota Department of Agriculture employees Danielle Daugaard and Paul Hugunin worked together with our advertising vendor to design, film, and produce television ads and new digital ads. Kare 11 television ads (digital sponsorship) achieved 3,798,000 impressions to adults over 18 years throughout Minnesota. Digital ads resulted in 16,006 clicks, 12,911,622 impressions, and 489 visits to detailed member pages. Daugaard created a social media contest using Facebook resulting in 115 likes and reaching 3,493 potential customers interested in healthy living, food, and family activities. Daugaard also promoted Honeycrisp apples with an apple guide through Minnesota Grown's consumer e-newsletter reaching over 17,000 recipients and resulting in a 31% email open rate and 665 total click throughs to the apple guide details. Additionally, the twelve-day Honeycrisp digital billboard campaign reached over 7 million impressions to adults over 18 years

who drive by 43 billboards around the Twin Cities metro area. The digital billboards rotate between up to 8 advertisers for 8 seconds each.

Daugaard handled the direction of design for campaign elements and execution as well as following up on results. Hugunin facilitated conversations and advertising agreements with established media vendors.

GOALS AND OUTCOMES ACHIEVED

PROJECT ACTIVITY	Responsible party	Completed
In coordination with KARE-11 Creative Services Department, developed scripts for television ads	Danielle Daugaard and Paul Hugunin with KARE-11	August 2017
Produced TV ads	KARE-11 with Danielle Daugaard	September 2017
TV ads aired on KARE-11	KARE-11 with Danielle Daugaard	September 2017
Produced digital ads	KARE-11 with Danielle Daugaard	September 2017
Digital ads ran on KARE11.com, KARE11 apps and mobile site, and on KARE11 digital partner sites	KARE-11 with Danielle Daugaard	September 2017
Created and executed social media campaign using Minnesota Grown and MDA Facebook accounts	Danielle Daugaard	September 2017
Worked with Clear Channel to design and launch digital billboard ads	Clear Channel with Danielle Daugaard	September 2017

This project achieved significant progress towards the long-term goal of increasing consumer recognition of Minnesota Grown Honeycrisp apples.

GOAL: To increase sales of Minnesota Grown Honeycrisp apples among Minnesota consumers by increasing awareness that Honeycrisp was developed by the University of Minnesota and tastes best when grown in Minnesota's unique climate.

The Minnesota Honeycrisp Apple campaign exceeded the targets set to reach the goal of increasing awareness of the Minnesota Grown Honeycrisp apples among Minnesota consumers.

	Television Ads	Digital Banner Ads
Target	3.5 million impressions	7 million impressions
Achieved	3.8 million impressions	12.9 million impressions

TARGET: $185,000 of new sales of Honeycrisp apples from Minnesota orchards.
The digital ads for the MDA's FFY 2015 SCBF project, resulted in 12.9 million digital ad impressions. This far exceeded the guaranteed ad delivery. Assuming that 1/10 of 1 percent (0.001) of the 12.9 million online ads resulted in a new purchase of Minnesota Honeycrisp apples, this campaign resulted in $324,951 in new sales.

BENEFICIARIES

Because Honeycrisp is the premier apple variety grown by Minnesota orchards, all Minnesota apple orchards benefited from the project, regardless of their size and regardless of whether they market directly to consumers or to grocery stores. Honeycrisp is estimated to be 30-40% of the average Minnesota orchard's annual harvest. It is important to note that because Honeycrisp is worth more per pound than other varieties (with SweeTango being the lone exception), Honeycrisp actually accounts for more than 30-40% of the typical orchard's annual revenue. More than one orchard that we talked to in preparing this project estimated that Honeycrisp accounts for closer to 60% of their annual a revenue.

This advertising campaign benefited all apple growers, even those that are not part of the Minnesota Grown Program (121 apple orchard members) or the Minnesota Apple Grower Association (more than 100 apple orchard members).

In addition to the benefit of increasing markets for Minnesota Honeycrisp, it is important to note that many consumers visit local retail apple orchards because of Honeycrisp. They often purchase additional apple varieties at the same time, but it is the opportunity to purchase local Honeycrisp that enticed them to the orchard.

By increasing demand for locally grown Honeycrisp, this project assisted growers in maintaining their price premium for Minnesota Grown Honeycrisp by reaching 20+ million impressions to Minnesota consumers. The digital ads by KARE 11 resulted in 489 direct clicks leading to member page visits.

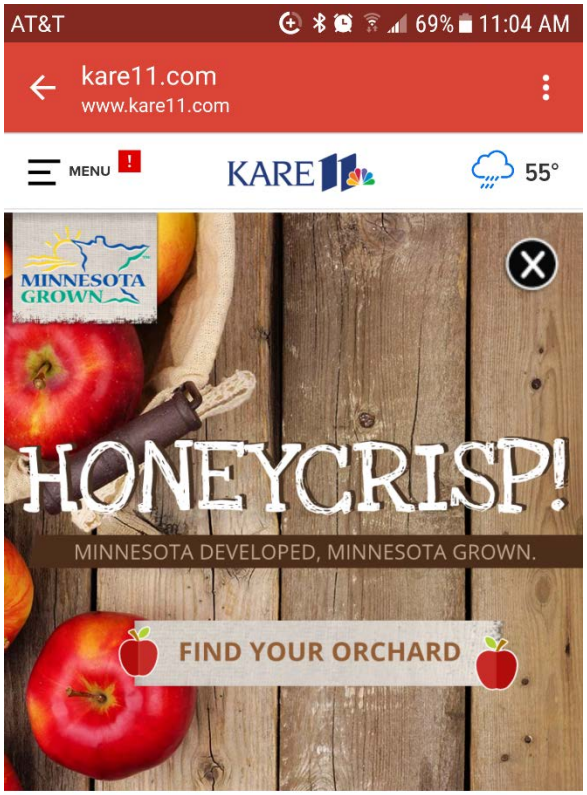
As part of the MDA's FFY 2015 SCBG project, we surveyed customers of Minnesota apple orchards in fall of 2016. 30 orchards participated and approximately 650 customers completed the survey. Results of the survey indicated that the average purchase was $25.19 meaning that the trackable results of this campaign led to an estimated $12,318 dollars in sales. However, this number does not account for unreportable sales. This would include visits to member pages attributed to other campaign efforts such as billboards and TV commercials as well as visitors who did not click directly on the ad to visit MinnesotaGrown.com but returned to the website at a later time.

LESSONS LEARNED

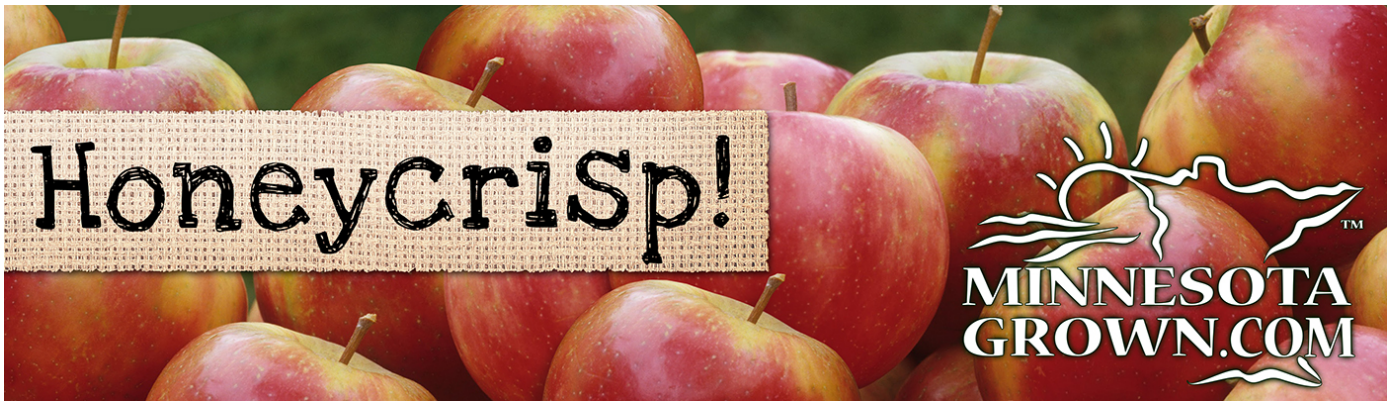
In a future project we would revisit the creative to emphasize the development of the Honeycrisp apple to be grown in Minnesota's unique climate. This would include featuring the researcher from the University of Minnesota who developed the Honeycrisp apple in commercial footage. Not only would this further the goal of building consumer recognition for Minnesota Grown (and developed) Honeycrisp, it would also strengthen our connection to the University of Minnesota.

ADDITIONAL INFORMATION

Desktop KARE 11 Homepage Takeover
On 9/19 and 9/26, all visitors on the KARE11.com saw this image filling their computer screen on the homepage.



Mobile KARE 11 Homepage Takeover



Digital Billboard – Clear Channel

43 billboards around the Twin Cities metro area that rotate between up to 8 advertisers for 8 seconds each.

Grant Administration

Funding Expended to Date:

- Total funds expended for grant administration from 9/30/2014 to 9/29/2017: $142,567.85
  Amount charged as indirect expenses: $22,913.52
  Amount charged as direct expenses: $119,654.33