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DEPARTMENT OF AGRICULTURE  
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**Specialty Crop Block Grant  
Program-Farm Bill  
FDA: 10.170**

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FINAL REPORT

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**MICHIGAN DEPARTMENT OF AGRICULTURE  
& RURAL DEVELOPMENT PROJECTS**

**PROJECT TITLE - FINAL**

**Export Promotion of Michigan Specialty Crops**

**PARTNER ORGANIZATION**

Michigan Bean Commission  
Michigan Apple Committee  
Michigan Potato Commission  
Cherry Marketing Institute

**PROJECT SUMMARY**

The project addresses the need of the specialty crop industry to expand and grow their export sales to keep stable prices and markets for growers. The project built on previous funded projects by exhibiting at new trade shows and showcasing new products that were not previously available.

The project assisted specialty crop commodity groups and companies in promoting their products at both domestic and international shows. The specialty crop groups attended the shows to showcase Michigan specialty crops and focus on increasing sales for the growers and processors of specialty crop products. Exhibiting at these shows helped to open up new opportunities for Michigan specialty crops in large crop years and help to educate current and potential buyers in years of crop failures.

**PROJECT PURPOSE**

The groups participating in the various activities included commodity groups, Michigan farmers, growers and producers as well as companies and cooperatives. Booth space was purchased at four domestic and international shows for the specialty crop companies to exhibit at and to showcase their products. This approach was a great way for the groups to see existing customers as well as find new buyers and markets.

An e-mail was sent to all Michigan commodity groups representing specialty crops. The e-mail was used to generate interest and participants for all of the events that were selected by the

committee of commodity groups to participate in during the 2014 calendar year. The commodity groups also helped to promote to shows and activities by sending information to their growers and processors.

Additionally e-mails specific to each activity were sent to specialty crop companies encouraging them to participate in the various trade shows and trade mission. Follow-up phone calls were made to companies, as well as social media posts promoting the activities to specialty crop companies.

Participation of the Michigan specialty crop companies and commodity groups was advertised to international buyers by placing an ad in *The American Exporter* magazine highlighting the specialty crop commodity groups of Michigan Apple Committee, Cherry Marketing Institute and the Michigan Bean Commission. This magazine is distributed to nearly 8,000 readers in over 50 countries and it is also distributed at the major international trade shows.

*Dear Specialty Crop Commodity Group,  
I am pleased to announce that the International Marketing Program was again awarded funding from the USDA's Farm Bill Specialty Crop Block for booth space at some of the largest and most important international and domestic trade shows in 2014 for the promotion of Michigan specialty crops.*

*The goal of the Specialty Crop Block Grant is to promote Michigan specialty crops in the domestic and international arena. The trade shows selected are among the most prominent in the world, which will bring high quality Michigan specialty crops to the forefront of domestic and international buyers.*

*MDARD will manage and administer the booths at these shows. There is no cost for specialty crop commodity groups to participate in the shows other than staff time and travel. Companies can participate in the shows for a nominal fee. If you are interested in exhibiting at one of the following shows, please complete the attached document indicating the shows you are interested in exhibiting at during 2014 and return by December 6. Please contact me at (517) 284-5738 or [zmitkoj@michigan.gov](mailto:zmitkoj@michigan.gov) for more information.*

*2014 Michigan Pavilion for Specialty Crops:*

- *Foodex Japan: Tokyo, Japan – March 4-7*
- *American Food Fair at National Restaurant Association Show (NRA): Chicago, IL - May 17-20*
- *U.S. Food Showcase at the Food Marketing Institute Show (FMI) : June 11-12*
- *SIAL Paris: Paris, France – October 19-23*
- *America's Food and Beverage Show: Miami, FL - October 27-28*
- *Trade Mission for Specialty Crops to Korea – Fall 2014*

## PROJECT ACTIVITIES

### Activity 1

#### **Foodex Japan- March 4-7, 2014- Tokyo, Japan**

MDARD, in cooperation with Cherry Marketing Institute, hosted a Michigan Specialty Crop Booth at Foodex Japan in Tokyo on March 4-7, 2014. This project was intended to reach out to buyers in the Asian markets and educate consumers about Michigan specialty crops. The booth at Foodex featured literature regarding the vast scope of Michigan specialty crops, while also highlighting and sampling Montmorency dried tart cherries.

### Activity 2

#### **American Food Fair at the National Restaurant Association Show - May 17-20, 2014, Chicago, IL**

MDARD secured booth space at the National Restaurant Association Show in Chicago, Illinois, May 17-20, 2014, for Michigan specialty crop commodity groups and companies to exhibit their products. The project was intended to assist specialty crop groups promote their products domestically and internationally. MDARD staff along with the Michigan Bean Commission and Michigan Potato Industry Commission worked to promote Michigan specialty crop products to the National Restaurant Association Show attendees. MDARD's booth showcased specialty crop brochures and information on specific specialty crop products such as apples and asparagus. MDARD staff was able to direct interested attendees to specialty crop commodity information and answer questions related to Michigan specialty crops.

### Activity 3

#### **U.S Food Showcase at Food Marketing Institute Show – June 11-12, 2014, Chicago, IL**

Two Michigan specialty crop commodity companies attended the Food Marketing Institute Show in Chicago, IL on June 11 and 12, 2014. This show returned to Chicago making it a prime location for Michigan companies to travel to in order to meet both domestic and international buyers. MDARD staff along with the Michigan Potato Industry Commission and Michigan Apple Committee promoted specialty crops from the state of Michigan. Literature and specialty crop value added products were available for tradeshow attendees to take and sample.

### Activity 4

#### **Trade Mission to South Korea- August 25-28, 2014 Seoul, South Korea.**

Four Michigan companies as well as two representatives from MDARD traveled to Seoul, South Korea on a trade mission. During this mission, Michigan specialty crop companies had the opportunity to meet with USDA representatives for an overview of the opportunities and barriers to entry in South Korea. Company participants had one-on-one meetings with buyers and distributors and also toured Korean bakeries and retail locations.

### Activity 5

#### **Michigan Pavilion at SIAL Paris- October 19-23, 2014 Paris, France**

MDARD staff as well as three companies traveled to Paris, France from October 18-23, 2014 to promote Michigan Specialty Crops to the international audience at the SIAL Paris tradeshow. Cherry Marketing Institute, Graceland Fruit and Michigan Dry Bean Commission shared a booth space at the 50<sup>th</sup> SIAL Paris show. Show attendance was strong and information was shared with interested buyers in regards to Michigan Specialty Crops.

## **Activity 6**

### **American Food & Beverage Show – October 27-28, 2014, Miami, FL**

Two specialty crop companies and three specialty crop commodity groups traveled to Miami, FL on October 28-29 to attend the American Food and Beverage Show. The show once again drew as strong domestic and international crowd, much of which was focused on doing business in Central America, South America and the Caribbean.

#### **GOALS AND OUTCOMES ACHIEVED**

##### **Foodex Japan**

Michigan specialty crops and in particular tart cherries were represented by the Cherry Marketing Institute. The show attracted 75,766 visitors from around the world, but mostly from Asian markets including Korea, Taiwan, China, Thailand Hong Kong and Japan. The Michigan specialty crop booth had an excellent location at the show and sampled U.S. grown Montmorency dried tart cherries. Over 25 good leads were generated as result of the show. The leads were shared with Michigan companies that manufacture and export tart cherry products. Cherry Marketing Institute was also able to educate buyers on the health benefits that are derived from specialty crops, specifically, tart cherries.

##### **National Restaurant Association Show**

The goal was to have a minimum of two Michigan specialty crops highlighted at this major food service show. This goal was achieved as both the Michigan Bean Commission and the Michigan Potato Industry attended the show. The 2013 growing year resulted in a bumper crop of Michigan specialty crops, allowing MDARD staff the ability to speak with attendees about the abundance of Michigan specialty crops available after the crop disaster in 2012. The additional goal was to promote Michigan specialty crops into the market and increase the demand for products. The promotional goal was achieved as the 2014 NRA Show was attended by more than 44,000 attendees from around the world, representing over 100 countries.

- The Michigan Bean Commission and Michigan Potato industry participated in this show and indicated in their evaluation that they received a total of 20 and 40 leads respectively while participating in the show, which meet the goal of having commodity groups receive a minimum of five leads.
- A total of 8 additional leads for specialty crops were collected by MDARD staff at the booth and shared with relevant specialty crop commodity groups or companies selling those products, this meets the goal to have commodity groups received a minimum of five trade leads.

##### **FMI**

The goal was to have a minimum of two Michigan specialty crops highlighted at this retail focused trade show. This was accomplished as both the Michigan Apple Committee as well as the Michigan Potato Industry Commission had booths providing information and samples of the commodity they were representing. FMI Connect was a well-attended show, meeting promotional goals with 15,000 attendees from 75 countries.

- Michigan Apple Committee generated 10 leads from the show meeting the goal of a minimum of five leads. The Michigan Potato Industry Commission generated a total of 20 leads, again, meeting the minimum of five leads.
- A total of five leads for specialty crops were collected by MDARD staff and shared with the appropriate specialty crop commodity groups or companies selling those products.

### **Trade Mission to South Korea**

The goal of having a minimum of two specialty crop companies participating was reached with Graceland Fruit and North Bay Produce participating in the trade mission. One of the major goals of the trip was to have discussions with USDA officials about the status and next steps for getting approval for Michigan fresh blueberries, which are currently not allowed in the market. Discussion were also held regarding the high duty that still remains on dried fruit. Even with the Korean Free Trade Agreement (KORUS) the duties make it difficult to increase sales significantly because the step down is over 10 years even though no significant domestic production of cherries exists in South Korea.

- The companies reported a combined total of 10 contacts made during the mission, meeting the minimum of 5 buyer contacts per company as a result of the activity
- Anticipated sales of \$1,250,000 over the next 6-12 months, meeting the goal of having at least 50% of the participating companies realize sales from participation

### **SIAL Paris**

Two commodity groups and one company traveled to Paris, France to attend SIAL Paris from October 18-23, 2014 as representatives of Michigan specialty crops. SIAL Paris is known for its impact in the agri-food industry; the 2014 show was attended by over 150,000 visitors and 6,500 exhibitors covering 200 countries. Cherry Marketing Institute, Graceland Fruit and Michigan Dry Bean Commission exhibited in the Michigan specialty crop booth as part of the USA Pavilion.

Interaction with show attendees was productive and steady. International buyers sought out the Michigan specialty crop booth to discuss specific products as raw ingredients as well as processed and retail products. Visitors to the Michigan specialty crop booth specifically expressed interest in dried fruits such as cranberries, cherries and blueberries as well as Montmorency cherries and dry beans. In addition to the three exhibiting companies, literature was also available about additional specialty crops cultivated in the state of Michigan and staff was on hand to answer questions from interested buyers and to collect leads.

- In total, 53-58 leads were collected and sent information regarding Michigan Specialty Crops. Most buyers were interested in sourcing dry beans, dried or IQF fruits
- All three specialty crop groups reported making new contacts, 21 new buyer relationships were reported, exceeding the minimum of five buyer contacts made per company and commodity group
- Anticipated sales from the show are estimated at \$1,000,000 and an increase of 10-15%, meeting the requirement that half of companies attending will anticipate sales

### **Americas Food & Beverage Show**

Three Michigan specialty crop commodity groups and two specialty crop companies traveled to Miami, FL from October 27-28 to exhibit at the 18<sup>th</sup> Americas Food and Beverage show. There were 420 companies with displays who were exposed to over 10,000 visitors representing 29 countries. The focus of this show is both domestic buyers as well as international buyers, a large majority of which are from Central America, South America and the Caribbean region. This provides a strong lead on Latin American buyers as well as entities such as resorts, hotels and cruise lines.

- Three organizations reported that they would enter a new market as a result of the show, one market being Uruguay. This exceeded the expectation that at least one company will enter a new export market due to participation
- 85 leads were made, exceeding the goal that each organization would make five new buyer contacts or trade leads

\$250,000 in export sales is anticipated in the next 12 months

## **BENEFICIARIES**

### **Foodex Japan**

Participants included:

- Cherry Marketing Institute (Representing 540 Michigan tart cherry growers, 60 growers nationally, and 470 sweet cherry growers.)

### **National Restaurant Association Show**

Participants included:

- MDARD representing all Michigan specialty crops
- Michigan Potato Industry Commission (representing 86 potato growers)
- Michigan Dry Bean Commission (representing 1500 Michigan dry bean growers)

### **Food Marketing Institute Show**

Participants included:

- Michigan Bean Commission (Representing 1,500 Michigan dry bean growers)
- Michigan Apple Committee (Representing 900 Michigan apple growers)
- Michigan Potato Industry Commission (Representing 86 potato growers)

### **Trade Mission to South Korea**

Participants included:

- North Bay Produce
- Graceland Fruit (Grower owned cooperative)
- MDARD representing all other Michigan specialty crops

### **SIAL Paris**

Participants included:

- Cherry Marketing Institute (Representing 540 Michigan tart cherry growers, 60 growers nationally, and 470 sweet cherry growers)
- Graceland Fruit (Grower owner cooperative)
- Michigan Dry Bean Commission (Representing 1,500 Michigan dry bean growers)
- MDARD representing all Michigan specialty crops

### **Americas Food and Beverage Show**

Participants included:

- Graceland Fruit (Grower owned cooperative)
- Cherry Central (Grower owned cooperative)
- Michigan Potato Industry Commission (Representing 84 Michigan potato growers)
- Michigan Apple Committee (Representing 900 Michigan apple growers)
- Michigan Dry Bean Commission (Representing 1,500 Michigan dry bean growers)

## LESSONS LEARNED

The activities conducted both in the U.S. and abroad for the promotion of Michigan specialty crops continue to be very beneficial for Michigan specialty crop companies and commodity groups. There continues to be more interest each year for the trade shows especially as the cost of booth space at these shows continues to increase.

Future considerations will include product specific shows in order to narrow the scope of buyers and provide exhibiting groups with a focused audience.

The seminar with a focus on entering the Brazil market was held in July. Due to a lack of interest from the specialty crop industry the International Marketing Program partnered with another organization to cover the cost of seminar speaker. No specialty crop funds were used for the seminar or speaker.

## CONTACT PERSON

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## ADDITIONAL INFORMATION

### EVALUATION/FOLLOW-UP FOR INTERNATIONAL ACTIVITIES

**Foodex Trade Show Evaluation  
Michigan Specialty Crop Booth  
March 4-7, 2014  
Tokyo, Japan**

#### **Introduction**

One Michigan specialty crop company participated in the Michigan Specialty Crop Booth at the Foodex Japan show in Tokyo, Japan

**No. of Participants:** 1

**No. of Returned Evaluations:** 1

**Specialty Crop Participant:** Cherry Marketing Institute

**Do you anticipate an increase in purchases over the next 6-12 months?:** Yes

**If yes, how much?:** \$1.5-2.0 million, 25% increase

**How many contacts/ leads resulted from your participation?:** 20 leads, 5 high quality leads

**How many new buyer relationships will result from your participation:** 5

**Please rate the activity on the following (1=poor, 5=excellent)**

Pre-event planning and communication:	5	Program execution:	5
Fulfillment of your company needs:	5	Cost/Benefit returns to your company	5
Quality of contacts or information:	5		

**Please estimate company financial and 'overhead' expenses for the activity:**

Total number of staff hours for planning, participation & follow up: XX Hours  
Direct costs of planning participation and follow-up (including travel): \$15,000  
Other Misc. Costs associated with participation of activity: \$0  
Total: \$15,000

**Please rate the overall effectiveness of the show: Excellent**

**Any additional comments or recommendations:** "IMEX staff was terrific and the interpreter was fantastic. It was a long show but a good show. FAS staff on the ground was terrific and we appreciated their help and support. It was excellent!"

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**National Restaurant Association Show  
Michigan Specialty Crop Booth Evaluation Report  
Chicago, IL  
Activity Date: May 17-20, 2014**

**Introduction**

Two Michigan specialty crop companies/commodity groups participated in the Michigan Specialty Crop Booth at the National Restaurant Association show in Chicago, IL.  
No. of Participants: 2                      No. of Returned Evaluations: 2

**Specialty Crop Participants:**

Michigan Bean Commission                      Michigan Potato Industry

**How many contacts/leads resulted from your participation?**

- 20
- 40

**How would you rate the quality of contacts/leads?**

Excellent                      Very Good 2  
Average                      Fair                      Poor

**Please rate the overall effectiveness of the show:**

Excellent 1                      Very Good 1  
Average                      Fair                      Poor

**Will you enter into a new export market as a result of your participation in the show?**

Yes X                      No X  
If yes, please list country: India, Pakistan

**If applicable, have any on-site sales resulted from your participation in this activity?**

Yes \_\_\_\_\_ No 2  
If yes, please list sales in US\$      Domestic \_\_\_\_\_ Export \_\_\_\_\_

**Does your company expect an increase in sales as a result of this activity?**

Yes 2                      No \_\_\_\_\_  
If yes, please estimate sales in US\$      Domestic \_\_\_\_\_ Export \_\_\_\_\_  
Would you have participated in this activity without the assistance of the Michigan Department of Agriculture and Rural Development (MDARD)?      Yes\_\_\_      No2

Please rate the performance of the MDARD Agriculture Development staff for this activity, as applicable, for the following areas:

(Excellent=5, Very Good=4, Satisfactory =3, Fair =2, Poor=1)

<b>MDARD Staff</b>					
Pre-event planning & assistance	1	2	3	4	<u>5</u>
Communication regarding event	1	2	3	4	<u>5</u>
Assistance at event itself	1	2	3	4	<u>5</u>

Please estimate company financial and “overhead” expenses for the activity:

Total Number of Staff Hours for Planning, Participation & Follow-up	50 Hours
Direct Costs of Planning Participation & Follow-up (including travel)	\$8,300
Other Misc. Costs Associated with Participation in Activity	\$6,000

Comments or suggestions:

- “free or affordable wi-fi would be a plus”

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**FMI– Michigan Pavilion**

Activity Date: June 11-12, 2014

Participants:

*Cherry Central Cooperative Inc.*  
*Michigan Apple Committee*  
*Shoreline Fruit*  
*Michigan Potato Industry Commission*  
*Graceland Fruit*  
*Safie Specialty Food*  
*True Blue Berry Management/ The Blueberry Store*  
*Honee Bear Canning*

**Please rate the importance of your company’s objectives in participating in this activity, as well as the activity’s effectiveness in helping your company meet these objectives:**

(Excellent=5, Very Good=4, Average=3, Fair=2, Poor=1).

Company Objective	Importance	Effectiveness
	Mean	Mean
Buyer Contacts/inquiries	4.9	4
Direct Sales	3.5	3
Agent/distributor search	3.3	2.9
Test marketing/ research	2.4	2.9
Product/company exposure	4.9	3.7

**Total Leads/Contacts:** 240 contacts

**How would you rate the quality of the contact/leads?** (No. of companies)

Excellent: 5      Very Good: 3      Average: 2      Fair: 0      Poor: 0

**Please rate the overall effectiveness of the show** (No. of companies)

Excellent: 3      Very Good: 1      Average: 4      Fair: 1  
Poor: 1 (Comment with poor ranking: "The actual show was not good, the trade mission was excellent)

**Will you enter into a new export market as a result of your participation in the show?**

Yes: 4      No: 4      Possibly: 2  
Markets listed: Middle East, Dominican Republic, Argentina, Multiple opportunities

**If applicable, have any on-site sales resulted from you participation in this activity?**

Yes: 3      No: 7  
Domestic: \$0      Export: \$0

**Does your company expect an increase in sales as a result of this activity?**

Yes: 8      No: 2  
Domestic: \$ 2,000,000      Export: \$ 100,000

**Would you have participated in this activity without the assistance of the Michigan Department of Agriculture (MDARD)?** (Number of Companies)

Yes- 2      No- 6      Unsure-3  
(One participant marked both no and unsure)

**Would you be willing to participate in a press conference or approve a press release related to sales, joint ventures, partnerships, or other success stories obtained as a result of your participation on one of our programs/events?**

Yes- 8      No- 2

**Please rate the performance of the MDARD Agriculture Development staff for this activity, as applicable, for the following areas:** (Excellent=5, Very Good=4, Satisfactory=3, Fair=2, Poor=1).

<b>MDARD Staff</b>	
<b>Pre-event planning and assistance</b>	5
<b>Communication regarding event</b>	5
<b>Assistance at event itself</b>	5

**Total Number of Staff Hours for Planning, Participation, and Follow-up:** 385 hours (four companies did not answer this question)

**Direct Costs of Planning, Participation, and Follow-up (including travel):** \$26,900  
(three companies did not answer this question)

**Other Misc. Costs Associated with Participation in Activity:** \$18,900  
(five companies did not answer this question)

**Comments or suggestions:**

Several companies had left some comments or suggestions. Listed below are the actual comments made from the companies that chose to leave a response.

- Trade mission was excellent
- None at this time. Great Show
- FMI and United Fresh should combine their booth listings to make it easier for our accounts to find is and make contact
- Happy FMI returned to Chicago. Needs more grocery buyers and distributor participants. Great show for our company, will participate next year.
- Thanks!
- Great show and thank goodness it is in Chicago.

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**Trade Mission Evaluation Report  
Michigan Specialty Crop  
Korea  
Activity Date: August 25-27, 2014**

**Introduction**

Two Michigan specialty crop companies participated in the Michigan Specialty Crop Trade Mission to Korea on August 25-27, 2014

No. of Participants: 2

No. of Returned Evaluations: 2

**Specialty Crop Participants:**

Graceland Fruit, Inc.

North Bay Produce

**Does your industry/company anticipate an increase in purchase over the next 6-12 months as a result of the Korea trade mission?**

Yes- 2            No- 0

**If Yes, approximately how much? (Please provide an estimated value)**

\$1,250,000 (total)

**Did the Korea trade mission yield contacts with new buyers?**

Yes- 2            No- 0                            **If yes, how many?**                            10 (total)

**Do you anticipate making a first time export into Korea as a result of participating in this trade show?**            Yes- 2                            No- 1 (already making export sales to South Korea)

**Please rate the Korea Trade Mission on the following:**

(Excellent=5, Very Good=4, Average=3, Fair=2, Poor=1)

<b>RATE THE ACTIVITY</b>	<b>MEAN</b>
Pre-event planning & communication	4.5
Program execution	5
Fulfillment of your company needs	4.5
Cost/benefit returns to your company	4.5
Quality of contacts or information	3.75

**Please estimate company financial and 'overhead' expenses for the Korea Trade Mission:**

<b>Total Number of Staff Hours for Planning, Participation &amp; follow-up</b>	160
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<b>Direct Costs of Planning Participation &amp; Follow-up (including travel)</b>	\$15,000.00
<b>Other Misc. Costs Associated with Participation in Activity</b>	\$5,000.00
<b>Total</b>	<b>\$20,000.00</b>

**Please rate the overall effectiveness of the show:**

Excellent- 1                      Very Good- 1  
Average- 0                         Fair- 0  
Poor- 0

**Do you have any additional comments for these activities or recommendations for future activities?**                      *(none)*

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**SIAL Paris Trade Show Evaluation**  
**Michigan Specialty Crop Booth**  
Activity Date: October 19-23, 2014

**Activity Evaluation**

**Does your industry/company anticipate an increase in purchases over the next 6-12 months as a result of the trade show?** Yes(3)    No

**If yes, approximately how much?** \$1,000,000 (1 respondent)    Percentage increase: %10-15

**Did the SIAL Paris Show yield contacts with new buyers?** Yes(3)    No  
**If yes, how many?** (15,16, 10-15)

**Did the SIAL Paris Show result in any new buyer relationships?** Yes(2) No    N/A (1)  
**If yes, how many?** (16, 5)

**Will you enter any new markets as a result of exhibiting at the SIAL Paris Show?**  
Yes (1)    No (1)    N/A (1)                      **If yes, which ones?** Greece

**Please rate the activity on the following: (1 = worst, 5 = best)**

**Pre-event planning & communication:** 4.6  
**Program execution:** 4.6  
**Fulfillment of your company needs:** 4.6  
**Cost/benefit returns to your company:** 4.6  
**Quality of contacts or information:** 4.6

**Please estimate company financial and 'overhead' expenses for the activity:**

<b>Total Number of Staff Hours for Planning, Participation &amp; follow-up</b>	86, 50-60, 130
<b>Direct Costs of Planning Participation &amp; Follow-up (including travel)</b>	\$9,500 7,000, 10,000
<b>Other Misc. Costs Associated with Participation in Activity</b>	\$ 54, 1,000 2,000

**Please rate the overall effectiveness of the show:**

   1 Excellent       2 Very Good       Average       Fair       Poor

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**Americas Food & Beverage Trade Show  
Michigan Specialty Crop Booth Evaluation Report  
Miami, Florida  
Activity Date: October 27-28, 2014**

**Introduction**

Two Michigan specialty crop companies and three specialty crop commodity groups participated in the Michigan Specialty Crop Booth at the Americas Food & Beverage Trade Show in Miami, Florida. No. of Participants: 5 No. of Returned Evaluations: 5

**Specialty Crop Participants:**

Graceland Fruit  
Cherry Central  
Michigan Bean Commission  
Michigan Apple Committee  
Michigan Potato Industry Commission

**How many contacts/leads resulted from your participation?**

85 (total for all participants)

**How would you rate the quality of contacts/leads?**

Excellent – 2 Very Good - 2  
Average - Fair  
Poor – 1

**Please rate the overall effectiveness of the show**

Excellent – 2 Very Good - 1  
Average – 1 Fair  
Poor - 1

**Will you enter into a new export market as a result of your participation in the show?**

Yes- 3, Uruguay No- 1 No response - 1

**Does your company anticipate an increase in sales over the next 12 months as a result of the trade show?**

Yes- 2 No- 1 Unsure – 1 N/A - 1

**If, yes approximately how much? (Please provide an estimated value)**

\$250,000 export (total)

**Please estimate company financial and ‘overhead’ expenses for the activity:**

<b>Total Number of Staff Hours for Planning, Participation, &amp; Follow-up</b>	258
<b>Direct Costs of Planning, Participation, &amp; Follow-up (including travel)</b>	\$15,033
<b>Other Misc. Costs Associated with Participation in Activity</b>	\$550
<b>Total</b>	<b>\$15,583</b>

Rate the performance of staff 5= excellent, 1=poor

**Pre- Event Planning 4**  
**Communication 4**  
**Assistance at event 3.8**

**Do you have any additional comments for this activity or recommendations for future activities?**

- *“We’re not sure this show attracts our target market anymore”*
  - *“Buyer Mission 1 on 1 meetings were very effective”*
  - *“Kim was a big asset in assisting us with the booth”*
- 

### **Show Photos**

Foodex Japan



National Restaurant Association Show



Trade Mission to South Korea



SIAL Paris



Americas Food and Beverage Show



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## SCOPE CHANGE – SIAL CHINA

### PROJECT TITLE

SIAL China Trade Show

**FINAL**

### PROJECT SUMMARY

China is a growing export market for tart cherries. As other export markets for tart cherries mature or see a decline in sales the cherry industry is looking for new growth markets. China's growing middle class and increase of wealth continues to drive consumption of high-value food and beverages. Imported food demand in China remains supported by growing urban populations, rising disposable incomes, and a desire for foreign luxuries. The current trends of consumer demand increasing for nutritional, healthy, safe, convenient and new food experiences provides a great opportunity to promote tart cherries. Tart cherries fit into many of the trend areas that consumers in China are demanding, as they are healthy and convenient. The goal of exhibiting at SIAL China will be to introduce potential importers, distributors and buyers on the health benefits and attributes of tart cherries while also introducing them to companies that process and sell tart cherry products.

### PROJECT APPROACH

MDARD's International Marketing Program staff worked collaboratively with the Cherry Marketing Institute to organize the booth space and promote the show to cherry processors. Additionally an e-mail was sent to all Michigan commodity groups representing specialty crops and companies with specialty crop products. Follow-up phone calls were made to companies as well.

Booth space was secured for the SIAL China show for the specialty crop companies to exhibit at and to showcase their products. This approach provided a low cost opportunity for the specialty crop commodity groups and companies to see existing customers as well as to launch into the market for the first time.

MDARD Staff as well as two Michigan companies and one commodity group traveled to Shanghai, China, from May 5-7, 2016 to promote Michigan Specialty Crops to the international audience at the SIAL China trade show. The Cherry Marketing Institute, Graceland Fruit, and Shoreline Fruit exhibited in three separate booths at the show. Show attendance was strong and literature and specialty crop value added products were available for tradeshow attendees to take and sample. As a result of the show, the two Michigan companies yielded dozens of new buyer contacts, and the Cherry Marketing Institute was able to launch their new promotion program in China.

#### GOALS AND OUTCOMES ACHIEVED

The goal of promoting Michigan Specialty Crops to global buyers was accomplished while also helping to offset the cost of participation. SIAL China is one of Asia's largest food and beverage exhibitions, drawing buyers from around the world. The three day show hosted 2,942 exhibitors from 67 countries and attracted over 76,986 attendees. The Cherry Marketing Institute, Graceland Fruit and Shoreline Fruit exhibited in the Michigan Specialty Crops Pavilion as part of the USA Pavilion. Products and literature from the Michigan Potato Industry was also showcased in the Michigan Specialty Crops booth.

The 17<sup>th</sup> edition of SIAL China was an excellent opportunity for the exhibitors in the Michigan Specialty Crops Pavilion to meet with world class buyers and distributors from across Asia and the world. The exhibitors were able to take a deeper look into innovations and trends in the food industry through multiple events during the show and all exhibitors felt that the overall effectiveness of the show was excellent. International buyers sought out the Michigan Specialty Crops booth to discuss specific products and sample specialty crop value added products.

- The two specialty crop companies yielded a total of over 85 new buyer contacts during the show and the one commodity group yielded a total of 15 new buyer contacts, exceeding the goal that the commodity group will receive a minimum of five leads.
- The two specialty crop companies anticipate sales of \$700,000 over the next 6-12 months, meeting the goal of having at least 50% of the participating companies realize sales from participation. The Cherry Marketing Institute anticipates sales of \$150,000 over the next 6-12 months from leads that they generated and passed on to tart cherry processors.
- SIAL China was the first step for the Cherry Marketing Institute (CMI) in launching their new promotion program in China. The show allowed CMI to enter the Chinese market by providing them with the opportunity to meet with Chinese buyers for the first time and showcase the uses and health benefits of Montmorency tart cherries.

## BENEFICIARIES

Participants included:

- Cherry Marketing Institute (Representing 540 Michigan tart cherry growers, 60 growers nationally, 470 sweet cherry growers)
- Graceland Fruit (Grower owned cooperative)
- Shoreline Fruit  
MDARD representing all Michigan specialty crops

## LESSONS LEARNED

Chinese consumers were receptive of tart cherries as a “Superfruit” and were eager to learn about the health benefits. Many consumers had never sampled Montmorency tart cherries prior to visiting the Michigan Specialty Crops booth.

## CONTACT PERSON

Jamie Zmitko-Somers, Manager  
International Marketing Program  
E-mail: [zmitkoj@michigan.gov](mailto:zmitkoj@michigan.gov)

## ADDITIONAL INFORMATION

**SIAL China Trade Show  
Michigan Specialty Crop Booth Evaluation Report  
Shanghai, China  
Activity Date: May 5-7, 2016**

### Introduction

Three Michigan specialty crop companies/commodity groups participated in the Michigan Specialty Crop Booth at the SIAL China Trade Show in Shanghai, China May 5-7, 2016.

No. of Participants: 3

No. of Returned Evaluations: 3

### **Specialty Crop Participants:**

Cherry Marketing Institute; Shoreline Fruit; Graceland Fruit, Inc.

**Does your industry/company anticipate an increase in purchases over the next 6-12 months as a result of the trade show?** Yes- 3      No- 0

**If, yes approximately how much? (Please provide an estimated value)**  
\$850,000 (total)

**Did the SIAL CHINA yield contacts with new buyers?** Yes- 2      No- 1  
**If yes, how many?**      65+

**Did the SIAL CHINA Show result in any new buyer relationships?**  
Yes- 3      No- 0  
**If yes, how many?**      19

**Will you enter any new markets as a result of exhibiting at the SIAL China Show?**

Yes- 1      No- 2      If yes, which markets?    China

**Please rate the SIAL CHINA Trade Show on the following:** (Excellent=5, Very Good=4, Average=3, Fair=2, Poor=1)

RATE THE ACTIVITY	MEAN
Pre-event planning & communication	5
Program execution	5
Fulfillment of your company needs	5
Cost/benefit returns to your company	5
Quality of contacts or information	5

**Please estimate company financial and ‘overhead’ expenses for the activity:**

<b>Total Number of Staff Hours for Planning, Participation, &amp; Follow-up</b>	553
<b>Direct Costs of Planning, Participation, &amp; Follow-up (including travel)</b>	\$59,129.69
<b>Other Misc. Costs Associated with Participation in Activity</b>	\$0.00
<b>Total</b>	<b>\$59,129.69</b>

**Please rate the overall effectiveness of the show:**

Excellent- 3      Very Good- 0  
Average- 0      Fair- 0      Poor- 0

**Do you have any additional comments for this activity or recommendations for future activities?**

- *“The Michigan Department of Agriculture (Allie Fox & Jamie Zmitko-Somers) does a great job organizing international trade shows. This show allowed CMI to make 15 new contacts/customers as well as meeting with distributors and importers in China. We are excited to launch a promotion program July 1, 2016.*



## PROJECT TITLE FINAL

**MI State Horticultural Society** - Innovative Fruit Plantings: Keeping Michigan Fruit Producers Competitive by Establishing Research Plots Designed for 21<sup>st</sup> Century Production Needs -

## PARTNER ORGANIZATION

Michigan State University

## PROJECT SUMMARY

The purpose of this project is to make Michigan specialty crops economically competitive and environmentally sustainable in the 21st Century, through the establishment of innovative fruit research plantings at key MSU research centers. Michigan is a national leader in the production of fruit crops, with apples, blueberries, cherries, grapes and peaches grown on approximately 104,700 acres (3,400 farms), contributing a farm level value of \$314 million to MI's annual economy (MI Agricultural Statistics 2007-2008). The economic contribution of specialty crops to the state's economy has grown in importance as other traditional industries like manufacturing have declined. Profitability in domestic and global fruit markets requires high food quality standards, the development of modern genetic resources such as cultivars and rootstocks, enhanced cultural techniques, and effective strategies for maximizing yields while controlling disease and insect pests. Since fruit crops are perennial plants that require several years of development to come into fruiting (and research) potential, the periodic establishment of modern research plantings to address critical production challenges, and maintain responsiveness to unexpected problems like invasive species, is a strategic priority for Michigan's specialty crop industries.

New horticultural plantings at MSU research centers are essential to develop and adapt new rootstocks, varieties, and technologies (for production and harvest efficiencies) to achieve maximum productivity and profitability. High tunnel fruit production is expanding across the world. Preliminary MSU research at the SW Michigan Research and Extension Center and the Clarksville Research Center confirms a strong potential for high tunnel fruit production under MI conditions, with results including higher fruit quality, more consistent yields, expanded marketing windows and less pesticide use for production of premium fresh market sweet cherries and raspberries. New plantings also are needed to develop new pest management strategies and tools for emerging and invasive disease and insect pests of fruit crops. This is the third year of the multi-year *Innovative Plantings* plan that will complete the re-establishment of strategically important research fruit plantings and technologies at university research locations. Each year's project targeted specific and unique planting/technology objectives leading towards the final four-year combined compliment of plantings/technologies.

Areas of industry-prioritized research to benefit from these new plantings include: labor efficiency and safety, machine assist technology, pest management, plant growth regulation research, vegetative & crop load control, precision planting, nutrition, soil & water management, chemigation, frost susceptibility and control, harvest technology and canopy management.

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*Objectives:*

1. Replacement and enhancement of modern apple, grape, cherry, blueberry and peach plantings at AgBioResearch research centers and campus locations
2. Develop and determine the effectiveness of new management practices and technologies in these modern research plantings, leading to commercial applications and adoption.

An oversight committee comprised of members of the MSHS, MSU researchers and extension educators, and commodity group representatives met at the start of the project and annually to review the project's priorities and progress, and to guide decisions about the investment in fruit research plantings. Plantings and technology activities were conducted in 2014-15 according to the work plan, including maintenance of plantings established in year 1 -3 of associated funded projects (SCBG). The outcomes from this grant significantly improved specialty crop research infrastructure at key MSU research centers, and in turn will lead to a range of relatively short- to relatively-long term positive outcomes on Michigan's fruit industry.

## PROJECT ACTIVITIES

The Michigan State Horticultural Society served as project partner to development of the project work plan and provided significant advisement to help this project succeed.

Plantings and technology activities were conducted in 2014-15 according to the work plan, including maintenance of plantings established in year 1 -3 of associated funded projects (Table 1). The outcomes from this grant significantly improved specialty crop research infrastructure at key MSU research centers, and in turn will lead to a range of relatively short- to relatively-long term positive outcomes on Michigan's fruit industry.

### **Table 1. Summary of plantings and technology projects (years 1-4) at five MSU locations.**

	Apples	Cherries	Peaches	Grapes	Blueberries	Technology
TNRC	2 acres (2011)	2 acres (2011)	1 acre (2013)	1 acre (2013)	2 acres (2011)	overhead irrigation for blueberries (2010)
SWMREC			2 acres (2010) 2 acres (2011)	2 acre (2010) 5 acre (2011)		support structure and bird netting (2011) prototype peach mechanical thinner (2010) prototype mechanical shoot positioner (2011)
NWHRS	1 acre (2011)	3 acres (2010) 1 acre (2011) 2 acres (2013)				computerized irrigation control system (2010)
CRC	3 acres tall spindle system (2010)	1 acre (2010)				
Campus	1 acre (Ent 2010) 1 acre (Path 2014)	0.5 acre (HTRC 2011)				high tunnel for raspberries (2010) high tunnel for sweet cherries (2010)

## GOALS AND OUTCOMES ACHIEVED

### Objectives:

3. Replacement and enhancement of modern apple, grape, cherry, blueberry and peach plantings at AgBioResearch research centers and campus locations
4. Develop and determine the effectiveness of new management practices and technologies in these modern research plantings, leading to commercial applications and adoption.

### Activities Performed:

#### **Trevor Nichols Research Center (TNRC)**

*Grape vineyard:* Final vineyard establishment activities on the 2013/14 Chancellor, Foch & Aurora vineyards were conducted, including re-plants and completing trellis and drip irrigation. Season-long vineyard maintenance, including weed control, mouse guards and pest control was conducted to ensure optimal growth. Plants that incurred winter injury were pruned and re-set to trellis in spring 2015.

*Peach orchard:* Fall planting of peaches, including soil tilling, fertilizer amendments, weed control, and planting and irrigation. Spring activities included re-plants, completing drip irrigation. Fall & spring orchard maintenance, including weed control, mouse guards and pest control was conducted to ensure optimal growth.

*Cherry orchard:* Season-long orchard maintenance of the 2011 cherry orchards, including pruning, weed control, and pest control was conducted in Fall 2014 & Spring 2015. Portions of the Balaton orchard that held sufficient fruit were used for the IR-4 field residue program, with placement of 2 GLP field residue trials. These trials were successful and will lead to two new EPA registered uses for Michigan cherry growers. Field efficacy trials were also conducted in this planting, leading to grower-targeted pesticide recommendations (MSUE E154 Michigan Fruit Management Guide).

*Blueberry plot:* Fall 2014 & Spring 2015 maintenance of the blueberries, including weed control, and pest control was conducted. Blueberry disease and insect pest susceptibility trials are being run on newly established cultivars. Portions of the blueberry planting that held sufficient fruit were used for additional research, including field efficacy trials leading to grower-targeted pesticide recommendations (MSUE E154 Michigan Fruit Management Guide).

*Apple orchard:* Fall 2014 & Spring 2015 orchard maintenance of the 2011 apple orchards, including re-plants, weed control, and pest control was conducted. The planting will host field efficacy trials in 2015 leading to grower-targeted pesticide recommendations (MSUE E154 Michigan Fruit Management Guide).

### **Southwest Michigan Research and Extension Center (SWMREC)**

*Concord Grape Vineyard:* Development of a 5-acre Concord vineyard at the MSU Southwest Michigan Research Center continued through the Fall 2014 & Spring 2015 season. The approximately 4000 vines in this project were pruned and tied to the trellis in Jan. to April, 2014. Vine replacements for missing vine spaces were planted in 2014. Trickle irrigation was installed for all vineyard rows of this project. Weed control and fertilization of vines was performed Fall 2014 & Spring 2015. Spot-spraying of herbicides to control weeds occurred throughout the growing season. Shoots on all vines were positioned twice to facilitate their attachment to the trellis wires. Fungicide and insecticide sprays were applied at a 14-day interval throughout the growing season.

A design for a mechanical pruning device to accommodate the vine structure of the model Concord vineyard in this project was devised. A major component of this device is an over-the-row trailer that was in use in the 2015 growing season for mechanical shoot positioning work that is a part of this project. The actual fabrication of the pruning device should be complete by the end of the project.

*Peach:* - Further testing and refinement of the hedger arm mounted Darwin Solo Tree pruner was done in mid-April and for May blossom thinning. Notes, pictures, and videos were taken on effectiveness of mechanical blossom thinning for the four tree training systems. Follow-up fruit thinning by hand was done in mid-June for all systems, with notes taken on the effects of blossom thinning on fruit load, and fruit distribution. The peach research planting at SWMREC was highlighted at a peach & plum industry meeting. MSU peach specialist Bill Shane showed approximately attendees the tree training systems, use of mechanical blossom thinning equipment, and the benefits / disadvantages of the four tree forms. Fruit were harvested at the appropriate times for the six peach varieties with notes and data collected on fruit yields and fruit sizes for the four training systems. Off station discussions and demonstration of peach tree training and blossom thinning were held at four grower locations. Our experiences with the tractor-mounted blossom thinner has emphasized the need for a narrow canopy (4 ft wide), which is proving to be not suitable for open center trained trees. We are now recommending the use of the hand held Cinch blossom thinner for open center trees.

*Blueberries:* The bird exclusion structure constructed over 0.5 acres of blueberries at the SWMREC is being used to prevent bird damage to the crop in 2015.

### **Clarksville Horticultural Experiment Station (CHES)**

*High Density Tall Spindle Apple Orchard:* The established Tall Spindle orchard is being used in a SCRI granted study “Development and Optimization of Solid-Set Canopy Delivery Systems for Resource-Efficient, Ecologically Sustainable Apple and Cherry Production”. Honeycrisp and “Rubinstar” Jonagold on Bud.9 dwarfing rootstock and “Crimson” Gala on M.9 NAKB 337. During the growing season of 2014, trees were used for this study where over 13 applications were made of insecticides, fungicides and chemical thinner with excellent results in comparison to tractor powered and pulled traditional sprayer. Applications were made on the 2-acre planting in 12 seconds compared to tractor pulled sprayer for the same area at 30 minutes. A power hedger was used to hedge canopies to confine canopy width in guard rows of each two varieties; Gala and Jonagold. Fruit quality was enhanced in comparison to non-hedged rows. Data regarding crop yield and canopy volume will be included in the final report.

*Sweet Cherry:* A one-acre site is being used for a new NC140 regional research project on high density sweet cherry training systems, one of twelve cooperating sites in North America (9 in the US, 2 in Canada, 1 in Mexico). The fundamental canopy architectures for state-of-the-art experimental cherry training systems: Tall Spindle Axe (TSA), Kym Green Bush (KGB), Upright Fruiting Offshoots (UFO), and Super Slender Axe (SSA) are being evaluated for horticulture attributes and also being used in a SCRI granted study “Development and Optimization of Solid-Set Canopy Delivery Systems for Resource-Efficient, Ecologically Sustainable Apple and Cherry Production”. Since protective covering systems were installed in summer 2012 for evaluation as part of this project, one covering system protected well against the frost, thereby providing good comparative results among training systems and rootstocks. The retractable roof covering structure yields, on average, were 153% higher than from the unprotected trees. The test variety, ‘Benton’, had the highest yields (3.2 to 3.5 tons/acre in this 4<sup>th</sup> season after planting) in the two central leader training systems, the Super Slender Axe (SSA) and the Tall Spindle Axe (TSA), on the very dwarfing and precocious rootstock, Gisela 3. Across all rootstocks under the retractable roof, the highest yielding training system was the SSA (mean 2.3 t/ac), followed by the TSA (1.6 t/ac), the Upright Fruiting Offshoots (UFO, mean 0.7 t/ac), and the Kym Green Bush (KGB, 0.4 t/ac). As this trial matures and year-over-year yield data are obtained, the results will dramatically change the way Michigan growers produce fresh market sweet cherries, with a high potential for increasing overall acreage, yields per acre, and consistent supplies for profitable regional and farm market opportunities.

### **Northwest Michigan Horticultural Research Station (NWMHRS)**

#### *Irrigation/Fertigation Installations into Experimental High Density Plantings:*

Season-long orchard maintenance of Honeycrisp apple trees on Nic 29 (dwarfing rootstock) that were planted at the NWMHRC in 2013, including re-plants, weed control, and pest control. Eight hundred seventy trees were planted at 3’x12’ spacing and trained to a tall spindle system. Irrigation and fertigation trials will be conducted in this block, and this planting will also serve as a demonstration plot for pruning and training apples to the tall spindle system. The trees were planted with nine trees per treatment and ten replications in the block. The following irrigation/fertigation strategies will be employed in 2014: 1) 2oz of N/tree/year + 0.25” of water, 2) 4oz of N/tree/year + 0.25” of water, 3) 2oz of N/tree/year + 0.50” of water per day, 4) 4oz of N/tree/year + 0.50” of water per day, 5) 0.25” of water per day, and 6) UTC.

Fall 2014 & Spring 2015 orchard maintenance of the two-acre Montmorency block at the NWMHRC was conducted so the orchard can be used for fungicide efficacy screening in spring 2015, including re-plants, weed control, and pest control. These trees were planted at a traditional spacing of 20’x20’ on standard Mahaleb rootstock. In addition, other plots established in years one and two were trained and maintained according to protocol.

Fruit production measures were collected in the high-density tart cherry block, which was our second yield evaluation since the trees were planted in May 2010, due to the crop loss in

2012. Season-long orchard maintenance of this block was conducted, including re-plants, weed control, and pest control. The average crop yield was used to calculate tree efficiency for the five different rootstocks: own-rooted, Mahaleb, Gisela 3, Gisela 5, and Gisela 6. In the five tree replicates, we evaluated the middle three trees with the outside two trees used as guard trees. In addition, we evaluated the trees for the following parameters: leaf area, fruit pull force, trunk diameters, and tree canopy height, depth, and width. Tree spacing in this test planting is 4'11" x 13', and we ran a double line of RAM tubing for irrigating and fertigating this block. Two pruning systems were evaluated in this planting: multiple leader bush and central leader axe. Renewal pruning was done where we removed the two largest branches on each of the trees. Differences in yield were observed between the five treatments, and Montmorency grown on Mahaleb rootstock and on its own-root had much lower yields compared to the more precocious Gisela rootstocks. Differences in yield were also observed between the different training systems, and fruit pullforce (the higher the pullforce reading, the more force it takes to remove the fruit from the stem without ethephon applications) was higher in the more dwarfing rootstocks. Trunk diameter measurements across rootstocks showed that only Montmorency on its own root had smaller trunk diameters than all other rootstocks; training system had little influence on trunk diameter.

### ***Entomology Planting – MSU Campus***

Season-long orchard maintenance of this block was conducted on the three-acre orchard comprised of six hundred fifty Crimson Crisp trees/acre (Bud 9 rootstock) is now available as a research orchard at the Michigan State University Entomology farm. The orchard is trained to a vertical axis, and ongoing maintenance, including disease and pest management was carried out in Fall 2014 & Spring 2015 season. This summer the orchard is used for pheromone aging studies. Plans are in the works for research trials on organic apple production and pheromone-based mating disruption.

### ***Horticulture Teaching and Research Center – MSU Campus***

*Blueberries:* Bird netting over blueberry planting at HTRC is deployed and measures of yield and fruit quality and entomological and pathological studies will be taken.

*Sweet Cherry:* The second fruiting occurred in the organic high tunnel sweet cherry plot (2014 was the 4th year after planting). Cover cropping experiments to examine organic strategies for weed control and soil health are on-going, with increasing evidence that weed or cover crop root competition with the trees during the spring can negatively impact tree growth. Among the strategies being tested the seasonally-timed combination of geotextile weed barrier fabrics during sensitive tree growth stages and cover crops during less sensitive stages.

### ***Measureable outcomes:***

Three major outcomes were expected from the improved specialty crop research infrastructure:

1. Improved yields and sustainable profits resulting from adoption of high efficiency technologies for irrigation, trellising, crop load management, and harvest systems, as well as genetically improved cultivars, leading to technologically-advanced and world-competitive Michigan commercial fruit farms.

(#1 Measurable Outcome: Dr. Perry and Schwallier measured apple yield and grower adoption & acceptability of tall spindle apple plantings and platforms, leading to grower recommendations for improved apple production.)

“Platforms have really taken off over recent years, matching the adoption of tall-spindle high density tree fruit plantings in Michigan. We have demonstrated the Phil Brown Welding platforms over the past four years. Five years ago there was one on the ridge, and now there are twenty.

The larger growers are buying them so perhaps percent wise over the last four years, .1%, 1%, 5%, and 8%. These platforms were purchased to prune high density (Tall Spindle and Vertical Axe) orchards but now being used to apply pheromones, build trellis, train trees, hand thin, summer prune and hand harvest assist.” (*Schwallier*)

(#2 Measurable Outcome: Dr. Lang measured and compared yields, fruit quality, tree growth, and pruning time for the high density sweet cherry canopy training system research in the CRC plot funded by SCBG. Two orchard covering systems that were established over that planting also were compared for effects on bloom, fruit ripening time and quality, and tree growth.)

(#3 Measurable Outcome: Dr. Rothwell measured irrigation efficiency and yields for the tart cherry training systems, leading to grower recommendations for improved cherry production, and grower acceptability of the training systems)

“Dr. Rothwell hosted irrigation and fertigation specialist, Dr. Denise Nielsen from Pacific Agri-food Research Center in British Columbia to discuss water and nutrient management. Topics covered at the workshop included water-use rights, the relationship of soil characteristics and irrigation, generally accepted agricultural and management practices related to on-farm irrigation, drip irrigation, optimizing scheduled irrigation and designing irrigation systems, and on-farm experiences with irrigation. Based on our research data and our evaluations from this survey and a survey conducted at Great Lakes EXPO, we found that 55% of respondents will install irrigation into their tart cherry orchards, and 75% of new orchards will have irrigation. Additionally, we received a MI Specialty block grant to place four high-density tart cherry orchards at grower sites (\$56,770) based on results generated at the NWMHRC; all of these sites will be irrigated based on irrigation data gathered from trials conducted at the NWMHRC test plots.” (*Rothwell*)

(#4 Measurable Outcome: Dr. Zabadal will measure grape planting yields and conduct grower surveys to measure acceptability of the mechanical grape pruner funded by SCBG, leading to grower recommendations for improved juice grape production.)

“The first crop for the Model Concord vineyard occurred in 2014. When compared to the treatment that represents the current commercial approach to growing Concord grapes in Michigan, the treatment involving the SO4 rootstock, two-tier cordon training, or both were 43%, 103% or 159% higher, respectively. There were no differences in fruit soluble solids among treatments, which averaged 16.2 Brix. The mechanical pruner for two-tier cordon training underwent further development and will require more development. A grower meeting was held at the location of the Model Concord Vineyard, and response at this meeting indicated that several growers intend to implement portions of this new vineyard architecture in their upcoming plantings. A device to mechanically position shoots in this new vineyard planting has been commercialized by 10 growers in two states.” (*Zabadal*)

(#5 Measurable Outcome: Dr. Shane will conduct performance measurements and conduct grower surveys to measure acceptability of the mechanical peach thinner, leading to grower recommendations for improved peach production.)

“In tests at SWMREC the palmette has emerged as the favored peach tree training system based on productivity, tree health, and suitability for blossom thinning. As a result of the SWMREC research planting and our educational programs highlighting it, four ‘early adopting’ Michigan growers are testing peach tree wall planting systems for use with mechanical blossom thinning equipment. The SWMREC peach research planting will be used to evaluate long-term productivity and tree longevity of the four training systems and to demonstrate mechanical

blossom thinning methods. Further refinements of the systems are being tested and demonstrated at the SWMREC research site.” (Shane)

(#6 Measurable Outcome: The bird netting installed with funding by SCBG prevented berry losses so that accurate yield figures could be determined. Dr. Hanson reported on the projects conducted that rely on accurate yield data.)

(#7 Measurable Outcome: Dr. Hansen measured yields for raspberries under the high tunnel system funded by SCBG, leading to grower recommendations for improved raspberry production.)

2. Improved preparedness of Michigan’s fruit producers to deal with emerging and invasive disease and insect pests, including Spotted Wing Drosophila, Brown Marmorated Stink Bug, Blueberry Shock Virus, Blueberry Scorch Virus, and Blueberry Leaf Rust, resulting from research-ready plantings to test experimental pesticide formulations, determine pest lifecycle stages, and integrate control strategies with current management practices.

- Outcomes were quantified in terms of the numbers of new pests identified in the state and the resulting “Best Management Practices” (BMPs) developed by the MSU fruit research and extension team.

(#1 Measurable Outcome: Dr. Schilder monitored occurrence of blueberry leaf rust and evaluated fungicide efficacy and cultivar susceptibility in the TNRC irrigated blueberry planting funded by SCBG, leading to time-sensitive grower alerts, as well as improved recommendations for leaf rust management. Furthermore, she conducted anthracnose fruit fungicide efficacy and timing trials in the planting, which supported the validation of the anthracnose fruit rot prediction model and new Spray-Weather-Wise fungicide timing model in Enviro-weather. Blueberry growers were surveyed on the use of new recommendations and tools for blueberry disease control at a blueberry grower meeting.)

(#2 Measurable Outcome: Dr. Isaacs conducted control studies for Spotted Wing Drosophila in the TNRC irrigated blueberry planting funded by SCBG, leading to emergency trapping and control strategy recommendations for growers)( [www.ipm.msu.edu/SWD.htm](http://www.ipm.msu.edu/SWD.htm)).

“Spotted wing Drosophila, *Drosophila suzukii*, was detected in 2013, and the response to this has included evaluation of insecticides to prevent fruit infestation and comparison of traps to monitor its activity.” (Isaacs)

(#3 Measurable Outcome: Dr. Gut conducted control & monitoring/detection studies for invasive or emerging pests, including Brown Marmorated stink bug, in the apple and peach plantings funded by SCBG, leading to grower recommendations).

“We have used the improved research plantings at TNRC and NWMHRS to sample for the following invasive pest insects: European grapevine moth, *Lobesia botrana*; light brown apple moth, *Epiphyas posivittana*; summer fruit tortrix, *Adoxophyes orana*; and Apple Stem Borer. After detection of Apple Stem Borer in 2014 we have initiated research trials to develop control strategies for Michigan farmers.” (Gut)

(#4 Measurable Outcome: Dr. Sundin will conduct fire blight research on the 2014 campus apple planting funded by SCBG, leading to grower recommendations for preventing this disease).

Outcomes were also quantified in terms of “Best Management Practices” (BMPs) and control

recommendations developed by the MSU fruit research and extension team reported in the MSU Fruit Management Guide (E0154), <http://www.bookstore.msue.msu.edu/>.

3. Improved pest management tools for growers and associated market quality of Michigan fruit crops, resulting from IR-4 field residue trials and IPM product performance studies conducted on MSU research-ready fruit plantings.

(#1 Measurable Outcome: Dr. Wise conducted 17 IR-4 field residue trials which will lead to eight+ new EPA registrations and/or uses in fruit crops.) The goal is to expand the number of pest control tools available to fruit growers for the Integrated Pest Management programs on their farms. The benchmark for this is the current existing pesticides registered and recommended for Michigan fruit pest management (2015 Michigan Fruit Management Guide, MSUE bulletin E-154), the performance measure is the number of new GLP field residue trials hosted conducted on MSU research center fruit plantings, and the target is ten new labeled uses for Michigan fruit growers. Note that from the time field residue trials are conducted, three - five years is needed before the EPA completes the registration process and provides a new label. The current status of IR-4 projects can be found at the IR-4 Project website, <http://ir4.rutgers.edu/index.html>.

“Expected outcomes for the NC Region IR-4 program is for increased number of safe, effective and economical pest management solutions to become available for growers of specialty crops, including ornamentals, and for minor uses on major crops, both for the NC region, and as a key partner in the national IR-4 program. The products/outputs targeted for this program in 2015/16 will support future clearances and label additions from EPA and the registrant to meet these needs. In an independent study at Michigan State University concluded that the approximately \$16 million investment in IR-4 annually contributes \$7.3 billion to the US economy and this includes over a \$290 million to the Michigan economy. This supports over 100,000 jobs nationally. In addition, through its pesticide residue analytical work, IR-4 helps to ensure that the food supply in the USA is kept safe from possibly dangerous pesticide residues, and by focusing most of its program on newer and safer pesticide products, it helps decrease the current risks to farm workers, consumers, and the environment.” (Wise)

## BENEFICIARIES

MSU fruit research center and campus orchards benefited directly from the new planting, since recent budget constraints have resulted in little to no new investments. Research plantings were becoming aged and obsolete, thus putting a major constraint on the relevance of MSU research to Michigan fruit industries.

Ultimately it is the Michigan fruit industries that will benefit since the new horticultural plantings at MSU research centers will help us deliver cutting edge research information to support their profitability. Michigan is a national leader in the production of fruit crops, with apples, blueberries, cherries, grapes and peaches contributing a farm level value of \$314 million to MI's annual economy (MI Agricultural Statistics 2007-2008). Profitability in domestic and global fruit markets requires high food quality standards, the development of modern genetic resources, such as cultivars and rootstocks, enhanced cultural techniques, and effective strategies for maximizing yields while controlling disease and insect pests.

## LESSONS LEARNED

Collaborative efforts between university and commodity organizations require more effort but yield enhanced outcomes for all.

## CONTACT PERSON

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## ADDITIONAL INFORMATION

None.

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## PROJECT TITLE **FINAL**

**LAKESHORE ENVIRONMENTAL INC** – A Study on the Effectiveness of Onsite Wastewater Treatment systems for Michigan Wineries

## PROJECT SUMMARY

Michigan wineries produce various amounts of wastewater onsite, much of which passes through preliminary treatment before being released to the ground surface through a variety of methods. The wastewater at these sites has been shown to contain elevated concentrations of sodium, chloride (intermittently), biochemical and chemical oxygen demand (BOD/COD), and nitrogen (in various states). As such, Michigan Department of Environmental Quality (DEQ) has begun to strongly encourage wineries to obtain groundwater discharge permits and provide adequate treatment of their process wastewater.

Within the winery industry, there was a general lack of knowledge with regard to effective onsite treatment options for the specific parameters regularly found in winery effluent. The wastewater is not inherently harmful; however, insufficient or unmonitored disposal methods can cause problems to the surrounding environment, specifically to nearby groundwater, if not properly managed. This study was designed to collect the necessary information to further explore onsite wastewater treatment options for Michigan wineries.

Furthermore, Lakeshore Environmental, Inc. (LEI) set out to provide essential permit information to the winery industry, in response to increased DEQ pressure. This project did not build off any previously funded projects.

## PROJECT APPROACH

Five Michigan winery participants were chosen to participate in this study. Wineries A, B, C, D, and E were chosen based on various factors. Ultimately, three different treatment systems were examined throughout this study. Wineries A, B, and E operated subsurface passive aeration systems; Winery C operated an existing dry well treatment system; Winery D utilized surface land application for wastewater treatment.

Monitoring equipment was used to collect wastewater, groundwater, and soil pore water samples to evaluate the effectiveness of the treatment system. LEI and the Grand Traverse Conservation District (GTCD) collected wastewater and soil pore water samples from each of the study sites on a bi-monthly basis, increasing to monthly during peak production season. Two of the study sites (Winery A and D) were equipped with upgradient and downgradient groundwater monitoring wells which were sampled quarterly throughout the study.

Wastewater samples were used for general characterization of the winery wastewater and represented the “influent” to each treatment system. Lysimeters were installed to collect soil pore

water samples at two and four feet below discharge level. Soil pore water samples represented the “effluent”, or treated wastewater, at each system. Lastly, groundwater samples were used as additional effluent results and represented final, treated wastewater comingled with natural groundwater.

Analytical results varied among the study sites, though the wastewater was generally categorized as “high strength” due to elevated BOD and other key parameter concentrations. Wastewater that was found to contain especially high concentrations of key analytes also appeared to strongly correlate with sediment accumulation in the settling tanks. Sodium and chloride were occasionally present in concentrations that exceed general DEQ Part 22 discharge standards. Fresh water dilution played a role in wastewater characterization at some sites.

Findings from this study indicated that surface land application and subsurface passive aeration were effective long term treatment options for Michigan wineries. The dry well system was found to be a short term solution only; evidence of clay and sludge development and general infiltration concerns arose in systems older than approximately two years (seasons) in use. Aeration in one or more of the settling tanks, where utilized, was highly effective as a pre-treatment option, prior to discharge to the onsite system. Additional information on study findings is provided below.

Contributing parties to this study include:

- Lakeshore Environmental, Inc. (LEI)
- Grand Traverse Conservation District (GTCD)
- 5 Michigan wineries
- Michigan Department of Agriculture and Rural Development (MDARD)

## GOALS AND OUTCOMES ACHIEVED

### ***Wastewater Characterization***

When characterizing wastewater, BOD and COD are the primary indicators of wastewater strength. Wastewater analytical data collected throughout this study (summarized in Table 1) showed that winery wastewater was a “high strength” wastewater stream. Full analytical results are provided in **Attachment A**.

**Table 1: Summary of Wastewater Analytical Results**

<b>Constituent (Results in mg/L, unless otherwise noted)</b>	<b>Average Concentration (All Wineries)</b>	<b>Standard Deviation (All Wineries)</b>	<b>Winer y A</b>	<b>Winer y B</b>	<b>Winer y C</b>	<b>Winer y D</b>	<b>Winer y E</b>
BOD	<b>2,046</b>	<b>1,768</b>	2,249	336	3,578	3,111	957
COD	<b>3,236</b>	<b>3,143</b>	3,423	493	5,244	5,722	1,299
Sodium	<b>279</b>	<b>300</b>	396	792	53	124	28
Chloride	<b>459</b>	<b>612</b>	673	1,500	10.8	53.2	7.20
Ammonia	<b>7.53</b>	<b>9.60</b>	4.97	3.64	18.4	7.90	2.43
Nitrite	<b>0.14</b>	<b>0.13</b>	ND	ND	0.23	0.07	0.02
Nitrate	<b>0.54</b>	<b>0.67</b>	0.07	ND	0.13	0.90	0.85
TIN (Calculated)	<b>7.60</b>	<b>9.50</b>	4.44	3.64	18.5	8.77	2.63
Phosphorus	<b>5.26</b>	<b>4.61</b>	8.26	1.29	5.82	9.19	1.72
pH (S.U.)	<b>6.13</b>	<b>0.90</b>	5.8	6.7	5.5	6.0	6.8
Dissolved Oxygen	<b>1.15</b>	<b>1.11</b>	2.1	1.0	0.3	0.8	1.0

High strength wastewater is very common in processing facilities, especially those involving fruit and/or other products high in natural sugar content. Although wastewater strength was generally high, there was a bit of variation between the study sites. Particularly high strength wastewater appeared to strongly correlate with sediment accumulation in the settling tanks. Treatment systems at Wineries A, C, and D each included the use of older settling tanks where sediment, particulate, and fruit pieces were observed during sampling events. Meanwhile, Wineries B and E utilized new settling tanks (about one year of use, at the time of this study) and showed BOD/COD concentrations below 1,000 mg/L. Furthermore, Winery B redirects some wash water from outdoor activities to a separate surface land application area, thereby bypassing the settling tanks analyzed during this study. Fresh water dilution effected analytical results at Winery E by reducing analytical concentrations but increasing overall water use and discharge rates. Sodium and chloride are also common in process wastewater and can often act as a tracer to demonstrate treatment within a system. The presence of high sodium and chloride was generally related to the use of a water softening system. Study sites where the water used in the process area was softened showed significantly higher sodium and chloride concentrations than those that did not. Furthermore, sodium and chloride concentrations in the wastewater at these sites occasionally exceeded DEQ Part 22 Discharge standards of 400 mg/L and 500 mg/L, respectively. These concentrations are not expected to cause concern to the surrounding environmental based on the several factors: depth to groundwater, low discharge volume (annually), diffusion/re-mineralization in the vadose zone, etc.

Finally, field readings of the study site wastewater indicated generally acidic, anaerobic (i.e. oxygen deficient) conditions. Typically, a dissolved oxygen concentration below 1.0 mg/L is considered anaerobic. Sites where aeration was installed in one or more of the settling tanks showed dissolved oxygen concentrations at or above 1.0 mg/L, while sites without aeration averaged closer to 0.0 mg/L. Volatile, odor causing compounds are created and maintained in low pH (acidic), low oxygen (anaerobic) environments and odor was often a primary concern at sites without aeration included for wastewater treatment.

### ***Design Considerations & Calculations***

This study successfully evaluated a few of the many treatment options for Michigan wineries in order to provide a base for the industry as it moves forward in sustainability and responsible management. With that, it is important to remember that wastewater treatment is not “one size fits all”. There are several considerations that should be taken into account when designing an onsite treatment system. In conjunction with loading calculations (discussed below), a facility must consider its specific site characteristics and land availability. The amount of land available to dedicate to the treatment system will greatly impact the design. Attention must always be paid to nearby supply wells, irrigation wells, and neighboring drinking water wells to prevent unintended impact to a neighboring water source. Isolation distances outlined by the DEQ Permit Section are as provide in the permitting discussion, later in this report.

Understanding the potential loading is an essential step in designing a successful treatment system. This includes BOD loading, hydraulic loading, and nutrient loading/accumulation potential, which requires a thorough understanding of a facility’s water use, both daily and annually, as it compares to activities in the processing area. Flow meters are the preferred way to track and monitor a process area’s water use, as they provide raw data to demonstrate water entering or leaving the facility.

BOD loading, the most common benchmark for onsite wastewater treatment systems, is measured in pounds per acre per day and is therefore dependent on the area available for disposal, the wastewater concentration, and wastewater flow rate or volume. The equation used to calculate this loading rate is as follows:

**Equation 1**

$$\frac{BOD \left(\frac{mg}{L}\right) * Volume (gallons) * 8.34}{Area (acres) * 1,000,000} = BOD \text{ Loading } \left(\frac{lbs.}{acre}\right)$$

Equation 1 can also be used to calculate loading of other analytical parameters, such as nitrate, sodium, or phosphorus by substituting the parameter concentration (also in mg/L) for BOD in the equation.

In Michigan, an average loading rate (or target maximum) of 50 pounds per acre per day is common. This study, along with several other documented cases, has shown that this standard can be exceeded as long as the area is given adequate periods of rest for recovery. A seasonal spike in processing activities and/or wastewater strength is very common in agriculture related production and must be accounted for in the treatment system’s design. In the case of wineries, considerably high loading for 60 days (+/-), followed by a reduced or even eliminated load for the remainder of the year is a feasible treatment strategy as long as the operator is aware of the process and monitoring the system. Example calculations based on one acre of discharge area and various flows/concentrations, are provided below.

**Table 2: Daily BOD Loading Example, One Acre Discharge Area**

lbs./ac./day BOD		BOD Concentration (mg/L)						
		250	500	750	1,000	2,000	3,000	4,000
Gallons Per Day (GDP)	250	0.5	1.0	1.6	2.1	4.2	6.3	8.3
	500	1.0	2.1	3.1	4.2	8.3	12.5	16.7
	750	1.6	3.1	4.7	6.3	12.5	18.8	25.0
	1,000	2.1	4.2	6.3	8.3	16.7	25.0	33.4
	1,250	2.6	5.2	7.8	10.4	20.9	31.3	41.7
	1,500	3.1	6.3	9.4	12.5	25.0	37.5	50.0
	1,750	3.6	7.3	10.9	14.6	29.2	43.8	58.4
	2,000	4.2	8.3	12.5	16.7	33.4	50.0	66.7
	2,250	4.7	9.4	14.1	18.8	37.5	56.3	75.1
	2,500	5.2	10.4	15.6	20.9	41.7	62.6	83.4
	2,750	5.7	11.5	17.2	22.9	45.9	68.8	91.7
	3,000	6.3	12.5	18.8	25.0	50.0	75.1	100.1
	3,250	6.8	13.6	20.3	27.1	54.2	81.3	108.4
	3,500	7.3	14.6	21.9	29.2	58.4	87.6	116.8
	3,750	7.8	15.6	23.5	31.3	62.6	93.8	125.1
	4,000	8.3	16.7	25.0	33.4	66.7	100.1	133.4
	4,250	8.9	17.7	26.6	35.4	70.9	106.3	141.8
	4,500	9.4	18.8	28.1	37.5	75.1	112.6	150.1
4,750	9.9	19.8	29.7	39.6	79.2	118.8	158.5	
5,000	10.4	20.9	31.3	41.7	83.4	125.1	166.8	
5,250	10.9	21.9	32.8	43.8	87.6	131.4	175.1	
5,500	11.5	22.9	34.4	45.9	91.7	137.6	183.5	

**Table 3: Example – Annual Treatment Schedule, One Acre Discharge Area**

	Days per Year	BOD Loading (lbs./acre/day)	BOD Loading (lbs./acre/yr.)
"Peak" Season	60	200	12,000
"Off-peak" Season	200	25	5,000
No Discharge	105	0	0
<b>Total Annual Loading (lbs. /acre/yr.):</b>			<b>17,000</b>
<b>Daily Average (lbs./acre/day):</b>			<b>47</b>

**Project Goals**

The proposed goals of this study, with results and discussion, are provided below.

**Goal #1: Determine the success and efficiency of one or more onsite treatment system(s) for Michigan wineries**

Surface land application and subsurface passive aeration were shown to be viable, long term treatment options for Michigan winery wastewater. These treatment systems demonstrated high reduction rates of key wastewater analytical parameters at both two feet and four feet below discharge, as shown below in Table 4.

**Table 4: Average Parameter Reduction Results**

Winery ID:	Winery A	Winery B	Winery C	Winery D	Winery E
<b>WW Treatment System:</b>	Subsurface, Passive Aeration	Subsurface, Passive Aeration*	Dry Well	Surface Land Application	Subsurface, Passive Aeration**
<b>Settling Tank Info:</b>	(2) 1,600-gal	(1) 1,000-gal (2) 1,600-gal	(1) 1,600-gal (two chamber)	(2) 14,000-gal (chambered)	(2) 2,000-gal
<b>Aeration?</b>	Yes	Yes	No	No	No
			<b>Avg. Percent Reduction: 2' Below Discharge</b>		
Sodium	99%	99%	ID	ID	Increase
COD	98%	97%	92%	92%	Increase
Chloride	99%	100%	ID	65%	Increase
Ammonia	84%	92%	98%	97%	82%
Nitrate-Nitrite	Increase	Increase	Increase	Increase	Increase
TIN	Increase	Increase	Increase	86%	63%
Phosphorus	97%	54%	94%	75%	72%
			<b>Avg. Percent Reduction: 4' Below Discharge</b>		
Sodium	95%	99%	ID	65%	Increase
COD	98%	91%	74%	92%	Increase
Chloride	99%	100%	ID	43%	Increase
Ammonia	97%	93%	98%	98%	44%
Nitrate-Nitrite	Increase	Increase	ID	Increase	Increase

TIN	<i>Increase</i>	1%	<i>ID</i>	90%	29%
Phosphorus	99%	75%	<i>ID</i>	64%	68%

*ID: Insufficient Data*

*\*Surface land application used for some outdoor wash down activities*

*\*\*Surface land application option, used for summer months.*

A complete reduction analysis has been provided in **Attachment B**.

In addition to the lysimeter results information, groundwater samples collected from Winery A and Winery D demonstrated further reduction of key parameters with no indication of groundwater quality degradation.

All wastewater treatment systems evaluated throughout this study demonstrated some reduction in key wastewater chemical compounds, thereby indicating that each system was an effective option for onsite wastewater treatment at Michigan wineries. However, surface land application and subsurface passive aeration systems (or a combination of the two) are recommended as long term treatment options based on treatment capacity, maintenance requirements, and system longevity.

The dry well system LEI evaluated was one which had been in use for at least two seasons prior to the study commencement. During the 2014 production season, some infiltration issues and treatment deficiencies were observed. A field investigation showed evidence of clay and sludge development in the stone infiltration bottom, as well as persistent anaerobic conditions and odor concerns. The reduced infiltration capacity limited lysimeter sample volumes and significantly reduced soil pore water data for this site. Observations made during this study indicated that the dry well treatment system can provide sufficient treatment, but is only recommended for short term use or in conjunction with significant pretreatment. After two or three seasons of use, plugging and decreased treatment efficiency can be expected and repair or replacement will be required.

Some parameters analyzed and compared throughout this study did not demonstrate a reduction from wastewater to soil pore water, but rather consistently showed increased concentrations. Soil pore water samples collected from each site consistently showed higher concentrations of nitrogen, specifically nitrate, than were observed in the respective site's wastewater stream. This was primarily due the presence of existing nitrate in the study areas, which is not uncommon for rural settings with historical agricultural use, and "nitrification" which is the biological oxidation of nitrogen from ammonia to nitrate.

With regard to nitrogen, it should be noted that ammonia was the most common form of nitrogen in the wastewater samples, while nitrate was the more prevalent form in soil pore water and groundwater samples. This was consistent with the characterization observation of generally anaerobic conditions in the wastewater. The perceived decrease of ammonia in the soil pore water samples indicated that treatment was occurring and ammonia was being converted to nitrite-nitrate in the process (i.e. "nitrification"), especially at sites with one or more forms of aeration included with the treatment system.

Winery E showed several areas of increased parameter concentrations when comparing wastewater to soil pore water results. This site included some dilution of the wastewater with fresh water from the cooling jackets and other areas of the process area. While this dilution resulted in generally lower analytical concentrations, it significantly increased the volume of water discharged to the system. This resulted in a temporary hydraulic overload to the system and slowed treatment capacity during peak season. Effective treatment was still observed, but at a slower rate since the time required for the wastewater to pass through the system was increased.

Results from this site, in conjunction with results collected from Wineries A and B indicated that the subsurface passive aeration system remained an effective treatment option.

Lastly, Winery D showed some increased soil pore water parameter concentrations between October and January, which correlated to peak production season when wastewater strength and the cycle rate of discharge was increased. Although important to note, this was not cause for concern. This particular system has been operating for several years, which indicated that samples collected at the beginning of the study (spring 2014) were likely representative of recovered field conditions. As previously mentioned, high strength low volume discharge patterns allow for short term heavy loading of the treatment system followed by a period of rest to allow for recovery in preparation for the following year. Groundwater monitoring at this site showed no evidence of impact.

**Goal #2: Determine the effect of sanitation additives on wastewater quality.**

Results for this portion were insignificant. Sanitation chemicals were generally consistent among the five wineries included with this study and did not appear to significantly impact water quality.

**Goal #3: Develop a guidance document for the selection of a permitting program and treatment system for Michigan wineries based on site-specific conditions.**

LEI developed the following summary and guidance information for the Michigan DEQ Groundwater Discharge Permit Program(s). All of the participating wineries for this study required a DEQ groundwater discharge permit, as opposed to a National Pollutant Discharge Elimination System (NPDES) Permit (NPDES permit required for discharge to surface water). LEI determined groundwater discharge permits to be the primary permit program for Michigan wineries.

A facility that discharges wastewater directly to surface waters without a NPDES permit is in violation of state and federal law. In Michigan, the DEQ's Water Resources Division has responsibility for processing NPDES permits under the authority of the Federal Water Pollution Control Act, and Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Please visit the following website for more information:

[http://michigan.gov/deq/0,4561,7-135-3313\\_3682\\_3713---,00.html](http://michigan.gov/deq/0,4561,7-135-3313_3682_3713---,00.html)

**Michigan DEQ Permit Program Overview**

General information for the Michigan DEQ Groundwater Discharge Permit is provided in **Attachment C**.

Under the Michigan Natural Resources and Environmental Protection Act (NREPA) of 1194, PA 451, as amended, any facility discharging waste or waste effluent into waters of the state must be in possession of a valid permit to discharge from the DEQ. A quick summary of all permit program options are outlined in Table 5.

**Table 5: Michigan DEQ Permit Program Summary**

Permit Group	Permit Type	Annual Fees	Brief Description
Group 3	Rule 2211	\$200	Pre-defined activity list; See Attachment C
	Rule 2213	\$200	Pre-defined activity list; See Attachment C
Group 2	Rule 2210(Y)	\$1,500	Site Specific Authorization for discharges with insignificant potential to be harmful based on volume and wastewater components. Typically requires additional monitoring.
	Rule 2215	\$1,500	Pre-defined activity list; See Attachment C

	Rule 2216	\$1,500	Pre-defined activity list; See Attachment C
Group 1	Rule 2218	\$3,650	Site Specific Authorization for all other discharges; very common for large processing facilities. Additional information required. Requires additional monitoring.

The 2211 Permit is a simple permit by “notification” to the department that includes the following pre-defined activities:

**Table 6: Rule 2211 Permit Pre-defined Activities**

Wastewater Type	Daily Maximum Discharge
(a) Sanitary Sewage	6,000 – 10,000 GPD
(b) Laundromat	< 500 GPD
(c) Non-contact Cooling Water	> 10,000 GPD
(d) Fruit & Vegetable Wash water	< 50,000 GPD
(e) Portable Power Washer	< 1,000 gal./ac./mo.
(f) Pump test Water	n/a
(g) Hydrostatic Test Water	n/a
(h) Commercial Animal Care	50 - 1,000 GPD

### **LEI Recommendations**

In conclusion to this study, LEI found that a 2211 Permit was the ideal program for Michigan wineries, although a 2210(Y) Permit may be required in some instances.

LEI recommends the Rule 2211(d) Fruit and Vegetable Wash Water Permit. Of the pre-defined permits outlined above, this is the most representative of the fruit component in winery production. This permit section has a maximum daily discharge limit of 50,000 gallons per day; significantly more than most wineries produce on a daily basis, even during peak season. This is a simple permit with little to no required monitoring and maximum daily discharge standards that wineries can easily adhere to. The use of this permit will allow the majority of wineries to be permitted under the same rule and provide consistency throughout the industry.

Historically, the DEQ has issued Rule 2211(e) Portable Power Washer Permits to Michigan wineries, and in some instances required a 2210(Y). The Rule 2211(e) permit is a viable option, if not only to remain in the “Group 3” permitting tier. However, this rule includes a maximum discharge of 1,000 gallons per acre per month. This is not a standard the majority of the industry can adhere to during peak production season. In this instance, the alternative to the Rule 2211(e) permit would be a Rule 2210(Y), which typically requires significantly more monitoring and reporting throughout the life of the permit. This is a significant discrepancy and inconsistency within the Part 22 rules overall which the use of a Rule 2211(d) Permit could eliminate. Based the information available during this study, LEI estimated between 10 and 12 gallons of wastewater were discharged per case of wine produced, on an annual basis. This total volume estimate is comprised as follows: approximately three to four gallons of wastewater was produced per case of wine during the 60 day production season with the remaining seven to nine gallons resulting from tank wash water, etc., throughout the year. These estimates are generally conservative to allow for fluctuation in the final application of LEI’s recommendations. Based on these numbers, LEI recommends a winery with an annual production less than or equal to 25,000 cases qualify for a Rule 2211(d) Permit. Wineries with annual production volumes

greater than 25,000 cases may require a Rule 2210(Y) Permit, unless data can be provided to demonstrate Rule 2211 applicability.

Using a conservative ratio of 12 gallons of wastewater per case of wine, an annual production of 25,000 cases would yield roughly 300,000 gallons per year. Assuming a 60 day season, during which both water use and wastewater concentrations are at their peak, maximum daily discharge volumes at a facility of this size would range from 1,000 to 1,500 gallons per day, with typical or “off season” discharge volumes of less than or equal to 500 gallons per day.

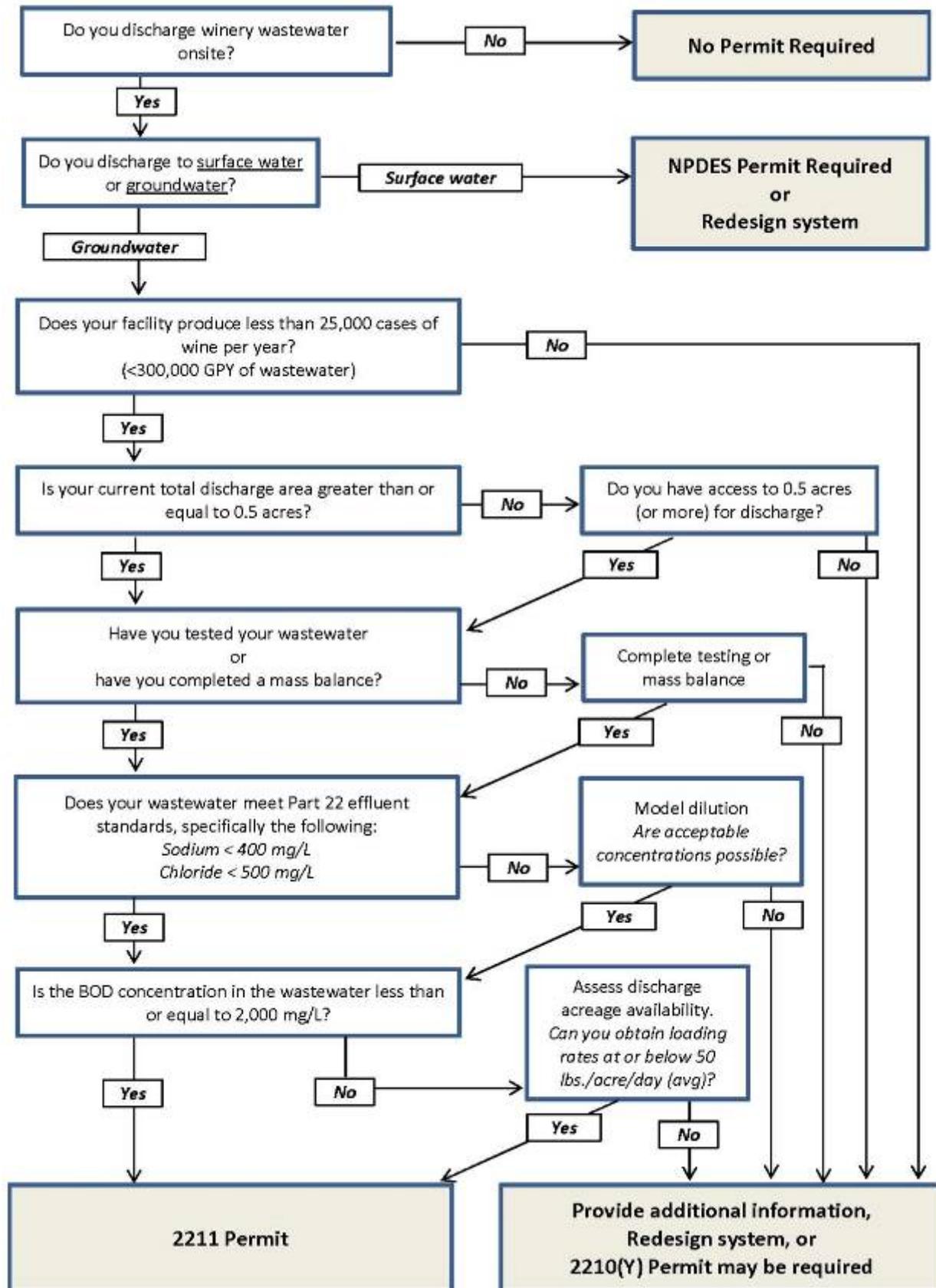
With a one-quarter acre discharge area, average BOD loading rates would not exceed the “standard” 50 pounds per acre per day over the course of an entire year. As previously discussed, a temporary increase in loading to a treatment system is acceptable when followed by adequate periods of rest.

Some guideline BOD loading calculations are provided in the table below.

**Table 7: Annual BOD Loading Example, One-Quarter Acre Discharge Area**

Average lbs./ac./day BOD		BOD Concentration (mg/L)						
		500	750	1,000	1,500	2,000	2,500	3,000
Gallons Per Year (GDY)	50,000	2.3	3.4	4.6	6.9	9.1	11.4	13.7
	75,000	3.4	5.1	6.9	10.3	13.7	17.1	20.6
	100,000	4.6	6.9	9.1	13.7	18.3	22.8	27.4
	125,000	5.7	8.6	11.4	17.1	22.8	28.6	34.3
	150,000	6.9	10.3	13.7	20.6	27.4	34.3	41.1
	175,000	8.0	12.0	16.0	24.0	32.0	40.0	48.0
	200,000	9.1	13.7	18.3	27.4	36.6	45.7	54.8
	225,000	10.3	15.4	20.6	30.8	41.1	51.4	61.7
	250,000	11.4	17.1	22.8	34.3	45.7	57.1	68.5
	275,000	12.6	18.9	25.1	37.7	50.3	62.8	75.4
	300,000	13.7	20.6	27.4	41.1	54.8	68.5	82.3
	325,000	14.9	22.3	29.7	44.6	59.4	74.3	89.1
	350,000	16.0	24.0	32.0	48.0	64.0	80.0	96.0
	375,000	17.1	25.7	34.3	51.4	68.5	85.7	102.8
	400,000	18.3	27.4	36.6	54.8	73.1	91.4	109.7
	425,000	19.4	29.1	38.8	58.3	77.7	97.1	116.5
	450,000	20.6	30.8	41.1	61.7	82.3	102.8	123.4
	475,000	21.7	32.6	43.4	65.1	86.8	108.5	130.2
	500,000	22.8	34.3	45.7	68.5	91.4	114.2	137.1
	525,000	24.0	36.0	48.0	72.0	96.0	120.0	144.0
550,000	25.1	37.7	50.3	75.4	100.5	125.7	150.8	
575,000	26.3	39.4	52.6	78.8	105.1	131.4	157.7	
600,000	27.4	41.1	54.8	82.3	109.7	137.1	164.5	

LEI’s permitting recommendations have been summarized in the following flow chart.



## BENEFICIARIES

Michigan's winery industry will benefit from the results of this study. Winemaking is a fast growing industry in the state of Michigan and continued environmental compliance is an essential component to the sustainability of the industry. In the past, many wineries expressed interest in proper management of the process wastewater, but the information was not available to them. The information provided in this report provides a knowledge base to the entire industry, in order to grow equally and sustainably.

## LESSONS LEARNED

The sampling frequency outlined in the grant proposal/agreement was decreased to bi-monthly sampling for wastewater and the lysimeters due to an increase in the overall study duration. Bi-monthly sampling continued through August 2014 and provided sufficient analytical data at each site to make the necessary conclusions. Sampling frequency was increased to monthly beginning in September 2014 and continued through the remainder of the study.

Winter data was limited due to improper protection and maintenance of the sampling equipment. LEI and the GTCD experienced some issues with the lysimeters freezing and/or breaking during the winter months.

Some lysimeter sampling events provided less than the required volume amount to analyze for the entire parameter list outlined in the grant proposal. Low sample volume is often an issue when using lysimeters to sample soil pore water. This is dependent on several factors during installation and has proven nearly unavoidable, though every effort was made to gather the greatest sample volume possible during each sampling event.

## CONTACT PERSON

Erin Gerber, Lakeshore Environmental, Inc.  
616-844-5050

## ADDITIONAL INFORMATION

Results from this study were presented at the 2015 Michigan Grape and Wine Conference on March 4, 2015. Additional information regarding this study is available by contacting Lakeshore Environmental, Inc.

Link to the Report and Attachments listed below at <http://www.lakeshoreenvironmental.com/wp-content/uploads/2015/07/Final-Report-Winery-Study-791N4300099-FINAL.pdf>

### **Attachment A**

Analytical Result Tables

### **Attachment B**

Reduction Summary of Key Analytical Parameters

### **Attachment C**

General information for Groundwater Discharge Permit Application,  
From Michigan DEQ

### **Attachment D**

Permitting Guidance Document for Michigan Wineries

## PROJECT TITLE - FINAL

### **Northwest Michigan Council of Governments – A Pilot Training Program for Northwest Michigan Winery Tasting Rooms**

## PROJECT SUMMARY

There is a need for an organized, credentialed training that teaches fundamentals of the wine and spirits trade to prepare winery tasting room candidates for jobs in Northwest Michigan. The wine industry is growing exponentially every year. To sell each unique product, tasting rooms are opening to support its commerce. Many hours are spent training candidates in our tasting rooms in the areas of wine fluency and alcohol management. The aim of this pilot program was to provide these necessary skills as a tool for these tasting room employees.

The purpose of this project was to increase the competitiveness of the wine grape industry in Michigan by developing an industry-recognized credential for wine tasting room staff and testing its effectiveness in Northern Michigan.

The pilot training program for Northwest Michigan Wine Tasting Rooms is an industry recognized credentialed program. The purpose was to increase the competitive advantage in our Northwest Michigan wine tasting rooms by delivering alcohol management training, wine sensory evaluation, and customer service skills to our employees. By doing so, this would elevate the customer experience and provide the foundation for the travelers, tourists, and patrons across the globe seeking the *Pure Michigan* experience.

## PROJECT APPROACH

Members of several Northwest Michigan wineries have determined the curriculum necessary to deliver on key points mentioned above. In return, graduates of the program received an industry-recognized credential that guarantees that they have successfully completed one or all of the following: alcohol management training, wine sensory evaluation training, and customer service training. The training curriculum will include three components: TAM, wine sensory evaluation, and customer service. Determination of the project's effectiveness will be tied to sales data and customer satisfaction.

- *The Project Oversight Committee* formed, coordinated the training, and took an active role in reviewing the winery tasting room manager/staff training, the post-training debriefing, the customer satisfaction evaluation project, finalizing the tasting room training objectives and content, and reviewing all materials prior to finalization. Project Oversight Committee Members include staff from the following Leelanau and Grand Traverse wineries: Chateau Chantal, Black Star Farms, Bel Lago, Left Foot Charley, and from the NWMCOG. The Steering Committee met monthly between October 2013-June 2014.
- *The Winery Tasting Room Staff Training* was attended by ten regional wineries, meeting the intended winery representation objective. Fifteen (15) wine tasting room staff from ten wineries participated in the two-day March training. All participants attended in the post-March training debriefing meeting held in May.
  - Four wine industry people participated in the Techniques for Alcohol Management (TAM) train the trainer program prior to the March 19<sup>th</sup> training event (two Steering Committee members; two additional industry staff members; one of the latter left the industry during this two year period. Three TAM educators currently remain).
  - In conjunction with the TAM training professionals, the two steering committee members co-taught the March 19<sup>th</sup> TAM training.

The two-day training curriculum offered participants exposure to Customer Experience, Sensory Evaluation, and Techniques for Alcohol Management training modules. All participants completed and passed the TAM post-training certification exam.

#### GOALS AND OUTCOMES ACHIEVED

- 500 Wine Vintage Michigan Incentive cards were secured through Michigan Grape & Wine Industry Council. The Wine Vintage cards offered wine tasting room customers an incentive for completing the survey.
- In total, 479 Customer Satisfaction Surveys were disseminated and completed on-site by 11 winery tasting rooms. Data was aggregated by site between June 2014 and March 2015. NWMCOG (Networks Northwest) collected and aggregated monthly on-site survey tallies.
  - According to Karel Bush, Promotion Specialist, the Michigan Grape & Wine Industry Council received 267 new Vintage Michigan member names from Grand Traverse and Leelanau Counties' participating wine tasting rooms. This number tripled the number of new members (70) resulting from the Vintage Michigan 2014 Christmas holiday campaign. (Vintage Michigan cards were offered to patrons completing the Customer Satisfaction Survey at the pilot winery tasting room sites.

More information provided below in "Additional Information".

Other Outcomes

- Project Awardee, The 2015 Governor's Awards for Innovative Tourism Collaboration

#### BENEFICIARIES

The beneficiaries from this pilot program are the Northwest Michigan wineries including Wineries of Old Mission Peninsula, the Leelanau Peninsula Vintners Association, and outlying wineries in Northwest Lower Michigan.

Wineries across Michigan now have curriculum, a Training Handbook, and customer service feedback data to review in their decision making regarding the value of winery room training for their own personnel. Northwest MI wineries participating in the project now have trained, knowledgeable staff in each tasting room to that understand and can exhibit safe practices, safe working environments, and quality customer experience.

The impact on the industry as a whole is an elevation of professional credibility, leading to long-term sustainable markets and increased demand for the specialty crop. Demand will spur growth and business opportunities for new and existing growers, distributors, retailers, and agri-tourism outlets.

#### LESSONS LEARNED

1. The customer satisfaction survey project offers the potential for future research on customer satisfaction and wine purchasing behavior among winery tasting room patrons:
  - Some indication that customers who enjoyed their interaction with a trained wine server were influenced to purchase bottles of wine.
2. Industry wide interest in the potential offered through winery tasting room staff training has occurred:
  - The Michigan Wine and Grape Council requested project coordinator Brian Lillie's participation as a panelist at their March 2015 annual conference. Brian discussed the pilot project training results and implications for Michigan Wine Industry.
  - The Michigan Wine and Grape Council supported our pilot project by offering Michigan Wine Vintage cards as an incentive to winery room customers to take the survey

## CONTACT PERSON

Brian Lillie, Director of Hospitality, Chateau Chantal Winery and B&B  
231-223-4110; BLillie@chateauchantal.com

Susan Cocciarelli, Networks Northwest, [cocciare@msu.edu](mailto:cocciare@msu.edu); 231-929-5096

## ADDITIONAL INFORMATION

Appendix A: Marketing to Winery Tasting Room Managers

### **Be a part of the most innovative training project in Michigan wine!**

**What:** The Northern Michigan Pilot Training Program is a developing program to institute an industry wide recognized credentialed program aimed at educating your current and future staff. A participant will learn alcohol management in TAM training, wine fluency in an on premise tasting training, and specialized customer service. This program is currently under development in collaboration with the Northwest Michigan Council of Governments, Wineries of Old Mission Peninsula and the Leelanau Peninsula Vintners Association with the support from the Michigan Grape and Wine Industry Council, and the Michigan Wine Foundation.

**Why:** Be a pioneer collaborating in an innovative training project in the Michigan wine industry *AND* earn a credential that will be recognized throughout the Michigan wine industry. Empower your employees to provide the best customer service in your tasting room while encouraging return patronage and increasing sales- safely.

**How:** FOR FREE!! ...For staff who meet the criteria below.

**Who:** The first 15 people who meet specific criteria:

1. Must be a leader in the tasting room.
2. Works as, or has the capacity to be, a trainer in the tasting room
3. Has access to winery-specific information to provide impact feedback
4. Willing to help determine training fair market value
5. Is available for approximately eight hours each for two days (see below)
6. Will take a test following the course

**Trainers and Modules:**

- Sue Radwan: *customer service module*
- Paul Gospodarczyk: *wine fluency module*
- Meridith Lauzon from Left Foot Charley, Kirstin Policastro, and Mike Dubois from Chateau Chantal: *Our newest Northern Michigan Wine Industry TAM Trainers*

**Training Dates:** Two Wednesdays in March 2014

Wednesday March 1<sup>st</sup> Customer Service (8 hours)

Wednesday March 19<sup>th</sup> TAM training (4 hours)

Wednesday March 19<sup>th</sup> Wine Fluency (4 hours)

Wednesday March 19<sup>th</sup> Comprehensive Review and Testing

May 2014 Program Success Follow Up Meeting

**Where:** Chateau Chantal March 12<sup>th</sup>

Black Star Farms Suttons Bay March 19<sup>th</sup>

Appendix A: Winery room Tasting Training – Participant Registration

### **The Northwest Michigan Wine Tasting Room Training Pilot 2014**

By completing this form, you are making a commitment to participate in a pilot program, funded through USDA Specialty Crop Block Grant dollars, to build a quality staff-training

program for wineries in Northwest Michigan. Below is a brief overview of the project, what your winery can expect by participating in the project, what the project expects of you as a participant, the training components, and time commitments. On the last page is the participation commitment.

#### Project Description

Based on demonstrated need and support for an organized, credentialed training program that teaches wine-tasting room staff fundamentals of the wine and spirits trade, several wineries representing Northwest Michigan have come together to offer a pilot training program to elevate winery staff wine fluency and alcohol management skills.

The ultimate goal of the project is an industry recognized credentialed program. The purpose is to increase the competitive advantage in our Northwest Michigan wine tasting rooms by delivering alcohol management training, wine sensory evaluation, and customer service skills to our employees. By doing so, we expect to elevate the customer experience and provide "brand recognition", a foundational experience for the travelers, tourists, and patrons across the globe seeking the Pure Michigan experience. The training curriculum offers staff a credential that guarantees that they have successfully completed all of the following: alcohol management training, wine sensory evaluation training, and customer service training.

#### Mutual Project Expectations

*What your winery can expect from project:*

- 1) Training in three important areas: wine fluency and sensory evaluation, alcohol management, customer service
- 2) A TAM certification
- 3) Recognition as a pilot participant

*What project expects from winery:*

- 1) Feedback regarding the success of the pilot training program
- 2) Help the committee determine successfulness of the program by issuing surveys at your place of business and collecting quality feedback from patrons pertaining to the implementation of the pilot modules.
- 3) Offering quality feedback from the impact of your business in the means of increased percentage sales, reduction in costs (labor or other), and other predicted or unforeseen impacts your business felt from this pilot training implementation.

#### Training Components and Time Commitments

*Training- online session:*

Wine Fluency "Welcome to Wine" (online at your own pace to be completed by March 19th) [www.todayswineprofessional.com](http://www.todayswineprofessional.com) (five to ten hours)

*Training- Classroom Sessions:*

Wednesday March 12th Customer Service (eight hours) Chateau Chantal Winery

Wednesday March 19th Wine sensory evaluation (four hours) and TAM training (four Hours)

Black Star Farms

Evaluation: May 2014 Program Success Follow Up Meeting- Date to be Determined

May through October 2014 tasting room measurement success surveys conducted in tasting rooms

#### Project Participation Agreement

Business

Name:

Participant

Name

Owner/General Manager

Signature: \_\_\_\_\_

Please initial the following:

\_\_\_\_\_ I acknowledge and agree that this pilot program is truly a benefit to our industry and will provide in depth consideration and feedback for the fine tuning of the curriculum and program efficiency.

\_\_\_\_\_ I understand that I will receive training in the areas of wine fluency on Wednesday March 19th, alcohol management on Wednesday March 19th, and customer service on Wednesday March 12th.

\_\_\_\_\_ I understand that I will be tested on what I have learned in order to receive a credential and provide substantial data on the program direction.

\_\_\_\_\_ I will take measurements in the means of surveys that the committee has predetermined beneficial for their purpose after the classes at my business to help the committee determine the success of the program.

\_\_\_\_\_ I will report to the committee on the winery owner's/General Manager on his/her perception of the program's success.

\_\_\_\_\_ I will attend a follow up meeting in May to share my thoughts with the committee.

Participant's Signature \_\_\_\_\_

Date: \_\_\_\_\_

## Appendix B: Training Overview and Agenda

### Northwest MI Winery Tasting Room Pilot Staff Training March 12 and March 19, 2014

#### Project Overview and Training Agenda

First, thanks to all of you for agreeing to help our regional and state's industry in creating this one-of-a-kind training program for tasting room staff. This is surely one of the reasons why we are one of the best industries in the nation- because of people like all of you! We expect great things to come of this and we couldn't do it without all of you Pilot Training Participants (PTPers;) Now... let's make history!

This is an exciting time for us as we determine a curriculum that is sure to benefit our industry. This week you will receive a pre-requisite online program link from Today's Wine Professional that is part of the pilot. It is a recommended time period of five to ten hours to complete. For some of us it could take longer, but my guess is since we are all experienced it could take less time. Please complete this by March 19th.

#### Two-Day Training Agenda

**March 12th** is at Chateau Chantal. Please be there at *Bam* for things to start promptly at 8:30am. You will receive instruction on how we will conduct the measurement period throughout the season and what you can expect for the remainder of the pilot. At 9am Sue Radwan from Leading Edge Mentoring will conduct her customer service training until 4pm with a short break for lunch. Chateau Chantal will provide a light pasta lunch for those interested with some iced tea and coffee. Please do not leave the facility during this time so we can stay on time.

**March 19th** is at Black Star Farms. There are two, four-hour sessions here. The first is the Wine Sensory Evaluation with Paul Gospodarczyk at 9am. Eat some breakfast so you can make it through the entire day. A short break will follow for lunch. Following lunch is

the Techniques of Alcohol Management Training (TAM training) conducted by our region's newest TAM trainers and observation from David Puck of the MLBA.

**May 28th** is the date scheduled for our post-training debriefing. Prior to that meeting, you will receive a post-training survey to complete. During the May 28th meeting, we will review your survey comments, discuss the Customer Experience Training Handbook content with Sue Radwan, revise and finalized the draft Customer Satisfaction Survey, and determine the methodology for the survey's dissemination between June and October, 2014, including how the survey will be disseminated at each winery, who takes responsibility for aggregating site data, and how data will be aggregated by the NWMCOG. If there are any questions please do not hesitate to contact me. Email is the best option at this time.

Looking forward to moving forward!  
Brian Lille- blille@chateauchantalwinery.com

#### Appendix C: Customer Experience Handbook and Trainer Guide (Cover)

#### Appendix D: Customer Satisfaction Survey Template

How was your overall experience in our Tasting Room today? (Circle One)

- 1- Glorious! I will be back to buy more wine... with friends!
- 2- I had a good time and bought some wine while doing it.
- 3- I'm indifferent- didn't have a good or bad time.
- 4- It was just "okay."
- 5- I am worse off now than when I started.

Please rate your experience with the wine tasting room staff person (s):

Did your knowledge of wine improve as a result of your interaction with the wine tasting room server today?

- A) Very Much
- B) Somewhat
- C) Neutral
- D) Slightly
- E) Not at all

Did your experience improve as a result of learning about different wines' aroma, tasting, and other sensory features?

- A) Very Much
- B) Somewhat
- C) Neutral
- D) Slightly
- E) Not at all

How many bottles did you purchase? a)1-3 b)4-6 c)7-12 d)12+ e)none

As a result of your experience today, would you refer your friends or others to this tasting room? 1-Yes 2-No

Other comment(s):

Appendix E: Data Aggregate

Northwest MI Winery Tasting Room Customer Satisfaction Survey  
Data Collection June 2014- March 2015

Winery: June	Blackstar; 45th North; Bel Lago; LFC; Northern Naturals								
Winery: July	Verterra; LFC; 45 North; Blackstar; Northern Naturals; Bel Lago								
Winery: August	Chateau Chantal; Blackstar Farms; Left Foot Charley;								
Winery: September	45th North; Chateau Chantal; Bel Lago (Aug/Sept); Douglas Valley								
Winery: October	Bowers Harbor; Veterra								
Winery: Feb-March	Bonobo								
Number of surveys reported: 479 surveys completed; 11 Wineries; two counties									
Survey Questions	Select ion Option	Monthly Response Totals						Total Responses	% per response
		June Total	July Total	Aug Total	Sept Total	Oct Total	Feb-Mar 2015		
<b>How was your overall experience in our Tasting Room today?</b>	1	102	86	44	58	26	47	363	76%
	2	22	20	16	20	14	18	110	23%
	3	1			1	1		3	0%
	4								
	5								
<b>Sub total</b>		125	106	60	79	41	65	476	
<b>Please rate your experience with the wine tasting room staff</b>	A	99	84	48	57	24	36	348	76%
	B	20	17	12	22	14	19	104	22%
	C	6	5			3	10	24	2%
	D						1	1	
	E								
<b>Sub-total</b>		125	106	60	79	41	66	477	
<b>Did your experience improve as a result of learning about different wines' aroma, tasting, and other sensory</b>	A	95	78	41	53	20	32	319	67%
	B	25	23	18	25	19	23	133	28%
	C	5	4		1	2	8	20	4%
	D						1	1	
	E		1	1					2
<b>Sub-total</b>		125	106	60	79	41	64	475	
<b>How many bottles did you purchase?</b>	A	21	17	6	13	2	21	80	17%
	B	74	62	48	46	22	43	295	62%
	C	18	17	3	10	8	4	60	12%
	D	5	1	1	2	3		12	2.00%

	E	7	9	2	8	6		32	6%
<b>Sub-total</b>		125	106	60	79	41	68	479	
<b>As a result of your experience today would</b>	1	123	106	59	79	41	54	46	96%
	2	0	0	0	0				
	NR	2	0	1	0		14	17	4%
Subtotal		125	106					479	
<b>Total Surveys</b>		125	106	60	79	22	68	47	

Appendix F: Northwest Michigan wine Tasting Room Customer Satisfaction Survey Summary June 1, 2015

Leelanau County and Grand Traverse County wineries participated in the Northwest Michigan Winery Tasting Room staff training and post-training customer satisfaction survey project. Four hundred sixty (479) customer satisfaction surveys were disseminated and completed between June 2014-March 2015.

- Eleven (11) wineries representing Leelanau and Grand Traverse Counties wineries submitted customer survey feedback data\*
- Surveys were distributed to customers whose winery tasting room server attended training
- 479 surveys were distributed and collected:
  - 76% of all respondents described their tasting experience as "*Glorious! I will be back to buy more wine ... with friends!*"
  - 76% of respondents determined their *wine knowledge* improved "very much" as a result of interacting with their wine server
  - 67% of respondents felt their *sensory experience* improved as a result of tasting wine
  - 93% of customers interacting with the trained wine server purchased at least one bottle of wine
    - 62% of respondents purchased between four-six bottles of wine as a result of their wine tasting experience; 17% purchased between one-three bottles; 12% purchased between 7-12 bottles; 2% purchased more than 12 bottles
  - 96% responded that, as a result of their wine tasting experience, they would refer friends or others to the winery

\*Leelanau County:

Grand Traverse County:

Bel Lago; Black Star Farms; 45 North; Verterra  
 Chateau Chantal; Douglas Valley; Left Foot Charley; Northern  
 Naturals; Bowers Harbor; Bonobo

# wine tasting room

Server Handbook



## PROJECT TITLE - FINAL

**Michigan Food and Farming Systems MIFFS** – Expanding Sales Connections and Food Safety Expectations between Producers and Buyers of Regional Specialty Crops

## PROJECT SUMMARY

The purpose of this project was to build the capacity of smaller-scale Michigan farmers (under 100 acres, majority under 20) to increase marketing and food safety literacy and practices in order to be competitive in selling to larger volume specialty crop buyers. The importance of this work was elevated by recent developments around the Food Safety Modernization Act and corresponding pressure from buyers and insurance companies that require farms of any size to have a farm food safety plan in place. A portion of our project was devoted to investigating a group certificate as a scale-neutral way to make food safety certification attainable and more cost effective to even the smallest of farms.

Laying the groundwork for the project, we intended to identify and document specialty crop buyers' sales and food safety expectations for individual and farm groups, then use that input to:

- Provide sales techniques and tools to specialty crop producers at workshops prior to “meet the buyers” events and facilitate additional opportunities for producers and buyers to connect by developing a Meet the Buyer Manual and by hosting regional meet and greet events.
- Conduct a pilot using a group approach to implement, test, review, and document a quality management system (QMS) to certify a minimum of 15 Michigan smaller-scale growers at an entry-level Good Agricultural Practices (GAP) food safety standard

A by-product of our project activities is the production and dissemination of operational manuals for three target audiences: organizations who desire to connect growers and buyers, certifying agencies who wish to use a group approach for Gap certification, and small growers who need a cost effective and customizable farm food safety plan.

This project builds on previously funded projects with the SCBGP, which was used to launch the first Meet the Buyer event. Over the years, we discovered that producers who want to establish new relationships with buyers overwhelmingly approve this event and their efforts were rewarded by increased sales, however, they lacked the skills necessary to approach buyers directly. Additionally, we recognized that Gap certification for small growers is a barrier and that a coordinated approach (Group Gap) could be tested and recommended for approval by USDA.

## PROJECT APPROACH

Approximately 400 industry representatives attended “Meet the Buyer” at Great Lakes EXPO (GLEXP) to establish and strengthen connections between producers and buyers. One fifth of producers indicated that they increased their sales by 6% or more and almost half of the producers meet three-five buyers that they could not have done without this event. To meet the demand for this type of programming, MIFFS developed a Meet the Buyer Operational Manual.

Five introductory sales workshops were conducted around the state at different venues to better prepare growers to approach buyers of specialty crops. Producer response to this new approach was overwhelming positive, including comments such as, “*I would attend another sales workshop*”, and “*Have again next year.*” Workshop participants who also attended Meet the Buyers noted that “increasing my comfort level when talking to buyers” was the most helpful aspect. Significant contributions from project partners included the Michigan Vegetable Council, Michigan Food Hub Network, Great Lakes Fruit, Vegetable & Farm Market Expo (Great Lakes

EXPO) and Michigan Department of Agriculture and Rural Development MDARD for event promotion, and The Learning Connection for design and delivery of the sales workshop.

At the conclusion of the Group Gap Pilot, 10 farms received USDA GAP/GHP certification for the 2014/2015 season. The U.P. Food Exchange (UPFE) and Michigan State University Center for Regional Food Systems (MSU-CRFS) led this project in conjunction with a larger pilot study being conducted nationwide by USDA-AMS and the Wallace Center, both of whom provided additional support. The Marquette Food Co-op and UPFE are providing ongoing education, and a statewide Group GAP working group has been formed.

## GOALS AND OUTCOMES ACHIEVED

### **Objective 1: Specialty crop producers will receive training on sales techniques and tools at Great Lakes EXPO and two regional events.**

GOAL: To increase the number of specialty crop producers that can sell their products' value and build food safety trust with buyers.

TARGET: 75 percent of the participants will report that their sales acumen and relationship building within the sales encounter increased as a result of these workshops.

BENCHMARK: No established baseline on number of producers with sales expertise.

PERFORMANCE MEASURE: At each "Meet the Buyer" event we will conduct a sales workshop and solicit up to ten growers per workshop to agree to give feedback in a follow-up workshop setting or a post event survey.

### **STATUS: Completed; Exceeded performance target.**

Outcomes:

Outcome A: "How to Make a Lasting First Impression" sales workshop delivered to 110 growers at Great Lakes EXPO (GLEXP) on December 10, 2013, One buyer was in the audience. From the post workshop evaluation, we learned that 89% of the participants "have a greater understanding of the sales processes". Approximately 85% of the participants feel that they are "better prepared to approach buyers of specialty crops" as a result of this workshop. Nearly 75% of the participants ranked the overall value of this workshop as above average and 91% said they "would attend another sales workshop". One half (12 of 24) of participants in the subsequent Meet the Buyer event at Great Lakes EXPO who had attended this workshop responded that "increasing my comfort level when talking to buyers" was the most helpful aspect of the workshop to them.

Outcome B: One "How to Make a Lasting First Impression" sales workshop delivered at regional event (Michigan Family Farms Conference) on January 16, 2014. Attendance at this event included 19 growers;

Outcome C: Two abbreviated "How to Make a Lasting First Impression" sales workshops were delivered in conjunction with the Eastern Market Vendors Meetings on February 18 and February 25, 2014, to approximately 60 vendors and buyers in attendance.

Outcome D: One "How to Make a Lasting First Impression" sales workshop was delivered at the Everybody Eats Conference in Lansing on February 8, 2014, with approximately 25 people in attendance.

### **Objective 2: Approximately 450 producers will attend three "Meet the Buyer" events and 25 buyer organizations will attend one of these events.**

**OVERALL GOAL:** Provide a forum for specialty crop producers that will enable them to sell more or enhance their sales of Michigan specialty crops to the buyer organizations by increasing value and trust.

**PERFORMANCE MEASURE:** Expand the “Meet the Buyers” model, adapt it to two regional events, and assess with the conference coordinators the new populations serviced, as well as solicit feedback from attendees. Feedback will inform the development of the operational guide and help decisions for further expansion/support in 2014.

**BENCHMARK/BASELINE DATA:**

- 50% of buyers indicated that over the past five years they've had an increase of 6-10% in expenditures of MI fruits and vegetables (2011)
- 50% of buyers expect to increase the number of MI fruit and vegetable producers with whom they do business (2011)
- 13% of producers increased their sale of produce to buyer institutions by 1-7% (2011).

**TARGETS:**

- 450 specialty crop producers in total attendance
- 25 buyer organizations at Great Lakes EXPO
- 75% of specialty crop producers enhance their relationship with buyers
- 85% of buyers will endorse expansion of Meet the Buyers model at regional events

**STATUS: Completed; exceeded performance targets.**

**Outcomes:**

**Outcome A:** Approximately 340 growers and 67 buyer representatives attended this event. Feedback was collected post event from growers via a Dot Survey as they exited and included the following:

- Nearly 50% of producers attended for the first-time. This is a trend that has been repeated annually, indicating that producers may be using this venue to meet buyers and establish relationships.
- After attending this event in 2012, 20% of producers indicated that they increased their sales by 6% or more.
- With over 35% of producers meeting three-five buyers, we can generally say that this is an effective venue for producers to enhance their relationships with buyers.

**Outcome B:** Two Meet & Greet opportunities were facilitated by MIFFS in conjunction with Eastern Markets Vendor Meetings on February 18 and February 25, 2014, to approximately 60 total participants.

**Objective 3. A “Meet the Buyer” Basic Operational Guide, including a sales tool appendix, will be disseminated to the MIFFS listserv (200 subscribers), Meet the Buyer mailing list (700 subscribers), e-newsletter list (381 subscribers), farmers market listserv (918 subscribers) and any planning teams associated with agri-food related conferences.**

**GOAL:** Make an operational guide and sales tools available to the smaller-scale, specialty crop industry.

**TARGET:** The “Meet the Buyer” Basic Operational Guide will be accessed at least 50 times through website “hits” and/or calls into the MIFFS office for support.

**BENCHMARK:** There is no benchmark established- this is a new product.

**PERFORMANCE MEASURE:** Use Google Analytics to track the number of visits to the MIFFS website and document calls, as well as requests for additional event support.

**MONITORING** the number of specialty crop producers and conference coordinators who search for more sales support and training and who identify these skills as critical to their development of profitable businesses.

**STATUS: Completed with modifications. A new process has been identified to ensure that groups access the guide and improve the model through practical application.**

Outcomes:

Outcome A: The Operational Guide has been posted on MIFFS website, but Google Analytics has not been useful in tracking downloads and actual use. On the positive side, MIFFS is fielding requests from users to provide coaching in the use of the manual and orchestrating an event. The sales tool has been shared with numerous organizations and is available upon request.

#### **Objective 4. Upper Peninsula group food safety pilot**

GOAL: Build capacity of Michigan smaller-scale specialty crop farmers to use a group approach to develop a quality management system in order to meet evolving food safety standards.

BENCHMARK: There is no benchmark established.

PERFORMANCE MEASURE: Quality Management System Manual, records collected on costs, time committed, processes, and case study publication and workshop evaluations at Michigan Family Farms Conference (MFFC).

TARGET: 15 Michigan UP smaller-scale farmers will use a robust quality management system to certify to GAP entry-level standards. Six participants will share their experiences at the MFFC and 25% of buyer in attendance will explore group gap as an option.

Useful Definitions that defined the project approach:

##### **1. What is Group GAP?**

Group GAP is a group of partners working together to achieve a collective Good Agricultural Practices (GAP) certification. These partners can be farmers, buyers, distributors, food hubs, local non-profits, etc. The concept is that a group provides internal verification that it's members is meeting GAP standards by performing internal inspections. These activities are managed through a Quality Management System (QMS). The USDA then audits a statistical sample of the members, and also audits the group's QMS. If the sample is good and the system is good, that provides the USDA enough confidence to issue a group certification.

##### **2. What is a QMS?**

A QMS is a system of interrelated processes designed to identify and gather customer inputs and deliver a product or service that meets them in a consistent, continuously improving way. For the USDA Group GAP program, it must be built on ISO 9001 or an equivalent standard. This is the tool that allows the USDA to issue a group certification without physically visiting each member. Manufacturers have been using QMS to deliver a consistent, verified output for decades. Group GAP adopts those same principles and applies them to food safety monitoring. Globally, more farms are GAP certified in groups than as individuals. Using a systems approach to food safety, Group GAP develops a culture of food safety that will promote wide adoption of food safety standards.

##### **3. Why Group GAP?**

Most things in life are better when done as a collaborative effort. Only a sampling of members goes through a USDA audit, and the cost burden is shared by the group, so this method certainly has the potential to be more cost-effective than an individual certification. The real benefit, however, comes from the interactions within the group, the sharing of knowledge and experience, and the technical assistance available to each member by their participation. Rather than striving to comply with a baseline standard, the members of the group can learn from each other and continuously improve their compliance.

**STATUS: Completed with modifications; the total number of farm who were GAP certified was less than expected, but all buyers have embraced the group approach.**

Outcome A: Eight representatives from the Group Gap Pilot led a discussion and project summary at the MFFC.

Participant feedback indicated an increased understanding of the pros and cons, the resources required to duplicate the model, and the value of this approach. No buyers were in attendance (See Lessons Learned).

Outcome B: UPFE completed a group food safety certification pilot with ten farms receiving USDA GAP/GHP certification in 2014 for the 2014/2015 season

A useful summary of the UPFE Group GAP Pilot Study project phases:

*16 farms started as part of the group in April*

- Development of Quality Management System (QMS) (2013-2014)
- Development of Farm Food Safety Manual by UPFE Management Team (March-April 2014)
- Internal Inspector Training by USDA (April 2014)
- Farmer Training by MSU Extension & UPFE Management Team (April 2014)
- Gap Analysis Visits to Participating Farms (June & July)

*4 farms left the group at this point*

- Pre-Official Internal Inspection Check-In Phone Call With Farms
- Internal Farm Inspections (end of July – early September)

*2 farms left the group at this point*

- USDA Audit of four farms in our group (early September)
- Internal QMS (quality management system) Audit (end of September)
- USDA QMS Audit (early October)
- Unannounced Surveillance visits to farms that include verification of corrective actions if applicable (mid-September – beginning of October)

*Debriefing with farms, internal inspectors, state auditor (November) resulting in certification*

Outcome C: UPFE completed a Quality Manual to oversee group Gap activities and requirements. Outcome D: Farms in the Group Gap pilot operationalized their food safety knowledge and skills into a Food Safety Manual for on-farm use. The template will be available to other growers.

### **Objective 5. Food Safety Case Study publication and engagement of MI Specialty Crop Buyers**

GOAL: Publish UP group food safety case study and use learning's to discuss and review food buyer concerns, opportunities, interest and questions with a group quality management system established to allow groups of small growers to meet evolving food safety standards. Conduct outreach on food safety.

BENCHMARK: There is no benchmark established.

PERFORMANCE MEASURE: Surveys, interviews.

TARGET: More than 500 pdf downloads of the case study publication on the Center for Regional Food Systems (CRFS) and MSU Extension web site. Seventy-five Michigan and regional buyers will be asked to respond with their level of interest and comfort, concerns, and questions regarding a robust quality management system for group food safety certification that is sound enough to help smaller-scale growers meet more stringent food safety standards if required by established rules in the Food Safety Modernization Act.

### **STATUS: In Progress.**

Representatives from buyers, including Cherry Capital Foods, Kroger, Whole Foods, GFS and Eastern Market participated in a telephone survey to help MIFFS gain a better understanding of 1) internal food safety practices, 2) degree of familiarity with the term, "Group Gap", and 3) overall

desire to learn more about Group Gap and Quality Management Systems for producers. Beyond that initial attempt to engage buyers in the development of a QMS, their lack of participation seems to indicate that they have high trust in the ability of MIFFS to eliminate food safety barriers for all parties involved.

The Case Study will be available via the CRFS website and feedback will be collected using the Farm to Institution Network.

A new statewide Group GAP working group is developing strategies for sharing information and processes with groups of farmers throughout the state, based on the learnings in the UP.

### **OVERALL STATUS:**

In comparing actual accomplishments to date with goals established, MIFFS either met or exceeded many of their performance targets, and in some cases, modified the outcome as lessons were learned in the process of administering the grant activities. Several of their activities, such as the Group Gap pilot, will result in long term impacts for specialty crop producers.

### **BENEFICIARIES**

- Approximately 340 growers met buyers to establish or strengthen relationships.
- Approximately 75 buyer representatives engaged growers in critical discussions about purchasing needs, food safety concerns and Group Gap certification.
- Over 200 growers learned new skills to improve their sales acumen and relationship building within the sales encounter.
- In the Upper Peninsula, 10 farms received USDA GAP/GHP certification via a group approach.
- Approximately 30 participants learned about Group Gap Certification at the Michigan Family Farms Conference
- An unknown number of specialty crop producers and buyers will benefit from the Group Gap pilot that clearly defines the coordination and resources required to utilize this cost-effective approach. Collaborating entities such as the Wallace Center, MSU-CRFS, USDA and MDARD are also beneficiaries of this successful pilot.

### **LESSONS LEARNED**

- The newly published [Meet the Buyer Operational Guide](#) is not sufficient as a standalone piece. In addition to the manual, many local, regional and state-wide organizations, conference coordinators, cooperatives, and others are requesting assistance in conducting their own events. Each of these entities could potentially take the lead in organizing events and expanding the model, which equates to an increased number of buyer seller relationships in the specialty crop industry.
- Invite buyers to the “How to Make a Lasting Impression” sales skills workshops, modify each program to fit the venue and audience, and include interactive activities for sharing and capturing the knowledge in the room.
- Identify alternate methods for collecting buyer sales data from Meet the Buyer events. Although we assume that stronger relationships lead to increased sales transactions between producers and buyers, the annual post event survey data for buyers has not been sufficient enough to make a direct correlation. Even with confidentiality statements, new methods may need to be considered. The buyer survey questions are an important aspect of the Operational Guide but users need to set realistic expectations and adhere to strict guidelines on how and when to administer the questionnaire.
- Group GAP is one option for getting farms certified that would otherwise struggle on their own. This certification process appears to be scalable and doable for small and very small

farms, as long as there is additional support of a coordinating/backbone administrative organization. However, that coordinating organization will have to invest substantial resources in the QMS and overall coordination efforts.

- Completing a Group Gap process together resulted in several unintended benefits to farmers, including 1) increased knowledge of business and production management techniques, 2) access to larger markets, such as institutions, 3) coaching through a first audit, 4) peer support, and 5) increased likelihood that they will pass their first audit.
- Farms dropped out of the Group Gap process because of time constraints, perception of costs, wrong expectations, or because they didn't see the potential market growth opportunities. Going forward, it's important for a coordinating agency to address the question, "Why is it for me?" when engaging farms that are currently exempt from food safety standards. One strategy would be to include buyer or end user requirements, the ease of incorporating food safety practices into Standard Operating Procedures from start-up, and the built in coaching and support mechanisms.
- Group Gap is about creating a culture of food safety, not just a food safety program.

MIFFS and the project collaborators wrongly assumed that buyers would be concerned about the conditions and particulars surrounding Group Gap Certification and would want to be kept informed and involved throughout the process, but this was not the case. This trend could potentially indicate a high level of buyer trust in established food safety programs overall. There may be some trust as well in the organizations involved in this pilot, including UPFE, MSU-CRFS, MDARD, USDA, and MIFFS.

#### CONTACT PERSON

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#### ADDITIONAL INFORMATION

Links – [Food safety | Michigan Food and Farming Systems](#)

[http://www.miffs.org/services/food\\_safety](http://www.miffs.org/services/food_safety)

[Meet the Buyers | Michigan Food and Farming Systems](#)

[http://www.miffs.org/events/meet\\_the\\_buyers](http://www.miffs.org/events/meet_the_buyers)

- MIFFS Meet the Buyer Guide
- UPFE Food Safety Manual (template)
- QM-01 Quality Manual (for Growers)
- U.P. Food Exchange Group GAP Pilot Study: Group GAP as an Alternative to Individual Certification (Project Summary)  
Group Gap Farmer promotional flyer

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## Quality Manual for Growers:

### 1. Purpose

- 1.1. This document exists to define the UP Food Exchange's approach to quality, by identifying requirements, planning for their fulfillment, monitoring and measuring customer satisfaction, and continuously improving effectiveness.

## 2. Scope

2.1. This document applies to the UP Food Exchange Group GAP Certification program. Current participating growers are listed in F-012, as well as on the UP Food Exchange website.

## 3. Responsibility

3.1. All UPFE personnel with roles that affect product quality are required to understand and follow this document.

3.2. The QMS Lead is responsible for revision of this document.

## 4. Quality Policy

4.1. The UP Food Exchange is committed to helping our farm partners achieve USDA GAP/GHP certification, and beyond. To accomplish this, we have adopted a quality management system, organized according to ISO 9001, as our primary tool. We are committed to unceasing improvement of its effectiveness.

## 5. Quality Objectives

5.1. Following our Quality Policy, the Quality Objectives of the UP Food Exchange are as follows:

5.1.1. 80% of UPFE farms to be USDA GAP/GHP certified.

5.1.2. Farms are USDA GAP/GHP certified within two years of selling through UPFE.

5.1.3. Measurable cost-savings are recognized by farms that participate in the Group GAP model, vs individual certification.

## 6. Document Requirements

6.1. Listed in F-001

## 7. UPFE QMS Model



## 8. "Customer" Defined

8.1. There are several "customers" that are involved in this process. The list below, while not exhaustive, does define the primary customers and their requirements.

8.2. United States Department of Agriculture

8.2.1. The USDA provides regulatory requirements in the form of the USDA Good Agricultural Practices (GAP) audit. The records provided by the UPFE QMS are used as evidence of conformity to the USDA GAP/GHP requirements, without which participating farms would not achieve certification.

8.2.2. USDA GAP/GHP program information can be found here:

<http://www.ams.usda.gov/AMSV1.0/HarmonizedGAP>.

8.3. Farm Partners

- 8.3.1. Farm partners receive USDA Group GAP/GHP certification by their participation, pending successful internal, and potential external, inspection results.
- 8.3.2. Participation is increasingly worthwhile if the cost per farm in time and dollars is less than pursuing individual certification.
- 8.3.3. Farm Partners also receive technical and community of practice support by their participation.

#### 8.4. Consumers

- 8.4.1. Consumers are increasingly taking interest in where and how their food is produced. Helping local farms achieve USDA GAP/GHP certification builds consumer confidence in the local food system.

### 9. Management Responsibility

#### 9.1. Top Management consists of the following roles:

- 9.1.1. Project Co-Lead – Responsible for communication and organization between management, customers, and other affected parties.
- 9.1.2. Documents Coordinator - Responsible for organization, storage, and distribution of controlled documents and records.
- 9.1.3. QMS Lead (Management Representative) – Responsible for implementation and maintenance of the QMS.

#### 9.2. Management Reviews are held twice a year. The content of the review determined by form F-011. Part of this review is a reevaluation of customer requirements and satisfaction, which serves as a measurement of the Quality Management System's effectiveness. Areas needing improvement are identified, and resources are allocated appropriately to ensure that effectiveness is continuously improving.

### 10. Resource Management

#### 10.1. Review of resources is a component of Management Review. During this process, resources are reviewed to ensure they are adequate to meet our customers' requirements, as well as formulating plans, as necessary, to acquire needed resources. These resources may be, but are not limited to the following: personnel, technical assistance, technology, workspace, office materials.

#### 10.2. Core Competency Requirements, by role:

##### 10.2.1. Project Co-Lead

- Knowledge of and experience with local, state and federal food safety regulations
- Currently serving in a position with established connections to potential Group GAP farms
- Complete food safety training and participate in related continuing education
- Attend USDA Internal Inspector training and maintain USDA Internal Inspector status
- Familiarity with UPFE's Group GAP/GHP On-Farm Food Safety Manual

##### 10.2.2. Documents Coordinator

- Complete food safety training
- Attend USDA Internal Inspector training within the last three years and maintain Internal Inspector status
- Familiarity with UPFE's Group GAP/GHP On-Farm Food Safety Manual

##### 10.2.3. QMS Lead

- Two years' experience working in a quality system-related role.
- Comprehensive understanding of an ISO 9001 quality management system, preferably formal training.
- Attended USDA Internal Inspector training within the last three years.

##### 10.2.4. Internal QMS Auditor

- Two years' experience auditing an ISO 9001 or equivalent quality management system, preferably in a service-related industry.

10.2.5. Internal Inspector

- Possess the following qualities: ethical, open-minded, diplomatic, observant, perceptive, versatile, tenacious, decisive, self-reliant, acts with fortitude, open to improvement, culturally sensitive, and collaborative.
- Demonstrate effective verbal and written communication skills
- Hold a high school diploma or equivalent
- Possess a combination of post-high school education and/or work experience in fields related to agriculture (farm experience, food processing, marketing, etc.), quality assurance, process or systems auditing, or laboratory testing.
- Successfully complete courses on basic auditing and GAP/GHP auditor training
- Maintain qualification by participating in Group GAP internal inspections on an annual basis
- Complete at least 20 hours/year of continuing professional development credits

10.2.6. Food Safety Educator/Trainer

- Have extensive experience (at least 3-5 years) in teaching on-farm food safety practices
- Comprehensive understanding of Good Agricultural or Manufacturing Practices including water, manure/biosolids, worker health and hygiene, sanitary facilities, field sanitation, packing facility sanitation and/or transportation issues.
- Maintain affiliation with a recognized organization working in on-farm food safety

10.3. Evidence that UPFE personnel have met the core competency requirements should be recorded in training files. Such evidence should include a minimum of the following:

10.3.1. Resume (including education and experience)

10.3.2. Proof of food safety and auditor course completion

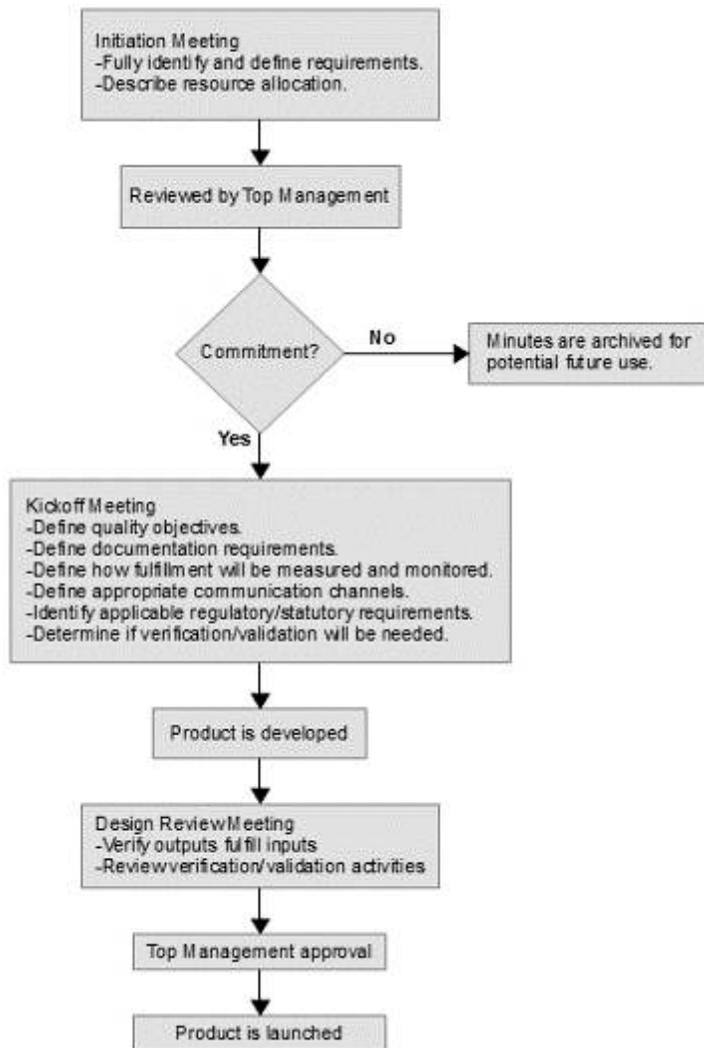
10.3.3. Proof of completion of continuing professional development credits (for ongoing participation)

10.3.4. Confidential Disclosure Agreement (F-014) and Internal Inspector Ethics Form (F-015) completed and signed

## 11. Product Realization

11.1. Customer requirements are defined in section 8.

11.2. If new customer requirements are identified or communicated, the following process is taken to ensure they are fulfilled:



11.3. Meeting minutes are kept according to QM-03.

11.4. Reviews of Outputs to Inputs and Verification/Validation activities are recorded on F-013.

## 12. Measurement, Analysis, Improvement

12.1. Primary methods of measurement, analysis, and improvement are described in QM-05, QM-06, and QM-07. Records of these activities are reviewed during Management Review.

12.2. Additionally, feedback from customers in the form of written and verbal communication, complaints, survey answers, etc. is reviewed quarterly by Top Management. Top Management then decides whether Corrective and/or Preventative Action shall be taken. Records of these meetings, as well as decisions made, are kept per QM-03.

12.3. These systems, as well as their further review by Top Management, serve as an ongoing assessment of existing and potential risks.

## 13. Exclusions

13.1. The following requirements do not apply to the UP Food Exchange's activities:

13.1.1. Control of Customer Property – The UP Food Exchange does not currently manage any customer property.

13.1.2. Verification and Validation of Food Safety Control Measures – the UP Food Exchange does not have any Food Safety Control Measures (i.e. temperature controls, etc.) in place.

**14. Outsourced Processes**

- 14.1. Outsourced processes are controlled by establishing clearly defined requirements and verifying that those requirements have been fulfilled.
- 14.2. The processes that UPFE currently outsources are the internal audit and GAP/GHP training for farmers. The requirements for these processes are established in section 10 for core competency. QM-05 outlines the internal audit process and F-007 is used for the final internal audit report.

**15. Revision History**

15.1.

Revision	Date	Description
1	06/17/2014	Initial Release of Document
2	12/10/2014	Updates to section 10, 11, added sections 13 and 14

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Revised 1.12.15

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## U.P. Food Exchange

### Western Food Hub

Coordinated by Western U.P. Health Department



Aggregation Site: To Be Determined

### Central Food Hub

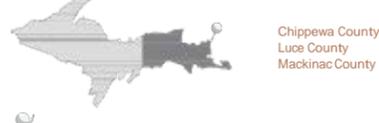
Coordinated by Marquette Food Co-op



Aggregation Site: Marquette Food Co-op

### Eastern Food Hub

Coordinated by Michigan State University Extension



Aggregation Site: Harmony Health Foods

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### Central Region

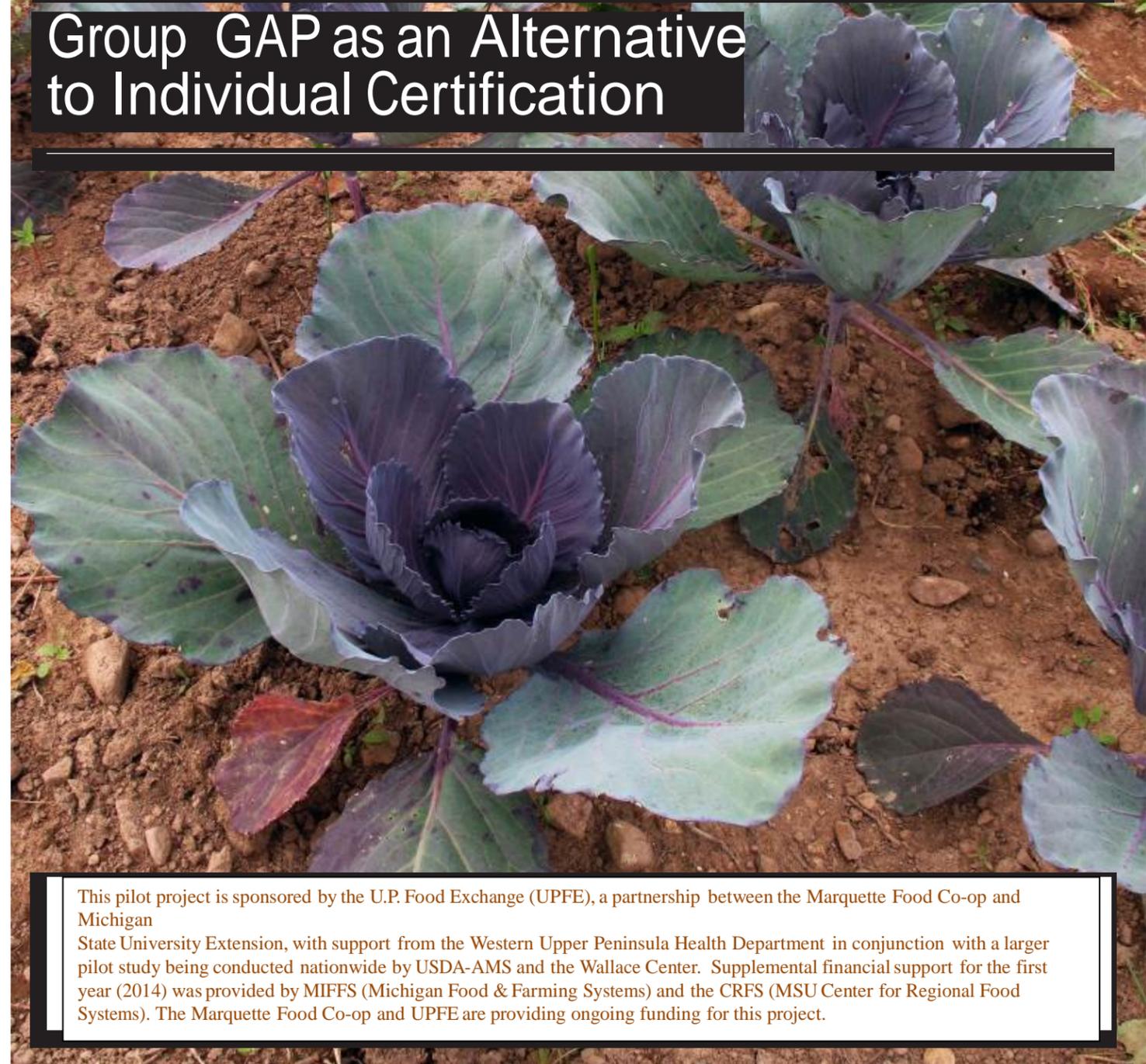
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# U.P. Food Exchange Group GAP Pilot Study:

## Group GAP as an Alternative to Individual Certification



This pilot project is sponsored by the U.P. Food Exchange (UPFE), a partnership between the Marquette Food Co-op and Michigan State University Extension, with support from the Western Upper Peninsula Health Department in conjunction with a larger pilot study being conducted nationwide by USDA-AMS and the Wallace Center. Supplemental financial support for the first year (2014) was provided by MIFFS (Michigan Food & Farming Systems) and the CRFS (MSU Center for Regional Food Systems). The Marquette Food Co-op and UPFE are providing ongoing funding for this project.



# Food Safety Manual 2015

Farm Name: \_\_\_\_\_ Legal Farm Address: \_\_\_\_\_

\_\_\_\_\_

Owner: \_\_\_\_\_

Phone: \_\_\_\_\_

Email: \_\_\_\_\_

Food Safety Manager: \_\_\_\_\_

\_\_\_\_\_ (if separate from owner)

Phone: \_\_\_\_\_

Email: \_\_\_\_\_

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## Scope of Food Safety Program Statement

### The Food Safety Manual

The following manual defines specific, measurable steps taken to reduce the risk of microbial, physical, and chemical hazards from contaminating our farm products. This food safety manual is designed to address the guidelines in the United States Department of Agriculture Good Agricultural Practices/Good Handling Practices (GAP/GHP) Audit Verification Checklist. Included in this manual are:

- General information about our farm
- Standard Operating Procedures (SOPs) outlining the policies and procedures for our operation
- Current documents and records showing evidence that the food safety plan is being implemented and followed

The UP Food Exchange (UPFE) created this Food Safety Manual as a template for us to change as necessary to fit the needs of our farm. We have adapted this template to accurately reflect the food safety practices used on our farm. The Food Safety Manual is reviewed and updated annually by UPFE and our farm to meet UPFE's needs and reflect any relevant changes to food safety laws, rules, and guidelines.

Food Safety Manager Signature: \_\_\_\_\_

Signature of person responsible if Food Safety Manager is absent:

---

## Notes on using this manual

**Bolded and italicized words** indicate that a record (log sheet) must be filled out corresponding to the relevant section of the Food Safety Manual



**This symbol in the margin indicates a part of the manual that needs to be adapted by each farm**

## Farm Maps

Maps and explanations of the following are included in our Food Safety Manual:

- Entire cultivated property showing buildings, fields, roads, irrigation source, septic system(s), wellheads, etc.
- Labeled field/sections with a name or number. Produce grown in each area is indicated. Acreage is included.
- Surrounding areas, including the direction of drainage.
- Floor plans of the buildings, labeling sinks, chemical storage areas, restrooms, locations of first aid kits, etc.
- Designated break areas (smoking, eating, etc.)
- Packing line/washing area flow diagram. Show where produce is boxed/bagged from field harvest, where product comes into the packing area, and where the finished product goes before it leaves the farm.
- Maps from previous years are included as necessary

## Crops

The crops included in the scope of our food safety program are:



## Traceability

A traceability plan is implemented so that the source of a product is known (one step backward) and where a product was sent (one step forward). In the event of a recall, every quantity of produce sold can be traced back to when and where it was harvested. This is accomplished by the following:

The following information is recorded in the *Harvest Log*:

- Item
- Field it was harvested from
- Quantity
- Date
- Any further unique identifying information

When leaving the farm, every container of produce delivered has a label with identification information and an accompanying invoice that will identify what the produce is and where it came from. This includes:

- Farm Name
- Item
- Quantity
- Delivery date
- Any further unique identifying information

Examples of labels and an invoice containing identification information are included below.

## Recall Program Policy:

A recall program is used to remove contaminated product from the supply chain after it has left the farm. How recalled products are to be handled will be established on a case-by-case basis with each individual buyer.

This information is recorded in the **Recall Log**.

Recalls will be initiated under circumstances such as:

- Intentional contamination of product
- Product found with high levels of pesticide residue and/or pesticide residue from an illegal or restricted chemical
- Known or suspected contamination by a chemical, physical or microbiological hazard
- Hazards including known infectious disease or blood contamination
- Notification from a supplier or business partner that any of the above occurred prior to receipt of the product at its final destination

## Mock Recall

A mock recall is performed on actual delivered product annually to verify the effectiveness of the recall program. Record is kept in the **Recall Log** below.

### Procedure:

1. A buyer is contacted and informed that a mock recall is being performed.
2. The buyer is asked to locate all containers of a particular purchased product.
3. The buyer is asked to supply an accounting of the number of cartons still in his possession and the number of containers sold. This can be done over the phone.
4. All communication with the buyer will be recorded and included in the **Recall Log**.

### Recall Log:



Step Backward					Step Forward		
Recall Date	Item Recalled	Tracking Code	Amount Shipped	Shipping Date	Customer contacted and date	Amount remaining at original customer	Status of the remainder

## Water Quality Assessment

### Policy:

Water used for drinking, hand washing, and on harvested crops is potable. Potable water is available to all workers. The quality of water used for chemical applications and irrigation is assessed and is known to be adequate for its intended use. All water sources are tested for generic *E.coli* and the results are quantified. Depending on the source and the use, the frequency of testing will vary.

Water Source	Tests per Year	Comments
Municipal	1	Test results are acquired from the local water authority or tested by the Food Safety Manager
Well	1	
Surface Water	3	At planting, peak use, and during harvest <i>Surface water is not considered potable, and should not be used for drinking, washing, or packing.</i>

All results are recorded in the **Water Quality Assessment Log**.

### Procedure:

1. Contact the lab that will be testing the water. Note any requirements the lab may have for testing water quality (i.e.: amount to sample, temperature of sample, age of sample, etc.).
2. Send sample to the lab.
3. Retrieve results from the lab. Determine if the results are within the accepted range. Record results in the *Water Quality Assessment Log*.
4. If unacceptable, perform an observational review of the water source area to see if there are any obvious problems or situations that can be mitigated. Record observations.

Take recommended actions to mitigate contamination and retest as needed. Record any mitigation actions and subsequent water test results in the *Water Quality Assessment Log*.

## Sanitation & Hygiene Policies

### Hand-Washing

All employees handling produce for processing or sale must use proper hand-washing techniques before beginning work and upon returning to work after taking breaks, going to the restroom, eating, smoking, sneezing, or other activities that could potentially contaminate the hands.

### Visitors

Visitors will be instructed as needed to follow the same hand washing, smoking, eating, clothing and jewelry, and illness policies as farm workers.

### Toilet/Restroom/Field Sanitation Units

Clean and well-maintained toilet and hand-washing facilities are provided for all visitors, workers, and customers. All toilet/restroom/field sanitation units are properly supplied with single-use towels, potable water, soap, signage about hand washing, and toilet paper.



#### *Documentation*

Monitoring, restocking, and cleaning are documented in the *Toilet/Restroom/Field Sanitation Units Cleaning Log* are performed per the following schedule:

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### Clothing and Jewelry

Employees will wear clothing free of debris and fecal matter to work every day. Employees are not required to wear hair or beard nets. No large, loose jewelry that risks falling off or out is permitted in the field, around machinery, or in the packing area.

### Break

Smoking and eating are confined to areas outside of the production and packing area. All workers are trained to store personal items in designated areas. The only personal containers that are allowed in the field, at any time, are those used for the sole purpose of carrying drinking water for consumption in the field. Under no circumstances will glass containers be allowed in the field or packing area.

### Training

All workers receive training when they start work on the farm and review the farm's food safety policies once a year. Training includes instruction on all company policies related to worker health and hygiene, on-farm food safety practices, and (where appropriate) specialized training related to specific jobs. Record of worker training is kept in the *Worker Training Log*

## U.P.Food Exchange Group Good Agricultural Practices(GAP)Pilot Study *For Farms*

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*U.P. farmers planning a mock recall as part of Farm Food Safety Training taught by Phil Tocco of MSU Extension*

The U.P. Food Exchange (UPFE) has been selected to partner with the USDA and Michigan Food and Farming Systems to participate in a pilot study exploring new ways to address the challenges of food safety certification for small farms. Due to anticipated changes to federal regulations related to the Food Safety Modernization Act, as well as mounting pressure from buyers and insurance companies, it appears that, in the near future, any farm (regardless of size) selling in any way other than directly to consumers may need a farm food safety plan. This study will investigate a collective certification model called Group GAP, which would mitigate the documentation and financial burden on small diversified farms by sharing resources—and risk.

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The “group” will be comprised of pioneering U.P. farms interested in assisting UPFE and the USDA in developing a Group GAP model. To help with this study, UPFE is looking for 16 farms that are already selling or would like sell their produce to institutional buyers. This study is not for those farms selling only direct to consumers and is for produce growers only.

#### **Partners**

USDA-AMS, Michigan Food & Farming Systems (MIFFS), MSU Extension (MSUE), Marquette Food Co-op (MFC), Western U.P. Health Department (WUPHD), MSU Center for Regional Food Systems (CFRFS), U.P. Food Exchange

#### **Target Number of Farms**

16 (may be located anywhere in Michigan's Upper Peninsula)

#### **Why Be Part of the Study?**

Joining this study will help ready your farm to comply with the changing farm food safety regulations on the horizon. If you sell produce beyond direct-market sales and already plan to become USDA GAP certified, participating in this pilot study will serve as an easy, low-risk way to move toward GAP with fewer financial costs than if you choose to seek certification on your own.

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#### **Farmers Receive the Following:**

- A farm food safety plan, including required food safety signage and standard operating procedures
- Support of other farmers within the group
- Access to an internal food safety consultant who will advocate on the farmer's behalf
- Opportunity to shape the process for the program's future
- Funds (up to \$500.00) to bring your operation into compliance with things like back flow preventers on sinks, installation of a hand washing station, bathroom accommodations for field workers, etc.
- Access to markets requiring food safety certification
- Wholesale Success resource guide from FamilyFarmed.org (\$85.00 value)

#### **Requirements for Participating Farms**

- Attend Group GAP Farmer Training (Saturday, April 12, 2014 in Marquette)
- Complete the Michigan Safe Food Risk Assessment tool

- Participate in an initial inspection of your farm by an internal group inspector (May-June)
- Participate in an official inspection of your farm by an internal group inspector (July-August)
- Participate in an official audit of your farm by a USDA GAP auditor if your farm is one of those selected at random from the group (August-September)
- Attend Pilot Study Debriefing Meeting (November/December 2014 in Marquette)
- Communicate and provide feedback in a timely manner to Group GAP Pilot coordinators
- Participate in interviews and share information about your Group GAP experience with researchers collecting data for the project
- Complete regularly scheduled monitoring tasks requiring 5-15 minutes (daily, weekly, monthly)
- Perform scheduled water sampling
- Comply with food safety regulations
- All farms in the group will share the cost of the audits of those selected by USDA to represent the group (estimated costs may reach \$500.00)
- Agree to make necessary upgrades and/or accommodations at your farm (at your own expense) to comply

**Natasha Lantz**

Community Liaison

[nlantz@marquettefood.coop](mailto:nlantz@marquettefood.coop)

906.225.0671 x 11

[www.upfoodexchange.com](http://www.upfoodexchange.com)



**PROJECT TITLE - FINAL**

**Michigan Apple Committee** – Promoting Fresh Michigan Apples in Southeast Michigan

**PROJECT SUMMARY**

After the significant crop loss of 2012, Michigan apples did not have a presence in the retail market for nearly a year, which made it doubly important for us to have a strong marketing presence within our own state, particularly in our state's largest city.

Detroit and the surrounding southeast Michigan suburbs have always been a top market priority for Michigan apples. Consumer panel research conducted by MAC in Detroit in 2008, 2009 and 2013 indicated that consumers are extremely interested in buying locally grown apples. However, they also indicated that they have difficulty determining the source of the apples they purchase in stores. Often consumers thought they were buying Michigan apples when, in fact, they were buying products grown elsewhere.

MAC's project included in-store activities, advertising, and community outreach to appeal to consumers and their children from the perspective of supporting locally-grown produce, the variety of taste profiles offered and the health benefits of regularly eating apples.

**PROJECT APPROACH**

The Michigan Apple Committee project focused on Southeast Michigan aimed to educate consumers and school-aged children through in-store activities, advertising and community outreach. The ultimate purpose of this project was to increase the number of Detroit-area consumers who choose Michigan Apples.

MAC has developed a Locally Grown marketing campaign, funded partially by past SCBG-FB dollars, to more prominently differentiate Michigan apples in the marketplace and encourage the sentiment of buying local. Past SCBG-FB funds were used in the Chicago market, where the Michigan apple is considered the local apple. Those two prior block grants for MAC (FY10, FY11) targeted groceries in Chicago's western suburbs. The efforts of those campaigns boosted the percentage of shoppers who buy Michigan Apples, therefore we felt they could be duplicated in southeast Michigan. MAC used FY13 granted funds to create in-store events, broadcast activities and community outreach efforts to help Southeast Michigan consumers correctly identify and purchase Michigan Apples in stores.

After the significant crop loss of 2012, Michigan Apples were not present in most stores for nearly a year. The grant funds helped the Michigan Apple industry begin to rebuild a strong, clearly identifiable presence in the marketplace after that absence, and we continue our work to regain the awareness of consumers as well as retailers. MAC has worked hard to promote and identify Michigan Apples in Detroit-area stores, and funding from the SCBG has helped us to address the "purchasing gap" between consumers wanting to buy local apples but being unable to identify where the apples they purchase come from. The timeliness of the project was also important for MAC as we continue to leverage our partnership with Pure Michigan, including broadcast media support in Detroit in the fall. A key message of this project to children and their parents is that Michigan apples are an economical and healthy snack – an alternative to sugary or salty snacks that often are more expensive.

#### GOALS AND OUTCOMES ACHIEVED

The Michigan Apple Committee focused on the important target area of southeast Michigan through marketing activities such as point-of-sale materials, radio advertising, in-store chef events and community outreach efforts.

In April, MAC staff met with Blue Cross Blue Shield of Michigan, to plan a partnership for the community outreach portion of this project. It was determined that we could reach southeast Michigan students with the locally grown, healthy choice message through their Building Healthy Communities program, which is a comprehensive school-wide program focusing on healthy eating and physical activity and creating a healthy, supportive school environment. The students learn about making healthy choices, and take those messages home to their parents. Through this program, MAC reached an estimated 33,000 elementary and middle school children.

Throughout the summer, MAC worked with our design firm to create banners, posters, tips cards (snack tips, breakfast tips and meal tips), and tasting forms to distribute to the schools in southeast Michigan who are participating in the Building Healthy Communities program. A price card for retail stores with a similar design was also created to be placed in stores in southeast Michigan.

Through the Blue Cross Blue Shield Building Healthy Communities program, apple tastings of three different Michigan Apple varieties were conducted in 20 schools. MAC provided apple tasting forms for elementary and middle school student to complete. They were "carbon copy" forms so the student could take home one copy, and the other copy could be returned to MAC. In the elementary outreach schools in southeast Michigan, (children ages 5 – 12) 50 percent of the students preferred the Gala apples, 35 percent chose Jonagold and the remaining 15 percent preferred Braeburn. In the middle schools (children ages 11-14), 49 percent preferred Gala, 25 percent liked Jonagold and 16 percent selected Braeburn, with 10 percent indicating they liked them all.

MAC also worked with Kroger Michigan on a promotion bringing more messaging about Michigan Apples to the retail stores (96 stores in southeast Michigan), and MAC placed 79 Pure Michigan Apple bins in Detroit-area retailers.

MAC continued our partnership with Pure Michigan, placing radio advertising in the greater Detroit area during the months of September and October. Pure Michigan matches 1:1 the financial commitment of this advertising.

While there was some delay in meeting with the partner and developing and finalizing materials and tactics, MAC did begin implementation of the project in September. Pure Michigan bins were placed in retail stores in the month of September, and print materials were finalized and sent to the printer. Some of the student materials for community outreach effort were translated into Spanish and Arabic to ensure the best communication of our message to the most students and their families.

The community outreach piece of this project also included a major event in the Detroit area. MAC worked with the Detroit Redwings to distribute health and locally grown information to 5,000 game attendees on November 26. In addition, MAC received advertising on the LED screens and Detroit Redwings website, as well as a social media post.

No baseline data exists for this project; however, MAC distributed a survey to retailers to gauge effectiveness of in-store activities. (Survey attached to report.) Among the results reported, 100 percent of the respondents indicated they saw an increase in sales of Michigan Apples due to the in-store activities and materials. Amount of sales increase reported ranged from 10 percent to 400 percent.

In regards to in-store activities the targets of 50% of the 111 retailers in southeast Michigan participating in the in-store materials and activities and the 28 in-store chef demos has been achieved.

In addition, we have collected Nielsen scan data from major retailers in the targeted area to help us set a benchmark for future work.

Period	Geography	Dollars % Change	Volume % Change	Avg. Retail	Avg. Retail % Change
Mo. ending 10/25/14	Kroger Michigan	9.7%	10.2%	\$1.48	-0.5%
Mo. ending 10/25/14	Meijer	7.1%	-5.1%	\$1.37	12.9%

Above, the chart shows a sampling of the data collected by Nielsen, which is from the month of October 2014. Kroger Michigan had a volume increase in Michigan Apples, and Meijer showed a retail price increase. This data is for the four weeks ending October 25. The percent change compares to data from a year ago.

The community outreach component of the project provided important data about varietal preferences of school-aged children. The apple tasting forms helped us to identify that Gala is the most preferred variety in this age group. In the elementary outreach schools in southeast Michigan, (children ages 5 – 12) 50 percent of the students preferred the Gala apples, 35 percent chose Jonagold and the remaining 15 percent preferred Braeburn. In the middle schools (children ages 11-14), 49 percent preferred Gala, 25 percent liked Jonagold and 16 percent selected Braeburn, with 10 percent indicating they liked them all. This information will continue to be valuable for MAC, knowing the flavor preferences of this age group as we market to children and their parents.

As a part of this project, MAC completed

- A survey to retailers participating with in-store activities and materials in the targeted area to gauge the success of the program from their perspective.
- Using week prior and week of sales data (based on contracts with independent retailers in the target area written by Michigan Apple Committee account manager) MAC achieved a 34 percent increase in sales. The goal of the project was to reach a 25 percent increase.

- Achieved participation in all of the 111 targeted grocery stores (Kroger, Meijer and independent stores) in the region. Previous benchmark was zero, and our goal was to achieve 50 percent participation.
- Implemented 31 in-store chef demos. No prior benchmarks have been set, and MAC set the goal of implementing 28 in-store demos.
- MAC also achieved increased purchases of Michigan apples based on actual cash register scan data from Nielsen-participating retailers. In particular, Kroger stores had a 10.2 percent increase in volume sales from the prior year.

Period	Geography	Dollars % Change	Volume % Change	Avg. Retail	Avg. Retail % Change
Mo. ending 10/25/14	Kroger Michigan	9.7%	10.2%	\$1.48	-0.5%
Mo. ending 10/25/14	Meijer	7.1%	-5.1%	\$1.37	12.9%

There is still more work to be done. While we saw increase in sales from the retailers, we believe a strong presence must be maintained to continue this momentum. Also, from a consumer perspective, we would like to know whether the community outreach piece actually motivated the recipients to purchase Michigan Apples. It is important to continue this work to raise awareness about identifying the product and communicating the importance of this locally-grown, healthy food. Additionally, continuous effort will be needed to keep Michigan Apples moving through the retail marketplace.

#### BENEFICIARIES

Beneficiaries of this project include Michigan’s 850 apple growers, as well as Michigan Apple shippers, processors and other industry partners.

Our job at the Michigan Apple Committee is to help set the stage for successful sale and marketing of apples at the retail level. This project is one component that helps us to achieve that, which benefits the entire Michigan Apple Industry.

#### LESSONS LEARNED

Many lessons were learned throughout the implementation of this project. One very valuable piece was the cultivation of a partnership with Blue Cross Blue Shield of Michigan. They felt the program was valuable and connected us with their Building Healthy Communities program, but we also faced challenges in working with their team such as lack of timely response, clear communication and clearly defined expectations. While we were able to successfully reach school-aged children through this partnership, we are doubtful that we would work with this program in the future.

A positive outcome of the project was connecting with a company to provide translation services of materials. This will be a benefit to MAC, and the apple industry as we market to non-English speaking consumers.

#### CONTACT PERSON

Diane Smith, Executive Director  
 517-669-8353  
 Diane@MichiganApples.com

#### ADDITIONAL INFORMATION

**APPENDIX A            Retailer Survey**



## 2014 Locally Grown Fresh Marketing SURVEY

The Michigan Apple Committee (MAC) works hard to ensure our marketing programs are effective for our partner retailers. Your feedback is important to us so that we can continue to deliver quality, effective programs that meet your marketing needs.

**Please take a few moments to complete this survey.**

Name

Store Name

1. In your opinion, how effective was the Locally Grown program in your store?\*

- Not very effective  
 No difference  
 Somewhat effective  
 Very effective

2. Please indicate whether you participated in any of the following as a part of the Locally Grown program. Check all that apply.\*

- Circular ad with MAC logo and sweepstakes information  
 Pure Michigan or Michigan Apple display bins  
 In-store chef demonstrations

3. Please indicate your opinion about the effectiveness of each of the tactics mentioned:

Circular ads\*

- Not very effective  
 No difference  
 Somewhat effective  
 Very effective

Display bins\*

- Not very effective  
 No difference

- Somewhat effective
- Very effective

In-store chef demos\*

- Not very effective
- No difference
- Somewhat effective
- Very effective

4. Did you notice an increase in Michigan apple sales during the time you were participating in the program, compared to prior or subsequent weeks? (check one)

\*

- Yes
- No
- Not sure

5. If you saw an increase, please indicate the estimated percentage of increase: 

6. Was the program easy for your store to implement?\*

- Yes
- No
- Not sure

7. Would you be willing to participate in the Locally Grown Marketing program in the future?\*

- Yes
- No
- Not sure

**Chain Information**

How many stores does your chain have?\*

Location: Check all that apply.\*

- Midwest (Michigan, Ohio, Indiana, Illinois, Wisconsin)
- Central United States (Missouri, Minnesota, Arkansas)
- SE United States (Kentucky, Tennessee, Georgia, North Carolina, South Carolina, Florida)
- Southern United States (Alabama, Mississippi, Louisiana, Arkansas)
- Western United States (Texas, Oklahoma, Colorado, North Dakota, South Dakota, Iowa)
- Nationwide

We understand how valuable your time is, and we appreciate you taking the time to fill out this survey. If you have additional feedback to share with us, please email it to Staff@MichiganApples.com. **Thank you!**

**APPENDIX B**

**Graphic Design, Translation and Print materials**

Crunch into a healthy and delicious Michigan Apple!

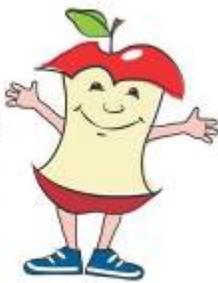
**ENTER FOR A CHANCE TO WIN**  
 a trip to Crystal Mountain  
 from Michigan Apples! Go to  
[www.MichiganApples.com/contests/](http://www.MichiganApples.com/contests/)  
 for official rules and other details.  
 No purchase or payment necessary.




Contest price card for retail use

School posters (English, Spanish and Arabic)

¡OIGAN,  
 NIÑOS!



¿Han comido una manzana Michigan  
 Apple saludable y deliciosa últimamente?



El mejor sabor, muchas variedades y gran calidad no son las únicas razones por la que debería comer manzanas de Michigan Apple regularmente. Las manzanas son parte importante de una dieta saludable. Estas frutas cargadas de flavonoides y antioxidantes poderosos y llenas de fibra, que a su vez contienen bajos niveles de sodio y calorías, resultan una opción saludable para todos.

¡Descubra más información en [MichiganApples.com](http://MichiganApples.com)!




HEY  
 KIDS!



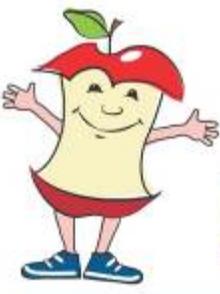
Have you eaten a healthy and delicious Michigan Apple lately?



Best taste, many varieties, and great quality are not the only reasons you should regularly eat Michigan Apples. Apples are an important part of a healthy diet. Loaded with powerful flavonoids and antioxidants, and filled with fiber—while being low in sodium and calories—they're a healthy choice for every body!

Find out more at [MichiganApples.com](http://MichiganApples.com)!



# أيها الأولاد!

هل اكلتم مؤخرًا تفاح ميشيغان (ميشيغن أبلز) الصحي واللذيذ؟

يحب أن تشارك Michigan Apples (ميشيغن أبلز) بشكل دائم، ليس فقط لأن طعمها هو الأفضل، وإنما لذيذ بألوان مختلفة ولأنها عالية الجودة، فلتفاح جزء مهم من النظام الغذائي الصحي، إذ أنه مليء بالفيتامينات ومضادات الأكسدة والالياف، وفي الوقت ذاته يحتوي على القليل من السعرات والسعرات الحرارية. إنه الخيار الأفضل للجميع!

اقرأ المزيد على الرابط التالي  
MichiganApples.com




Tips cards (English, Spanish and Arabic)

### Quick and tasty ideas for adding Michigan Apples to your breakfast

- Make an apple parfait by layering chopped Michigan Apples, plain or flavored yogurt and low-fat cinnamon granola in a glass.
- Add a chopped Michigan Apple to a box of quick bread mix.

### Fun and nutritious tips for adding Michigan Apples to your snacks!

- Mix up a quick fruit salad with 1 chopped Michigan Apple, a small can of drained mandarin oranges, a sliced banana and top with toasted coconut.
- Spread Michigan Apple slices with peanut butter then dip in your favorite cereal.
- Add a finely chopped Michigan Apple to a jar of prepared salsa. Serve with whole grain tortilla chips.
- Top your scoop of low-fat vanilla ice cream or frozen yogurt with Mich slices and 1-2 tbsp. of caramel topping or just a dash of cinnamon.
- Serve Michigan Apple wedges with 2 tbsp. of peanut butter or vanilla.

Michigan Apples

- Michigan Apples and sprinkle
- Michigan Apples

### Great ideas for adding Michigan Apples to your lunch or dinner

- For a quick microwave applesauce — core and chop 4 Michigan Apples into 1/2 inch chunks. Place in a microwaveable bowl with 1/4 cup water. Cover and cook on high for 10 minutes. Stir and cook uncovered for another 5 more minutes. Mash apples and stir in 1-2 tbsp sugar and 1/4 tsp cinnamon.
- Mix 1 (16 oz) bag of prepared coleslaw mix with 1 large Michigan Apple, cored and finely diced, 1/4 tsp celery seed and 1/4 cup bottled low-fat coleslaw dressing.

Michigan Apples

### Michigan Apple Breakfast Tips



### Michigan Apple Snack Tips



### Michigan Apple Meal Tips



### Consejos para bocadillos con manzanas de Michigan



## Consejos para un desayuno con manzanas de Michigan



## Ideas rápidas y sabrosas para añadir manzanas de Michigan a su desayuno

- Haga un postre helado de manzanas. Para ello, ponga capas de manzanas de Michigan cortadas, yogur sin sabor y saborizado y galletas de cereales con bajo contenido de grasas en un vaso.
- Añada una manzana de Michigan cortada en una caja de mezcla para pan.
- Cubra un bol de avena integral cocida con 1/2 manzana de Michigan en cubos, 1 cucharada de nueces picadas, 1 cucharada de pasas de uva y 2 cucharaditas de azúcar negra.
- Cubra una tostada de pan francés integral con salsa de manzanas de Michigan sin azúchar y espárragos con azúcar con cereales.
- Añada la salsa de salsas de manzanas de Michigan y 5 cucharaditas de canela al desayuno.
- Caliente la salsa de manzanas de Michigan en el microondas y úntela en un panecillo inglés integral tostado; añada una pizca de cereales.

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## nutritivos para añadir a sus bocadillos

- Mezcle una ensalada de frutas rápida con 1 manzana de Michigan cortada, una lata pequeña de mandarina escarificadas, una banana en rodajas y cubra con coco tostado.
- Unte manguita de mariscos en rebanadas de manzanas de Michigan, luego rebótelas con su cereal favorito.
- Añada una manzana de Michigan cortada finamente a una jarra de salsa preparada. Sirva con pedacitos de tortitas integrales.
- Cubra su cuchara de helado de vainilla con bajo contenido de grasas y yogur helado con rebanadas de manzanas de Michigan, 1-2 cucharadas de cobertura de chocolate o simplemente una pizca de canela.
- Sirva cubos de manzanas de Michigan con 2 cucharadas de mermelada de miel y yogur de vainilla.

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## Buenas ideas para añadir manzanas de Michigan al almuerzo o a la cena

- Para hacer una salsa de manzanas: corte el cítrico en cuartos, córtalo y corte 4 manzanas de Michigan en trozos de 1/2 pulgada. Coloque las manzanas en un bol aplo para microondas con 1/2 taza de agua. Cubra y cocine a temperatura alta durante 5 minutos. Revuelva, cocine destapado durante aproximadamente 5 minutos más. Triture las manzanas y revuelva agregando 1 o 2 cucharadas de azúcar y 1/2 cucharadita de canela.
- Mezcle 1 pavo (8 oz) de mezcla de ensalada de pavo preparada con 1 manzana de Michigan grande descorazonada y cortada en pedacitos chicos, 1/2 cucharadita de semillas de sésamo y 1/2 taza de aderezo en botella para repollo con bajo contenido de grasas.
- Coloque las rebanadas de manzanas de Michigan en una ensalada escarificadas de hojas verdes verdes. Cubra con aderezo helado con bajo contenido de grasas.
- Para hacer una salsa rápida de manzanas con jengibre: pise un pedazo de ajo; combine 1 taza de jugo de manzana con 1/2 taza de caldo de pollo reducido en cocción en una olla pequeña. Haga hervor y agua cocinando a fuego lento destapado durante aproximadamente 15 a 20 minutos. Mezcle 4 cucharadas de agua fría con 1 cucharadita de almidón en polvo. Añada lentamente el almidón al caldo con un tenedor. Cocine durante 2 minutos más. Retire del fuego y revuelva agregando una 1 cucharadita de jugo de manzana, 1 cucharadita de menta y 1/2 cucharadita de jengibre molido.

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## Consejos para comidas con manzanas de Michigan



## Nصالح لاستخدام تقاح Michigan Apples (ميشيغن أبلز) في الفطور



## Nصالح لاستخدام تقاح Michigan Apples (ميشيغن أبلز) في الوجبات



## نصائح مسلية ومغذية لإضافة تقاح Michigan Apples إلى الوجبات الخفيفة

- اصنع سلطة سريعة لمدة العشاء مع تقاح Michigan Apples واحدة على سفوف من البازيل والسمسم والملح مع زيت الزيتون.
- اصنع على شرائح تقاح Michigan Apples ربة الفول السوداني أو غيرها من البقول التي تصليها.
- اصنع تقاح Michigan Apples الصغرى على سبواك من المصاصة المشوية المصنوعة ومنها مع الخبز المشوي الرفيع من القشرة اللينة.
- اصنع على الوجبة اللذيذة الصغرى الحرارية بكم القليل أو اللين السعة تقاح Michigan Apples وملحة في بصلتين كبيرتين من الكرفس أو بعض الوجبة على.
- اصنع تقاح Michigan Apples بمخلطتين كبيرتين من زبدة الفول السوداني أو غيرها بكم القليل.



## أفكار مريحة ولذيذة لإضافة تقاح Michigan Apples لتطويره

- اصنع الوجبة تقاح في كوب غير وضع تقاح من تقاح Michigan Apples فوق بعضها البعض وغطها باللبنة التي تليها أو الشاي ورائق البوب، القليل الصغرى الحرارية بكم القليل.
- اصنع تقاح Michigan Apples الطبخ على خذ حلبة الخبز الخبز.
- اصنع على مسنن الكرفس اللين الصغرى اصنع تقاح Michigan Apples معلمة وملحة كبيرة من جوز الكافور.
- اصنع على الوجبة كبيرة من كرفس وبصلتين مسفوفين من السكر الأحمر.
- اصنع على الوجبة الكرفس من التقاح الكافور مسفوفين تقاح Michigan Apples غير الصلابة ورائق عليها سكر ملحة بكم القليل.
- اصنع نصف كوب من مصاصة تقاح Michigan Apples ونصف ملحة مسفوفين من الوجبة لذيذة الطبخ القليل في القليل.
- مسنن مصاصة تقاح Michigan Apples في الميكروويف، اصنعها على ظهره الكرفس مسننًا من الوجبة اللين، واصنع ربة من القليل.

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## أفكار رائعة لإضافة تقاح Michigan Apples إلى العشاء أو العشاء

- اصنع مصاصة تقاح سريعة على يدوية البازيل ورائق - تقاح Michigan Apples فوق بعضها البعض في الوجبة كرفس اصنع تقاح أو ربة الفول السوداني أو غيرها من البقول التي تصليها.
- اصنع على شرائح تقاح Michigan Apples الصغرى على سبواك من المصاصة المشوية المصنوعة ومنها مع الخبز المشوي الرفيع من القشرة اللينة.
- اصنع على الوجبة كبيرة من كرفس وبصلتين مسفوفين من السكر الأحمر.
- اصنع على الوجبة الكرفس من التقاح الكافور مسفوفين تقاح Michigan Apples غير الصلابة ورائق عليها سكر ملحة بكم القليل.
- اصنع نصف كوب من مصاصة تقاح Michigan Apples ونصف ملحة مسفوفين من الوجبة لذيذة الطبخ القليل في القليل.
- مسنن مصاصة تقاح Michigan Apples في الميكروويف، اصنعها على ظهره الكرفس مسننًا من الوجبة اللين، واصنع ربة من القليل.



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Tasting Forms (English, Spanish and Arabic)

A TASTE OF  
**MICHIGAN**

**Name:** \_\_\_\_\_

**Age:** \_\_\_\_\_

I tried these Michigan Apple varieties:

\_\_\_\_\_

\_\_\_\_\_

My favorite was Michigan \_\_\_\_\_

 **MICHIGAN APPLES**

A TASTE OF  
**MICHIGAN**

**Nombre:** \_\_\_\_\_

**Edad:** \_\_\_\_\_

He probado estas variedades de Michigan Apple:

\_\_\_\_\_

\_\_\_\_\_

Mi favorita fue la Michigan \_\_\_\_\_

**MichiganApples.com**

تذوق طعم  
ميشيغان

**الاسم:** \_\_\_\_\_

**العمر:** \_\_\_\_\_

لقد جربت الأنواع التالية من MICHIGAN APPLES (ميشيغان أبلز)  
- تفاح ميشيغان:

\_\_\_\_\_

\_\_\_\_\_

وإني أفضل منها (ميشيغان أبلز):

\_\_\_\_\_

\_\_\_\_\_

Banner for schools



Pictures from Apple Tastings

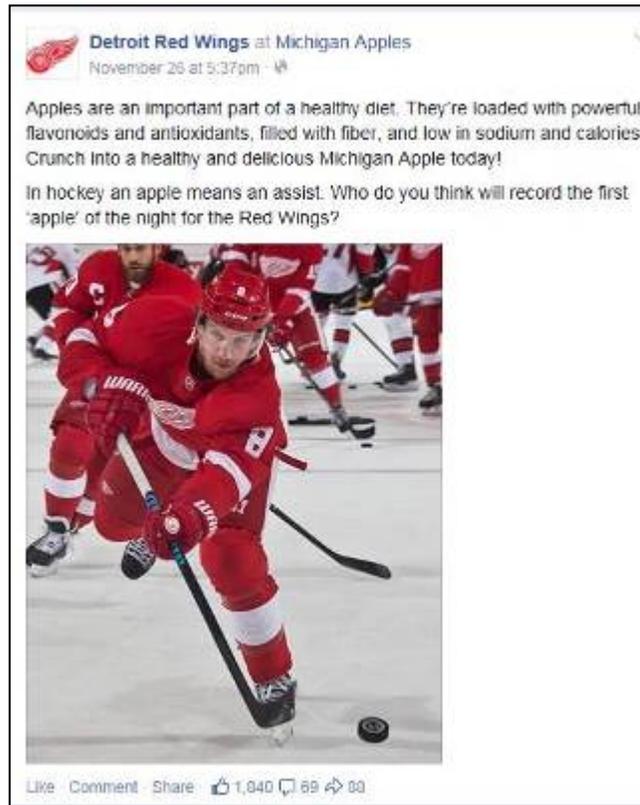


**APPENDIX C**  
RedWings web ad

**RedWings Event**



RedWings Facebook post



LED Display at RedWings Game



Flyer for handout to 5,000 fans at RedWings Game

**Crunch into a healthy and delicious Michigan Apple!**

**ENTER FOR A CHANCE TO WIN**  
 a trip to Crystal Mountain from Michigan Apples! Go to [www.MichiganApples.com/contests/](http://www.MichiganApples.com/contests/) for official rules and other details.  
 No purchase or payment necessary.



**Have you eaten a healthy and delicious Michigan Apple today?**

**Apples are:**

- a rich source of plant-based antioxidants
- high in fiber
- a good source of Vitamin C

More health information can be found at [MichiganApples.com/Healthy-Living](http://MichiganApples.com/Healthy-Living)



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APPENDIX D

Online Component

http://www.michiganapples.com/Just-for-kids/Games



APPENDIX E

Win with Kroger

Print and Online materials





**APPENDIX F**

**In-Store Materials – Wooden Apple Bins**





**APPENDIX G**

**In-Store Chef Demos with Chef Paul Penney**



## PROJECT TITLE - FINAL

**Michigan Blueberry Advisory Committee** – Research and Extension to maintain the Short-and Long-Term Competitiveness of the Michigan Blueberry Industry

## PROJECT SUMMARY

In the past five years, Spotted Wing Drosophila (SWD) has become the major insect pest of soft-skinned fruit in the main fruit production regions of North America and Europe. As SWD has moved from its native range in Asia to new regions, it has become a key challenge to the harvest of marketable fruit. In 2012 in Michigan, the economic impact of SWD to the blueberry industry was estimated by MSU Extension at \$23.8 million from crop rejections, downgraded fruit, and increased production costs. This pest is a real and present threat to the production and marketing of blueberries from our state.

Effective control of SWD is based on repeated use of insecticides, and this pest's arrival has set our Integrated Pest Management programs back 30 years. Growers control SWD through repeated use of synthetic pyrethroids, organophosphates, and carbamates, and depending on when the fly activity starts, effective control requires seven-eight insecticide sprays applied five-seven days apart. The issue of Maximum Residue Limits (MRL) allowed in food affects all food industries, but this is of particular concern to the blueberry industry under the threat of this pest because of the need to spray and protect fruit, while also meeting the MRL for domestic and especially export markets. The lower MRLs in many trading partners greatly reduce grower options. However, if they knew that application of an insecticide some days earlier than the pre-harvest interval set in the US would allow them to meet the limit, this would greatly expand options of the insecticides available.

In addition to these issues with MRLs for export, the dependence of growers on insecticides for control of SWD is also an area where loss of marketability of fruit could quickly develop. Drosophila flies, such as SWD are well known to have a high capacity for developing tolerance to insecticides. If this tolerance is heritable and is selected for in the population by the repeated use of insecticides, resistant populations may develop. While MSU Extension and the SWD Response Team are highlighting resistance management to growers, this situation is ripe for insecticide resistance development. If that happens, it is essential that we have the information to guide growers to make informed selection of effective insecticides. Our work on resistance monitoring started with a now-expired US-EPA grant, showing that SWD collected from a commercial farm had a slightly higher tolerance to malathion than a population collected from an unsprayed site. The information gathered from this project provides a baseline for future comparison of SWD tolerance to insecticides.

Rainfall is another issue that is very important in the Great Lakes region. Unlike our west coast blueberry competitors, we can have frequent and sometimes heavy rains during blueberry harvest season. In 2012, we discovered that most insecticides lose efficacy against SWD after rainfall, meaning that growers will have to make an expensive reapplication. This can have the effect of disrupting harvest schedules, can increase the potential for resistance development, and may also increase the chance of harvested fruit exceeding MRLs. However, there are "sticker" additives that claim to reduce loss of insecticides to rainfall. Growers consider it important to assess the claims of these additives, and we intend to address this issue as part of this project.

## PROJECT APPROACH

We conducted experiments in 2014 to determine the insecticide residue profiles of ten of the most commonly applied insecticides by the commercial blueberry industry in Michigan. We applied insecticides to a blueberry planting and collected residue samples at one, three, seven, and 14 days after treatments.

We also monitored the susceptibility of SWD to two of the most commonly applied insecticides, zeta-cypermethrin and malathion. We established SWD colonies by collecting infested blueberries from six fields and determining mortality curves for each of the colonies.

Semi-field laboratory bioassays were conducted to test the efficacy of three spreader-sticker additives (Nu-Film, Transfix, and Masterlock). Blueberry bushes were sprayed with Delegate insecticide plus one of the three spreader-stickers. Fruit and foliage from these sprayed bushes were then brought back to the laboratory and exposed to adult SWD inside deli cups. The efficacy of the products was assessed by counting the number of adult flies that died, as well as the number of larvae that were found in the fruit.

## GOALS AND OUTCOMES ACHIEVED

**Objective 1. Determine insecticide residue profiles to meet MRL restrictions.** An experiment to determine insecticide residue profiles was conducted in 2014 in a blueberry planting at the Trevor Nichols Research Complex. Four replicates of twelve-bush plots were sprayed with one of two insecticide tank mixes (Group A or Group B) using an FMC 1029 airblast sprayer calibrated to deliver 30 gallons of water per acre. Insecticides were applied to bushes on 17 July 2014 and fruit samples were collected from sprayed bushes at one, three, seven, and 14 days after treatment. Insecticide rates and product names were as follows:

Group A: imidacloprid, Admire Pro, 2.8 oz/acre; malathion, Malathion 8F, 2.5 pints/acre; methomyl, Lannate 2.4LV, 3 pints/acre; spinosad, Entrust 2SC, 6 oz/acre; zeta-cypermethrin, Mustang Maxx 0.8EC, 4 oz/acre.

Group B: carbaryl, Sevin XLR+, 2 quarts/acre; esfenvalerate, Asana XL 0.66 EC, 9.6 oz/acre; phosmet, Imidan 70WP, 1.33 lbs/acre; spinetoram, Delegate 25WG, 6 oz/acre; thiamethoxam, Actara 25WG, 4 oz/acre.

Sprayed bushes were exposed to any natural conditions except rain. During rainfall, bushes were covered with tarpaulins to prevent wash-off of residues. Blueberry samples were frozen immediately after collection and analyzed for residues using gas chromatography-mass spectrometry (GC/MS) and liquid chromatography-mass spectrometry (LC/MS).

Results from the residue analysis show declining residue levels over time for all insecticides (Tables 1 and 2). The initial residue levels, as well as the rate of decline varied from one chemical to another. These decline curves provide valuable insight into the longevity of residues in the field and will be analyzed this winter to predict the duration from treatment when fruit can meet export tolerances for other countries. This will be valuable information for growers, processors, and exporters to meet target MRL values.

**Table 1.** Detectable residues of insecticides from Group A that were applied to blueberry bushes on 17 July 2014. Fruit samples were collected from sprayed bushes at 1, 3, 7, 14, and 21 days after insecticides were applied to bushes. Chemicals were applied using an FMC 1029 airblast sprayer and were exposed to natural conditions except during times of rain when bushes were covered with tarps. All residue values are expressed as parts per million ( $\mu\text{g}$  per gram).

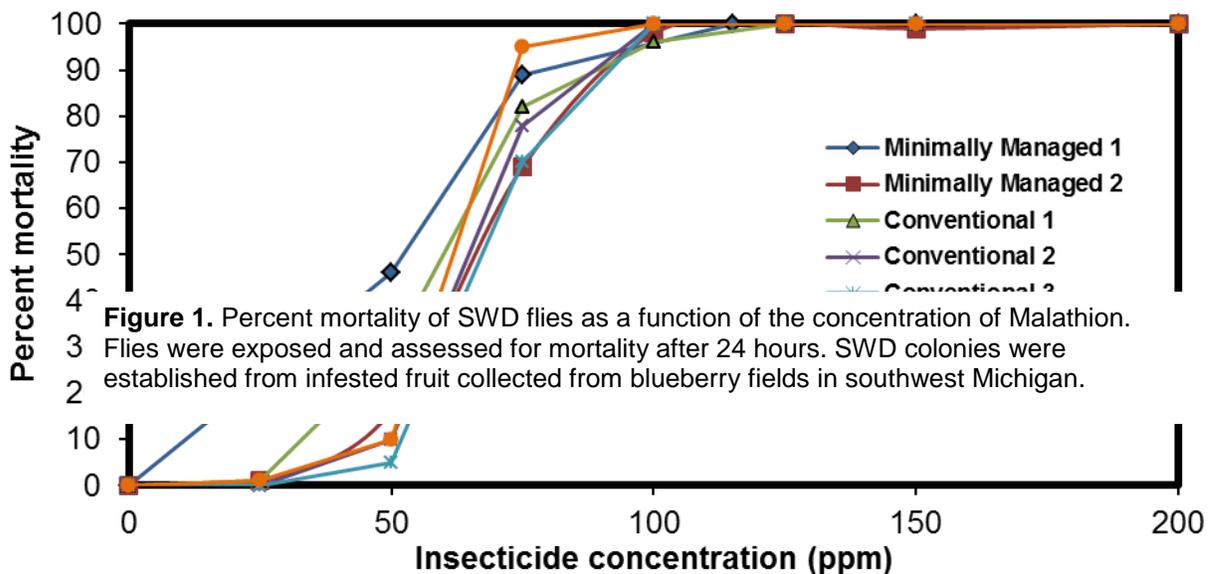
Days After Treatment	imidacloprid	malathion	methomyl	spinosad	zeta-cypermethrin
1	0.18 $\pm$ 0.016	2.77 $\pm$ 0.30	4.80 $\pm$ 0.59	0.029 $\pm$ 0.0039	0.28 $\pm$ 0.022
3	0.13 $\pm$ 0.025	0.50 $\pm$ 0.18	3.25 $\pm$ 0.46	0.003 $\pm$ 0.0025	0.19 $\pm$ 0.022
7	0.068 $\pm$ 0.0095	0.11 $\pm$ 0.0085	1.49 $\pm$ 0.29	0 $\pm$ 0	0.11 $\pm$ 0.012
14	0.050 $\pm$ 0.011	0.038 $\pm$ 0.011	0.71 $\pm$ 0.12	0 $\pm$ 0	0.13 $\pm$ 0.019
21	0.054 $\pm$ 0.0057	0.021 $\pm$ 0.0058	0.31 $\pm$ 0.047	0 $\pm$ 0	0.065 $\pm$ 0.0041

**Table 2.** Detectable residues of insecticides from Group B that were applied to blueberry bushes on 17 July 2014. Fruit samples were collected from sprayed bushes at one, three, seven, 14, and 21 days after insecticides were applied to bushes. Chemicals were applied using an FMC 1029 airblast sprayer and were exposed to natural conditions except during times of rain when bushes were covered with tarps. All residue values are expressed as parts per million ( $\mu\text{g}$  per gram).

Days After Treatment	carbaryl	esfenvalerate	phosmet	spinetoram	thiamethoxam
1	8.28 $\pm$ 2.46	0.22 $\pm$ 0.058	2.95 $\pm$ 0.75	0.095 $\pm$ 0.02	0.082 $\pm$ 0.021
3	4.65 $\pm$ 1.24	0.18 $\pm$ 0.034	1.29 $\pm$ 0.35	0.044 $\pm$ 0.0083	0.070 $\pm$ 0.02
7	2.40 $\pm$ 0.24	0.17 $\pm$ 0.0074	0.72 $\pm$ 0.12	0.026 $\pm$ 0.004	0.058 $\pm$ 0.014
14	0.31 $\pm$ 0.089	0.15 $\pm$ 0.042	0.24 $\pm$ 0.058	0 $\pm$ 0	0.029 $\pm$ 0.0023
21	0.13 $\pm$ 0.036	0.078 $\pm$ 0.016	0.14 $\pm$ 0.039	0 $\pm$ 0	0.024 $\pm$ 0.0009

**Objective 2. Monitor susceptibility of SWD populations to insecticides.** A series of laboratory bioassays were conducted during 2014 to assess Michigan-collected populations of Spotted Wing Drosophila (SWD) for resistance to common insecticides. In the fall of 2013 SWD were reared out of infested fruit collected from four conventionally managed (heavy insecticide use) blueberry fields and two minimally managed (little to no insecticide use) blueberry fields. Flies were reared out and once colonies were established, groups of flies were exposed to different concentrations of three insecticides (methomyl, Lannate 2.4LV; malathion, Malathion 8F; and zeta-cypermethrin, Mustang Max 0.8EC) by placing anaesthetized flies in a Petri dish and treating them, then moving the flies to an untreated dish. Flies were assessed for their mortality 24 hours after exposure.

Figure 1 shows the mortality values for the Malathion bioassays. The average  $\text{LC}_{50}$  values were slightly higher at the conventional sites than the minimally managed sites. This was the case for all three compounds (*Lannate*: Conventional-120.3 ppm, Minimally Managed-57.5 ppm; *Malathion*: Conventional-63.4 ppm, Minimally Managed-59.3 ppm; *Mustang Max*: Conventional-1.75 ppm, Minimally Managed-1.43 ppm). While these increased levels are not cause for great concern it does highlight the need for continued resistance monitoring. In addition, these results also highlight the need to promote resistance management to our growers and ensure that chemical classes are being rotated through the growing season.



### Objective 3. Improve rainfastness of insecticides for SWD control.

An insecticide trial was conducted in 2014 in a blueberry field ('Bluecrop' variety) at the Trevor Nichols Research Complex in Fennville, Michigan to test for efficacy against SWD after exposure to simulated rainfall. Twelve-bush plots were sprayed with insecticides and adjuvants using an FMC 1029 airblast sprayer calibrated to deliver 50 gallons per acre at 2.5 miles per hour or were left unsprayed. Insecticides with and without spray adjuvants were applied to bushes on 2 September 2014. Spray treatments included the following: Delegate 25WG (6 oz), Delegate 25WG (6oz) plus Masterlock (5 oz), Delegate 25WG (6oz) plus Nu-Film-P (8 oz), and Delegate 25WG (6 oz) plus Transfix. At one day after treatment (DAT), two sets of treated shoots containing ten leaves and five ripe berries were collected from the bushes and placed in water picks and placed on blocks of floral foam. Foliage and fruit were either placed in a rain booth and exposed to one inch of rain (applied over a 15 minute period) or received no simulated rainfall.

All shoots were left to sit for one day to allow rain-exposed foliage and fruit to dry completely. Bioassays were set up the following day (2 DAT); twelve adult SWD (six males, six females) were added to the cups containing foliage and fruit and adult health (classified as either alive, moribund, or dead) was assessed 24 hours later. After seven days the fruit were collected out of the cups and assessed for the presence of *Drosophila* eggs, larvae and pupae using a modified salt test for detection. The modified salt test consisted of sifting the salt test liquid through a reusable coffee filter and counting the eggs, larvae, and pupae using a stereomicroscope. The percent of adult flies that were dead or moribund data were arcsine transformed before analysis using two-way analysis of variance (ANOVA), followed by a Fischer's least significant difference (LSD) test for post-hoc comparisons. The number of *drosophila* larvae found in the five berries per cup data were log (X+1) transformed before analysis using two-way ANOVA, followed by a Fischer's LSD test for post-hoc comparisons.

There was significantly higher adult mortality in all of the insecticide treatments than the untreated controls (Table 3). There were also significantly fewer SWD larvae in the insecticide-treated fruit than in untreated berries. Exposure of fruit and foliage to simulated rainfall resulted in lower adult mortality for most of the chemical treatments, but did not result in any significant increase in the number of larvae in fruit.

**Table 3.** Percent of *Drosophila suzukii* adults (six males, six females) that were dead or moribund after 24 hours exposure to foliage and fruit treated with insecticides and the number of *Drosophila suzukii* larvae and pupae found in blueberries. Foliage and fruit were collected from bushes at one day after treatment (DAT), exposed to either one inch of simulated rainfall or no rain, and exposed to *D. suzukii* adults at 2 DAT for seven days. Means and percentages followed by the same letter within each column are not significantly different at  $\alpha=0.05$ .

Treatment	Percent of flies dead or moribund		Number of <i>D. suzukii</i> larvae in 5 berries	
	Rain	No Rain	Rain	No Rain
Control	4.2 ± 2.4 a	0 ± 0 c	13.3 ± 0.9 a	10.3 ± 4.2 a
Delegate 25WG 6 oz	6.3 ± 4.0 a *	37.5 ± 16.1 b	4.3 ± 0.8 ab	4.8 ± 4.1 b
Delegate 25WG 6 oz+ Masterlock 5oz	16.7 ± 11.3 a *	64.6 ± 2.1 ab	1.3 ± 0.5 b	0.8 ± 0.5 b
Delegate 25WG 6 oz+ Nu-Film-P 8oz	18.8 ± 9.2 a *	70.8 ± 8.0 a	3.3 ± 1.3 b	3.8 ± 1.3 ab
Delegate 25WG 6 oz+ Transfix 5oz/100 gal	16.7 ± 10.2 a	29.2 ± 29.2 b	1.0 ± 0.4 b	2.0 ± 1.4 b

Statistics: Two-way ANOVA: df=1, 30; F=7.71; P<0.0001      Two-way ANOVA: df=1, 30; F=8.32; P<0.0001

\* Indicates Rain and No Rain treatments for this chemical are significantly different from each other.

#### **Objective 4. Deliver comprehensive education programs to the Michigan blueberry industry.**

We held three workshops in the spring of 2014 at various locations in west Michigan to provide growers and consultants with hands-on training for SWD. The workshops consisted of a short overview presentation on SWD biology followed by hands-on training stations including monitoring with traps, adult identification, and larval sampling methods. Surveys conducted after the 2013 field season indicate the majority of growers (67%) applied at least six insecticide sprays against SWD and the cost of controlling SWD increased from \$150 in 2012 to \$250 in 2013. Survey participants indicated that management of insecticides and spray problems are some of the biggest obstacles for implementing a successful control program. These results provide valuable insight into grower response to SWD and how future educational programs can be tailored to fit the needs of the growers.

A follow up workshop in spring 2015 was conducted in Ottawa County with 25 participants to demonstrate the Enviroweather system and how information on weather conditions can be used to inform selection of sprays for SWD.

During the summer growing season of 2014 and during the winter of 2015, articles written by SWD researchers and MSUE educators were disseminated to the public through MSUE News for Agriculture and educator newsletters. Articles included warnings of increasing SWD populations across the region as well as management advice based on ongoing research. In addition, talks were given at several grower meetings (Great Lakes Expo, Southwest Hort Days, etc.) during the winter months of 2013/2014; attendance of these talks was mostly standing room only.

#### **BENEFICIARIES**

The data gathered from the MRL study were compiled into a stand-alone fact sheet that was available to processors and some leading growers for 2015 growing season as a first version. Feedback from this initial version has been gathered and a final version will be available for the

2016 growing season. This information will also be disseminated via the MSU News for Agriculture that is sent weekly to thousands of growers in Michigan and beyond.

Data collected from the objective that involved monitoring of SWD susceptibility to insecticides have been analyzed and used to establish baseline susceptibility for commonly used insecticides in Michigan blueberries. This will serve as an invaluable resource that can be used as a reference when conducting future susceptibility monitoring experiments. Knowing the baseline susceptibility will help with efforts to provide an early warning regarding resistance if it begins to develop in SWD populations.

Data from rainfastness experiments have been disseminated to growers via extension articles as well as extension talks. Growers have expressed great interest in these results and are using this information to help maximize the efficiency of the insecticides they are applying to control SWD.

#### LESSONS LEARNED

This project provided a unique opportunity to conduct research where a lack of information has been hurting the competitiveness of the Michigan blueberry industry. It was exciting to be able to determine residue profiles for insecticides and to distill the residue data into a fact sheet that growers, consultants, and processors can use, knowing that the growers and processors will be able to use this information for planning in the future. In addition, being able to conduct research on SWD insecticide susceptible was exciting, knowing that this information will be vital for providing an early warning for resistance development in the future. Also, it was nice to be able to provide growers and consultants with practical information on the performance of spreader-stickers for control of SWD.

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#### ADDITIONAL INFORMATION

None.

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PROJECT TITLE - FINAL approved in First Annual Report to USDA

**Cherry Marketing Institute** – Reintroducing Tart Cherries to Key Ingredient Decision Makers

#### PROJECT SUMMARY

Coming off a devastating crop year for Michigan in 2012, where the total crop harvested was a mere 11.5 million pounds in a state that has a capacity to produce 275 million pounds, the Michigan cherry industry needed to take aggressive action in order to maintain relationships with

key ingredient decision makers. Many companies that previously utilized tart cherries as an ingredient unfortunately sought alternatives during 2012 when U.S. cherries became scarce.

It was crucial for the Cherry Marketing Institute (CMI) to leverage a strong “comeback” campaign in conjunction with the anticipated 2013 harvest, to help reconnect with ingredient decision makers and resurrect on-shelf demand for tart cherries to revive the Michigan tart cherry industry and its more than 10,000 tart cherry industry employees.

The fiscal year following the 2013 harvest season presented a window of opportunity for CMI to develop and sustain awareness for the unique benefits of tart cherries through a strategic trade (business-to-business or B2B) advertising plan to reintroduce tart cherries as a healthful and available ingredient to key ingredient decision makers.

Given the continued increase in demand for tart cherry products over the last seven years, now more than ever, following a tough year for the tart cherry industry in 2012, strategic trade advertising in key publications (*Baking & Snack*, *Food Business News*, *Food Processing*, *Food Product Design*, *Snack Food & Wholesale Bakery* and *Prepared Foods*) presented a great opportunity to communicate that U.S. Montmorency tart cherries, in all product forms, are broadly appealing and **available**.

The Cherry Marketing Institute created two trade advertisements (*images of both are included in the additional information section*) to highlight the different usage applications for tart cherries.

## PROJECT APPROACH

With the awarded \$75,000, CMI worked to secure a robust trade media plan. CMI's final trade media campaign resulted in:

- 23 print advertising insertions (a full insertion list is in the additional information section)
- Four bonus advertising insertions (a full insertion list is in the additional information section)
- 11 pieces of added value opportunities fostered through the new trade media relationships
- The March Readers' Choice award from Food Business News for the CMI muffin ad, as determined by Food Business News' annual Baxter report survey results
- More than 750,000 media impressions generated on behalf of CMI
- More than 25,000 visits to CherryProcessor.com

Work on the trade media plan began in October of 2013 and the program's successes were presented to the CMI Board of Directors in August and September of 2014. Timing details are outlined below:

- **October 2013:** The media plan was finalized, purchased and presented to the CMI Board of Directors.
- **November 2013:** The advertising insertions were submitted to the trade media publications.
- **January-July 2014:** CMI ad insertions were featured in the trade media publications reaching ingredient decision makers (see full insertion list and dates).
- **August/September 2014:** The CMI Board of Directors was informed of the trade ad campaign's performance.

## GOALS AND OUTCOMES ACHIEVED

**Project Goal 1:** Re-introduce tart cherries as a powerful and *available* ingredient to target ingredient decision makers, supported by trade advertising in strategic trade publications.

- **Target:** We will target ingredient decision makers at food manufacturers and foodservice establishments to support renewed interest in choosing tart cherries as an

ingredient. The trade advertising campaign will support 15-20 paid insertions and up to five bonus insertions between January 2014 and December 2014. Knowing that we'll likely receive added value editorial placements via the campaign, and also have strong relationships with trade media from ongoing outreach, we'll look to generate up to two print and three online trade stories.

- **Benchmark:** For the trade advertising campaign, we hope to secure 15-20 paid insertions and up to five bonus insertions. The total outreach we expect with this project is more than 500,000 impressions.
- **Performance Measure:** We hope to continue building the momentum for tart cherries as an on-trend ingredient – which is why a strong trade media presence will be crucial to reaching ingredient decision makers. A key performance measure with ingredient decision makers and our trade ad campaign will be driving people to our supplier directory website, CherryProcessor.com, so we can use website analysis to determine whether we've increased traffic, and indirectly, interest in using/purchasing tart cherries for product ingredients.
- **Monitoring:** We will obtain a copy of each trade publication to ensure that the advertisements were placed. We will also use website analysis/back-end monitoring tools to assess traffic and drivers to CherryProcessor.com.
- **Outcome:** We successfully exceeded our goal, securing 23 paid insertions and four bonus insertions for a total of 27 trade advertisement insertions. This generated more than 750,000 impressions and helped facilitate 11 added value opportunities. Additionally, we saw more than 25,000 visits to CherryProcessor.com over the course of the media plan.

**Project Goal 2:** Increase tart cherry sales in Michigan based on industry analysis and statistics.

- **Target:** With a strong trade ad program in place for 2014 our goal is to increase sales by 25% over all categories.
- **Benchmark:** We are targeting 25% increase sales for calendar year, starting crop year 2013/14 fiscal year. A strong industry comeback program is critical for the entire cherry industry.
- **Performance Measure:** Sales will be based on industry analysis and statistics.
- **Monitoring:** Sales will be measured and compared to previous year's movement based on USDA figures.

**Outcome:** Sales for 2013 totaled 222.0 million pounds, compared to 123 million pounds in 2012. With the crop disaster in 2012 our goal was to build momentum going into the 2013 and 2014 marketing year. The 2014 crop is forecast at 265 million pounds and we are poised to grow the market because of last year's investment.

## BENEFICIARIES

The trade advertising plan executed benefited the tart cherry industry in many different facets:

- **Jobs/Sales:** Michigan has 420 tart cherry growers and 22 processors that produce and process more tart cherries than any other state, annually producing 75-80% of the U.S. supply. If one includes input suppliers (chemicals, petrol, nurseries, transportation, farm equipment, etc.), the cherry industry helps employ more than 10,000 people. Tart cherries are a great value added product used as an ingredient in many traditional and new products. Therefore, the healthier and more robust the tart cherry industry, the more jobs and income will flow to these families. The reintroduction of tart cherries to ingredient decision makers helped reignite interest in the tart cherry industry through targeted advertising placements. Recapturing the market loss to imports was critical for the future of Michigan cherry farmers.

- **Awareness/Usages:** Increased awareness in Business to Business (B2B) audiences is absolutely essential to continue building demand and growing the industry. We aggressively want to take our message back to manufacturers that tart cherries are available, make a great addition to most any recipe and are one of today's top "Superfruits" due to the health benefit research that has been published on tart cherries. By generating more than 750,000 impressions, we successfully engaged with key ingredient decision makers, increasing awareness of tart cherries' health properties and availability. Additionally, we accessed more than 25 ingredient decision makers, offering up our materials and key messaging continuously over the course of the year.
- **Attitudes:** Increasing the marketing funds behind this specific variety of tart cherries (Montmorency – mainly grown in Michigan) will help continue to develop highly positive attitudes toward the fruit and lead to increased utilization and consumption, the cornerstones of growth. Attitudes toward the tart cherry industry are also favorable, as evidenced by the receipt of the March 2014 *Food Business News* Readers' Choice award, which also provided specific feedback from readers about our advertisement including, "grabs attention", "great picture and interesting headline that made me want to read further," "eye grabbing layout – product main focus with bright and bold text top of page," among other positive comments.

#### LESSONS LEARNED

**Diverse and robust media plan:** We learned that the best way to reach a broad range of ingredient decision makers is by purchasing a diverse media plan in a variety of food, beverage and baking publications across the industry. Timing was key in making sure product was available and when U.S. tart cherries were once again available we immediately launched a very strong trade ad campaign that built momentum and was sustainable during the past winter and spring.

#### CONTACT PERSON

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#### ADDITIONAL INFORMATION

**Paid Insertions:**

1. November 2013 Food Business News
2. November 2013 Snack Food & Wholesale Bakery
3. November/December 2013 Food Product Design
4. December 2013 Prepared Foods
5. December 2013 Food Business News
6. December 2013 Food Processing
7. January/February 2014 Food Product Design
8. January 2014 Food Processing
9. January 2014 Baking & Snack
10. February 11, 2014 Food Business News
11. February 25, 2014 Food Business News
12. March 2014 Food Processing
13. April 2014 Snack Food & Wholesale Bakery
14. April 2014 Baking & Snack
15. April 2014 Food Processing
16. May 2014 Snack Food & Wholesale Bakery
17. May 2014 Prepared Foods
18. May/June 2014 Food Product Design

19. May 2014 Food Processing
20. June 2014 Baking & Snack
21. June 2014 Baking & Snack Full Page Adjacent Page
22. June Food Processing
23. July Food Business News

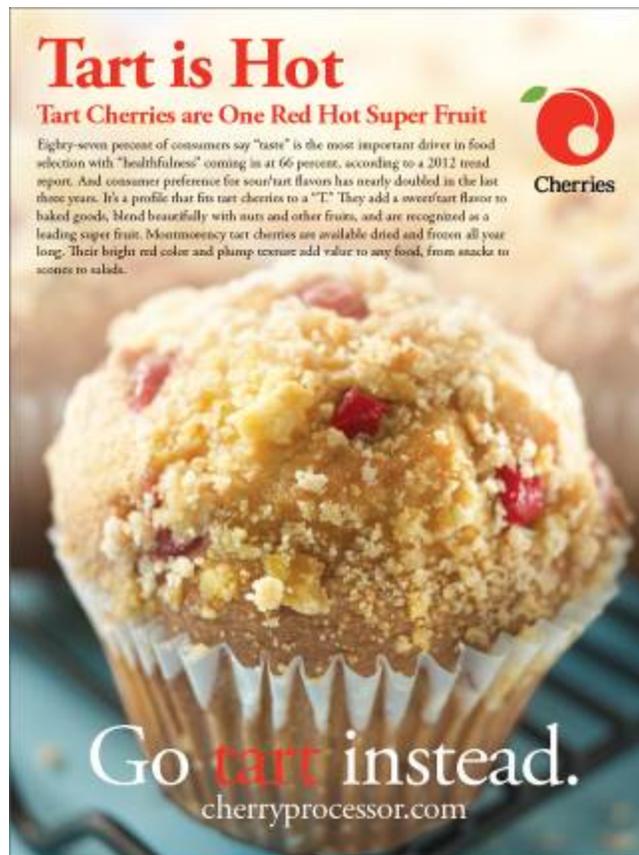
**Bonus Insertions:**

1. March 2014 Food Business News
2. April 2014 Food Business News
3. May 2014 Food Business News
4. June 2014 Food Business News

**Added Value:**

1. December 2013 Prepared Foods Healthy Ingredients Supplier Profile (3)
2. December 2013 Prepared Foods Online Banner Ads
3. December 2013 Food Business News Supplier Innovations and News Profile
4. February 2014 Baking & Snack Ingredient App Feature
5. February 2014 Prepared Foods Ad Readership Study
6. March 2014 Food Processing Supplier Profile
7. March 2014 Food Business News Ad Readership Study
8. May 2014 Prepared Foods Online Supplier Profile Advertorial

**Cherry Marketing Institute  
Muffin Advertisement:**



## Cherry Marketing Institute Power Bar Advertisement:



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### PROJECT TITLE - FINAL

**Michigan Vegetable Council** – *Phytophthora Capsici* on Brassica spp.: A New Threat to Vegetable Production

### PROJECT SUMMARY

Michigan ranks sixth nationally in cabbage production, an industry worth almost \$11.9 million representing 2,800 acres (Anonymous, 2015). Other *Brassica* spp. grown in Michigan include broccoli, Brussel sprouts, Chinese cabbage, collards, cauliflower, kale, horseradish, mustard greens, radish, and turnips, which collectively represent an additional 4,000 Michigan acres (Anonymous, 2007). Brassica cover crops including mustards and oilseed radish are planted in Michigan vegetable fields and have been promoted as having the potential to manage weeds and soilborne pathogens, including *Phytophthora capsici* (Ji et al., 2012), through the release of glucosinolate compounds upon incorporation.

Phytophthora crown, root, and fruit rot, caused by *P. capsici*, is a major constraint to cucurbit and pepper production in Michigan (Granke et al., 2012). *P. capsici* is also an occasional but significant problem for eggplant, tomato, and succulent bean production (Gevens et al., 2008). Prior to 2003, beans were thought to be a good rotational crop for growers producing cucurbit and solanaceous vegetables on farms with *P. capsici*-infested parcels. However, from 2003 until 2005, losses of approximately 10 to 35% were noted in some snap bean fields in Michigan

(Gevens et al., 2008). Hence, succulent beans are no longer considered a good rotational crop for *P. capsici* management. Stunting, chlorosis and plant death were observed on cabbage grown in soil infested with a *P. capsici* isolate from snap bean in a preliminary replicated greenhouse study (Krasnow and Hausbeck, 2015). Prior to our research, this pathogen was not considered a threat to other crops including those currently being used as cover crops. As a result of the research conducted through this grant, *P. capsici* is now reported to infect Brassica biofumigant cover crops (Krasnow and Hausbeck, 2015) and was isolated from the roots of 7 Brassica vegetables grown in infested potting soil. This research has been peer reviewed and accepted for publication in the refereed journal Plant Disease so that this information can be disseminated widely. At this juncture, we have not attempted to isolate *P. capsici* from infected *Brassica* spp. growing in infested field soils. Although growers have mentioned that their *Brassica* spp. cover crops do not always become well established, it is unlikely that a pathogen had been considered to be at fault. The susceptibility of *Brassica* spp. to *P. capsici* will most certainly result in the buildup of pathogen populations in the soil; rotating cucurbits with Brassica crops may be inadvisable.

*P. capsici* is widespread in major vegetable production regions in Michigan and is a major constraint to cucurbit and pepper production. The results from this grant indicate for the first time that certain Brassica cover crops should no longer be used specifically to reduce *P. capsici* levels in infested fields, and that Brassica vegetables should be monitored for Phytophthora blight in fields with a history of *P. capsici*. This information will substantially alter grower recommendations.

#### PROJECT APPROACH

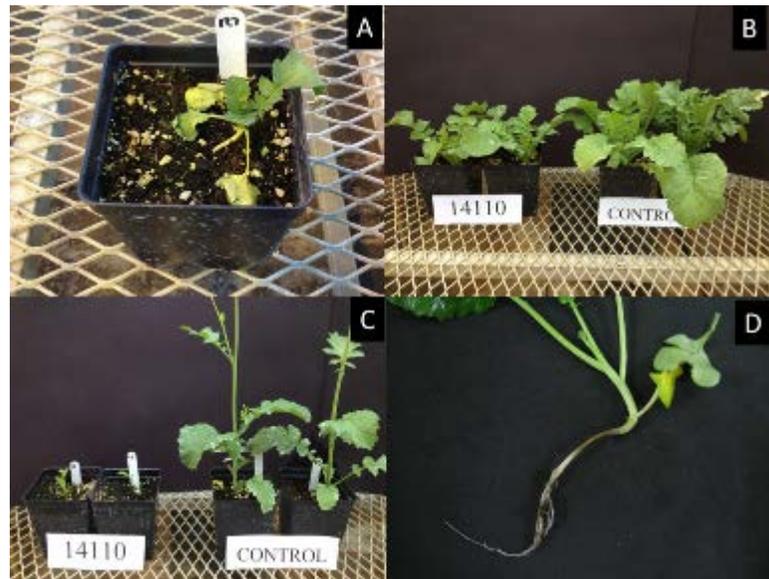
Phytophthora crown, root, and fruit rot, caused by *P. capsici*, is a major constraint to cucurbit and pepper production in Michigan. Tomato, eggplant, and succulent bean are also infected by this pathogen. Brassica vegetables have historically been considered non-hosts for *P. capsici*. We determined the susceptibility of Brassica vegetables (broccoli, cabbage, mustard greens, radish, turnip) and cover crops (oriental mustard, oilseed radish) to *P. capsici* in replicated greenhouse and field studies to assess the threat of this pathogen to Brassica production and to improve rotational crop recommendations for *P. capsici* management. The results of this research have been communicated to growers along with practical management recommendations for *P. capsici* on Brassica and other vegetable crops. These results have been submitted for peer review and accepted for publication in the journal of Plant Disease.

#### GOALS AND OUTCOMES ACHIEVED

- 1. Determine susceptibility of Brassica vegetables (broccoli, cabbage, mustard greens, radishes, turnips) to *Phytophthora capsici* isolates from bean, pepper, and cucurbits.**
- 2. Determine susceptibility of Brassica cover crops (oilseed radish and oriental mustard) to *P. capsici* isolates from bean, pepper, and cucurbits**

Objectives 1 and 2 were completed in the same study. Ten Brassica crops were seeded into 288-well flats in the Plant Science Research greenhouses at Michigan State University (MSU). After eight days, the seedlings were transplanted into 5-inch greenhouse pots containing potting

media (Sure-Mix, Galesburg, MI) and 3 g of *P. capsici*-infested millet gently mixed to incorporate with the soil. Millet was infested separately with three virulent *P. capsici* isolates (10193, A2 mating type [MT] originally from snap bean; 12889, A1 MT originally from pepper; 14110, A2 MT originally from cucumber). There were six pots per replication and pots were organized in a completely randomized design. The experiment was repeated once. Ratings were taken for five weeks postinoculation using a zero-four scale adapted from Glosier et al. (2007): 0=healthy, 1=minor wilt/stunt, 2=moderate wilt/chlorosis/stunt, 3=severe stunting/chlorosis, 4=plant death. Plant height and width were measured during the growing period. After the final rating, plants were harvested and fresh weights of shoots were recorded as well as radish/turnip root weights. Data were analyzed using SAS Proc Mixed, and statistical differences were compared using the Fisher's Least Significant Differences test ( $P = 0.05$ ). Average temperature and relative humidity in the two experiments were 79.9°F and 19.1%, and 85°F and 41%, respectively.



**Figure 1.** Symptoms of disease caused by *P. capsici* on (A,B) 'Groundhog' radish and (C,D) 'Pacific Gold' mustard, including (A) severe wilting, (B) stunting, (C) plant death, and (D) necrotic lesion on the lower stem of the seedling.

Disease symptoms observed on inoculated Brassica plants included stunting, wilting, chlorosis, and plant death (Figure 1). Initial wilting and chlorosis were usually evident within three days after inoculation. All *Brassica* spp. tested were able to become infected, and discolored roots and constriction of the stem at the soil-line were apparent upon harvest of symptomatic plants. The cultivars Pacific Gold and Groundhog displayed a 78% and 24% reduction in fresh weight (Table 1), respectively, compared to the controls ( $P < 0.001$ ). All *P. capsici* isolates tested reduced the height of 'Pacific Gold' plants ( $P < 0.001$ ) while significant differences were not observed in 'Florida Broad Leaf' ( $P = 0.213$ ); both are *B. juncea* (Figure 2). *P. capsici* reduced root weight of all three *Brassica* spp. that form enlarged roots ( $P = 0.1$ ). *P. capsici* was successfully isolated from the roots of all *Brassica* spp. included in this study.

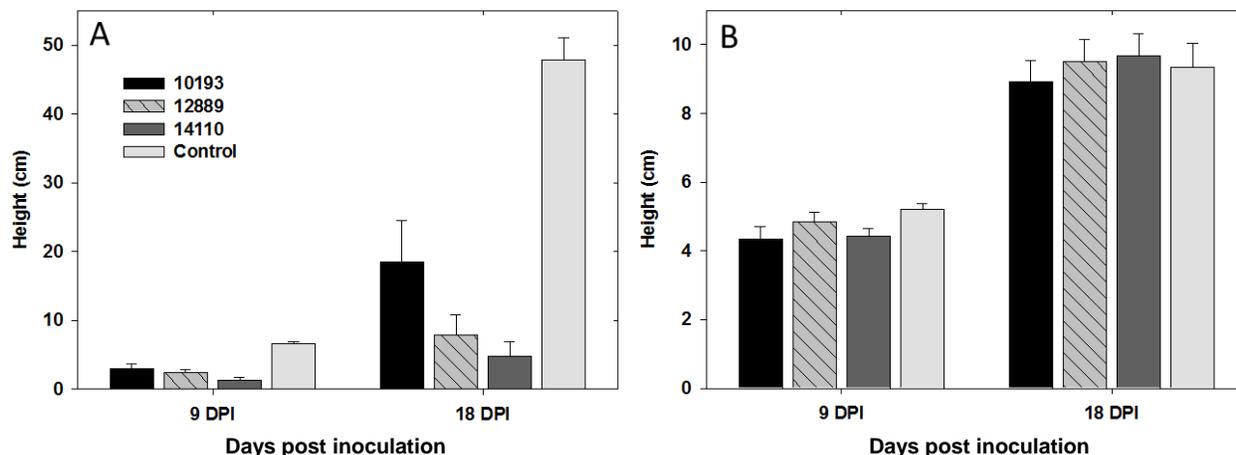
**Table 1.** Effect of inoculation with *P. capsici* isolates 10193, 12889 and 14110 on foliar fresh weight of cultivars of Brassica vegetables and cover crops.

Crop 'cultivar' (species)	Reduction in foliar fresh weight (%) <sup>x</sup>				
	10193 <sup>y</sup>	12889 <sup>y</sup>	14110 <sup>y</sup>	Mean <sup>z</sup>	
<b>Brassica Vegetables</b>					
Broccoli 'Emerald Crown' ( <i>B. oleracea</i> var. <i>botrytis</i> )	11	17	15	14	
Cabbage 'Bronco' ( <i>B. oleracea</i> var. <i>capitata</i> )	16	24	22	21	**
Cabbage 'Buscaro' ( <i>B. oleracea</i> var. <i>capitata</i> )	13	22	29	21	*
Cauliflower 'Snow Crown' ( <i>B. oleracea</i> var. <i>botrytis</i> )	9	11	19	13	
Mustard greens 'Florida Broad Leaf' ( <i>B. juncea</i> )	19	4	10	11	
Radish 'Rover' ( <i>Raphanus sativus</i> )	0	13	2	5	
Turnip 'Purple Top White Globe' ( <i>B. rapa</i> )	17	3	19	13	*
<b>Brassica Cover Crops</b>					
Rape 'Dwarf Essex' ( <i>B. napus</i> )	6	0	0	2	
Oriental mustard 'Pacific Gold' ( <i>B. juncea</i> )	66	78	90	78	**

<sup>x</sup>Percent decrease in foliar fresh weight as compared to control plants. Foliar fresh weight (g) measured at the conclusion of each trial.

<sup>y</sup>*P. capsici* isolate designation from the culture collection of Dr. M.K. Hausbeck.

<sup>z</sup>Single and double asterisks \* and \*\* indicate significant treatment differences at  $P < 0.1$  and  $P < 0.01$ , respectively, according to Fishers LSD test.



**Figure 2.** Differences in height of (A) 'Pacific Gold' oriental mustard and (B) 'Florida Broad Leaf' mustard at 9 and 18 days postinoculation (DPI) with *P. capsici* isolates 10193, 12889, 14110 and a control. Each column represents the mean of 2 trials with 6 replicate plants per isolate per trial. Error bars represent the standard error of the mean.

These findings are highly significant to Michigan vegetable producers due to the importance of *P. capsici* in pepper, tomato, and cucurbit production. If *P. capsici* can survive and reproduce on the roots or debris of Brassica crops, then using these crops in rotations and as biofumigant cover crops may not reduce inoculum levels in the field. This further limits growers' crop rotation options. Additionally, biofumigant cover crops are often marketed as possessing the ability to decrease the quantity of soilborne pathogens present in the soil, and published research has even shown reductions in *P. capsici* inoculum levels in biofumigated soil or media. The ability for this pathogen to cause plant death to certain biofumigant cover crops is thus highly significant. As a direct outcome of this research, growers should be advised that certain cover crops are highly unlikely to reduce *P. capsici* inoculum.

### 3. Determine effect of inoculum density on disease development in cabbage.

Seeds of 'Bronco' cabbage were planted into 128-well flats. Two weeks after sowing, the seedlings were transplanted into five-inch black greenhouse pots containing Sure-Mix peat potting media and 3 g of *P. capsici* infested millet (100 g millet, 72 ml water, 0.08 g asparagine, 7 colonized agar plugs) mixed into the transplant hole. Plants were organized in a completely randomized design with a control treatment receiving millet that was inoculated with sterile agar plugs. There were seven replicate plants per pathogen isolate. Pathogen isolates were used to separately infest the millet: including 11 *P. capsici* isolates originally isolated from solanaceous (12889, 13695, 13692), cucurbitaceous (OP97, SP98, 14110), and fabaceous (10193, 10170, 9948, 13707, 13704) hosts, and a *P. dreschleri* isolate (13594). Plants were watered heavily to promote disease. Temperature and relative humidity were measured with WatchDog dataloggers (Spectrum Technologies, Inc., Aurora, IL). Plants were rated weekly for four weeks post transplant on a 0-4 scale adapted from Glosier et al. (2007): 0=healthy, 1=minor wilt/stunt, 2=wilt/chlorosis/stunt, 3=severe stunting/chlorosis, 4=plant death. The number of fully-expanded leaves were counted and whole plant dry weights were taken after the final rating. Average temperature was 79.9°F and relative humidity was 22.1% during the study.

Cabbage plants in this study did not exhibit severe wilting or chlorosis. Plants inoculated with certain isolates, however, were stunted as compared to the control. Of the twelve isolates tested, the three most virulent, from three host families, were selected for use in future studies: pathogen isolates 10193, 12889, and 14110.

#### 4. Test cabbage varieties for tolerance to *P. capsici*.

Due to a better understanding of the pathogenicity of *P. capsici* to *Brassica* spp., cabbage varieties were not used. Cabbage varieties tend to become stunted, not killed, when infected with *P. capsici* and were less susceptible than 'Pacific Gold' mustard. Therefore, biofumigant cover crops were selected for this trial. Seven biofumigant cover crops were selected and sown into 288-well flats in the Plant Science Research Greenhouses at MSU. After eight days, the seedlings were transplanted into 5-inch greenhouse pots containing Sure-Mix potting media and 3 g of *P. capsici*-infested millet gently mixed to incorporate with the growing media. Millet was infested separately with four virulent *P. capsici* isolates (14118, A1 MT, originally from cucumber; 14119, A2 MT, originally from squash; 12889, A1 MT, originally from pepper; 14110, A2 MT, originally from cucumber). There were six pots per replication and pots were organized in a completely randomized design. Ratings were made for five weeks postinoculation using a 0-4 scale adapted from Glosier et al. (2007): 0=healthy, 1=minor wilt/stunt, 2= moderate wilt/chlorosis/stunt, 3=severe stunting/chlorosis, 4=plant death. Plant height and width were measured during the growing period. After the final rating, plants were harvested and fresh weights of shoots were recorded. Data were analyzed using SAS Proc GLIMMIX, and statistical differences were compared using the Fisher's Least Significant Differences test ( $P=0.05$ ).

Disease symptoms observed on inoculated Brassica plants included stunting, wilting, chlorosis, and plant death. Initial wilting and chlorosis were usually evident within three days after inoculation. All *Brassica* spp. tested were able to become infected, and discolored roots and constriction of the stem at the soil-line were apparent upon harvest of symptomatic plants. The cultivars Nemat and Ida Gold displayed the largest differences compared to the control (Table 2). Isolate 14119 reduced the fresh weight of cultivars Ida, Nemat, and Rumba. Isolate 12889 was not virulent on the cultivars tested.

**Table 2.** Effect of inoculation with *P. capsici* isolates 12889, 14110, 14118 and 14119 on foliar fresh weight of cultivars of Brassica cover crops.

Brassica cover crop cultivar	Foliar fresh weight (g) <sup>x</sup>				
	12889 <sup>y</sup>	14110 <sup>y</sup>	14118 <sup>y</sup>	14119 <sup>y</sup>	Control
'Braco' white mustard	9.2 a <sup>z</sup>	5.8 b	6.8 ab	5.5 b	6.7 ab
'Buckbuster' rape	9.8 ab	10.0 a	9.8 ab	8.1 c	8.3 c
'Ida Gold' yellow mustard	8.3 a	5.7 ab	5.7 ab	4.8 b	8.3 a
'Kodiak' brown mustard	8.7 a	7.8 a	8.0 a	5.3 b	7.5 ab
'Nemat' arugula	5.2 a	3.8 ab	3.5 ab	2.1 b	5.0 a
'Rumba' white mustard	6.7 ab	6.8 ab	5.8 b	6.0 b	8.5 a
'Tiller' radish	16.7 a	16.7 a	11.7 b	13.2 ab	14.3 ab

<sup>x</sup>Foliar fresh weight (g) measured at the conclusion of each trial.

<sup>y</sup>*P. capsici* isolate designation from the culture collection of Dr. M.K. Hausbeck.

<sup>z</sup>Treatments with a letter in common not significantly different  $P < 0.05$ , according to Fishers LSD test.

#### 5. Evaluate soil-applied fungicides for control of *P. capsici* on cabbage.

Cabbage cultivar Bronco was seeded into 128-well transplant flats. Eight days after sowing, the seedlings were transplanted into five-inch plastic pots containing 3 g infested millet using the most and least virulent *P. capsici* isolates identified in Objective 3, 10193/12889 and 13707, respectively. The study was arranged as a completely randomized design with 6 pots per replicate. Fungicides (Table 3) were drenched into the pots at 60 ml per pot immediately

following transplant and again 14 days later. Plants were watered heavily to promote disease. Plants were rated for disease using a 0-4 scale adapted from Glosier et al. (2007): 0=healthy, 1=minor wilt/stunt, 2=wilt/chlorosis/stunt, 3=severe stunting/chlorosis, 4=plant death. Plant height and width were measured during the growing period. After the final rating, foliar fresh weights were recorded. Isolations from roots were made onto selective media. Data were analyzed using SAS Proc Mixed, and statistical differences were compared using the Fisher's Least Significant Differences test ( $P=0.05$ ). Average temperature was 77.7°F and average relative humidity was 22.9%.

The *Phytophthora* inoculum in this trial resulted in minimum damage to the inoculated control (Table 3), possibly due to the vigor of 'Bronco.' Isolates were significantly different, ( $P=0.01$ ). Four fungicides resulted in phytotoxicity to the cabbage plants: Ridomil Gold, Presidio, V10208, and Reason. Plants with phytotoxicity were stunted with cupped leaves and burned leaf margins. The fungicide Vital resulted in plants which were significantly heavier than the untreated control ( $P=0.05$ ).

This objective was also completed as a field trial; however, due to unseasonably cool temperatures in 2014 (averages in the mid 60's), disease pressure was low. Results are not presented due to insignificant differences among treatments.

**Table 3.** Effect of *P. capsici* isolate and fungicides on foliar fresh weight and height of cabbage.

Fungicide rate/A	Foliar fresh weight (g)		Height (cm)	
	<i>P. capsici</i> 10193/12889	<i>P. capsici</i> 13707	<i>P. capsici</i> 10193/12889	<i>P. capsici</i> 13707
Untreated inoculated.....	18.6 ab <sup>z</sup>	16.3 b	11.4 a	11.8 a
Untreated uninoculated...	17.4 b	17.4 b	11.0 a	12.1 a
Aliette 5 lb.....	17.7 b	17.4 b	10.6 a	11.4 a
Forum 6 fl oz .....	20.7 ab	16.1 b	11.7 a	11.7 a
Presidio 4 fl oz.....	9.1 d	11.7 c	8.6 b	9.1 b
Ranman 2.75 fl oz .....	19.0 ab	16.3 b	11.0 a	11.7 a
Reason 500 8.2 fl oz.....	6.4 d	9.4 c	6.0 c	6.9 c
Revus 8 fl oz.....	20.6 ab	17.3 b	11.4 a	11.8 a
Ridomil Gold 0.25 pt.....	6.3 d	1.6 d	6.0 c	4.3 d
V10208 0.5 pt .....	12.7 c	12.1 c	8.9 b	9.1 b
Vital 4 pt .....	21.6 a	22.4 a	11.6 a	12.1 a
Zorvec OD 0.6 pt .....	20.1 ab	17.4 b	11.9 a	10.9 a

<sup>z</sup> columns with a letter in common are significantly different (Fisher's LSD,  $P = 0.05$ ).

## 6. Disseminate research findings to growers so that they may be incorporated into the grower's production plan in a timely manner.

Results from the objectives in this grant were presented at the 2014 Great Lakes Fruit and Vegetable Expo in Grand Rapids, MI during the Cole Crops Session. Results were also discussed with growers who attended the Twilight Meeting in Byron Center, MI.

A survey on this research was distributed at a growers' meeting. The growers' years of experience in producing Brassica crops ranged from 1 to 44 and averaged 20.8 years. Broccoli was grown by 17% of the respondents, the rest did not grow any of the seven Brassica vegetables crops listed on the survey, but grew other Brassica crops. Sixty percent of the growers grew Brassicas on 51-100 acres of their farms in 2014, the remainder grew less than 25 acres. Seventeen percent of the growers used mustards as a cover crop and 17% have rotated Brassicas with other *Phytophthora*-susceptible crops such as cucurbits, asparagus, beans, tomatoes or peppers. Sixty-seven percent of the growers were unaware that Brassica crops are susceptible to *Phytophthora*, and 67% of the growers will use this information when planning use of Brassica cover crops in the future.

**Figure 3.** Cabbage head rotted by *P. capsici* 10 days postinoculation in simulated storage conditions.



## BENEFICIARIES

*P. capsici* has the potential to infect and cause significant losses on 70,000 acres of known susceptible vegetables grown annually in Michigan; adding Brassica vegetables to the list increases the acreage to 73,100 (Anonymous, 2015). These susceptible fresh market and processing vegetable crops (bean, cabbage, cucumber, pepper, pumpkin, squash, tomato) were worth \$163.7 million to Michigan growers in 2014 (Anonymous, 2015). Land to be used for vegetable production that does not have a history of *P. capsici* is becoming increasingly scarce. The widespread utilization of *Brassica* spp. as vegetable crops and for biofumigation in vegetable production, and the prevalence of *P. capsici* in vegetable fields, highlights the importance of conducting research into the virulence of this pathogen on *Brassica* spp. Even though severe disease was not observed on some of the vegetable crops tested in this study, roots infected at a low level may enable survival of *P. capsici* in soil, thereby unintentionally increasing inoculum levels, and result in significant reductions in yield. This could negatively affect vegetable growers who use *P. capsici*-infested parcels or use Brassica cover crops as part of a *P. capsici* management program. This information will impact growers and industry stakeholders who produce any of the susceptible vegetables, and any grower who rotates their crops with Brassica cover crops.

## LESSONS LEARNED

Brassica cover cropping is an important cultural practice used in annual vegetable production due to potential improvements in soil drainage, weed suppression, and soil organic matter. In vegetable production systems, Brassica cover crops are often planted immediately preceding planting or post-harvest, usually with the aim to decrease populations of soilborne pathogens. Our study indicates that *P. capsici* is able to colonize the roots of diverse *Brassica* spp. and can cause plant death of mustard (*Brassica juncea*) and radish (*Raphanus sativus* var. *oleiferus*) used specifically for biofumigation. The susceptibility of Brassica tissue to *P. capsici* observed in previous studies may be related to the plant part used, as there are differences between above-ground tissue and roots in quantity and composition of glucosinolates. However, *P. capsici* was also able to cause lesions on the foliage of cabbage, mustard, and other *Brassica* spp. when plants were inoculated in the laboratory and greenhouse with zoospores or mycelia (*data not shown*). The ability of the pathogen to infect diverse tissue types means that Brassica residues incorporated into the soil may act as a reservoir for *P. capsici* instead of reducing inoculum levels. It is very important to continue to communicate these results to growers so that wise choices can be made in the selection of cover crops. ***Without this research, the levels of the pathogen would build up in the soils as a result of the cover crop being used. This research will directly impact grower recommendations.***

The objectives in this grant focused on root rot; however, additional work showed the above-ground plant parts of the *Brassica* spp. tested in this study were susceptible to Phytophthora rot. When two-week-old seedlings of the ten cultivars listed in Table 1 were sprayed with a *P. capsici* zoospore suspension and placed in a humid chamber, all species became infected, with disease most severe on the 'Bronco' and 'Buscaro' cabbage and 'Pacific Gold' mustard. Inoculation with a *P. capsici* mycelial plug resulted in infection of the foliage of mature cabbage, turnip, and

mustard plants. In a postharvest experiment, cabbage, turnip, and radish were grown until maturity and inoculated via wounds that could occur during harvest (i.e., the cut stem end of a harvested cabbage head, or a “topped” turnip). Infection occurred within three days postinoculation at ambient temperature, resulting in large lesions from which *P. capsici* was isolated. Cabbage was further tested for postharvest head rotting in a simulated storage environment at the MSU Plant Pathology Farm storage building. Ten days after inoculation of the cut stem end with *P. capsici*, heads were completely rotted (Figure 3). This suggests that harvesting cabbage during wet weather may result in post-harvest losses due to *Phytophthora*. The pathogen was also found to produce oospores (the overwintering structure of *P. capsici*) in cabbage foliage.

#### CONTACT PERSON

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#### ADDITIONAL INFORMATION

##### **Publications:**

- Krasnow, C., and Hausbeck, M. 2015. Pathogenicity of *Phytophthora capsici* to Brassica vegetable crops and biofumigation cover crops (*Brassica* spp.). Plant Disease 99 (in press).
- Krasnow, C., and Hausbeck, M. 2014. Know the diseases that affect cole crops. Pages 6-8 in: Cole Crops Session Summaries, Great Lakes Fruit, Vegetable and Farm Market Expo, Grand Rapids, MI, Dec. Online.

##### **Presentations:**

- 'Know the diseases that affect cole crops,' C. Krasnow and M. Hausbeck, Cole Crops Session, Great Lakes Fruit, Vegetable and Farm Market Expo, Grand Rapids, Dec 2014.

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## PROJECT TITLE - FINAL

### Michigan Onion Committee – Characterizing Onion Pathogens to Develop Disease Management

## PROJECT SUMMARY

Michigan ranks seventh in the U.S. for production of storage onions. In 2010, 2011, and 2012, respectively, Michigan produced 100, 91, and 72 million pounds of onions worth \$10, \$10, and \$8 million dollars on 4,200, 3,900, and 3,000 acres (USDA NASS). Foliar and soilborne diseases are responsible in part for a decrease in acres planted and the reduced profitability of this crop to Michigan's economy. Michigan onion growers need better tools to manage two diseases in order to improve crop quality and increase overall profitability.

Pink root is caused by the soilborne fungus *Setophoma terrestris*. Infection results in wilting, yellowing, and death of leaves; bulbs are soft and undersized. Infected roots become pink in color. Currently, there are no economically feasible management tools available for pink root control.

In the last three years, bacterial diseases have become a major limitation for growers in Allegan and Ottawa County, MI. The specific pathogens associated with the losses had not been previously identified, but bacterial leaf blight (*Pantoea agglomerans*) and bacterial center rot (*Pantoea ananatis*) have now been verified. Symptoms generally appear as tan lesions with water-soaked margins and progress to wilting and leaf dieback. Copper-based bactericides are the only products which may provide some protection but growers have not observed control with high disease pressure. Tools to better identify and limit bacterial pathogens are necessary to ensure high yields and high quality, marketable onions.

The objectives of this project included characterizing pathogen populations, sampling Michigan onion fields, testing fungicide programs, and developing diagnostic markers to readily identify pathogens affecting onions.

## PROJECT APPROACH

In recent years, Michigan onion growers have suffered yield losses and storage rots due to pink root and/or bacterial diseases. In this study, five fungicide treatments, Quadris Flowable, Quadris Top, Inspire, Inspire Super, and Fontelis significantly limited pink root disease as determined by root density; Fontelis increased plant fresh weight compared to the other treatments. Phytotoxicity was observed for the applications of Inspire Super, Quadris Top, Switch 62.5WG, and Vanguard at zero days after inoculation and with Inspire Super, Quadris Top, Switch 62.5WG, Vanguard, and Quadris Flowable applied zero and 14 days after inoculation.

Prior to 2012, bacterial leaf blight had not been reported previously on Michigan onions. Bacterial diseases result in losses both before harvest, and infected onions cannot be successfully stored. Thus, there is a critical need to develop management tools for Michigan onion growers to manage these pathogens. Studies were conducted to characterize the bacterial pathogens and determine efficacy of bactericides applied through the season to limit bacterial diseases.

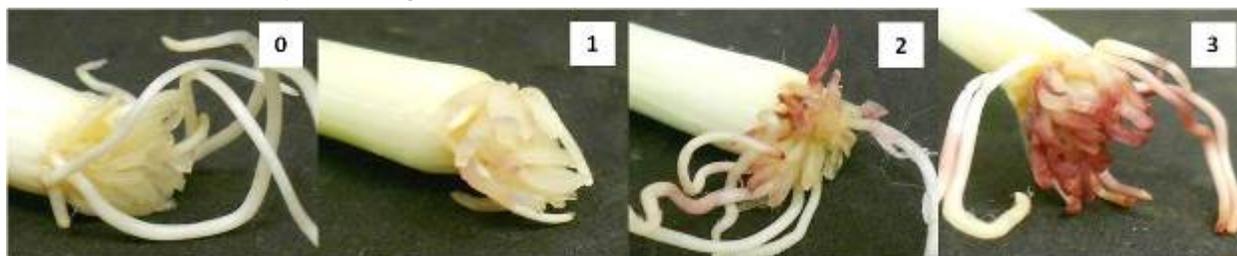
Michigan onion fields were sampled to determine bacterial disease onset and prevalence, and bacterial isolates were characterized.

## GOALS AND OUTCOMES ACHIEVED

**1a. Pink root: Characterize variation within a collection of the pink root pathogen from Michigan onion fields. We will determine if some isolates can cause more disease than others, and if isolates are genetically diverse.**

**Sampling, isolation and identification.** Fifty onion bulbs with pink-colored roots were collected randomly from fields in nine locations: Byron Center/Kent County (BYC); Charlotte/Eaton (CLT); Grant/Newago (GRT); Hudsonville/Ottawa (HUD); Lansing/Ingham (LAN); Martin/Allegan (MAR); Plainwell/Allegan (PWL); Portland/Ionia (POR); and Stockbridge/Ingham (STO). Different stages of disease development were observed. Symptoms appearing on the roots were various shade of pink discoloration. The root density of severely affected plants was small. Many diseased roots were shriveled and easily disintegrated. Five disinfected roots per bulb were placed on water agar and incubated under darkness for seven days at  $26\pm 1^{\circ}\text{C}$  then removed to place under 13-hour photoperiod and 11-hour darkness for another seven days at the same temperature. Dark brown setose pycnidia bearing hyaline, one-celled, ellipsoidal conidia that formed on the culture medium were preliminarily identified as the genus *Setophoma terrestris*, and a total of 469 isolates of *S. terrestris* were confirmed.

**Disease virulence testing.** A total of 98 isolates of *S. terrestris* were evaluated for the virulence of pink root on green bunching onions. Pathogen inocula were prepared by culturing each isolate on cornmeal agar and were incubated at  $26\pm 1^{\circ}\text{C}$  under darkness for seven days. A 15 mm diameter of mycelium disc was taken from the edge of a colony and placed on top of a sterile moist cotton ball in a sterile test tube. The green bunching onions were disinfected with 0.5% sodium hypochlorite for five minutes, rinsed three times with distilled water, and blotted dry on paper toweling. Roots of each plant were trimmed into 1 cm in length, and placed on top of the colonized agar plug in the test tube. A disc of sterile cornmeal agar was used as an uninoculated control. Test tubes were capped and were sealed with parafilm for maintaining humidity. Tubes were incubated at  $26\pm 1^{\circ}\text{C}$  and a 16-hour photoperiod. Each isolate was replicated three times. The experimental unit was performed as a completely randomized design with two replicates. Disease virulence was rated at ten days post inoculation (dpi) using a scale from zero-three; where 0=healthy roots with no disease symptoms, 1=<10% of root tissue showing slight, and only a few (<10%) roots with strong coloration, 2= $\geq 10\%$  to 50% of the root tissue showing strong pink discoloration, and 3= $> 50\%$  of the roots completely pink (Figure 1).



**Figure 1.** Scale used to rate disease virulence on green bunching onion in growth chamber evaluation; where 0=no disease symptoms, 1=slight pink coloration showing on the roots, and only a few (<10%) roots with strong coloration, 2=10 to 50% of the roots with strong pink coloration, 3= $> 50\%$  of the roots completely pink.

Pink coloration of roots of inoculated green onion was initially observed at 3 dpi. New roots of the inoculated plants were 100% infected. Control plants inoculated with sterile agar disc did not show disease symptoms. All isolates of *S. terrestris* used in this study caused disease on green bunching onions. The ranges of disease virulence of the isolates were from 1.5 to 3.0 with an average of 2.48 and of the populations were from 2.17 to 2.67 (Table 1). When compared at the population level, the PWL population was the most virulent whereas the STO population was the least virulent (Table 1). Analysis of variance showed statistically significant differences in virulence among the isolates ( $P=0.0004$ ,  $\alpha=0.05$ ), as well as among the populations ( $P=0.0027$ ,  $\alpha=0.05$ ).

**Table 1.** Means of disease virulence of nine populations of *S. terrestris* from different Michigan onion fields collected from 2011 through 2012.

Population	Sample size	Mean <sup>2</sup>	Population	Sample size	Mean <sup>2</sup>		
BYC	8	2.35	ab	MAR	7	2.48	abc
CLT	14	2.36	ab	PLW	7	2.67	c
GRT	20	2.61	c	POR	14	2.46	abc
HUD	14	2.43	ab	STO	3	2.17	a
LAN	11	2.52	b				

<sup>2</sup>Means with a common letter do not differ significantly based on Kruskal-Wallis multiple comparison tests ( $\alpha = 0.05$ ). Disease virulence was rated based on a scale of 0 to 3 as described previously.

**Genetic diversity.** Spores of *S. terrestris* were grown in half-strength of potato dextrose broth on a rotary shaker (100 rpm) at  $26 \pm 1^\circ\text{C}$  under darkness for 5 days. Mycelium was harvested, vacuum-filtered through a  $0.45 \mu\text{m}$ -pore-size filter (Whatman), and frozen at  $-20^\circ\text{C}$  until use. Genomic DNA was isolated from 40 to 80 mg of lyophilized mycelium using the Wizard Genomic DNA Purification kit (Promega Corp., Leiden, Netherlands).

Partial 28S nrRNA gene (LSU) was amplified with primers LR0R and LR7. The PCR reactions were conducted in a Mastercycler Pro thermocycler (Eppendorf, Hauppauge, NY). The amplified DNA products were sequenced with a single PCR primer by submitting to Macrogen Corp. (Macrogen USA, Rockville, MD). The nucleotide sequences were compared to the nucleotide collection in NCBI using a BLASTn search (<http://blast.ncbi.nlm.nih.gov/Blast>) analysis. The nucleotide sequences of the LSU region had 97% to 100% homology with those of nucleotide sequence data of *S. terrestris* species that are available in the NCBI database. Seven ISSR primers were used in the PCR amplification. The ISSR data were transformed into a binary data set; present or absent bands were scored as 1 or 0, respectively. To determine genetic diversity across the 98 individuals Nei's gene diversity (H), and Shannon information index (IS), number of polymorphic bands (NP), percentage of polymorphic bands (P) were calculated using the software program POPGENE ver. 1.32. To investigate the relationships among populations, unweighted pair group method with arithmetic average (UPGMA) was generated from a matrix of Nei's genetic distance between individuals using POPGENE ver. 1.32. Analyses of molecular variance (AMOVA) evaluated for genetic variability within and among populations and genetic differentiation among individuals (PhiPT) were performed using program GenALex ver. 6.5. Pearson's correlation coefficients used to determine the relationship of morphological characteristics, disease virulence, or genetic diversity were calculated using PROC CORR of SAS version 9.3 (SAS Institute Inc., Cary, NY).

Genetic diversity was assessed using seven inter-simple sequence repeats (ISSR) markers. The percentage of polymorphic bands, Nei's gene diversity, and Shannon's information index at the population level and species level were 63.8%, 0.2399, 0.3413 and 96.2% 0.2843, 0.4336, respectively. The average number of migrants per generation (Nm) among population was 2.3663, indicating genotype flow occurred among populations. The population differentiation was low ( $G_{ST} = 0.1744$ ), which was supported with AMOVA that the genetic variation occurred within populations (93%) rather than among populations (7%).

Analyses of the ISSR-fingerprints based on Nei's genetic distance grouped the 98 isolates into two distinct clusters. The UPGMA dendrogram revealed that there was no grouping of the isolates according to their geographical origins. Pearson's correlation coefficients were calculated for measuring the relationship among morphological characteristics, disease virulence, and number of polymorphic bands. The result showed that the relationships between number of polymorphic bands and the percentage of isolates lacking pycnidia, disease virulence

and colony diameter, and the high level of pycnidia production and the presence of chlamydospores were positively correlated ( $\alpha = 0.05$ ).

### 1b. Pink root: Evaluate efficacy of soil-applied fungicides for control of pink root.

In order to propose control strategies for the control of pink root on onions, a fungicide trial was conducted in a research greenhouse at Michigan State University (MSU). Approximately six-week-old 'Highlander' seedlings were transplanted into plastic pots. Plants were inoculated with millet seed infested with the pink root pathogen followed by drenching with fungicides (Table 2). There were a total of 20 treatments that included healthy and diseased controls and nine fungicide treatments. Fungicides were either applied once (0 day after inoculation) or twice (0 and 14 days after inoculation). Root density and plant fresh weight were measured at 55 days after inoculation.

**Table 2.** Fungicides tested for control of pink root in greenhouse trial in 2014.

Trade name	Active ingredient (A.I.)	FRAC code *	Rate/acre **
Cannonball	fludioxinal	3	0.44
1b Fontelis	penthiopyrad	7	2.90 pt
Inspire	difenoconazole	3	0.44 pt
Inspire Super	cyprodinil+difenoconazole	9, 3	1.25 pt
Quadris Flowable	azoxystrobin	11	1.19
pt Quadris Top	azoxystrobin+difenoconazole	11, 3	0.88 pt
Switch 62.5WG	cyprodinil+fludioxinal	9, 12	0.88 lb
Vanguard	cyprodinil	9	0.63 lb
Serenade Soil	<i>Bacillus subtilis</i>	--	8.0 pt

\* FRAC=Fungicide Resistance Action Committee. Numbers and letters are used to distinguish the fungicide groups based on their mode of action, therefore fungicides with the same FRAC code have similar mode of action.

\*\* Rate/acre was calculated based on % A.I.

Two isolates of *S. terrestris* were used for inoculum. A colonized agar plug of each isolate was transferred onto cornmeal agar, incubated under darkness for one week then removed to an environment with a 13 hour light/11 hour dark cycle for one week to enhance spore production. All incubation periods were maintained at  $26\pm 1^\circ\text{C}$ . The spore suspension was prepared by collecting pycnidia using a sterile scalpel blade and putting them into a 15-ml sterile centrifuge tube containing 5 ml sterile distilled water. The test tube was shaken vigorously to release the conidia. The conidial suspension of each isolate was adjusted to  $10^5$  spores/ml with sterile distilled water. Aliquots (10 ml) of the spore suspension from each of the two isolates were mixed to inoculate sterile millet seeds. Millet seed (600 g) was mixed with water (423 ml) in a clear autoclavable plastic bag, autoclaved for two consecutive cycles at  $121^\circ\text{C}$  for 75 minutes, and allowed to cool at room temperature. The sterile millet seed was then inoculated with 20 ml of the conidial suspension and incubated at  $26\pm 1^\circ\text{C}$  for four weeks.

Nine fungicides were evaluated for their ability to limit pink root in greenhouse trials conducted on the campus of MSU. Fungicides selected for this study (Table 2) are commercially available products registered to control foliar diseases of dry bulb onions. The fungicides were applied as a soil drench zero day post inoculation (dpi) or at zero and 14 dpi. Fungicide rates were obtained from the manufacturers' labels with the exception of Fontelis that was not yet labeled at the initiation of these trials. The experiment was a completely randomized design with two replicates. Each treatment consisted of ten seedlings. An experimental unit was one 'Highlander' seedling at the three-true-leaf stage (six weeks old) grown in a  $5.5 \times 7.5 \times 5.0 \text{ cm}^3$  plastic pot containing autoclaved muck soil which was taken from the east side of the Plant

Pathology farm at MSU. Seedlings were inoculated with 12 g of millet seeds infested with *S. terrestris*. An equal amount of sterile millet seeds were added to the uninoculated control.

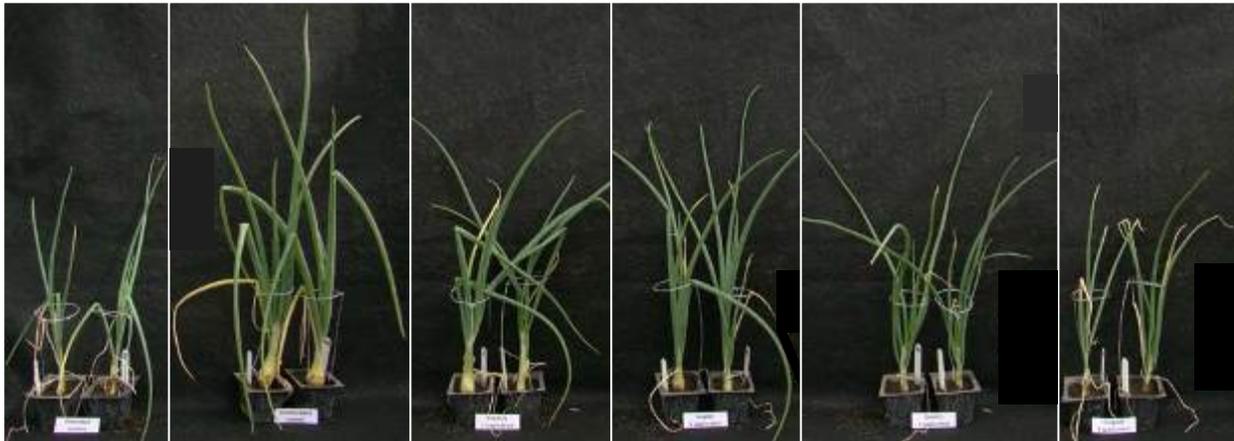
At 49 dpi, the number of leaves per plant was counted and plant height (soil line to the tip of the tallest leaf) was measured. At 55 dpi, onions were carefully removed from the pots and the roots were washed with tap water. The entire bulb with attached foliage was weighed for fresh weight. Bulb circumference was measured at the widest point of the bulb or stem base. Onion roots were visually assessed for density using a scale from one-five, where 1=low (0 to 20%), 2=intermediate-low (>20 to 40%), 3=intermediate (>40 to 60%), 4=intermediate-high (>60% to 80%), and 5=high (>80%) (Figure 2).

After the onions were harvested and evaluated for root infection and plant growth, three plants were randomly sampled from each replicate. Root surfaces were disinfected with 0.5% sodium hypochlorite solution for ten minutes, rinsed three times with sterile distilled water, and blotted dry with paper toweling. Five excised roots were placed on water agar and incubated under darkness for seven days and then placed under 13-hour light/11-hour dark for an additional seven days at  $26\pm 1^{\circ}\text{C}$ . Fungal structures were compared to the isolates used for inoculum. The morphological characteristics of the isolates used in this study were compared to *S. terrestris* isolates used in inoculum.

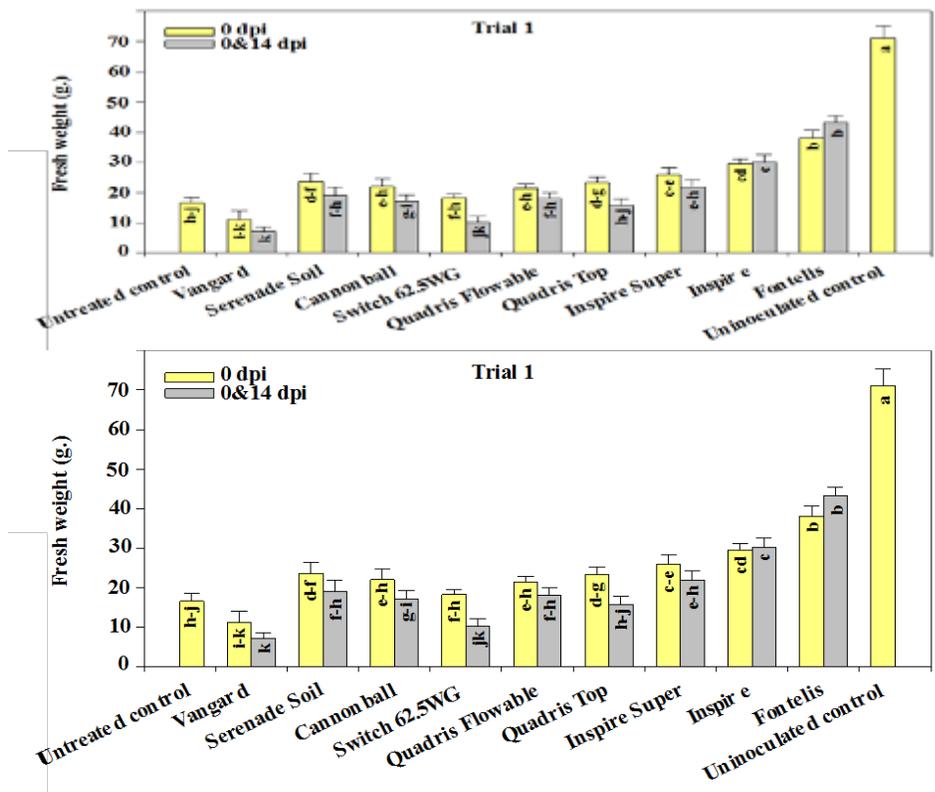
Means of the number of total leaves per plant, plant height, fresh weight, and bulb circumference were analyzed separately by analysis of variance (ANOVA) using the PROC MIXED procedure. Trials were considered random variable. Fungicide treatments were considered fixed variables. Data were tested for normality and homogeneity of variance (Levene's test) of the residuals. The root density was compared among treatments using



**Figure 2.** Scale used to rate root density on onion following inoculation with *S. terrestris* to evaluate the response to fungicides; 1 = low (0 to 20%), 2 = intermediate-low (>20 to 40%), 3= intermediate (>40 to 60%), 4 = intermediate-high (>60% to 80%), and 5 = high (>80%).



**Figure 4.** Results of pink root trial comparing (A) an untreated inoculated control, (B) an untreated uninoculated control, and onion plants treated with fungicides (C) Fontelis, (D) Inspire, (E), Quadris, and (F) Vangard. Photos were taken 55 days after inoculation.



**Figure 5.** Root density and plant fresh weight of onions treated with fungicides in the greenhouse 0 days after inoculation with the pink root pathogen (yellow bars) or 0 and 14 days after inoculation (gray bars). Root density was rated using a scale from 1 to 5. Bars with a letter in common are not significantly different (least significant means test,  $\alpha=0.05$ ).

the PROC GLIMMIX procedure (SAS Institute Inc., Cary, NC). Five fungicide treatments, Quadris Flowable, Quadris Top, Inspire, Inspire Super, and Fontelis significantly limited disease as determined by root density;

Fontelis had increased plant fresh weight compared to the other treatments (Figure 4,5). Phytotoxicity was observed for the applications of Inspire Super, Quadris Top, Switch 62.5WG, and Vanguard at 0 days after inoculation and with Inspire Super, Quadris Top, Switch 62.5WG, Vanguard, and Quadris Flowable applied 0 and 14 days after inoculation.

Overall, Fontelis applied as a drench was the most effective treatment among the other fungicides (Figure 4,5); however, the severity of pink root was only partially limited with the fungicide treatments as compared with the untreated healthy control. Phytotoxicity was observed on the plants treated with fungicides that had either azoxystrobin or cyprodinil as an active ingredient. It was also observed that the phytotoxic effect increased with two applications.

### **1c. Pink root: Develop a management plan for Michigan growers to manage pink root.**

Treatment with Fontelis (penthiopyrad) and cultivar selection could improve pink root control. Planting onion cultivars less susceptible to pink root such as 'Hendrix' and 'Sedona' tend to contribute to inoculum buildup in the soil less than more susceptible cultivars, such as 'Highlander.' Even though the cultivar Highlander performs well in season when the environmental conditions do not favor to pink root development, continued planting of this Highlander would allow the level of inoculum to increase over time, therefore crop failure can result.

### **2a. Bacterial Rot: Scout fields and collect onion bacterial pathogen (*P. agglomerans* and *P. ananatis*) isolates from symptomatic onions in commercial onion fields in Michigan.**

Seventeen onion plots were scouted every two weeks in six Michigan counties during June through August 2014 for the presence of foliar bacterial symptoms, such as leaf blight, water-soaked lesions or soft rot. Fourteen yellow and two red onion cultivars showing disease symptoms were selected for sampling beginning when the plants were at the two-leaf stage until the time of bulb enlargement. Fifty to 100 symptomatic plants were randomly collected for each sampling from each county for bacterial isolation. Disease incidence was estimated from 100 to 150 plants in each plot.

The symptoms appeared as leaf blight with water-soaked margins, a soft rot of the inner leaf, or shriveling at the base of the inner leaf. Disease symptoms were detected as early as at the two-to-three leaf stage (Figure 6) when plants were approximately 10 cm tall in some locations. More frequently, bacterial leaf blight was observed approximately six-seven weeks after planting. In scouted fields, disease incidence progressed throughout the season and reached an incidence of up to 80% fields within three months after planting.



**Figure 6.** Bacterial disease on onion at the 2-3 leaf stage.

**2b. Bacterial Rot: Test and use a diagnostic molecular marker to quickly and effectively identify bacterial pathogens affecting Michigan onion fields.**

A portion of healthy and infected leaf tissue was cut into about 1.5 x 1.5 cm<sup>2</sup> and transferred into a 1.7-ml microcentrifuge tube containing 200 µl of sterile distilled water. The tissue was ground with a sterile pestle into fine particles to release bacterial cells from the leaf tissue, and the suspension was streaked on a semi-selective onion extract medium. Individual colonies of bacteria showing different morphological characteristics such as color, margin, and size were transferred to nutrient broth yeast extract agar twice to obtain pure cultures. Purified bacterial cultures were submitted to MSU Diagnostic Services for biochemical analyzing through BIOLOG (Hayward, CA). *Pantoea ananatis* species were identified using diagnostic primers PanITS1 and EC5 as they are not in the BIOLOG database. The identification was confirmed by using 16s rRNA sequencing.

A total of 414 isolates of bacteria obtained from onion samples were identified through BIOLOG (Table 3). For *P. ananatis* isolates that were identified by using diagnostic primers (PanIST1 and EC5) provided a very consistent banding pattern (~400 bp). All bacterial isolates, including *P. ananatis*, were confirmed by sequencing of 16s rRNA gene. The results obtained by using BLASTN showed that the nucleotide sequences of bacterial isolates had 97 to 99% similarity compared to the sequences of bacterial species on the NCBI nucleotide collection database. Among 414 bacterial isolates identified, the majority of bacterial species obtained were *Pantoea agglomerans* and *P. ananatis* with a total number of 176 and 83, respectively. Other bacteria included *Enterobacter cowanii*, *Pseudomonas fluorescens*, *Pantoea dispersa*, *Enterobacter cloacae*, *Burkholderia ambifaria*, and *Rahnella aquatilis*. These combined identification methods effectively identified bacterial pathogens affecting onion.

**Table 3.** Summary of identified bacterial isolates by county.

Bacteria isolated	Counties						Total	%
	Allegan	Ottawa	Ingham	Newaygo	Eaton	Calhoun		
<i>Pantoea agglomerans</i> .....	41	43	27	30	12	33	176	42.5
<i>Pantoea ananatis</i> .....	23	13	12	8	8	19	83	17.4
<i>Enterobacter cowanii</i> .....	8	2	2	3	5	11	31	7.5
<i>Pseudomonas fluorescens</i> .	3	2	1	4	2	3	15	3.6
<i>Pantoea dispersa</i> .....	4	1	0	1	2	2	10	1.2
<i>Enterobacter cloacae</i> .....	0	0	0	2	0	0	2	0.5
<i>Burkholderia ambifaria</i> ....	0	0	0	0	0	2	2	0.5
<i>Dickeya dadantii</i> .....	0	0	0	2	0	0	2	0.5
<i>Rahnella aquatilis</i> .....	0	0	2	0	0	0	2	0.5
No ID .....	20	16	14	15	4	16	85	20.5
<b>Total</b>	<b>99</b>	<b>68</b>	<b>58</b>	<b>65</b>	<b>35</b>	<b>87</b>	<b>414</b>	

**2c. Bacterial Rot: Characterize variation within a collection of bacterial pathogens from Michigan onion fields. We will determine if some isolates cause more disease than others and if bacterial isolates are clonal (genetically the same) or genetically diverse from each other. We will also determine if isolates in some areas (counties) are similar to isolates from other counties or if they are different.**

The results from the previous study showed that the most common three bacterial species isolated from onion were *P. agglomerans*, *P. ananatis*, and *E. cowanii*. Ten selected isolates of each species was preliminarily tested for their virulence on onion plants by using spray inoculation. Bacteria were streaked on NBY medium and incubated in the dark at ~30°C for

24 hours. A bacterial suspension for each isolate was prepared in sterile water to achieve an optical density at 600 nm ( $OD_{600}$ ) = 0.20, which corresponds to approximately  $10^8$  colony-forming units (CFU)/ml. One known virulent isolate of *P. agglomerans* and sterile water were used as controls. Inoculated plants were covered with plastic bags to promote humidity and were stored in growth chambers for seven days at 20°C with constant light. Plants were arranged in completely randomized design with three replicates for each isolates. After a week postinoculation, onion plants were checked for leaf blight symptoms by using control plants as comparison. Of ten isolates tested, eight isolates of *P. agglomerans*, nine of *P. ananatis* with *E. cowanii*. and seven of *E. cowanii* (Figure 7A) caused disease.



**Figure 7.** Infection of onion (A) foliage and (B) bulb

Since *E. cowanii* has never been reported as a pathogen on onion before, this experiment tested its pathogenicity on onion foliage. Preliminary study of its ability to infect onion bulbs was also

tested. Inoculum of three *E. cowanii* isolates were prepared as described previously. For each isolate, 0.5 ml of bacterial suspension was injected in three onion bulbs with sterile water as a control by using a 12.7-mm-long hypodermic needle and 1-ml gauge syringe. Injected onion bulbs were placed in a plastic container to promote moist conditions and store under room temperature (~23°C). Two weeks after incubation, all injected bulbs with *E. cowanii* showed rot symptoms at the injected sites when the bulbs were cut open, while the water controls were negative (Figure 7B).

Hypersensitivity reaction on tobacco was also tested among 23 selected *E. cowanii* isolates. The bacterial suspension was prepared as described above. The inoculum was injected into well-expanded tobacco leaves by using a 1-ml gauge syringe and replicated three times for each isolates. Tobacco leaves injected with sterile water were used as a control. The inoculated tobacco plants were kept under greenhouse condition and watered daily. Two days after inoculation, all plants inoculated with *E. cowanii* isolates displayed chlorotic to severe necrotic lesions at the injected sides; leaves inoculated with sterile water remained healthy.

## **2d. Bacterial Rot: Develop a management plan for Michigan growers to manage bacterial diseases of onion.**

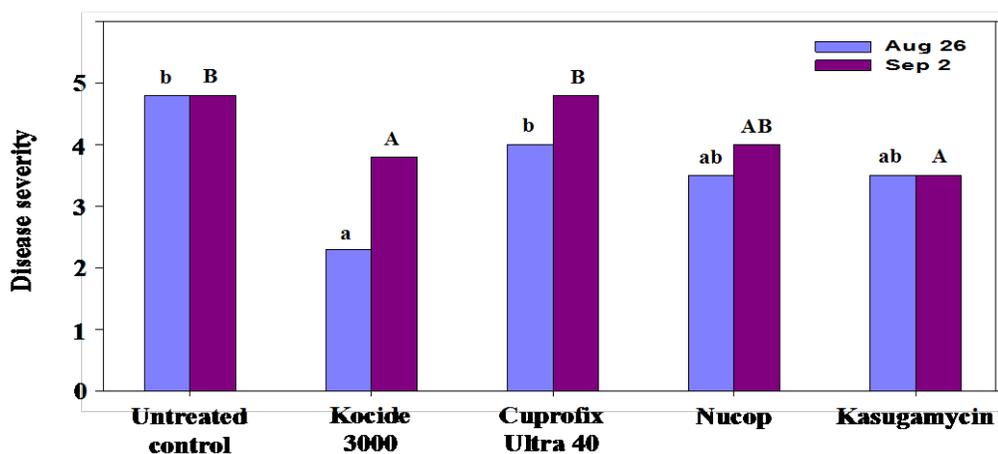
A replicated trial was conducted in a commercial field with a grower cooperator in Ingham County, MI to investigate the ability of copper-based and antibiotic products to control bacterial leaf blight (Table 4). Treatments were applied as a foliar spray at seven-day intervals. The first treatment was applied on 2 July and additional treatments were made until 20 August. Disease severity was assessed twice using a scale of one-five; where 1=no disease, 2=1 to 25% of foliage blighted, 3=>25 to 50%, 4=>50 to 75%, and 5=>75% of foliage blighted.

Kocide 3000 was significantly better in reducing bacterial blight severity on the first disease assessment date in comparison to the other treatments. On the second observation date, both Kocide 3000 and Kasugamycin limited bacterial leaf blight compared to the untreated control (Figure 8).

**Table 4.** Products tested for control of bacterial leaf blight in 2014.

Treatment	Active ingredient	FRAC* code	Rate/Acre	Spray Schedule	App. Type
Untreated control ....	--	--	--	--	--
Kocide 3000 .....	Copper hydroxide	M1	1.50 lb	7 days	Foliar
Cuprofix Ultra 40....	Basic copper sulfate	M1	1.25 lb	7 days	Foliar
Nucop .....	Copper hydroxide	M1	1.50 lb	7 days	Foliar
Kasugamycin.....	Kasugamycin	24	2.0 pt	7 days	Foliar

\*FRAC stands for Fungicide Resistance Action Committee. Numbers and letters are used to distinguish the fungicide groups based on their mode of action, therefore fungicides with the same FRAC code have similar mode of action.



**Figure 8.** Products tested for control of bacterial leaf blight in 2014. Disease severity assessed on 26 August (blue bars) and 2 September (purple bars). Disease severity was rated using a scale of 1 to 5. Bars with a letter in common are not significantly different (LSD t test,  $\alpha = 0.05$ ).

### Grower survey.

Onion growers at a growers meeting were surveyed regarding this research project. The growers represented 1 to 40 years of experience in growing onions, and averaged 18.1 years of experience. Half (50%) of the growers grew 26-50 acres of onions in 2014, half grew 51-100 acres (50%). All growers believed that pink root is a problem in their fields. Most growers (85.7%) have become aware that some fungicides, including Fontelis, Quadris Top and Inspire Super, are effective in controlling pink root. Some growers (28.6%) have applied Fontelis, Quadris Top or Inspire Super to their onions in 2014 to control pink root. All growers were

aware that multiple applications of products containing difenoconazole, such as Quadris Top and Inspire Super, may cause injury or stunting to onions.

All growers have found onions with bacterial rot in both their fields and storage facilities. All growers scout their onion fields for bacterial rot and pink root. In regards to concern over bacterial rot, growers ranked onion production phases affected by bacterial rot in order of importance (1=most important, 6=least important): 4.4 field drying, 4.0 seedling, 4.0 shipping/retail, 3.0 bulb initiation, 3.0 storage, 2.9 bulb enlargement.

Other disease issues that growers would like to see addressed: downy mildew (42.9% of growers), other bacterial diseases (14.3%), sprouts (14.3%, NOT a disease).

#### BENEFICIARIES

Onions (92.5 million pounds) worth \$11.1 million were grown on 2,500 acres in Michigan in 2014 (USDA NASS). This industry has still not rebounded to production levels of 2009 (133 million pounds of onions worth over \$14.3 million on 4,000 acres) (USDA NASS); diseases seriously limit onion production in Michigan. Development of disease management programs, communicating results, and implementing novel production strategies are vital to improving the onion industry. Boosting onion production will benefit onion growers, processors and allied stakeholders in the state of Michigan; information developed will also be communicated to onion growers outside of the state.

#### LESSONS LEARNED

The occurrence of bacterial diseases has increased over the last several years in Michigan and has expanded to onion growing areas in multiple counties. Copper-based bactericides are the only options for field control. *P. agglomerans*, *P. ananatis* and *E. cowanii* are the most dominant bacterial species infecting onion foliage in Michigan. The two *Pantoea* spp. are known onion pathogens, but further research is needed on *E. cowanii* to determine if it is pathogenic on onion. Evaluation of onion cultivars for their susceptibility to *P. agglomerans*, *P. ananatis*, and *E. cowanii* will be performed in growth chamber experiments at MSU. Integration of effective bactericides with selection of less susceptible cultivars may result in reduction of bacterial leaf blight incidence.

Treatment with Fontelis (penthiopyrad) and cultivar selection could improve pink root control. Planting onion cultivars less susceptible to pink root such as 'Hendrix' and 'Sedona' tend to contribute less to inoculum buildup in the soil than more susceptible cultivars such as 'Highlander.' Growers are interested in trying Fontelis in the furrow to protect the onion roots during the early stage of development.

#### CONTACT PERSON

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#### ADDITIONAL INFORMATION

##### Presentations

'A smorgasbord of vegetable diseases is on today's menu,' North Carolina State University Department of Plant Pathology Seminar, 25 March 2015.

'Survey of bacterial disease in onion in Michigan and identification,' K. Eang Tho, P. Wiriyajitsomboon, J.M. Byrne, and M.K. Hausbeck, National Allium Research Conference, Scottsdale, AZ, 3-5 December 2014.

'Characterization of *Setophoma terrestris* populations in Michigan onion fields and fungicide testing,' P. Wiriyaitsomboon and M. Hausbeck, National Allium Research Conference, Scottsdale, AZ, 3-5 December 2014.

'Identifying and managing new and old onion disease, M. Hausbeck, P. Wiriyaitsomboon, J. Byrne, and K. Eang Tho, Great Lakes Fruit, Vegetable and Farm Market Expo, Grand Rapids, MI, 10 December 2014.

### Publications

Eang Tho, K., Wiriyaitsomboon, P., and Hausbeck, M. 2015. First report of *Pantoea agglomerans* causing onion leaf blight and bulb rot in Michigan. Plant Disease 99 (First Look/accepted). DOI: <http://dx.doi.org/10.1094/PDIS-01-15-0091-PDN>.

Eang Tho, K., Wiriyaitsomboon, P., Byrne, J.M., and Hausbeck, M.K. 2014. Survey of bacterial diseases in onion in Michigan and identification. Abstract. Page 9 in: Proceedings of the 2014 National Allium Research Conference, Scottsdale, AZ, 3-6 December.

Wiriyaitsomboon, P., and Hausbeck, M.K. 2014. Characterization of *Setophoma terrestris* populations in Michigan onion fields. Abstract. Pages 15-16 in: Proceedings of the 2014 National Allium Research Conference, Scottsdale, AZ, 3-6 December.

Wiriyaitsomboon, P., Eang Tho, K., Byrne, J.M., and Hausbeck, M.K. Identifying and managing new and old onion diseases. Pages 7-11 in: Onion Session Summaries, Great Lakes Fruit, Vegetable and Farm Market Expo, Grand Rapids, MI, 10 December 2014. Online.

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### PROJECT TITLE - FINAL

**Michigan Asparagus Advisory Board** – Increasing Asparagus Production through the use of Disease –Tolerant varieties, Targeted Fungicide Applications, and Irrigation

### PROJECT SUMMARY

Imports of asparagus over the past decade have grown substantially with most of the supply coming from Peru and Mexico. Under NAFTA, Mexico receives preferential tariff treatment in the U.S. market, while Peru receives duty-free access to the U.S. market as a benefit of the Andean Trade Preference Act of 1991. Due to increased imports of processed asparagus from Peru, the Michigan industry has been transitioning from a processed to a fresh market product. Successful expansion of fresh market asparagus production in Michigan will require new disease-resistant cultivars and the development and refinement of integrated disease management practices that promote spear quality (no blemishes due to disease, closed tips at long harvest lengths) and yield while maintaining or reducing production costs.

Foliar diseases (purple spot and rust) can result in defoliation of the fern (Meyer et al., 2000). In some instances, 60-90% of the harvested spears may display purplish lesions characteristic of purple spot (Hausbeck et al., 1999) and are not acceptable for the fresh market. In addition to negatively impacting yields, premature defoliation of asparagus by foliar pathogens negatively affect crown vigor and may increase susceptibility of the crown to *Fusarium* and *Phytophthora* infection. *Fusarium* species cause damping-off of seedlings in crown nurseries, poor stand establishment in young asparagus fields, and a slow decline in productivity of mature fields (Elmer et al., 1996). *Phytophthora* crown and spear rot has recently emerged as a threat to the

industry (since 2004) and is widespread in asparagus production regions in Michigan (Saude et al., 2008). The cultivars currently grown in Michigan are all susceptible to these diseases. Only the fungicide Cannonball is labeled for *Fusarium* control as a crown soak; this can be applied immediately before planting.

Following several seasons with prolonged drought periods, asparagus grower interest in irrigation has increased, with gradual increases in irrigated acreage occurring annually. Previous studies suggest that reductions in drought stress and improvements in fern health in irrigated systems may improve asparagus resilience to *Fusarium* root rot (Panka and Rolbiecki, 2008). However, excessive irrigation could exacerbate both foliar and soilborne diseases. As growers adopt irrigation, their irrigation must be optimized to improve fern growth while limiting disease.

## PROJECT APPROACH

Asparagus breeding lines and commercial varieties were evaluated for tolerance to foliar and soilborne diseases. Fungicides were tested for efficacy against purple spot foliar disease at the Asparagus Research Farm located in Oceana Co. and soil-applied fungicides were tested against *Fusarium* and *Phytophthora* in a commercial grower's seedbed. The effects of an irrigation delivery system and timing of watering was evaluated in relationship to disease incidence, crop quality and yield in research plots located at the Asparagus Research Farm. Dr. Hausbeck, Michigan State University (MSU), performed the disease research while Dr. Brainard, MSU, performed the irrigation research. Different cultivars responded differently to diseases; in some cases different isolates of the pathogens varied in their ability to cause disease. However, over multiple trials, 'Millenium' asparagus appeared to be highly susceptible to purple spot and *Fusarium* whereas UG09 was significantly less susceptible to purple spot and *Phytophthora*. Overhead irrigation had slightly higher foliar disease incidence than unirrigated treatments, but greater fern growth. Successful asparagus production requires an integrated strategy, including choosing high yielding cultivars that are not susceptible to disease, effective fungicides applied at key times in the production cycle, and monitoring foliar disease if using overhead irrigation.

## GOALS AND OUTCOMES ACHIEVED

### **1. Evaluate breeding lines and commercial varieties for disease tolerance to foliar and soilborne diseases.**

A trial was established with one-year-old plants of 16 asparagus cultivars (Table 1) in May of 2014 at Hart, MI. The asparagus seedlings were initially grown in plastic pots with Baccto® professional potting mix and maintained under greenhouse conditions. A representative number of plants (a minimum of 8) per cultivar and experimental line were selected, transplanted to 2-gallon plastic pots and placed near an asparagus field with natural disease pressure at the Asparagus Research Farm in Hart, MI. The experiment was arranged as a complete randomized unbalanced design with a potted asparagus plant serving as one replicate. Disease severity (expressed as the percentage of the aerial plant tissue affected) was visually assessed according to the Horsfall-Barratt grading system, where 1=0% plant area diseased, 2=>0 to 3%, 3=>3 to 6%, 4=>6 to 12%, 5=>12 to 25%, 6=>25 to 50%, 7=>50 to 75%, 8=>75 to 87%, 9=>87 to 94%, 10=>94 to 97%, 11=>97 to <100%, 12=100% plant area diseased. Ratings were taken on 20 August, 3 and 16 September. The area under the disease progress curve (AUDPC) was calculated through the trapezoidal method. Data were squared root transformed to meet statistical assumption of normality. Analysis of variance was performed using the general linear models procedure of SAS (version 9.4) and means were separated using Fisher's least significant difference test.

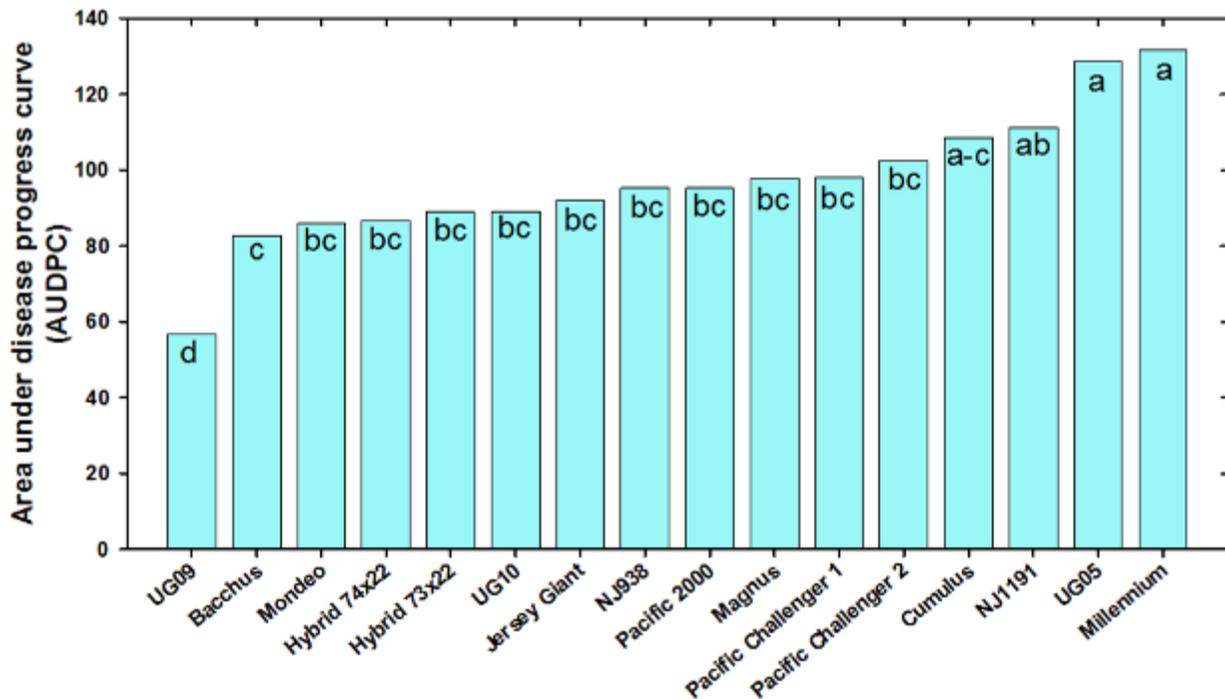
**Table 1.** List of asparagus cultivars and breeding lines evaluated for purple spot tolerance.

Cultivars/breeding lines	Seed source	Cultivars/breeding lines	Seed source
Bacchus	Bejo Seeds Inc.	NJ1191	Rutgers University
Cumulus	Bejo Seeds Inc.	NJ938	Rutgers University
Hybrid 73x22	Aspara Pacific Ltd	Pacific 2000	Aspara Pacific Ltd
Hybrid 74x22	Aspara Pacific Ltd	Pacific Challenger 1	Aspara Pacific Ltd
Jersey Giant	Walker Bros Inc.	Pacific Challenger 2	Aspara Pacific Ltd
Magnus	Bejo Seeds Inc.	UG10	University of Guelph
Millennium	University of Guelph	UG05	University of Guelph
Mondeo	Vilmorin	UG09	University of Guelph

Temperatures during the growing season were relatively cool and conducive for purple spot development. Results of the disease severity assessment are shown in the Table 2. Significant differences in cultivar susceptibility to asparagus purple spot were detected, with the UG09 line demonstrating the highest level of resistance (Fig. 1). This variety showed the lowest AUDPC value over the period of time evaluated. A total of thirteen lines included in the test showed moderate levels resistance, whereas Millennium and UG05 showed the highest disease susceptibility when compared to UG09 in this particular trial.

**Table 2.** Response of sixteen cultivars and breeding lines of asparagus to purple spot disease.

Cultivar/breeding line	Purple spot severity			Cultivar/breeding line	Purple spot severity		
	8/20	9/3	9/16		8/20	9/3	9/16
UG09 .....	1.54	2.14	2.36	Pacific 2000 .....	2.93	3.43	3.86
Bacchus .....	2.56	2.89	3.56	Magnus.....	3.30	3.08	3.38
Mondeo.....	2.50	3.07	3.57	Pacific Challenger 1 ...	3.09	3.07	3.71
Hybrid 74x22.....	3.00	2.73	3.36	Pacific Challenger 2...	2.92	3.79	4.07
Hybrid 73x22.....	2.83	3.29	3.50	Cumulus .....	3.33	3.57	4.07
UG10 .....	2.86	3.23	3.36	NJ1191 .....	3.29	4.00	4.71
Jersey Giant.....	3.18	3.31	3.92	UG05.....	4.11	4.56	5.22
NJ938 .....	2.83	3.46	3.69	Millennium .....	3.82	4.91	5.27

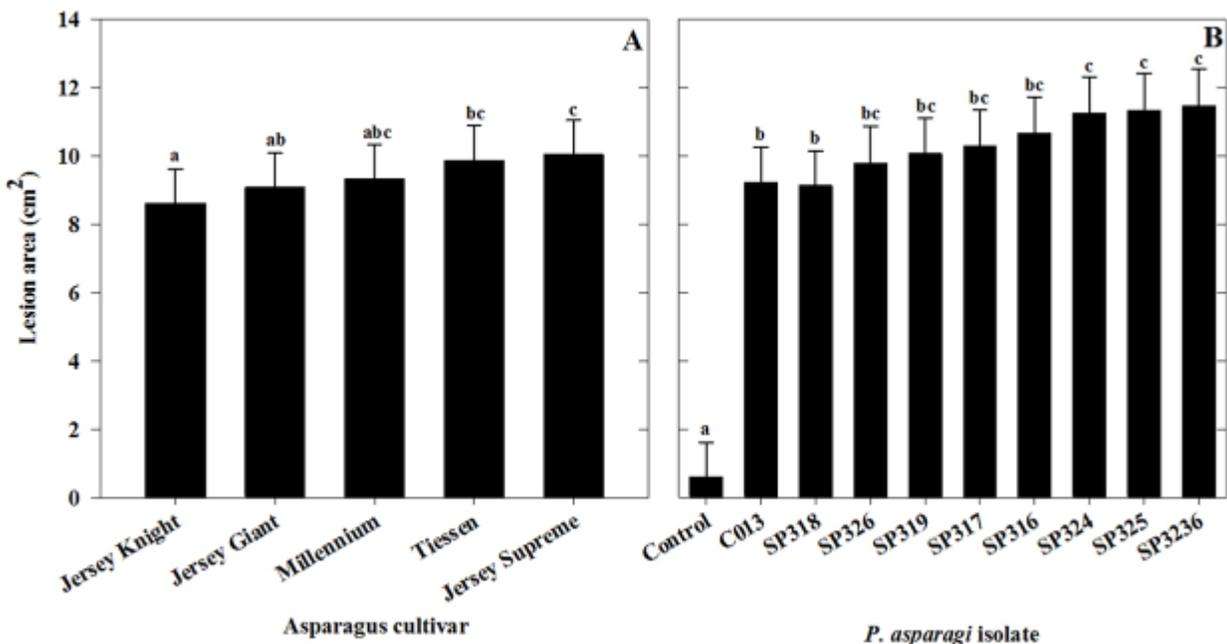


**Fig. 1.** Area under disease progress curve (AUDPC) of asparagus cultivars and breeding lines evaluated for purple spot resistance in Hart, MI. Disease was rated according to the Horsfall-Barratt disease scale. Bars with a letter in common are not significantly different (Fisher LSD;  $P=0.05$ ).

**Phytophthora asparagi spear rot experiments.** Commercial grade spears (1.5 to 2.0 cm in diameter and  $\geq 14$  cm tall) of ‘Millennium,’ ‘Tiessen,’ ‘Jersey Giant,’ ‘Jersey Knight,’ and ‘Jersey Supreme’ were harvested from fields in Oceana County, MI. In the first and third trials, the spears were kept overnight in a cold room maintained at approximately 4.4°C. In the second trial, the spears were inoculated within 12 hours of harvest. Michigan *P. asparagi* isolates C013, SP316, SP317, SP318, SP319, SP324, SP325, SP326, and SP3236 from the collection of M.K. Hausbeck were maintained on AR-(150 ppm ampicillin and 30 ppm rifampicin) amended V8 agar (840 ml distilled water, approximately 163 ml unclarified V8 juice, 16 agar, 3 g CaCO<sub>3</sub>) at room temperature (23±2°C) under continuous fluorescent lighting and transferred every two weeks. Broth cultures were initiated by adding agar plugs from the mycelial margin of actively growing 4-9 day old cultures to AR-amended V8 broth (840 ml distilled water, approximately 163 ml clarified V8 juice, 3 g CaCO<sub>3</sub>). For the spear rot experiments, a 7-mm mycelial plug was added to 4 ml AR-V8 broth, incubated for four-seven days, and 4 ml of the broth culture of each isolate was added to 10 g of autoclaved Benona sandy loam from Oceana County that was placed in test tubes (25x150 mm). Sterile AR-V8 broth was used for the uninoculated control treatments.

Asparagus spears were surface disinfested by washing in 5% sodium hypochlorite for five seconds, rinsing three times in distilled water for five seconds. Spears were air dried on clean paper towels in a laminar flow hood, and trimmed to 12 cm, with the apical tips and below-ground tissue removed. Spears were immediately placed into the test tubes with the base in direct contact with the infested soil. Five spears of each cultivar were used for each isolate and for the uninoculated controls. Tubes were arranged in a complete randomized design in test tube racks and incubated for seven days at room temperature under continuous fluorescent lighting. After incubation, the length and width of each lesion was measured. Because lesions were not uniform in height but were similar to a rectangle shape, area was calculated as  $A=W*H$ , where  $W$ =width at the spear base edge and  $H$ =the average of three separate length measurements. Experiments were conducted three times with 'Millennium,' 'Jersey Giant,' 'Jersey Supreme,' and 'Jersey Knight' spears, and twice with 'Tiessen' spears.

Lesion area differed significantly among cultivars and isolates, but there was no significant interaction between factor levels. 'Jersey Supreme' spears had significantly larger lesions compared to 'Jersey Giant' and 'Jersey Knight.' 'Tiessen' spears had a larger average lesion area compared to 'Jersey Knight.' Lesion size was similar between 'Jersey Knight,' 'Jersey Giant,' and 'Millennium' and between 'Millennium,' 'Tiessen,' and 'Jersey Supreme' (Fig. 2A). When spears were inoculated with isolates SP324, SP325, and SP3236, the lesions were larger



**Fig. 2.** Effect of (A) cultivar and (B) *Phytophthora asparagi* isolate on mean lesion area on detached asparagus spears 7 days after inoculation. Bars with common letters are not significantly different, (A) LSD  $P=0.05$  and (B) Tukey's  $P=0.05$ .

than those resulting from isolates SP318 and C013. Spears inoculated with isolates SP316, SP317, SP319, and SP326 produced lesions that were statistically similar to all other isolates (Fig. 2B).

***Phytophthora asparagi* seedling root rot experiments.** Asparagus seedlings of 18 cultivars and breeding lines were selected to evaluate differences in susceptibility to *P. asparagi* pathogen isolates SP316 and SP317 from our collection. These isolates were originally

obtained from infected asparagus obtained from Oceana Co., MI. Sterile broth/agar media (AR-V8; 2 ml) was used as the negative control. Six seedlings were used for each cultivar/pathogen isolate combination and the controls. Seedlings were arranged in a complete randomized design in test tube racks and incubated under growth chamber conditions.

Asparagus seeds were surface disinfested by agitating in a solution of 25,000 ppm benomyl in acetone on a rotary shaker (1000 rpm) for 24 hours, rinsing three times in acetone and three times in distilled water. Seeds were agitated in 20% household bleach at 1000 rpm for 1 hour and rinsed three times in distilled water. After being allowed to air dry for one-two hours in a laminar flow hood, the seeds were placed on water agar (16 g agar and 1000 ml distilled water) and germinated in the dark at room temperature for seven to 14 days. Once the hypocotyls emerged, the seeds were planted in 12 ml Hoagland's agar in test tubes (25x150 mm) and grown in growth chambers (16-hour photoperiod at 25/20°C day/night).

An AR-V8 broth culture (2 ml) of each *P. asparagi* isolate was prepared as described previously and a 4-mm mycelial plug was added. When seedlings were approximately 11 cm in height and secondary branches with cladophylls had formed (approximately two weeks), the broth culture was placed directly on the agar of each test tube. Following inoculation, seedlings were allowed to grow and the infection to develop for four weeks under growth chamber conditions as described previously. Severity of Phytophthora root rot was visually assessed weekly, starting at seven days post inoculation (dpi). A disease severity scale of zero-four was used (0=no disease; 1=<10% of root system area water-soaked; 2=10-20% water-soaked; 3=20-50% water-soaked; 4=>50% water-soaked). A disease severity index (DSI) where 0=no disease and 100=all seedlings with >50% of their roots water-soaked was calculated for each isolate/cultivar combination. For the fourth and final rating, seedling roots were removed from the agar prior to the visual assessment. The AUDPC was calculated to obtain the cumulative DSI throughout the experiments.

Root rot symptoms were first observed at seven days postinoculation, and all cultivars were symptomatic at 14 days postinoculation. The symptoms appeared as described above. All isolates were readily recovered from root tissue (78 to 100%). Main effects isolate ( $P=0.05$ ) and cultivar ( $P=0.05$ ) significantly affected both DSI and AUDPC. Pathogen isolate SP317 was statistically more virulent than isolate SP316. 'Jersey Giant' and UG009 were significantly less susceptible than 'Cumulus,' NJ1191, and UG005. The interaction between cultivar and *P. asparagi* isolate had a significant effect on DSI, but not on AUDPC (Table 3). SP317 inoculation resulted in significantly higher DSI in cultivars Cumulus, Jersey Supreme, Mondeo, NJ1191, and Pacific Challenger 1. SP316 caused higher DSI in 'Jersey Giant,' 'Jersey Supreme,' 'Pacific 2000,' and 'UG009' had the lowest DSI values, while 'Cumulus', NJ1191, and UG005 had the highest DSI values when inoculated with pathogen isolate SP316. 'Pacific Challenger 2' and 3 x Phy99 also had low DSI means when inoculated with SP316, although unequal variances affected the DSI significance. 'Jersey Giant,' 'Pacific 2000,' and UG009 were significantly less susceptible than 'NJ1191', 'Mondeo,' and 'Cumulus' when inoculated with the pathogen SP317. 'Pacific Challenger 2,' UG010, and 74 x 22 also had low DSI means when inoculated with SP317, although unequal variances affected the DSI significance. 'Pacific 2000' and UG009 had the smallest AUDPC values.

**Table 3.** Average disease severity index (DSI) and AUDPC of asparagus seedlings infected with *Phytophthora asparagi* isolates at 28 dpi.

Cultivar	Disease severity index*		AUDPC
	<i>P. asparagi</i> SP316	<i>P. asparagi</i> SP317	
Millenium.....	50.0 aABC*	65.3 aBCDE	1130.2 BCD

Cultivar	Disease severity index*		AUDPC
	<i>P. asparagi</i> SP316	<i>P. asparagi</i> SP317	
UG005 .....	72.2 aC	68.1 aCDE	1227.4 D
UG009 .....	36.1 aA	40.3 aABC	585.8 AB
UG010 .....	40.3 aAB	44.4 aABCDE	663.5 ABC
UG020 .....	47.2 aABC	48.6 aBCDE	824 BCD
Jersey Giant.....	40.3 bAB	31.9 aA	544.5 ABC
NJ938 .....	44.4 aAB	55.6 aABCDE	743.8 ABCD
NJ941 .....	44.5 aAB	54.2 aABCDE	853.2 BCD
NJ1191 .....	55.6 aBC	68 bDE	896.9 CD
Jersey Supreme.....	37.5 aA	61.1 bCDE	717 C
Mondeo.....	44.4 aAB	70.8 bDE	999 CD
Pacific Challenger 1 .....	43.1 aAB	65.3 bCDE	947.9 CD
Pacific Challenger 2 .....	44.0 aABC	42 aABCDE	805.8 ABCD
Pacific 2000 .....	31.9 aA	44.4 aABC	449.7 A
3 x Phy99.....	37.8 aAB	64.9 aCDE	827.6 BCD
74 x 22.....	54.2 aABC	43.1 aABCD	753.5 BC
Bacchus.....	55.6 aABC	66.6 aCDE	904.2 CD
Cumulus.....	57.0 aBC	70.8 bE	909 CD

\*Seedlings were given disease ratings (0-4) that were used to calculate a DSI (0 to 100), where 0=no disease, 100=all seedlings with >50% of their roots water-soaked. Each DSI is the average of three repeated tests with six asparagus seedlings per cultivar/isolate combination per test.

\*\*Column means with the same letter are not significantly different among *P. asparagi* isolates for each cultivar (lower case) or between cultivars for each isolate (upper case).  $P=0.05$ .

***Fusarium* seedling root rot experiment.** Eleven cultivars and breeding lines were selected to compare relative susceptibility against *Fusarium oxysporum* f. sp. *asparagi* and *F. proliferatum*. Asparagus seeds were surface disinfested using by agitating in solutions of 25,000 ppm benomyl in acetone on a rotary shaker (1000 rpm) for 24 hours, then rinsing three times in acetone and three times in distilled water. Seeds were agitated in 20% household bleach at 1000 rpm for one hour and rinsed three times in distilled water. After being allowed to air dry for one-two hours in a laminar flow hood, the seeds were placed on water agar (16 g agar and 1000 ml distilled water) and germinated in the dark at room temperature for seven to 14 days. Once hypocotyls emerged, the seeds were planted in 13 ml of Hoagland's agar in test tubes (25x150 mm) and grown under continuous fluorescent light at room temperature.

When seedlings were approximately 11 cm in height and secondary branches with cladophylls had formed (approximately two weeks), a 0.5 ml aliquot of *F. oxysporum* f. sp. *asparagi* FOA-50 ( $10^6$  conidia/ml) or *F. proliferatum* P-67 ( $10^5$  conidia/ml) was placed directly on the agar of each test tube. Following inoculation, seedlings were allowed to grow and infection to develop for four weeks under laboratory conditions. Michigan isolates of FOA-50 and P-67 from the collection of M.K. Hausbeck were taken from long-term storage by aseptically transferring infested silica crystals to PDA (39 g potato dextrose agar and 1000 ml distilled water) plates. Cultures were maintained at room temperature ( $23\pm 2^\circ\text{C}$ ) under continuous fluorescent lighting and transferred every seven-ten days. Spore suspensions were prepared by flooding cultures after fungal growth covered the entire media surface with sterile distilled water and scraping with a flame-sterilized glass rod. The resulting spore suspensions were collected and diluted to  $10^6$  conidia/ml for FOA-50 and  $10^5$  conidia/ml for P-67 using a hemicytometer. Suspensions were used within 30 minutes of preparation. Sterile distilled water (0.5 ml) was used for uninoculated

controls. Four seedlings were used for each cultivar/breeding line. Seedling test tubes were arranged in a randomized complete block design in test tube racks.

Seedlings were rated for disease incidence and severity of root rot every seven days beginning at seven dpi. Disease incidence was recorded, and severity was measured as a visual estimate of the area (%) of each root system with *Fusarium* lesions. For the final rating (week four), seedlings were removed from the test tubes and the roots were mechanically separated from the agar. The AUDPC was calculated to obtain the cumulative severity (%) throughout the experiments. The experiment was conducted four times. Data were statistically analyzed.

At four weeks postinoculation, all inoculated plants were diseased. Seedlings infected with both *Fusarium* spp. developed dark red-brown lesions with distinct margins. Root tissue of uninoculated controls remained vigorous without discoloration. The respective pathogen was successfully isolated from seedlings infected with *F. oxysporum* f. sp. *asparagi* and *F. proliferatum*. An unidentified *Fusarium* spp. was also isolated from approximately 3% of the asymptomatic uninoculated controls (NJ938 and NJ1191).

**Table 4.** Average disease severity (%) and area under the disease progress curve (AUDPC) of asparagus seedlings infected with *Fusarium oxysporum* f. sp. *asparagi* and *F. proliferatum*.

Cultivar	<i>F. oxysporum</i> f. sp. <i>asparagi</i>		<i>F. proliferatum</i>	
	Disease severity (%) <sup>z</sup>	AUDPC <sup>y</sup>	Disease severity (%) <sup>z</sup>	AUDPC <sup>y</sup>
Millennium .....	14.8 bBC <sup>x</sup>	318.3 aA	12.7 bBCD	233.0 aA
UG005 .....	11.5 bAB	365.3 aA	10.6 bABC	242.8 aA
UG009 .....	15.0 cBC	271.3 aA	12.4 bABCD	262.5 aA
UG010 .....	11.5 bAB	248.3 aA	16.2 cD	220.9 aA
UG020 .....	12.7 cAB	309.5 aA	10.0 bAB	225.3 aA
Mary Washington .....	14.2 cABC	340.2 aA	7.1 bA	249.4 aA
NJ938 .....	13.3 bAB	352.6 aA	14.5 bCD	356.6 aA
NJ941 .....	34.2 cD	1097. 2 bB	28 bE	448.0 aA
NJ1191 .....	18.6 bC	378.9 aA	15.9 bD	296.6 aA
Jersey Supreme .....	10.3 bA	362.0 aA	8.9 bAB	263.6 aA
Mondeo .....	12.1 cAB	254.8 aA	8.0 bA	251.6 aA

<sup>z</sup>Seedlings were rated by a visual estimation of the percentage of root system infected taken at 28 days postinoculation. Each disease severity value represents the average of four repeated tests with four replicate asparagus seedlings per pathogen/cultivar combination per test.

<sup>y</sup>AUDPC values were calculated from weekly severity ratings over the period of four weeks.

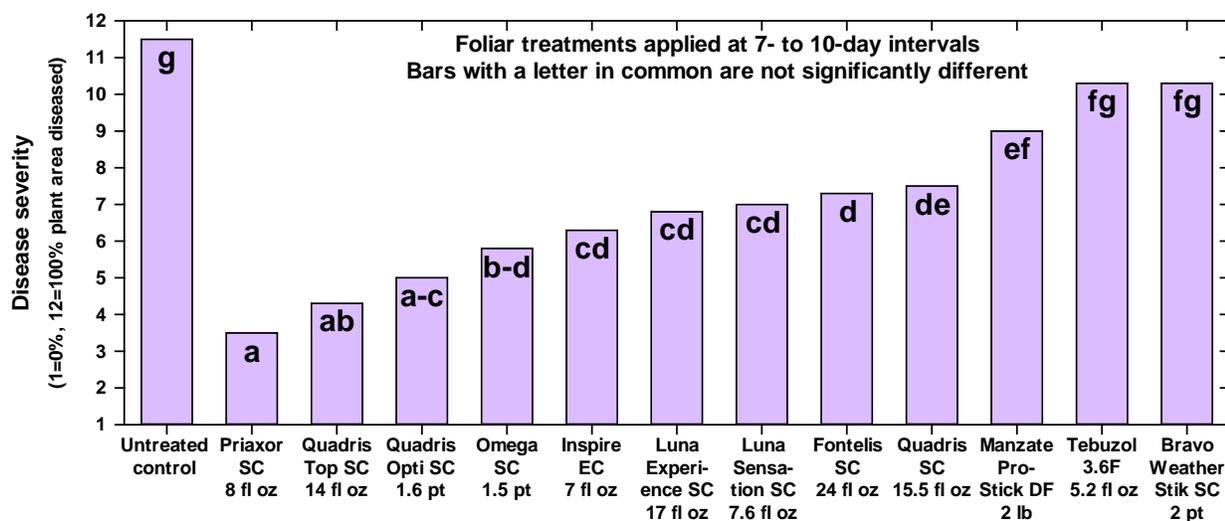
<sup>x</sup>Column means with the same letter are not significantly different among pathogens for each cultivar (lower case) or between cultivars for each pathogen (upper case). Tukey's,  $P=0.05$ .

The interaction between pathogen and asparagus cultivar was significant ( $P > 0.05$ ) for root rot severity. The main effects, cultivar ( $P=0.05$ ) and isolate ( $P=0.05$ ) were significant. *F. oxysporum* f. sp. *asparagi* caused significantly higher disease severity in cultivars Mary Washington and Mondeo and breeding lines NJ941, UG009, and UG020 compared to *F. proliferatum*. *F. proliferatum* caused higher disease severity in UG010. NJ941 was most susceptible to both pathogens. 'Jersey Supreme' was significantly healthier than 'Millennium,' UG009, NJ1191, and NJ941 when inoculated with *F. oxysporum* f. sp. *asparagi*. UG005, UG009, UG020, 'Mondeo,' and NJ938 were less susceptible than NJ941 and NJ1191 when inoculated with *F. oxysporum* f. sp. *asparagi*. Cultivars Mary Washington, Mondeo, Supreme, and breeding line UG020 were significantly less susceptible than NJ938, NJ941, NJ1191, and UG010 when inoculated with *F. proliferatum* (Table 4). The interaction between pathogen and

cultivar significantly affected AUDPC. Infection by *F. oxysporum* f. sp. *asparagi* resulted in a higher AUDPC than *F. proliferatum* in most cultivars, but was only significantly higher in NJ941. There were no significant differences between cultivars when inoculated with *F. proliferatum* (Table 4).

## 2. Develop specific fungicide programs to manage foliar diseases.

Experimental plots were set up in an established asparagus field at the Asparagus Research farm in Oceana County, MI. Plots were 13 rows wide by 100 feet long. Each row was 20 feet with a five-foot untreated section separating plots within the row. Crowns were spaced nine inches apart in the row and rows spaced five feet apart. Treatments were replicated four times in a randomized complete block design. The crop was managed according to standard cultural practices. Fungicide sprays were applied with a CO<sub>2</sub> backpack boom sprayer equipped with three 8003XR nozzles spaced 19 inches apart, operating at 50 psi, and delivering 50 gal/acre. Treatments were applied on a seven-ten-day schedule on 6, 17 and 27 June; 3, 11, 18 and 28



**Fig. 3.** Evaluation of fungicides for control of rust disease on 'Millennium' asparagus.

July; 8, 18 and 25 August. Disease severity was visually assessed according to the Horsfall-Barratt grading system (1=no visible symptoms, 2=0 to 3% plant area diseased, 3=3 to 6%, 4=6 to 12%, 5=12 to 25%, 6=25 to 50%, 7=50 to 75%, 8=75 to 87%, 9=87 to 94%, 10=94 to 97%, 11=97 to 100%, 12=100% plant area diseased) on 13 and 20 August; 3, 16 and 29 September. Analysis of variance was performed using the general linear models procedures of SAS (version 9.4) and means separated using Fisher's least significant difference test.

Disease pressure from asparagus rust was severe with the untreated control plants receiving a disease severity rating of 11.5 (>97% but <100% plant area diseased) by the end of the trial. Especially effective treatments that limited disease severity rating to ≤5.0 (>12% to 25% plant area diseased) were Priaxor SC, Quadris Top SC and Quadris Opti SC. Plants treated with Bravo Weather Stik SC and Tebuzol 3.6F were statistically similar to the untreated control plants (Fig. 3). The data for Quadris Top SC were shared with the registrant Syngenta and prioritized at the Annual Food Use Workshop for the IR-4 Project. As a direct result of this study and the data garnered, efforts are underway to establish the needed residue information to support a full label for use of Quadris Top on the asparagus crop.

## 3. Evaluate soil-applied fungicides for control of *Fusarium* and *Phytophthora*.

***Phytophthora asparagi* in vitro seed treatments trial.** Five fungicides and two biocontrol agents were screened for efficacy as seed treatments in vitro. A mycelial plug (7-mm in diameter) of pathogen isolates SP316 or SP326 was placed in the center of 15-cm-diameter petri plate containing 50 ml of V8 agar. The isolates were allowed to colonize the plates for 3 days. Seeds of 'Millennium' were surface disinfested as described previously and allowed to air dry in a laminar flow hood for approximately one hour. Treatments were applied to seed lots (0.33 g) at the rates listed in Table 4. Seeds were soaked in each treatment for approximately 30 minutes, and air-dried in a laminar flow hood for approximately one hour. Seeds from each treatment were equally spaced in a randomized order around the plate, approximately 3 cm from the edge.

At 10 dpi, both pathogens had colonized most of the agar disc area, including the area immediately surrounding seeds. Seeds from all treatments, except for Serenade Soil®, were colonized with mycelial growth. Growth of *Bacillus subtilis*, the active ingredient in Serenade Soil®, was observed on the treated seeds and the agar surrounding the seeds. Average inhibition of mycelial growth caused by *B. subtilis* was observed surrounding the immediate area outside of the bacterial growth for both *P. asparagi* isolates.

Both main effects isolate and treatments ( $P=0.05$ ) were significant for seed germination rate (Table 5). Seeds inoculated with the pathogen isolate SP316 (approximately 18%) had a significantly lower germination rate compared to those inoculated with SP326 (42%). Apron® (approximately 73%) and Serenade Soil® (approximately 97%) were most effective to increase germination rate compared to the untreated control (approximately 1%). The interaction between isolate and treatment ( $P=0.05$ ) significantly affected seed germination rate. *P. asparagi* isolates were statistically similar within treatments, although SP316 germination rates were usually lower than SP326 (Table 5). Apron®, DPX-QGU42, and Serenade Soil® treatments had the highest germination rates when seeds were inoculated with pathogen isolate SP316 (Table 5). The remaining treatments were statistically similar to the untreated seeds. Apron® and Serenade Soil® were the only treatments with higher germination rates compared to the untreated control when seeds were inoculated with SP326 (Table 5).

The main effects isolate ( $P=0.05$ ) and treatment ( $P=0.05$ ) significantly impacted disease incidence, but the interaction between isolate and treatment was not significant at  $P=0.05$ . Seeds inoculated with pathogen SP316 (approximately 79%) had higher root rot incidence than those inoculated with SP326 (approximately 63%). Serenade Soil®-treated seeds had the lowest incidence (Table 5). All remaining treatments were statistically similar to the untreated control.

**Table 5.** The effect of *Phytophthora asparagi* isolate and seed treatment on germination rate and disease incidence.

Treatment and rate/100 lb seed	Germination (%)				Disease incidence (%)	
	<i>P. asparagi</i> SP316		<i>P. asparagi</i> SP326			
Control .....	0.0	A*	8.3	A	71.6	B
Apron 14.19 ml.....	50.0	BCD	100.0	B	75.7	B
Presidio 29.57 ml .....	20.0	ABCD	23.3	AB	93.1	B
Micora 237.00 ml .....	13.3	ABCD	40.0	AB	82.3	B
V-10208 17.74 ml.....	11.1	AB	55.6	AB	93.1	B
DPX-QGU42 59.14 ml.....	76.7	CD	53.3	AB	78.1	B
Actinovate AG 340.20 g .....	11.1	ABC	52.8	AB	88.1	B
Serenade Soil 813.18 ml....	100.0	D	93.3	B	13.0	A

\* Column means with the same letter are not significantly different among *P. asparagi* isolates for each isolate (upper case). Tukey's,  $P=0.05$ .

Of the seedlings inoculated with pathogen isolate SP316 and that germinated successfully, Micora® and Serenade Soil® had the highest percentage of low (0, 1) disease severity ratings (100% and 85%, respectively). All seedlings treated with Apron® and Actinovate® received a severity rating of 3 when inoculated with SP316. All seedlings in the Presidio® and V-10208 treatments received a rating of 2 when inoculated with SP316. More than half of the seedlings treated with DPX-QGU42 and inoculated with SP316 were given a rating of three, and the remaining seedlings received a rating of one or two. No seedlings germinated successfully in the untreated control when inoculated with SP316, and therefore were not given a disease severity rating. All seedlings treated with Serenade Soil® and inoculated with SP326 received a rating of zero, except for one seedling which was given a rating of one. Approximately 27% and 20% of seedlings treated with Apron® and Actinovate®, respectively, were given a rating of zero when inoculated with SP326. Most of the seedlings inoculated with SP326 and treated with Micora® (approximately 83%) were given a rating of one. Varying numbers of seedlings in the remaining seed treatment groups were given ratings between one and three. Only one seedling in the untreated control successfully germinated and was given a rating of one.

***Fusarium in vitro* seed treatment trial.** Three fungicides and two biocontrol agents were screened for efficacy as seed treatments in vitro. A mycelial plug (7-mm in diameter) of FOA-50 or P-67 was placed in the center of 15-cm-diameter petri plate containing 50 ml of PDA. Seeds of 'Millennium' were surface disinfested as described previously and allowed to air dry in a laminar flow hood (approximately 1 hour). Treatments were applied to seed lots (0.33 g) at the rates listed in Table 5. Seeds were soaked in the treatments for approximately 30 minutes, air-dried in a laminar flow hood for approximately one hour. Seeds from each treatment were equally spaced in a randomized order around the plate, approximately 3 cm from the edge.

At 11 days after plating the seeds, inhibition of mycelial growth was measured as the distance between the seed and margin of mycelial growth along the radius of the agar plate. The seeds were removed from culture. Successfully germinated seeds were rated for disease severity. The number of seeds that successfully germinated on inoculated plates was compared with the number that germinated on the uninoculated plates. Seeds were considered successfully germinated if the hypocotyl had emerged or the radicle was >5 mm long. Treatments were scored according to a 0 to 3 rating scale, where 0=100% germination with no disease symptoms, 1=<50% radicle tissue water-soaked, 2=>50% radicle tissue water-soaked and 3=all seed tissues colonized. Each treatment was replicated five times for each isolate and the uninoculated control, and the experiment was conducted a total of four times: twice with 'Jersey Giant' and twice with 'Mary Washington.'

At 11 dpi, both pathogens had colonized most of the agar surface area, including the area immediately surrounding seeds. Seeds from all treatments, except for Serenade Soil®, were colonized with mycelial growth. Growth of *B. subtilis* (active ingredient in Serenade Soil®) was observed on the treated seeds and the agar surrounding the seeds. Average inhibition of mycelial growth caused by *B. subtilis* was observed at an average length of 8.5 mm from the bacterial growth in plates inoculated with *F. oxysporum* f. sp. *asparagi* and immediately surrounding the bacterial growth in *F. proliferatum* cultures.

The main effect, pathogen ( $P=0.05$ ), significantly affected germination rate, but main effect, treatment ( $P=0.05$ ), and the interaction between main effects ( $P=0.05$ ) were not significant. Both pathogens reduced seed germination compared to the uninoculated seeds, and *F.*

*proliferatum* infection resulted in significantly lower germination (2.5%) than seeds inoculated with *F. oxysporum* f. sp. *asparagi* (40.0%). Pathogen ( $P=0.05$ ) did not have a significant effect on disease incidence. Seeds treated with Serenade Soil® had significantly lower incidence than the remaining treatments (Table 6). The interaction between pathogen and treatment was did not significantly affect incidence. All germinated seedlings inoculated with *F. proliferatum* were given the highest severity rating. Of the seedlings inoculated with *F. oxysporum* f. sp. *asparagi*, those treated with Serenade Soil® had the lowest severity ratings. However, germinated seedlings treated with Serenade Soil® were often stunted with discoloration at the radicle tip. This was most likely related to phytotoxicity from *B. subtilis*, since pathogen growth was not recovered from most of the seeds and seedlings in this group. All germinated seedlings treated with Dynasty® and Maxim® were given the highest severity rating.

**Table 6.** The effect of *Fusarium* spp. and seed treatment on germination and disease incidence.

Treatment and rate/100 lb seed	Germination (%)	Disease incidence (%)
Untreated	21.7 <sup>*</sup>	100.0 B
Dynasty 44.36 ml	62.5	100.0 B
Fontelis 29.57 ml	31.3	93.8 B
Maxim 4.54 g	29.2	100.0 B
Actinovate AG 340.20 g	30.0	100.0 B
Serenade Soil 813.18 ml	25.0	6.3 A

\* Column means with the same letter or with no letter are not significantly different among seed treatments. LSD,  $P=0.05$ .

**Soilborne pathogens field seedbed trial.** A trial was established in Oceana County, MI in cooperation with a commercial asparagus grower where asparagus ‘Millennium’ seeds were sown by the grower-cooperator on 30 May 2014. The trial was set up with 100 feet plot length and 11 rows per plot. Treatments consisted of 20 feet of row and four replicates. Weeds, insects and fertilization were managed according to standard commercial production practices. Treatments (Table 7) were applied with a backpack sprayer calibrated to deliver 50 gal/acre to the soil on 11 July, 8 August and 8 September. Crowns were dug from the field on 15 April and the soil removed by washing with tap water on 16 April. Crowns were weighed and roots rated on a scale of 1-4, where 1=low root mass, 2=low-medium root mass, 3=medium-high root mass, and 4=high root mass (Fig. 4) on 22 April.

Plants treated with Cannonball produced crowns that weighed significantly more than plants treated with Ridomil Gold or Fontelis (Table 7). When visually rated, plants treated with Cannonball produced the highest percentage of crowns with the highest rating of four, statistically better than the untreated control, DPX-QGU42, Topsin M, Fontelis, Presidio alternate Cannonball, Ridomil Gold alternate Cannonball, and Ridomil Gold alternate Topsin (Table 7, Fig. 4). Untreated plants produced the largest percentage of crowns with the lowest rating of one, significantly larger than plants treated with Presidio, DPX-QGU42, Presidio alternate Cannonball, and Presidio alternate Topsin M (Table 7, Fig. 4). The results from culturing plant tissue samples representing the various treatments indicated that *Fusarium* spp. was the pathogen likely being controlled by the fungicide treatments at this site. Since the Cannonball fungicide targets *Fusarium* disease, this is likely why this specific fungicide proved to be effective in this study. At other sites, where *Phytophthora* and/or *Fusarium* could both be problems, a program that alternates fungicides with different chemistry could also be beneficial.

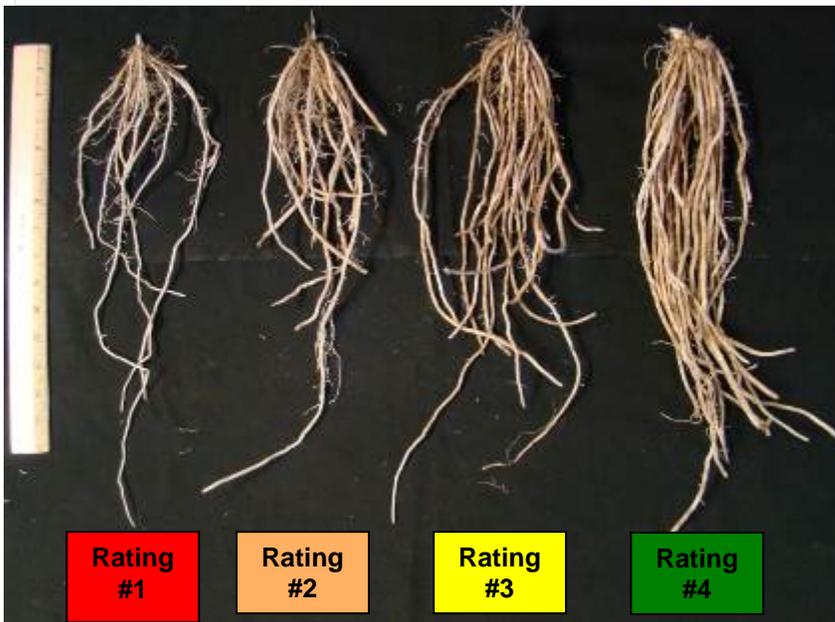
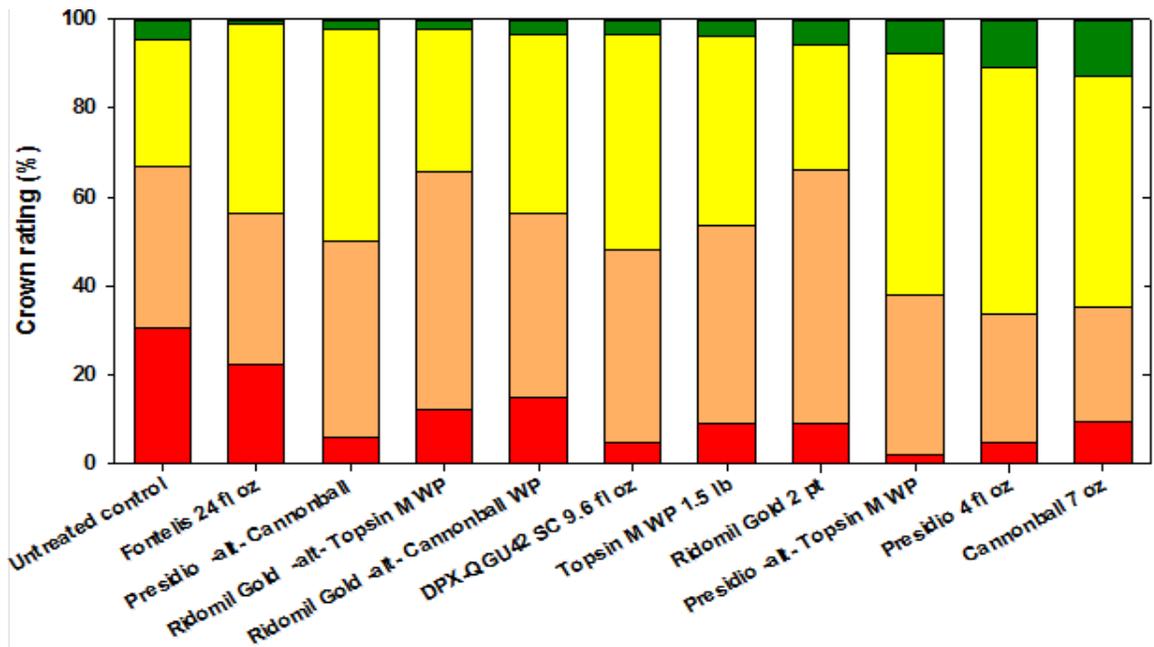
**Table 7.** Effect of fungicides applied to asparagus seedlings during the 2014 growing period on the health of crowns dug in 2015.

Treatment <sup>1</sup> and rate/A, applied at monthly intervals	Crown rating <sup>2</sup> (%)				Yield (oz/crown)
	#1	#2	#3	#4	
Untreated control .....	30.75 b <sup>3</sup>	36.25 a-c	28.25 a	4.75 ab	1.4 ab
Presidio SC 4 fl oz .....	4.69 a	28.94 ab	55.44 b	10.94 bc	1.5 ab
Ridomil Gold SL 2 pt .....	9.19 ab	56.94 d	28.19 a	5.69 a-c	1.2 b
DPX-QGU42 SC 9.6 fl oz .....	4.63 a	43.63 b-d	48.38 ab	3.38 a	1.4 ab
Cannonball WP 7 oz .....	9.56 ab	25.56 a	52.06 ab	12.81 c	1.8 a
Topsin M WP 1.5 lb.....	9.31 ab	44.31 b-d	42.56 ab	3.81 ab	1.4 ab
Fontelis SC 24 fl oz.....	22.50 ab	34.00 ab	42.50 ab	1.00 a	1.2 b
Presidio SC 4 fl oz -alt- Cannonball WP 7 oz ....	5.94 a	44.19 b-d	47.69 ab	2.19 a	1.4 ab
Presidio SC 4 fl oz -alt- Topsin M WP 1.5 lb.....	2.25 a	35.75 a-c	54.25 b	7.75 a-c	1.5 ab
Ridomil Gold SL 2 pt -alt- Cannonball WP 7 oz ....	15.06 ab	41.31 a-d	40.31 ab	3.31 a	1.5 ab
Ridomil Gold SL 2 pt -alt- Topsin M WP 1.5 lb.....	12.19 ab	53.69 cd	31.69 ab	2.44 a	1.3 ab

<sup>1</sup>-alt = alternate.

<sup>2</sup>Rated on a scale of 1 to 4, where 1=low root mass, 2=low-medium, 3=medium-high, and 4=high root mass.

<sup>3</sup>Column means with a letter in common are not significantly different (LSD t Test;  $P=0.05$ ).



**Fig. 4.** Effect of monthly drenches of fungicides applied alone or in alternation on crown quality of asparagus seedlings (top). Treatments were applied on 11 July, 8 August and 8 September 2014. Crowns were harvested on 16 April 2015 and evaluated according to a 1-4 rating system on 22 April 2015 (left).

#### 4. Evaluate the effects of irrigation delivery system and timing on disease incidence, crop quality and yield.

**Irrigation field experiment 1.** A long-term field study established in 2010 at the Michigan Asparagus Research Farm in Hart, MI was used to evaluate the effects of irrigation delivery system (none, overhead or sub-surface drip) on two cultivars of asparagus (Millennium and Jersey Supreme). During fern growth, irrigation was applied when soil volumetric water content (VWC) dropped below 50% available, and replenished to field capacity based on readings from the Diviner 2000 soil moisture monitoring system. Purple spot and rust incidence and severity were visually assessed and recorded.

Irrigation applications and soil moisture monitoring occurred throughout July and August. The incidence of foliar disease was assessed on 2 October. Overhead irrigated treatments had slightly higher disease incidence than unirrigated treatments (mean rating of 7.0 vs 6.0 on the Horsfall-Barratt scale), but greater fern growth. The impact of these irrigation treatments on yield will be assessed in spring 2015.

**Irrigation field experiment 2.** A second field trial was conducted in Hart, MI to assess the effects of overhead irrigation *during harvest* on spear quality and disease. Irrigation was applied when temperatures during harvest exceeded 30°C, and VWC in the top 12 inches was less than 75% of available water. Spear quality and yield were assessed in all treatments as described for Experiment 1. Air and soil temperatures were also monitored, to assess the effects of irrigation on these factors.

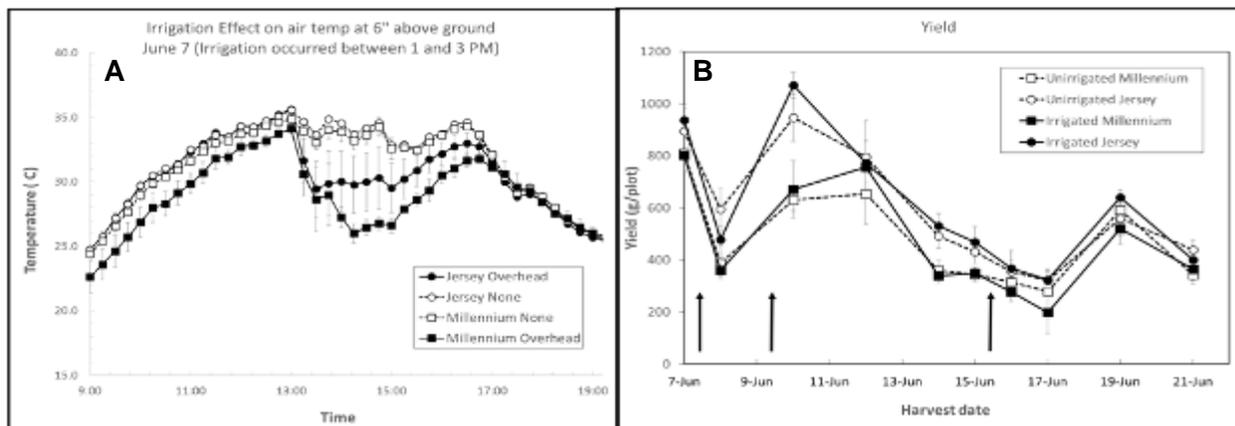
	Moisture content			Length			Diameter			Purple stem			Tip openness on 6/10		
	6/10	6/16	6/17	6/10	6/16	6/17	6/10	6/16	6/17	6/10	6/16	6/17	Closed	Slightly open	Open
	-----%-----			-----mm-----			-----mm-----			-----%-----			-----%-----		
<b>Jersey Supreme</b>															
None	94.0	94.4	93.8	18.6	14.3	14.9	10.1 ab	8.1	9.2	0.0	3.8	3.8	31.5 c	55.3	13.2
Irrigated	94.0	94.4	93.8	18.5	14.6	14.5	9.8 b	8.3	9.3	0.0	3.8	6.3	39.1 ab	50.3	10.6
<b>Millennium</b>															
None	93.8	93.9	93.5	18.9	14.4	14.8	10.0 b*	9.2	9.3	0.0	0.0	2.5	33.9 bc	56.6	9.6
Irrigated	93.9	93.9	93.4	18.5	14.2	14.7	10.8 a	9.3	9.1	0.0	1.3	1.7	45.2 a	49.4	5.4
<b>Variety (V)</b>	0.019	0.002	0.021	NS	NS	NS	0.069	0.005	NS	NS	NS	NS	NS	NS	0.055
<b>Irrigation (I)</b>	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.004	NS	NS
<b>V x I</b>	NS	NS	NS	NS	NS	NS	0.048	NS	NS	NS	NS	NS	NS	NS	NS

Irrigation and temperature monitoring occurred during harvest in June. Irrigation was applied for two-three hours on 7, 9 and 15 June, when air temperatures exceeded 30°C. Irrigation treatments resulted in a significant reduction in air temperature at spear height, with the greatest cooling effect occurring following the 7 June irrigation (see Fig. 5A). These irrigations had no detectable effect on spear weight (Fig. 5B); nor were any differences detected in spear moisture content, spear length, or the incidence of purple spot on spears on 10 June (Table 8). However, irrigation resulted in an 8% increase in spear diameter for ‘Millennium’ on 10 June (Table 8). In addition, irrigation resulted in improvements in tip quality on 10 June, with the percentage of tightly closed tips increasing by seven percentage points for ‘Jersey Supreme’ and by nine percentage points for ‘Millennium’ (Table 8). At this point, the economic implications of improvements in tip quality are not clear, nor are the net impact of irrigation during harvest on profitability.

**Table 8.** Effects of irrigation during harvest on spear quality: moisture content, length, diameter, purple stem incidence and tip quality.

**5. Disseminate new management recommendations to the asparagus industry at the Great Lakes Fruit, Vegetable and Farm Market Exposition and Oceana Asparagus Days.**

Oceana Asparagus Day was held in March in 2014 and 2015 with approximately 150 attendees from 18 Michigan counties and from out of state. Attendees were surveyed, and 92% of them were from farms growing 1-300 acres of asparagus, totaling ~4,400 acres in 2013 and ~4,600 acres in 2014. Acreage of respondents represented 40-45% of the total Michigan asparagus acreage according to USDA-NASS. Approximately half of respondents indicated they use or are thinking about using irrigation due in part to MSU research and extension. Reported irrigated acreage from survey respondents increased by approximately 30% from 337 acres in 2013 to 437 acres in 2014. Both overhead and drip irrigation are being used, with more growers using overhead. Assuming survey respondents are representative of Michigan asparagus as a whole, irrigated acreage is approximately 1000 acres, representing about 10% of total acreage. Farms on which irrigation is occurring are generally large, with their irrigated acreage accounting for 10-15% of their total acreage.



**Fig. 5.** Irrigation effects on (A) air temperature at 6" above ground on 7 June, and on (B) spear yield (arrows indicate timing of irrigation events).

A survey concerning asparagus diseases was distributed at the 2015 Oceana Asparagus Day. Growers represented approximately 3,500 planted acres of asparagus or about 33.7% of Michigan acreage. Growers ranged from three to 55 years of experience of growing asparagus, with half of growers with more than 35 years of experience. A majority of the growers (85.7%) are concerned that that the asparagus cultivars they grow may be highly susceptible to *Phytophthora* and/or *Fusarium*. Over half (60.4%) of the growers were unaware that Folicur, an important fungicide for controlling rust disease, is no longer labeled for use on asparagus; and 52.1% of the growers were aware that Tebuzol 3.6F has the same active ingredient and is an alternative to Folicur. When asked about fungicides they used to control foliar disease in 2014, all applied Bravo or a generic chlorothalonil product, 41.7% applied a mancozeb product, 29.2% applied Tebuzol, 4.2% applied Rally, 4.2% applied Quadris, and 2.1% applied Flint. Only 12.2% of these respondents irrigated their asparagus, and none of them applied fungicides through the irrigation system.

Results of this research were presented at the Great Lakes Fruit, Vegetable and Farm Market Exposition on 9 December 2014 in Grand Rapids, MI. This regional extension meeting was attended by over 4,200 people from 42 states and eight Canadian provinces.

Presentations on this research included:

'Asparagus pathology research,' M. Hausbeck, Great Lakes Fruit, Vegetable and Farm Market Expo, Grand Rapids, MI, 9 December 2014.

'Asparagus irrigation update—effects on spear cooling, quality, and yield,' Zachary Hayden and D. Brainard, Great Lakes Fruit, Vegetable and Farm Market Expo, Grand Rapids, MI, 9 December 2014.

'Asparagus purple spot update and new research on cover crops—results of 2014 trials,' C. Krasnow and M. Hausbeck, Asparagus Day, New Era, MI, 12 March 2015.

'Asparagus irrigation update,' Z.D. Hayden and D.C. Brainard, Asparagus Day, New Era, MI, 12 March 2015.

## BENEFICIARIES

Diseases threaten the Michigan asparagus industry, which ranks 2<sup>nd</sup> in the U.S. for production. Michigan growers produced 11,000 tons of asparagus on 9,000 acres, valued at \$20.5 million in 2014. Not only do diseases threaten the current year's crop, but chronic infection can reduce the productivity of this perennial crop over years. Research resulting in the reduction of the impact of disease and promoting crown health benefits not only Michigan growers, but also allied industry stakeholders such as processors, contractors, etc., as well as national asparagus stakeholders.

## LESSONS LEARNED

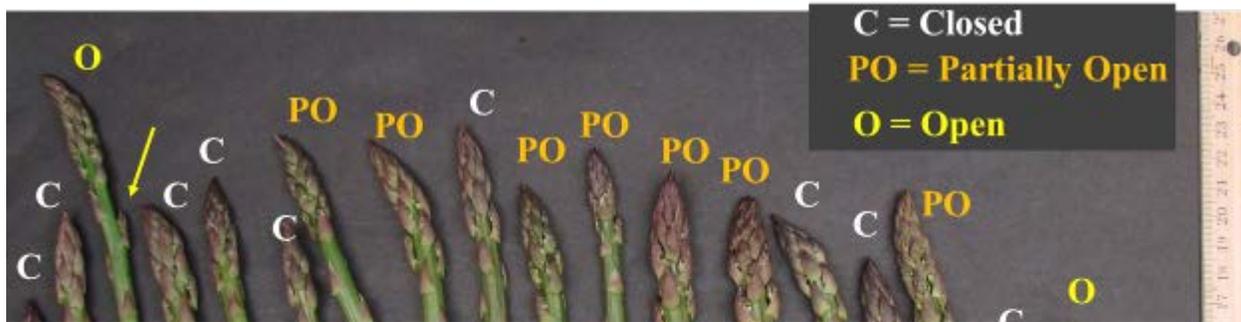
1. The most popular asparagus cultivar 'Millenium' is highly susceptible to purple spot. While this cultivar has many positive attributes, it will require more intensive managing to limit purple spot development.
2. 'Jersey Knight' was significantly less susceptible to Phytophthora spear rot than other cultivars tested including 'Jersey Supreme'. However, 'Jersey Knight' is not a commonly grown cultivar.
3. Susceptibility of seedlings to Phytophthora root rot varied among the cultivars; UG009 and Pacific 2000 exhibited less susceptibility than the other cultivars tested.
4. New fungicides were identified as being especially effective against the foliar disease purple spot. Priaxor, Quadris Top SC, and Quadris Opti were especially effective; Quadris Top SC has been prioritized for labeling by the registrant and the IR-4 Project.
5. Fungicide treatments made to the asparagus seedbed as a means to prevent infection by *Fusarium* and/or *Phytophthora* resulted in varying degrees of crown health. *Fusarium* was determined to be the primary pathogen at this particular site and Cannonball treatments yielded the highest percentage of large, high quality crowns. Treating the seedbed with fungicide applications as a means to improve the crown health is a new technique for disease management in asparagus. Results from this study will be used to communicate this new treatment option with fungicide registrants to open discussion regarding product labeling. This program has tremendous potential to positively impact the Michigan asparagus industry and asparagus growers in other states.
6. Irrigation during harvest can substantially reduce spear temperatures and is likely to improve spear quality (larger diameter and more closed tips) during hot dry periods. This benefit, coupled with previously observed improvements in yields associated with irrigation during fern growth, make irrigation a potentially valuable investment on light soils, especially for the Guelph Millennium cultivar. These results have influenced several large asparagus growers to invest in irrigation.

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## ADDITIONAL INFORMATION

- Hausbeck, M., and Escobar-Ochoa, C. 2014. Management strategies for purple spot control of asparagus. Pages 4-7 in: Asparagus Session Summaries. Proceedings of the Great Lakes Fruit, Vegetable and Farm Market Expo, Grand Rapids, MI, 9-11 December. Online. (<http://glexpo.com/summaries/2014summaries/Asparagus.pdf>)
- Woods, C.A. 2014. Evaluation of strategies for managing soilborne pathogens of asparagus in Michigan. M.S. Thesis, Michigan State University.



*Fig. 7. Overhead irrigation system used for spear cooling in Objective 4.*

## PROJECT TITLE - FINAL

**Michigan Carrot Committee** – Advanced Technology for Addressing the Challenge of Quality Assurance of Processed Carrot

## PROJECT SUMMARY

The Michigan Carrot Committee is the lead organization on this project and is responsible for fiscal management and reporting. Drs. Daniel Guyer and Irwin R. Donis-González from the Department of Biosystems and Agricultural Engineering, and Dr. Renfu Lu, USDA-ARS-SBRU, at Michigan State University are responsible for executing the work outlined in this project.

This document represents the final performance report (10/2013 thru 04/15/2015) for the project involving 1) X-ray computed tomography (CT), 2) Visible/Near-infrared (VIS/NIR) spectral measurements, and 3) VIS/NIR imagery as a means for detecting undesirable fibrous tissue in processing carrots. Examples of fibrous tissue, commonly found in processing carrots, can be seen in Fig. 1.

Image analysis methods (algorithms) for the automatic classification of CT images, VIS/NIR images, and VIS/NIR spectral measurements obtained from fresh processing carrots, during the 2013 and 2014 harvesting years, were developed and tested. Classification accuracy was evaluated by comparing the classes obtained from each non-invasive method to the presence of undesirable fibrous tissue.

Fibrous carrot dices are undesirable and difficult to detect, regardless of the type of fibrous tissue type, but are especially problematic when found in ready-to-eat infant food, where they might represent a choking hazard. Much work has gone into removing fibrous carrots in the field prior to harvest and also in the processing plant before (with human manual labor) and after dicing (i.e. commercial spectral-based sorters), in addition to the study of the potential reasons behind the presence of fibrous carrots (e.g. cultivars and growing conditions). While these efforts have reduced the incidence of fibrous carrot dices, they have not kept pace with the stricter consumer demands and infant food producer tolerances. In addition, the structural polymers content (cellulose, hemicellulose and lignin) of different types of fibrous tissue, fibrous-free and fibrous carrots, which might be related to the presence of undesirable fibrous tissue, have not been documented.

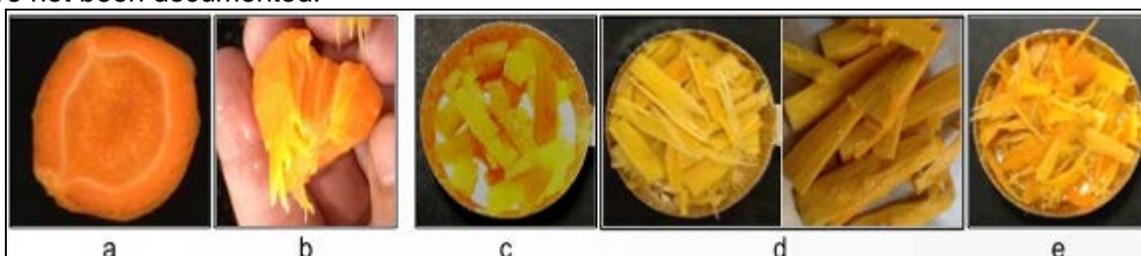


Fig. 1 a) End-view of a fresh cut carrot containing fibrous tissue, and b) fibrous tissue shown in the carrot tip. Examples of different types of undesirable fibrous tissue in processing carrots: c) gelatinous-like, d) woody, and e) mix of woody and gelatinous-like.

## PROJECT APPROACH

Included is a brief description of performed activities, which include carrot (*Daucus carota* subsp. *Sativus*, var. 'Canada') sample preparation, CT scanning, VIS/NIR spectral measurements, VIS/NIR imaging, and invasive fibrous tissue assessment & validation. An overview of the experimental design is included in Fig. 2. After collecting data, automatic

classification algorithms to infer the presence of undesirable fibrous tissue in fresh processing carrots were developed.

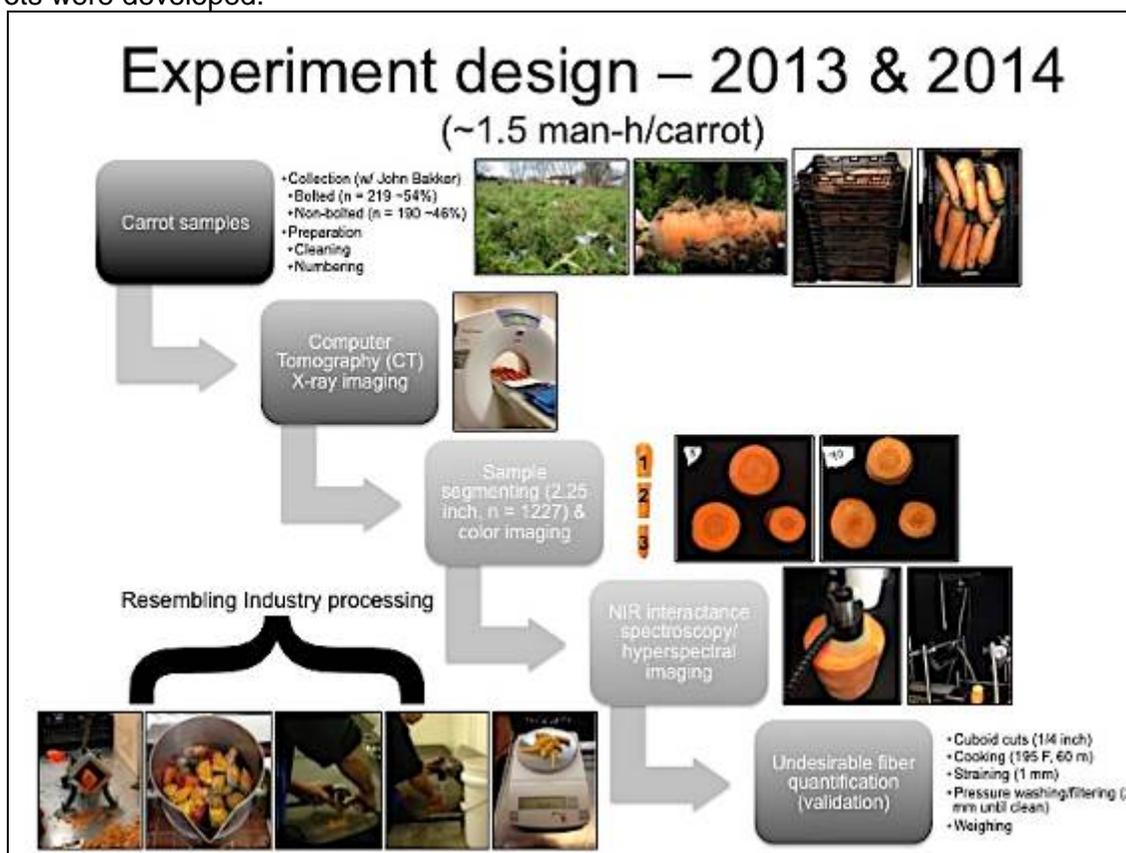


Fig. 2 Project experimental design (Workload: ~ 1.5 man-h/carrot)

## GOALS AND OUTCOMES ACHIEVED

- **Task 1: Obtain carrot samples containing varying degrees of fibrous tissue ranging from no undesirable tissue to severe fibrous tissue presence.**

A total of 409 physiologically mature fresh carrot samples were hand-harvested directly from a Michigan commercial production field (Oceana county, Hart, MI) mid-November 2013 and 2014, with the help of John Bakker from the Michigan Carrot Committee, and were subsequently processed at Michigan State University ~ Department of Biosystems and Agricultural Engineering. Of the samples, 219 were bolted (premature production of a seed-head) suspected of containing undesirable fibrous tissue, and 190 were non-bolted suspected to be fibrous-free samples. Based on the distribution of collected samples for both seasons (Fig. 5.), approximately 50% of samples contain fibrous tissue, of which the majority (~93%) contain less than 15% of undesirable fibrous tissue.

- **Task 2: Scan all samples under the available MSU CT.**

Whole fresh carrot CT scans were performed on a GE BrightSpeed™ RT 16 Elite, multi-detector CT instrument (General Electric Healthcare, Buckinghamshire, United Kingdom), located in the Department of Small Animal Clinical Sciences at Michigan State University. Scanning parameters and CT equipment specifications can be found in table 1. CT scanning was performed by placing carrots onto a whole polyethylene board, placed on the CT scanner table, as shown in Fig. 2. A representative sample of two-dimensional (2D) CT images can be seen in Fig. 6.

Table 1. Scanning parameters for the CT – General Electric, BrightSpeed™ RT 16 Elite (GE Healthcare, Buckinghamshire, England, Great Britain)

Units	Parameter
Voltage (kV)	120
Current (mA)	250
CT 2D image thickness (mm)	2.5
Pixel area (mm <sup>2</sup> )	0.952
Voxel volume (mm <sup>3</sup> )	2.381
Resolution in the trans-axial plane (X-Y) (pixels/mm)	1.024
Pitch (table movement – mm : rotation)	1.75:1
Scan time per 12 carrots (s)	18.1
Reconstruction matrix (pixels)	512 x 512
Field of view (FOV) diameter (mm)	500
Original image intensity resolution	16-bit

- **Task 3: Measure samples under visible and near infra-red spectral measurement and imaging instruments available in Post-harvest Lab at Michigan State University.**

Each fresh carrot sample was transversely cut (after CT measurements as a whole carrot) into 3-sections using a sharp hand knife resulting in 1227 fresh carrot segments. As specified in Fig. 2, each segment size is equal to 57.2 mm (2.25 inch) length. Color images of the top-end of each segment were acquired using an 8-megapixel, *f*/2.4 aperture Iphone 4s camera (Apple Inc., Cupertino, CA, USA) for record keeping and to use as reference. Examples of color images can be seen in Fig. 5 and 6. Thereafter the top-end of each segment was imaged using the VIS/NIR hyperspectral imaging system (Sensors Unlimited, Princeton, NJ, USA), located in the Department of Biosystems and Agricultural Engineering/Post-harvest laboratory at MSU. This hyperspectral imaging camera acquires a set of images over a range of different wavelengths (367-980 nm). A schematic representation of how each segment was imaged can be seen in Fig 3. Examples of NIR images acquired at 914 nm can be seen in Fig. 6.

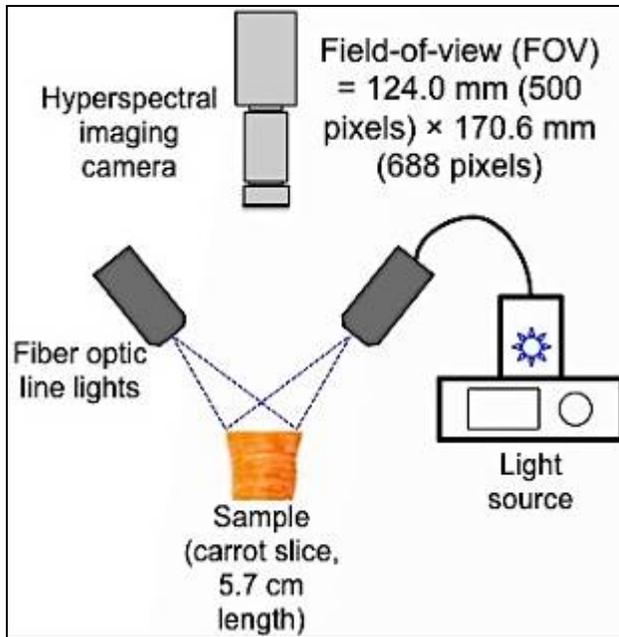


Fig. 3. Schematic representation of the VIS/NIR hyperspectral imaging system

Subsequently, as a third electronic measurement mode, two VIS/NIR spectra were acquired per segment end (approximately at segment centroid, and at 1 cm from segment edge) using a VIS/NIR spectrophotometer/detector (Tec5USA, Inc., Plainview, NY, USA) (307-1148 nm), schematized in Fig. 4. /NIR spectroscopy studies the interaction between the sample and light as a function of the wavelengths. Data is represented as a spectrograph, a plot of interacted light intensity as a function of the wavelengths. Example of carrot sample mean VIS/NIR spectra can be seen in Fig. 6.

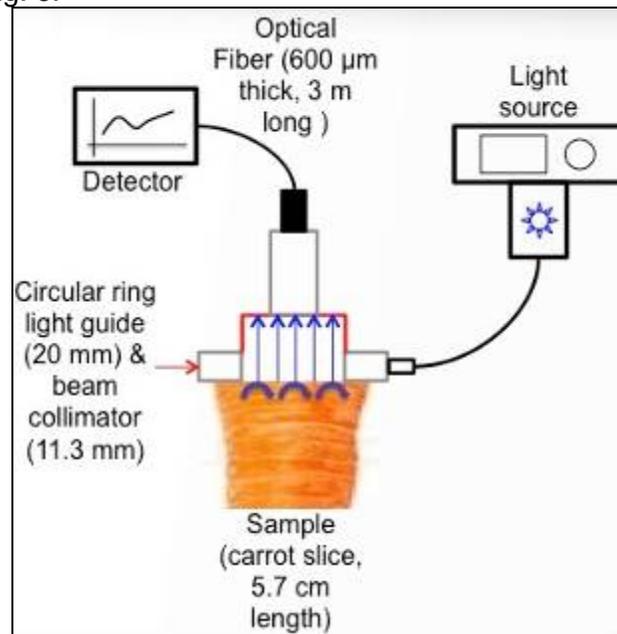


Fig. 4. Schematic representation of the VIS/NIR spectroscopy system

- **Task 4: Manually/destructively quantify fibrous tissue content for electronic measurement validation.**

After CT scanning, VIS/NIR hyperspectral imaging, and VIS/NIR spectroscopy, each fresh carrot segment was similarly processed as done in the industry. The objective was to mimic the industrial dicing and processing process and therefore quantify the amount of undesirable fibrous tissue in each sample. First, carrot segments were peeled, and longitudinally cut into 6.35 mm (1/4 inch.) diameter cuboids, using a manual French fry cutter/slicer (New Star Foodservice Inc., Chino, Ca, USA). Second, each set of cuboids from each cut carrot segment was identified, weighed, and put into a mesh-bag. Third, mesh bags containing samples were cooked for 1-h in steam-heated kettles (Model D10SP, Groen, Chicago, Il, USA) at 90.5° C (195° F). Fourth, each sample was individually strained using a 1-mm diameter-hole manual ricer (Browne FoodServices, Ontario, Canada). Fifth, whatever carrot tissue did not go through the manual ricer was filtered through a 2-mm stainless steel sieve, using a hose/water, until all fibrous-free carrot tissue passed through the sieve. Sixth, fibrous tissue (not passing through the sieve) was collected and weighed. Finally, fibrous tissue content (%\_Fiber) in proportion to total sample weight was calculated using the formula in Fig. 5c. An example of the section end color images from different fibrous-tissue classes, from this experiment, for four different carrot segments can be seen in Fig. 5c. Carrot fibrous tissue sample number distribution for 2- and 4-classes, based on invasive analysis, is summarized in Fig. 5a and 5b, respectively.

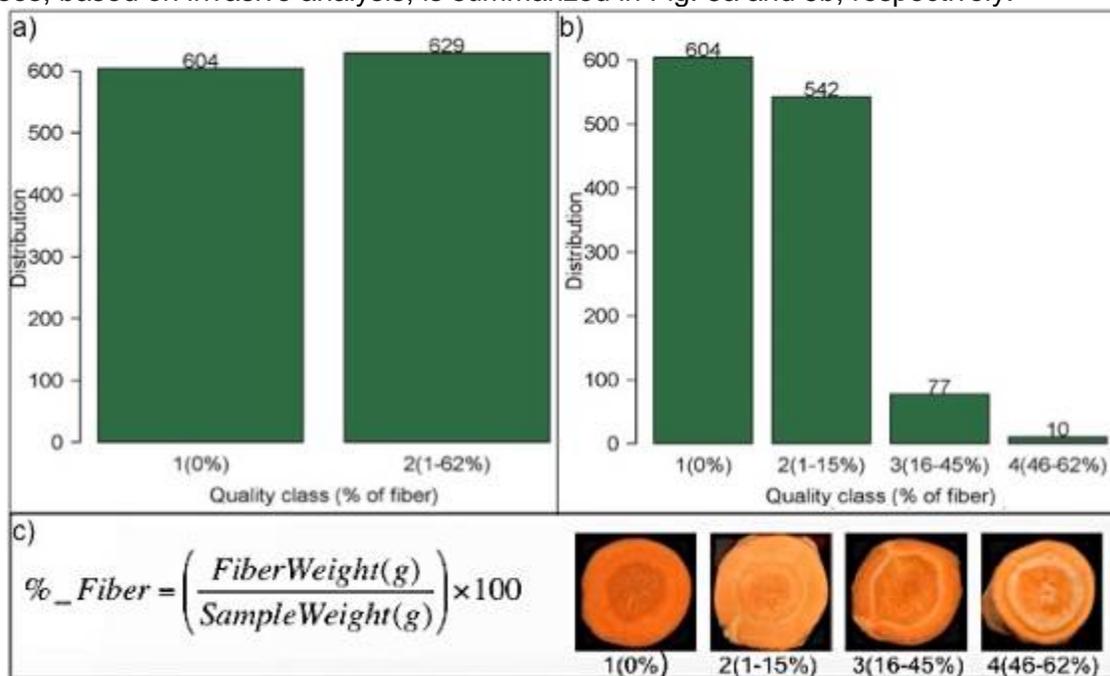


Fig. 5. Carrot fibrous tissue (%\_Fiber) sample distribution for (a) 2- and (b) 4-classes based on invasive analysis. (c) Formula used to calculate undesirable fibrous tissue content (%) in samples, and four different examples (color images) of the fibrous tissue classes.

- **Task 5: Analysis of the data using new and previously designed spectral and image analysis routines.**

#### Visual Analysis:

Fig. 6 includes a representative example of cross-sectional CT 2D images of uncut fresh carrots, which reflects the range of healthy and fibrous tissue among carrot samples. In these images, non-fibrous (desirable/safe) and different degrees of fibrous carrots can be viewed. Above every CT image, color images of fresh slices, which correspond to approximately the same CT 2D images, can also be observed. These images proved useful when judging internal quality. As can be observed, it is easy from the CT images to visually distinguish between fibrous and acceptable tissue in carrots. Fibrous tissue appears darker, therefore concluding

that its density is lower in relationship to non-fibrous tissue. This approach/technology can also perform a spatial analysis of the whole carrot, thus showing that if a carrot is moderately fibrous at the top-end, it might not be fibrous on the tail-end. In addition, this enables us to study how fibrous tissue is distributed in the carrots.

As in 2D CT images, a visual difference can also be seen from the VIS/NIR hyperspectral images and from VIS/NIR spectra from non-fibrous and fibrous carrots (Fig. 6). In the case of NIR hyperspectral images at 914 nm, non-fibrous carrot xylem (inner-ring) appears darker in comparison to fibrous carrots, in addition to fibrous carrot NIR images being more homogenous in comparison to non-fibrous carrots. This indicated that light at 914 nm interacts differently if fibrous tissue is present. In addition, lower overall mean intensity values, including the centroid and edge measurements, can be observed in the VIS/NIR spectra from non-fibrous carrots in comparison to fibrous carrots.

Preliminary visual results indicated that CT, VIS/NIR hyperspectral imaging, and VIS/NIR spectroscopy could be useful to develop future prediction models of carrot quality. Methods related to image processing, feature extraction, and pattern recognition, and automatic classification was evaluated to determine if carrots can be automatically separated based on if they contain fibrous tissue or they do not.

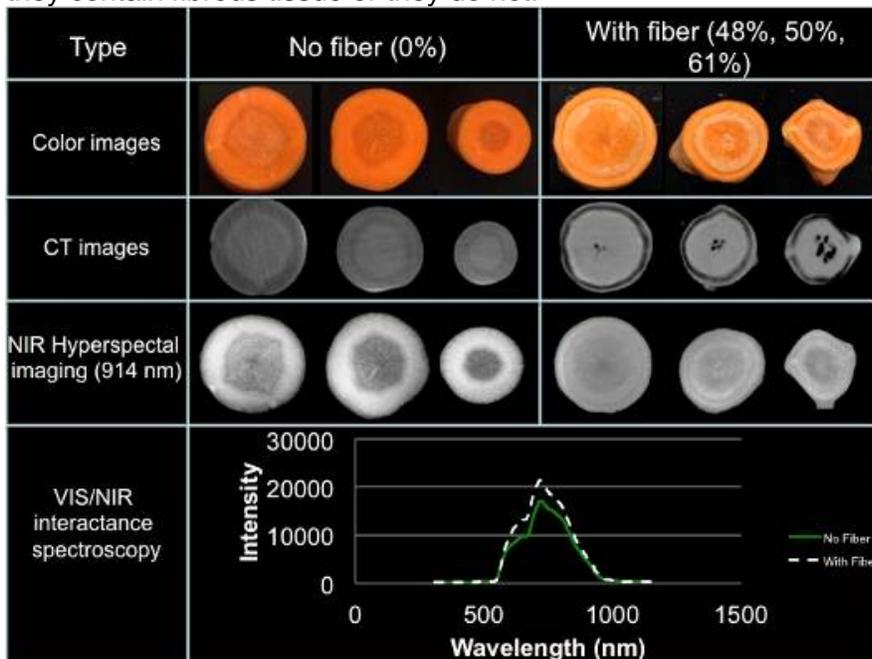


Fig. 6. Color raw carrot images of healthy (no fiber) and fibrous samples (with fiber) with its corresponding cross-sectional 2D CT images, where darker (black) sections correspond to fibrous tissue; NIR hyperspectral images at 914 nm; and mean VIS/NIR interactance spectrograph.

#### Qualitative Analysis:

Fig. 7a offers an outline of the variation of CT Hounsfield-units (HU) values (tissue density) associated with the absence/presence of different types of undesirable fibrous tissue, within carrot. In CT the difference in physical density of materials is visualized by changes in image intensity, and it is expressed as HU. Darker regions are represented by lower HU values. Except for the phloem, where woody and mix fibrous tissues are not statistically different

between each other; HU values indicating the presence of undesirable fibrous tissue are statistically different, within each carrot component. In the case of the xylem, phloem and whole carrot data, it can be seen that values higher than 39.8, -1.2, and 24.3 HU respectively, could be observed in carrots that are fibrous-free. On the other hand, HU values acquired from fibrous-free vascular cambium is statistically lower in comparison to HU values from carrots that contain fibrous tissue. Fig. 7b through 7e exemplify how HU values acquired at the white profile-line (PL) significantly change when different types of fibrous tissue are present in the carrot. Threshold value testing (accuracy, false negatives, and false positives - Fig. 7f) showed how well the HU values could forecast the presence or effect of undesirable fibrous tissue within carrots from each of the different carrot components. Results show that the mean overall accuracy rate is equal to 82%, with false negatives (carrots classified as fibrous when being fibrous-free), and false positives (carrots classified as fibrous-free, however, being fibrous) equal to eight, and ten percent, respectively. Accuracy rate for each carrot component varies. 3D images of carrots (Fig. 7g and 7h) enable a more accurate spatial visualization of internal attributes of whole carrots, showing how HU value regions volumetrically change when fibrous tissue is present.

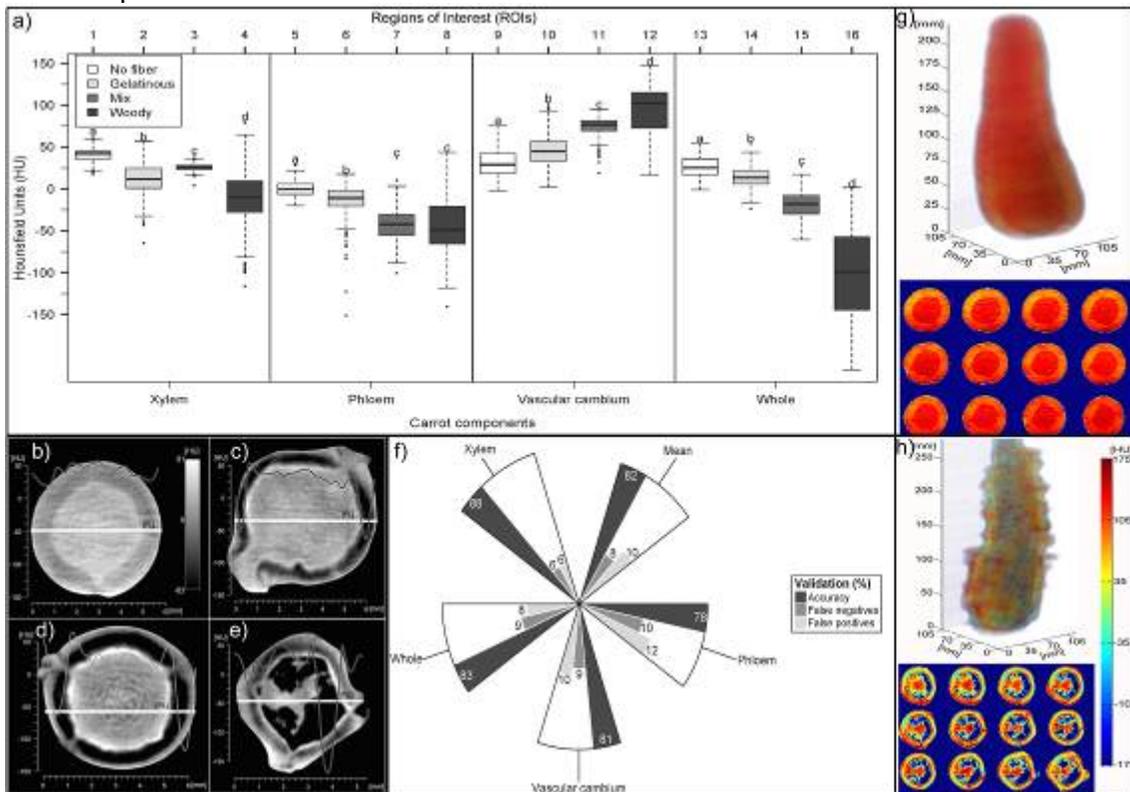


Fig. 7. (a) Box-plots of HU values from ROIs (training data set). HU value profiles taken at the white PL for: (b) fibrous-free, (c) gelatinous, (d) mix, and (e) woody fibrous carrots. Grey scale HU-standard-bar is included. (f) Fibrous carrot prediction using estimated Lower and Upper Confidence interval (CI) thresholds (testing data set) per carrot component. 3D CT reconstruction of carrots (top) with a set of 2D CT images (bottom) for a: (g) fibrous-free, and (h) woody fibrous carrots. Color HU-standard-bar is included.

With the objective of automatically obtaining information from images acquired using the CT and hyperspectral imaging system, an automatic segmentation algorithm was implemented to separate each carrot from their background. The first step was to build a binary mask to

recognize whole carrots from the background, using an automatic threshold segmentation method (Otsu).

In the case of hyperspectral images, this was done on the spectral image at 842 nm, which offered the maximum visual contrast between the carrots and the background. Then, multiple morphological operations (opening and closing) were applied to recognize other regions of interest (ROI - xylem, vascular cambium, phloem and horizontal line) as exemplified in Fig. 8. Segmentation was also done for carrot CT images representing virtual cross-sections of carrots along the longitudinal.

The segmentation procedure is robust and independent of the amount of fiber in the carrot. From the regions of interest of each segmented carrot, relative reflectance information was extracted (mean, standard deviation (SD), mean/SD and Fourier transform).

Fiber content (%)	Carrot slice hyper spectral gray-scale image (842 nm)	Segmented whole carrot	Segmented carrot xylem	Segmented carrot vascular cambium	Segmented carrot phloem	Segmented line
No fiber (0 %)						
Partial fiber (30.8 %)						
High fiber (66.5 %)						

Fig. 8. Hyperspectral images of 842 nm used to segment regions of interest (ROI - marked in green). ROIs (Whole, xylem, vascular cambium, phloem and horizontal line) obtained using Otsu threshold and a combination of morphological operations (opening and closing).

#### Classification:

After CT image preprocessing, cropping and segmentation, gray-scale intensity and textural features were extracted from CT images for all of the segmented regions. Relevant features were selected using a sequential forward selection algorithm with the Fisher discriminant objective function. The best classifier indicated that 96 features, extracted from the vascular cambium (See Fig. 8), were effective in designing a neural network classifier with a four-fold cross-validation (75% training and 25% validation) and a mean performance accuracy of 85.9% ( $\pm 2.2\%$ ). This method is accurate and objective in determining fresh carrot internal quality (undesirable fibrous tissue), and the methodology is applicable to automatic noninvasive inline CT sorting system development.

After VIS/NIR hyperspectral image cropping, segmentation, and extraction of image intensity values (VIS/NIR interactance reflectance spectra), significant wavelengths were selected using a sequential forward selection algorithm with the Fisher discriminant objective function. The best classifier (mean raw intensity values extracted from whole segmented ROIs - See Fig. 8) indicated that two wavelengths (811 and 813nm) were effective in designing a probabilistic neural network classifier with a four-fold cross-validation and a mean performance accuracy of 71.0% ( $\pm 2.2\%$ ).

Using principal component analysis (PCA) of the mean NIR interactance spectrograph, it could be concluded that the best classifier was the support vector machine classifier using with a four-fold cross-validation with mean performance accuracy of 59.8% ( $\pm 3.1\%$ ).

#### Fiber Analysis:

Samples of the different types of fibrous tissue were collected and evaluated to determine their constituents and structural carbohydrate content make-up, and further help direct detection approaches. This will help us better understand the structure of fibrous tissue. During the quantification of carrot fibrous tissue, different types of fibrous tissue were randomly collected (~50 carrots). In addition, a set of three homogenized whole un-processed fibrous-free carrots and three containing fibrous tissue, were analyzed for their structural carbohydrate content (Cellulose, hemicellulose and lignin). Constituent proportion was calculated in triplicate as the weight of each constituent (Constituent-w) divided by total biomass weight (T\_biomass-w). Preliminary results regarding this added task are seen in Fig. 9.

Whole fibrous carrots contain a statistically higher ( $P < 0.05$ ) proportion of cellulose and hemicellulose in comparison to fibrous-free carrots. Extracted woody fibrous tissues contain statistically higher proportions of all of the constituents in comparison to gelatinous and mix fibrous tissue. Mix fibrous tissue contains a statistically higher proportion of hemicellulose and lignin in comparison to gelatinous fibrous tissue.

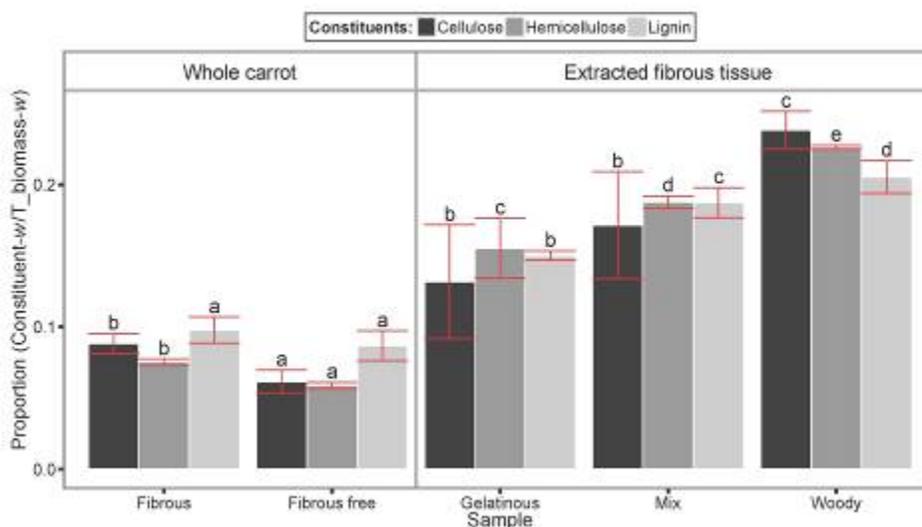


Fig. 9. Proportional constituent content per sample. Bars followed by the same letter, within a specific constituent, are not significantly different between each other at  $P = 0.05$  (ANOVA, Tukey) within whole carrot, and extracted carrot fibrous tissue samples. Red error bars indicate sample standard deviation.

#### BENEFICIARIES

Better understanding and an efficient detection method of the presence of undesirable fibrous tissue in carrots will enable the Michigan carrot industry, as a whole (producers and processors), to offer a better quality and safer product, therefore increasing consumer satisfaction and decreasing industry liability issues. In 2010, approximately 220 thousand tonnes were produced in the United States destined to the processing/value-added market, yielding a total revenue of around 2.2 billion US\$. With appropriate equipment and classification algorithms, the generated information will contribute toward the development of technology,

which is practical and suitable to apply for inline sorting systems to accurately determine carrot quality before processing.

Currently, based on our studies, there is a risk of introducing approximately 100 lb. of undesirable fibrous tissue per ten tones of processed product. This is unacceptable by the carrot processing industry, as it represents a high choking hazard. Therefore, results of this study indicate that of approached tested, CT is the best and might be a useful technique to enhance product safety.

#### LESSONS LEARNED

The medical-grade traditional GE-CT imaging system provided CT images of the internal structure, issues, and components of fresh carrots. Visual assessment of processing carrots, manual quantification/validation of fibrous tissue, and mostly the assessment of HU values within 2D and 3D CT images, has proven effective in better understanding the occurrence of undesirable fibrous tissue in processing carrots, and its relationship to changes in physiological carrot components. Significant changes ( $P < 0.05$ ) and variation of HU values associated with the presence of undesirable fibrous tissue in carrots could be discerned. Furthermore, reconstructed 3D images, obtained by a set of 2D CT images, enable the spatial visualization of the presence of undesirable fibrous tissue and its effects in whole carrots. In general, this study indicated that CT has a high potential for nondestructively visualizing and classifying internal quality attributes of fresh processing carrots with an 85.9% accuracy rate. In addition, a significant increase ( $P < 0.05$ ) in structural polymers content is observed in fibrous tissue collected from carrots, in comparison to tissues that do not contain fibrous tissue.

Classification based on VIS/NIR hyperspectral imaging presents a significantly lower accuracy in comparison to the classification of CT images. If the hyperspectral VIS/NIR classification accuracy rate can't be improved over 80%, it would not be recommended as an objective determinant of the presence of undesirable fibrous tissue in fresh carrots. It is likely that slightly modifying the classifier or in depth study of important wavelengths might improve the classification accuracy (future studies will be pursued).

Classification based on VIS/NIR interactance spectroscopy offers a significantly lower accuracy in comparison to the classification of CT images and hyperspectral VIS/NIR images. As before, if classification accuracy rate can't be improved over 80%, it would not be recommended as an objective determinant of the presence of undesirable fibrous tissue in fresh carrots. Based on this study, we can conclude from following this methodology, it is highly unlikely that VIS/NIR interactance spectroscopy could be used to determine the presence of undesirable fibrous tissue in fresh carrots.

#### CONTACT PERSON

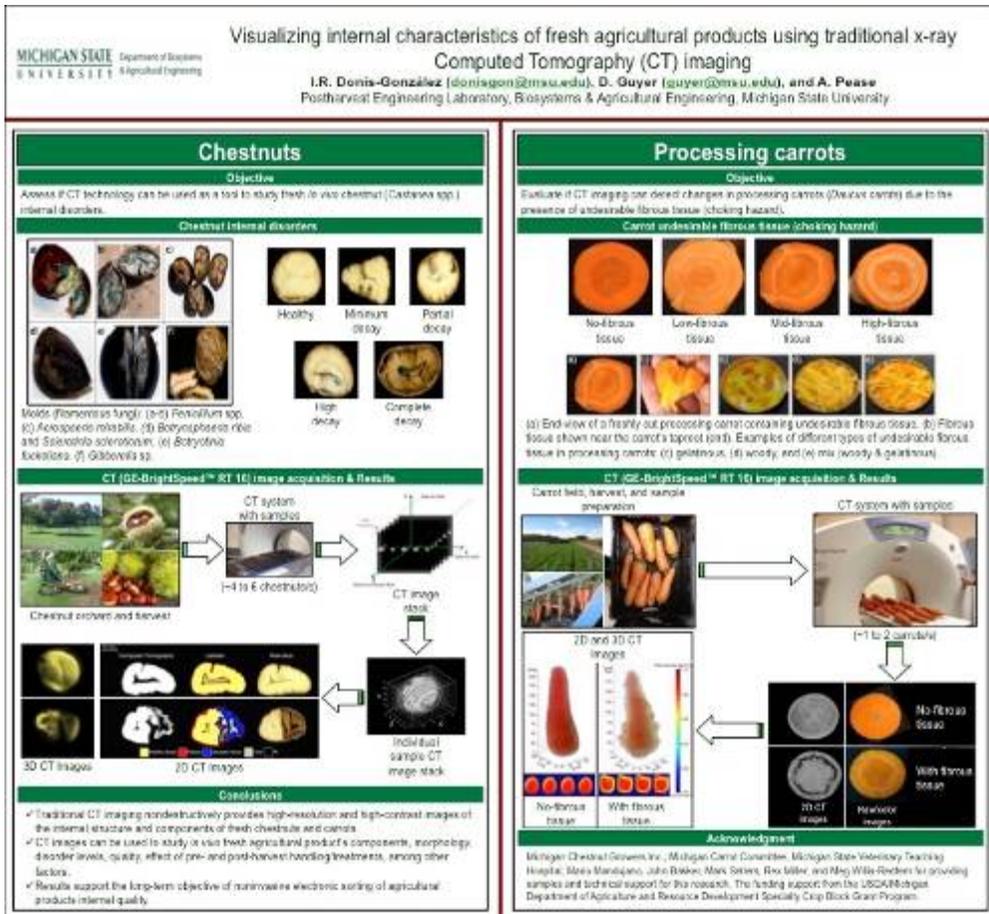
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#### ADDITIONAL INFORMATION

##### **Publications:**

Donis-González, I.R., Guyer, D.E., Chen R., & Pease, A. Evaluation of undesirable fibrous tissue in processing carrots using X-ray CT and structural fiber biochemistry. 2015. J. of Food Engineering 153: 108-116.

**Poster Agriculture and Natural Resources Week (ANR) 2015 at MSU**



**PROJECT TITLE - FINAL**

**Michigan Christmas Tree Association – Utility of Plant Growth Regulators in Christmas Tree and Conifer Nursery Production**

**PROJECT SUMMARY**

Plant growth regulators (PGR's) are compounds that are widely used to control growth in many horticultural crops but their utility in Christmas tree plantations and conifer nursery crops is largely unknown. In this project we conducted a series of on-farm trials to determine the utility of PGR's, particularly paclobutrazol, to reduce the need for shearing of conifers and to reduce the need for cone removal in Fraser fir Christmas trees. Soil-applied paclobutrazol reduced shoot growth of Fraser fir, Norway spruce and blue spruce in several field trials, although efficacy varied among farms. Soil-applied paclobutrazol reduced cone formation of Fraser fir by 44% in the third growing season after application. Paclobutrazol was highly effective in controlling height growth of container-grown white pine, Norway spruce and Serbian spruce trees. Based on the current cost of product, however, soil-applied paclobutrazol is not cost-effective for Christmas tree or field-grown conifer nursery stock production. Paclobutrazol may

have utility for container conifer production but additional research on dose-rate responses is needed.

## PROJECT APPROACH

Michigan is among the leading producers of Christmas trees and landscape conifers in the United States. Michigan ranks third in the U.S. in Christmas trees harvested annually (American Christmas Tree Association). In addition, conifer nursery production makes up nearly two-thirds of the nursery production acreage in Michigan (MASS Rational Survey). Many Michigan Christmas tree growers also produce trees for the landscape market and face many issues related to maintaining tree growth and quality while trying to keep labor costs in line. Plant growth regulators (PGR's) may reduce labor for shearing in Christmas tree and landscape conifer production and the need for cone removal in Fraser fir production.

Plant growth regulators (PGR's) are compounds that regulate plant growth, often by inhibiting synthesis or translocation of gibberellic acid (GA), a plant growth hormone. Historically, these compounds have been widely used in greenhouse floriculture production to control plant stem elongation ([MSU Floriculture Plant Growth Regulator website](#)). Paclobutrazol has been the most widely studied PGR for use on woody plants and can effectively control growth of a variety of trees and shrubs (Bai et al., 2004; Mann et al., 1995; Martínez-Trinidad et al., 2011). Paclobutrazol products such as Cambistat<sup>®</sup>, Trim-tect<sup>®</sup> (Rainbow Treecare Scientific Advancements, Minnetonka, MN) and Shortstop<sup>®</sup> (Greenleaf Chemical Henderson, NV) are now marketed for urban forestry and landscape application. In addition to direct control of height growth, additional benefits of paclobutrazol applications to trees have been observed. These include increased drought tolerance, increased disease resistance, and increased insect resistance (Chorbadian et al., 2011. Percival and AlBalushi, 2007; Zhua, 2004).

GA-inhibitors, such as paclobutrazol may provide an additional benefit to Christmas tree producers that grow Fraser fir. Heavy coning in Fraser fir is a major issue for growers, who must devote substantial labor to cone removal each year. In conifers, GA stimulates cone production and is frequently applied to enhance cone production in conifer seed orchards. Therefore, GA inhibitors such as paclobutrazol may potentially reduce coning of Fraser fir.

In this project we evaluated the effectiveness of PGR's in Christmas tree and conifer nursery production. We conducted the project in cooperation with five Christmas tree farms in Michigan (Fig. 1). The project was conducted in two phases. In Phase One, we examined the efficacy of PGR application on field-grown conifers. In Phase Two, we investigated the response of container-grown conifers to PGR application. In addition, we conducted a focus group meeting with several Christmas tree growers to determine the potential economic benefit of reducing labor costs for cone removal and shearing based on PGR application.

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## GOALS AND OUTCOMES ACHIEVED

### Field trials

In May 2013 we installed field trials in Christmas tree plantations at five tree farms in Michigan (Fig. 1). At four of the farms we applied paclobutrazol (Cambistat) to 120 Fraser fir trees in each of three size classes (Table 1). Paclobutrazol was applied as a soil injection using a pressurized backpack system (Fig. 2). Treatments were applied via three soil injections distributed evenly around each tree. We applied two foliar PGR treatments: paclobutrazol (TrimTect) and chlormequat (Cycocel). Gibberellin A<sub>4</sub>A<sub>7</sub> (ProVide) was applied as a positive control to compare against the other PGR's.

In addition to the Fraser fir test, we applied paclobutrazol via soil injection to field-grown blue spruce and Norway spruce at two farms (Table 1).

For Fraser fir plots, coning was assessed on all trees in May 2014 and May 2015. The number of cones on each tree was recorded and tree responses were analyzed as cone density (cones per tree). Terminal leader growth was assessed for all trees, including spruces, in late summer 2014 and 2015. The length of the terminal leader was measured to the nearest cm with a meter stick.

### Container trial

In spring 2014 we applied paclobutrazol as a drench treatment to container grown conifers at Dutchman Tree Farms, Manton, MI (Fig. 3). The container trial was installed as a set of six experiments. Treatments were applied to Norway spruce, eastern white pine and Serbian spruce in three gallon (#3) and five gallon (#5) containers. In each experiment, 75 trees were assigned at random to one of three treatments: high rate of paclobutrazol (200 ml), low rate of paclobutrazol (100 ml) or untreated control. The trees were grown in an operational block of

container-grown trees in the pot-in-pot production area of the nursery. Trees were grown in a standard mix of pine bark and compost. Trees were fertilized with a controlled release fertilizer and irrigated daily via an overhead irrigation system. Terminal leader growth was assessed for all trees in late summer 2014 and 2015.

## **Results - Field trials**

### *Fraser fir growth*

Paclobutrazol, applied either by soil injection (Cambistat) or as a foliar application (Trimtect), significantly ( $P < 0.05$ ) reduced shoot leader growth of Fraser fir trees on at least one size class of trees at each test location (Tables 2-5). Cycocel and GA4/7 did not affect growth of Fraser fir trees at any of the farms in 2014 or 2015.

At the farm in Mason, MI, paclobutrazol consistently controlled growth of Fraser fir trees in all size classes in 2014 and 2015 (Table 2). Cambistat reduced mean leader growth across all tree sizes by 32% in 2014 and by 46% in 2015. The foliar application of paclobutrazol reduced growth in 2014 but not 2015. Cambistat and Trimtect also reduced growth of Fraser fir trees in 2014 at the farm in Horton, MI (Table 3). We were unable to re-evaluate growth at this farm in 2015 due to shearing operations on the farm.

The effect of Paclobutrazol on leader growth was less consistent at the other farms. At the Sidney, MI, location Cambistat reduced growth for trees in the largest and smallest size classes but not in the intermediate size category (Table 4). Trimtect did not affect growth at this location. At the Manton tree farm, Cambistat reduced growth on the small and medium trees in 2014 and on the large trees in 2015 (Table 5). Trimtect reduced growth of Fraser fir trees at this site in 2014 but not 2015.

### *Fraser fir coning*

The effect of PGR's on cone formation in Fraser fir varied by farm, year, and size class of trees. In 2015 Cambistat reduced coning of large Fraser fir trees at Manton, MI, and the Sidney, MI, sites and reduced coning of small Fraser fir trees at the Horton, MI, farm. Cone density was very low across all size classes at the Mason, MI, farm, making it difficult to assess treatment effects. In general, the effect of Cambistat on coning increased over time. Averaging across all farms and tree size classes, Cambistat reduced the number of cones per tree by 12% in 2014 and by 43.5% in 2015.

### *Spruce growth*

The effect of Cambistat on shoot growth varied by farm and species. At the Sidney location Cambistat reduced shoot growth of medium sized (5'-6') Norway spruce and blue spruce trees in both 2014 and 2015 by up to 55% compared to untreated control trees (Table 6, Fig. 4). Cambistat did not affect growth of large (6'-8') blue spruce trees at Sidney or medium blue spruce at Manton.

## **Container study**

Applying Cambistat as a container drench treatment had little or no effect on shoot growth in the season following spring application (Fig. 5). In the second season after application, however, both rates of Cambistat reduced leader ( $P < 0.001$ ) growth of Norway spruce, Serbian spruce and white pine trees in #3 and #5 containers. Leader growth did not differ between high and low rates for any species or size class. In 2015 leader growth reductions ranged from 46% for Serbian spruce trees in #5 containers to 76% for white pine in #3 containers.

## BENEFICIARIES

The primary beneficiaries of this project are Christmas tree and landscape conifer growers. Based on the results of these trials, soil-applied paclobutrazol is the only PGR treatment that consistently affected conifer shoot growth or cone formation in Fraser fir. The current retail price of Cambistat is approximately \$400 per gallon. Using a standard dilution of 11:1 this results in a product cost of \$1.76 to \$5.28 per tree depending on rate (Table 7). A single operator can treat 100 trees per hour. Based on a typical planting density of 1,200 trees per acre and assuming \$10 per hour for labor, this results in a labor cost of \$120 per acre for application. Depending on dosage, the total cost for product and labor will range between \$2,234 and \$6,461 per acre. Based on a survey of growers, typical costs for shearing spruce and pine range from \$1,068 to \$1,194 per acre. For Fraser fir the combined costs of shearing and cone removal are \$1,888. This analysis suggests that the cost of using PGR's to control growth and/or reduce cone formation in field grown conifers would exceed cost of current shearing and cone removal practices even if the lowest rate trialed completely eliminated the need for shearing or cone removal, which is highly unlikely.

Although we did not conduct a specific economic analysis of the use of paclobutrazol to control growth in container-grown conifers, the use of PGR's may have a better fit in this production system than in field production. Additional research will be needed, however, in order to determine appropriate rates since the rates used in the current trial resulted in excessive growth reductions.

## LESSONS LEARNED

We did not observe any consistent evidence of phytotoxicity, such as needle browning, in either the field or container study. In both studies, however, we did observe trees which lacked apical dominance as a result of Cambistat application (Fig. 4). Moreover, growth reductions of trees in the container trials were likely greater than growers would desire. This suggests that additional studies on optimizing rates are needed.

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## ADDITIONAL INFORMATION

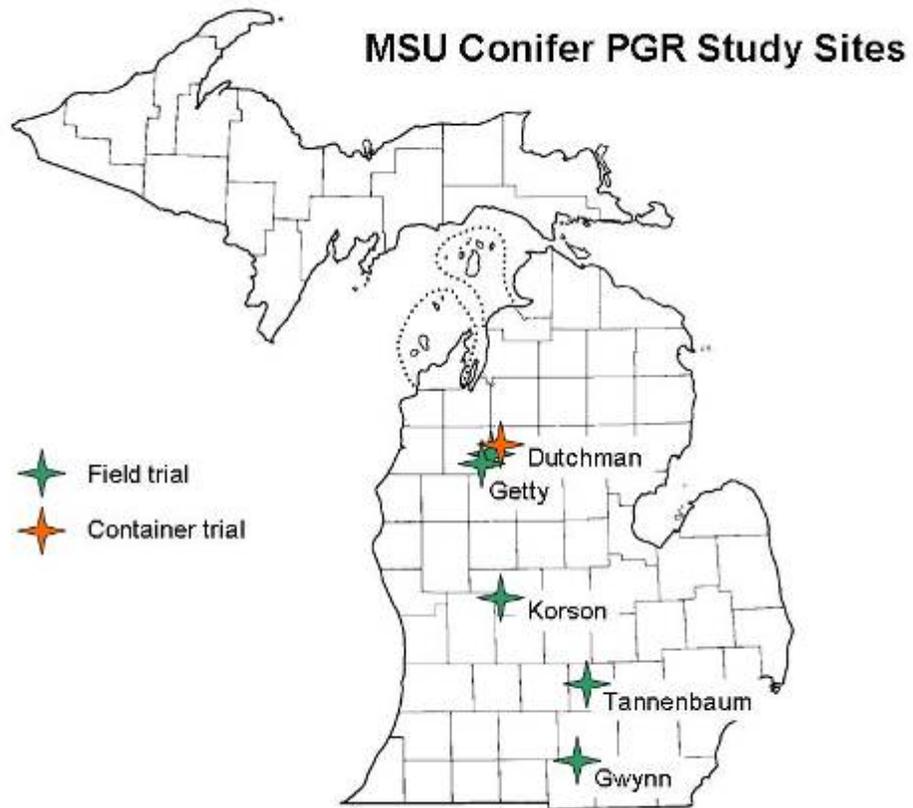


Figure 1. Location of PGR trials in Michigan

Table 1. Distribution of trees in PGR trials at tree farms in Michigan

<b>Species: Fraser Fir</b> <b>Locations: Dutchman Tree Farms, Korson's Tree Farms, Tannenbaum Farms, Gwinn's Tree Farm</b>		<b>Number of trees</b>		
<b>Treatment</b>	<b>Application method</b>	<b>Small (3-4')</b>	<b>Medium (4-6')</b>	<b>Large (6-7')</b>
Control		40	20	20
Cambistat(200ml)	Soil injection	40		
Cambistat(400ml)	Soil injection		20	
Cambistat(600ml)	Soil injection		20	20
Trimtect	Foliar spray		20	
Cycocel	Foliar spray		20	
GA 4/7	Foliar spray		20	

<b>Species: Blue spruce</b> <b>Location: Getty Tree Farms</b>				
<b>Treatment</b>	<b>Application method</b>	<b>Small (3-4')</b>	<b>Medium (4-6')</b>	<b>Large (6-7')</b>
Control			40	
Paclobutrazol	Soil injection		40	

<b>Species: Blue spruce</b> <b>Location: Korson's Tree Farms</b>				
<b>Treatment</b>	<b>Application method</b>	<b>Small (3-4')</b>	<b>Medium (4-6')</b>	<b>Large (6-7')</b>
Control		20		20
Paclobutrazol	Soil injection	20		20

<b>Species: Norway spruce</b> <b>Location: Korson's Tree Farms</b>				
<b>Treatment</b>	<b>Application method</b>	<b>Small (3-4')</b>	<b>Medium (4-6')</b>	<b>Large (6-7')</b>
Control		20		
Paclobutrazol	Soil injection	20		

Figure 2. Soil injection application of paclobutrazol at Korson's Tree Farms



Figure 3. Container-grown Norway spruce in #5 containers at Dutchman Tree Farms, Manton, MI.



Figure 4. Soil-applied paclobutrazol (Cambistat) reduced leader growth of field-grown Norway spruce trees but also reduced apical dominance, resulting in multiple leaders.

**Table 2. Mean cone density (cones/tree) and leader growth of Fraser fir trees in response to treatment with PGR's. Tannenbaum Farms, Mason, MI**

Treatment	Mean Cones (Cones/tree)		Mean Leader Length (cm)	
	2014	2015	2014	2015
<b>Size Class: Small</b>				
Cambistat(200ml)	2.1*	4.1	26.8*	23.4*
Control	5.5	6.4	41.1	39.8
<b>Size Class: Medium</b>				
Cambistat(400ml)	8.2	7.6	28.5*	19.5*
Cambistat(600ml)	7.5	6.0	24.8*	19.4*
Cycocel	12.5	4.8	39.8	47.2
GA4/7	21.7	7.0	44.6	42.1
Trimtect	16.8	11.2	29.7*	40.1
Control	10.7	11.9	46.1	46.0
<b>Size Class: Large</b>				
Cambistat(600ml)	20.7	6.0	32.4*	23.6*
Control	24.2	12.0	40.1	39.2

\* indicates mean is different from control at P<0.05 level.

**Table 3. Mean cone density (cones/tree) and leader growth of Fraser fir trees in response to treatment with PGR's Gwinn's Tree Farm, Horton, MI**

		Mean Cones (Cones/tree)		Mean Leader Length (cm)	
Treatment		2014	2015	2014	2015 (na)
<b>Size Class:</b>					
<b>Small</b>	Cambistat(200ml)	11.8	39.9*	43.4*	-
	Control	8.4	65.2	52.8	-
<b>Size Class:</b>					
<b>Medium</b>	Cambistat(400ml)	26.8	46.9	44.2*	-
	Cambistat(600ml)	14.5	76.2	45.2*	-
	Cycocel	31.0	137.8	53.1	-
	GA4/7	27.4	42.4	55.5	-
	Trimtect	28.9	66.0	45.6*	-
	Control	17.4	84.8	57.7	-
<b>Size Class:</b>					
<b>Large</b>	Cambistat(600ml)	30.8	81.8	47.7*	-
	Control	47.7	138.1	58.1	-

\* indicates mean is different from control at P<0.05 level.

na: Trees at this farm were sheared before leader growth could be assessed

**Table 4. Mean cone density (cones/tree) and leader growth of Fraser fir trees in response to treatment with PGR's. Korson's Tree Farms, Sidney, MI**

		Mean Cones (Cones/tree)		Mean Leader Length (cm)	
Treatment		2014	2015	2014	2015
<b>Size Class:</b>					
<b>Small</b>	Cambistat(200ml)	6.1	10.1	24.2*	46.6*
	Control	3.1	13.2	38.9	56.9
<b>Size Class:</b>					
<b>Medium</b>	Cambistat(400ml)	13.6	22.3	34.1	47.9
	Cambistat(600ml)	10.7	29.7	25.8	46.9
	Cycocel	41.7	45.2	42.2	65.0
	GA4/7	15.2	31.8	27.1	57.5
	Trimtect	5.1	21.5	38.9	59.1
	Control	21.1	57.9	36.4	58.8
<b>Size Class:</b>					
<b>Large</b>	Cambistat(600ml)	55.2	71.3*	22.3*	40.5*
	Control	38.5	130.2	38.5	61.8

\* indicates mean is different from control at P<0.05 level.

**Table 5. Mean cone density (cones/tree) and leader growth of Fraser fir trees in response to treatment with PGR's. Dutchman Tree Farms, Manton, MI**

		Mean Cones (Cones/tree)		Mean Leader Length (cm)	
Treatment		2014	2015	2014	2015
<b>Size Class:</b>					

<b>Small</b>	Cambistat(200ml)	16.6	12.0	37.6*	39.6
	Control	16.2	13.2	44.0	41.9
<b>Size Class:</b>			12.2		43.1
<b>Medium</b>	Cambistat(400ml)	36.9		35.4*	
	Cambistat(600ml)	45.3	18.2	37.7	41.2
	Cycocel	42.5	32.5	40.6	47.0
	GA4/7	53.7	18.0	47.9	45.6
	Trimtect	51.9	18.8	32.4*	45.5
	Control	50.2	31.0	45.7	47.0
<b>Size Class:</b>					
<b>Large</b>	Cambistat(600ml)	63.4	11.6*	38.4	46.9*
	Control	75.2	47.9	42.9	51.8

\* indicates mean is different from control at P<0.05 level.

**Table 6. leader growth of Norway spruce and blue spruce trees in response to treatment with PGR's.**

	Treatment	Mean Leader Length (cm)	
		2014	2015
<b>Farm: Getty Tree Farms, Manton, MI</b>			
<b>Field: Blue spruce 5'-6'</b>			
	Cambistat	29.3	35.5
	Control	27.7	34.1
<b>Farm: Korson's Tree Farms, Sidney, MI</b>			
<b>Field: Blue spruce 5'-6'</b>			
	Cambistat	16.6*	22.8*
	Control	36.7	45.1
<b>Field: Blue spruce 6'-8'</b>			
	Cambistat	32.5	30.3
	Control	35.6	37.0
<b>Field: Norway spruce 5'-6'</b>			
	Cambistat	30.3*	37.3*
	Control	67.0	69.2

\* indicates mean is different from control at P<0.05 level.

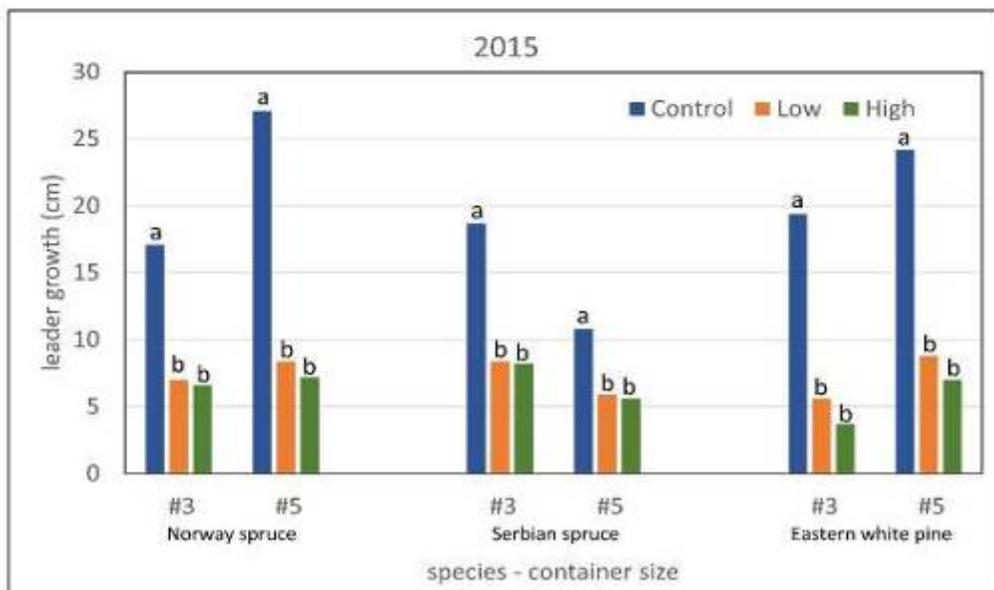
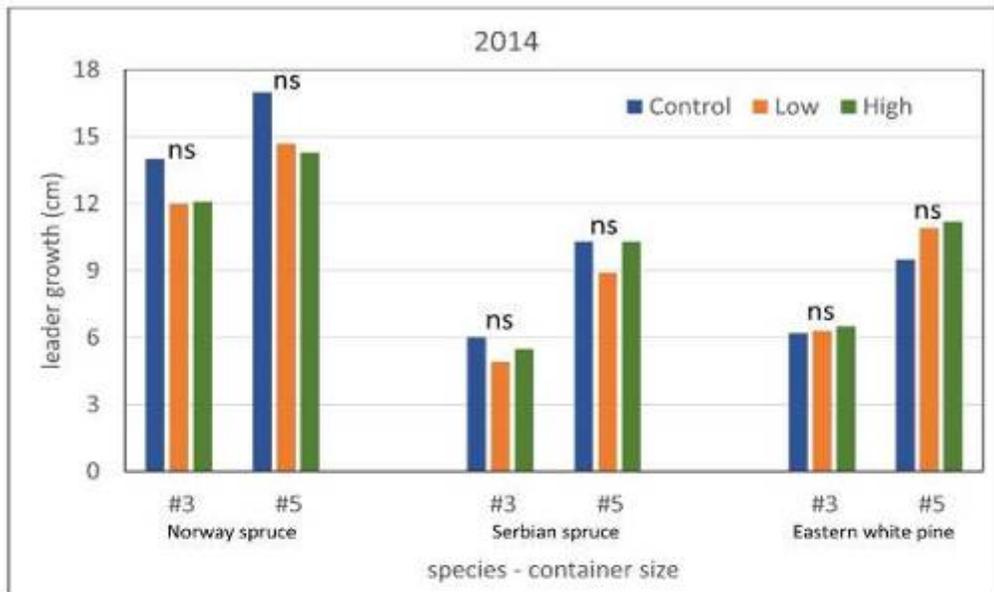


Figure 5. Mean leader growth of Norway spruce, Serbian spruce, and eastern white pine trees grown in #3 or #5 containers in response to PGR (Cambistat) applied in spring 2014. Dutchman Tree Farms, Manton, MI. Note: ns indicates no PGR treatment effect. Means within a species/container size group headed by the same letter are not different at  $p < 0.05$ .

Table 7. Cost comparison of soil applied placlobutrazol (Cambistat) versus current grower practices for shearing and cone removal

Cost of Cambistat application					
Application rate (ml per tree)	Product cost \$ per tree	Product cost \$ per acre <sup>1</sup>	Labor cost \$ per acre	Total \$ per acre	
200	\$1.76	\$2,114	\$120	\$2,234	
400	\$3.52	\$4,227	\$120	\$4,347	
600	\$5.28	\$6,341	\$120	\$6,461	

Cost of current practices for shearing and cone removal <sup>2</sup>					
	3 years before harvest \$ per acre	2 years before harvest \$ per acre	1 year before harvest \$ per acre	harvest year \$ per acre	Cumulative \$ per acre
White pine – shearing	\$216	\$258	\$312	\$408	\$1,194
Spruce – shearing	\$200	\$240	\$280	\$348	\$1,068
Fraser fir - shearing	\$268	\$300	\$360	\$432	\$1,360
Fraser fir - cone removal	\$68	\$93	\$150	\$217	\$528
Combined	\$336	\$393	\$510	\$649	\$1,888

1. Assuming 1,200 trees/acre
2. Based on estimates from MCTA members

## PROJECT TITLE - FINAL

### Michigan Apple Committee – Trade Advertising for Promoting Michigan Apples

#### PROJECT SUMMARY

After the significant crop loss of 2012, Michigan apples did not have a presence in the retail market for nearly a year. The Michigan apple industry needed a strong presence in trade advertising after that absence, in order to regain visibility with our retail partners. In addition, the crop loss dramatically impacted the Michigan Apple Committee budget. Grant funding for our trade advertising allowed us to direct our limited funds toward other marketing, education and research efforts on behalf of our growers.

The motivation for this project is the fact that our job at the Michigan Apple Committee is to help set the stage for successful sale and marketing of apples at the retail level. After the crop loss of 2012, our retail partners needed to be made aware that the Michigan apple industry was prepared to make a strong comeback in 2013 with the high-quality fruit and effective marketing programs they have come to expect. One of our key tactics for achieving that was through advertising in trade publications, announcing marketing programs available in which they can participate, as well as crop updates and other industry information.

## PROJECT APPROACH

The Michigan Apple Committee trade advertising project aimed to facilitate strong recover of the Michigan apple industry after the crop loss in 2012. It was important to the industry to reestablish our position in the marketplace with a strong presence in trade publications. Through advertisements in the popular print publications The Packer and Produce Business, our message has been shared with thousands of readers in our target audience. From October 2013 to September 2014, we have placed 12 ads in The Packer and one ad in Produce Business.

In addition, we sent a survey to our fresh retailer email list of 376 contacts to gauge whether the ads increased their awareness of Michigan Apples, and whether it increased their purchases of Michigan Apples.

By focusing our efforts on advertising in trade publications, it allowed us to make a splash in a powerful way that reaches our key partners. However, with an absence from the marketplace in 2012, we know it will take more than one year of heavy participation in trade advertising to truly have an impact. This project is moving the industry forward in a positive direction with retailer recognition and building awareness.

## GOALS AND OUTCOMES ACHIEVED

As a part of this project, MAC completed

- 12 advertisements in The Packer
- One advertisement in Produce Business
- A survey to 376 fresh retail customers
- This has allowed us to set benchmarks for future efforts

The survey we distributed allowed us to ask retailers about immediate impacts of the trade advertising, however, we do feel a continued, long-term focus on trade advertising will be necessary to maintain a strong presence and cultivate recognition with this audience.

The goals established for this project were to place a total of 13 trade advertisements, which was achieved. In addition, MAC also set the goal to increase sales of Michigan Apples by 10% based on our survey of retailers about the advertisements.

According to our retailer survey, 100% of respondents saw our advertisements, and 40% said the ads increased their awareness of Michigan Apples. Unfortunately none of the respondents said that they increased purchases of Michigan Apples because of the advertising. Our thoughts were also confirmed, in that only 40% of the respondents regularly read Produce Business, while 100% indicated that they regularly read The Packer.

There is still more work to be done. As mentioned above, a long-term focus on trade advertising as a way to reach the important retailer audience is needed. While this year, the survey indicates that purchasing decisions were not influenced by the advertising, we feel that continued work in this area can move the needle for Michigan Apples.

## BENEFICIARIES

Beneficiaries of this project include Michigan's 850 apple growers, as well as Michigan Apple Shippers, processors, and other industry partners.

Our job at the Michigan Apple Committee is to help set the stage for successful sale and marketing of apples at the retail level. This project is one component that helps us to achieve that, which benefits the entire Michigan Apple Industry.

### LESSONS LEARNED

As indicated in a prior report, one lesson we learned was that The Packer is the ideal publication in which to advertise. With reasonable advertising rates (including multi-ad discounts), a weekly distribution and circulation of 13,052 (with 67% of those being retailers) it provided us with the biggest impact for the grant dollars spent, in terms of reach.

This project allowed us to build positive relationships with the trade publications and bring more attention to the Michigan Apple Industry.

Although the goal of increasing Michigan Apple sales by 10% was not achieved, the project helped to confirm our belief that trade advertising will need to be a continued focus of our work.

### CONTACT PERSON

Diane Smith, Executive Director  
 517-669-8353  
 Diane@MichiganApples.com

### ADDITIONAL INFORMATION

#### Advertisements

#### The Packer (not actual size – the ads were 17” x 3”)

October 2013



November 2013



December 2013



January 2014

**COOKING WITH APPLES**  
**Inspire your shoppers with the versatility of Michigan apples!**

There are so many ways to cook with Michigan apples. From breakfast to dinner and everything in between, the Michigan Apple Committee has the ingredients for you to increase sales and put smiles on the faces of your shoppers. Offer an array of apple-inspired dishes for any cook from beginner to professional with our Michigan apple recipe cards.

Contact the Michigan Apple Committee today for recipe cards and details on the Cooking with Apples program.

**MICHIGAN APPLES**

MichiganApples.com • 800-456-0753  
 For supplies, visit MichiganApples.com/meal

February 2014

**EXPERIENCE THE GREAT FLAVORS OF MICHIGAN APPLES**  
**Flavor, Variety and Freshness**

Are your shoppers looking for an apple with a crisp, tangy bite? Or something sweet and juicy? Do they prefer an apple that is tart or has a spicy flare? Michigan apples have all that and more. With about 20 commercially available varieties, there's a Michigan apple perfect for every consumer's taste.

**MICHIGAN APPLES**

MichiganApples.com • 800-456-0753  
 For supplies, visit MichiganApples.com/meal

March 2014

**MICHIGAN FUJI**  
**A refreshingly sweet flavor**

Consistently a consumer favorite and one of Michigan's premium varieties, Fujis have low acid content and stay fresh for long periods. Their crisp, sweet flavor will have shoppers coming back for more. Order your refreshingly sweet Michigan-grown Fujis today!

This variety, harvested in late fall, benefits from Michigan's climate—especially cool autumn nights—to enhance its flavor and crisp texture.

**MICHIGAN Fuji**

MichiganApples.com • 800-456-0753  
 For supplies, visit MichiganApples.com/meal

April 2014

**MEET YOUR MICHIGAN APPLE GROWERS**  
**A strong commitment to bringing you quality.**

Michigan apple growers take great pride in the product that ends up in your stores. With 800 family-owned orchards and a multi-generational tradition of growing apples, you can count on Michigan apples for the variety, flavor and freshness your consumers want. Michigan growers are committed to food safety, environmental stewardship and social responsibility, giving your shoppers another reason to choose Michigan.

Contact your Michigan Apple supplier today.

**MICHIGAN APPLES**

MichiganApples.com • 800-456-0753  
 For supplies, visit MichiganApples.com/meal

May 2014

**EXPERIENCE THE GREAT FLAVORS OF MICHIGAN APPLES**  
**Flavor, Variety and Freshness**

Are your shoppers looking for an apple with a crisp, tangy bite? Or something sweet and juicy? Do they prefer an apple that is tart or has a spicy flare? Michigan apples have all that and more. With about 20 commercially available varieties, there's a Michigan apple perfect for every consumer's taste.

**MICHIGAN APPLES**

MichiganApples.com • 800-456-0753  
 For supplies, visit MichiganApples.com/meal

June 2014

**GROWING THE 2014 MICHIGAN APPLE CROP**  
**Cultivating quality and freshness for you!**

The 2014 Michigan Apple crop is on its way, as the small beginnings of apples emerge after the past fall of blossoms. Start planning your fall programs today! Contact your Michigan Apple Supplier now to plan for 2014. Visit MichiganApples.com/meal for supplier contact information.

**MICHIGAN APPLES**

MichiganApples.com • 800-456-0753  
 For supplies, visit MichiganApples.com/meal

July 2014



**GROWING GREAT TASTING APPLES FOR YOU**

**Have you made your fall plans with Michigan Apples?**

Get ready for fall by sourcing Michigan Apples and planning fall programs today. Michigan's sunny summers, cool nights and nutrient-rich soil produce the best-tasting apples.

Give your shoppers the best apples they'll ever taste. Contact your Michigan Apple supplier today. Get information at [MichiganApples.com/retail](http://MichiganApples.com/retail).



August 2014



**LOCALLY GROWN MICHIGAN APPLES**

**Better, fresher flavor from an orchard near you**

Consumers prefer the fresh flavor of locally grown Michigan Apples, buying local supports their wallets and the economy and gives them the freshest, most delicious things to the unique climate and seasons of the Great Lakes State.

Your shoppers can also enter to win one of three trips to Crystal Mountain in Northern Michigan with our Locally Grown Incentivized Visit in MI, OH, IN, IL, WI and MN. Contact the Michigan Apple Committee for more information.



September 2014



**MICHIGAN HONEYCRISP APPLES**

**This premium apple is creating quite a buzz!**

Shoppers everywhere have been waiting for the sweet, crisp and juicy Honeycrisp apple. Order your supply of Michigan Honeycrisp apples today and get ready for the consumer excitement.

Michigan Apples taste better because of the ideal climate and geography of our growing region. Cool autumn temperatures make for a juicy, sweet crunch of a Honeycrisp! CONTACT your supplier today! Get more information at [MichiganApples.com/retail](http://MichiganApples.com/retail).



Produce Business (Ad size 2.333" x 5")  
October 2013

**CONSUMERS PREFER MICHIGAN APPLES!**

Consumer research shows that shoppers believe Michigan apples are fresher and taste better than the same varieties grown elsewhere.\*



**MichiganApples.com**  
**(800) 456-2753**  
Contact your Michigan apple supplier today.  
For more information, visit [MichiganApples.com/marketingprograms](http://MichiganApples.com/marketingprograms).



\*This claim has not been substantiated by Michigan Apple Committee 2006-2011. It applies to areas including Ann Arbor, Lansing and Detroit, MI, and Metro Chicago.

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Retailer Survey



# RETAILER Trade Advertising Survey

**Please take a few moments to complete this survey.**

Name

Store Name

---

1. Do you regularly read any produce trade publications? Check all that apply.\*

- Produce News
- Produce Business
- The Packer
- Other

---

2. Beginning in fall 2013 did you see Michigan Apples advertising in any produce trade publications?\*

- Yes
- No
- Not sure

*If you answered "No" or "Not sure" you may proceed to the Chain Information section.*

---

3. If you did see Michigan Apple advertising in produce trade publications, did it increase your awareness of Michigan Apples?

- Yes
- No

---

4. Did the advertising increase your purchases of Michigan Apples for your chain?

- Yes
- No

---

5. If it did increase your purchases of Michigan Apples by what percentage did you increase your purchases? 

---

---

**Chain Information**

How many stores does your chain have?\*

Location: Check all that apply.\*

- Midwest (Michigan, Ohio, Indiana, Illinois, Wisconsin)
  - Central United States (Missouri, Minnesota, Arkansas)
  - SE United States (Kentucky, Tennessee, Georgia, North Carolina, South Carolina, Florida)
  - Southern United States (Alabama, Mississippi, Louisiana, Arkansas)
  - Western United States (Texas, Oklahoma, Colorado, North Dakota, South Dakota, Iowa)
  - Nationwide
- 

**Thank you for your time!**

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## PROJECT TITLE - FINAL

**Michigan Potato Industry Commission** – 2013 Soil Health Initiative for Michigan Upper Peninsula Potato Production Systems

## PROJECT SUMMARY

This project started with a simple scope of research: to analyze the microbial community and its role in potato production systems in Michigan. Our research found ample data which will be used in further studies. The heuristic value for this project is high as we look to the next step we see this project as a template for future research goals. This study was able to confirm other data collection studies and also inspire further research and analysis.

## PROJECT APPROACH

The purpose of this grant was to look at microorganisms in the soil and see how they can impact a potato crop. Several contributing factors were analyzed and recorded. As seen in Appendix I (data maps), potato crops seem to utilize the microorganisms as soil enhancers. On a macro level we see the potato crop influencing soil organisms. Every day we learn more about soil and the impact of our crops on microbial communities. With soil management and sustainability taking center stage in research today as we look at agriculture through a global lens, finding new and effective production systems for potato crops in Michigan is vital for the 21<sup>st</sup> century.

## GOALS AND OUTCOMES ACHIEVED

On August 27<sup>th</sup>, 2014 the Michigan State University (MSU) personnel presented this soil health initiative to a grower audience at the UP summer potato meeting. An overview of the projects objectives and the desired outcomes were presented to the audience. Approximately, forty grower or grower representatives were present at this presentation.

All proposed sampling of the 2014 potato production field were completed as specified. Nematode, verticillium, microbial community, potato yield and common scab evaluation were conducted as proposed. The Cornell, basic soil health sampling was reduced to only on-grid points due to the cost of processing these samples. Overall, soil sample processing costs have exceeded budgeted values and a reduction in the number of Cornell soil samples were made to reduce sample processing costs.

The four hay-alfalfa rotation fields that are a part of this long term soil health study were soil sampled for base line microbial community data on September, 4<sup>th</sup> 2014. This data will aid future research and will serve as base line data, allowing this team to evaluate the impacts of future cropping on these soils.

The nematode, verticillium, potato yield, common scab and Cornell, basic soil health data evaluations were conducted as proposed. This data shows an increase in the verticillium population in the soil, along with an increase in the numbers of root lesion and stunt nematodes present as a result of the potatoes being a part of the cropping system (Appendix I). In addition, the populations of Mycorrhizal fungi and Oligochaetes present in the soil are higher during the potato crop than before the potatoes were present. These beneficial soil organisms are enhancers to the soil microbial community. The potato crop appears to be influencing soil organisms on a macro level based on these data. One of the major objective of this study was to observe how a potato crop influenced soil microorganisms. The microbial community data collected during the spring, summer and fall sampling events in the potato production field, as well as, the alfalfa rotation is currently pending analysis. The potato yield and Cornell soil health data has not revealed any new information to date (Appendix I). The potato yield and soil health

data would be most useful under a long-term production system study. Funding was sought for the continuation of this project from Project GREEN, but was denied, hence the project will not continue in 2015. This project was instrumental in MSU obtaining a GREEN funded project titled: "Influence Of An Alfalfa/Hay Rotation On Soil Health In A Potato Production System In The UP of MI and Integrated Crop-Livestock Farming Solutions For Building Soil In MI's UP". The MDARD Block Grant funding obtained in 2013 was fundamental in laying the ground work and establishing many of the techniques that will be used in this new GREEN project. Without the continued funding of this MDARD Block Grant research project, it is not possible to demonstrate the temporal impact of a potato crop on a hay/forage/potato production system or conversely the ability of the hay/forage system to restore the soil quality after a potato crop. We still plan to present these findings we have to potato growers at the Michigan Potato Industry Commission's (MPIC) Winter Potato Conference (WPC) in February 2016. We expect 300 people in attendance at this event. We hope to use this meeting as an opportunity to share with the grower audience the impact of potato production on the hay-alfalfa cropping system.

#### **BENEFICIARIES**

Direct beneficiaries from this research include potato growers from around the area. It extends beyond potato growers specifically. Our research looked to alfalfa growers and other crop rotations. Any grower who uses potatoes for rotation can benefit from this research. In Michigan that means over 70 farms will have a better understanding of the microbial communities in their soil and how to maximize their yields based on that data. Another beneficiary is the academic community; the base of this research will act as a spring board for future research goals. This has been a foundational lesson for many.

#### **LESSONS LEARNED**

Due to the secondary nature of its objective and the quantity of work required, the alfalfa hay component of this study was removed from the proposed work plan. It was decided that this information was tangential to the affect in question. That primary objective of this study was to identify how a potato crop effects the soil nematode, verticillium and microbial communities of soil after a crop of potatoes is grown. By not investigating the forage component of this study, we believe we narrowed the scope of this project.

We believe this project was successful at demonstrating that a potato crop does influence soil organisms. Without temporal data it is impossible to show the influence of the rotational crops on the soil flora and fauna after the potato crop. We plan to continue to investigate the impact of potato production and the use of rotational crops, in a larger cropping system context, on the physical, chemical and microbial properties of soil.

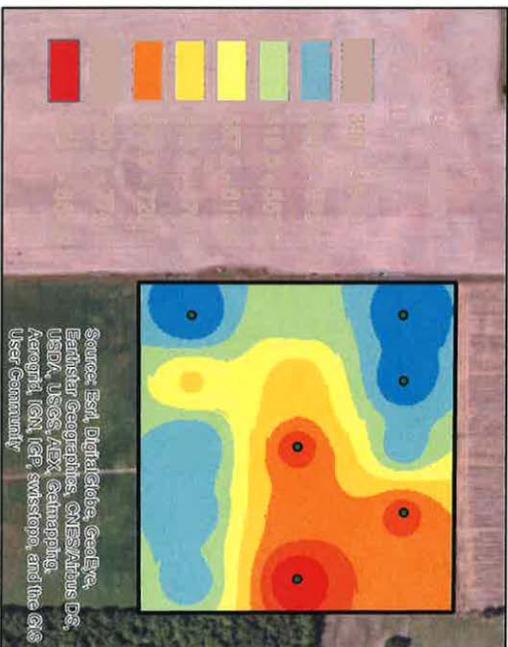
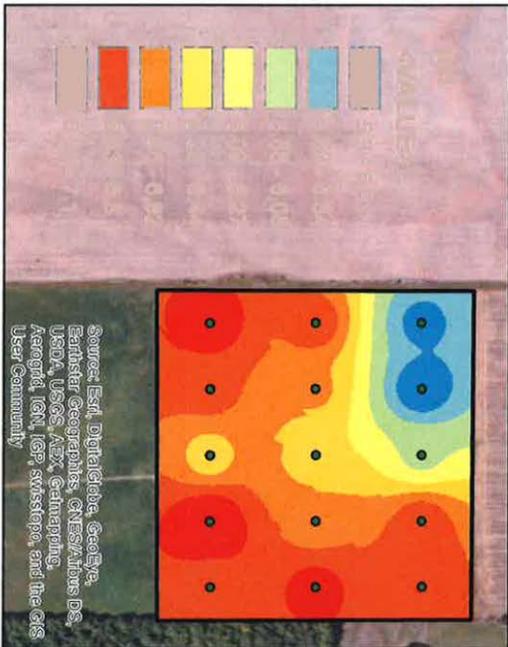
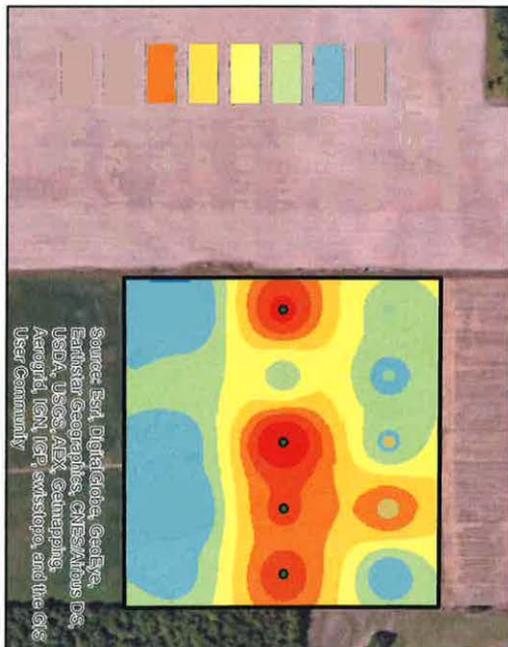
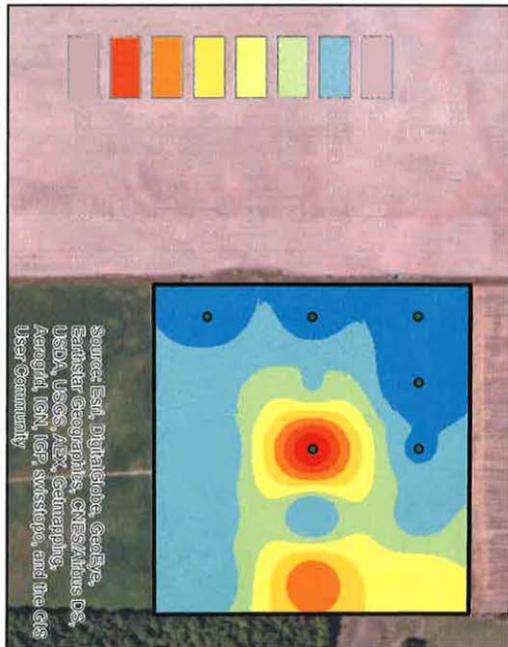
To date, the MSU Team has requested payment from MPIC for \$21,056.57 of work associated toward the completion of the objectives of this grant. This number includes consulting fees, sampling and laboratory analysis costs. Also included in this figure is some travel, labor and supply costs.

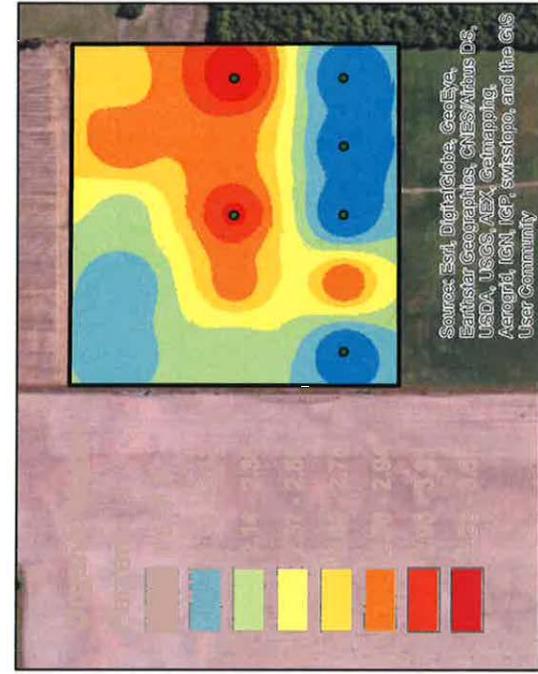
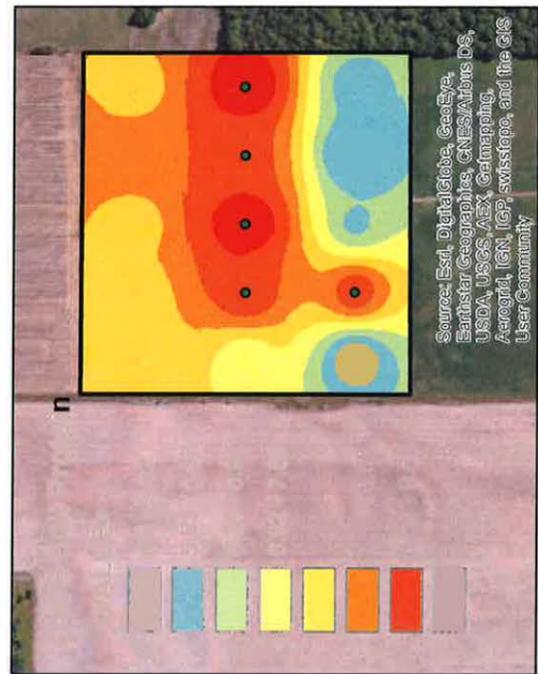
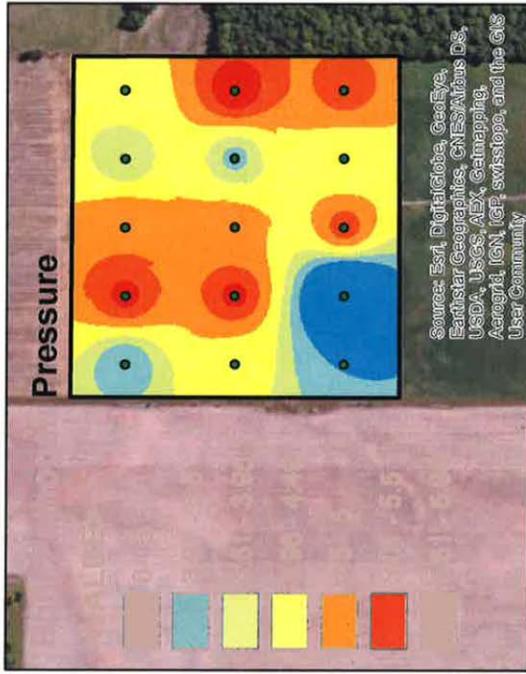
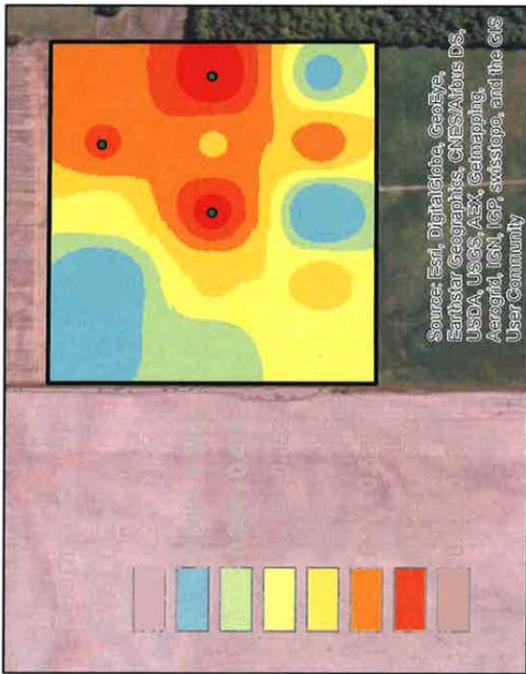
#### **CONTACT PERSON**

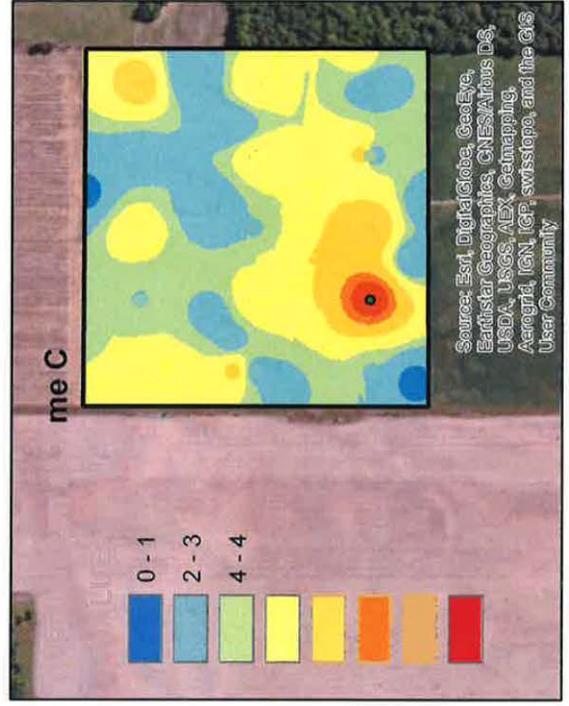
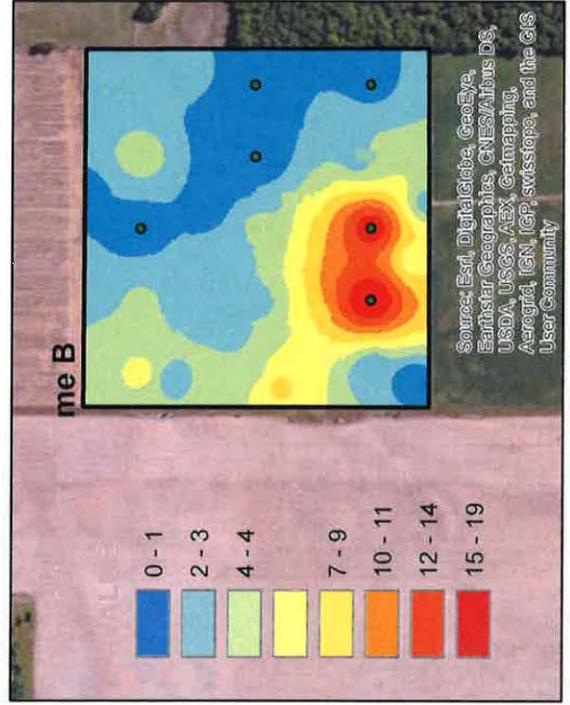
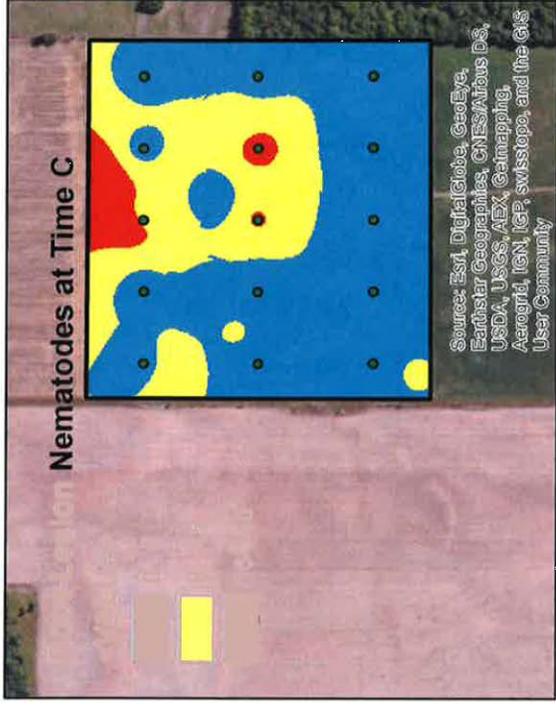
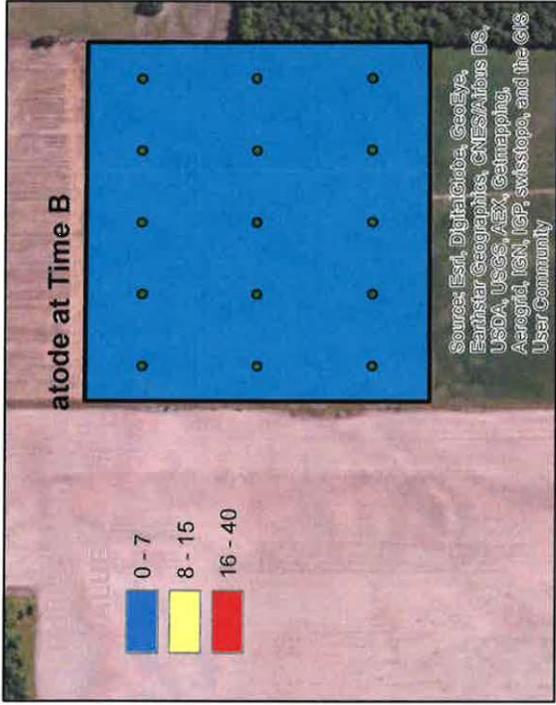
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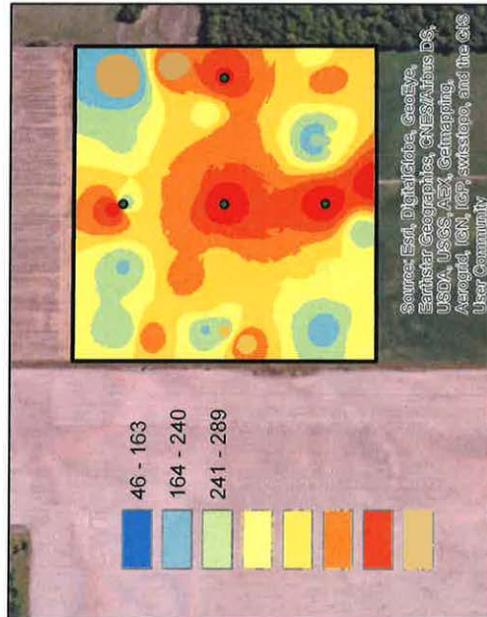
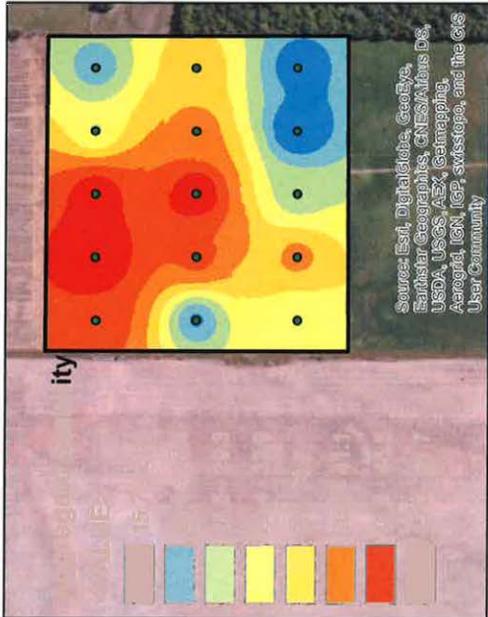
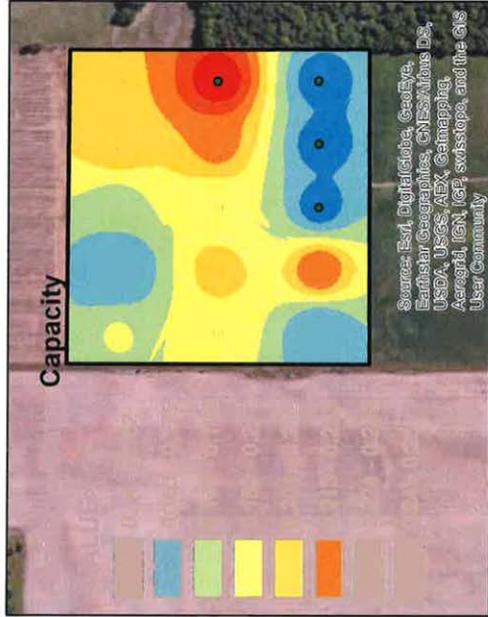
#### **ADDITIONAL INFORMATION**

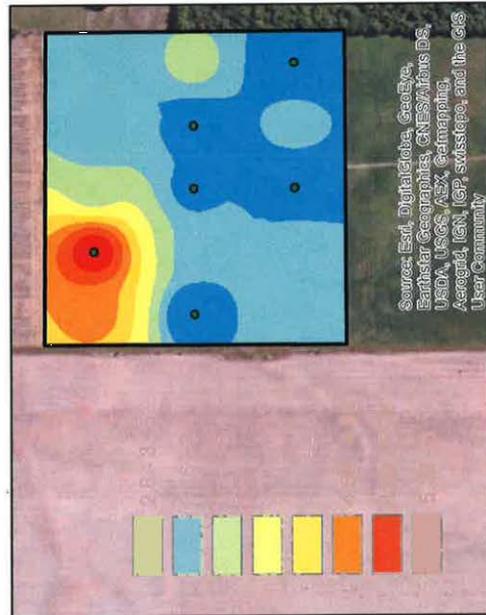
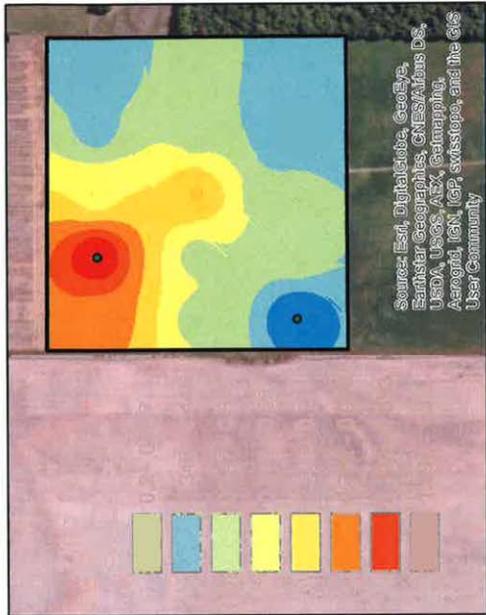
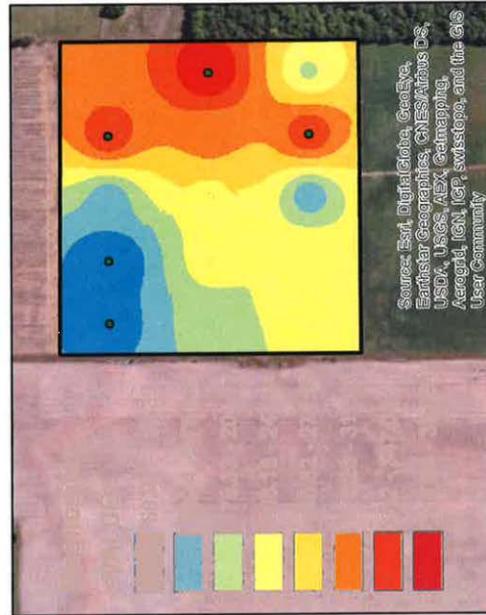
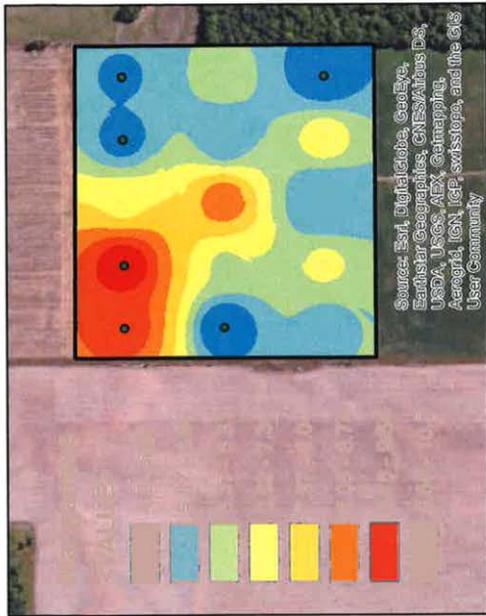
See Appendix I with Data Maps











## PROJECT TITLE – FINAL

**Michigan Organic Food & Farm Alliance (MOFFA)** – Developing Integrated High Tunnel Production Strategies that Enhance the Feasibility and Competitiveness of Michigan Organic Fruit Production

## PROJECT SUMMARY

Currently, the availability of locally-produced organic fruit at Michigan farmers markets and groceries is almost non-existent. Organic fruit production in Michigan has been quite limited due to the pest complexes in our humid Midwest environment. Sweet cherries and raspberries are among the highest valued (per lb) fruits grown in Michigan, yet they are very challenging to grow organically due to several negative climatic impacts, including risk of spring frost damage, risk of rain-induced fruit cracking, and risk of rain-disseminated debilitating diseases. In addition, several new invasive pests have appeared in Michigan the two years before this project began, with the spotted wing drosophila (SWD, *Drosophila suzukii*) fruit fly quickly causing substantial losses in 2012 fall raspberry production in Michigan and other states. This and the brown marmorated stinkbug (*Halyomorpha halys*) have further increased the challenges for organic growers.

High tunnels are increasingly used for production of fresh, high value fruit crops because they allow growers to manipulate the environment to minimize climatic constraints and risks associated with weather events, such as the devastating spring climatic conditions in Michigan in 2012. Tunnels can be used to trap supplemental heat for spring frost protection, trap solar radiation to hasten crop development and advance harvest into earlier market windows when fruit prices are higher (or before certain pests become prevalent), reduce the incidence of certain diseases by eliminating wetting of leaves and fruit by rain, alter insect pest movement, or extend harvest of indeterminate crops, such as fall raspberries and blackberries later into the fall.

Profitability and competitiveness in organic fruit markets requires high food quality standards, the adoption of suitable cultivars and rootstocks, enhanced cultural techniques, and effective organic strategies for maximizing yields while controlling disease and insect pests. This project addresses those requirements.

Regional markets and consumer demand for organic produce continues to grow year over year. These attractive markets, and MSU's preliminary research on organic cherry and raspberry production, have generated significant interest among Michigan organic food growers who currently primarily grow organic vegetables and herbs. Furthermore, the sudden appearance of SWD fruit flies has created a new, critical management hurdle for organic fruit growers. Thus, a timely and important project has become even more timely and important with respect to the need for on-going research and discovery.

The project was initiated with federal funding from the USDA-Organic Research and Extension Initiative (OREI, 2011-2013). Furthermore, a USDA-Specialty Crop Research Initiative (SCRI) proposal to advance portions of this work was prepared for 2013 consideration, but this fiscal year program never materialized due to Congress' failure to reauthorize and allocate funds to that key portion of the Farm Bill. Therefore, SCBGP funding served to maintain and bridge critical organic fruit research progress for Michigan growers during 2014 until the next generation of federal funding can be obtained.

## PROJECT APPROACH

This project addressed current barriers to successful organic fruit production in Michigan—specifically the study of organic management strategies for key insect and arthropod pests, as well as diseases and soil fertility for raspberries and sweet cherries grown in high tunnels, and evaluation of raspberry and sweet cherry cultivars, rootstocks, and training systems suitable for organic high tunnel production. In organic cherries, the previously negative impact of aphids was negligible in 2014, but plum curculio and brown rot were problematic with no as-yet effective organic controls. Bacterial canker incidence was minimal under the protective tunnel covers. Overall tree health was impressive, considering the harsh winters experienced during 2013-14 and 2014-15. These reduced summer raspberry yield about 75%, but fall raspberry yield was about 12,000 lbs/acre, about 50% greater than anticipated. SWD was present in 2014, but not nearly to the same extent as in 2013, presumably due to 2014 being a cooler season, preventing rapid population increases. Management strategies of developing narrower rows of fruiting canes and more frequent picking to reduce overripe fruit available for ovipositing likely contributed to the reduced SWD infestation levels. Insect exclusion netting studies appear promising thus far.

The principal investigators for this project were Drs. Gregory Lang and Eric Hanson of the Michigan State University Horticulture Department, assisted by co-investigators Drs. Dan Brainard and John Biernbaum (MSU Horticulture), Dr. Annemiek Schilder (MSU Plant, Soil, & Microbial Sciences), Drs. Rufus Isaacs and Matt Grieshop (MSU Entomology), and Ms. Vicki Morrone and Mr. Adam Montri (MSU Extension Organic Outreach). Two project employees were paid by the grant funds, Josh Moses (field manager for the organic tunnels) and Tammy Wilkinson (research technician for data collection and analysis).

The project team met during Fall 2013 and Fall 2014 to summarize the 2013 and 2014 season harvests, plant performance, and insect/disease incidence, and to plan for the 2014 and 2015 research and production seasons, respectively. Project partners Greg Lang, John Biernbaum, Eric Hanson, Matt Grieshop, Annemiek Schilder, and Vicki Morrone provided updates and outcome data to fruit growers and other organic farmers at the Organic Reporting Session in March 2014, two field days held at the high tunnel facility during the summer of 2014, and a formal presentation at the Great Lakes Fruit and Vegetable Expo in December, 2014.

## GOALS AND OUTCOMES ACHIEVED

The four specific research objectives for the project are listed below, with brief descriptions of the activities accomplished relating to each. (The first two topics are reported on together as several activities pertained to both insect pests and disease.)

- 1) Develop and refine organic management strategies for key insect and arthropod pests of raspberries and sweet cherries in high tunnels; and**
- 2) Develop and refine organic management strategies for key diseases of raspberries and sweet cherries in high tunnels.**

Insect and disease scouting began after budbreak in spring of 2014 and 2015; aphid populations in the cherry tunnels were greatly reduced from 2013. While it could not be determined whether this was due to the new management plan or due to the severe winter of 2013-14, preliminary indications for spring 2015, following a second severe winter, is that the control achieved is due to the dormant oil program. Aphids populations in a comparable non-organic protected environment plot flared up in spite of the 2014-15 winter. Isolated outbreaks of eastern tent caterpillars were easily removed manually before significant damage occurred. Cherry harvest in 2014 was still plagued by insufficient control of plum curculio and brown rot

infestations of the fruit, making harvest data collection irrelevant. Further organic cherry pest management research will be needed to develop effective grower recommendations for adequate protection against these pests.

Summer raspberry harvest data were collected in 2014 and insect exclusion netting treatments were imposed for fall raspberry production as a potential management strategy for spotted wing drosophila (SWD). Bumblebees were used for pollination in the netted treatments since native pollinators were excluded.

Analysis of SWD traps gave promising results. Where inadvertent gaps in netting occurred, SWD found entry, but fully-enclosed treatments resulted in SWD-free fruit production. Temperatures did not seem to be adversely affected by the netting treatments. Consequently, exclusion netting is also being considered for potential future control of plum curculio for organic high tunnel cherry production.

### **3) Develop and refine organic management strategies for soil health and plant/crop nutrition for raspberry and sweet cherry production in high tunnels.**

Soil samples were collected and analyzed during 2014, and weed populations were recorded. In late winter 2014 and 2015, raspberry and cherry plants were dormant-pruned and organic mulch was applied to raspberry plots prior to emergence and to cherry plots during the spring and fall. Organic fertigation was applied during the growing season.

### **4) Evaluate raspberry and sweet cherry cultivars, rootstocks, and training systems most suitable for organic high tunnel production.**

Mechanized summer pruning (hedging) was imposed in the cherries for the first time after harvest in 2014. As desired, re-growth was minimal and no structural tree canopy winter damage of significance was observed in spring 2015. As expected, flower bud damage was evident due to several periods of extremely low temperatures, but bud damage was less than that which occurred in winter 2013-14.

Double-cropping of raspberries (production of a summer crop on selected floricanes retained from 2013, followed by a fall crop on new 2014 primocanes) resulted in low yields (1,000-2,000 lbs/acre) for the summer portion due to poor floricanes quality following the severe winter. However, primocane yields were the highest yet achieved under organic management, 10,000 to 12,000 lbs/acre. This is a 35 to 50% increase over previous years, presumably due to improvement in organic nutrient management.

Cane pruning of raspberries for 2015 production will further examine the potential for summer+fall cropping by studying the effect of number of floricanes retained on summer yield, as well as on development of primocanes and subsequent fall yields. The target yields we are working towards are to balance seasonal yield potentials at about 8,000 lbs/acre for each of the cropping seasons, totaling 16,000 lbs/acre annually. One benefit of floricanes retention noted in 2014 was taller primocane formation, which may have been a component of the increased fall yields.

The two overall project goals were to increase the number of cherry and raspberry growers in Michigan who utilize organic production methods and high tunnel technologies, and to increase the number of organic and/or high tunnel fruit producers in Michigan at five years after the project is initiated (30 Sept 2018).

With respect to the first goal, there were at the inception of the project no more than five producers of cherries and raspberries utilizing high tunnel, organic production methods in Michigan. The planned performance measure of progress towards achieving the first goal was to survey participants at the organic fruit field day (summer) and the Great Lakes Fruit, Vegetable, & Farm Market Expo (winter) to determine if they will implement one or more of this project's organic and high tunnel fruit production strategies, and if so, which component methods or technologies they plan to adopt or integrate into their operations. The survey following the summer field day revealed few participants who currently grow either crop organically, and few who intended to adopt one or more organic production components right away, though most respondents indicated that they would continue to follow progress in solving the remaining key organic pest control problems. Therefore, the Expo survey was not conducted in the winter, as the summer survey indicated several years of results were desirable in order to affect grower adoption.

With respect to the second goal (increasing the number of organic and/or high tunnel fruit producers in Michigan at five years after the project is initiated), at the beginning of the project less than five of the ~350 commercial high tunnels in Michigan were being used for fruit-growing. Of the more than 250 organic farm operations in Michigan, fewer than five produced organic raspberries or sweet cherries. The planned performance measure of progress towards achieving the second goal will be a five-year survey by MOFFA and MSU Extension educators to quantify the number of commercial growers in Michigan who utilize high tunnels and/or organic methods for fruit production. MOFFA and MSUE now interact more closely as a result of this jointly-conducted grant, with no anticipated barriers to conducting the 2018 survey. The target outcome will be at least 35 high tunnels planted to fruit production, of which at least 20 will be growing organic raspberries or sweet cherries.

## BENEFICIARIES

Both organic and non-organic growers of raspberries and sweet cherries have benefitted from the accomplishments of this project. The former group remains extremely limited in number in Michigan, due to the few remaining organic pest control problems. The latter group in Michigan comprises the fourth highest (by acreage) producers of sweet cherries in the U.S.; newly-planted orchard acreage in 2014-15 was at least 20 acres, nearly all of which utilized the tree training system information associated with this project. Twenty acres with mature annual yields of 12,000 lb per acre of fruit valued at \$3.75 per lb farm market price would be \$0.9 million production value annually; once the remaining organic pest problems are solved, a higher price per lb would be expected, and previously established non-organic orchards can transition to organic, so the potential remains for significant future expanded organic and economic impacts.

The partnership between the MSU researchers and extension educators and the MOFFA membership, for reaching out to and informing the organic fruit community, was successful via the organic reporting session and two twilight tours. Project personnel provided oral updates to constituents on March 7, 2014, at the MSU Organic Reporting Session (Eric Hanson, Matt Grieshop, Annemiek Schilder, Vicki Morrone). A twilight tour/field day was held on July 1, 2014, for growers during cherry harvest and was attended by 32 participants (led by Greg Lang, Eric Hanson, John Biernbaum, Vicki Morrone, and Annemiek Schilder). A second twilight tour for educators was held on September 12, 2014, during raspberry harvest and was attended by 27 participants (led by Eric Hanson, Greg Lang, John Biernbaum, and Jeremy Moghtader). Topics for the twilight tours included: organic cherry production, organic raspberry production, production using three-season tunnels, space-efficient trellising systems for cherries and raspberries, organic pest management, and soil health. Project reports were developed for oral

presentation and summaries were handed out at the Great Lakes Fruit and Vegetable Expo held in Grand Rapids in early December 2014.

## LESSONS LEARNED

Insights, outcomes, and conclusions from the project include:

- Organic cherry soil health and fertility has been satisfactory throughout the life of the orchard thus far, with certain weed/orchard floor management treatments having the greatest impact on tree growth. Tree performance is best when root competition with weeds or cover crops is minimized during spring through early summer, thereby allowing the sowing of late summer cover crops for soil-building during fall and winter. Once regular cropping begins (as it has been limited by winter flower bud damage as the trees matured), fertility regimes may need adjustment.
- Organic cherry growth and fruiting was not negatively impacted by aphids following adoption of dormant oil applications, but plum curculio remains problematic with no as-yet effective organic control strategies. The typical organic control for PC in apples, the spray application of kaolin clay particles, is not feasible with cherry due to difficulty with residue removal. Insect exclusion netting, which can also serve as bird exclusion netting, may be one potential solution for organic control of plum curculio (PC). Perimeter trapping of PC may also be effective as part of an integrated approach for control.
- Brown rot remains problematic, with no effective organic control measures yet discovered. Bacterial canker incidence has been minimal under the protective tunnel covers, presumably due to minimal dissemination by rain. Overall tree health has been impressive, considering the two harsh winters experienced during 2013-14 and 2014-15, with minimal tree mortality.
- Organic summer raspberry yield was 2,000 lbs/acre in 2014, about 75% lower than anticipated, as a result of severe low temperature damage to the overwintering floricanes. It is conceivable, though not yet documented, that stable summer yields could reach 8,000 lbs/acre.
- Organic fall raspberry yield was about 12,000 lbs/acre, about 50% greater than anticipated, presumably as a result of the reduced summer crop. It is conceivable, though not yet documented, that if summer yields do reach 8,000 lbs/acre, stable fall yields may be maintained at 8,000 lbs/acre.
- SWD was present in 2014, but not nearly to the same extent as in 2013. 2014 was a cooler season, which likely helped prevent rapid population increases as occurred in 2013. Management strategies of developing narrower rows of fruiting canes and more frequent picking to reduce overripe fruit available for ovipositing likely contributed to the reduced SWD infestation levels. The insect exclusion netting studies (see photo below) appear promising thus far; similar studies of insect exclusion netting in Europe for organic SWD control have also appeared promising.
- Organic raspberry and cherry grower number and acreage surveys were not undertaken by the MSU extension team and the MOFFA partnership, as it appeared (from twilight tour feedback) that such numbers are currently insignificant, and unlikely to change until well-documented organic solutions for SWD (raspberry) and brown rot and PC (cherry) are discovered. The continued study of organic high tunnel raspberry production (see **Additional Information** below) will provide additional opportunities to document increases in the number of organic raspberry growers.



*Insect exclusion netting for organic control of Spotted wing drosophila (SWD) in the raspberry high tunnels at the MSU-Horticulture Teaching and Research Center.*

#### CONTACT PERSON

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Principal Investigator: Dr. Gregory Lang, langg@msu.edu, 517-353-0388

#### ADDITIONAL INFORMATION

An extension publication, [Organic Raspberry Production in Three-Season High Tunnels \(Hanson, Morrone, Isaacs; MSU Extension Bulletin E3235\)](#) on best management plans (BMPs) for organic raspberry grower clientele was published as a result of this project, as was an extension publication on [Cherry Training Systems \(Long, Lang, Musacchi, Whiting; PNW Extension Bulletin 667\)](#). A third planned extension publication, *High Tunnel Sweet Cherry Production for Organic and Other High Value Market Opportunities*, on BMPs for organic cherry grower clientele was not completed during the project due to the unsolved issues of organic plum curculio and brown rot control.

Organic high tunnel raspberry research will continue with the awarding of a USDA-SCRI grant to E. Hanson for 2014-2019. Organic high tunnel cherry research may or may not continue, as competitive grant proposals submitted in 2014 for organic pest management challenges were not successful.

## PROJECT TITLE - FINAL

Michigan Maple Syrup Association – Producing High Sugar Content Planting Stock for the Michigan Maple Syrup Industry

## PROJECT SUMMARY

Maple syrup production is typically constrained by the volume of sap gathered from the taps and the sugar concentration of the sap (SSC). Establishing new stands of sugar maple with inherently high SSC would boost production, cut costs, and give the stand owner a competitive advantage in the marketplace. Maple syrup producers have long recognized that there are dramatic variations in the SSC of individual sugar maple trees. The key question for anyone trying to produce high SSC planting stock is: how much of this variation is under genetic control? After measuring the SSC of 4,500 trees Taylor (1956) found trees with higher SSC values tended to maintain their ranking both within and between seasons, hinting at the presence of enough genetic control to make a breeding program practicable. Hoping to capitalize on this potential genetic variation, William Gabriel of the USDA Forest Service (USFS) initiated a multi-state program to identify trees with consistently high SSC values (Gabriel 1964). Because SSC is so strongly influenced by site and climatic factors, Gabriel monitored each candidate for selection a minimum of two years and evaluated their performance relative to three or more neighboring trees. Only trees whose SSC was higher than its neighbors by 30% or more for a minimum of two years were finally selected. Open-pollinated seed and scion wood were collected from each of the selected trees. The scion wood was used to establish a grafted orchard at Grand Isle, Vermont. The open-pollinated seed, each lot representing a ½-sib family produced by a selected tree, was established in progeny tests in Vermont, Ohio and Michigan.

The Michigan planting was established at MSU's Kellogg Forest in 1978. It occupies 1.2 acres and was established with four-tree row plots of 46 ½-sib families replicated in five blocks. Early mortality obviated the need for thinning until 1992 when the two smallest trees/plot were removed to provide adequate growing space for sap production. By 2013 it was clear that the planting would require thinning within the next five years to maintain a basal area amenable to sap production. Prior to the second thinning the relative sweetness of each tree, and their respective family, needed to be determined to estimate the degree of genetic control of SSC and to retain the best individuals in the best families for future breeding work.

Coincidentally, another sugar maple genetics planting was established in 1979 in the same field as the USFS selections. The 1979 planting is also a ½-sib progeny test, but unlike the USFS planting, the maternal parents were selected completely at random from across Michigan. The goal was to examine genetic variation in the growth, survival, fall leaf color, and SSC of sugar maple in Michigan. This planting will also require thinning in the near future, and the effective completion of this thinning requires the collection and analysis of SSC data from each tree.

Both the USFS and MI sugar maple progeny tests at Kellogg Forest present an opportunity to identify a breeding population of high SSC trees and to eventually produce genetically improved sugar maple planting stock. This opportunity, and the years of effort devoted to the selection and establishment of the two plantings, would have been lost without the data collection and analysis funded by this project.

## PROJECT APPROACH

The goals of this project were:

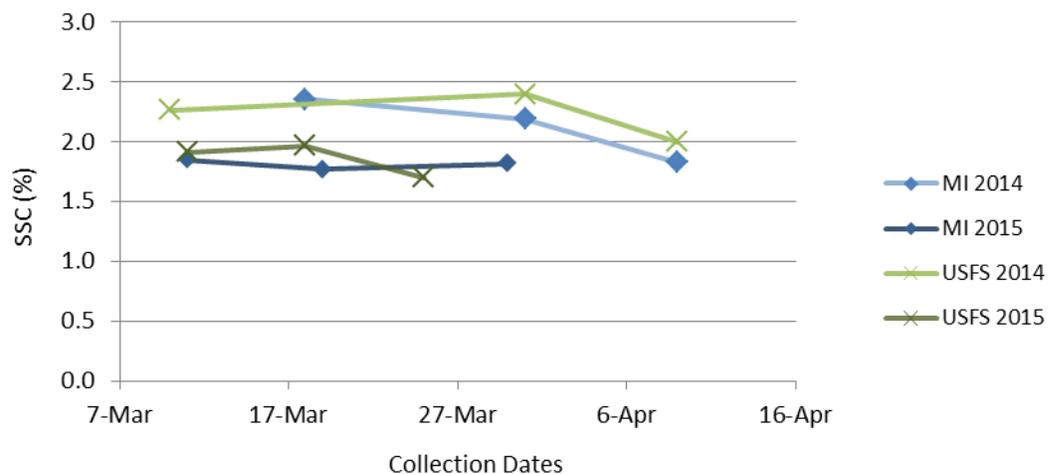
- 1) Identify trees in the USFS and MI progeny test plantings with consistently high SSC values.
- 2) Estimate the heritability of SSC in both plantings and the magnitude of expected genetic gains after roguing the plantations.
- 3) Mark both plantings for roguing by applying the results of the analyses of two years of SSC data.

Analysis of the SSC data identified 37 trees from 28 families with mean SSC values more than 24% above plantation means across all collection dates. Although these trees were significantly sweeter than their cohorts, their absolute SSC values were lower than expected, primarily due to low planting wide SSC values in 2015 (Figure 1).

Estimated single-tree ( $h^2_s$ ) and family ( $h^2_f$ ) heritabilities averaged across both years of measurement were high in the USFS planting ( $h^2_s=0.80$  and  $h^2_f=0.67$ ) and significantly lower in the MI planting ( $h^2_s=0.20$  and  $h^2_f=0.13$ ). Heritability estimates for the USFS planting are certainly high enough to support genetic improvement efforts, and roguing this planting should result in substantial genetic gains in SSC. Although the success of selection efforts in the MI planting is less clear, results from this project will nonetheless be used to thin this plantation and the SSC of the residual trees monitored to assess improvement.

## GOALS AND OUTCOMES ACHIEVED

All trees in the USFS and MI plantings were tapped in February of 2014 and 2015, and the SSC of each tree determined using digital refractometers at the dates shown in Figure 1. It is noteworthy that plantation means for SSC were significantly lower in 2015 for both the USFS and MI plantings.



**Figure 1. Plantation means for sap sugar content (SSC) by date of measurement in the 1978 USFS and 1979 Michigan sugar maple progeny tests at Kellogg Forest.**

### Goal 1.

Consistent SSC values are paramount to the effective selection of “sweet” trees. To assess the consistency of individual tree SSC values within the 2014 and 2015 sugar seasons Spearman rank order correlation coefficients were computed between each date of measurement (Table

1). For clarity, the first, second, and third collection dates within each year are hereafter noted as *A*, *B*, and *C* respectively (e.g. 14*B* denotes the second collection date in 2014). Spearman correlations in both tests were generally higher in 2014 (Table 1) which had higher SSC test means than 2015 (Figure 1). In both tests in both collection years, SSC rankings were more consistent between adjacent collection dates, i.e. correlations were higher between dates *A-B* and *B-C* than *A-C*. Clearly, changes in individual tree SSC ranks increased between the first and third collection dates.

To assess the consistency of individual tree performance between the 2014 and 2015 sugar seasons, a metric that accurately reflects each tree's performance in both years must be used. Given that there are three data points for each year, the use of a mean value between two or more of the collection dates is the most viable option. The best metric is the mean which shows the most consistency (i.e. highest Spearman correlation) between the two years of measurement. To make this determination, Spearman correlations were computed for the means of all collection date combinations within a given year (Table 2). Collection date means are noted using the *A*, *B*, *C* designations described previously (e.g. 15*ABC* is the mean of all collections dates in 2015).

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Table 1. Spearman rank order correlation coefficients (n in parentheses) between SSC values collected on three dates in the 2014 and 2015 sugar seasons in the USFS and MI sugar maple progeny tests. All coefficients significant at  $P < 0.0001$ .

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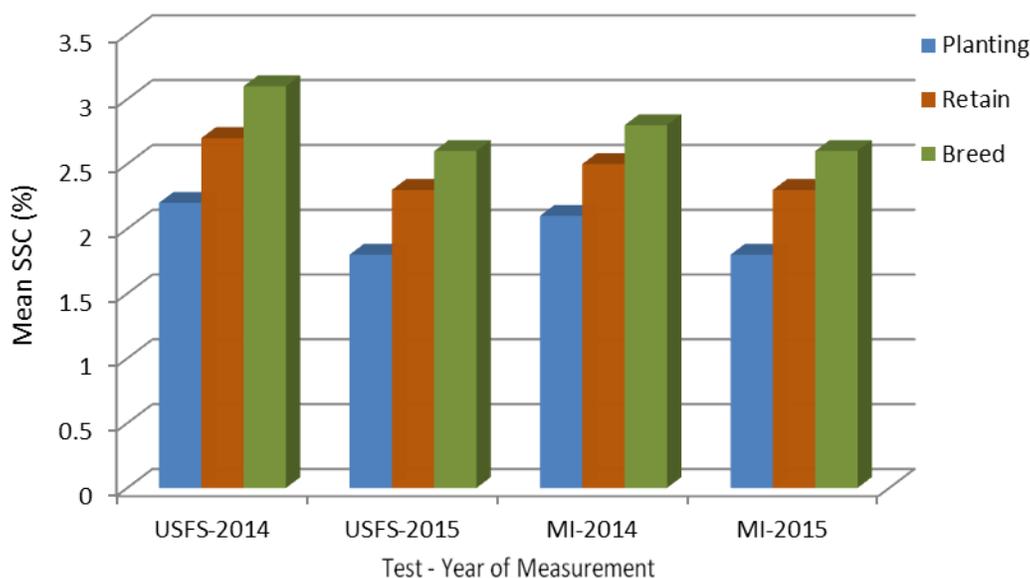
<b>USFS test</b>					
		14A	14B	15A	15B
14B		0.74 (346)		0.58 (344)	
14C		0.54 (327)	0.74 (327)	0.56 (344)	0.67 (347)
<b>MI test</b>					
		14A	14B	15A	15B
14B		0.78 (322)		0.60 (335)	
14C		0.43 (288)	0.64 (288)	0.30 (335)	0.69 (340)

The correlations between the means of each collection date combination were very stable between 2014 and 2015 (Table 2) for both tests, and varied substantially less than correlations between dates within a given year (Table 1). In both tests the correlation between means of all three collection dates, i.e. 14ABC and 15ABC, were the highest or second highest correlation in their respective matrix ( $r=0.77$  in USFS test and  $r=0.78$  in MI test; Table 2). The magnitude of the rank order correlation between 14ABC and 15ABC in both tests indicates that the mean of all three collection dates is a strong metric for evaluating individual tree performance.

Table 2. Spearman rank order correlation coefficients (n in parentheses) for the SSC means of all collection date combinations in the 2014 and 2015 sugar seasons in the USFS and MI sugar maple progeny tests. All coefficients significant at  $P<0.0001$ .

USFS test					MI test				
	15AB	15BC	15AC	15ABC		15AB	15BC	15AC	15ABC
14AB	0.73 (343)	0.70 (344)	0.75 (343)	0.77 (342)	14AB	0.78 (317)	0.76 (319)	0.77 (316)	0.81 (316)
14BC	0.64 (323)	0.74 (325)	0.69 (323)	0.72 (322)	14BC	0.60 (284)	0.70 (285)	0.62 (283)	0.68 (283)
14AC	0.68 (324)	0.70 (325)	0.71 (324)	0.73 (323)	14AC	0.69 (284)	0.73 (285)	0.69 (283)	0.74 (283)
14ABC	0.71 (323)	0.73 (324)	0.74 (323)	0.77 (322)	14ABC	0.72 (284)	0.76 (285)	0.72 (283)	0.78 (283)

Using 14ABC and 15ABC as selection criteria, two sets of above average trees were identified in both the USFS and MI tests. The first set, hereafter referred to as the RETAIN set (so named because this set should be retained after any future thinnings), contains trees that averaged a minimum of 10% above their respective plantation means across both years of measurement. In the USFS test 86 trees are in the RETAIN set, while 78 trees are in the RETAIN set in the MI test. A subset of the RETAIN group was also identified in each test, and will be referred to as the BREED set. The BREED set contains trees that averaged a minimum of 25% above their plantation means for both years of measurement. The BREED set contains 22 trees in the USFS test and 15 trees in the MI test. The BREED set clearly contains the sweetest trees in both plantings, and any future breeding efforts should focus on these trees. The SSC means for each plantation and the RETAIN and BREED sets are plotted in Figure 2, which illustrates the increase in SSC of the RETAIN and BREED sets over the planting means.



**Figure 2. 2014 and 2015 SSC means for the USFS and MI plantings and their respective RETAIN and BREED subsets.**

*Goal 2.*

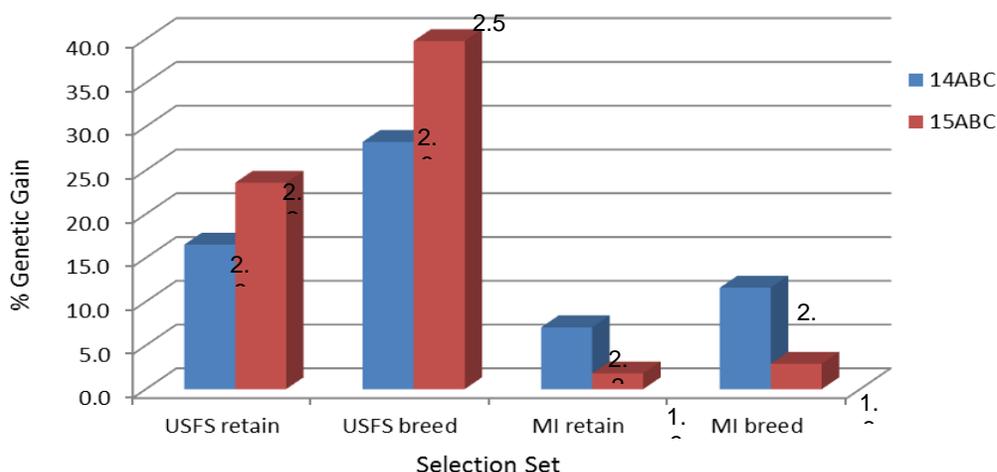
Having identified two sets of trees whose SSC values averaged consistently above their respective plantation means, the next step is to estimate how much of this increase is under genetic control. This is typically accomplished by computing narrow-sense heritabilities which estimate the percent variation in a measured trait that is explained by additive genetic effects. Two types of heritabilities were calculated: single-tree ( $h^2_t$ ) which estimates the heritability of individual trees values, and family ( $h^2_f$ ) which estimates the heritability of family means. Heritabilities for 14ABC and 15ABC were computed for both tests using variance components generated by the SAS statistical software (Proc Varcomp) and the formulae outlined by Wright (1976) (Table 3). All heritabilities and predicted genetic gains presented here are likely inflated because they do not include estimates of family x site effects; to estimate this interaction term a progeny test must be established on two or more sites.

The  $h^2_t$  and  $h^2_f$  estimates were two to ten times higher in the USFS test than in the MI test over both years of measurement (Table 3). This disparity may be an artifact of sample size (the USFS test averages 7.7 trees/family while the MI test averages 3.1 trees/family). It is also possible that the population in the USFS test has a stronger genetic structure due to the intense phenotypic selection process that was used to construct it (recall that the MI test population was randomly selected). Heritabilities in the USFS test were relatively stable between 2014 and 2015, and their magnitude indicates that SSC is under strong genetic control and should respond to selection. In the MI test,  $h^2_t$  and  $h^2_f$  for SSC decreased dramatically from 2014 to 2015, and their magnitude suggests that the response to selection would be low to minimal. All  $h^2_t$  estimates were greater than their corresponding  $h^2_f$  estimates (Table 3) which indicates that mass (individual tree) selection will be more efficient than family, within family, or family + within family selection methods.

Table 3. Single-tree ( $h^2_t$ ) and family ( $h^2_f$ ) narrow-sense heritability estimates for SSC means for each year of measurement in the USFS and MI sugar maple progeny tests.

	USFS		MI	
	14ABC	15ABC	14ABC	15ABC
$h^2_t$	0.73	0.88	0.33	0.08
$h^2_f$	0.64	0.70	0.21	0.06

Predicted % genetic gains and predicted SSC means for 14ABC and 15ABC for each selection set are presented in Figure 3. Averaged across years of measurement the USFS RETAIN set would produce progeny with a predicted mean SSC value of 2.4 which represents a genetic gain of 20% over the planting mean. The USFS BREED set would yield progeny with a predicted mean SSC value of 2.65 which represents a genetic gain of 34% over the planting mean. Average predicted gains in the MI test are much lower, with a predicted mean SSC value of 1.85 (essentially 0% gain) in the RETAIN set, and a predicted mean SSC value of 2.25 in the BREED set (an average genetic gain of 7.4%).



**Figure 3. Predicted % genetic gains for 14ABC and 15ABC for the RETAIN and BREED selection sets in the USFS and MI sugar maple progeny tests. Predicted mean SSC values for the progeny of each set are given on top their respective bars.**

*Goal 3.*

The final goal of this project is to use the results of Goals 1 and 2 to start marking trees for removal in the USFS and MI sugar maple tests. Both plantings are currently overstocked for optimal sap production, and thinning both plantings will increase the growing space for residual trees which will in turn increase sap production and sugar content. According to guidelines presented by Smith and Gibbs (1970) the recommended basal area (BA) for the USFS planting (with mean DBH=9.8" in 2013) is 37 ft<sup>2</sup>/acre. In 2013 the BA of the USFS planting was 107 ft<sup>2</sup>/acre. To reduce the BA to 37 ft<sup>2</sup>/acre in a single thinning would risk damage to the residual stand from exposure and windthrow. Consequently, a two stage thinning is recommended with the first thinning removing most of the below average trees (as identified by the mean of their 14ABC and 15ABC SSC values); the second thinning would leave only the RETAIN set identified in Goal 1. This thinning regime would yield BAs of approximately 60 ft<sup>2</sup>/acre and 38 ft<sup>2</sup>/acre from the first and second thinnings respectively. Maintaining relatively uniform spacing

is requisite to increasing the live crowns of residual trees, and minor additions and deletions could be made to the RETAIN set to preserve adequate spacing. However, the BREED set shall remain inviolate due to its clear genetic value. The BREED set in the USFS planting presents a unique opportunity for the future production of sugar maple planting stock for Michigan with increased sugar content. If resources allow, controlled-pollinations will be made between the best members of the BREED set to establish a third generation breeding population and sugar bush.

The genetic benefits of thinning the MI planting are far less promising. The BA of the MI planting in 2013 was 82 ft<sup>2</sup> (mean DBH=6.8"). Implementing Smith and Gibbs' (1970) thinning recommendations would decrease the BA to 25 ft<sup>2</sup>. Although the benefits may be negligible from a genetics standpoint, this planting will be thinned using guidelines similar to those outlined above for the USFS planting in order to maintain sap production and sugar content.

## BENEFICIARIES

This work will ultimately benefit Michigan maple syrup producers and landowners that want to establish sugar bushes with high sugar content planting stock. This benefit will not be realized until the USFS progeny test thinning is completed and seed is collected, but the work reported here is a critical first step in producing genetically improved sugar maple for Michigan. While there are many variables in determining the total cost of maple syrup production, simply increasing the SSC from 2.0% to 2.5% decreases the amount of sap required to produce a gallon of syrup by 20%. Increasing SSC boosts production and reduces the energy costs associated with concentrating sap into syrup. The genetic improvement of most tree species is notoriously slow due to the length of their life cycles, but once achieved the dividends can extend indefinitely into the future. This work also benefits the broader research community by providing genetic parameter estimates of SSC monitored across two sugar seasons; information of this type is scarce in the literature. Finally, both the USFS and MI progeny tests are located at MSU's Kellogg Forest which has over 10,000 visitors a year and hosted over 600 visitors at its Annual Maple Syrup Day in 2015. Because of their location at Kellogg Forest, the planned thinnings provide an excellent opportunity to demonstrate the benefits of genetic improvement and sugar bush management to both the general public and Michigan maple syrup producers. These outreach efforts will promote the use and production of maple syrup in Michigan.

## LESSONS LEARNED

The sap sugar content of maple trees is famously inconsistent both within and between sugar seasons, and at the outset of this project it was uncertain how many trees could be identified in the USFS and MI progeny tests that exhibited consistently high SSC values. After two sugar seasons we identified 22 trees in the USFS test (6.3% of the test population) and 15 trees in the MI test (4.1% of the test population) that averaged 25% or more above their respective planting means over both the 2014 and 2015 sugar seasons. This BREED set will serve as the foundation of any future breeding work that MSU Forestry might undertake. The heritability of SSC in the USFS test was higher than anticipated and this will aid in capturing the genetic gain identified in the RETAIN and BREED sets.

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#### ADDITIONAL INFORMATION

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#### PROJECT TITLE – FINAL

Michigan Bean Commission – Establishing Dry Bean Acreage in Non-Traditional Regionals with the State of Michigan

#### PROJECT SUMMARY

It is clearly recognized that total dry bean acreage has dramatically declined in the State of Michigan (e.g. 560,000 acres in 1982, 270,000 acres in 2002, 198,000 in 2012 and 175,000 in 2013). This is frequently attributed to the increased availability of alternate cash crops (e.g. corn, soy) and their adaptability as GMO based production; increased complexity and risk inherently associated with dry bean production. Thus, the dry bean acreage base has declined and become more geographically centralized. Efforts to expand the grower base in non-traditional areas will increase the diversification of dry bean acreage and provide a broader array of profitable cropping strategies to growers and processors. Further, it is essential to engage growers in local programs to demonstrate performance and to train specific skills and knowledge in the best management practices used in dry bean production. This project will build on past Specialty Crop Block Grant (SCBG) projects by teaching dry bean growers the skills to grow narrow row, direct harvest dry beans in selected Northern and South Central counties of Michigan. Dry bean growers will gain valuable knowledge and skills by these new objectives.

- Assessment of selected dry bean cultivars and breeding lines suitable for non-traditional dry bean growing regions in Michigan;
- Assessment of weed and desiccant requirements and pest control strategies for production of dry beans in non-traditional regions;
- Engagement and demonstrations appropriate for training growers in the management and advantages for selecting dry beans as a profitable crop alternative.

#### PROJECT APPROACH

The Production Research Advisory Board (PRAB) compiled, statistically analyzed and reported on small plot and large strip plot trials previously harvested from September 8 to October 25. All the dry bean varieties in these trials were canned for quality appearance and reported to the dry bean industry. The black bean strip trial in the Garden Peninsula did not fully mature before the

killing freeze and this black bean trial could not be harvested. These yield trials were included in the Dry Bean Research Report and posted on websites [www.agbioresearch.msu.edu/saginawvalley/index.html](http://www.agbioresearch.msu.edu/saginawvalley/index.html) and [www.michiganbean.org](http://www.michiganbean.org) for growers to access during the late fall and winter. The Dry Bean Research Reports were given out to growers during the winter and spring grower meetings. Reports were also given out to dry bean elevators and extension offices. The white mold trial yields were also reported on websites and in the Dry Bean Research Report.

Dr. Jim Kelly reported yield and other agronomic data from two locations, the Saginaw Valley Research and Extension Center (SVREC), near Richville and the Montcalm Research Center in Central Montcalm County. A total of 2,742 yield trial plots in 20 trials were harvested. The Montcalm County site also included a white mold screening trial to measure genetic tolerance to white mold. Jim Kelly also reported on two small organic trials in the Tuscola and Sanilac Counties. With the absence of chemical use, the organic growers need good dry down at maturity, like Northern Michigan growers. Bean yields at Richville were exceptional in 2014; averaging 35 cwt/acre with top yields exceeding 50 cwt in some trials. The major problem at Montcalm was the presence of severe root rots, mainly Fusarium that was accentuated by the cooler soil conditions early in the season. Dr. Jim Kelly's released varieties of Zenith black and Alpena navy will improve variety choices in these non-traditional areas. Dr. Christy Sprague reported yields and desiccant data on three black beans, Zorro from MSU, Eclipse from NDSU and MSU Zenith at the SVREC Research Farm. Two planting dates of these black beans and treatments of Gramoxone, Glyphosate and Sharpen desiccants produced variable yields. Dr. Sprague showed that desiccants would affect color retention if they were sprayed too early before the bean plant reaches physiological maturity. Glyphosate exhibited more influence in color than others when sprayed too early. Dr. Sprague's canning trials showed Zenith to have the best black color, followed by Zorro and then Eclipse. Christy Sprague reported on a dry bean weed control trial on the MSU Farms to evaluate Blazer herbicide for potential use in dry beans. If we could use Blazer herbicide, growers could control common ragweed in the Upper Peninsula. UP dry bean growers cannot use Reflex herbicide due to label restrictions on Northern soils in the United States. Reflex is the only post spray Michigan has labeled to give good ragweed control. Lower Peninsula growers can use Reflex.

Dr. Chris Difonzo, along with three extension educators, reported data and gave many presentations on the Western Bean Cutworm (WBC) Moth. Moth numbers were used to predict the effects of anticipated damage to dry beans. Moth flights were very late in 2014 and minimum damage was reported. Other dry bean insects, such as the Potato Leafhopper and the Mexican Bean Beetle were measured. Multiple publications were made available in 2014 on the Internet, including the extension bulletin 'Managing Western Bean Cutworm in Dry Beans' on the MSU Field Crops Entomology web site (<http://www.msuent.com/dry-beans/>) and the graduate thesis 'Biology and Management of Western Bean Cutworm in Michigan Dry Beans' (<http://gradworks.umi.com>).

## GOALS AND OUTCOMES ACHIEVED

1. Cultivars have been identified for adoption in non-traditional areas in Northern and South Central Michigan. Zenith has been released and commercial seed will be available to Michigan growers in 2016. Other newer lines B12712 and B12724 have shown excellent adaptation for Northern Michigan areas. These future black beans need more agronomic information before they can be released as varieties. Alpena navy will be available in 2015 for Michigan dry bean growers.
2. Desiccant sprays have shown variable yields in two planting dates and in treatments of three desiccants. Growers will have to follow labels to avoid applying desiccants too early before

maturity. Michigan growers will have to be aware that spraying green areas in a black bean field will result in mixed color values on processed black beans.

3. White mold disease control strategies of varietal tolerance, biological and chemical controls were discussed at grower plot tours and winter meetings. Michigan growers are fully aware of the best fungicides, timing of sprays.

4. Grower and Bean Elevator surveys from 16 target counties were conducted during the 2014 growing season to measure dry bean interest and possible increased acres. We knew there would be some increase in acres due to the poor yields of soybeans in 2013. We also used Farm Service Agency Reported Acres Reports and the Michigan Agricultural Statistics Service Acreage Reports.

5. Educational meetings and private communication with dry bean growers were conducted throughout this project. Growers received information from the Michigan Bean Commission, dry bean elevators, fertilizer and chemical salespeople, Extension Educators, crop insurance agents and local bean growers in their area. Extension Educators Jim Isleib and James DeDecker conducted webinars and a research reporting meeting for growers in the UP and Northern Michigan. Growers wanted new production information and assurance that dry beans could be grown profitably on their farms. These meetings are summarized below in the Beneficiaries section.

#### GOALS

Our target to increase the total dry bean acreage in Michigan by 3% was easily achieved. We used a baseline of 198,000 acres Michigan produced in 2012. 2013 Michigan dry bean planted acres were 175,000 (11.6% decrease). 2014 acres in Michigan was 250,000 (26.3% increase) and the 2015 Planting Intentions Report is 290,000 (46.5% increase) acres. We added Genesee, Shiawassee and Isabella counties to a selected 16 county target because we knew growers were interested in growing more dry beans. This raised our baseline dry bean acres from 10,371 to 14,815. If we specifically look at the 16 target counties using 2012 FSA County Reported Acres, we had 14,815 acres of dry beans. The same 16 counties in 2014 had 23,252 acres or an increase of 8,437 acres representing a 57% increase a dry beans. If we just add the 16% increase from the 2015 Intentions Report to those 16 counties, acres would be 26,972 or 12,157 acres representing an 82% increase from 2012. Bean industry people feel 2015 acres will be more than 16% in our target area. One thing that slowed down dry bean acres in 2015 was the shortage of good dry bean seed for planting. Many growers were turned away or had to take less seed in 2015 due to this seed shortage. We did achieve our target to work with at least 36 selected growers to plant, harvest and market dry beans. Some of these growers were new and many others increased their acreage or had dry beans in past years and started raising them in 2014 and 2015. Many of these growers attended at least two dry bean meetings over the past 18 months.

#### BENEFICIARIES

This project has benefited 136 growers from the 16 target counties and indirectly benefited the 1200 Michigan dry bean growers, the dry bean elevators in Michigan and the dry bean canners across the U.S. who are producing, canning and selling a superior canned and packaged beans to the U.S. consumers. The 8,437 and 12,157 extra acres in 2014 and 2015 will result in an additional 1.434 and 2.067 million dollars at the grower level for the 16 target counties. This is based on the assumption dry beans will net \$170 over soybeans in 2014 and 2015. Michigan's extra 92,000 dry bean acres in 2015 compared to 2012 will be 15.640 million dollars at the grower level.

This research project will also indirectly benefit other dry bean growers in the United States. Attendance numbers for each of the Michigan events are listed below:

Event	Date	Attendance
Winter County Dry Bean Days 5	January 2014	192
State Dry Bean Day	February 18, 2014	174
North MI and UP Meeting	February 19, 2014	34
Planning Meeting	March 12, 2014	24
Bean and Beet Field Day-SVREC	August 26, 2014	188
County Dry Bean Field Tours 8	August, 2014	243
Dry Bean Outlook Meet.	December 17, 2017	184
West MI Bean Meeting	December 18, 2014	32
Canning Evaluation-MSU	January 12, 2015	47
Miller Feed Grower Meet.	January 15, 2015	52
County Bean Days 2	January 19, 20	63
NE Ag Res. Results	February 4, 2015	28
UP Dry Bean Webinar	February 20, 2015	8
Planning Meeting	March 11, 2015	26
MSU Ext Bean Webinar	March 16, 2015	43
Organic Dry Bean Meet.	April 30, 2015	61

#### LESSONS LEARNED

We were very conservative on our goal of increasing Michigan's dry bean acreage by 3% or roughly 6,000 acres. The 16 target counties achieved 8,437 additional acres. We underestimated the potential problems going into Northern Michigan and the UP in 2014. The rain delay at planting in the Garden Peninsula was the biggest problem early in the growing season. All of downstate Michigan was planted by June 20 and we were still too wet in the UP. Late planted or delayed growth due to a cooler than normal 2014 made dry beans susceptible to freezing temperatures before maturity. The wet weather in the first two weeks of October delayed harvest of the Harrisville and Hawks locations of both the black bean strip and small variety trials. The Harrisville location had low temperatures of 29 degrees on September 19 and we were fortunate to have our trials mature on this date. White mold disease all across Michigan and especially in Harrisville and Hawks area contributed to very large yield losses. We estimate both Harrisville and Hawks black bean strip trials lost at least 50% of the potential yield. Some black beans showed severe losses compared to other varieties and we had the opportunity to show these differences at the August 12 field day. The Western Bean Cutworm life cycle was very late compared to the previous five-year history of the WBC in Michigan. This lateness was due to the cold season Michigan experienced in 2014. There is a shortage of people who can help dry bean growers once you get north of M-61. We wanted to find people who actually called on growers in the North. When we would find a salesperson, some of them were very secretive of their customer growers, thinking we were inviting competition for them. We do have very knowledgeable bean growers doing a very good job of growing dry beans. Some Michigan growers were not interested in trying to expand Michigan's dry bean acreage. Some looked at this project as creating a surplus of dry beans and lowering the bean price.

#### CONTACT PERSON

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#### ADDITIONAL INFORMATION

Presentation of results to Michigan growers and agri-business representatives:

- 1) Saginaw Valley Research and Extension Center Field Day. August 26, 2014. Richville, MI. Presentation on dry bean diseases found during the 2014 crop.
- 2) Alcona, Bay, Delta, Gratiot, Huron, Montcalm, Sanilac and Tuscola County Dry Bean Tours. August 11-27 and September 3-4, 2014. Showed 243 dry bean growers commercial and experimental dry bean cultivars planted in 20-inch rows.
- 3) Michigan Dry Bean Variety Trials, Canning Trials and Research Report posted online at [www.agbioresearch.msu.edu/saginawvalley/index.html](http://www.agbioresearch.msu.edu/saginawvalley/index.html). The Research Report is posted on the Michigan Bean Commission website at <http://michiganbean.org/crop-information/>
- 4) PowerPoint Presentation on Small Plot Trials and White Mold Control at 2015 County Dry Bean Meetings.
- 5) State Dry Bean Day in January, 2015 Dissemination Dry Bean Research Reports and Presentation on 2014 Dry Bean Production Practices. Trials in Northern Michigan.
- 6) Michigan Dry Bean Commission Newsletter. Approximately 2400 circulation. 2014 and 2015 articles on dry bean production. Variety Trials, White Mold and Desiccation. Can be found at [www.michiganbean.org](http://www.michiganbean.org).

### 2012 Versus 2014 FSA Reported Dry Beans Acres in Michigan

County	Black	Nav y	Sm. Red	LR K	Cra n	W Kid	DR K	Pinto	Adzuk i	Teb o	2012 Total	2014 Total	Diff.
Alcona	786	48				215					1049		
2014	1397	38				112						1547	498
Alpena	521	334					396	128			1379		
2014	1728	972	421				409					3530	2151
Antrim	51										51		
2014	68					41						109	58
Arenac	3334	568	446					69			4417		
2014	4316	325	1258				150			37		6086	1669
Clare	107										107		
2014	282								15			297	190
Delta							774				774		
2014	177						753					930	156
Genesee	168	161	40						93		462		
2014	561	28	224									813	351
Gladwin	732	409	170								1311		
2014	576	407	784									1767	456
Iosco	1041										1041		
2014	1537		29									1566	525
Isabella	735	122	275	13	150			265	65		1742		
2014	2043	228	219	14	150	525	77	56	232			3671	1929
Montmorency		98									98		
2014	196	203										399	301

Ogemaw	554				554		
2014	21					21	533
Otsego	199	36	118	73	426		
2014	302	8	318			628	202
Presque Isle				719	719		
2014	281			655		936	217
Schoolcraft				292	292		
2014	61			161		222	70
Shiawassee	369	24			393		
	652	78				730	337
					1481	2325	
				2012 versus 2014 Acres	5	2	8437
						2697	1215
				2015 Estimate of 16%		2	7

MASS Crop Report-Michigan Dry Bean Acres				2014	57% increase
198,000	2012		Difference from 2012	2015	82% increase
175,000	2013		11.6% decrease		
250,000	2014		26.3% increase		
290,000	2015	3-31 Intentions	46.5% increase		

Dry Edible Bean Area Planted - States and United States: 2013-2015

1/Intended plantings in 2015 as indicated by reports from farmers.

: Area planted

State	2013	2014	2015	Percent of previous year
	1,000 acres	1,000 acres	1,000 acres	percent
Arizona	10.0	11.0	9.0	82
California	50.0	48.0	50.0	104
Colorado	39.0	46.0	69.0	150
Idaho	125.0	125.0	120.0	96
Kansas	5.0	7.5	7.0	93
Michigan	175.0	250.0	290.0	116
Minnesota	125.0	155.0	180.0	116
Montana	24.0	37.5	53.0	141
Nebraska	130.0	165.0	150.0	91
New Mexico	10.0	10.5	8.0	76
New York	9.0	8.0	9.0	113
North Dakota	440.0	630.0	610.0	97
Oregon	8.3	8.5	10.0	118
South Dakota	12.0	14.0	13.0	93
Texas	33.0	23.0	25.0	109
Washington	120.0	130.0	100.0	77
Wisconsin	5.4	7.9	7.9	100
Wyoming	39.0	42.0	32.0	76
United States	1,359.7	1,718.9	1,742.9	101

## Harvest aid effects on black bean desiccation and yield with early planting

Amanda Goffnett and Christy Sprague, Michigan State University

<b>Location:</b> Richville (SVREC)	<b>Tillage:</b> Conventional
<b>Planting Date:</b> June 5, 2014	<b>Variety:</b> Zorro, Zenith and Eclipse black bean
<b>Replicated:</b> 4 times	<b>Population:</b> 106,000 seeds/A
<b>Soil Type:</b> Clay loam, 3% OM, pH 7.6 (SVREC)	<b>Row width:</b> 30-inch

Table 1. Effect of preharvest treatment on black bean desiccation three and seven days after treatment (DAT) and yield for early planting.

Treatment	Desiccation				Yield <sup>a</sup>	
	%				cwt/A	
	3 DAT <sup>b</sup>		7 DAT		Early	Late
	Early	Late	Early	Late	Early	Late
Gramoxone (2 pt/A) + NIS	79 A <sup>c</sup>	98 A	97 A	99 A	20.4 B	25.5 A
Sharpen (2 fl oz/A) + MSO + AMS	77 A	98 A	98 A	99 A	9.5 C	21.9 B
Roundup (22 fl oz/A) + AMS	68 B	95 B	88 B	99 A	21.2 B	22.1 B
Untreated	60 C	94 C	75 C	97 B	25.8 A	26.9 A

<sup>a</sup> Yield obtained by direct harvest

<sup>b</sup> Days after treatment

<sup>c</sup> Means within a column with different letters are significantly different from each other

**Summary:** This study was conducted to evaluate the effects of preharvest herbicide applications on black bean desiccation and yield with two application timings at an early planting date. Desiccation treatments of Gramoxone, Sharpen, and Roundup were applied to three varieties: 'Zorro', 'Zenith', and 'Eclipse' at an early application timing (50% of pods were yellow), and a standard application timing (80% of pods were yellow). The early application was to evaluate differences in treatments and simulate green areas in a field that may be present during standard applications of harvest aids. **Growers should not make preharvest applications at this earlier timing.** Data were averaged over all varieties. Differences in black bean desiccation between the application timings was greatest 3 DAT, with Gramoxone and Sharpen demonstrating the quickest desiccation at the early timing. By 7 DAT, desiccation for preharvest treatments were at acceptable levels, except for Roundup, which took up to 14 DAT for maximum desiccation. Lower yields were observed with all preharvest herbicides at the early application timing and with Sharpen and Roundup at the standard timing. The lowest yield was observed with early applications of Sharpen, which may be due the quicker speed of activity halting dry bean development, **again preharvest treatments should never be made this early.** Overall, the speed of desiccation and yield were influenced by application timing and desiccation treatment. Beans from this trial will be canned and evaluated for color retention. This research was supported by MSU Project GREEN, Michigan Dry Bean Commission, and the Michigan Department of Agriculture Specialty Crops Grant.

## Harvest aid effects on black bean desiccation and yield with late planting

Amanda Goffnett and Christy Sprague, Michigan State University

<b>Location:</b> Richville (SVREC)	<b>Tillage:</b> Conventional
<b>Planting Date:</b> June 27, 2014	<b>Variety:</b> Zorro, Zenith and Eclipse black bean
<b>Replicated:</b> 4 times	<b>Population:</b> 106,000 seeds/A
<b>Soil Type:</b> Clay loam, 3% OM, pH 7.6 (SVREC)	<b>Row width:</b> 30-inch

Table 1. Effect of preharvest treatment on black bean desiccation three and seven days after treatment (DAT) and yield for late planting.

Treatment	Desiccation				Yield <sup>a</sup>	
	%				cwt/A	
	3 DAT <sup>b</sup>		7 DAT		Early	Late
	Early	Late	Early	Late	Early	Late
Gramoxone (2 pt/A) + NIS	88 B <sup>c</sup>	96 A	99 A	99 A	18.0 AB	19.6 A
Sharpen (2 fl oz/A) + MSO + AMS	91 A	95 A	99 A	99 A	15.1 C	17.0 B
Roundup (22 fl oz/A) + AMS	76 C	96 A	98 B	99 A	17.2 B	17.9 B
Untreated	68 D	92 B	97 C	98 B	19.0 A	20.0 A

<sup>a</sup> Yield obtained by direct harvest

<sup>b</sup> Days after treatment

<sup>c</sup> Means within a column with different letters are significantly different from each other

**Summary:** This study was conducted to evaluate the effects of preharvest herbicide applications on black bean desiccation and yield with two application timings at a later planting date. Desiccation treatments of Gramaxone, Sharpen, and Roundup were applied to three varieties: 'Zorro', 'Zenith', and 'Eclipse' at an early application timing (50% of pods were yellow), and a standard application timing (80% of pods were yellow). The early application was to evaluate differences in treatments and simulate green areas in a field that may be present at the standard application timing. **Growers should not make preharvest herbicide applications to dry beans when less than 80% of the pods are yellow.** Data were averaged over all varieties. Similar to the earlier planting date, the greatest difference in black bean desiccation between application timings were observed at 3 DAT, with Sharpen demonstrating rapid desiccation at the early application timing. By 7 DAT, desiccation for all preharvest treatments was above 95%. Lower yields were observed with Sharpen and Roundup, with early applications of Sharpen having the greatest impact. This may be due to the quick activity of Sharpen halting the continued development of the dry bean. **Again preharvest treatments should never be made this early.** Overall, the speed of desiccation and yield for the later planted dry beans were influenced by application timing and desiccation treatment. Beans from this trial will be canned and evaluated for color retention. This research was supported by MSU Project GREEN, The Michigan Dry Bean Commission, and the Michigan Department of Agriculture Specialty Crops Grant.

## Evaluation of Ultra Blazer as a possible herbicide in dry edible beans

Christy Sprague and Gary Powell, Michigan State University

<b>Location:</b>	E. Lansing	<b>Tillage:</b>	Conventional
<b>Planting Date:</b>	June 16, 2014	<b>Variety:</b>	'Zorro' black beans
<b>Row width:</b>	7.5-inch	<b>Planting population:</b>	105,000 seeds/A
<b>POST application timing:</b>	V3 dry bean	<b>POST application date:</b>	July 17
<b>Soil Type:</b>	Loam	<b>Replicated:</b>	4 times

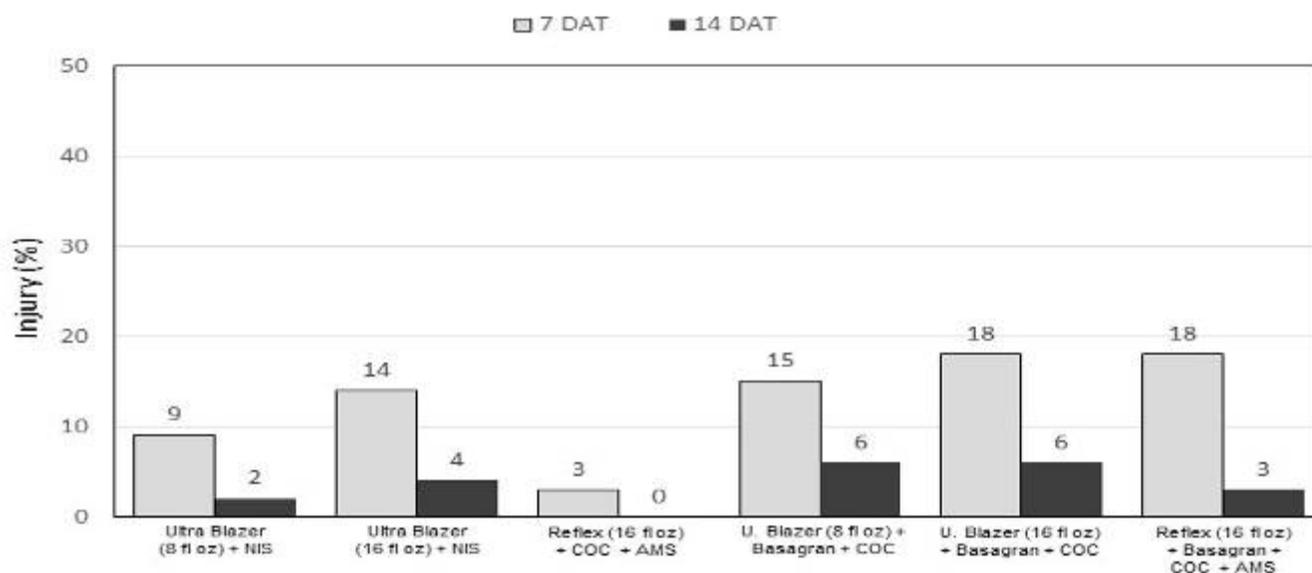


Figure 1. Crop injury three and seven days after treatment (DAT) from Ultra Blazer.

**Summary:** Currently Reflex is the only postemergence Group 14 herbicide that can be used for weed control in dry bean. This herbicide is particularly important to control common ragweed, pigweed, and eastern black nightshade populations that are resistant to ALS-inhibiting (Group 2) herbicides. Unfortunately, there are some longer crop rotation restrictions with Reflex that may not be met with later application dates. For example, the rotation restriction for winter wheat is four months, corn is ten months, and sugarbeet is 18 months. Reflex carryover concerns are also greater the further north you get in Michigan, because of the shorter growing season that decreases the potential breakdown of the herbicide. There is another Group 14 herbicide, Ultra Blazer that has a similar weed control spectrum as Reflex. The potential for crop carryover is much less from this herbicide. Therefore, our objective was to examine dry bean response from applications of Ultra Blazer compared with Reflex and tank-mixtures with Basagran. Ultra Blazer alone either at eight or 16 fl oz/A caused slightly more injury to dry bean than Reflex alone, 7 DAT. However by 14 DAT there was no difference in dry bean injury. This was also the case when these herbicides were tank-mixed with Basagran. Even though there was significant dry bean injury from Ultra Blazer and tank-mixtures with Basagran, injury was never greater than 20% and by 14 DAT dry bean injury was less than 10%. The use of Ultra Blazer in dry bean may be an alternative option to Reflex in the future. However, additional research will need to be conducted and further discussions would need to happen for the development of a dry bean label for this herbicide. This research was supported by Michigan Dry Bean Commission funding from the Michigan Department of Agriculture Specialty Crops grant.

### 2014 Western Bean Cutworm Report

Dr. Chris Difonzo, Entomologist, Michigan State University

Western Bean Cutworm (WBC) populations dropped dramatically in Michigan during the 2012 drought year, and with an increase in the level of biological control (predation, parasitism, and

pathogen). Larval damage in corn remained low in most of Michigan in 2013 and 2014, but corn growers have transgenic options for WBC management. However, populations remain persistent in dry bean production from Montcalm County, north into the Upper Peninsula. Our research since 2008 gave us an understanding of how WBC should be managed in dry beans – that is, pheromone trap to determine the peak, then scout fields for larval feeding to determine the need and timing of a single spray application of a pyrethroid. Activities now involve education to make growers aware of, and to adopt, the guidelines. In 2014, western bean cutworm was discussed at ten extension meetings in the central, thumb, and northern counties; an estimated 815 growers and crop consultants attended these meetings. Although all are not dry bean growers, even corn growers have a role to play in WBC management in dry beans, as management of populations in corn reduce the overall level of WBC in an area. Multiple publications were made available in 2014 on the internet, including the extension bulletin 'Managing western bean cutworm in dry beans' on the MSU Field Crops Entomology web site (<http://www.msuent.com/dry-beans/>) and the graduate thesis 'Biology and management of western bean cutworm in Michigan dry beans' (<http://gradworks.umi.com>). Besides this graduate research, I assisted or advised three other students interested in WBC at MSU and the University of Guelph. Finally, a refereed article detailing the impact of WBC damage in dry beans, and giving recommendations for management, was accepted for publication. This article (Impact of western bean cutworm infestation and insecticide treatments on damage and marketable yield of Michigan dry beans by DiFonzo, Chludzinski, Jewett, and Springborn) will appear in the in the Journal of Economic Entomology in 2015.

To: Upper Peninsula dry bean growers

From: Jim Isleib, MSU Extension U.P. Crop Production Educator

Subject: Western Bean Cutworm situation

Today's Date: September 10, 2014

Based on Western Bean Cutworm moth trap counts on three Fayette area dry bean farms, the population of moths is moderate this year and damage from Western Bean Cutworm larvae in our area is not expected to be severe.

I inspected three dark red kidney bean fields and two black bean fields in the Fayette/Garden area yesterday, September 9, and did not find pod feeding. After consulting with MSU Field Crop Entomology professor, Dr. Chris DiFonzo and my extension colleague Fred Springborn, I am not recommending insecticide treatment for Western Bean Cutworm this year.

**Title: Development and Maintenance of High-Yielding, Disease Resistant, Processor Quality Dry Bean Varieties suitable for Direct Harvest in Michigan**

**Principal Investigator:** James D. Kelly and Evan Wright, Plant, Soil and Microbial Sciences, Michigan State University, East Lansing MI 48824 [kellyj@msu.edu](mailto:kellyj@msu.edu)

**Cooperators:** Greg Varner, Production Research Advisory Board, [varnerbean@hotmail.com](mailto:varnerbean@hotmail.com)  
Karen Cichy, USDA Geneticist in PSM, [Karen.Cichy@ARS.USDA.GOV](mailto:Karen.Cichy@ARS.USDA.GOV); Jim Palmer, Manager Foundation Seed Stocks, MCIA, [palmerj@michcrop.com](mailto:palmerj@michcrop.com)

**Objectives:** Improve yield, architecture, disease resistance, stress tolerance and canning quality traits of the major commercial dry bean market classes important in Michigan.

**Activities, Accomplishments, Impacts:** The dry bean breeding program initiated its sixth season on the new 320 acre Saginaw Valley Research & Extension Center (SVREC) research farm near Frankenmuth in 2014. A total of 2,742 yield trial plots (20 tests) were harvested in 2014 and ~3000 single plant selections were made in the early generation nurseries. Yield trials

at SVREC included 36-entry standard navy test; 30-entry standard black test; 48-entry prelim navy tests; 36-entry and 72-entry prelim black tests; 36-entry standard GN; 30-entry standard pinto test; 36-entry standard red/pink test; 32-entry prelim GN test; 40-entry, 80-entry, and 56-entry prelim red tests; 24-entry drought trial and 48-entry Co-op and regional test that includes pinto, GN, red and pinks. At the Montcalm Research Farm near Entrican yield trials included 30-entry bush cranberry test; 36-entry kidney test; 30-entry preliminary kidney test; and 64-entry white mold test. Two 36-entry certified organic trials were conducted in Tuscola and Sanilac counties. All trials were direct harvested except for kidney and cranberry beans at Montcalm. Bean yields at Frankenmuth were exceptional in 2014 averaging 35 cwt/acre with top yields exceeding 50 cwt in some trials. Temperatures were moderate not exceeding 90F and rainfall for four-summer months was 2.2 inches above the 30-year average. The extra rainfall was well distributed with most falling in July so there was no stress to the crop due to limited moisture or high temperatures at the critical flowering period. White mold was a serious problem in the commercial crop but not in research plots where the extra tile drainage allowed for more rapid drying of the soil surface following rain. Plots at Montcalm had similar rainfall pattern but the supplemental irrigation did contribute to the development of white mold. Incidence in the National Sclerotinia Initiative nursery was very high in the susceptible checks and proved to be an excellent screening nursery. The major problem at Montcalm was the presence of severe root rots mainly Fusarium that was accentuated by the cooler soil conditions early in the season. Despite this, yields in kidney beans approached 40 cwt/acre and many lines with tolerance to root rot and with resistance to common bacterial blight were identified in kidney bean nurseries.

**Progress in black bean breeding:** The new black line B10244 was released as Zenith in 2014 and breeder/foundation seed was produced in Idaho. Yields varied from 34 to 43 cwt/acre and were variable throughout the state due to white mold pressure. Other new black bean lines exceeded 50 cwt at SVREC and showed considerable yield potential under favorable growing conditions in the absence of white mold.

**Progress in navy bean breeding:** The new navy line N11283 was released as Alpena in 2014 and breeder/foundation seed was produced in Idaho. It had mixed performance in 2014 ranging from 37 to 39 cwt but showing a consistent three cwt advantage over Medalist. New navy lines exceeded 45 cwt in the same trials, and many of these possess resistance to race 73 anthracnose.

**Progress in pinto bean breeding:** Eldorado pinto continues to dominate yield trials in Michigan and it significantly outyielded La Paz, and Stampede in plots and strip trials in 2014. It performed well under white mold pressure. Efforts to introduce the slow darkening gene in Eldorado through backcrossing are underway.

**Progress in GN/Otebo bean breeding:** Powderhorn GN ranged in yield from 26 to 40 cwt depending on the level of CBB in the trial. A series of new GN lines derived from crosses with Eldorado pinto are showing excellent yield potential with yields exceeding 47 cwt. In the Otebo class the new upright line G12901 continues to significantly outyield the Fuji check by margins of 10-16 cwt. Interest in the otebo line comes from Hensall District Coop in Ontario and from Red Diamond Brand Seeds. A seed sample will be sent to Japan this winter to determine its acceptability and quality characteristics prior to any release decision.

**Progress in small red/pink bean breeding:** Rosetta pink showed excellent performance, consistent yields of 39 cwt and good dry down in 2014. In general pink beans showed better overall dry down and better levels of CBB resistance than the small red seed types. Two new small red sister lines topped yield trials at over 44 and 50 cwt in 2014. The lines will be evaluated for canning quality, virus resistance and both showed clear superiority over Merlot. We have received complaints regarding the variability in maturity currently in Merlot. The problem is under discussion as how best to proceed in the absence of a new small red variety.

Seneca Foods has expressed interest in testing the new Gypsy Rose Flor de Mayo and Desert Song Flor de Junio Mexican varieties for canning quality in their commercial process.

**Progress in kidney/cranberry bean breeding:** Snowdon topped one trial at 42 cwt and fell back to 35 cwt in another trial where stands were a problem due to cool wet Fusarium infected soils. More attention is being given to other new high-yielding early-season white kidneys possessing bullet-shaped seed. The new yellow bean Y11405 yielded over 37 cwt ahead of all current commercial varieties at Montcalm. Dark red kidney line K11306 topped the trial at 40 cwt and is considered to have some root rot and CBB resistance along with excellent canning quality. Two new high-yielding early-season bush cranberry bean sister lines yielded over 43 cwt but possess smaller seed size. These lines will continue to be advanced and tested by MSU, but all future cranberry breeding will be conducted by USDA-ARS group at East Lansing.

**Matching Funds:** Royalty funds from current MSU varieties; MSU continues to provide field, greenhouse and lab facilities and equipment; Continue to collaborate with PRAB to conduct statewide testing of elite MSU breeding lines with funding from MDARD Block Grant and the MDARC Strategic Growth Initiative –SGI on bean powder; Funds from the National Sclerotinia Initiative for research on white mold; Legume Innovation Lab project for work on drought and USAID NIFA grant to work on root rot in large-seeded beans (focus of last two projects is in East Africa); BeanCAP grant on bean genomics, and two NIFA grants on drought and organic production have ended.

#### **Publications:**

1. Kelly, J.D., G.V. Varner, K.A. Cichy, and E.M. Wright. 2014. Registration of 'Powderhorn' great northern bean. J. Plant Registrations 8:1-4.
2. Miklas, P.N., J. D. Kelly, J. R. Steadman and S. McCoy. 2014. Registration of partial white mold resistant pinto bean germplasm line USPT-WM-12. J. Plant Reg. 8:183–186.

#### **Bulletins:**

3. Kelly, J. D., Wright, E. M., Varner, G. V., and Sprague, C. L. 2014. 'Powderhorn': A new variety of great northern bean for Michigan .Ext. Bulletin E3218.

#### **DRY BEAN RESEARCHERS AT MSU REPORT A RECORD 5000 POUND YIELD IN 2014**

When news of record bean yields flashed among the dry bean community, I took the opportunity to interview Dr. Jim Kelly, the researcher and dry bean breeder at MSU who reported the record yields.

*Q: What was the actual top yield?*

A: The actual record yield was 51.3 cwt per acre or 85 bushels per acre in a new numbered black bean line grown in our breeding nurseries at the Saginaw Valley Research and Extension Center (SVREC) near Frankenmuth.

*Q: Is this the first time you exceeded the 5000 pound or 50 bag yields in your breeding trials?*

A: Actually we exceeded the 50 bag limit with the Eldorado pinto bean grown under irrigation and high fertility conditions in Montcalm in past years. This is the first time we exceeded 50 bag yield for beans grown under normal rainfall and management conditions with minimum inputs.

*Q: What factors do you attribute to achieving this record yield?*

A: Favorable weather conditions and genetic potential. Weather patterns were near ideal for bean production in 2014. Moderate temperatures (below 90F) and well distributed rainfall patterns at key times in the growing season ensured that the beans were never under stress the entire season and had adequate moisture to grow, fix nitrogen and carbon that contributes to the final yield. When temperatures exceed 90F, beans shut down and likewise when moisture is limiting, growth is restricted. Other factors were timely planting during the first week of June, a single pre-incorporated herbicide treatment, no post herbicide treatments that can damage and delay bean harvest and the plots were direct harvested under optimum conditions around 18% seed moisture.

Q: *Where there any special fertility or pesticide treatments?*

A: No, just the usual 60 pounds N broadcast prior to planting. We did not have any insect - potato leafhopper pressure in 2014, so the plots did not require any insecticide sprays in 2014. No fungicide treatments were applied to the breeding plots to control white mold as we like the opportunity to rate breeding lines for resistance or avoidance to white mold.

Q: *You mention white mold and I know the entire bean industry is worried about the damage white mold may cause to the commercial bean crop in general. Did you not have problems with white mold in your trials?*

A: We did not have serious white mold pressure in our trials which brings up a very interesting point as I see the devastation that white mold is having on neighboring soybean fields. When MSU purchased the SVREC farm, the farm advisory board made up largely of bean and sugarbeet farmers insisted and paid that the farm be retiled between the existing tile lines, which means we have tile lines every 17 feet or so. The reason was to handle heavy 2-4 inch rains that can occur and could damage the research plots. I believe the advantage of the extra tile lines means that the farm drains faster to field capacity and allows the soil surface to dry more quickly which prevents the white mold disease from establishing. In addition the breeding program has been developing upright bean varieties with architectural avoidance that also contributes to the low incidence of white mold.

Q: *Are there other factors that you wish to add?*

A: I would add that these yields were from plots that were direct harvested, whereas previous high yields were from plots that were pulled and threshed, which reduces harvest losses. One recognizes that soybeans out-yield dry beans due in part to their longer growing season, so I would point out that these yields were obtained from 94 day (seed to seed) maturity bean plants.

Q: *You said that the record yield was a numbered black bean line, what were the yields of current black bean varieties in the same trial?*

A: The highest yielding variety in the same trial was the new black bean variety, Zenith at 43.1 cwt followed by Zorro black bean at 41.4 cwt. The new lines appear to possess more genetic potential than current varieties but they need to be tested in future years to ensure that the yield potential is consistent and not just a 'flash in the pan' in one year.

Q: *Any other new developments in bean breeding that you want to share with the industry?*

A: Yes we have some news to share regarding a new Otebo bean. We have developed the first upright Otebo bean that can be direct harvested as the traditional varieties are all short bush types that need to be pulled and windrowed prior to harvest. The new Otebo bean will be considered for release this fall when we receive additional data from statewide trials conducted by Greg Varner, Research Director for the Production Research Advisory Board. In our trials the new line yielded 33.7 cwt compared to 17.4 cwt for the Fuji variety. Since the Otebo beans are marketed in Japan we still need to ensure that the new line meets all the quality standards of that market. I appreciate the opportunity to share these developments with our industry partners.

#### 2014 DRY BEAN CANNING EVALUATION-Canning Score is 1-5, 5=best

Michigan Dry Bean PRAB		CANNING
No.	VARIETY	SCORE
1	HMS MEDALIST H	3.8
2	MERLIN H	2.9
3	HYLAND T9905	2.3
4	INDI	2.3

5	ALPENA N11283	3.2
6	GTS OB-1723-03	3.5
7	GTS 0B-4048-03	2.6
8	VIGILANT	2.8
9	REXETER	2.2
10	NAUTICA	2.4
11	MIST	3.2
12	FATHOM	2.3
13	COOP 99039-3	2.1
14	COOP 03036	2.9
15	COOP 06063	3.7
16	COOP 07073	3.7
17	COOP 08070	4.0
18	COOP 08072	2.8
19	COOP 12039	2.1
20	COOP 12041	3.1
21	COOP 12047	2.8
22	COOP 12051	3.1
23	COOP 12059	3.5
24	ADM N8118340	2.9
25	ADM N8120345	3.1
26	ADM N5023584	2.7
27	ADM N8118321	2.3
28	ADM N8118339	2.4
29	ADM N9007081	2.7
30	ADM N9029100	2.1
31	SEM NAVC6V1200	2.3
32	MSU N12440	2.5
33	MSU N13140	3.8
34	MSU N11238	2.5
35	HMS MEDALIST T	3.2
36	MERLIN T	2.8
37	HYLAND T9905	2.3
No.	VARIETY	SCORE
38	INDI	3.2
39	ALPENA N11283	2.7
40	GTS OB-1723-03	3.2
41	GTS 0B-4048-03	2.5

42	VIGILANT	3.7	
43	REXETER	2.3	
44	NAUTICA	2.2	
45	MIST	3.3	
46	FATHOM	1.9	
47	COOP 99039-3	1.8	
48	COOP 03036	3.2	
49	COOP 06063	3.2	
50	COOP 07073	4.3	
51	COOP 08070	3.6	
52	COOP 08072	2.3	
53	COOP 12039	2.4	
54	COOP 12041	3.3	
55	COOP 12047	2.7	
56	COOP 12051	3.2	
57	COOP 12059	3.6	
58	ADM N8118340	2.2	
59	ADM N8120345	2.6	
60	ADM N5023584	2.2	
61	ADM N8118321	2.9	
62	ADM N8118339	2.2	
63	ADM N9007081	1.9	
64	ADM N9029100	2.2	
65	SEM NAVC6V1200	2.9	
66	MSU N12440	2.2	
67	MSU N13140	3.3	COLOR
68	MSU N11238	2.8	SCORE 1-5, 5=best
69	ZORRO H	4.2	4.0
70	SHANIA H	3.3	3.3
71	LORETO	3.5	3.4
72	ZENITH B10244	4.1	5.0
73	ECLIPSE	3.6	2.4
74	BL 04352	3.5	3.3
75	BL 06252	3.3	2.6
76	BL 11353	3.1	2.2
No.	VARIETY	SCORE	COLOR
77	BL 11355	3.3	3.3
78	BL 12576	3.1	2.1

79	BL 12577	3.3	2.8
80	BL 12579	3.8	4.1
81	BL 12581	3.5	2.4
82	BL 13489	3.8	3.5
83	BL 13505	3.6	3.7
84	BL 13506	2.4	3.0
85	MSU B12710	3.3	4.4
86	MSU B12720	3.8	3.1
87	MSU B12724	3.3	4.4
88	ADM B8039279	3.3	2.9
89	ADM B8006282	3.4	2.9
90	ADM B8052293	3.0	3.3
91	ADM B8090330	3.8	3.9
92	GTS COB -83-03	3.4	3.8
93	GTS COB-698-03	3.6	3.8
94	SEM BKBC6V1312	3.5	1.8
95	ND071206	3.2	2.7
96	NDF090303	2.8	3.0
97	T-39	3.3	3.7
98	EXP. 50/50	3.9	4.4
99	EXP. 33/67	3.8	4.5
100	ZORRO T	3.3	3.8
101	SHANIA T	2.6	3.3
102	LORETO	3.5	3.3
103	ZENITH B10244	4.1	5.0
104	ECLIPSE	3.5	2.5
105	BL 04352	3.4	3.9
106	BL 06252	3.3	2.8
107	BL 11353	3.3	2.1
108	BL 11355	3.3	3.6
109	BL 12576	2.8	2.3
110	BL 12577	3.1	2.7
111	BL 12579	3.5	3.8
112	BL 12581	2.8	2.6
113	BL 13489	3.5	3.8
114	BL 13505	3.6	3.6
115	BL 13506	2.3	3.3
No.	VARIETY	SCORE	COLOR

116	MSU B12710	3.8	3.8
117	MSU B12720	3.4	2.9
118	MSU B12724	3.4	4.2
119	ADM B8039279	3.2	2.9
120	ADM B8006282	3.0	2.8
121	ADM B8052293	2.7	2.9
122	ADM B8090330	3.6	3.9
123	GTS COB -83-03	3.0	3.6
124	GTS COB-698-03	3.5	3.8
125	SEM BKBC6V1312	3.0	2.1
126	ND071206	2.7	2.7
127	NDF090303	2.8	2.8
128	T-39	3.2	3.4
129	ZORRO RV	3.7	4.0
130	SHANIA	2.6	3.8
131	LORETO	3.2	3.5
132	ZENITH B10244	4.1	4.8
133	ECLIPSE	2.8	2.8
134	BL 04352	3.5	3.8
135	BL 06252	3.3	2.8
136	ZORRO DELL	3.8	4.2
137	SHANIA	3.3	3.7
138	LORETO	3.4	3.4
139	ZENITH B10244	4.0	4.9
140	ECLIPSE	3.4	2.8
141	BL 04352	3.6	4.0
142	BL 06252	3.0	2.9
143	ELDORADO	3.3	
144	LA PAZ	2.4	
145	LARIAT	2.8	
146	MEDICINE HAT	2.4	
147	MSU P12603	1.7	
148	MSU P11519	3.7	
149	Sem-PIN-DJ091012	2.9	
150	POWDERHORN	2.9	
151	MSU G11438	3.0	
152	MSU G13424	4.3	
153	MSU G13467	3.4	

154	MERLOT S	2.8	
No.	VARIETY	SCORE	
155	SR 09303 S	2.4	
156	RUBY SR 09304	1.8	
157	SR 11511	2.7	
158	RIO ROJO	1.2	
159	MSU R12844	3.8	
160	MSU R12859	2.8	
161	MSU R13526	3.3	
162	MSU R13538	3.0	
163	MERLOT T	3.3	
164	SR 09303 T	2.4	
165	RUBY SR 09304	2.7	
166	SR 11511	2.8	
167	RIO ROJO	1.0	
168	MSU R12844	4.1	
169	MSU R12859	3.2	
170	MSU R13526	3.8	
171	MSU R13538	3.7	
172	ROSETTA T	2.5	
173	MSU S12906	2.5	COLOR
174	PK 11544	2.3	SCORE 1-5, 5=best
175	CALIF ELRK M	2.7	2.9
176	PINK PANTHER	2.1	3.3
177	CLOUSEAU	2.3	2.9
178	INFERNO	1.8	2.8
179	MSU K11709	2.6	2.8
180	MSU K13602	4.3	3.6
181	GTS-IG-INF	1.8	2.8
182	LRK 09351	2.1	3.4
183	LRK 09354	1.3	3.4
184	LRK 09360	2.3	4.1
185	LRK 09383	2.8	4.1
186	LRK 09378	1.8	3.0
187	ND 061106	1.9	2.7
188	CALIF ELRK G	2.4	2.8
189	PINK PANTHER	2.1	2.8
190	CLOUSEAU	2.4	2.6

191	INFERNO	1.9	3.3
192	MSU K11709	2.8	2.7
193	MSU K13602	3.3	3.4
No.	VARIETY	SCORE	COLOR
194	GTS-IG-INF	2.2	3.5
195	ND 061106	1.3	3.7
196	RED HAWK	4.2	
197	MONTCALM	3.1	
198	RED ROVER	2.5	
199	DYNASTY	3.6	
200	KDD-DJ091013	3.8	
201	KDD-DJ091030	4.2	
202	MSU K11306	3.1	
203	GTS 104	2.0	
204	ND061210	3.0	
205	DRK 07323	3.1	
206	DRK 09424	2.4	
207	DRK 09429	2.8	
208	DRK 09430	2.7	
209	DRK 09431	3.1	
210	RED HAWK G	2.9	
211	MONTCALM	2.9	
212	RED ROVER	3.3	
213	DYNASTY	1.6	
214	KDD-DJ091013	2.4	
215	KDD-DJ091030	3.7	
216	MSU K11306	2.3	
217	GTS 104	2.1	
218	ND061210	2.3	
219	BELUGA M	2.7	
220	SNOWDON	1.8	
221	YETI	1.9	
222	MSU K11914	1.5	
223	MSU K11916	1.9	
224	MSU K13902	2.1	
225	BELUGA G	2.8	
226	SNOWDON	2.5	
227	YETI	2.7	

228	MSU K11914	1.7
229	MSU K11916	1.8
230	MSU K13902	3.2

#### ZENITH NEW from MSU.

A New Black Bean Variety for Michigan.

New upright full-season black bean variety suited for direct harvest.

Highest yielding black bean variety in five years of testing.

Matures in 100 days, similar to 'Zorro'.

Exhibits uniform maturity coupled with good dry down similar to 'Zorro'.

White mold avoidance due to upright plant habit.

Resistant to race 73 of anthracnose.

Attractive black bean seed that possesses unique canning quality.

'ZENITH' is a new erect, high-yielding black bean variety from Michigan State University (MSU) that has out-yielded all current black bean varieties. This full-season maturing variety has an upright, short vine growth habit. The upright narrow plant profile, combined with resistance to lodging, makes 'Zenith' suitable for direct harvest under narrow row production systems. 'Zenith' is resistant to race 73 of anthracnose to which most current black bean varieties are susceptible. 'Zenith' is equivalent to 'Zorro' in tolerance to white mold and is resistant to strains of bean rust and bean common mosaic virus (BCMV) present in Michigan. The seed of this variety is similar in size to that of 'Zorro', yet it possesses unique canning properties. Following canning, 'Zenith' retains the black color better than current black bean varieties such as 'Eclipse' that tend to bleed and produce a less desirable chocolate-brown canned product.

#### Origin and Breeding History.

'Zenith', tested as MSU black bean breeding line B10244, was developed from the cross of black bean breeding line B04644 and the black bean variety 'Zorro' from the MSU breeding program. B04644 is an upright black bean derived from the three-way cross of B98306/'Jaguar'/NG8025. B04644 carried the anthracnose resistance gene Co-1 from the 'Jaguar' parent. In testing, it exhibited superior canning quality as it retains black color following canning, a characteristic coming from the black bean parent NG8025 from Mexico. 'Zorro' is a high-yielding upright black bean variety well adapted to Michigan that lacks resistance to anthracnose. The cross was made to transfer anthracnose resistance and superior canning quality into new high-yielding upright black bean varieties.

#### Agronomic and Disease Information.

'Zenith' exhibits the upright type-II indeterminate short vine growth habit combined with good resistance to lodging (1.4 on a 1–5 scale). Plants average 21 inches in height, similar to the heights of 'Zorro' and 'Shania'. 'Zenith' is a full-season bean maturing 100 days after planting. The range in maturity is from 89 to 105 days, depending on season and location. It matures with 'Zorro' and 'Loreto', one day earlier than 'Shania' and four days later than 'Eclipse'. 'Zenith' has demonstrated the same uniform maturity and dry down as 'Zorro', and is more erect than 'Shania'. 'Zenith' has a high agronomic acceptance rating based on its upright habit, resistance to lodging, excellent pod load and favorable high pod placement in the plant canopy.

'Zenith' has been tested for five years (2010–2014) in 45 locations by MSU researchers in cooperation with colleagues in Michigan, New York and Ontario. The combined yield data comparisons with other black cultivars are shown in Table 1. Over 45 locations, 'Zenith' yielded 28.4 hundredweight per acre (cwt/acre) and significantly out-yielded 'Zorro' by 6%, 'Shania' by 5%, 'Eclipse' by 12%, 'Loreto' by 9% and 'T-39' by 13%. Yield ranged from a high of 41.2

cwt/acre in Blyth, Ontario, in 2012, to a low of 13.4 cwt/acre under severe white mold conditions in Huron County, Michigan, in 2014.

Planted in narrow rows (20 inches) and combined with direct harvest, 'Zenith' has produced competitive yields in excess of 30 cwt/acre in Michigan and appears well adapted to a range of production systems in New York and Ontario (41 cwt/acre), where black beans are grown commercially. 'Zenith' appears to be well adapted to this increasingly popular management system. Growers should follow current recommended practices for fertility and weed control in growing 'Zenith' beans. Recommendations can be found online from the Saginaw Valley Research and Extension Center ([agbioresearch.msu.edu/saginawvalley](http://agbioresearch.msu.edu/saginawvalley)) and MSU Weed Science ([msuweeds.com](http://msuweeds.com)).

'Zenith' possesses the single dominant hypersensitive I gene, which confers resistance to seed-borne BCMV. All the black varieties listed in Table 1 possess the same resistance gene. 'Zenith' possesses the Co-1 gene that provides resistance to anthracnose race 73 to which all other black bean varieties except 'Loreto' are susceptible. 'Zenith' exhibits similar tolerance to white mold compared to other black bean varieties. Percent white mold was 36% compared to 'Zorro' (35%) and 'Shania' (63%), 'Eclipse' (52%) and 'T-39' (70%) when grown in irrigated trials over 4 years. 'Zenith' exhibits a range of reactions to other pathogens similar to commercial black bean varieties. It is susceptible to common bacterial blight; it possesses resistance to some races of rust but is susceptible to rust race 22:2 now prevalent in Michigan.

#### **Quality Characteristics.**

'Zenith' has a typical small-sized black bean seed, averaging 22 g/100 seeds and a size range from 20 to 25 g/100 seeds. The seed is similar in size and appearance to 'Loreto' and 'T-39' (22g), is slightly larger than 'Zorro', 'Shania' and 'Eclipse' (20g), and resembles the round plump appearance of 'T-39'.

In canning trials, 'Zenith' has been subjectively rated by a team of trained panelists as being excellent in cooking quality. This evaluation is based on whole bean integrity (no splitting or clumping), uniformity of size (uniform water uptake), cooked seed color (limited color leaching) and clear brine (no starch extrusion into canning liquid). 'Zenith' rated 4.5 on a scale of one to five where five is best and three is mid-scale (neither acceptable nor unacceptable). Within the commercial black bean class, 'Zenith' was rated highest in visual color (4.6) when compared to 'Zorro' (3.5), 'Eclipse' (2.3) and 'T-39' (3.3). Data on L-color (lightness scale) of cooked beans showed that 'Zenith' was blacker (13.1)



Photo of Zenith Black Beans in Harrisville Black Bean Strip Trial, 2014.

**Table 1. Comparison of yield, agronomic, disease and canning characteristics of ‘Zenith’ with five other black bean varieties over five years testing (2010-2014) in Michigan, New York and Ontario.**

Traits.	Varieties.					
	‘Zenith’	‘Zorro’.	‘Shania’.	‘Eclipse’.	‘Loreto’.	‘T-39’.
<b>Agronomic traits.</b>						
Days to flower	45	46	46	43	44	45
Days to maturity	100	100	101	96	100	100
Height in inches	21	21	21	20	21	18
Lodging scoreAverage (1–5)	1.4	1.7	1.8	1.3	2.3	3.1
Agronomic indexb Average (1–7)	5.5	5.1	3.8	4.2	3.8	3.4
100-seed weight in grams	21.7	20.2	20.3	20.1	22.1	21.5
Mean yield(cwt/acre)	28.4	26.7	26.6	25.2	25.6	24.5
Yield percentage	100	94	95	88	91	87
<b>Disease resistance traits.</b>						
BCMV	R	R	R	R	R	R
Anthraco-nose: race 73	R	S	S	S	R	S
Rust race 22:2	S	S	S	S	S	S
Common bacterial blight	S	S	S	S	S	S
White mold percentage	36	35	63	52	—	70
<b>Canning quality traits.</b>						
Color L-scale	13.1	15.8	16.9	18.1	16.2	16.2
Visual color	4.6	3.5	3.1	2.3	3.1	3.3
Texturei (kg/100g)	41	43	39	47	37	38
Visual rating	4.5	4.0	3.2	3.6	3.4	3.5

2014 White Mold Trials

Montcalm Research Center

Treatment	Rate	Appl.	% Incidence	% Severity	% Pick	Yield in lbs
UTC			70	55	4.2	1618
Proline	5.7 oz	2	48	36	3.1	2192
Proline+Ser Opt	5.7 oz+32 oz	2	48	34	2.5	2201
Pulpulse	8 oz	2	31	20	2.5	2505
Propulse+Ser Opt	8 oz+32 oz	2	32	20	1.9	2707
Endura	8 oz	2	20	12	2.3	2510
Omega	8 oz	2	20	12	2.0	2544
Aproach	12 oz	2	47	33	3.0	2424
Aproach+Endura	12 oz+8 oz	1	31	19	2.7	2517
Aproach+Omega	12 oz+8 oz	1	34	22	4.0	2601
Endura+Omega	8 oz+8 oz	1	33	17	2.8	2458
Merlot Small Red Beans			LSD.05=16 CV=30.6%	LSD.05=13 CV=36.6%	LSD.05=1.2 CV=27.5%	LSD.05=597 CV=17.7%

Ruth, MI-Buckley Creek Farms Inc.

Treatment	Rate	Appl.	% Incidence	% Severity	% Pick	Yield in lbs
UTC			98	94	22.5	222
Proline	5.7 oz	2	91	87	20.3	591
Proline+Ser Opt	5.7 oz+32 oz	2	92	88	20.8	496
Pulpulse	8 oz	2	77	73	9.2	1395
Propulse+Ser Opt	8 oz+32 oz	2	87	84	13.95	627
Endura	8 oz	2	85	82	10.3	830
Omega	8 oz	2	79	71	7.7	1256
Aproach	12 oz	2	92	89	17.3	509
Ruby (09304) Small Red Beans			LSD.05=7 CV=6.4%	LSD.05=12 CV=10.7%	LSD.05=2.6 CV=14.3%	LSD.05=331 CV=21.4%

Montcalm White Mold Strip Trial at Montcalm Research Center

Treatment	Rate	Appl.	% Incidence	% Severity	% Pick	Yield in lbs
Endura	8 oz	1	61	49	2.1	1778
Omega	8 oz	1	68	56	2.6	1650
UTC			79	69	5.1	1005
Pulpulse	8 oz	1	65	44	4.1	1926
Aproach	12 oz	1	65	52	4.9	1519
Merlot Small Red Beans			LSD.05=16 CV=15.2%	LSD.05=10 CV=12.2%	LSD.05=1.2 CV=20.5%	LSD.05=537 CV=22.1%

Dry Bean Insects in West Michigan, 2014 Season

Western Bean Cutworm continues to be a concern for dry bean production in much of West, Northern, and Central Michigan. Levels were relatively low in 2014 as monitored by adult flight and observed damage to dry beans. Table 1 shows the number of moths captured per trap for the 2014 season in Central and West Michigan

Table 1

Trap name	Total number of moths captured
Coral 1	124
Coral 2	19
Howard City	33
Entrican	50
Stanton 1	96
Stanton 2	13
Sheridan	110
Greenville 1	29
Greenville 2	17
Ithaca	23
Allegan 1	27
Kent	46
Allegan 2	72
Rockford	76

The majority of growers did not apply an insecticide for Western Bean Cutworm control in 2014. This decision was based primarily on trap data and field observations of larval feeding activity. At harvest some damage to Light Red and White Kidney beans was observed in unsprayed beans in 2014. Levels of damage generally ranged from 0 to 1% of harvested beans with the vast majority showing only traces of feeding damage. The low level of damage observed was considered to be acceptable overall though there are still individual fields where damage was significant. It will take additional work to better understand the biology of the pest and its interaction with the environment and its natural controls to be able to define which fields may benefit from insecticide applications targeting this pest.

Brown Marmorated Stink Bug is a new invasive pest in Michigan. It has the potential to cause significant damage to dry beans primarily by reducing quality from stinging pods. While this pest has been detected in the state on various fruit crops, we did not find it in dry beans during the 2014 season.

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**PROJECT TITLE - FINAL**

**Michigan Farmers Market Association (MIFMA)** – Field Days and Online Training Videos to Enhance the Competitiveness of Specialty Crops

**PROJECT SUMMARY**

This project addressed the need of diversified specialty crop farmers for hands-on training and technical assistance to improve production efficiency, increase sales and facilitate overall

business growth. A farm-based education program was developed for specialty crop producers and focused on practical production, management and promotion techniques.

The project was important and timely because many of Michigan's specialty crop producers have small, diversified businesses and have entered the marketplace through direct producer-to-consumer sales such as farmers markets. As farmers markets develop and expand, these farmers have an opportunity to expand their individual businesses and enhance the overall competitiveness of the specialty crop industry. In order to do that, many need the type of hands-on training best provided by other farmers.

This project did not build on a previously funded SCBGP or SCBGP-FB project.

## PROJECT APPROACH

The Michigan Farmers Market Association (MIFMA) developed a farm-based education program for specialty crop producers that included six on-farm field days, one webinar and six online training videos. Farmers evaluated each field day, the webinar and each video. An operations manual was developed to guide the development of future field days.

Project partners made significant contributions which included:

- MIFMA: Identified host farmers, made initial site visits, developed promotion, accepted registrations, and organized the on-farm logistics.
- Michigan State University (MSU) Department of Horticulture: Provided technical assistance, supplied talent for videos, and developed the video training guides.
- MSU Extension: Assisted with project promotion, attended most sessions, assisted in identifying farmer hosts, and helped with logistics.
- MSU Center for Regional Food Systems: Provided use of Qualtrics software for project evaluation.
- Michigan Fitness Foundation: Provided speakers and helped identify farmer hosts for one field day.
- MIFFS: Helped promote the farm-based education program.

## GOALS AND OUTCOMES ACHIEVED

- Hired a Project Manager, Kat Curtis. Kat left the area in August 2014. Hired Samantha Collins as new Project Manager.
- Identified six farms and one direct market setting to effectively address each of the following topics:
  - **Using Equipment and Tools to Improve Production Efficiency - 9/15/2014**  
Nature's Pace Organics - Jacob Bach and Katie Mullane  
5191 Chambers Road, Mayville, MI 48744
  - **Drip Irrigation for Specialty Crop Producers - 7/28/2014**  
Kuntry Gardens - Andy Stutzman  
29910 R-Drive S. Homer, MI 49245
  - **Season Extension to Expand Your Marketing Potential - 10/12/2014**  
Ski Country Farm - Greg Zimmerman and Carolyn Rajewski  
2281 W. 7 Mile Rd., Sault Ste Marie, MI 49783  
*and*  
Beaver Meadow Creek Farms - Mark and Deanna Jones  
5600 S. Shunk Road, Sault Ste Marie, MI 49783

- **Engaging Customers to Increase Sales and Improve Community Health - 9/8/2014**  
 YMCA of Greater Grand Rapids (Veggie Van)  
 475 Lake Michigan Dr. NW, Grand Rapids, MI 49504  
*and*  
 New City Urban Farm - Lance Krai  
 1226 Union NE, Grand Rapids, MI 49505
  - **Maintaining Produce Quality from Farm to Market - 9/29/2014**  
 Green Gardens Community Farm - Trent & Ruthie Thompson  
 14201 H Drive, N Battle Creek, MI 49014
  - **Hoophouses and Cold Storage Crops for Michigan Winters -11/10/2014**  
 MSU Student Organic Farm - Jeremy Moghtader and Dan Filius  
 3291 College Road Holt, MI 48842
  - **Technology and Apps for Production and Promotion (webinar) 12/15/2014**
- Visited five farmers and one direct market setting to plan for and discuss the format of the on-farm, farmer-led field days.
  - Hired videographer Dan Hartley to record, edit and produce six web-based videos that are now available at [www.youtube.com/user/MIFarmersmarkets](http://www.youtube.com/user/MIFarmersmarkets) Video topics include: Soil Blocking for Transplant Production, Hoophouse Winter Cover, Direct Seeding with a Tractor-mounted Seeder, Hoophouse Soil Preparation, Stringing Peppers, and Drip Irrigation Basics for Hoophouse Production.
  - Developed a training manual/field guide to accompany each video that can be downloaded from the MIFMA website, [www.mifma.org](http://www.mifma.org).
  - Promoted field days using a variety of strategies:

Electronic Promotion and Physical Mailings:

Designed and printed program flyers for each event. Copies of each flyer were available at [www.mifma.org/farm-based-education-programs/](http://www.mifma.org/farm-based-education-programs/). Distributed program flyers electronically to MIFFS (360 subscribers), FoodSpeak and Michigan Farmers Market (1029 subscribers) listservs. Printed versions of the flyers were mailed with a letter to all MIFMA members in each event county and adjacent counties. The number of pieces mailed:

- Engaging Customers to Increase Sales and Improve Community Health - 27
- Using Equipment and Tools to Improve Production Efficiency - 43
- Maintaining Produce Quality from Farm to Market - 57
- Season Extension to Expand Your Marketing Potential – 16
- Hoophouses and Cold Storage Crops for Winter --- 86
- Technology for Production and Profitability -- an email was sent to Michigan Farmers Market, MIFFS and FoodSpeak listservs.

Sent promotional postcards to all MIFFS and MIFMA members (481 households) highlighting the Maintaining Produce Quality from Farm to Market on 9/29/14 and Season Extension to Expand Your Marketing Potential on 10/13/14.

Press Release Distribution:

- Drip Irrigation For Specialty Crop Producers
- Maintaining Produce Quality from Farm to Market (to Battle Creek Enquirer, Kalamazoo Gazette and 10 general agriculture media contacts)
- Season Extension to Expand Your Marketing Potential (Sent to 20 media contacts in northern lower and Upper Peninsula and to the Michigan Farmers Market, MIFFS and FoodSpeak listservs.) An Upper Peninsula television station (WLUC TV6) publicized the event on 10/8 and a Sault Ste. Marie television station (Soo Evening News) publicized the event on 10/13.
- Hoophouses and Cold Storage Crops for Winter – a press release was sent via email to Michigan Farmers Market, MIFFS and FoodSpeak listservs. The event was also promoted via the MSU Student Organic Farm on Facebook, Twitter and email blast which in turn brought in a large number of registrants.
- Technology for Production and Profitability – a press release was sent via email to Michigan Farmers Market, MIFFS and FoodSpeak listservs.

Social Media Promotion:

Established Facebook events for each field day on MIFMA's Facebook page, [www.facebook.com/MichiganFarmersMarketAssociation](http://www.facebook.com/MichiganFarmersMarketAssociation). The table on the following page shows the number of people reached through several different aspects of Facebook. Posts were not boosted.

Table 1: Social Media Promotion

\* Facebook makes this information available only for events created after 7/24/14. Most of the event posts were created earlier than this date.

^ No photos were posted because the field day was held on an Amish farm where photographs of people were not permitted or it was a webinar.

	Facebook Event Interaction	Facebook Timeline Promo Posting Reach & Interaction	Facebook Views of Photos From Event
Drip Irrigation for Specialty Crop Producers	NA*	Reached 84 users, 1 share, 1 comment and 2 likes	NA^
Engaging Customers to Increase Sales and Improve Community Health	215	Reached 93 users	Viewed by 173 users, had 7 likes
Using Equipment and Tools to Improve Production Efficiency	NA*	Reached 344 users	Viewed by 831 users, 2 shares, 1 comment
Maintaining Produce Quality from Farm to Market	NA*	Reached 772 users, 13 shares, 12 likes and 1 comment	Viewed by 98 users, 4 likes

Season Extension to Expand your Marketing Potential	NA*	Reached 141 users, 21 likes	Viewed by 130 views, 2 shares, 14 likes
Hoophouses and Cold Storage Crops for Michigan Winters	667	Reached 435 users, 4 shares, 2 likes	Viewed by 225 users, 3 shares, 27 likes, 2 comments
Technology for Production and Profitability	197	Reached 41, 3 likes	N/A^

**Table 2: Field Day Registration Information**

Conducted six on-farm field days and one webinar. The following table shows the topics, hosts, number of those who pre-registered, number of participants, number of farming operations and other separate organizations represented at each of the field days.

Topic	Host(s)	Date	Registrants	Participants	Operations/ Organizations
Drip Irrigation for Specialty Crop Producers	Kuntry Gardens	7/28/2014	17	28	14
Engaging Customers to Increase Sales and Improve Community Health	YMCA of Greater Grand Rapids and New City Urban Farm	9/8/2014	10	11	9
Using Equipment and Tools to Improve Production Efficiency	Nature's Pace Organics	9/15/2014	12	19	14
Maintaining Produce Quality from Farm to Market	Green Gardens Community Farm	9/29/2014	14	19	15
Season Extension to Expand your Marketing Potential	Ski Country Farm & Beaver Meadow Farm	10/12/14	9	16	12
Hoophouses and Cold Storage Crops for Michigan Winters	MSU Student Organic Farm	11/10/14	74	73	46
Technology for Production and Profitability	Webinar	12/15/14	34	25	32

Google Analytics shows that when individuals accessed the website through [www.mifma.org](http://www.mifma.org), the page <http://mifma.org/farm-based-education-programs/> received 750 page views from March 2014 to March 2015.

MIFMA also created individual web pages to promote each field day, which included details about the event and how to register. In total, these pages received 1,116 page views. The page promoting Hoophouses and Cold Storage Crops for Michigan Winters had the highest number of page views at 411, which is about 40% of the total views. The 1,116 total page views was reached through direct click thrus to specific field days from social media.

Specialty Crop Producer Videos:

MIFMA created six videos to assist specialty crop producers in learning basic techniques to increase production. The videos can be viewed at [www.youtube.com/user/MIFarmersmarkets](http://www.youtube.com/user/MIFarmersmarkets)

Field guides were also created to accompany the videos. They can be viewed online at <http://mifma.org/farm-based-education-programs>  
<http://mifma.org/farmbaseded/> Farm-based Education Program - Michigan Farmers Market Association (MIFMA)Michigan Farmers Market Association (MIFMA)

Table 3: Specialty Crop Producer Video Promotion

NA – video was posted but then removed for an update, stats not valid.

	Facebook Event Interaction	Facebook Timeline Promo Posting Reach	Youtube Views
Direct Seeding with a Tractor Mounted Seeder	3 shares, 14 likes, 4 comments	Reached 884 users	89 views
Hoophouse Winter Cover	25 likes, 3 shares, 2 comments	Reached 1,260 users	135 views
Soil Blocking for Transplant Production	7 shares, 16 likes	Reached 1,151 users	N/A
Drip Irrigation Basics for Hoophouse Production	43 likes, 2 comments, 17 shares	Reached 3,262 users	223 views
Stringing Peppers	42 likes, 23 shares	Reached 2,904 users	270 views
Hoophouse Soil Preparation	5 shares, 20 likes	Reached 1,574 users	154 views

**BENEFICIARIES**

A goal was set to reach a total of 120 specialty crop producers, 20 per field day through six on-farm field days. There were no fees collected to attend the field days or participate in the webinar; however, pre-registration was requested. A total of 192 people pre-registered for the field days. MIFMA counted that at least 177 participants attended six field days and one webinar, ranging from 11 to 73 at any given field day and averaging 25 per session. Some individuals who registered failed to attend and others came who had not registered. Some participants attended multiple sessions: six attended two sessions, two attended three sessions, four attended four sessions, and one individual attended all six of the field days. Most

participants were specialty crop producers. The sessions also attracted people who work with specialty crop producers such as educators and resource providers.

Field day participants were a diverse group. Although predominantly current and future specialty crop growers, agricultural resource providers also participated. Locations for the field days were selected to provide opportunities for specialty crop producers to participate in one or two of the sessions without traveling a long distance. Participants reported driving as little as five miles and as far as 175 miles one-way to attend the field days. The average distance driven one-way by participants was between 50 and 60 miles.

Participants were contacted following each event with an electronic survey. Their responses indicated that they learned a lot at each session, made plans for using what they had learned and found the field day format very positive. Results from all seven surveys were combined, the following table shows the percent of survey respondents who agreed or strongly agreed with each statement.

<b>Percent Respondents who Agreed or Strongly Agreed with Statement</b>	
98%	Overall I was satisfied with the field day/webinar
98%	Attending the field day/webinar was a valuable learning experience
90%	I gained concrete ideas about how to make my farm more efficient
78%	I gained concrete ideas about how to make my farm more profitable
96%	Attending was worth the time I committed to be there
95%	I would recommend sessions like this one to other farmers
95%	The farmer host(s) presented relevant information
83%	I gained from my interaction with other farmers

Survey respondents reported learning a wide range of information and skills that can potentially enhance the efficiency and profitability of their farming operation including:

- How to use a tractor-mounted seeder and mulch harrow, a four-row pinpoint seeder and a flame weeder.
- How to move toward a paperless farming operation.
- How to use software to keep required organic certification input records.
- How to determine which crops are more or less profitable.
- That farm records may be a make-or-buy feature as farms scale up.
- That some farm software applications are less complicated than previously thought.
- Hoophouses: importance of location, options for rotations, how to maximize production.
- Seeding and planting dates and cultivar selection for winter hoophouse crops.
- How to use raised beds in a hoophouse to grow carrots in heavy soil.
- Benefits of using an opaque end wall in some hoophouses.
- Hoophouse overhead hose design to facilitate watering direct-seeded beds.
- Pros and cons of various hoophouse types, single versus double layers of plastic.
- Compost application rates.
- Crop storage requirements.
- How hydroponic systems work.
- Customer engagement strategies to help people feel welcome at market and more likely to use food assistance benefits.
- How to set up a drip irrigation system.
- How to determine drip irrigation schedules and rates and set up zones.

- How to take a water sample and interpret the results.
- The value of food demonstrations to increase sales at farmers markets.
- Ways to enhance customer service to increase sales.

Of course, new knowledge and skills will be beneficial only when applied. When asked what they plan to do as a result of participating in a field day, participant responses included the following:

- Use more season extension techniques.
- Purchase a small row crop tractor and pinpoint seeder.
- Grow more ginger, strawberries, kale, overwintered in a hoophouse.
- How to make compost tea.
- Collect additional farming information and expand recordkeeping.
- Incorporate farm software applications.
- Add specific hoophouse costs and designs to farm business plan.
- Manage hoophouses more intensively.
- Adjust planting dates, crops, cultivars, hoophouse space utilization, watering methods.
- Add hoophouses and walk-in cooler to a farm.
- Provide recipes at the farmers market.
- Install and improve drip irrigation.
- Begin using a harvest list.

## LESSONS LEARNED

Specialty crop farmers across Michigan enjoyed having an opportunity to visit other farms and to learn from one another. A field day provides a relaxed setting and the opportunity to talk and ask questions not only of the host farmer, but also of the other participating farmers. They see how things are working at the host farm and they take home practical ideas to tweak their own operations.

The field days were located around the state to reduce the distance that farmers had to travel, we learned that some farmers are willing to drive long distances in order to participate. Mondays proved to be a good day for scheduling the field days.

A very short timeline based on the grant funding and its relationship to the growing season meant that it was not possible to have all the field days firmly scheduled before the series began. Marketing efforts focused on one day at a time and on a several county area surrounding the specific host farm for that field day. A missed opportunity was getting statewide media attention for the season-long series of field days plus webinar.

A Field Day Operations Manual has been developed to guide MIFMA and partnering organizations in planning, promoting and implementing annual Farm Based Education programs. The manual includes sections, instructions and recommendations about field days, site visits, marketing and evaluation templates for site visits, field day planning, on-site registration and on-site sign-in and lists for packing and tasks at the field day. This project demonstrated that there is demand for more field days geared towards direct market, diversified specialty crop producers. [Dropbox - MIFMA Field Day Operations Manual 3-17-15.pdf](#)

## CONTACT PERSON

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## ADDITIONAL INFORMATION

None.

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## PROJECT TITLE – FINAL – Scope Change Project

**Michigan Cherry Committee** – Assisting Growers with Detection, Identification, and Management of Spotted Wing Drosophila on Michigan Cherry Farms

## PROJECT SUMMARY

Spotted wing drosophila (SWD), an invasive insect pest native of Asia, has become a significant threat to Michigan's fruit industry since this pest arrived in the state in 2010. In 2015, Michigan tart cherry growers experienced economic losses as a result of SWD fruit infestation. In an effort to minimize the risk of future economic loss caused by SWD, a training program was offered to growers, consultants, and processors during the 2016 growing season; this effort was led by Michigan State University (MSU) Extension in northwest Michigan. This program consisted of 26 workshops where MSU Extension educators taught participants about SWD biology, identification, and integrated pest management strategies to control SWD. Participants were also provided with the opportunity for hands-on monitoring for SWD using a trap-swap system and fruit sampling techniques were demonstrated. To better understand what constitutes effective SWD management programs, educators evaluated the level of SWD damage and compared these results with individual SWD management programs. Results from an end-of-season participant survey indicated that 97% of respondents (n=72) improved their knowledge of SWD biology, monitoring, and management strategies. Furthermore, there was a 46% increase in on-farm SWD monitoring in 2016 compared with previous seasons.

## PROJECT APPROACH

Spotted wing drosophila (SWD) has become a significant threat to Michigan's fruit industry. To combat the threat of SWD, Michigan State University (MSU) Extension formed an SWD monitoring network in 2013 that has been in effect for every growing season since its inception. Impact assessment surveys (2013 and 2014), indicated that the monitoring reports published through regional newsletters and on the MSU Extension News website helped 92% of respondents (n=25) with insect management decisions on their farm, and 76% (n=25) altered their insecticide program based on SWD trap catches in their region. Furthermore, the 2015 northwest Michigan Integrated Pest Management (IPM) Updates' survey showed that 80.5% of respondents (n=33) relied on MSU's monitoring network to guide their SWD management decisions. Despite the efforts of MSU Extension to assist growers and consultants with SWD detection through the monitoring network and management strategies through educational programs, there were SWD-infested tart cherries in Michigan in 2015 that resulted in fruit rejections and economic losses.

Following the 2015 season's SWD challenges, MSU Extension and AgBioResearch hosted cherry growers, consultants, processors, and industry leaders for a daylong SWD Summit. The Summit intended to educate the industry on current and future SWD research and set priorities to address evolving cherry pest management programs that include SWD. The project outlined in this report was developed in direct accordance with priorities set by the Michigan cherry industry at the Summit. This project also drew upon lessons learned from past seasons that demonstrated we needed to expand SWD monitoring to individual farms to improve early detection and SWD management. This project also addressed the need to increase growers'

knowledge of SWD and provide training to confidently deploy traps, monitor, identify, and make SWD management decisions. MSU Extension offered training sessions distributed in four counties of northwest lower Michigan and a trap swap program to work toward improving IPM in cherries. The objectives of the project were to: **1. Conduct training sessions to promote and improve growers' and consultants' skillsets for SWD monitoring and identification, 2. Establish and maintain grower/consultant-led on-farm SWD monitoring from the time cherries become susceptible through harvest, 3. Correlate on-farm SWD management practices with trap catches of adult flies and potential larvae in fruit, and 4. Measure impact of SWD training sessions.**

**GOALS AND OUTCOMES ACHIEVED**

**Objective 1. Conduct training sessions to promote and improve growers' and consultants' skillsets for SWD monitoring and identification.** Through the extensive trapping network in northwest Michigan, SWD was detected on 31 May 2016. MSU Extension educators began educating growers about SWD at weekly meetings soon after this initial detection; the official SWD training sessions began during the week of five June. A total of 26 sessions were held, and during these sessions, growers were provided with hands-on activities, demonstrations, handouts, and presentations that covered SWD biology, identification, monitoring, and management. The 2015 *Managing Spotted Wing Drosophila in Michigan Cherry* MSU Extension publication was used as a primary resource for SWD education. Additional factsheets containing results of SWD research projects such as alternate hosts that harbor SWD and insecticide efficacy for SWD management were also provided. Seven weekly sessions were held in each Leelanau and Grand Traverse Counties, and six weekly sessions were held in each Antrim and Benzie Counties. At least two additional informal meetings were held at each of the four meeting locations on an as needed basis. Weekly meetings were designed to address the most applicable and timely information in relation to crop development and pest abundance. For example, pest biology, local population distribution, and stages of cherry susceptibility were discussed at the initial meetings. Successive meetings' topics included monitoring protocols, weekly IPM strategies, and fruit sampling techniques used to observe SWD fruit damage.

**Objective 2. Establish and maintain grower/consultant-led on-farm SWD monitoring from the time cherries become susceptible through harvest.** The on-farm SWD monitoring program (AKA SWD trap-swap) began the week of 12 June. During that week, a total of 46 traps were given to and deployed by growers/consultants in Leelanau, Grand Traverse, Antrim, and Benzie-Manistee counties. Trap-swap participants returned the traps the following week and each week thereafter for the duration of the program. Participants were provided a refreshed trap to place back into the original trap's location in the cherry block; participants were given the option to obtain a new trap weekly through harvest. During the training sessions, traps were inspected for the presence or absence and number of SWD adult flies in the traps using a dissecting

microscope. Upon finding SWD, participants had the opportunity to view the specimen using the microscope. Management strategies based on trap counts for individual growers or the grower collective in a particular region were discussed at training

Table 1. Total Number of Adult SWD Detected in Trap-Swap

Location	Sampling Date				
	6/21-6/22	6/27-6/28	7/5-7/6	7/12-7/13	7/19-7/20
Leelanau	0	7	25	14	22
Grand Traverse	1	3	2	4	0
Antrim	1	3	2	0	1
Benzie-Manistee	0	17	16	32	109
<b>Grand Total</b>	<b>2</b>	<b>30</b>	<b>45</b>	<b>50</b>	<b>132</b>

sessions. One-on-one conversations and/or on-farm meetings to discuss management were also held with growers that detected SWD on their farms. The total number of SWD detected in specific regions were compiled with regional trapping data and published in local bi-weekly monitoring reports (Table 1).

**Objective 3. Correlate on-farm SWD management practices with trap catches of adult flies and potential larvae in fruit.** The effectiveness of nine growers' SWD management programs was evaluated by correlating spray programs with SWD adult trap counts and larval detections in fruit sampled near harvest. This grower-collaborative project was separate from the trap-swap program that used additional on-farm traps. We found that SWD programs ranged from two to six full cover applications with (a total of 33.5 and average of 3.72 full cover equivalent (FCE) applications per nine farms) targeting SWD in 2016. The number of sprays that were applied was dependent on the harvest date (i.e. the later the harvest, the more sprays were applied) and when SWD were detected on individual farms (i.e. the earlier SWD was detected, the earlier management programs began if cherries were at a susceptible stage). These findings indicate that growers used efficacious materials for SWD management including those recommended by MSU Extension at weekly training meetings and during one-on-one discussions. Grower spray strategies ranged from all alternate row middle applications to all full cover applications or a combination of these application strategies.

Traps were checked weekly during the growing season, and the number of SWD at each of the nine grower collaborator sites was recorded. Adult SWD were also detected at each of the nine farms before harvest; however there was no significant relationship among the number of adults trapped and the number of larvae that were detected in fruit samples. Cherries were also collected from each of these sites near harvest timing or on the day of harvest to monitor for SWD larvae. A brown sugar extraction method was used to determine the presence/absence and number of SWD per 300 fruit collected per farm. Using this intensive sampling protocol, larvae were detected in fruit samples before and/or on the date of harvest at six of the eight farms that harvested fruit; one farm chose to divert the cherries that were used in this study and was therefore removed from the comparison. Anecdotally, we hypothesize that SWD may have a clumped distribution, but further investigation is needed to better assess the influence of local populations and distribution, SWD host preference, and/or harvest timing on the potential for SWD-infested cherries.

**Objective 4. Measure impact of SWD training sessions.** The transfer of knowledge, in-depth collective discussions, and ongoing applied research on SWD improved grower understanding and ability to control SWD in 2016. Based on the 2016 IPM Update survey data (n=72 respondents):

- 97% improved their knowledge of SWD biology, monitoring, and management strategies
- 94% improved their knowledge of efficacious materials for SWD management
- 79% used or intended to use the regional SWD trap reports published by the Northwest Michigan Horticultural Research Center to assist management decisions
- 75% managed or intended to manage susceptible fruit for SWD using materials recommended by MSU
- 72% used or intended to use on-farm monitoring for SWD
- 26% monitored for SWD in previous seasons

The results of this project indicated that MSU Extension was successful in improving participants' knowledge of SWD biology, monitoring, and management through the trap-swap and SWD training sessions. The SWD trap-swap program allowed for an expanded monitoring

network and also provided hands-on SWD trapping experience to growers and consultants. Survey results indicated a 46% increase in on-farm SWD monitoring from previous seasons to the 2016 season. Furthermore, spray records indicated that growers were receptive to implementing SWD recommendations from MSU Extension educators. Future SWD effort should continue to address effective management strategies to reduce the risk of economic losses caused by SWD while promoting cherry IPM practices.

#### BENEFICIARIES

The primary beneficiaries of this project were cherry growers, processors, and consultants. There were more than 300 total participants that attended the 26 SWD workshops; however, many of these participants returned each week to the workshops. A total of 46 growers and/or consultants participated in the trap swap program. These beneficiaries received SWD integrated pest management education, as well as hands-on identification and monitoring experience.

#### LESSONS LEARNED

The Cherry Industry Administrative Board (CIAB) voted to temporarily suspend the zero tolerance policy for larvae in fruit for 2016 due to the difficulty of meeting this industry standard with the current knowledge and tools available for SWD management in cherries. This decision posed an unanticipated challenge for Objective 3 to correlate on-farm SWD management practices with trap catches of adult flies and potential larvae in fruit. For this objective, we would have preferred to collect growers' spray records from all of the farms that participated in the trap-swap program. These growers' management programs would have been placed into one of two categories: programs that resulted in fruit that were free of SWD larvae or programs that resulted in infested fruit at the processor level. The suspension of the tolerance resulted in few reports of farms that had infested fruit at the farm or processor level. Despite this challenge, we were able to collaborate with growers to assess programs that were successful or unsuccessful for preventing SWD infested fruit.

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#### ADDITIONAL INFORMATION

Bulletin referenced for training program:

**J. Wilson, L. Gut, N. Rothwell, M. Haas, E. Pochubay, K. Powers, M. Whalon, and J. Wise.** 2015. Managing Spotted Wing Drosophila in Michigan Cherry. Michigan State University. <http://www.ipm.msu.edu/uploads/files/swd/swdmanagementguidecherries.pdf>

**SWD Trap-Swap Participants  
Antrim Co. Training Workshop  
June 22, 2016**

