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Michigan Department of Agriculture & Rural Development FY2012 – FINAL REPORT

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MDARD INTERNAL ACTIVITIES

PROJECT TITLE Export Promotion of Michigan Specialty Crops FINAL

PROJECT SUMMARY

This project addressed 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 Michigan Bean Commission worked jointly with the Michigan Department of Agriculture & Rural Development (MDARD) International Marketing Program, to secure booth space at major domestic and international trade shows for Michigan specialty crop commodity groups and companies to exhibit at during 2013. 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 of 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 APPROACH

The Michigan Bean Commission worked jointly with MDARD to offer a number of domestic and international marketing opportunities to Michigan specialty crop groups. 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 a number of 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 2013 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.

Participation of the Michigan specialty crop companies and commodity groups was advertised to international buyers by placing an ad in *The American Exporter* magazine indicating the shows and booth numbers that specialty crop companies and commodity groups would exhibit at during 2013. 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 is working with the Michigan Bean Commission to utilize 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 2013.*
>
> *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. 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 2013 and return by December 21. Please contact me at (517) 241-3628 or zmitkoj@michigan.gov for more information.*
>
> *2013 Michigan Pavilion for Specialty Crops:*
>
> - *Trade Mission for Specialty Crops to Brazil & Columbia (potentially) – March 4-8*
> - *American Food Fair at National Restaurant Association Show: Chicago, IL - May 18-21*
> - *ANUGA: Cologne, Germany – October 5-9*
> - *America's Food and Beverage Show: Miami, FL - October 28-20*

GOALS AND OUTCOMES ACHIEVED

Activities Completed

Activity 1: American Food Fair at the National Restaurant Association Show - May 18-21, 2013, Chicago, IL

MDARD secured booth space at the National Restaurant Association Show in Chicago, Illinois, May 18-21, 2013, 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 Apple Committee worked hard 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 dry beans and cherries. MDARD staff was able to direct interested attendees to specialty crop commodity information.

Activity 2: Anuga – October 5-9, 2013, Cologne, Germany

Three Michigan companies attended the Anuga trade show in Cologne, Germany on October 5-9, 2013. The project was to assist specialty crop groups promote their products to a worldwide audience at an affordable rate. MDARD, along with The Michigan Bean Commission, secured booth space and provided signage and furniture at the trade show for Michigan companies and commodity groups at a reduced cost.

Activity 3: American Food & Beverage Show – October 28-29, 2013, Miami, FL

The Michigan Bean Commission, along with MDARD, helped specialty crop companies participate at the Americas Food & Beverage Trade Show in Miami, Florida, October 28-29, 2013. The show primarily targets buyers from the Caribbean, Central and South American markets. The Blueberry Store, Better Made Snack Foods, Cherry Central, Graceland participated in the Michigan Pavilion for a nominal cost. The Michigan Apple Committee, Michigan Bean Commission and Michigan Specialty Crops participated in the show.

Activity 4
Trade Mission to Brazil – March 4-8, 2013 – Sao Paulo & Rio, Brazil

MDARD staff coordinated a Trade Mission to São Paulo and Rio, Brazil. This trade mission was designed to take specialty crop commodity groups and companies to Brazil to explore the growing opportunities in the market for dry beans, and fruits and vegetables. Recruitment for the trade mission was succcessful with the Michigan Apple Committee along with three speciality crop companies attened the trade mission. The companies and commodity groups visited retail establishments to learn more about Brazilian consumer shopping habits along with having one-on-one meetings with potential buyers for their products.

GOALS AND OUTCOMES ACHIEVED

National Restaurant Association Show

The goal was to have a minimum of two Michigan specialty crops highlighted at this major food service show. Unfortunately, due to the frost damage in 2012 for the fruit industry, only one fruit commodity group was able to participate. MDARD shared a booth with Michigan Apple Committee and was dedicated to specialty crop promotion that passed out the specialty crop brochures and received and distributed leads for specialty crops. 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 2013 NRA Show was attended by more than 60,000 professionals from over 100 countries.

- The Michigan Apple Committee participated in this show and indicated in their evaluation that they received 5-10 leads while participating in the show, which meet the goal of having commodity groups receive a minimum of five leads.

- A total of six additional leads for specialty crops were collected by MDARD staff at the booth and distributed to the appropriate specialty crop commodity groups after the show.

Anuga

The goal of promoting Michigan specialty crops to global buyers was successful while also helping to offset the cost of participation. The show resulted in contacts with 38 new buyers which developed into 22 relationships.

- The company participating reported that their sales increased as a result of participating in the show. Both commodity groups indicated that sales of their

respective specialty crops would increase as a result of the show leading to 50% of participants realizing sales. Projected six to twelve month sales as a direct result of the show is $5,028,000.

- The specialty crop company exhibiting in the booth reported six new buyer relationships as a result of their participation in the show.

- Both commodity groups participating generated over five leads that they were able to share with their growers and processors.

Additional goals and outcomes are reported in the evaluation summaries included in the additional information at the end of the report.

Americas Food & Beverage Show
The goal was to have a minimum of two Michigan specialty crop commodity groups or companies participate in the Americas Food & Beverage Trade Show. This goal was met and exceeded by having a total of six specialty crop participants. The show was attended by 10,792 professionals, 24% of which were international attendees, representing 23 different countries. The additional goal was to promote Michigan specialty crops into the export market and increase the demand for products. Increasing the demand for specialty crop products was also achieved as the Michigan specialty crop groups that participated in Americas Food & Beverage Trade Show expect to receive a combined total of $1,050,000 in increased sales. The following expected outcomes were also achieved.

- The expected outcome of having 50% of the companies realizing sales from their participation was met with all six of the companies reporting increased purchases in the next 6-12 months for a total of 100%.

- All four of the specialty crop companies participating indicated receiving over five buyer contacts as a direct result of participating in the show.

- One of the commodity groups reported receiving over five buyer contacts as a direct result of participating in the show.

Additional goals and outcomes are reported in the evaluation summaries included in the additional information at the end of the report.

Trade Mission to Brazil
The goal of promoting Michigan specialty crops was achieved during the mission with Michigan blueberries, cherries and apples all being represented. The overall goal of having two or more commodity groups and/or Michigan companies with specialty crops was achieved, as well as the following expected outcomes being achieved.

- All three companies participating indicated they would realize sales as a result of their participation which is 100% of company participants and exceeds the goal of 50%.

- It is expected that at least two companies will enter the Brazilian market for the first time as a result of this activity. The third company was already in the market and expects to increase their sales.
- The three company participants all reported more than five new buyer contacts for a total of 26 total new contacts among the three companies.
- The commodity group participating reported making 11 new contacts.
- Approximately $400,000 in sales is projected after 37 new contacts with buyers were made.

Additional goals and outcomes are reported in the evaluation summaries included in the additional information at the end of the report.

BENEFICIARIES

National Restaurant Association Show - Participants included:

- MDARD - representing all Michigan specialty crops
- Michigan Apple Committee (Representing 900 Michigan apple growers)

Anuga

Participants included:

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

- Michigan Bean Commission (Representing 1,500 Michigan dry bean growers.)

Additional Michigan companies in the pavilion selling specialty crops included:

- Graceland Fruit (Grower owned cooperative)

American Food & Beverage Show

Participants included:

- Graceland Fruit (Grower owned cooperative)
- Cherry Central (Grower owned cooperative)
- Michigan Bean Commission (Representing 1,500 Michigan dry bean growers)
- Michigan Apple Committee (Representing 900 Michigan apple growers)
- Better Made Snack Foods
- The Blueberry Store

Trade Mission to Brazil

Participants included:

- Michigan Apple Committee (Representing 900 Michigan apple growers)
- North Bay Produce (Grower owned cooperative)
- Graceland Fruit (Grower owned cooperative)
- BelleHarvest

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.

MDARDs goal was to have two or more commodity groups and/or Michigan companies with specialty crops participate in each of the domestic and international trade shows to increase the sales of Michigan specialty crops. MDARD was unable to meet this goal for the National Restaurant Association Show. Key specialty crop commodity groups were unable to attend this event do to conflicting schedules and budget restraints. Commodity groups affected by the crop failure in 2012 are still dealing with limited funding and resources.

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Michigan Bean Commission

ADDITIONAL INFORMATION

National Restaurant Association (NRA) Show

Anuga

USA Pavilion at Americas Food & Beverage Show

Trade Mission to Brazil

EVALUATION/FOLLOW-UP FOR INTERNATIONAL ACTIVITIES

ANUGA Trade Show - Michigan Specialty Crop Booth Evaluation Report
Cologne, Germany Activity Date: October 5-9, 2013

Introduction

Three Michigan specialty crop companies/commodity groups participated in the Michigan Specialty Crop Booth at the ANUGA Trade Show in Cologne, Germany October 5-9, 2013.
No. of Participants: 3 No. of Returned Evaluations: 3

Specialty Crop Participants:
Cherry Marketing Institute Germany Representation/UK Representative
Michigan Bean Commission 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) $5,028,000 (total)

Did the ANUGA yield contacts with new buyers? Yes- 3 No- 0
If yes, how many? 38

Did the ANUGA Show result in any new buyer relationships?
Yes- 3 No- 0 N/A- 0

If yes, how many? 22

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

RATE THE ACTIVITY	MEAN
Pre-event planning & communication	4.3
Program execution	4.7
Fulfillment of your company needs	4.3
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 62	
Direct Costs of Planning, Participation, & Follow-up (including travel)	$37,241.61
Other Misc. Costs Associated with Participation in Activity	$4,500.00
Total	$41,741.61

Please rate the overall effectiveness of the show:

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

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

- *"ANUGA was a particularly good venue this year to meet existing customers and potential new ones and really get a lot of business accomplished."*

Americas Food & Beverage Trade Show - Michigan Specialty Crop Booth Evaluation
Miami, Florida Activity Date: October 28-29, 2013

Introduction

Six Michigan specialty crop companies participated in the Michigan Specialty Crop Booth at the Americas Food & Beverage Trade Show in Miami, Florida, September 28-29, 2013.
No. of Participants: 6 No. of Returned Evaluations: 6

Specialty Crop Participants:

Graceland Fruit Cherry Central
Michigan Bean Commission Michigan Apple Committee
Better Made Snack Foods The Blueberry Store

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

If, yes approximately how much? (Please provide an estimated value) $1,050,000 (total)

Did the Show of the Americas Food & Beverage Trade Show yield contacts with new buyers? Yes- 4 No- 2
If yes, how many? 77

Did the Show of the Americas Trade Show result in any new buyer relationships?
Yes- 4 No- 1 N/A- 1
If yes, how many? 26

Please rate the Americas Food & Beverage Trade Show on the following: (Excellent=5, Very Good=4, Average=3, Fair=2, Poor=1)

RATE THE ACTIVITY	MEAN
Pre-event planning & communication	4.3
Program execution	4.2
Fulfillment of your company needs	3.8
Cost/benefit returns to your company	3.3
Quality of contacts or information	3.5

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

Total Number of Staff Hours for Planning, Participation, & Follow-up	330
Direct Costs of Planning, Participation, & Follow-up (including travel)	$25,200
Other Misc. Costs Associated with Participation in Activity	$4,800
Total	$30,000

Please rate the overall effectiveness of the show:
Excellent- 0 Very Good- 2 Average- 3
Fair- 1 Poor- 0

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

- *"Would like to have more contact with restaurants lots of interest in exporting apples."*
- *"We were able to meet with several potential distributers from Latin America. This gives potential for increased sales."*
- *"We made better contacts with buyers than the two previous shows we attended here."*
- *"Thanks"*

Trade Mission Evaluation Report - Michigan Specialty Crop
Brazil - Activity Date: 4-7, 2013

Introduction

Four Michigan specialty crop companies participated in the Michigan Specialty Crop Trade Mission in Brazil, March 4-7, 2013.
No. of Participants: 4 No. of Returned Evaluations: 4

Specialty Crop Participants:
Graceland Fruit, Inc. Michigan Apple Committee
Belle Harvest Sales, Inc. North Bay Produce

Does your industry/company anticipate an increase in purchase over the next 6-12 months as a result of the Brazil trade mission? Yes- 3 No- 0 N/A- 1

If Yes, approximately how much? (Please provide an estimated value) $400,000 (total)

Did the Brazil trade mission yield contacts with new buyers? Yes- 4 No- 0
If yes, how many? 37

Do you anticipate making a first time export into Brazil as a result of participating in this trade show? Yes- 2 No- 1 N/A- 1

Please rate the Brazil Trade Mission on the following:
(Excellent=5, Very Good=4, Average=3, Fair=2, Poor=1)

RATE THE ACTIVITY	MEAN
Pre-event planning & communication	4.5
Program execution	4.5
Fulfillment of your company needs	4.3
Cost/benefit returns to your company	4.7
Quality of contacts or information	5

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

Total Number of Staff Hours for Planning, Participation & follow-up	200
Direct Costs of Planning Participation & Follow-up (including travel)	$11,388.79
Other Misc. Costs Associated with Participation in Activity	$1,000.00
Total	$12,388.79

Please rate the overall effectiveness of the show:

Excellent- 4	Very Good- 0	
Average- 0	Fair- 0	Poor- 0

Do you have any additional comments for these activities or recommendations for future activities?

- *"Allowing for more time per meeting and more time between each meeting would be helpful. This was a very beneficial trip, thank you!"*
- *"Thank you for a great mission."*

"Our agent in Brazil attended the trade mission in both cities. Our people there thought it was great and that they got contact with customers that they would not have ordinarily been able to get themselves. They only comment that they made as a recommendation for improvement was that it would have been helpful if they could have gotten the meeting schedule earlier than the day before. The fully realize that the Brazilians attending the meeting were probably changing their commitments right up until the last minute and that the delay in the schedule could have been out of the control of the organizers."

PROJECT TITLE Michigan Pavilions at Michigan Trade Shows FINAL

PROJECT SUMMARY

The Michigan Department of Agriculture & Rural Development (MDARD) sponsored and organized Michigan pavilions for specialty crop producers at the Michigan Grocers Association Show (MGA) in Thompsonville, Michigan, on September 16, 2013; and the Michigan Restaurant Association Show (MRA) in Novi, Michigan, October 15 and 16, 2013.

MDARD staff recruited Michigan specialty crop companies for these trade shows to give them a competitive advantage and opportunity for new growth in each of the shows' markets. MDARD passed along the lowest exhibitor group rate to specialty crop businesses. Staff recruited companies, organized the pavilions, coordinated the companies' participation, assisted in providing media coverage for the exhibitors, and conducted an exhibitor evaluation of the events.

The pavilions assisted specialty crop businesses and commodity groups promote their products to the Michigan retail and food service industries. The pavilions showcased Michigan specialty crops and focused on increasing sales of the products. It was important for the specialty crop businesses and commodity groups to exhibit at these shows on a regular basis to ensure existing and potential customers of the continued high quality and availability of specialty crop products from Michigan. Exhibiting at these shows also opened up new opportunities for Michigan specialty crops, which is extremely beneficial.

PROJECT APPROACH

MDARD sponsored Michigan pavilions at the MGA and MRA trade shows; focusing on reaching the large and small chain retail stores and specialty food stores and the restaurant and food service sectors.

MDARD negotiated a discounted exhibitor rate with the organizing association of each trade show. A discounted rate was then passed on to specialty crop businesses and commodity groups. Recruiting for the trade shows was done through e-mails from MDARD to an extensive Michigan specialty crop company database, in addition to follow-up phone calls to Michigan specialty crop companies.

Special emphasis was placed on recruiting new and established specialty crop business that had not previously participated in the Michigan pavilions at these trade shows. New businesses were recruited in efforts to broaden the presentation, and increase the promotion, of new Michigan specialty crop businesses and products into these sectors.

A state-wide press release and social media post announcing the opportunity to exhibit in the Michigan pavilions at the MGA and MRA shows and receive a discount rate for being a crop business was also sent out by MDARD in efforts to attract specialty crop businesses. Staff aimed for the Michigan pavilions at the MGA and MRA shows to be filled with at least ten participating specialty crop companies.

MDARD organized the pavilions and coordinated the companies' participation by communicating with each of the associations and overseeing all details of each Michigan pavilion. Invoices and forms were compiled for each exhibitor. Event details were given to all exhibitors.

Specialty Crop Block Grant funds paid to off-set the cost of booth space for specialty crop companies and commodity groups, as well as signage, electricity, and exhibiting furniture for the specialty crop exhibitors of the Michigan pavilion. Funds also paid for the contractual staff to recruit specialty crop vendors, coordinate booth space, and conduct evaluations.

Evaluations were handed out to all exhibitors on the day of the show. Evaluation answers provided by specialty crop participants were compiled into a word document through open-ended questions and charts. Survey analyses for each show can be found in the Additional Information section at the end of this report.

GOALS AND OUTCOMES ACHIEVED

Michigan Grocers Association Show

The goal for the Michigan Marketplace at the Michigan Grocers Association Show and Michigan Restaurant Show was to have ten specialty crop companies exhibit, with 50% of them realizing sales or making significant contacts at the show. MDARD greatly exceeded these goals, with 17 specialty crop businesses exhibiting in the Michigan Marketplace and 94% of them realizing sales or making significant contacts. Eleven of the 17 participants were first time exhibitors to the MGA Michigan Marketplace.

At the MGA show, Michigan specialty crop businesses made a total of 92 contacts, with 65% of the contacts rated as "very good" and 6% of the contacts rated as "Excellent." One specialty crop business connected with a new potential distributor and at least three MGA Michigan Pavilion specialty crop participants reported meeting with several new stores interested in carrying their products.

According to the surveys completed by the specialty crop businesses that participated in the MGA Michigan Pavilion, 88% reported that participation increased their brand awareness within the Michigan grocers industry. Additionally 94% of specialty crop participants reported making contacts and/or leads at the MGA show that would have been challenging to make otherwise.

Michigan Restaurant Association Show

The goal for the Michigan Restaurant Association Show and the Michigan Grocers Association Show was to have a minimum of 10 specialty crop companies and/or commodity groups with 50% of them realizing sales. MDARD met these goals with seven total specialty crop businesses and/or commodity groups exhibiting in the Michigan Pavilion and 100%, all seven, realizing sales or making significant contacts. Four of the seven participants were first time exhibitors to the MRA Michigan Pavilion.

The Michigan specialty crop businesses that exhibited in the MRA Michigan Pavilion made a total of 265 contacts, with 57% of the contacts rated as “very good” or above. Eighty-six percent of specialty crop businesses that exhibited with the Michigan Pavilion at the MRA show believe that their brand awareness was increased within the restaurant industry.

In addition to specialty crop exhibitors, the MRA Michigan Pavilion also hosted the Michigan Food and Wine Pairing. MDARD partnered with the Michigan Grape and Wine Industry Council to organize and provide this food and wine paring, focusing on Michigan specialty crop products. A Michigan winery was on hand each day of the show to give attendees tips and information on pairing Michigan wines with Michigan specialty crop dishes and ingredients. This unique event proved successful as it educated attendees on various ways to cook with Michigan specialty crops, and significantly increasing pavilion traffic.

Forty-four food and wine pairing participants were surveyed about their use of Michigan specialty crops. Of those surveyed, 41% reported using Michigan specialty crops “year round,” and 27% reported using Michigan specialty crops “whenever available.” Sixty- one percent of food and wine paring participants reported interest in receiving additional information on purchasing Michigan fruits, vegetables, dry beans, herbs, etc.

In addition to educating participants about the many ingredient uses of Michigan specialty crops, the food and wine pairing attracted many attendees to the pavilion area. This benefited Michigan specialty crop exhibitors by providing a chance to speak one-on-one with show attendees, enabling them to share information about their businesses while promoting their products. In addition, the event also increased restaurant owners’ awareness of Michigan specialty crop food dishes and wines.

The specialty crop businesses that participated in the MRA Michigan Pavilion benefited as they experienced a combined total of $540.00 in domestic sales, with an additional $5,500.00 expected sales over the next 12 months, as a result of exhibiting at the show. Overall, participating specialty crop businesses found exhibiting in the Michigan pavilions at the MGA and MRA shows to be beneficial. The most important objective desired by all participating specialty crop companies was to gain company exposure, and a majority of exhibitors from both shows reporting beneficial company exposure.

BENEFICIARIES

The specialty crop companies that participated in the MDARD hosted Michigan pavilions at the 2013 Michigan trade shows benefited greatly from the shows as they received a total of 357 solid leads at both shows combined.

Michigan Grocers Association Show

Participating specialty crop exhibitors included:

- Bur Oaks Farm
- Food For Thought
- Great Lakes Pierogies
- Heeren Bros. Produce
- Higher Grounds Trading Co.
- King Orchards
- Michigan Apple Committee
- MI Farm Market
- Morano Gourmet Sauces
- Mrs. Glee’s Gluten Free Foods
- MyBecs LLC
- Northern Seasons, LLC
- Old Mission Traders
- Shoreline Fruit
- Slabtown Coffee Caramel Corn
- Volcano Sauce Company
- Wee Bee Jammin’

Michigan Restaurant Association Show
Participating specialty crop exhibitors included:

- Aunt Nee's Fresh Foods
- Veritas Vineyard LLC
- Honee Bear Canning
- Michigan Potato Industry Commission
- My Family's Backyard Barbecue
- Riggio Distribution Company
- Sandhill Crane Winery

LESSONS LEARNED

Michigan Grocers Association Show – September 16, 2013
The Michigan Marketplace at the MGA show helped MDARD to meet its goal of increasing the offerings of Michigan specialty crops products available at retail while promoting awareness to the supermarkets about Michigan specialty crops' availability. These goals were met as a result of specialty crop exhibitors being present at the show and making contacts and leads with industry attendees.

The MGA show continues to be important for specialty crop businesses and commodity groups to exhibit at on a regular basis, ensuring existing and potential customers of the continued high quality and availability of the specialty crop products from Michigan.

In addition, the MGA show allowed participating Michigan specialty crop companies to develop an understanding of what type of specialty crop products consumers are currently interested in, as the desire and need for Michigan grown and processed food continues to increase. The MGA show also supported a current "buy local" trend developing amongst local grocers, proving that retailers really do want to buy locally to both support Michigan businesses and strengthen Michigan's economy.

MGA was a great opportunity for Michigan specialty crop businesses to meet with distributors, grocers and supermarkets to get their foot in the door of more retail outlets.

Michigan Restaurant Association Show – October 15 - 16, 2013
The Michigan Pavilion at the MRA show helped MDARD to meet its goal of increasing the offerings of Michigan products available at food service establishments in Michigan and promoting awareness about the Michigan specialty crop industry.

The MRA show was beneficial for participating specialty crop businesses as it provided an opportunity to connect with owners and managers of restaurants and hotels, with chefs, culinary students, and more.

This year there seemed to be a continued "buy local" trend amongst attendees. The attendees were more knowledgeable of the types of specialty crops available in Michigan, compared to last year, with a larger number of attendees reporting that they buy Michigan specialty crop products year round. This developing trend confirms that local chefs and restaurant managers do want to buy locally grown specialty crops to both support Michigan businesses and strengthen Michigan's economy.

The MRA show continues to be an important show for specialty crop businesses and commodity groups to exhibit at on a regular basis, ensuring existing and potential customers of the continued high quality and availability of the specialty crop products from Michigan.

MRA was a great opportunity for Michigan specialty crop businesses to meet with restaurants and hotels and get their products into the industry.

CONTACT INFORMATION

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ADDITIONAL INFORMATION

Michigan Grocers Association Show

Michigan Restaurant Association Show

Michigan Grocers Association Show

Seventeen Michigan specialty crop companies participated in the Michigan Marketplace at the MGA show in Thompsonville, Michigan on September 16, 2013. Each of the participants of the Michigan Marketplace received a survey at the beginning of the show and was asked to return at the end of the show.
Number of specialty crop participants: 17
Number of specialty crop returned evaluations: 17
Note: The below information is tallied from the specialty crop companies only. Some answers were not completed by every exhibitor.
All of the following figures are averages among the participants *(rounded to the nearest tenth)*
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:
(Poor=1, Fair=2, Average=3, Very Good=4, Excellent=5) (Averages listed below)

Buyer contacts, inquires
Importance: 4.4
Effectiveness: 3.4
Direct sales
Importance: 4.0
Effectiveness: 2.9
Agent/distributor search
Importance: 3.2
Effectiveness: 2.9
Test marketing/research
Importance: 2.5
Effectiveness: 3
Product/company exposure
Importance: 4.4
Effectiveness: 3.9

Is this your first time participating in the MGA show as a result of the Michigan Pavilion?
Yes: 11 *No:* 6

Did you receive any contacts/leads for markets/industries that are new to your product? If so please explain. *Yes:* 14 *No:* 3

- Grocery chains
- A few new stores are showing interest
- Several grocery stores in upper peninsula and lower Michigan
- Received contacts for markets outside of our current distribution
- New customers
- Connected with a distributer
- Grocery chains
- Received information on Lipari
- A couple of stores in areas of the state where we are not well represented

Did you make contacts/leads here that would have been challenging to make otherwise?
Yes: 16 *No:* 1

How many contacts/leads resulted from your participation? 92 (combined total)

How would you rate the quality of contacts/leads?
Excellent: 3 *Very Good:* 11
Average: 3 *Fair:* 0 *Poor:* 0

Did participation in this show increase your brand awareness within this industry? Please explain. *Yes:* 15 *Maybe:* 2

- A few more people heard the story
- Great Exposure
- Exposure to new customers
- Very little
- Putting oneself in front of buyers year after year simply increased familiarity and comfort with our products.
- It is always important to keep our name in front of any retailor.
- Always good to have customers see your products
- We spoke with a handful of people who were not familiar with our brand.
- Thank you!
- Need more retail outlets
- Hard to tell
- Virtually unknown until now!

Please rate the overall effectiveness of the show.
Excellent: 1 *Very Good:* 11
Average: 3 *Fair:* 2
Poor: 0 *N/A:* 0

If applicable, have any on-site sales resulted from your participation in this activity?
Yes: 3 *No:* 14
N/A:1 If yes, please list sales in US$: $1,110.00 (total)
Does your company expect an increase in sales as a result of this activity?
Yes: 12 *No:* 4 *N/A:* 1
If yes, please list sales in US$:

Would you have participated in this activity without the assistance of the MDARD?
Yes: 2 *No:* 7 *Unsure:* 8

Please rate the performance of the MDARD staff for this activity, as applicable, for the following areas: (averages listed below)
Pre-event planning & assistance: 4.8 *Communication regarding event:* 4.8
Assistance at event itself: 4.8

Please estimate company financial and "overhead" expenses for this activity:

Total of staff hours for planning and follow-up: **Combined total of 231 hours**

- Direct costs of planning participation and follow-up *(including travel)*:
  Combined total of $6,675.00
- Other misc. costs associated with participation in activity:
  Combined total of $740.00 for misc. costs

Would your company be interested in participating in the 2013 Michigan Grocers Show?
Yes: 15 *No:* 0 *Maybe:* 2

Any Comments or Suggestions:

- I wish the show was just a little longer. That would attract more interest and more activity.
- Could not thank you more for getting us in! Keep the hours the same. They are great!

Michigan Restaurant Association Show

Eight Michigan specialty crop companies participated in the Michigan Pavilion at the MRA show in Novi, Michigan October 15-16, 2013. Each of the participants of the Michigan Pavilion received a survey at the beginning of the show and was asked to return at the end of the show.

Number of specialty crop participants: 7 Number of specialty crop returned evaluations: 7
Note: The below information is tallied from the specialty crop companies only. Some answers were not completed by every exhibitor. All of the following figures are averages among the participants *(rounded to the nearest tenth)*

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:
(Poor=1, Fair=2, Average=3, Very Good=4, Excellent=5) (Averages listed below)

Buyer contacts, inquires
Importance: 4.3
Effectiveness: 3.7
Direct sales
Importance: 3
Effectiveness: 2.8
Agent/distributor search
Importance: 3
Effectiveness: 2.6
Test marketing/research
Importance: 2
Effectiveness: 2.5
Product/company exposure
Importance: 4.4
Effectiveness: 4.4

Is this your first time participating in the MRA show as a result of the Michigan Pavilion?
Yes: 4 *No:* 3

How many contacts/leads resulted from your participation? 265

Did you make contacts/leads here that would have been challenging to make otherwise or on your own? *Yes:* 6 *No:* 1

How would you rate the quality of contacts/leads?
Excellent: 1 *Very Good:* 3
Average: 2 *Fair:* 1
Poor: 0 *N/A:* 0

Please rate the overall effectiveness of the show?
Excellent: 1 *Very Good:* 3
Average: 3 *Fair:* 0
Poor: 0 *N/A:* 0

Did participating in the show increase your brand awareness within the industry?
Yes: 6 *No:* 1

If applicable, have any sales resulted from your participation in this activity?
Yes: 4 *No:* 2
N/A:1 If yes, please list sales in US$: $ 540.00 (total)

Does your company expect an increase in sales as a result of this activity in the next 6-12 months?
Yes: 5 *No:* 2
*N/A:*0 If yes, please list sales in US$: 5,500.00 (total)

Would you have participated in this activity without the assistance of the MDARD?
Yes: 0 *No:* 5 *Unsure:* 2

Please rate the performance of the MDARD staff for this activity, as applicable, for the following areas: (averages listed below)
Pre-event planning & assistance: 4.6
Communication regarding event: 4.6
Assistance at event itself: 4.9

Please estimate company financial and "overhead" expenses for this activity:
Total of staff hours for planning and follow-up:
Combined total of 185 hours

- Direct costs of planning participation and follow-up *(including travel)*:
  Combined total of $ 2,305.00
- Other misc. costs associated with participation in activity:
  Combined total of $500.00 for misc. costs

Would your company be interested in participating in the 2013 Michigan Restaurant Show? *Yes:* 6 *Maybe:* 1

Any Comments or Suggestions:

- Thanks for all the food Chef Paul and friends. This is our first MDARD Food expo and we look forward to our next.

PROJECT TITLE Cherry Marketing Institute (CMI) Disaster Relief Outreach for Michigan Cherry Growers FINAL

PROJECT SUMMARY

Michigan is the largest producer of tart cherries and has the capacity to produce 275 million pounds annually and 58 million pounds of sweet cherries. The 2012 tart cherry harvest was 11.5 million pounds and the sweet cherry harvest was 8 million pounds. Pest and disease pressure has been extremely high as a result of the substantially reduced crop. Growers dealt with a very long and tough season, and unfortunately there was no tart cherry crop insurance available and sweet cherry crop insurance was only available in two counties where there is a pilot program.

Cherry growers had all the expenses of trimming, mowing, applying fertilizer, and chemically treating for pests and disease with little to no income last year. In fact, growers had to spray their orchards more last year since the growing season started five weeks early. Grower expenses remain the same, whether they harvest a crop or it is destroyed. Cherry growers had no risk management tools available and many of them need disaster assistance to overcome the 2012 devastation.

CMI has diligently worked on disaster relief, crop insurance coverage, low interest loans and pesticide issues. Meetings were held at two events in Michigan to update/educate growers on the options and tools that are available to deal with their devastating losses.

PROJECT APPROACH

Meetings and listening sessions were held at the Great Lakes Expo in Grand Rapids, with attendance of 3,932, and the Farm and Orchard Show in Traverse City with attendance over 400. The State of Michigan passed low interest loan legislation for cherry growers and they were provided information on how to apply for these loans as well as other disaster relief information. USDA's Risk Management Agency (RMA) has contracted with Agralytica of Alexandria, Virginia to develop an insurance program for tart cherries. The sweet cherry pilot program was expanded last summer to cover most of the sweet cherry production regions in the state and growers were informed of all the details of crop insurance that is available. Our plan is to have a tart cherry policy in place for the 2014 season. This is to verify that no grant funds were used for lobbying activities.

Reports were provided to educate the industry on the latest studies to help improve harvest, pest and disease issues as well as new technology that might be used in the future.

Weather risk management was provided to help understand and hopefully overcome natural disasters on the farm in the future.
Project partners included Grand Traverse Fruit Growers' Council, Michigan State University Researchers and Extension Staff.

GOALS AND OUTCOMES ACHIEVED

The Michigan Cherry Committee (MCC) met on Monday, December 3rd for Michigan State University researchers to present progress reports on the cherry research that was funded in 2012 as well as crop assistance, weather management techniques and pesticide application. The reports included all research funding for cherries (SCRI, Project GREEEN, state and industry). There was a joint luncheon with the Michigan Apple Committee, the Michigan Apple Research Committee and MACMA Apple Committee board members. The luncheon speaker was Dr. Matt Grieshop from Michigan State University. After the research sessions were complete Jim Nugent, Chairman of the MCC, provided an update on the crop insurance meetings and listening sessions that were held in Michigan and Utah. The meetings were held to get input from U.S. tart cherry farmers and develop a recommendation to RMA and the Federal Crop Insurance Board. Phil Korson educated the MCC members on the various disaster programs that are available so they were able to answer any inquiries they may receive while working the booth during the Expo. These funds were not used to influence RMA or the Federal Crop Insurance Board.

The Michigan Association of Cherry Producers met between the educations sessions on Wednesday,

- December 5th and had a working lunch to update members of the cherry industry on the various programs that are available to them as well as the cherry growers they represent. CMI employees, Julie Gordon and Phil Korson, along with members of the Michigan Cherry Committee (cherry farmers), staffed a booth during the Expo providing information on disaster relief programs and resources that are available. The total attendance for this event was 3,932. Over 500 handouts on "Resources for Michigan Fruit Growers" were distributed. Over 1,000 cherry juice samples and recipe brochures were provided to visitors of the booth. We surveyed participants of the event, and 71% said that they will consider purchasing crop insurance. The final result will be the actual number of tart cherry growers who actually buy crop insurance. The sign up was in November 2013 for the 2014 crop season. This grant was to prepare and educate the industry and to provide them with new risk management options. **Up** until the fall of 2013 there was "no" crop insurance available to tart cherry farmers and only sweet cherry growers in Leelanau and Grand Traverse County. This meeting brought together speakers from Michigan State University to explain crop insurance. The results will be the actual number of growers who sign up for the various programs. These numbers have not yet been released.

Educational sessions at the Expo included:

<u>Tuesday, December 4th ~ Weather Risk Management in Tree Fruit</u>

- *Reflections on a Growing Season: Weather Extremes, Climate Trends, and Some Implications for Tree Fruit Production in the Great Lakes Region* - Jeff Andresen, Geography Dept., MSU
- *How to Best Use Frost Protection Methods in Tree Fruit* - Robert Evans, USDA Northern Plains Ag Research Lab, Sidney, MT
- *Frost Protection Methods in Michigan – Costs and Considerations* - Amy Irish-Brown, Tree Fruit IPM Educator, MSU Extension
- *MSU Enviro-Weather: Decision-making Tools for Weather Risks* - Beth Bishop, Enviro-weather Coordinator, Entomology Dept., MSU

- *Calibration of Personal Weather Data Loggers and What to Do with the Data Once You Have It* - Julianna Wilson, Tree Fruit IPM Outreach Specialist, Entomology Dept., MSU

Wednesday, December 5th ~ Tart Cherry

- *Cherry Leaf Spot and the Challenges of Managing this Disease in 2012* - George Sundin, Plant, Soil and Microbial Science Department, MSU
- *Grower Decision Support Tool for Conversation to a High-Efficiency Tart Cherry Orchard System* - Jacob McManus, Lookout Ridge Consulting in Kalamazoo.
- *Understanding Risks and Benefits of Copper Products for Tree Fruits* - David Rosenberger, Hudson Valley Laboratory at Cornell University.
- *Life without Azinphos Methyl (AZM)* - Larry Gut, Entomology Department at MSU

Wednesday, December 5th ~ Sweet Cherry

- *Understanding Bacterial Canker in Sweet Cherry Orchards* - Tiffany Lillrose, Horticulture Dept., MSU
- *Exploring New Rootstock Possibilities for Sweet Cherry*- Amy Iezzoni, Horticulture Dept., MSU
- *Pruning Techniques and Bactericides for Managing Bacterial Canker of Sweet Cherry* - Juliet Carroll, New York State IPM Program, Cornell University.
- *Using Mycoshield to Control the Blossom Blast Phase of Bacterial Canker* - George Sundin, Plant, Soil and Microbial Sciences Dept., MSU

A survey was distributed among the attendees and the results were:

- 81% of the expo attendees surveyed visited our booth at the Expo
  - 100% that did visit our booth found our booth to be informative
- 48% of the expo attendees surveyed attended the listening sessions
  - 100% of the attendees found the information provided informative
- 71% of the surveyed will consider purchasing crop insurance
  - 10% will not consider purchasing crop insurance
  - 19% are undecided or did not answer that question

- The Cherry Marketing Board of Directors met on January 21, 2013 at the Grand Traverse Resort in preparation for an industry luncheon and educational programs during the Grand Traverse Farm and Orchard Show. There were 281 registered attendees (not including exhibitors or speakers) and 221 attended the luncheon on January 22nd. Growers were very interested in disaster relief programs that provided low interest loans to get through the 2012 season and the 2013 harvest. Information on both federal and state programs was provided. We estimated 90% of the growers utilized the information provided. – We estimated 90 percent based on our interaction with board members, industry leaders and grower meetings. We believe the commitment to purchase crop insurance was extremely high. USDA has not released the actual numbers yet, that is why we estimated this number and we still believe it is an accurate estimate based on the information we have.

The morning learning sessions included:

- *Frost Protection Methods in Michigan* - Amy Irish-Brown, MSU Extension
- *Climate Change and Tart Cherries* - Dr. Julie Winkler, MSU
- *What to Consider when Evaluating the Purchase of Crop Ins.* - Dr. Roy Black, MSU
- *Climate Variability: How it is Affecting Decisions on the Farm* - Panel of Growers from NW Michigan including:
  - Jim Bardenhagen, Bardenhagen Farms
  - Ken Engle, EngleRidge Orchards

- Don Gregory, Cherry Bay Orchards
- Patrick McGuire, Royal Farms
- Travis Bratschi, Bratschi Orchards
- Bruce Veliquette, Cherry Ke Orchards

➢ *CMI Report to the Industry* - Phil Korson, Cherry Marketing Institute

The luncheon speaker Michael Wehman, Vice Present, Weber Shandwick provided an overview of the 2012 marketing program and explained the adjustments that were made to the marketing program after the 2012 crop loss. Michael also provided the strategy plan that is in place for this year for the industries "Comeback Campaign".

Red tart and sweet cherry crop statistics and market analysis is underway and the statistical book will be available to the industry in March 2013. This information will serve as a marketing tool and will track cherry production, movement, prices and acreage. It will also be updated with the new tree survey data to give growers new information to make marketing decisions in the future.

A survey was distributed among the attendees and the results were:

- 86% of the Farm & Orchard Show attendees attended the luncheon program
  - 100% that participated in the luncheon found it to be informative
- 67% of the Farm & Orchard Show attendees attended the listening sessions
  - 93% of the attendees found the information provided informative
- Of those that attended the luncheon and participated in the survey, 79% said they will consider changing their on farm practice, 16% were unsure and 6% indicated that they would did not think they would change their farm practice at that time.

BENEFICIARIES

Although we don't have an exact number of cherry growers and processors that attended the CMI events, we do know from the surveys and feedback that we received that everyone that did participate found them to be informative and benefited from the information that CMI provided to them. There were growers and processors from Michigan, Utah and Wisconsin that benefited from our programs.

The State of Michigan passed low interest loan legislation and in September passed the appropriation bill to allocate the resources needed to make these loans possible. The bill made available $300 million to growers and processors. Fruit growers affected by the frost events this year will be able to access these funds through their bankers. There is a two year period where no payments will need to be made, which should really help growers and processors that had little or no cash flow this growing season. There were over 3,900 in attendance for the December meeting/show/exhibits. It would have been very difficult to accurately count the number of cherry growers and processors that attended these events since they were all held over a three day period and the booth was staffed by the Michigan Cherry Committee members that each volunteered their time for a half day shift. We estimate we reached 350 tart cherry growers and 250 sweet cherry growers as a result of this effort.

USDA's Risk Management Agency (RMA) has contracted with Agralytica of Alexandria, Virginia to develop a new insurance program for tart cherries. The sweet cherry pilot program was expanded last summer to cover most of the production regions in the state and will be a great help in the future.

Production research conducted at Michigan State University will provide cherry growers with crop protection in an unprecedented year. Weather related sessions will help prepare growers for unforeseen weather issues and crop protection strategies should help offset increased production expenses. All of these tools will help growers manage risk where possible. These funds were strictly used to provide information to growers. They were not used to lobby.

LESSONS LEARNED

With little to no income last year cherry growers remain optimistic for a good crop in 2013. Crop insurance is a necessity for cherry growers today. With unforeseen weather in the great lakes states a natural disaster can, and will, devastate an entire crop and possibly force farmers out of business. We need to stay ahead of these issues and prepare our growers when natural disasters hit.

The information collected on the survey will be very valuable as we move forward to press for federal tart cherry crop insurance. We did not know how many cherry growers would be interested in crop insurance and the survey revealed that the majority of the industry not only is interested in coverage; many absolutely have to have some sort of safety net to maintain their orchards if another disaster should happen. The survey also concluded that the information that CMI provided during the two events was informative to all that participated.

There were no unexpected outcomes or results that effected implementing this project.

CONTACT PERSON

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ADDITIONAL INFORMATION

EXPO Education Session Summaries can be found @ www.glexpo.com/index.php?c=summaries

SUB-GRANTEE REPORTS

PROJECT TITLE Michigan Farm Bureau – Fruit Inventory Survey FINAL

PROJECT SUMMARY

The purpose of this project was to conduct a fruit inventory survey. As provided for in the project, the survey was conducted and data was published by the NASS Michigan Field Office. The basic need for this project is for the collection and distribution of reliable and timely data from the Fruit Tree Survey so that the industry – growers, input suppliers, handlers, industry organizations and policy makers – can best make informed business decisions. Fruit is produced on a perennial tree, vine or bush. The cost of planting perennial fruit crops is rather costly to growers and considerable time and expense is required before production and revenue is achieved. For this reason, growers need to plant the right crop, the right variety and the right rootstock utilizing the right production system. Growers will use data from the Fruit Inventory Survey so that they can make informed planting and/or removal decisions. Input suppliers will use data from the Fruit Tree Survey to help determine what supplies and products growers will require. Fruit handlers will use the data from the Fruit Tree Survey to plan marketing strategies based on what and how growers have planted. Industry organizations and policymakers will use the data from the Fruit Tree Survey to help plot industry-wide activities and to respond to policy issues.

Making informed decisions, based on real world data, collected by a trustworthy impartial third party (NASS Michigan Field Office), is a critical factor to maintaining and improving the competitiveness of Michigan's dynamic fruit industry. The Michigan fruit industry is both large and diverse. As a large national producer of fruit, it is critical that the Michigan industry stay ahead of the curve compared to other respective production areas. Due to our considerable diversity of production and marketing outlets, it was important that this survey be broadly based and comprehensive in nature.

The last compilation of comprehensive inventory data was completed in 2006. While still important from a historical standpoint, data from the 2006 survey is now too old for practical and reliable use in 2012. Some inventory data is also available from USDA's 2007 Census of Agriculture. Data from the Census provides a useful tool, but provides no information about plantings and removals by year, varieties, rootstocks, production systems or other critical needs as were obtained in the 2011 Fruit Inventory Survey.

The 2012-13 Fruit Inventory Survey builds on a SCBGP or SCBGP-FB conducted in 2011-12. The 2013-13 project completes the 2011-12 project as a two year combined effort to plan, conduct, distribute, promote and utilize the survey.

PROJECT APPROACH

This is the second year of a two-year project with two separate granting periods (FY 2011-12 & FY 2012-13). The 2012-13 report, as filed, does include a limited review of information regarding the project conducted in the 2011-12 fiscal year. Those areas dealing with activities in 2011-2012 are highlighted below. The remainder of the report focuses entirely on the 2012-13 project. The portions of the 2012-13 report which refer to the 2011-12 project were only added to help explain that this was a two-year project, and that some activities conducted in 2011-12 were important factors which contributed to the successful outcomes and results achieved in the 2012-13 project. The following is a brief summary of the activities and tasks performed in year one (FY 2011-12):

- The project partners cooperated with the USDA-NASS Michigan Field Office to plan the overall survey strategies, enhanced and updated the mailing lists, developed the survey questionnaire and conducted pre-survey promotion. The actual survey was sent to growers in early October 2011.
- The final 16 page questionnaire is linked in the "Additional Information"; click the "sample questionnaire" section.
- Following collection of the data from growers, USDA-NASS Michigan Field Office began the process to edit, key, analyze, summarize and prepare data for release. Reports were released by NASS for sweet cherries, tart cherries, blueberries, grapes, apples, pears, plums, nectarines, peaches and neglected orchards.

In year two of the project (FY 2012-13), NASS completed and released the remainder of the reports, which included brambles, strawberries and all fruit.

A copy of the final report may be found at this link.
http://www.nass.usda.gov/Statistics_by_State/Michigan/Publications/Michigan_Rotational_Surveys/mi_fruit12/fruitrot.pdf

Following the release of the data by the USDA-NASS Michigan Field Office, activities focused around promotion of the availability of the data and the actual use of the data. While the USDA-NASS Michigan Field Office did assist in efforts to promote the release and use of the data, most of the actual work in this area was by the project partners. These efforts are explained in more detail in the Goals and Outcomes Achieved section.

GOALS AND OUTCOMES ACHIEVED

As this entire project was conducted over a two year period, and two separate granting periods (FY 2011-12 & FY 2012-13), the following is a brief summary of the activities and tasks performed in year one (FY 2011-12):

- A planning meeting with partners and NASS officials discussed the project goals, activities and timelines.
- Individual partner groups then worked directly with NASS regarding commodity specific activities, including survey questions and mail lists.
- Commodity groups communicated to growers through direct communications and/or through industry wide media channels regarding the upcoming survey and the importance of growers providing their timely and accurate response to the survey.
- Pre survey supporting articles were placed in both the Michigan Farm News and the Fruit Growers News.
- Joint press releases were prepared and distributed by Michigan Farm Bureau and the Michigan Department of Agriculture and Rural Development.
- NASS conducted the survey in the late fall and winter when growers generally have time to respond to surveys like the Fruit Inventory.
- The TV give-a-way at the 2011 Fruit and Vegetable Expo helped build grower motivation and provided a way to highlight the survey at the largest grower event of the year for fruit growers.
- Following completion of the data from growers NASS has proceeded with compilation of the survey data and reporting the results.
- Full publication of the survey results by NASS will be completed on schedule, which continued into the second year of the project (FY 2012-13).
- NASS was unable to provide the necessary historical data to track the number of website "hits" from the previous 2006 Fruit Inventory Survey. This will prevent the partners from comparing the number of "hits" between those received on the 2011 Survey and those received on the 2006 Survey. While it is unfortunate to lose this planned for tracking opportunity, the lack of this information will in no way diminish the importance of the survey nor reduce the use of the survey data by the fruit industry.
- Following release of the survey data by NASS, the focus of the project partners turned to promotion and dissemination of the information. The partners tracked these efforts, which had never been attempted before on this magnitude.

In year-two of the project (FY 2012-13), NASS completed and released the remainder of the reports, which included data for brambles, strawberries and all fruit.

The successful planning, conducting and final release of the survey data was just the beginning of this project. To be truly successful the data provided by the survey must be utilized by growers, handlers, input suppliers, commodity groups, researchers, policymakers and others in the fruit industry to make informed and educated decisions. While much of the outcomes from the use of this data will be on a very long term basis, the project recorded and summarized how the data is actually utilized.

During the 2012-13 fiscal year project partners promoted the availability of the survey data and assisted in the disseminated of the data. Here is just a sample of data utilization efforts reported by partner groups:

- The apple, cherry and blueberry industries utilized the data to respond to the EPA regarding the use of the insecticide AZM.
- The apple industry used the data to work with the USDA Risk Management Agency on improvements to apple crop insurance programs.
- The cherry industry the data to work with the USDA Risk Management Agency on improvements to the sweet cherry crop insurance program, and to help develop support for a new tart cherry policy.

- Several organizations, including Michigan Farm Bureau, Michigan Apple Committee, MACMA Apple Growers, Cherry Marketing Institute and MBG Marketing, indicated that they will utilize data from the survey in their comments to the U.S. Food and Drug Administration regarding the proposed rule on Produce Safety Standards.
- According to the NASS Michigan Field Office a total of 1440 hits were recorded since the time that the data from the 2011 Survey began appearing on the NASS Michigan Field Office website, the number of hits have averaged 85 per month. The largest number of monthly hits was recorded in November 2012 with 161 hits, and the smallest number of 40 hits was reported in October 2013. The pattern of hits appears to show that use declines slightly during the busy fall harvest season and then expands in the winter-early spring when grower and the industry are making various planting decisions.
- As reported by partner groups and recorded by the project coordinator, we estimate the following number of growers and other fruit industry personnel who have used or been exposed to data from the 2011 Fruit Inventory Survey:
  - Website hits: 1440 as of October 31, 2012 (averaging 85 per month),
  - Michigan Farm News: 2020 fruit growers,
  - Fruit Growers News: 2386 fruit growers,
  - Michigan Farm Bureau Board of Directors: 17 growers, 3 fruit growers,
  - Michigan Agricultural Cooperative Marketing Association Board of Directors: 11 growers, 7 fruit growers,
  - Michigan Farm Bureau Policy Development Committee: 17 growers, 4 fruit growers,
  - Michigan Cherry Committee: 9 fruit growers, plus distribution to all 600 cherry growers,
  - CherrCo: Board of Directors, plus all 23 members,
  - Cherry Industry Advisory Board: 36 growers, of which 18 are Michigan growers,
  - Michigan Apple Committee: 7 growers,
  - Michigan Processing Apple Growers: 32 growers, plus distribution to all 540 grower members,
  - Michigan State Horticultural Society: 13 grower board, plus the 4000 attendees at both the Societies 2012 & 2013 Great Lakes Expos, of which 1250 for both 2012 & 2013 are estimated to be fruit growers in Michigan,
  - Michigan Grape and Wine Council: 11 growers, plus distribution to all 455 grape growers,
  - MGB Marketing: 11 growers,
  - Michigan Blueberry Advisory Committee: 10 growers,
  - Michigan Peach Sponsors: 7 growers,
  - Michigan Food Processors association: 16 processors,
  - The total number of uses and exposures to the 2011 Fruit Inventory Survey is estimated from the above at: 10,047 occurrences. With a universe of 1985 growers, many growers and other fruit industry representatives were obviously exposed to the data numerous times or had the opportunity to utilize the data on many opportunities. The partner groups that participated in this project believe that expose to the data via articles, newsletters, presentations, meeting and data downloads probably exceeds 95% of the fruit growers in Michigan.
- Through August 1, 2013, there were 1261 downloads of the information from the NASS Michigan Field Office website. All partner groups indicated that they downloaded and utilized the survey data at least once. We estimate that approximately 40 percent of the industry universe (growers, handlers, input suppliers, commodity groups, media and policy makers) have accessed the data from the NASS website at least once.
- All of the partner organizations reported that they discussed the survey and the data provided in the survey with their respective board and/or committees. Most of the

partner groups reported that they distributed information regarding the survey to their entire membership or provided a copy of the report to their membership.

- Several commodity sectors report that they use the survey data in support of pesticide registration information, including Section 18 emergency use requests.
- MACMA Apple Growers report that individual apple handlers have used to the data to plan future buying decisions and to plan apple product variety blends.
- The cherry industry also utilized the data in the development of an ad hoc fruit crop disaster loan program in the new farm bill.
- CherrCo discuss the survey data results with their processor members. They also utilize the data in preparing their annual estimated crop production reports.
- Articles about the survey data was published in the Michigan Farm News and Fruit Growers News.
- The Michigan Grape and Wine Council published a Fast Facts brochure (http://www.michiganwines.com/docs/About/mi_wine_fast_facts.pdf) that contained information from the survey. The Council also reported that they regularly uses the data provided from survey to analyze trends regarding the overall growth of the Michigan wine industry and changes in the mix of varieties being grown for wine. They also reported that information from the survey is used frequently used by MGWIC staff, industry members and Michigan State University faculty and staff in public presentations (at least monthly since the report was published).
- MSU Extension reports that they use the data from the survey in many ways, and they are frequently involved in disseminating the data to growers and other data users. They maintain a spreadsheet showing data back to 1984 which is used to prepare graphs and presentations about production, acreage and yield trends. They use the data to:
    - o Assist in preparing yield loss estimates for USDA crop disaster programs.
    - o Prepare and post information on their website (here is the example for blueberries (http://blueberries.msu.edu/uploads/files/The_Michigan_Blueberry_Industry_2012_MSUE_online.pdf).
    - o Prepare maps and charts showing crops and production areas.
    - o Make crop estimates.
    - o Make recommendations to growers about varieties, rootstocks, planting systems, and irrigation systems.
    - o Assist growers and industry leaders with information about direct marketing, organic production, agri-tourism and the location and impact of neglected orchards.
- The Michigan Apple Committee utilizes the varietal information quite regularly to establish different marketing programs with apple retailers. The data is also used to determine premium variety programs and rebate/volume incentive programs with retailers and wholesalers. They also use the information in preparations with focus groups regarding varietal preferences by consumers. Apple retailers use the varietal information provided by the apple Committee in planning future sales programs.
- MBG Marketing reports that they utilize the survey data to estimate crop production and to determine the amount of irrigation in use. They also report that they have used the data in our company's strategic planning process, and to compare their member's acreage and production as a percentage of the state's total acreage and production.
- The MACMA Apple Growers presented the survey information to their Apple Marketing Committee and at their 2013 Apple Division Annual Meeting. They will also utilize the information in preparing for their annual processing apple price negotiations with handlers. MACMA reports that both apple processors and fresh shippers use the survey data to formulate their 2013 apple marketing and sales plans. Processors also report that they use the varietal data to determine future applesauce recipes.

- Michigan Farm Bureau presented and discussed data from the survey with their Board of Directors, Fruit and Vegetable Advisory Committee and Policy Development Committee. Data from the survey was also used in Farm Bureaus long range planning process that began in 2012.
- The Tree Fruit Drafting Committee utilized the data in constructing a proposed grower check off program designed to boost tree fruit research and extension programs.
- The blueberry industry along with Michigan Farm Bureau utilized the data in wetland preservation discussions with the Michigan Department of Environmental Quality.
- NASS Michigan Field Office had a booth at the Great Lakes Fruit and Vegetable Expo in Grand Rapids on December 4-6. The Expo is the largest event of its kind in the region and is attended by 2500 fruit/vegetable/greenhouse producers from across Michigan and Midwest/Great Lakes region. NASS provided copies of Fruit Inventory Survey press releases, and promoted access to the report through the NASS website. Limited copies of the completed fruit sections of the report will be made available to attendees.

BENEFICIARIES

The beneficiaries of this project include:

- Growers – Michigan has approximately 3500 fruit growers who annually generate nearly $400 million in fruit crop sales. Michigan has about 110,000 acres of fruit crops. The MSU Product Center estimates the direct economic impact of fruit production in the state is $337.9 million. The total economic activity including backward linked industries related to fruit production is $758.4 million. Growers will use the survey data to help make plant decisions regarding varieties, rootstocks and planting systems. Michigan growers plant 2500 to 3500 acres of fruit per year. With land values averaging $5000 per acre and fruit site planting and development cost averaging an additional $5000 per acre the annual investment in new plantings is $30 million based on the planting of 3000 acres annually. Making the right planting decision is a critical factor in the grower's ability to capitalize on this considerable investment.
- All partner groups indicated that they downloaded and utilized the survey data at least once. We estimate that approximately 40 percent of the industry universe (growers, handlers, input suppliers, commodity groups, media and policy makers) have accessed the data from the NASS website at least once.
- Handlers – Michigan has a large number of both fresh and processed (canned and frozen) fruit handlers. By extrapolating data from the MSU Product Center we estimate that the fruit processing, packing and wholesaling industry in Michigan has a total economic impact of $1.27 billion, and these industries provide 13,136 jobs. Handlers will utilize data from the survey to determine future equipment and infrastructure needs, estimate product blends, make market plans and acquire workers and storage space.
- Input suppliers – Fruit growers and handlers require services and supplies to produce; pack and sell fruit products. Farm products are produced through converting inputs such as fertilizer, fuel, credit, equipment, land, chemicals, trees, packaging and other factors of production into fruit crops. The farm input supply industry is a critical link in the food and agriculture supply chain. For example, in 2010, Michigan farmers purchased $599 million in fertilizer and lime, $222.6 million in pesticides, and $275.2 million in petroleum fuels and oil according to NASS. Approximately 280 input suppliers exhibit the Fruit and Vegetable Expo in Grand Rapids, and the Fruit Growers News lists 120 vendors in their 2013 Buyers' Guide. Input suppliers and service vendors us the survey data to tailor marketing program and guide product/service development.
- Commodity groups – Fruit industry commodity groups include commodity specific organizations like Cherry Marketing Institute and the Michigan Blueberry Growers Association to general organization like Michigan State Horticultural Society and Michigan

Farm Bureau. Virtually every sector of the fruit industry is represented by the partner organization involved in supporting the Fruit Inventory Survey. These groups will utilize the survey data for use in the development of promotion and marketing program, to help direct research efforts and to respond to legislative and regulatory issues.

- Researchers and Extension Specialist – While some private sector research is conducted, most fruit research is performed by personnel at Michigan State University, other land grant institutions or at USDA research centers. Extension Specialists assist in carrying the knowledge gained from research efforts to the producer community where the knowledge can be applied. Researchers and Extension personnel need access to up-to-date fruit inventory data so that they can best direct research and extension efforts toward the most critical problems, issues and opportunities facing the fruit industry.
- Policymakers – Local, state and federal policymaking can have a very significant impact on the success and vitality of the fruit industry. Policymakers -- elected officials, regulatory bodies, public institutions and allied organization -- will use the survey data in the development of laws, regulations, ordnances and other public programs. It is critical that policy decisions be based on accurate and timely information.

LESSONS LEARNED

The partnership created by this project between the government crop reporting service (NASS Michigan Field Office) and the fruit industry groups has been very important to the successful completion of the Fruit Inventory Survey. Input, advice and public support from the commodity sectors enabled NASS to plan, construct and carryout an efficient and highly usable survey. Since the commodity and data user segments were involved in the planning and conducting of the survey, they have somewhat unexpected built-in ownership of the process and a strong desire to utilize the data as it becomes available. We believe that this project can help create some very positive spinoff between NASS and fruit industry data users in future years. The partners believe that the use of the data as indicated in the Goals and Outcomes section above is a clear illustration of the usefulness and importance of the data provided in the Fruit Inventory Survey. Since one of the goals of this project is to create baseline data regarding the actual use of the data from the survey, we expect that NASS and the industry will be able to use the knowledge gained to evaluate and plan future surveys with upmost usefulness.

The only portion of this project which the partners failed to achieve was the comparison of website “hits” from the last available Fruit Inventory Survey in 2006, to the number of “hits” on the 2011 Fruit Inventory Survey. While it is unfortunate to lose this planned for tracking opportunity, the lack of this information will in no way diminish the importance of the survey nor reduce the use of the survey data by the fruit industry. NASS has agreed to track website “hits” on a going forward basis. This will allow for comparison of this data as future fruit inventory surveys are conducted, which will allow this tool to be used in future surveys.

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ADDITIONAL INFORMATION

For the Michigan Rotational Survey – Fruit Inventory click NASS - Michigan Publications and Press Releases
http://www.nass.usda.gov/Statistics_by_State/Michigan/Publications/Michigan_Rotational_Surveys/index.asp; then “Fruit Inventory 2011-2012”.

PROJECT TITLE Michigan Onion Committee, Controlling Pathogens that Limit the Michigan Onion Industry's Profitability FINAL

PROJECT SUMMARY

Michigan ranks #7 in the U.S. for production of storage onions. The profitability of the Michigan onion industry is seriously threatened by foliar and root diseases caused by fungi. Onion diseases can cause severe losses by reducing yield and quality of marketable onions. In 2009, Michigan produced 133 million pounds of onions worth over $14.3 million on 4,000 acres. In 2010, leaf and neck anthracnose, a new foliar disease of onion, was discovered in Michigan resulting in serious yield reductions. In 2010 and 2011, respectively, Michigan produced 65 and 82 million pounds of onions worth $9 and $10 million dollars on ~4,000 acre. In 2010 and 2011, significant yield reductions were observed following severe epidemics of leaf and neck anthracnose on onions. The causal fungus was identified as *Colletotrichum coccodes*, and this is the first known occurrence of *C. coccodes* as a pathogen of onion in the world. Bleached lesions were observed along the leaves, from the tip to the bulb. In some cases, other foliar blights were present along with the *Colletotrichum* lesions, causing complete leaf necrosis. In other fields, the onion leaves were green and healthy, but were peppered with *Colletotrichum* lesions, and reduced yields were observed. Anthracnose on onions was found in 17 of 33 commercial fields sampled in Michigan in 2010. *C. coccodes* was found to be capable of causing severe disease on onion seedlings.

Another major limitation to onion yield is the soil borne disease known as pink root, which is caused by the fungus, *Setophoma terrestris*. Pink root is the most common and damaging root disease. Infection of the roots leads to wilting, yellowing, death of leaves, and the bulbs can become soft and undersized. After infection has occurred, the color of the roots may vary from a pink to red as the disease progresses. New roots are infected, turn pink, and die when they form on an infected bulb. Poor emergence or collapse of seedlings can result from early pathogen infection, which also impacts yields. In cases of severe pink root infection, affected plants show symptoms typical of nutrient deficiency or drought. Plants are stunted, leaf number and size are reduced, and bulb development begins earlier in infected than in healthy plants. In Michigan, pink root is a common problem favored by hot summers. Currently, the only management tool available for pink root control is fumigation, but this is not economically sustainable for onion growers, and the environmental impacts of fumigation are of concern.

Leaf and neck anthracnose and pink root lead to significant yield reductions and revenue losses for Michigan onion growers. In order to stay profitable, Michigan onion growers need information as to which cultivars can tolerate infection by these two pathogens and what fungicide products are available that will provide adequate disease control. Since *C. coccodes* had never been reported as an onion pathogen, research into weather conditions that will favor this disease is needed to better plan fungicide applications.

PROJECT APPROACH

Research addressed the Michigan Onion Committee's second research priority (www.greeen.msu.edu): 'Disease control management,' 'Improved understanding and control of Michigan's new onion disease: *Colletotrichum*,' and 'Estimated economic impact: Potential for 10 to 50 percent yield loss from reduced yields and culls ($1.5 million to $7.5 million).' Research investigated cultivars resistant/tolerant to and fungicides effective at controlling diseases, and determined the environmental conditions required for anthracnose to develop. Optimal conditions for anthracnose include high temperatures (77,86°F) and long hours of high humidity (24,48,72). Cultivars were not completely resistant to anthracnose or pink root; 'Hendrix' and 'Redwing' were least susceptible to both diseases. Bravo alternated with Quadris resulted in

fewer anthracnose-infected plants than the untreated control. Inspire Super had a low pink root severity rating and yielded the most. In a second trial, plants treated with the biopesticide Serenade Soil in-furrow at planting had significantly lower pink root severity rating than the untreated control. Effective fungicides have been identified for anthracnose, but pink root needs more research. Growers should consider an integrated management program for anthracnose and pink root, growing tolerant cultivars with effective fungicides. Expecting and scouting for anthracnose when temperatures and relative humidity are high may save some early-season fungicide applications.

GOALS AND OUTCOMES ACHIEVED

1. Epidemiology: Determine the environmental conditions required for infection of onion by *C. coccodes*. Onion seeds were sown in 288 flats and transplanted into 10 cm pots at the three-leaf stage. Onion seedlings were kept in the greenhouses for 4 weeks, watered as needed and fertilized weekly. Pots were placed into a 13 cm saucer enclosed in plastic bags with 350 ml distilled water (to maintain high humidity) and a hand-made wire holder to keep the bag from collapsing. Inoculum suspensions were prepared by flooding seven-day-old cultures of *C. coccodes* with 1 ml of water and 0.001% Tween. Conidia were dislodged and filtered through three layers of sterile cheesecloth, and concentration adjusted to $2x10^5$ conidia/ml using a hemocytometer. Infested millet inoculum was prepared by growing eight 0.7-mm plugs of seven-day-old *C. coccodes* mycelium in flasks of sterile millet seed at room temperature under fluorescent lights for 20 days. Inoculum for the dry millet treatment was dried in sterile paper bags for 3 days at 86°F (30°C), then in a sterile tray in a flow hood for two days.

Greenhouse experiments were conducted to study the effect of different inoculation methods using 'Prince' onion seedlings. Conidial suspension inoculum was applied as a foliar spray with an airbrush, a foliar spray with a wounding/abrasive agent (diatomaceous earth), or as a 10-ml drench. Millet inoculum was applied wet or dry (2 and 5 g) to the soil surface around each seedling. The percentage symptomatic leaf area was evaluated at 5, 7, 14, 21 and 28 days after inoculation (DAI) and used to calculate area under the disease progress curve values (AUDPC), a measure of disease intensity over the time of the experiment.

Inoculation methods based on conidial suspension, sprayed over the foliage (alone or with abrasive agent) or as drench resulted overall high disease severity when compared with the inoculation methods using *C. coccodes*-infested millet seed.

Table 1. Inoculation method effect on the area under the disease progress curve (AUDPC) for *C. coccodes* disease severity on 'Prince' onion seedlings.

Inoculation method (df=6, P value<0.0001)	**Mean AUDPC[z]**	
Conidial suspension spray with abrasive agent	728.16	a
Conidial suspension spray	698.11	ab
Conidial suspension drench	513.99	b
Dry millet 5 g	146.32	c
Dry millet 2 g	232.11	c
Wet millet 5 g	133.74	c
Wet millet 2 g	172.63	c

[z]Means with a same letter in common are not significantly different (LSD).

Growth chamber studies were conducted to study the effect of temperature and relative humidity on leaf and neck anthracnose severity on 'Infinity' onion seedlings. Conidial suspensions (without the abrasive agent) were prepared as for the greenhouse experiments and applied to the seedlings. Combinations of four temperatures: 59, 68, 77, 86°F (15, 20, 25, 30°C), and five humidity periods: 0, 12, 24, 48 and 72 hours of ≥ 95% RH, were factors in a split plot design. Humidity was maintained by enclosing plants in sealed clear plastic bags. The percentage of symptomatic leaf area was evaluated at 5, 7, 14 and 21 DAI and used to calculate AUDPC values.

Significant differences among temperatures and humidity periods and significant interaction among levels of main effect were observed. The combination of high temperatures, 77 and 86°F (25 and 30°C), and increased duration of high relative humidity, 24, 48 and 72 hours, resulted in more severe onion leaf and neck anthracnose.

Table 2. Effect of temperature and relative humidity period on the area under the disease progress curve (AUDPC) on 'Infinity' onion seedlings inoculated with *C. coccodes*.

Effect (df, pvalue)	**Mean AUDPC[z]**	
Temperature (3, 0.00081)		
59°F (15°C).....	7.5132	a
68°F (20°C).....	68.6276	a
77°F (25°C).....	253.76	b
86°F (30°C).....	305.82	b
Relative humidity period (4, <0.0001)		
0 hours.....	6.8473	a
12 hours.....	11.6797	a
24 hours.....	168.51	b
48 hours.....	271.26	bc
72 hours.....	336.34	c

[z]Means with a letter in common are not significantly different (LSD).

Table 3. Temperature and relative humidity duration interaction on severity values (mean AUDPC) of onion anthracnose on 'Infinity' onion seedlings inoculated with *C. coccodes*.

Temperature x Humidity period (12, <0.0001)

	Interaction sliced by temperature (°C)							
	15		**20**		**25**		**30**	
0 hours.....	5.3	a[z]	6.8	a	10.2	a	5.1	a
12 hours.....	2.2	a	7.1	ab	37.2	a	0.3	a
24 hours.....	18.7	a	16.2	ab	275.7	b	363.4	b
48 hours.....	2.8	a	109.5	bc	399.1	b	573.7	b
72 hours.....	8.6	a	203.6	c	546.6	b	586.6	b

Interaction sliced by humidity period (hours)

	0		12		24		48		72	
59°F (15°C).....	5.3	a	2.2	a	18.7	a	2.8	a	8.6	a
68°F (20°C).....	6.8	a	7.1	ab	16.2	a	109.5	b	203.6	b
77°F (25°C).....	10.2	a	37.2	b	275.7	b	399.1	c	546.6	c
86°F (30°C).....	5.1	a	0.3	a	363.4	b	573.7	c	586.6	c

[z]Means within effect interaction with a letter in common are not significantly different (LSD).

2. Cultivar trials: Determine whether there are differences in susceptibility of onion cultivars to *C. coccodes* and *S. terrestris*.

Evaluation of susceptibility of onion cultivars to anthracnose. In 2013, the study was conducted at the Michigan State University Southwest Michigan Research and Extension Center located near Benton Harbor, MI. Cultivars were replicated four times in a randomized complete block design in a plot of onions 11 beds wide by 100 ft long. The soil at the site is Benona fine sand that was previously planted to yellow summer squash. Prior to planting the field was fertilized with 350 lb/A of 8-21-29 plus micronutrients (0.5% Cu, 1% Mn, and 0.5% Zn). Onion seeds were planted at a density of 325 M/A into two-row beds spaced 12 in. apart on 21 May. Cultivar plots were 20 ft long with 5 ft of unplanted buffer between plots. Weeds were controlled with applications of Prowl H_2O (2 pt/A) on 22 May. Insects were controlled with applications of Lannate LV (3 pt/A) on 26 June. Supplemental hand weeding was performed as needed. Disease was assessed on 25 plants selected from each cultivar.

Diseased plants ranged from 46.2 to 65.3%. Most of the cultivars have exhibited a moderate susceptibility to anthracnose. Across the different trials, 'Hendrix' has consistently been at the lower end of susceptibility to anthracnose.

Table 4. Evaluation of onion cultivars for resistance to leaf and neck anthracnose.

Cultivar	Diseased plants (%)	Cultivar	Diseased plants (%)
Braddock	46.2	Madras.....	54.3
Hendrix.....	46.9	Highlander	55.1
Redwing	48.6	Latigo.....	55.2
Sedona.....	53.3	Pontiac.....	56.2
Crockett.....	53.4	Trailblazer.....	56.7
Scorpion	53.4	Scout	60.6
Safrane.....	53.7	Sherman	65.1
Delgado.....	53.9	Patterson	65.3

Evaluation of onion cultivars for resistance to pink root. The experiment was conducted in a commercial field that had a history of pink root in previous years. Selected onion cultivars were sown in naturally infested soil. The experiment was designed as a randomized complete block with four replicates. Individual plot was planted with 16 onion cultivars in two rows wide by 20 feet in length. Seeds were planted on 3 May 2013 in Stockbridge, MI. Plots were fertilized by the grower. Weeds, onion thrips, and bacterial and fungal diseases were controlled with herbicides, insecticides, copper products and fungicides. Bulbs were dug to preserve the root system, plants placed in plastic bags to maintain root moisture, transported to the lab and kept in a cold room before and during disease evaluation. Twenty-five bulbs were harvested from the middle 10 feet of the row. Each bulb was examined for percentage of the roots infected and percentage of total bulbs having pink root. Disease severity was assessed on a scale of 0 to 8, where 0 = roots are vigorous, white, abundant, and no pink root, 1=pink root is observed but disease is very light, ≤25% of the bulbs are infected (each bulb has <50% of the roots infected); 2=25-49% of the bulbs have pink root (each bulb has <50% of the root infected); 3 = 50-74% of

the bulbs have pink root (each bulb has <50% of the root infected); 4=≥75% of the bulbs have pink root (each bulb has <50% of the root infected); 5=≤25% o of the bulbs are infected (each bulb has >50% of the roots infected); 6=25-49% of the bulbs are infected (each bulb has >50% of the roots infected); 7=≥75% of the bulbs have pink roots (each bulb has >50% of the root infected); and 8=≥75% of the bulbs have pink roots (each bulb has >50% of the root infected). Means of disease severity was analyzed using the PROC Glimmix procedure of SAS, version 9.4 (SAS Institute, Cary, NC). Two plants were randomly selected from each replication for pathogen confirmation. Five roots showing pink discoloration from each plant were surface disinfected with 10% bleach for 10 minutes, followed by three serials of sterile distilled water, and blotted dry with paper towel. Disinfected roots were placed on water agar and incubated under darkness for one week at 27°C then moved to a combination of 13-hour photoperiod for one week. Morphological characteristics of the *P. terrestris* isolates grown on water agar were compared to those of the isolate used for inoculum.

Several onion cultivars had moderate to moderate-high pink root severity. Highlander had highest disease severity, while Sedona had a lowest severity compared to other cultivars. Disease symptoms showing on the roots were confirmed to be caused by the pink root pathogen, *S. terrestris*, based on morphological characteristics observed on the symptomatic roots after incubated in laboratory.

Table 5. Evaluation of onion cultivars for resistance to pink root.

Cultivar	Disease severity[a]		Yield (lb/25 bulbs)[b]		
			Small	Medium	Total
Sedona	4.75	e	1.19	2.76	3.95
Redwing.....	5.00	de	1.31	3.25	4.56
Hendrix	5.25	de	0.80	4.73	5.53
Infinity	5.25	de	0.85	3.94	4.79
Latigo.....	5.50	de	0.26	4.31	4.57
Bradley	5.50	de	1.16	4.31	5.47
Prince	5.50	de	1.38	3.85	5.23
Hamlet	5.75	cd	1.54	3.20	4.74
Pontiac.....	5.75	cd	0.89	3.85	4.74
Candy	5.75	cd	1.08	4.18	5.26
Stanley.....	6.00	cd	1.76	3.00	4.76
Madras.....	6.50	bc	0.81	4.61	5.42
Sherman	6.50	bc	0.33	5.10	5.43
Safrane	6.75	b	0.83	5.25	6.08
Livingston.....	7.00	b	0.34	6.06	6.40
Highlander	8.00	a	1.10	3.50	4.60

[a] Average disease severity from 25 bulbs per replicate in four replicates rated based on the disease severity scale described previously.
[b] Averages of weight were taken based on the bulb diameters: small=diameters are <2 inches; medium=diameters ≥2 inches and <3 inches; large=diameters are ≥3 inches.

Onion cultivar trials were conducted over the last three years to compare their tolerance to pink root. Evaluations were made throughout the growing season and then the cultivars were placed into one of four pink root susceptibility categories. While susceptibility to pink root is not the only consideration in choosing an onion cultivar, the disease ratings that have been established may

be helpful especially when deciding how to manage parcels of land that are heavily infested with the pink root pathogen.

Table 6. Susceptibility of onion cultivars to pink root tested during 2011-2013 growing seasons.

Low susceptibility	Medium-low susceptibility	Medium-high susceptibility	High susceptibility
Hendrix (4)*	Infinity (3)	Infinity (3)	Madras (2)
Sedona (2)	Bradley (3)	Hamlet (3)	Sherman (2)
Redwing (3)	Prince (3)	Stanley (3)	Livingston (3)
--	Marco (2)	Safrane (2)	Highlander (4)
--	Polo (2)	Talon (2)	--
--	--	Vespucci (2)	--
--	--	Milestone (2)	--
--	--	Pulsar (2)	--

*Number in the parentheses indicates the number of trials conducted that included that particular cultivar.

3. Fungicide trials: Identify effective fungicides for managing leaf and neck anthracnose of onion with foliar sprays.

Table 7. List of fungicides and biopesticides tested in this research project.

Product	Active ingredient	FRAC code	Labeled
Bravo WeatherStik 6SC	chlorothalonil	M5	yes
Cannonball 50WP**	fludioxonil	12	yes (supplemental label)
Fontelis 1.67SC	penthiopyrad	7	yes
Inspire 2.08EC	difenoconazole	3	no
Inspire Super 2.8EC	difenoconazole/cyprodinil	3/9	yes
Manzate Pro-Stick 75DF	mancozeb	M3	yes
Meteor 4SC	iprodione	2	yes
Omega 4.18SC**	fluazinam	29	yes
Quadris 2.08SC**	azoxystrobin	11	yes
Quadris Top 2.72SC	azoxystrobin/difenoconazole	11/3	yes
Rovral 4FL	iprodione	2	yes
Serenade Soil 1.34EC*	*Bacillus subtilis*		yes
Switch 62.5WDG**	cyprodinil/fludioxonil	9/12	yes
Vangard 75WDG**	cyprodinil	9	yes

*Classified by the EPA as a biopesticide.
**Classified by the EPA as a reduced risk fungicide.

Evaluation of fungicides for control of anthracnose of onion. This study was conducted in a grower-cooperator's field in Calhoun County, MI in a muck soil previously planted to soybean. Eight treatments were replicated four times in a randomized complete block design. Field preparation, sowing of 'Brandt' onion seeds, and plot maintenance were provided by the grower and were conducted according to commercial production standards. Plots were 5 double rows wide by 10 ft long and seeds were sown at 250,000 seeds/A. Six spray applications were made at 7-day intervals and were applied on 14, 21 and 27 June; and 3, 10 and 17 July. Treatments were applied with a CO_2 backpack sprayer equipped with three XR8003 flat fan nozzles spaced 19 in. apart and calibrated to deliver 50 gal/A at a boom pressure of 50 psi. Onion plants were harvested from the inner 3 ft of the plots on 26 July and evaluated for disease on 29 July by counting the number of plants with anthracnose lesions. Bulbs were sorted for size (small=<2" diameter, medium=2-3" diameter, large=>3" diameter) and weighed on 4 Sep. Data were

analyzed using Sigma Stat version 3.1 (Systat Software Inc.) and treatments were compared using Student-Newman-Keuls comparison test.

Only treatments of Bravo alternated with Quadris resulted in significantly fewer anthracnose-infected plants than the untreated control (Table 8). Although not statistically different from other treatments and the control, Fontelis, Rovral and Switch limited anthracnose-infected plants to ≤4. There were no statistical differences among treatments for yield. Fungicide treatments were also evaluated for activity against Botrytis blight. All treatments significantly limited moderate and severe infections of Botrytis blight compared to the untreated control and received better ratings of total health compared with the untreated control. Bravo alternated with Quadris prevented both moderate and severe infections of Botrytis blight and resulted in the best health rating of 1.8, as well as proving very effective for limiting plants with anthracnose.

Table 8. Evaluation of fungicides for control of anthracnose and Botrytis blight of onion.

Treatment and rate/A, *application schedule*[z], applied at 7-day intervals	**Plants with anthracnose**	**Botrytis blight[y]**			**Total health[x]**
		Mild	**Moderate**	**Severe**	
Untreated control	14.3 b[w]	22.5	25.0 b	35.0 b	6.5 c
Bravo WeatherStik 6SC 2 pt					
-alt- Quadris 2.08SC 0.75 pt	2.3 a	7.5	0.0 a	0.0 a	1.8 a
Manzate Pro-Stick 75WP 3 lb					
-alt- Quadris 2.08SC 0.75 pt	10.3 ab	32.5	3.8 a	7.5 a	3.8 ab
Fontelis 1.67SC 1 pt	3.8 ab	18.8	2.5 a	0.0 a	3.0 ab
Rovral 4FL 1.5 pt	4.0 ab	18.8	10.0 a	5.0 a	4.3 b
Switch 68WG 0.88 lb	4.0 ab	36.3	2.5 a	0.0 a	4.3 b
Omega 4.18SC 1 pt	7.3 ab	11.3	0.0 a	0.0 a	3.0 ab
Manzate Pro-Stick 75DF 3 lb, *apps 1-3*					
then Meteor 4SC 1.5 pt					
+ Manzate Pro-Stick 75DF 3 lb					
-alt- Quadris 2.08SC 0.6 pt					
+ Manzate Pro-Stick 75DF 3 lb	8.0 ab	8.8	0.0 a	5.0 a	2.5 ab

[z]*-alt-*=alternate.
[y]Based on a visual estimation of percentage of plants with mild (1-10 lesions/plant), moderate (11-20 lesions/plant, or severe (≥21 lesions/plant) Botrytis symptoms.
[x]Rated on a scale of 1=10, where 1=healthy and 10=severely diseased.
[w]Column means with a letter in common or with no letter are not significantly different (Student-Newman-Keuls; *P*=0.05).

Evaluation of in-furrow fungicides for control of pink root of onion. The trial was conducted from 6 May to 14 August in a commercial field in Stockbridge, MI, where pink root had been observed in previous years. Each treatment was replicated four times in a randomized complete block design. Plots were two rows wide by 20 ft in length, separated by 2 ft of buffer plants. An untreated control was included. The susceptible cultivar, Highlander, was used in the experiment. The fungicides were prepared per the manufacturer's instructions and applied in furrow at planting by using nozzles calibrated to 40 psi at 2 mph for delivering the fungicide at a rate of 33 GPA or 1.14 gallon per 1,000 row ft. Assessment of pink root was made on 14 August. Twenty five bulbs of each treatment were carefully harvested using a gardening fork to preserve the roots, then transported back to campus, and kept in the cold room before and during disease evaluation. The severity of pink root was rated using the following scale; 1=roots were vigorous, white, abundant, with no pink root; 2=pink root observed but disease was very light, ≤25% of the bulbs were infected (each bulb had <50% of their roots infected); 3=25-49% of the bulbs had pink roots (each bulb had >50% roots infected); 4=50-74% of the bulbs had pink roots (each bulb had >50% roots infected); 5=≥75% of the bulbs had pink roots (each bulb had >50% roots infected).

Severity ratings were high overall, ranging from 4.5 to 5.0. Plants treated with Inspire Super had the highest yield and were among those receiving the lowest severity rating.

Table 9. Evaluation of in-furrow fungicides for control of pink root of onion.

Treatment and rate/A	Application	Severity*	Yield (lb/25 bulbs)
Untreated control	--	5.0**	4.5
Inspire Super 2.8EC 1.25 pt..	In-furrow at planting	4.5	5.0
Switch 62.5WDG 0.88 lb.....	In-furrow at planting	4.5	4.4
Vangard 75WDG 0.63 lb.....	In-furrow at planting	4.8	4.6
Quadris Top 2.7SC 0.88 pt ...	In-furrow at planting	4.5	4.7
Quadris 2.08SC 1.19 pt	In-furrow at planting	4.8	4.4
Inspire 2.08EC 0.44 pt	In-furrow at planting	4.8	4.4
Cannonball 50WP 0.44 lb	In-furrow at planting	4.5	4.5

*Rated on a scale of 1-5, where 1=healthy and 5=≥75% of the bulbs had pink roots (each bulb had >50% roots infected).

**There were no significant differences among treatments (Student-Newman-Keuls; *P*=0.05).

Evaluation of a biopesticide and fungicides for control of pink root of onion. The pink root trials were conducted from 6 May to 14 August in a commercial field in Stockbridge, MI, where pink root had been observed in previous years. Each treatment was replicated four times in a randomized complete block design. Plots were two rows wide by 20 ft in length, separated by 2 ft of buffer plants. An untreated control was included. The susceptible cultivar, Highlander, was used in the experiment. The fungicides were prepared per the manufacturer's instructions and applied in furrow at planting by using nozzles calibrated to 40 psi at 2 mph for delivering the fungicide at a rate of 33 GPA or 1.14 gallon per 1,000 row ft. Assessment of pink root was made on 14 Aug. Twenty five bulbs of each treatment were carefully harvested using a gardening fork to preserve the roots, then transported back to campus, and kept in the cold room before and during disease evaluation. The severity of pink root was rated using the following scale; 1=roots were vigorous, white, abundant, with no pink root; 2=pink root observed but disease was very light, ≤25% of the bulbs were infected (each bulb had <50% of their roots infected); 3=25-49% of the bulbs had pink roots (each bulb had >50% roots infected); 4=50-74% of the bulbs had pink roots (each bulb had >50% roots infected); 5=≥75% of the bulbs had pink roots (each bulb had >50% roots infected).

Severity ratings were high overall, ranging from 4.0 to 4.8. Only plants treated with the biopesticide Serenade Soil 8 pt in-furrow at planting had significantly lower severity rating than the untreated control. The fungicides Fontelis and Quadris exhibited good activity against *S. terrestris* in agar plates amended with these fungicides. Therefore, additional studies are warranted to determine whether efficacy in the field can be enhanced through improved delivery to the plant's roots and surrounding soil.

Table 10. Evaluation of a biopesticide and fungicides for control of pink root of onion.

Treatment and rate/A	Application	Severity*	Yield (lb/25 bulbs)
Untreated control.....	--	4.8 b**	5.1
Serenade Soil 1.34EC 8 pt	In-furrow at planting	4.0 a	4.7
Serenade Soil 1.34EC 4 pt	In-furrow at planting, 30 day seedling spray	4.8 b	4.4
Fontelis 1.67SC 2.17 pt	In-furrow at planting (1.2 fl oz /1000 ft)	4.5 ab	3.7

Treatment and rate/A	Application	Severity*	Yield (lb/25 bulbs)
Fontelis 1.67SC 2.9 pt	In-furrow at planting (1.6 fl oz /1000 ft)	4.5 ab	3.8
Fontelis 1.67SC 2.17 pt	Pre-plant incorporated (1.2 fl oz /1000 ft)	4.8 b	4.2
Fontelis 1.67SC 2.9 pt	Pre-plant incorporated (1.6 fl oz /1000 ft)	4.8 b	4.2
Quadris Top 2.72SC 0.88 pt	In-furrow at planting (0.8 fl oz /1000 ft)	4.8 b	4.4
Quadris Top 2.72SC 0.88 p	Pre-plant incorporated (0.8 fl oz /1000 ft)	4.5 ab	4.2

*Rated on a scale of 1-5, where 1=healthy and 5=≥75% of the bulbs have pink roots (each bulb has >50% roots infected).
**Column means with a letter in common or with no letter are not significantly different (Student-Newman-Keuls; *P*=0.05).

BENEFICIARIES

Pink root is a common disease of onion and other *Allium* crops in North America, Australia, Europe and South Africa. Although *C. coccodes* was first identified as an onion pathogen in Michigan, occurrence in other locations is expected. This research will benefit all onion growers in the U.S., as well as Michigan onion growers. Onion production in Michigan still has not regained the scope it had before anthracnose became a problem in 2010. In 2013, Michigan produced 81 million pounds of onions, a 39.1% decrease in production compared to 2009, with a 22.5% decrease in revenue ($11.1 million). However, production and revenue in 2013 were higher than in 2010. To maintain and strengthen the Michigan onion industry, new and old pathogens must be managed. This research benefits Michigan onion growers and allied agricultural businesses by maintaining the sustainability of these industries. Results were presented at the Onion Session of the Great Lakes Fruit, Vegetable and Farm Market Expo in December 2013.

LESSONS LEARNED

Pink root is a soil borne disease, directing fungicides to the root zone where the pathogen is active can be challenging. The pink root experiments in this project tested one-time in-furrow applications at the time of planting. Only one experiment had statistical differences among treatments for disease; there were no significant differences among treatments for yield in any experiment. More research is needed on fungicides for managing pink root.

CONTACT INFORMATION

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ADDITIONAL INFORMATION

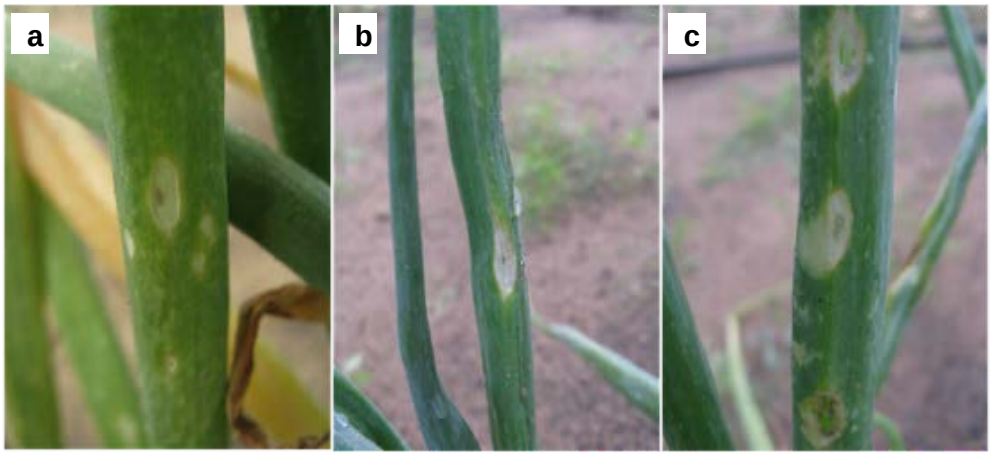


Figure 2. Anthracnose trial: pale, bleached lesions of anthracnose on foliage of onion cultivars: **a**, Candy; **b**, Marco; and **c**, Hendrix.

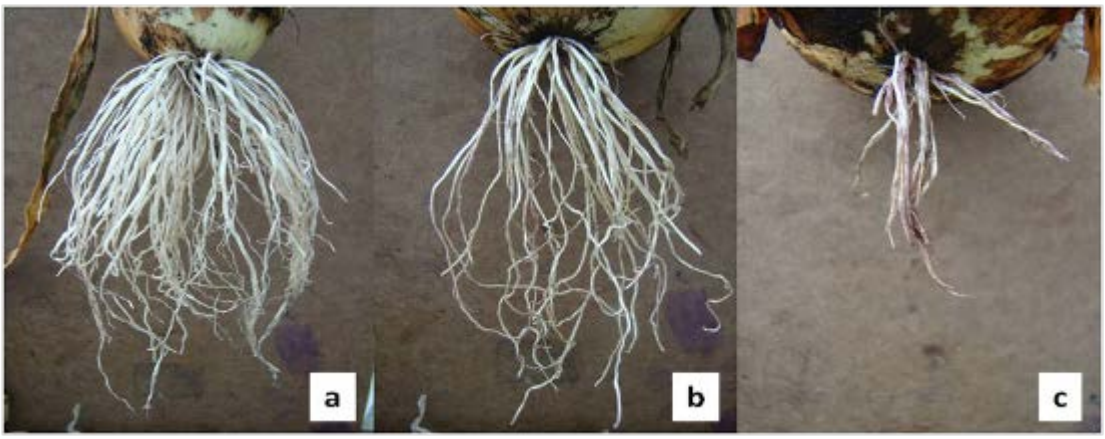


Figure 1. Pink root trial: onion cultivars were rated on percentage of the roots infected: **a**, no symptoms observed; **b**, <50% of roots infected; and **c**, ≥50% of the roots infected. Note pink coloration on the roots of **c**.

PROJECT TITLE	**Michigan Christmas Tree Association: Make it a Real Christmas 2012: Strengthening Michigan Poinsettia and Christmas tree Production FINAL**

PROJECT SUMMARY

Michigan Christmas tree and poinsettia growers have been experiencing static to declining sales. This decline can be attributed to a variety of factors including competition from foreign competitors producing artificial trees and poinsettias, consumer apathy and changing consumer habits. In an effort to rejuvenate sales and profitability, we began an educational and promotional campaign in 2011, featuring the campaign slogan "Make it a Real Michigan Christmas." The concept was to leverage the current consumer trend toward buying local and supporting the local economy. The

goal of the campaign was to preserve or increase sales and people employed in plant production with three key messages: buying real products helps preserve or build Christmas traditions while being an economically, emotionally, and ecologically beneficial choice.

We were pleased with the results from the first year of the campaign, even with a very short time-frame to execute the program. By expanding the campaign to second holiday season in 2012, we had enough lead time to coordinate our efforts with the Detroit Lions and increase the visibility and reach of the campaign.

PROJECT APPROACH

The plan for the "Make it a Real Michigan Christmas" campaign in 2012 was to use the existing materials (logo, point of sale items, website) and expand the campaign with greater funding for public service announcement (PSA) efforts and the public relations/media campaign. We also chose to direct financial resources to a few high visibility events featuring Michigan grown poinsettias and Christmas trees.

The team executed a very successful PSA campaign by producing a new, humorous 60 second PSA that was aired more than 4,477 times; a significant increase over 2011. Our public relations team secured 23 television placements for a total of 75 on-air minutes, seven radio interviews and 13 print opportunities.

In our partnership with the Detroit Lions, we provided a stunning, 21 foot Christmas tree, professionally decorated in blue and silver (team colors). It was on display for the Thanksgiving Day football game, as well as for three additional professional games, a college bowl game and the Michigan high school football finals. A complimentary poinsettia was placed in each of 132 suites at Ford Field for the Thanksgiving Day game. This effort led directly to television and newspaper coverage.

GOALS AND OUTCOMES ACHIEVED

As stated in our grant proposal, the objective of the campaign was to increase awareness of Michigan-grown Christmas trees and poinsettias by Michigan consumers, with a long term goal of increasing sales.
The activities of this project fell into the following primary categories:

- Educational Media Campaign
- High Visibility Special Events
- Website management and point of purchase material production
- Pre and post campaign survey execution

Educational Media Campaign: Once again we contracted with Jenny Schilp of Media Matters and her partners; Kirsten Borgstrom and Joanna Wilbee-Amis to execute media contacts and garner television, radio and print interviews for the campaign. To secure these opportunities, members of the media received press kit that consisted of a professionally produced dvd containing the campaign press releases and artwork. Approximately 95 key members of the media received a personally delivered poinsettia as a follow up to the press kit as a reminder to consider the topic when making production plans for the holidays.

Because many television stations no longer will send camera crews to cover feature stories, the PR team suggested that we invest in producing b-roll footage of poinsettia and Christmas tree production that stations can use when preparing holiday stories. Footage of poinsettia production was shot by freelance producer, Shawn O'Donnell at Henry Mast Greenhouse in

Byron Center and previously shot Christmas tree footage was included to save production costs. A b-roll dvd was produced at Such Video and made available to television stations that requested it.

The more professional packaging of our media kit and the addition of the b-roll dvd produced by our team secured 23 television placements for a total of 75 on-air minutes, as well as seven radio interviews and 13 print opportunities. A detailed campaign report is included as an addendum to this report as well as a sample of the press kit. Marsha Gray was the primary partner contact for all media appearances and partnered with Dean Krauskopf in press kit/poinsettia deliveries.

In addition, we chose to sponsor the Thanksgiving through Christmas segments for the weekly "Michigan Farm and Garden Show." Host, Jody Pollok-Newsome, dedicated one entire show to Christmas trees and other segments to poinsettias during the holiday season. This television program is seen on weekends in Lansing and more rural Michigan markets. We also held a press conference at Post Gardens in Battle Creek, featuring Michigan Department of Agriculture $ Rural Development Director, Jamie Clover Adams.

MDARD Director, Jamie Clover Adams, second from left, participates in a press conference with Poinsettia and Christmas tree growers.

As a result of these efforts, the key messages of the campaign were once again highlighted in 23 television placements for approximately 75 on-air minutes, 13 print features and seven radio interviews. Media Matters reported a total of nearly 37 million impressions; an increase of more than 15 million over the 2011 campaign. A number of additional media opportunities mentioned Christmas trees and poinsettias, however did not specifically mention the "Make it a Real Michigan Christmas" campaign. Links to some of the featured stories are available on the campaign website: www.realmichiganchristmas.com on the "In the News" section. A media recap is included as an addendum to this report.

To support the media efforts, the committee decided to write and record a new public service announcement. This PSA was 60 seconds in length and was made available along with last year's 30 second spot. A professional writer was hired to create a humorous script and the spot was recorded at Mackinaw Harvest Productions. Time slots were secured on radio stations around the state through a contract with the Michigan Association of Broadcasters. Although they were only required to use the 30 second spot, many chose to use the 60 second PSA because of its humorous nature. Even stations not included in the buy, were running the new PSA. A recording of that PSA can be heard on the campaign website: www.realmichiganchristmas.com on the media page.

According to the final report, the reported airings of the PSA far outpaced the contracted number. The campaign contracted 1,260 airings with a value of $12,500. During the months of November and December, 2012 the PSAs received 4,477 airings with an estimated value of $117,267! The biggest surprise was the 139 airings on one of the Midwest's biggest radio stations, WJR 760 AM. Not only did they air the longer 60 second spot, they aired it during key

times, such as drive time and during their popular morning talk shows as well as during the syndicated Rush Limbaugh and Shawn Hannity programs. Rod Crittenden oversaw the PSA production and contract with the Michigan Association of Broadcasters.

High Visibility Special Events: The most notable new offering in the campaign was the addition of a partnership with the Detroit Lions professional football team. A stunning, 21 foot Christmas tree, professionally decorated in blue and silver (team colors) by Alice Waterous, was on display for the Thanksgiving Day football game and remained in place for three additional professional games, as well as a college bowl game and the Michigan high school football finals. The tree, delivery and set up were donated by Dutchman Tree Farms and MCTA. Poinsettias were featured around the base of the tree and in a poinsettia "tree" frame at Ford Field. A complimentary poinsettia was placed in each of 132 suites at Ford Field for the Thanksgiving Day game. The Christmas tree placement at Ford Field led directly to two television opportunities and newspaper placements in the Detroit Free Press and Crain's Detroit Business.

Michigan-grown poinsettias were delivered to each of the 132 suites at Ford Field for the Thanksgiving Day game.

The 21 ft. Concolor Christmas tree at Ford Field was used as a backdrop for a variety of events with the Detroit Lions.

(Left) Detroit Lions quarterback, Matthew Stafford, and his girlfriend used the Tree as the backdrop for this photo that was "tweeted" to thousands of followers.
(Right) Photo of the Detroit Lions tree that appeared on page 5a of the Detroit Free Press.

Left) Crain's Detroit Business covered the connection between the Detroit Lions and the "Make it a Real Michigan Christmas" campaign.

Through our relationship with the Detroit Lions, we also developed a special promotion at Detroit's Eastern Market. The event included a prize drawing for a Matthew Stafford signed football (quarterback of the Detroit Lions) and an appearance by Roary, the Detroit Lions mascot. This event secured a series of four interviews on Fox 2 in Detroit featuring Christmas tree growers, poinsettia producers as well as our campaign representative and a Detroit Lions spokesperson.

Jennifer Hammond of Fox 2 in Detroit interviews Michigan Christmas tree grower, Chet Szuber. Roary draws the winning name for the signed football at the Eastern Market event. One of dozens of campaign banners displayed at Eastern Market is visible in the background.

For a second year, we were directly involved in the Christmas tree lighting at Campus Martius Park in Detroit. The campaign banners were featured prominently at the press conference when the 55 foot tree was delivered and at the tree lighting ceremony. 20 large poinsettias were provided for the VIP reception and 16 additional Christmas trees and eight fresh wreaths were provided for the stage and festival area.

(Right) The Campus Martius Christmas tree lights up the city with 18,000 lights.

Marsha Gray was the point person for all special events and was assisted by Dean Krauskopf with on-site activities at Ford Field and Eastern Market.

Pre and Post Campaign Survey Execution: As they did in 2011, Dr. Bridget Behe and Kristin Getter of Michigan State University provided both consumer and producer survey support to determine consumer familiarity with our products and campaign as well as producers' feedback on the campaign. The same 37 item questionnaire that was developed for this campaign last year was used to measure attitudes of Michigan residents about their Christmas decorating and other related activities. The instrument was reviewed and approved by the Michigan State University Committee for Research Involving Human Subjects (IRB#11-846). Market Tools was sub-contracted to collect approximately 500 responses from Michigan residents for the online survey. In October 2011, 644 responses were collected from Michigan residents, and in January 2013, 581 responses were collected.

Roughly, one third of the sample was from the Greater Metro Detroit region, one third was from the Greater Grand Rapids region, and one third was from the remainder of the state. Ninety-three percent had a real, live, or artificial Christmas tree in 2011. 30% purchased a Christmas tree in 2011 and, of those, 66.3% were cut or live with 32.6% artificial. This reflects a slight increase in fresh trees purchased from 2010. There was a slight (2%) increase over the 2011 survey in the number of respondents indicating that that purchased a poinsettia or other living

plant for the holiday season. There was a significant increase (from 27.9% to 36.5%) of those who reported purchasing a poinsettia as a gift.

Attitudinally, the campaign achieved a positive result. Two questions were concerned with "Buying a live Christmas tree (or poinsettia) supports Michigan businesses and farmers." We documented a positive increase in level of agreement which can be, at least in part, attributed to the success of the "Make it a Real Michigan Christmas." This was a key talking point of the campaign.

Table 11. Changes in tree numbers sold or harvested.

# Respondents	% Change	Amount of Change
5	15.2%	6-67% decrease
8	24.2%	0-5% increase
16	48.5%	6 to 67% increase
3	9.1%	108 to 370% increase
1	3.0%	not enough information
33	100.0%	

On the average, there was a numerical increase in the average number of trees sold. However, the variation in total tree sales/harvests between growers was considerable. Statistically, the sample size would need to be much larger to report any significant increase.

Dr. Bridget Behe of Michigan State University, who oversaw the above surveys, also prepared a brief grower and retailer survey for poinsettia and Christmas tree growers and retailers. 81 % of Christmas tree growers who responded to the survey reported an increase in sales in 2012, with a wide range of percentage increase. Many of the responding Christmas tree growers and retailers reported using the "Make it a Real Michigan Christmas" point of sale items (primarily the banner) and indicated that the campaign and banner were useful. Responses from the poinsettia growers were not great enough to produce a significant result.

Website Management and Point of Purchase Materials: Web Zone Marketing was contracted once again to update the existing website: www.realmichiganchristmas.com. The website served two primary purposes; to provide consumer information on the care and use of Michigan-grown Christmas trees and poinsettias as well as where to purchase these products, and as a resource for those in the media to access press kits, story ideas and campaign images.

The visually attractive website addresses the three key benefits of Michigan-grown Christmas trees and poinsettias: good for the local economy, a mood booster and the environmentally friendly choice. The website answers basic consumer questions on care of these products and addresses common myths regarding poinsettias (they are not poisonous) and Christmas trees (they are not bad for the environment).

Further, the website directed consumers where to purchase Michigan-grown poinsettias and Christmas trees. A simple re-direction to the MCTA website (www.mcta.org) effectively addressed those consumers looking for a Christmas tree. Identifying retail locations to purchase Michigan-grown poinsettias was accomplished by compiling lists from the Michigan Floral Association and individual poinsettia growers.

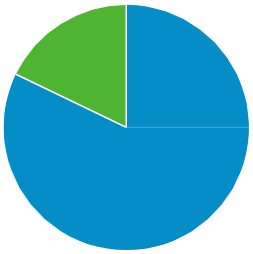
The website features a section for press releases and backgrounders for members of the media looking for story ideas, as well as an “In the News” section that provided links to some of the best campaign stories. The 30 second and humorous 60 second PSA are also available for preview on the website.

The homepage of the campaign website included cycling photos of Christmas trees and poinsettias.

At the completion of the holiday season, Web Zone Marketing was able to provide information on the activity and traffic of the website using Google Analytics. Although we would have preferred more “hits” to the website, traffic was clearly influenced by media appearances.

1,369 people visited this site

New Visitor 17.9%



Returning Visitor 82.1%

Visits
1,651

Unique Visitors
1,369

Pageviews
4,178

Pages I Visit	Avg. Visit Duration	Bounce Rate	% New Visits
2.53	00:01:40	38.16%	82.13%

Audience Overview - Google Analytics

Many of the point-of-sale items were able to be used by retailers, greenhouses and tree lots and farms from the previous year; however we printed a limited quantity of additional posters and banners for wider distribution among retail outlets as well as at some of the high visibility events. These items were again printed by MasterTag and no design changes were made. New for 2012, we designed, produced and distributed 173,000 “statement stuffers” that featured the campaign logo and a message about purchasing Michigan-grown Christmas trees and

poinsettias. These were put in October and November billing statements by approximately 220 Michigan retail florists. Rod Crittenden coordinated the design, printing and distribution of the inserts which were printed by ASAP Printing in Okemos, MI.

Michigan's poinsettia growers were interested in using the campaign logo on their printed materials and pot tags; however they didn't seem to use many of the pre-printed poinsettia pot stickers. For that reason, the campaign provided the campaign logo and printable designs to the poinsettia growers on flash drives that were shipped directly to the growers.

Goal: As stated in our original proposal, the primary objective of the campaign was to increase awareness of Michigan-grown Christmas trees and poinsettias by Michigan consumers. This outcome was successfully achieved by considering the following:

Performance Measures

- The PSA radio campaign aired our message at least 4,477 times on radio stations around the state during the November through December timeframe. Although we cannot confirm total audience of these messages, a strong example of the reach of this campaign would be the 139 airings of the message on WJR radio in Detroit. The listener base of WJR is between 38,000 and 43,000 for the Paul W. Smith and Frank Beckmann shows.
- The media relations campaign secured 23 television placements of the campaign for a total of 75 on-air minutes. The addition of seven radio interviews brings the total broadcast impressions to more than 1,155,584. (Impression data for 9 of the segments was not available).
- The media relations campaign also secured more than 400,000 print and 35.3 million online impressions.
- More than 200,000 visitors to Ford Field were exposed to the campaign through posters and banners displayed by the Detroit Lions Christmas tree.
- More than 200 of Michigan's florists shared the campaign "statement stuffer" with their clients with a total of 173,000 being printed. Even if only 80% were used, that is a reach of 138,400 residents.
- According to the consumer surveys executed by Dr. Behe at Michigan State University, 3.3 – 5% of respondents were aware of the "Make it a Real Michigan Christmas" campaign. If this number (5%) is extrapolated to the population of Michigan (9.883 million; US Census), the campaign reached approximately 494,181 Michigan residents after just two promotional seasons.

The target for the campaign was an increase in consumer understanding of the environmental and economic benefits provided by real Christmas trees and poinsettias by 10% after the 2012 holiday season. Although a 10% increase was not realized, there were positive attitudinal changes:

- Regarding the environment, there was a very little change is responses from before the campaign to the completion on the environmentally-friendly nature of real Christmas trees. Although responses averaged 2.99 on a scale of one (strongly disagree) to five (strongly agree) that real Christmas trees are environmentally friendly, there was little to no demonstrable improvement.
- However, the message of supporting the state's economy by purchasing locally grown Christmas trees and poinsettias did show a marked increase. In the first survey (Oct. 2011) using the same five point scale, consumers went from 3.89 agreement factor for

Christmas tree supporting the state's economy to 4.11, 4.11 and 3.95 in subsequent surveys. This would equate to an approximately 5%increase in understanding by consumers. Poinsettias experienced a significant increase as well, going from 3.64 in the first (Oct. 2011) survey to 3.86, 3.87 and 3.72 in subsequent surveys. This also equates to a nearly 5% increase in consumer understanding. Again, the complete report of survey results is attached as an addendum to this report.

LESSON LEARNED

As we experienced the previous year, the timing of notification of grant approval and the execution of a holiday campaign proved to be one of our biggest challenges. However, with the campaign theme, logo and point of sale materials previously developed, we had fewer things to worry about in executing this year's campaign. We also had the advantage of past experience to help us in making strong media contacts and securing high visibility opportunities for the campaign.

We were disappointed in not being able to find a workable partnership with The Parade Company, the sponsor of America's Thanksgiving Day Parade. We spent much time and effort in securing this opportunity, when in the end, the visibility of the campaign and our products just didn't seem to justify the expense. However, it did allow us to put more resources toward the Detroit Lions and Eastern Market partnerships.

Our other disappointment was not being able to secure a relationship with Meijer stores in Michigan to display the campaign poster in their floral departments. Michigan's largest poinsettia producer, Masterpiece Floral, is their sole supplier and we thought that Meier was ready to join the campaign. In the end, they didn't feel that there was enough time to organize the poster display in their stores. This once again points to the timing issues of executing a campaign on relatively short notice.

After the 2011 campaign, it became apparent that the poinsettia growers were not interested in using the campaign logo sticker that we had produced, but instead wanted access to the campaign logo to include in their own printing. We were able to provide artwork and supporting materials to the poinsettia growers on flash drives that were prepared by MCTA staff and sent to MFGC members.

The most important lesson realized by this committee was the need to be flexible when working on a promotional campaign. When one promotional opportunity falls through, you need to be prepared to consider other options. We had situations where we didn't receive the expected media coverage, however found other opportunities where the media surpassed our expectations. We learned that partnering with a highly visible organization such as the Detroit Lions can be beneficial although it wasn't a panacea for promoting our industries. However, we never stopped looking for opportunities and relationships and we believe that helped to insure the success of the "Make it a Real Michigan Christmas" campaign.

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ADDITIONAL INFORMATION

Addendums included with this report:

- Public Service Announcement Summary Report
- Press Kit Sample
- Media Campaign Report
- Website Activity Report
- Expense Report

PROJECT TITLE **Michigan State University/Entomology, Reducing the Impact of Brown Marmorated Stink Bug on Michigan Fruit - FINAL**

PROJECT SUMMARY

The Brown Marmorated Stink Bug (BMSB) was recently detected in Michigan and poses a significant threat to specialty crops, particularly fruit crops. Michigan is a major producer of fruit, valued at $380 million annually. Many Mid-Atlantic growers have experienced a minimum of 25% crop damage with up to complete crop loss due solely to this invasive pest. If BMSB becomes established in MI and no management programs are developed, we estimate a minimum of $92 million in direct losses of sales for fruit growers. Our major project goal was to prevent the loss of fruit IPM programs due to widespread infestations of BMSB. We surveyed key "at-risk" crops including apples, peaches, cherry, grapes and blueberries to identify the presence of BMSB throughout the state. Over 400 individuals were captured in traps. This surveillance program identified key "potential invasion fronts". This allowed growers to preserve extant tree fruit IPM programs. Our second objective was to identify effective control treatments for MI tree fruit that fit into IPM programs. This work provided a foundation for updating BMSB control options in the Michigan Fruit Management Guide, E154. The final objective was to communicate results to Michigan growers, commodity groups, MDA personnel, and MSU extension educators. Up to date information has been provided to growers on the web, through MSU Ag News articles and presentations at meetings.

PROJECT APPROACH

Monitoring traps were deployed at more than 50 sites in 2013, spread across the Southeast, Southwest, West-central and Fruit Ridge production regions. Over 400 individuals were captured in traps. The majority of individuals were consistently caught in pheromone-baited traps. Adults and nymphs were captured. The most effective trap was the Rescue trapped baited with the BMSB aggregation pheromone plus a synergist. The only commercial fruit planting where BMSB was captured was at an apple site in the SW that was adjacent to soybean fields infested with BMSB adults and nymphs. Four new sites along the Michigan and Ohio border produced 20 positively identified individuals this spring. BMSB were not recovered this year from light or pheromone baited traps deployed in Kent, Ottawa, Newago, Oceana, Monroe, Macomb, Oakland, Genesee, Lenawee, Montcalm, Ionia, Leelanau, Benzie, or Grand Traverse counties. Most importantly, stink bug damage was not detected during our fruit inspections in commercial orchards. Additional finds in the state were made in urban sites. Individual BMSB have now been detected in 19 MI counties (see map). Up to date information has been provided to growers through MSU Ag News articles, presentations at meetings, and on the web at http://www.ipm.msu.edu/invasive_species/brown_marmorated_stink_bug or http://www.treefruit.msu.edu/.

A BMSB colony was maintained in a tightly controlled rearing facility at MSU. Developing potential controls entailed exposing lab-reared individuals to insecticides using a field-based bioassay. Apple or peach trees at the MSU Trevor Nichols Research Center (TNRC) were treated at the label rate with the insecticides selected for testing. Shoots were collected post-treatment (1 and 7 days), brought back to the lab and placed in water-soaked OASIS ssoral foam in clear plastic containers with lids. The foam was covered with sealing wax to preserve the integrity of the fruit and foliage. Adults (n=5) were placed in the containers and mortality assessed 1 and 3 days after exposure. In assay one conducted in June, apple trees at the TNRC were treated with Proclaim (emamectin benzoate) at 4.8 oz/acre, Venom (dinotefuran) at 6 oz/acre, Admire Pro (imidacloprid) at 2.8 oz/acre, or Warrior (lambda-cyhalothrin) at 5 oz/acre. In assay two conducted in July, peach trees were treated with Imidan 70 W (phosmet) at 3 lb/acre, DoubleTake 3 L (diflubenzuron) at 4 oz/acre, Danitol 2.4 EC (fenpropathrin) at 21 oz/acre, or Annihilate SP (methomyl) at 1 lb/acre. Mortality of BMSB adults exposed to treated shoots indicated significant impacts from Warrior in assay one, and DoubleTake, Danitol and Annihilate in assay two. Substantial mortality also was recorded for Venom and Imidan 72 hours after exposure. Proclaim was the only insecticide that did not kill BMSB, nor provide fruit protection. This work provided a foundation for updating BMSB control options in the Michigan Fruit Management Guide, E154.

GOALS AND OUTCOMES ACHIEVED

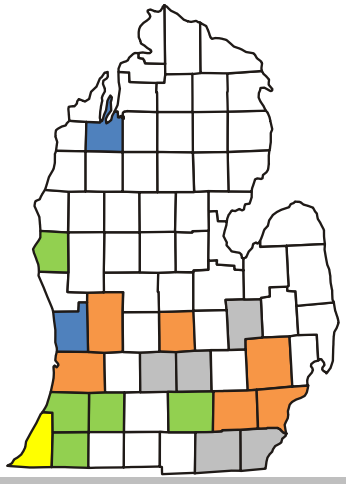
Activities completed: BMSB monitoring took place in the Southeast, Southwest, west-central and Fruit Ridge fruit production regions. Traps were deployed at more than 50 sites. This was supplemented with direct observations and sweep net sampling at over 20 sites. Identifying effective controls was accomplished by conducting field-based bioassays. Four effective compounds were identified. Control options for BMSB were updated in the Michigan Fruit Management Guide, E154.

Progress toward achieving outcomes: Although over 400 individuals were captured in traps, BMSB were not recovered during this project from traps deployed in Kent, Ottawa, Newago, Oceana, Monroe, Macomb, Oakland, Genesee, Lenawee, Montcalm, Ionia, Leelanau, Benzie, or Grand Traverse counties. The only fruit orchard where BMSB was captured in traps is at an apple site in the SW that is adjacent to soybean fields infested with BMSB adults and nymphs. Most importantly, stink bug damage was not found during our fruit inspections in commercial orchards. This allowed more than 500 tree fruit growers to preserve extant tree fruit IPM programs and maintain environmental, consumer and worker safety. No BMSB injury to fruit crops occurred.

Goals vs actual accomplishments: We accomplished all three established goals: 1) determining the distribution of BMSB in primary MI fruit growing regions, 2) determining effective control treatments, and 3) communicating results to Michigan growers, commodity groups, MDA personnel and MSU extension.

Baseline data to convey completion of achieving outcomes: The confirmed distribution of BMSB prior to the project was in 12 counties. It is now confirmed in seven additional counties, Grand Traverse, Ottawa, Jacksons, Oceania, Cass, Kalamazoo and VanBuren (Figure 1).

Figure 1 Brown marmorated stinkbug (BMSB) distribution in MI based on APHIS confirmed samples. BMSB first detected in 2010 (yellow), 2011 (gray), 2012 (orange), 2013 (blue) and 2014 (green).



BENEFICIARIES

Our findings were published in a timely manner:

Nielsen, A, M. Grieshop and L. Gut. 2014. Brown marmorated stinkbug. In Wise, J., L. J., Gut, R. Isaacs, A. M. C. Schilder, B. Zandstra, E. Hanson & B. Shane, eds. Michigan Fruit Management Guide, MSU Extension Bulletin E-154, pp. 69-70. Over 1000 copies were purchased by the fruit industry.

Mar 2014. Southeast MI Spring Tree Fruit Meeting. Flint, MI. *BMSB and SWD update.* Meeting attended by 65 growers.

Haas, M. and L. Gut. 2014. Brown marmorated stink bug spring update 2014. MSU Extension News for Agric. March 26. http://msue.anr.msu.edu/news/brown_marmorated_stink_bug_spring_update_2014

McGhee P. M. Haas, M. Whalon and L. Gut. 2013. Brown marmorated stink bug in Michigan fall 2013 Update. MSU Extension News for Agric. Sept 11. http://msue.anr.msu.edu/news/brown_marmorated_stink_bug_in_michigan_fall_2013_update

Haas, M., L. Gut, P. McGhee and M. Whalon. 2013. Brown marmorated stink bug in Michigan 2013 Update. MSU Extension News for Agric. March 6. http://msue.anr.msu.edu/news/brown_marmorated_stink_bug_in_michigan_2013_update

Dec 2013. Michigan State Horticultural Society. Grand Rapids, MI. Poster: *Monitoring for Potential Invasive Pests in Michigan Tree Fruits.* Meeting attended by 3000 growers.

Feb 2013. Michigan State University Tree Fruit IPM School: *Managing perennial pests in a season following no crop and in the context of new pest threats*; *Current status of Invasives in Michigan.* School attended by 45 growers or consultants.

Mar 2013. Southeast MI Spring Tree Fruit Meeting. Flint, MI. *New Fruit Invasive Pests – SWD and BMSB.* Meeting attended by 55 growers.

Feb 2013. Southwest Michigan Horticultural Days, Benton Harbor, MI. *Tree fruit insect management update.* Meeting attended by 75 growers.

Jan 2013. Northwest Michigan Horticultural Show, Acme, MI. *Life without AZM: Pest management options for cherry growers in 2013.* Meeting attended by 200 growers.

Our findings were presented to grower and industry groups at the major MI grower meetings in 2013 and 2014, including the Great Lakes Fruit, Vegetable, and Farm Market (GLFVFM) Expo (over 3500 attendees/year), and West Central, Southwest, and Southeast regional horticulture meetings with 50-300 attendees per meeting/year.

Meeting attendees and readers of the publications included more than 1500 MI apple, cherry, peach and blueberry growers, other industry stakeholders, MSU Extension Educators, and MDA personnel. Organizations supportive of the project and benefiting from the outcomes include the: Michigan Apple Research Committee, Cherry Research Committee, Michigan Peach Sponsors,

Horticultural Society, Michigan Blueberry Growers Association, MBG Marketing, and Michigan Agricultural Cooperative Marketing Association (MACMA).

LESSONS LEARNED

A major lesson learned is that blacklight trapping is an unreliable technique for BMSB monitoring. Attractant-baited pyramid traps are the best monitoring system. On the positive side, despite not having an established BMSB population in the state, we were able to gather valuable information on potential controls using a field-based bioassay and colony insects.

CONTACT INFORMATION

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ADDITIONAL INFORMATION

PROJECT TITLE Michigan Potato Industry Commission, Development of Baseline Soil Data as an Ecological Foundation to Revere Yield Decline in Michigan Potatoes

PROJECT SUMMARY

Potato production in Michigan (MI) is valued at $128 million and ranks seventh nationally. A grower survey identified an increase in soil-borne disease complexes and declining yields in parts of MI. This has raised concerns over the inability to serve high-demand chipping markets. Growers in MI identified soil microbial activity and diversity as important factors related to soil health and contributing to limiting yield. The amount of acreage affected by potato soil borne diseases increased by 11% or more over the last decade, but the soil ecology related to disease severity is not adequately understood. Soil samples from 26 fields (n=520) in potato production were taken and GPS marked in the fall/spring of 2012-13, and environmental DNA was extracted. Next generation DNA sequencing technology allowed simultaneous high throughput processing of samples. DNA sequences were identified at multiple taxonomic levels. Sequencing identity, soil properties and information gathered on yield and scab pressure was used to create GIS-based maps. This information allowed comprehensive mapping of potato production fields that will be used to develop predictive sub-field management tools. We will use this data to leverage matching funds with the goal of submitting a proposal to the USDA-NIFA Specialty Crop Research Initiative Program.

PROJECT APPROACH

The purpose of this project was to generate precise data through a grower web-based survey and to provide a foundation of information upon which recommendations can be made for production modifications to achieve higher yields. This will require the development of a database, correlation analyses, soil sampling, laboratory tests and comprehensive DNA analyses. The proposed project is an outgrowth of a January 11, 2012 meeting of a “soil ecology” group comprising growers, marketers, university specialists, consultants and professional agronomists to develop a strategy to reverse the declining-yield trend. The consensus of the group was that soil ecology has been negatively affected by a number of factors. These factors have created an imbalance in the soil microbial, microflora and microfauna populations.

The Michigan potato industry comprises approximately 43,000 acres, about three-fourths of which produce potatoes for processing and the rest for seed, or for the fresh market. About one-third of the state's production is concentrated in Montcalm County MI. The Michigan potato industry has been experiencing a period of declining yields. Quality problems have further reduced the marketable output. Many growers have a perception that formerly productive fields are no longer performing to expectations. They speculate about the causes but have no solid answers. The competition for land for rotation purposes is intense because farm owners forfeit government payments if land is put into non-program crops like potatoes. Therefore owners decline to lease to potato growers. Some acreage, particularly that owned by growers, goes into shorter rotations than are optimal. Potatoes are adapted to light soils with relatively low (within certain parameters) organic matter (OM), if OM falls too low, crop productivity can suffer. The soil-ecology group has concluded that soils have suffered from compaction, intensive use of pesticides and fertilizers which degrade soil organic matter and reduce the diversity of the microbial community, which is so vital for maintaining soil health.

A chronic condition in soils in which Michigan potatoes are grown is the bacterial disease common scab (*Streptomyces* spp.) and a syndrome termed potato early-die (PED) complex which involves interactions between fungi (*Verticillium* spp.) and the Root-Lesion Nematode (*Pratylenchus penetrans*). This project developed a systematic structure and an analysis of quantified information to move beyond a perception of productivity and quality problems to the realm of scientific documentation of the complex nature of potato fields. Because of recent industry expansion many growers are using fields that have been in potato production for a relatively short time. For purposes of the proposed study, acreages used would be categorized as mature potato fields (in production more than 15 years) and recently introduced potato fields (less than that threshold). This project did not build upon a previously funded project under SCBGP-FB or SCBGP.

Subsequent to completion of this project the potato industry in the Northwest (Idaho, Oregon and Washington) and stakeholders (e.g. ConAgra Foods, J.R. Simplot, Frito-Lay and McCain Foods) have become interested in replicating and building upon the Michigan Potato Industry's soil health initiatives. With this in mind we will use our tools, data, lessons learned from the past experience and resources to help in the submission of a USDA-NIFA planning grant proposal to the Specialty Crop Research Initiative Program. A letter of intent was submitted for the upcoming funding cycle (FY15). The ultimate goal is to develop a multi-state, multi-institutional Coordinated Agricultural Project or a Standard Research and Extension Project grant proposal to the USDA-NIFA Specialty Crop Research Initiative Program for the FY16 funding cycle.

A web-based survey of 10 Michigan potato growers was completed and selected results are included in the appendices (see Appendix I). Growers selected particular fields scheduled to be in potato production in 2013 from their operations as candidates for soil sampling and these fields were sampled during fall 2012 and spring 2013. Sections of approximately 50 acres of 20 fields affected by either PED or common scab that are considered relatively new or mature in terms of production, but that are severely affected by the diseases, were sampled in blocks of approximately 5-10 acres in size, each of which yielded 10 aggregated samples. The soil samples were analyzed at the soils laboratory of MSU's Department of Plant Soil and Microbial Sciences Soil Testing Laboratory. DNA was extracted from the samples and sequence analysis was completed (Kirk). The nematode and *Verticillium* levels were measured. Microbial populations were analyzed by Next-Generation Sequencing technology at Michigan State University's Research and Technology Support Facility (MSU-RTSF) and were processed in the laboratory of plant pathologist Dr. W. Kirk at MSU. A total of 564 samples were sequenced on the Illumina MiSeq platform. Potato tubers were harvested and evaluated for yield and visually examined for disease symptoms during the summer and fall of 2013. Disease symptoms on

potato tubers were scored based on established criteria. The high quality and complex data set will be used to inform future research. The potential use of the dataset to inform further management and expand our work into a tool that can easily be used by farmers is something we did not anticipate when starting this research.

GOALS AND OUTCOMES ACHIEVED

The outcome of this project was to work towards achieving short-term goals focused on sustainable potato production systems with an emphasis on crop and soil health. The results were integrated into a database that contained previous data from the Soil Testing Lab at MSU along with data from the DNA sequence analysis. Field boundaries and grid soil sampling schemes were mapped using Geographic Information Systems (GIS). Maps were generated for the grower's fields sampled (see Appendix II). The short-term goals achieved in this project were:

1) to better understand soil-borne pathogen inoculum levels in potato fields;
2) to better understand the soil biology and quantify soil microbial diversity and
3) to make correlations between yield and soil biological and physical factors.

In addition to soil interactions, the research team incorporated GIS to create predictive maps of entire fields from the known sample points using interpolation and geostatistical methods. After all data were collected, each field was examined individually for spatial continuity and variability of the sample points using geostatistical parameters. Data were then interpolated using various geostatistical mapping methods and visual correlations were made between yield and biological and physical soil properties (see Appendix III).

The mid-term goals were to use the procedures and methods developed during this study to build a framework on which to construct tools for understanding microbial interactions within soil as well as visualizing pathogen levels across fields as part of an integrated pest management system. Currently we are building capacity at MSU to host a centralized website to make the information available to the growers and stakeholders who participated in the project. Ultimately we would like to make the information available to the public. Moreover we are developing a program to automate the interpolation process and map-making pipeline and continue to evaluate different sampling schemes.

The long-term goals are to expand DNA based detection to map specific soil-borne pathogens of potato. We hope to incorporate predictive and conditional probability maps into integrated soil borne disease management in commercial potato production. The hope is the development of high throughput parallel pathogen detection coupled with sub-field management programing to develop disease management strategies growers can use to control soil borne pathogens of potatoes. In this way growers can input data collected in the field directly into a web based mapping service that allows them to easily visualize the soil properties of their fields and will allow them to manage portions of their potato fields as separate entities.

BENEFICIARIES

This program supported training of undergraduate, graduate students, postdoctoral researchers and future professionals in potato pathology. The direct beneficiaries of the project activities were potato growers, potato chip processors and Michigan potato industry stakeholders who participated in the initial survey and some or all of the various activities during the project. They benefited by learning more about soil health in specialty crop potato production through the interaction and open dialog among growers, processors and research experts involved with the Michigan potato industry. Attendance numbers for the events during the course of the project are listed below:

Event	Date	Attendance
Montcalm Field Day	August 7, 2013	70
Summer Potato Program	August 27, 2013	20
UP Potato Field Day	August 28, 2013	60
Chip Processors Tour	September 4-5, 2013	9
Winter Potato Conference	February 10-11, 2014	206

LESSONS LEARNED

Sampling was delayed due to early onset of winter conditions in the Upper Peninsula and northern Lower Peninsula. The Upper Peninsula fields were sampled in the spring. Four of the 26 fields selected for soil sampling were not included in yield and disease evaluations because they were not planted in potato or they were harvested concurrently while other fields were being evaluated. The amount of data and information generated will be sufficient in generating baseline data. The utility of the ABC database was compromised, as the data were incompatible with the database software used in our program, however this was an in-kind contribution and did not affect the overall outcome of the project. This may not affect the outcome of the project, as the quality of data was incompatible with the robust nature of the dataset generated at MSU. Considerable funding has been added to the project from the Kirk lab to address *Verticillium* spp. and nematode sampling that was not covered in the initial budget. The cost however of the intensive sampling for PED risk was unforeseen and we cut back to sampling 50% of the locations within each field to determine risk. Kirk has contributed ca. $7500. In addition, Kirk has contributed to the project by purchasing SST software and GPS devices that enabled mapping of growers fields; an additional ca. $7500. These actions taken improved the quality of data for the project and will enhance the interpretation of the results for the industry. DNA sequencing was delayed due to the fact that the platform (Illumina MiSeq) only came online at the MSU-RTSF in late mid-summer. This project was the first on campus to employ this technology and have validated the protocol for implementing this sequencing technology. The switch to the new sequencing platform has enabled “deeper” sequencing of the soil DNA sampling and a more comprehensive census of the soil microbial communities. Additionally the amount and unique nature of data generated has proven to be challenging to make accessible on a centralized website/database for public consumption.

CONTACT INFORMATION

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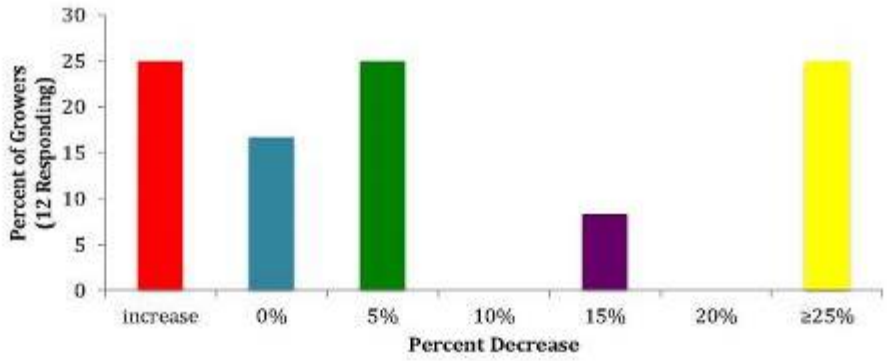
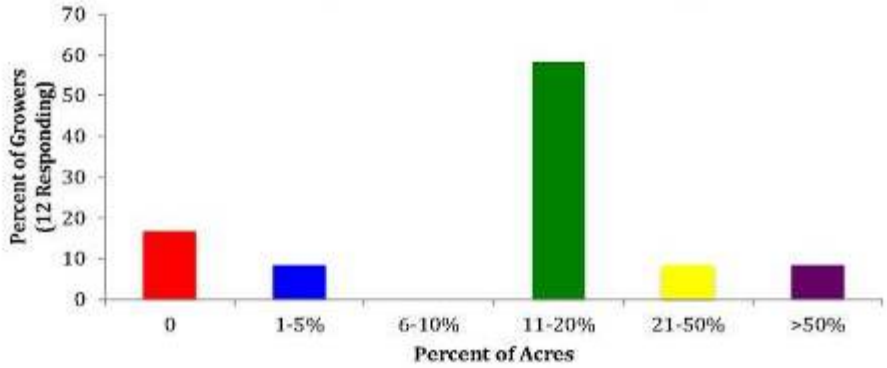
See next page.

Appendix I. Web-based grower survey results

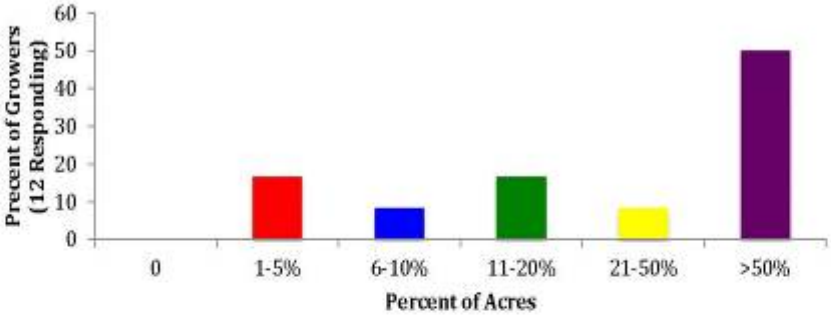
Level of Decrease in Sold Yield Acres Over Last 10 Years



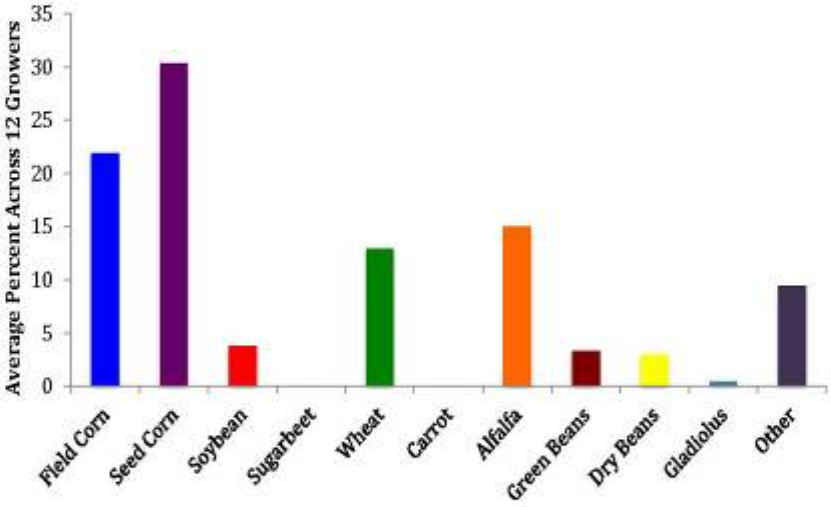
Percent of Acres Affected by Common Scab Compared to 10 Years Ago



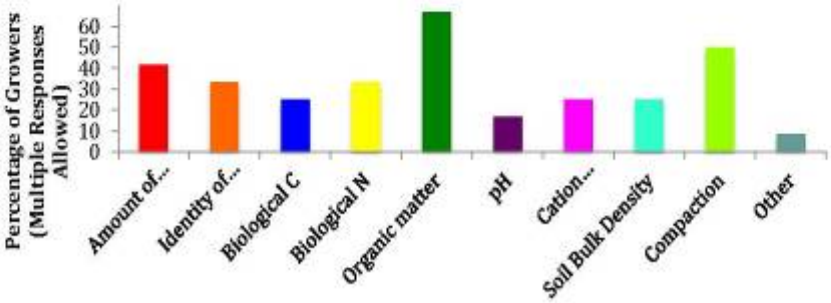
Perecentage of Acres Affected by Potato Early Die

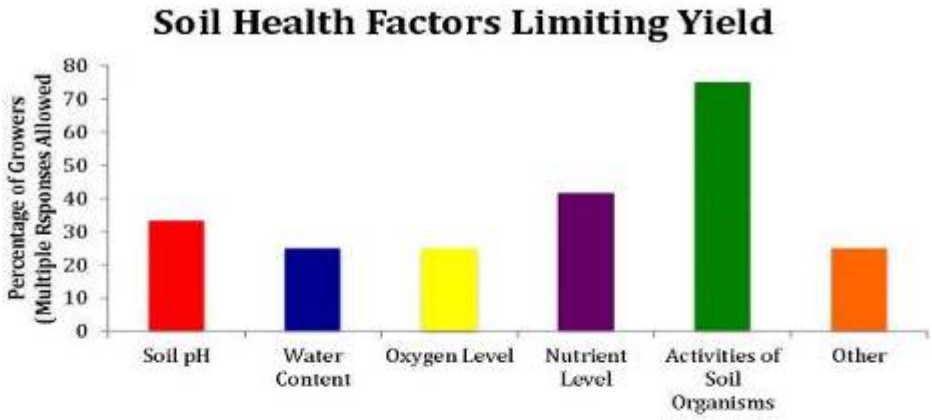


Rotation Crops Prior to Potatoes



Soil Quality Factors Limiting Yield



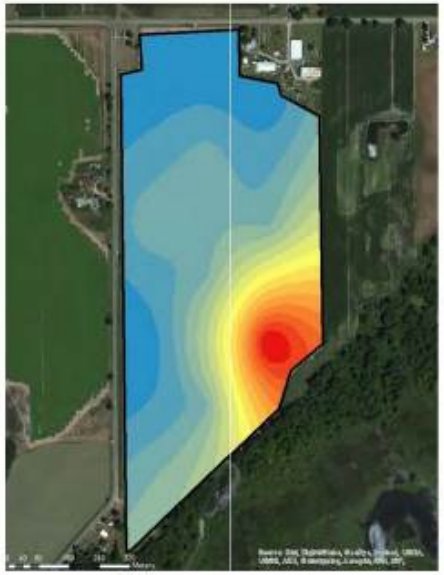

Soil Health Factors Limiting Yield
Percentage of Growers (Multiple Rsponses Allowed)
80
70
60
50
40
30
20
10
0
Soil pH
Water Content
Oxygen Level
Nutrient Level
Activities of Soil Organisms
Other

Appendix II. GIS based contour maps

Soil Types

- Histosols and Aquents, ponded (0.01 ha)
- Oshtemo sandy loam, 0 to 6 percent slopes (10.63 ha)
- Spinks loamy sand, 0 to 6 percent slopes (18.79 ha)

pH

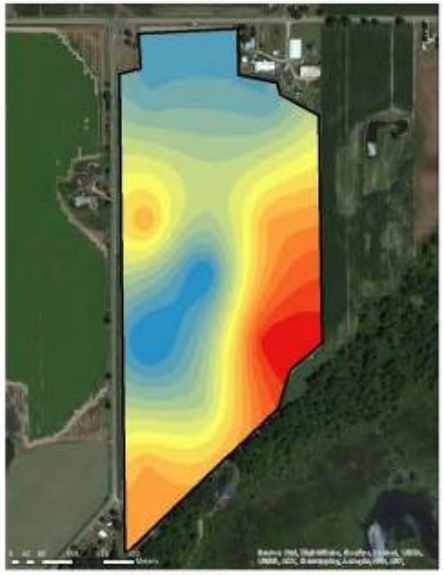


pH

pH Units

6.297585981 - 6.330031166
6.330031167 - 6.367111419
6.36711142 - 6.401874138
6.401874139 - 6.436636857
6.436636858 - 6.476034606
6.476034607 - 6.515432354
6.515432355 - 6.554830102
6.554830103 - 6.594227851
6.594227852 - 6.633625599
6.6336256 - 6.673023347
6.673023348 - 6.717056125
6.717056126 - 6.758771388
6.758771389 - 6.798169136

Liming Index



Liming Index

pH Units

7.128675657 - 7.171598788
7.171598789 - 7.218088846
7.218088847 - 7.278906615
7.278906616 - 7.346868238
7.346868239 - 7.414829862
7.414829863 - 7.482791486
7.482791487 - 7.550763109
7.55075311 - 7.615137805
7.615137806 - 7.679522501
7.679522502 - 7.74033027
7.74033027 - 7.797561111
7.797561112 - 7.851215024
7.851215025 - 7.904868937
7.904868938 - 7.957138271

Appendix II. GIS based contour maps

Soil Types

- Histosols and Aquents, ponded (0.01 ha)
- Oshtemo sandy loam, 0 to 6 percent slopes (10.63 ha)
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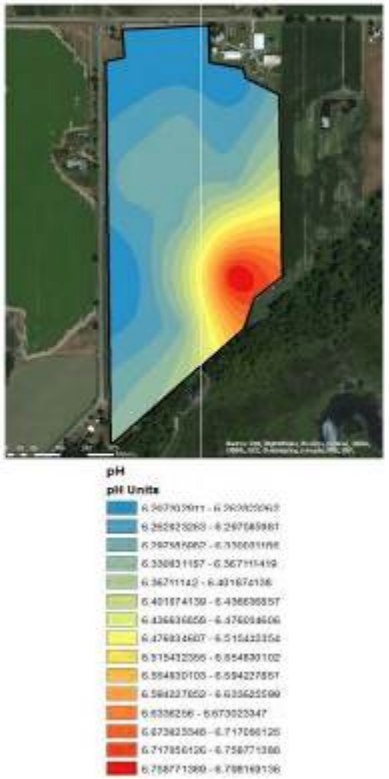
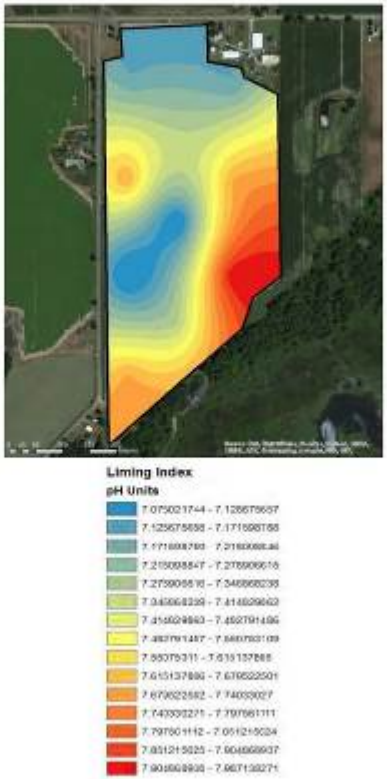
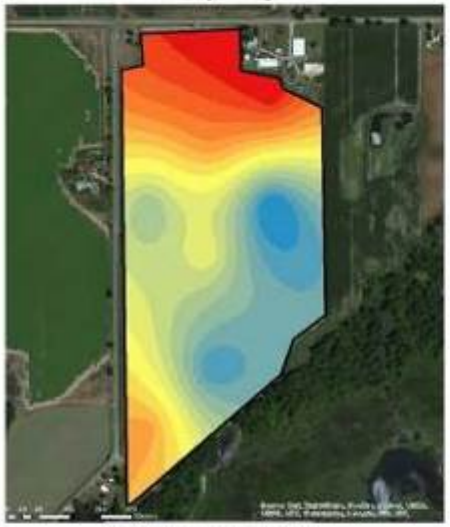
pH



Liming Index



Cation Exchange Capacity

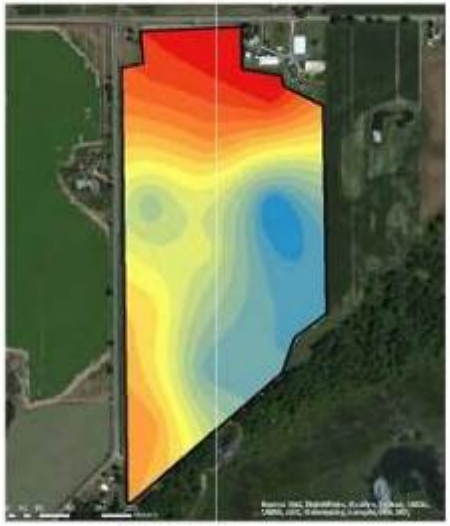


Cation Exchange Capacity

meq

- 2.59465003 - 2.809313145
- 2.809313146 - 2.916644702
- 2.916644703 - 3.02397626
- 3.023976261 - 3.130676638
- 3.130676639 - 3.279920743
- 3.279920744 - 3.395508574
- 3.395508575 - 3.527609852
- 3.527609853 - 3.684478151
- 3.684478152 - 3.933091077
- 3.933091078 - 3.965191455
- 3.965191456 - 4.105548107
- 4.105548108 - 4.27067358
- 4.270673581 - 4.427542779
- 4.42754278 - 4.576155705
- 4.576155706 - 4.686998609

Organic Matter

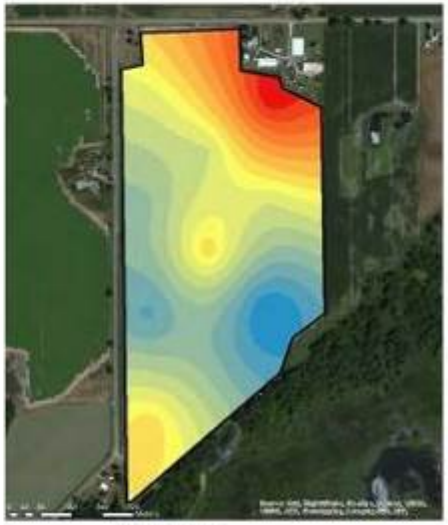


Organic Matter

Percent

- 0.903951049 - 0.961272729
- 0.961272730 - 0.994027975
- 0.994027975 - 1.034972032
- 1.034972033 - 1.086634506
- 1.086634506 - 1.138696978
- 1.138696979 - 1.179641036
- 1.179641036 - 1.220585092
- 1.220585093 - 1.266868357
- 1.266868358 - 1.316121226
- 1.316121227 - 1.362524491
- 1.362524492 - 1.411657361
- 1.411657361 - 1.460790229
- 1.460790230 - 1.512852701
- 1.512852702 - 1.56178557
- 1.561785571 - 1.600000024

Phosphorus

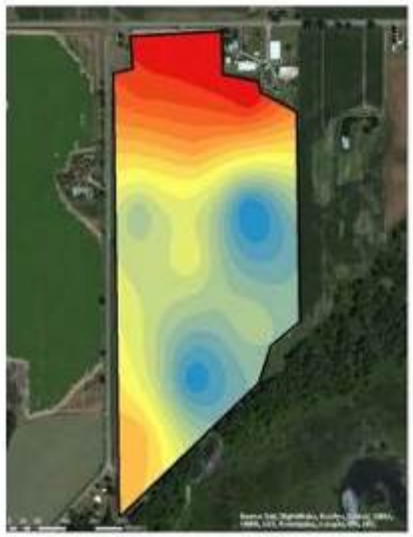


Phosphorus

ppm

- 66.51524353 - 71.69485492
- 71.69485493 - 75.36374631
- 75.36374632 - 78.81682057
- 78.81682058 - 81.83826056
- 81.83826056 - 85.07551766
- 85.07551767 - 88.31277478
- 88.31277479 - 91.55003189
- 91.55003319 - 94.35565473
- 94.35565474 - 97.59291184
- 97.59291185 - 101.4776204
- 101.4776205 - 105.362329
- 105.362329 - 109.2470375
- 109.2470376 - 113.131746
- 113.1317461 - 117.2332717
- 117.2332718 - 121.3327974

Calcium

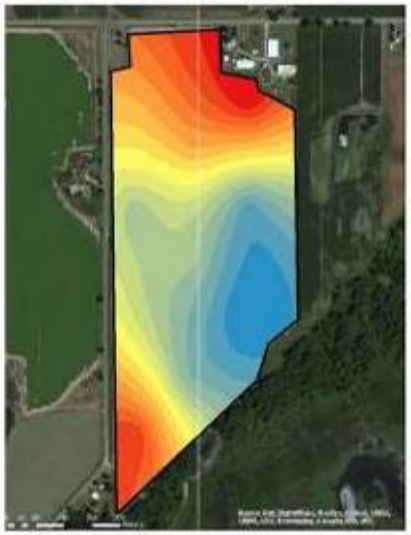


Calcium

ppm

- 381.4757588 - 413.1368539
- 413.136834 - 430.1288493
- 430.1288494 - 444.6379293
- 444.6379294 - 459.5470093
- 459.5470094 - 475.367557
- 475.3675571 - 491.2281047
- 491.2281048 - 509.3315877
- 509.3315878 - 531.9609416
- 531.9609417 - 553.4988277
- 553.4988278 - 573.6252463
- 573.6252463 - 593.0601968
- 593.060197 - 613.4266154
- 613.4266155 - 633.7930338
- 633.793034 - 654.1594523
- 654.1594524 - 675

Magnesium

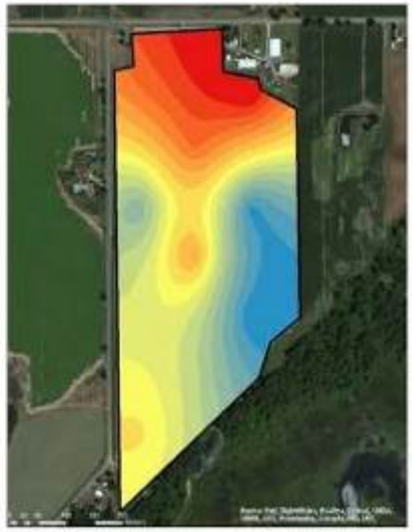


Magnesium

ppm

- 53.12823723 - 56.35975441
- 56.35975442 - 59.232223
- 59.23222301 - 62.46375017
- 62.46375018 - 65.67489663
- 65.67489664 - 68.74727523
- 68.74727524 - 71.26068526
- 71.26068526 - 74.13015365
- 74.13015366 - 77.18515173
- 77.18515174 - 80.23714962
- 80.23714963 - 83.2891475
- 83.2891475 - 86.34114538
- 86.34114539 - 89.21361398
- 89.21361399 - 92.08608258
- 92.08608259 - 95.13808046
- 95.13808047 - 98.9061955

Potassium

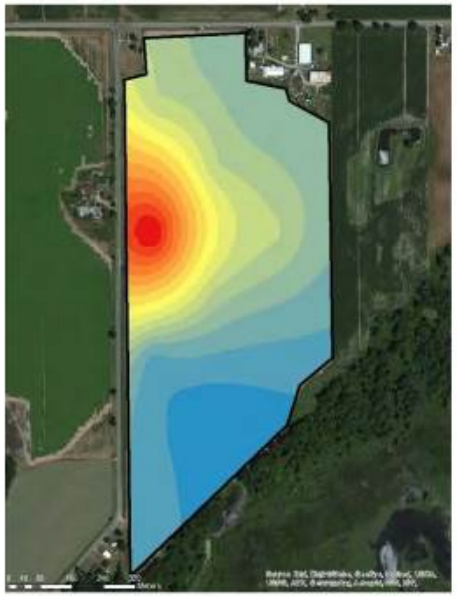


Potassium

ppm

- 76.65906525 - 83.65033225
- 83.65033226 - 92.63910412
- 92.63910413 - 102.1272522
- 102.1272523 - 111.1160241
- 111.1160242 - 119.6054197
- 119.6054198 - 127.5964391
- 127.5964392 - 134.5867962
- 134.5867963 - 142.0773494
- 142.0773495 - 150.566745
- 150.5667451 - 160.0548631
- 160.0548632 - 168.5430412
- 168.5430413 - 176.531813
- 176.5318131 - 187.5205849
- 187.520585 - 196.5089806
- 196.5089807 - 204

V. dahliae

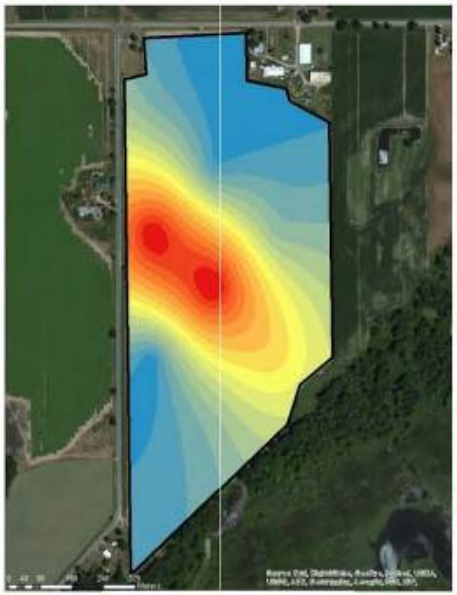


Verticllium Levels

CFU/10g Soil

- 0 - 0.582949793
- 0.582949793 - 1.237770232
- 1.237770233 - 1.854071822
- 1.854071823 - 2.393335713
- 2.393335714 - 2.894080755
- 2.894080756 - 3.471863495
- 3.471863496 - 4.126683934
- 4.126683935 - 4.781504374
- 4.781504375 - 5.474843662
- 5.474843663 - 6.168182951
- 6.168182952 - 6.861522239
- 6.86152224 - 7.554861528
- 7.554861529 - 8.209681967
- 8.209681968 - 8.864502406
- 8.864502407 - 9.82747364

Root-Lesion Nematode

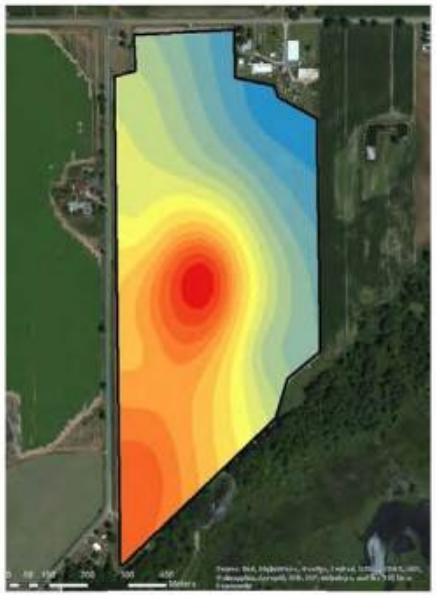


Root Lesion Nematodes Levels

Per 10/g Soil

- 0- 2.074823043
- 2.074823044 - 4.956653637
- 4.956653638 - 8.22272831
- 8.222728311 - 11.68092502
- 11.68092503 - 15.33124378
- 15.33124379 - 18.59731845
- 18.59731846 - 21.67127108
- 21.67127109 - 24.74522372
- 24.74522373 - 27.81917636
- 27.81917636 - 31.08525102
- 31.08525103 - 34.3513257
- 34.35132571 - 37.42527833
- 37.42527834 - 40.30710892
- 40.30710893 - 43.18893952
- 43.18893953 - 48.18411255

Yield

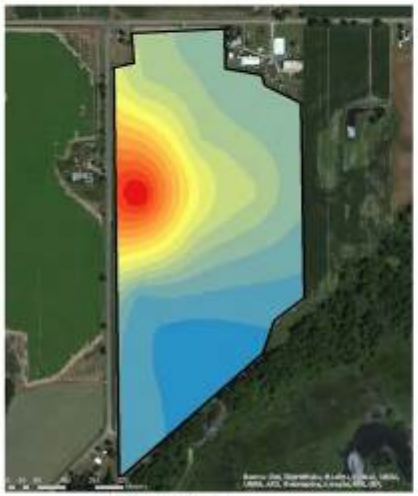


US#1

t/ha

- 26.25344066 - 27.47623901
- 27.47623902 - 28.77096647
- 28.77096648 - 29.92183533
- 29.92183534 - 31.07270418
- 31.07270419 - 32.29550234
- 32.29550235 - 33.44637119
- 33.4463712 - 34.66916935
- 34.66916936 - 35.96389681
- 35.96389682 - 37.33055357
- 37.33055358 - 38.48142242
- 38.48142243 - 39.41650337
- 39.41650338 - 40.27965501
- 40.27965502 - 41.43052386
- 41.43052387 - 42.79718062
- 42.79718063 - 44.58541321

V. dahliae

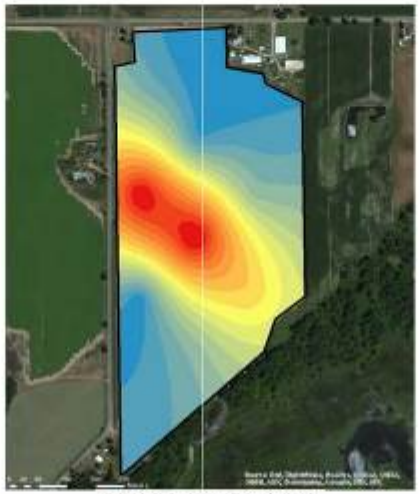


Verticillium Levels

CFU/10g Soil

- 0 - 0.582946790
- 0.582946790 - 1.237770232
- 1.237770232 - 1.854071822
- 1.854071822 - 2.393335713
- 2.393335714 - 2.894860755
- 2.894860756 - 3.471863495
- 3.471863496 - 4.126683934
- 4.126683935 - 4.781504374
- 4.781504375 - 5.474843662
- 5.474843663 - 6.168182951
- 6.168182952 - 6.861522239
- 6.861522224 - 7.554861526
- 7.554861526 - 8.209681867
- 8.209681868 - 8.864502408
- 8.864502407 - 9.62747364

Root-Lesion Nematode

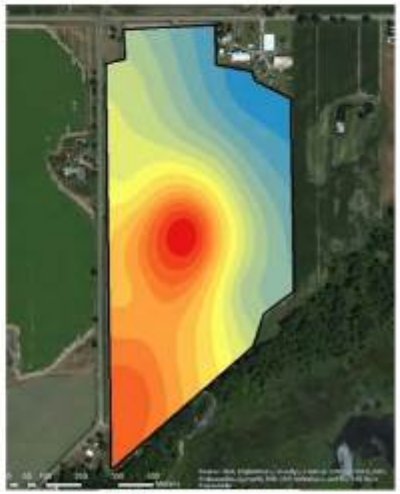


Root Lesion Nematodes Levels

Per 10/g Soil

- 0- 2.074823043
- 2.074823044 - 4.999653637
- 4.999653638 - 8.22272631
- 8.222726311 - 11.68092502
- 11.68092503 - 15.33124378
- 15.33124379 - 18.59731846
- 18.59731846 - 21.67127168
- 21.67127169 - 24.74522372
- 24.74522373 - 27.81917635
- 27.81917636 - 31.08525102
- 31.08525103 - 34.3513257
- 34.35132571 - 37.42527838
- 37.42527834 - 40.30710892
- 40.30710893 - 43.18809952
- 43.18809953 - 46.18411255

Yield

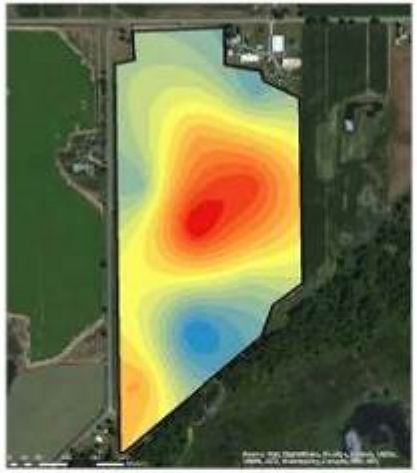


US#1

t/ha

- 26.2534.6066 - 27.47623901
- 27.47623902 - 28.77096647
- 28.77096648 - 29.92183533
- 29.92183534 - 31.07270418
- 31.07270419 - 32.29550234
- 32.29550235 - 33.44637119
- 33.4463712 - 34.66916935
- 34.66916936 - 35.96389681
- 35.96389682 - 37.33055357
- 37.33055356 - 38.48142242
- 38.48142243 - 39.41650337
- 39.41650336 - 40.27965501
- 40.27965502 - 41.43052386
- 41.43052387 - 42.79718062
- 42.79718063 - 44.58541321

Acidobacteria

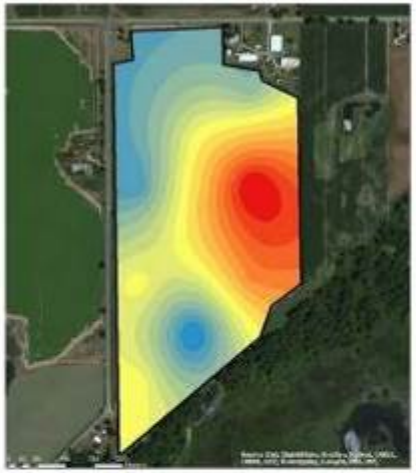


Acidobacteria

Taxa per 0.5/g Soil

- 164.4451752 - 176.8739719
- 176.8739719 - 189.3027687
- 189.3027687 - 197.7420984
- 197.7420984 - 206.0667049
- 206.0667049 - 213.8360563
- 213.8360563 - 221.6054084
- 221.6054084 - 229.3747605
- 229.3747605 - 238.2540201
- 238.2540201 - 247.6882133
- 247.6882133 - 256.5674729
- 256.5674729 - 266.0017661
- 266.0017661 - 275.4359194
- 275.4359194 - 284.3151789
- 284.3151789 - 292.6394847
- 292.6394847 - 300.0189374

Actinobacteria

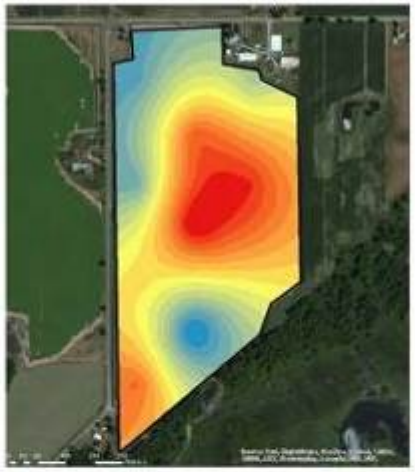


Actinobacteria

Taxa per 0.5/g Soil

- 154.9639605 - 155.9430159
- 155.943016 - 166.6836212
- 166.6836213 - 176.7721457
- 176.7721458 - 188.412751
- 188.412751 - 200.0533562
- 200.0533563 - 211.6939615
- 211.6939616 - 222.5585264
- 222.5585265 - 235.7512123
- 235.7512124 - 250.466079
- 250.466791 - 264.4647053
- 264.4647054 - 277.6573912
- 277.6573913 - 290.0740368
- 290.0740369 - 301.7146421
- 301.7146422 - 313.3552473
- 313.3552474 - 332.7562561

Proteobacteria

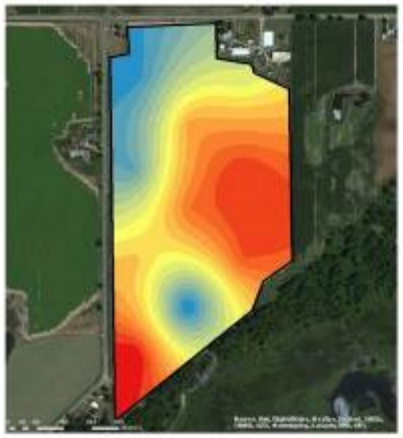


Proteobacteria

Taxa per 0.5/g Soil

- 398.7974243 - 455.9185576
- 455.9185577 - 487.4336636
- 487.4336637 - 515.0993651
- 515.0993652 - 542.5851045
- 542.5851046 - 572.1305153
- 572.1305154 - 603.6456263
- 603.6456264 - 637.1304286
- 637.1304286 - 666.6756423
- 666.6756424 - 698.1909533
- 698.1909534 - 731.6757525
- 731.6757526 - 763.1908605
- 763.1908606 - 792.7362743
- 792.7362744 - 822.281688
- 822.2816881 - 851.8271018
- 851.8271019 - 901.069408

Firmicutes

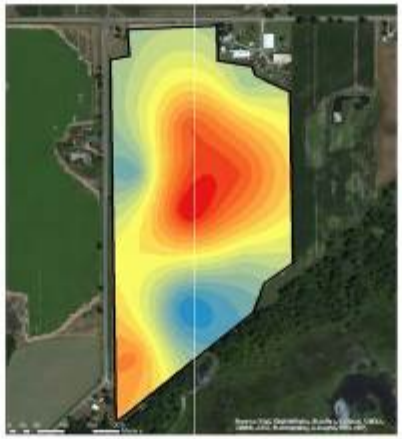


Firmicutes

Taxa per 0.5/g Soil

- 63.8601386 - 74.34079689
- 74.34079689 - 81.15727503
- 81.15727503 - 87.97375309
- 87.97375309 - 94.79023114
- 94.79023114 - 102.0327391
- 102.0327391 - 109.275247
- 109.275247 - 116.5177549
- 116.5177549 - 123.334233
- 123.334233 - 130.1507111
- 130.1507111 - 137.393219
- 137.393219 - 144.6357209
- 144.6357209 - 151.452208
- 151.452208 - 157.4166233
- 157.4166233 - 164.6591312
- 164.6591312 - 173.6057597

Verrucomicrobia

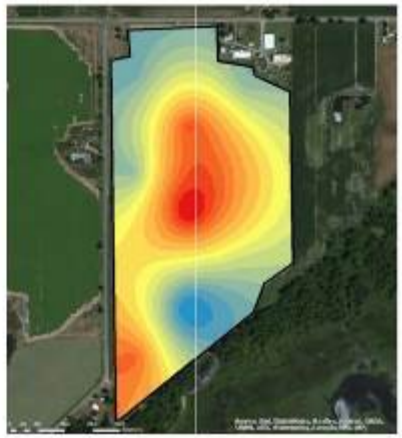


Verrucomicrobia

Taxa per 0.5/g Soil

- 63.13669968 - 75.24382223
- 75.24382223 - 83.45936979
- 83.45936979 - 90.57772556
- 90.57772556 - 96.96368413
- 96.96368413 - 102.9172454
- 102.9172454 - 108.8708068
- 108.8708068 - 115.4867653
- 115.4867653 - 122.3751211
- 122.3751211 - 128.8610796
- 128.8610796 - 135.7794354
- 135.7794354 - 142.6977912
- 142.6977912 - 150.0485442
- 150.0485442 - 156.5346028
- 156.5346028 - 162.5896441
- 162.5896441 - 172.9656970

Unclassified



Unclassified Microbial Phylum

Taxa per 0.5/g Soil

- 508.9541445 - 631.7079768
- 631.707877 - 703.5429236
- 703.5429237 - 793.3480738
- 793.3480738 - 918.4100919
- 918.410092 - 877.8153421
- 877.8153422 - 945.7070566
- 945.7070567 - 1.009.555539
- 1.009.55554 - 1.073.004321
- 1.073.004322 - 1.140.895738
- 1.140.895737 - 1.217.273915
- 1.217.273916 - 1.289.488861
- 1.289.488862 - 1.353.057344
- 1.353.057345 - 1.412.462594
- 1.412.462595 - 1.480.354389
- 1.480.35431 - 1.590.076345

Appendix III. Conditional probability map for *Verticillium dahliae*

Conditional probability map for *Verticillium dahliae* created using indicator kriging with a threshold value of 5 CFU/g. The area in red shows a 100% probability of being greater than the threshold while the blue area shows a 0% chance of being greater than the threshold value.

PROJECT TITLE Michigan Nursery & Landscape Association: Increasing the Economic Impact of Michigan's Nursery Crops - FINAL

PROJECT SUMMARY

The Michigan nursery, perennial plant production, Christmas tree, sod producers, landscaping and lawn care industries contribute $1.2 billion to Michigan's economy. Nursery and perennial plant producers generate about $291 million* in annual sales and distribute their products into 35 states, Mexico and Canada, making us the 2nd largest agriculture commodity group in Michigan and the 5th largest nursery industry in the nation. Our landscape contractors and designers generate $655 million** in annual sales, and our lawn service companies and sod growers have expenses that contribute $272 million*** to Michigan's economy.

Michigan's nurseries comprise the fourth largest agricultural commodity in the state and face enormous challenges in the wake of recent pest and disease disasters and the recession and decline in residential and commercial construction. Anecdotal evidence suggests a decrease in nursery sales, nursery producers, and nursery workers in subsequent years. The objectives of this proposal were to increase knowledge of, access to, and purchase of Michigan's nursery crops, which is critical to the long-term health of Michigan's nursery industry. An increased effort to market nursery crops is required as overall markets improve, providing Michigan growers with a competitive advantage as very few comprehensive sourcing guides exist in the nursery market and none exist to solely promote and market Michigan producers.

This project is an initiative designed to enhance the competitiveness of the nursery industry through marketing of our products and services to the end consumer, i.e. increasing plant sales in Michigan and increasing exports throughout the U.S. and internationally. The objectives of this proposal were to increase sales opportunities, increase distribution of crops and assist Michigan's nursery growers in their marketing efforts via these methods: online product/services catalog (Buyers' Guide), a locator for plants and their sources, and an inspiration gallery of videos and photos.

The immediate impacts of this project will be substantial. Not only does it give industry buyers and consumers a recognized and authoritative sourcing guide, it promotes the quality, variety and marketability of Michigan's nursery crops. At-will access to growers gives them the opportunity to update and promote materials as they become ready for market. Efforts to market this online tool will focus on volume buyers in and out-of-state such as landscape architects, city planners, municipalities, retail garden centers, wholesale distribution centers, commercial and residential landscape contractors, and consumers. Users can source hard-to-find crops and locate them in Michigan, resulting in an increased pool of buyers and a boost in sales volume. Increased profitability can create increased jobs along the entire distribution chain, from wholesale producers to retail establishments to installation companies. Additionally, Michigan green industry businesses, like landscape contractors and retail garden centers, as well as consumers, will have access to plant materials produced in Michigan.

*Michigan Rotational Survey Nursery and Christmas Tree 1999-2000
**MASS 2004 Economic Impact Study of Michigan Landscape Contractors and Designers
***MASS Michigan Rotational Survey Turfgrass 2002

PROJECT APPROACH

Results and accomplishments provided in Goals and Outcomes achieved.
The objectives of this proposal were to increase sales opportunities, increase distribution of crops and assist Michigan's nursery growers in their marketing efforts via these methods:

- Online product/services catalog (Buyers' Guide): This source guide is a collection and detailed description of every plant available for sale in Michigan.
- Locator for plants and their sources: This is a searchable online database for consumers to locate plants for their specific needs or landscape projects and where to purchase them, establishing Michigan's nurseries as the preferred resource for Michigan gardeners needing inspiration, information, advice and assistance.
- Inspiration gallery of videos and photos: Photos and descriptions of award winning projects to inspire consumers to become more active gardeners, thus increasing sales opportunities, increasing distribution of nursery crops and assisting Michigan's nursery growers in their marketing efforts.

- Grower surveys to be conducted post site launch via online survey methods and will request such feedback as:
    - Whether the grower is updating listings regularly
    - Quantify how many sales leads were generated
    - Calculate the dollar volume of sales as a result of the leads

Results will be used to strengthen site content and refine the marketing efforts for the site.

- Website traffic to the site will be measured using Google Analytics, which will provide details on the heaviest visited areas and will determine which method (browser and keyword search) visitors used to find the site (i.e. through traditional search engines). Data will be used to build upon the site beyond the scope of this grant.

- User surveys of buyers to be conducted post site launch and of consumers during the spring home and garden show circuit via online and face-to-face survey methods and will request such feedback as:
    - Where users found the site
    - If they found the information they were seeking
    - If they successfully purchased nursery crop from Michigan, and, if not, what kind of nursery crop they were looking for and where they ultimately located it.

Results will be used to strengthen the site's content and to communicate back to the grower industry potential areas for crop development.

- Website traffic to the site will be measured using Google Analytics, which will provide details on the heaviest visited areas and will determine which method (browser and keyword search) visitors used to find the site (i.e. through traditional search engines). Data will be used to build upon the site beyond the scope of this grant.

GOALS AND OUTCOMES ACHIEVED

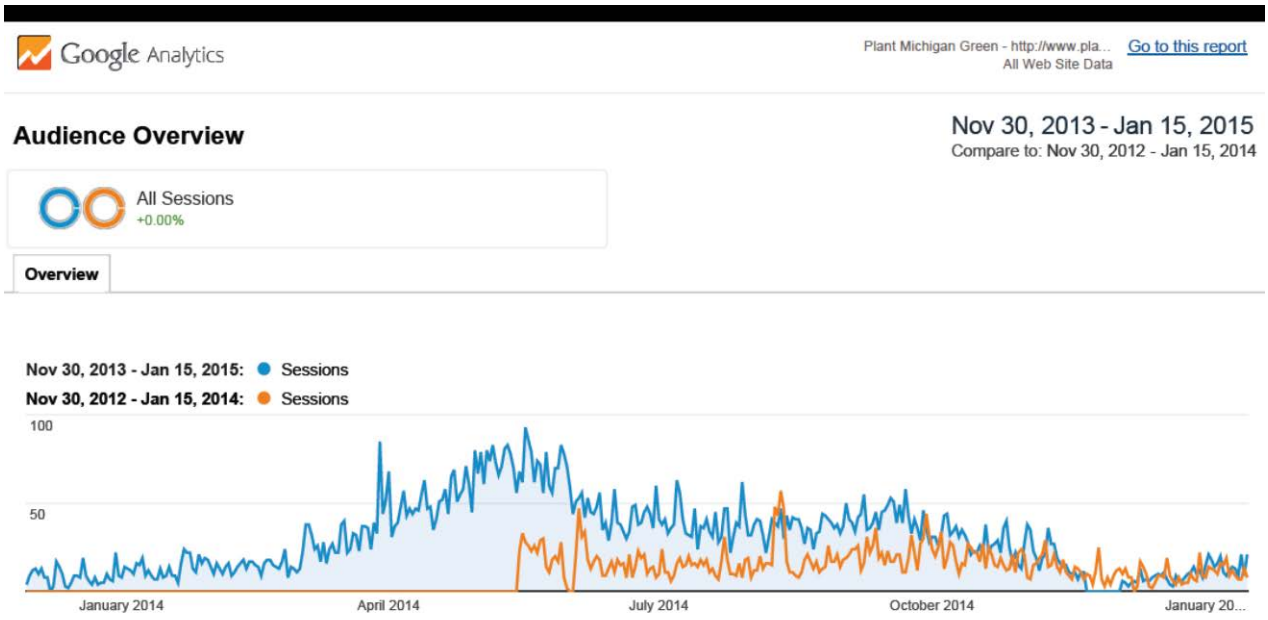
Programming of the platform to support the additional features on this site has been completed. The Member Proximity Locator, which drives the ability of consumers to locate specific types of service providers and products, has been completed. This locator serves as the foundation to support the searchable plant catalogs and the inspiration gallery. The Inspiration Gallery of photos is complete and is active for the spring season.

1) Online product/services catalog (Buyer's Guide):
This catalog is a database collection and detailed description of plants available for sale in Michigan. This catalog shows information and photos of each plant and the database is searchable by various selection criteria as defined with the database.

Performance Goals and Outcomes Achieved:

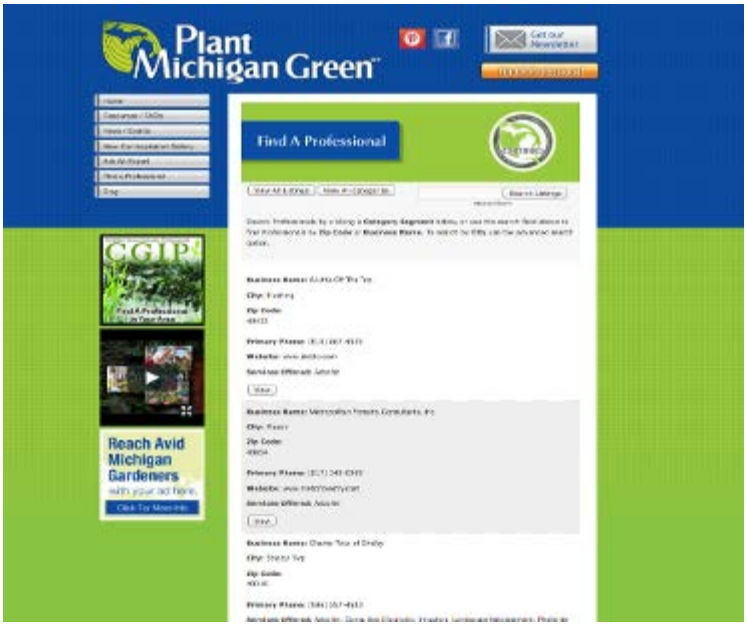
- Website revamped and relaunched using WordPress CMS platform, which will accommodate all future features and allow for easy modification of databases by individual end users such as growers and retailers. http://www.plantmichigangreen.com/favicon.ico
- Defined the fields that are included in the plant catalog database.
- Developed and approved layout for search page, search results page and individual product pages for the plant catalog.
- Wrote code, programmed and tested all of the needed pages to support the plant catalog database and interfaces with the Member Proximity Locator that provides results of queries by users.
- Uploaded plant information into the plant catalog database and completed testing of the database. Database currently has over 3,700 records in it.
- Will continue to search for and add photos to the plant catalog database.

ADDED:



2) Locator for plants and their sources:
A searchable online database was developed that provides the availability of plants in the plant catalog so consumers can locate retailers, or wholesale buyers can locate growers that have the plants they are interested in.

Retailers and landscape firms create a login and profile on the site. They select the plants that they carry from the searchable plant catalog. Consumers searching for plant information then have the option to find information about the plants and then select sources in their area that carry the plants they are looking for.



Growers create a login and profile on the site. They select the plants that they carry from the searchable plant catalog. Wholesale buyers searching for plant inventory can find sources that carry the products they are looking for.

Performance Goals and Outcomes Achieved:

- Completed Program Member Proximity Locator that provides the member search for all databases.
- Defined the fields that will be included in the Consumer / Retail & Grower / Wholesale Buyer database.
- Developed and approved layout for search page, search results page and individual product pages shown as the result of consumer inquiries.
- Developed and approved layout for search page and search results page for wholesale buyer inquiries.
- Retailer logins are active and retailers begin to populate their individual profile and the database with the plants that they carry so Member Proximity Locator can match retailer availability with consumers' requests.
- Programming and testing all of the needed pages to support the Grower/Wholesale database and results of queries by users is complete.
- Grower logins are active, and growers can begin to populate their individual profile and add the plants that they carry to the database.
- Created and disseminated materials to train growers on how to establish and update accounts with information to support the Member Proximity Locator and the Consumer/Retail & Grower / Wholesale Buyer databases.
- Conducted training seminar and individual training at the 2015 Great Lakes Trade Exposition for users on how to use the site and the advantages of participation**.**
- Promoted Plant Michigan Green Site at Consumer Gardening Shows to make consumers aware of the resources available to them to locate plants and sources for their gardening needs.

3) Inspiration Gallery of videos and photos:
The Photo Gallery provides photos and descriptions of award winning projects to inspire consumers to become more active gardeners, thus increasing sales opportunities, increasing distribution of crops and assisting Michigan's nursery retailers and growers in their marketing efforts.

Performance Goals Achieved:

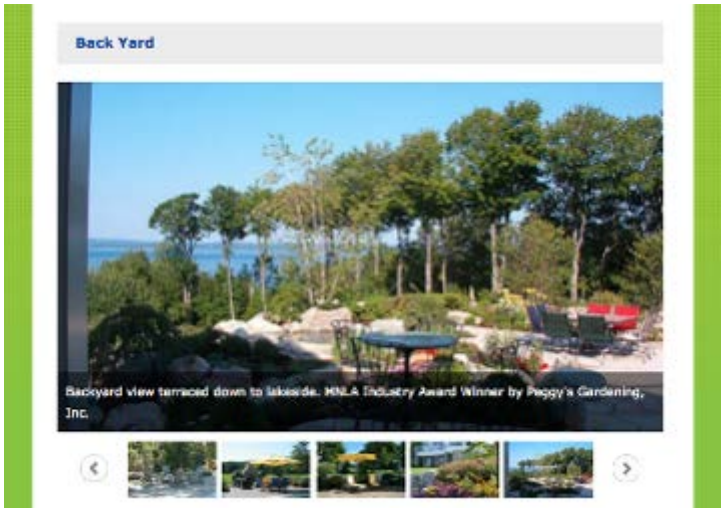
- Program gallery includes revolving image selections and descriptions in each of these areas:
  - Back Yard
  - Front Yard
  - Containers
  - Lighting
  - Patio – Deck – Seating
  - Pool Area
  - Rockscaping
  - Sculptures

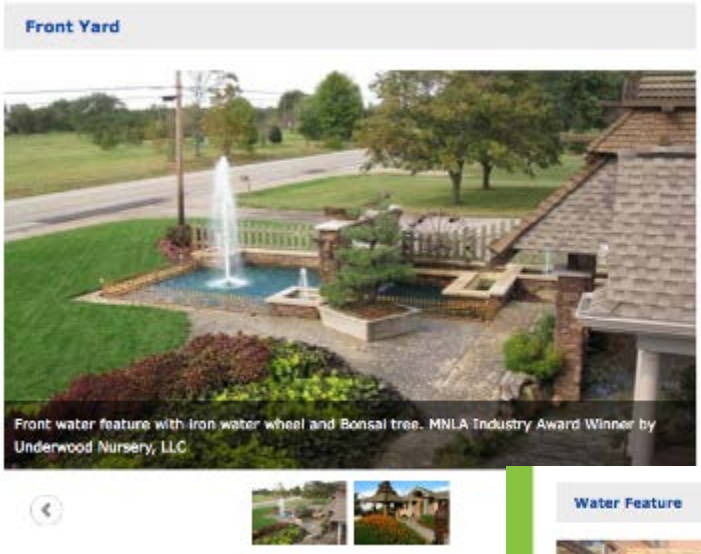
- Shade Garden
- Structures
- Sunny Garden
- Water Feature

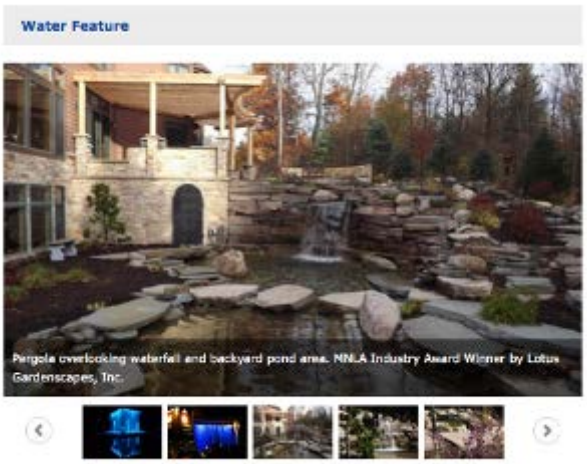
L***ong Term Outcome Measures:***

- User surveys of buyers will be conducted post site launch and of consumers during the spring home and garden show circuit via online and face-to-face survey methods and will request such feedback as:
    - Where users found the site
    - If they found the information they were seeking
    - If they successfully purchased nursery crop from Michigan, and, if not, what kind of nursery crop they were looking for and where they ultimately located it.

  Results will be used to strengthen the site's content and to communicate back to the grower industry potential areas for crop development.
- Website traffic to the site will be measured using Google Analytics, which will provide details on the heaviest visited areas and will determine which method (browser and keyword search) visitors used to find the site (i.e. through traditional search engines). Data will be used to build upon the site beyond the scope of this grant.







BENEFICIARIES

The results of this project will have direct and immediate impact to the over 1,525 licensed nursery producers (including container, field and greenhouse producers) in Michigan (MDARD 2011 Licensee List), with indirect impact to the 2,943 related green industry businesses. Only specialty crops benefitted from this project, and all funds granted were used to solely enhance the competitiveness of specialty crops.

LESSONS LEARNED

CONTACT INFORMATION

Michigan Nursery & Landscape Association
Amy Frankmann (517) 381-0437 Email: **amyf@mnla.org**

ADDITIONAL INFORMATION

PROJECT TITLE	Michigan Bean Commission, Expanded Research to Address Critical Issues Associated with Narrow Row Production of Dry Beans FINAL

PROJECT SUMMARY

Research will be designed to assess two critical issues identified in the past three years of dry bean narrow row research. One is black color retention in processed black beans and second is reducing potential yield losses due to white mold disease in narrow row dry bean production systems.

Major processors of black beans (Bush Brothers & Company, Knoxville, TN; Goya Foods, Fairbault Foods, MN; and Furman Canning Company, PA) have stated their specific concerns with overall appearance and color variability of commercially available black beans. Another canner and a frozen food processor have stated similar problems during the past year. They are specifically interested in obtaining black beans that possess and retain the black pigment and have reduced lot-to-lot variability that may be associated with various agronomic practices and genetic differences. Black bean color retention has not been used as selection criterion for new black bean varieties. The recent release of Eclipse black bean from North Dakota State University with a lighter black color may be the reason for the complaints on black bean processed color variations.

It is common practice to apply a pre-harvest foliar desiccant to reduce leaves and aid in the rapid drying of plants prior to harvest. This pre-harvest spray treatment is very important in narrow-row plantings to enable removal of extensive vegetative growth and, thus, facilitate natural air drying of the plant and seed prior to harvest with a direct-cutting combine. Limited prior research suggests that black bean pigmentation may be compromised if seed is harvested prior to full maturity. Premature application of the spray will have adverse impact on yield and seed quality. Thus, the application timing of pre-harvest desiccants may have a detrimental impact on black bean pigmentation. This research aligns with these concerns and will address the impact and importance of appropriate application of pre-harvest desiccants on selected black bean cultivars and promising breeding lines.

White mold is a serious problem in the production of dry beans in Michigan. There is a need to identify dry bean varieties tolerant to white mold, which would reduce the overall use of expensive fungicide treatments to dry beans. There is also a need to identify and use the best fungicides available to dry bean growers. Our past SCBG projects with Narrow Row Dry Bean Production identified white mold to be a limiting factor in achieving maximum yields. White mold disease in plants is not controlled by a single gene, thus dry bean producers will have to use both varietal tolerance and biological and chemical fungicides for economic control. These evaluations will build on past efforts and give Michigan growers another year's comparison of fungicide activity to white mold disease.

PROJECT APPROACH

The 2012 black bean samples were processed and canned in early December at the MSU Food Science Pilot Plant. The Research Board (PRAB) processed 21 black bean samples from two locations, nine black bean samples from one location and six commercial varieties from two strip trial locations. The MSU dry bean breeding program processed 83 black bean varieties and elite lines from three separate nurseries at the Saginaw Valley Research and Extension Center (SVREC) Research Farm. Dr. Karen Cichy asked to participate in the project and we evaluated an additional 98 black bean breeding lines from Colorado, Michigan, North Dakota, Nebraska and Washington. The Zorro black bean retained the black color consistent with older black bean

varieties. The new black bean from North Dakota, Eclipse, did not have a good black color over the four locations tested. One MSU line (B10244) and GTS 1103 exhibited the best color scores in both the Hunter Color Meter and subjective evaluation. There was no correlation between dry seed color and canned seed color. Eclipse dry color scores were almost the same as the MSU B10244. Six people representing three canners in the U.S. attended the canning evaluation. 2012 processed color scores were shared with the Michigan and U.S. dry bean industry. U. S. canners started buying more Zorro black Beans from Michigan than North Dakota due to Eclipse being their dominant black bean variety.

Seven small plots and five large strip plot trials were planted in June and harvested in September and October. All seven of the small trials had grower tours in late August. The Alcona County trial actually had two plot tours on August 8 and September 5. We were asked to show growers dry bean varieties very close to maturity. The growers were able to view commercial and experimental black beans planted in 20-inch rows at all seven locations. A total of 242 growers, extension and agri-business employees attended these tours.

2013 black bean variety samples from the different locations were canned to determine color retention. Dry bean elevator representatives and eleven people representing four major canners in the U.S attended the canning evaluation. The 2013 canned bean samples reaffirmed the 2012 results showing Eclipse black bean inferior to Zorro black beans. This proved there is a genetic difference in color retention between black bean varieties. Two white mold control trials were conducted in 2013 to evaluate fungicides. One grower strip trial to evaluate Contans biological fungicide was conducted. Fungicides added 2-6 cwt more per acre compared to the untreated checks. Endura, Omega, Propulse and Approach had the highest yield increases over the untreated beans. The Contans trial did not show consistent yield increases in 2013. Dr. Jim Kelly tested standard black bean varieties and new elite experimental lines developed at Michigan State University. Black bean nurseries were conducted at the Saginaw Valley Research and Extension Center (SVREC) and at the Montcalm Research Farm where a white mold screening trial was used to measure genetic tolerance to white mold. Dr. Kelly's line B10244 performed very well and will be released as a new black bean variety. To study desiccant by color retention interactions, Dr. Christy Sprague planted three black beans, Zorro from MSU, Eclipse from NDSU and MSU Elite line B10244 at the SVREC Research Farm. Two planting dates of these black beans were used to ensure that growing conditions and pre-harvest herbicide applications for desiccation of black beans in the fall will occur over a wide range of environmental conditions. Christy sprayed three desiccant systems, early and late (labeled) over the two planting dates and the three varieties. Gramoxone, Glyphosate and Sharpen were used. Dr. Sprague showed that desiccants would affect color retention if they were sprayed too early before the plant reaches physiological maturity. Glyphosate exhibited more influence in color than others when sprayed too early. Dr. Sprague's canning trials showed B10244 to have the best black color, followed by Zorro and then Eclipse. The SVREC Field Day event was on August 21. 188 growers, extension and agribusiness employees attended this event. Dr. Christy Sprague, Dr. Jim Kelly, Dr. Karen Cichy and Greg Varner talked on the Black Bean Color Retention Project.

GOALS AND OUTCOMES ACHIEVED

1 Desiccant sprays to dry down dry beans before harvest did not affect the overall color of processed black beans when used at the labeled dry bean maturity. However, these same desiccants used early when 50% of the pods had green color resulted in lower color scores. 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. Dr. Christy Sprague will duplicate this research in 2014 using other grant funds to have two years of research on desiccant influence on black beans.

Two cultivars have been identified having excellent color retention and low infection rates to white mold disease. MSU B10244 will be released and commercial seed will be available to Michigan growers in 2016. Other newer lines B11363 and B12724 have shown this excellent black color exhibited by B10244. These future black beans need more agronomic information before they can be released as varieties.

Three 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 and the use of Contans biological fungicide to reduce white mold infection. The Contans grower strip trial did not show any significant differences due to severe white mold infection in all the treatments.

GOALS

1. Increase demand for quality black beans from Michigan. Results of 2012 black bean canning trials did increase the demand for Michigan grown black beans. Michigan had little to no carryover of 2012 black beans. Most of the carryover black beans were in North Dakota. Michigan elevators have said the 2013 black bean crop sales are very good and little carryover is expected. Michigan dry bean industry experts are projecting to have 98,800 acres of Black beans in 2014. This will be a 19% increase over the 2011-2013 average acres of black beans planted in Michigan. This number of extra acres achieves our goal of 10% more demand for Michigan black beans.

2. Increased dry bean yields by 5%. Yields have not reached the stated goal of one additional bag or 5%. 2010/2011 yields averaged 1920 ponds per acre and 2012 yields were 1900 pounds. Weather influences played a big role in overall yields in 2013 and we expect higher yields in 2014. This goal should be judged on the 2014 yield as the project finished in 2013.

3. 2013 Michigan growing season was conducive to white mold infection in the dry bean area. Even soybean fields were showing white mold disease as early as August 5. Michigan dry bean growers sprayed fungicides on close to half of their acres. Informal surveys with growers, custom applicators and chemical salespeople confirmed this high use. Some growers are starting to evaluate the use of fungicides on white mold tolerant varieties. In future years, growers will access the need to spray two tolerant navy varieties, Medalist and Merlin.

BENEFICIARIES

This black bean project has 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 black beans to the U.S. consumers. The 16,000 extra acres will result in an additional 11.2 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, 2013	223
State Dry Bean Day	February 19, 2012	204
Planning Meeting	March 20, 2012	24
Bean and Beet Field Day-SVREC	August 21, 2012	188
County Dry Bean Field Tours 8	August, 2012	242
Canning Evaluation-MSU	January 14, 2013	44

LESSONS LEARNED

Food processors and canners can be convinced that color variations between black bean varieties are genetically controlled. The need to involve canners in canning quality evaluation is a must. The Michigan Bean Commission sent out a flyer announcing our 2014 canning evaluation, and it was well received. Goya foods sent five people to view our black bean samples. This was a big surprise for a company to send so many people to Michigan. Some Michigan growers were not too interested in this color retention project because they didn't see the benefit to them on their individual farm operation. When growers were told more black beans were moving out of Michigan, they did understand the benefit. Growers tend to look at the production and not the quality aspect to dry beans. There is a need to get more growers to meetings, field tours and planning sessions. The need to do surveys and establish good accurate baseline data is an area we have to improve on. The Michigan dry bean industry has to set a priority to get a grower production survey completed in 2014. Getting our goal achieved for Contans fell short. Weather and field selection gave us extremely high infection rates and little differences were observed between treatments. The biological work can be very difficult when conditions fail to be adequate for controlling a pest. We plan to continue this work. Dry bean growers have to spray black beans when very little green pods are in the field. Goya Foods supplied some canned black beans with additive, ferrous gluconate. This additive did turn samples very black like ripe olives.

CONTACT INFORMATION

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ADDITIONAL INFORMATION

Link to the 2013 Dry Bean Research Report - http://michiganbean.org/wp-content/uploads/2014/02/Dry-Bean-Report-final-for-web.pdf

PROJECT TITLE	**Michigan Apple Committee, Building on Success in Suburban Chicago: Expanding Market Exposure for Michigan Apples via Health-Related Promotion - FINAL**

PROJECT SUMMARY

The initial purpose of this project was to utilize $75,000 to expand Michigan's market share in Chicago and stimulate consumer purchases of Michigan Apples in suburban grocery stores though health messaging about Michigan Apples.

This project aimed to keep Michigan Apples in the Chicago market for an extended period, and leverage not only the consumer desire to eat healthier after the first of the year, but also the Chicago consumers' desire to support the "locally grown" movement.

The project built on prior work funded by SCBG funds in Chicago and has allowed MAC to continue to have a strong presence in the western suburbs of Chicago. Additionally, grant funded efforts in Detroit and Chicago have been especially important in 2013, as Michigan apples were completely out of the marketplace in 2012 due to the crop loss.

PROJECT APPROACH

During the period of this grant, MAC began by researching and identifying 42 Health and Fitness Clubs located in the targeted area of the Western Suburbs of Chicago. Once identified, we produced materials (table tent, poster, flyers) and distributed them to those health and fitness locations.

In-store signage was also created with a look consistent with the health and fitness club materials. The goal was to allow consumers to make the connection between the message they see in the health club and the message they see in the produce department of their grocery store. In addition to the signage, MAC purchased radio advertising in the Chicago market for the months of January and February 2014 to supplement the in-store efforts.

The Healthy Living program began January 1 and ran through March 31, 2014. In-store chef demos (52) were conducted in the target market during this time, as well as in-store signage. MAC exceeded our goal of 50% placement in target stores by reaching 74% placement with chef demos and signage.

Upon completion of the program, in spring 2014, MAC worked with Nielsen to analyze scan data in in three targeted retailers – Roundy's, Jewel and Meijer Chicago. This data, along with participation data was examined. It was determined that volume movement increased in all three target retailers, and sales increased (from prior year data) in two of the three retailers.

The overall scope of this project benefited only Michigan Apples. Project staff ensured the funds were used to solely enhance the competitiveness of specialty crops by focusing all efforts solely on the marketing of Michigan Apples, as is the mission of the Michigan Apple Committee.

Activities and tasks performed in the western suburbs of Chicago during the grant period include creative in-store activities, special events, and radio use. Creative in-store activities included 52 in-store chef demonstrations in Chicago over the course of a nearly three month period. Special events with WTMX and WILV radio remotes took place at retail stores in conjunction with chef demos. MAC also developed flyers, table tents and posters and distributed them to all 42 health clubs in the western suburbs of Chicago. Additionally, MAC worked with Chicago Parent magazine to advertise in their publication, send messages to their e-blast list of 15,100 recipients, and provide flyers, table tents and posters to partner organizations such as swim clubs and play places where families are active. MAC also partnered with the Chicago Wolves minor league hockey team for a Michigan Apple night, in which 5,000 fans received a Michigan apple and a flyer with health information upon exit from the arena.

The combination of in-store activities, messaging at healthy family events and locations and use of media created a great deal of excitement amongst consumers in the target markets.

The overall scope of this project benefited only Michigan Apples. Project staff ensured the funds were used to solely enhance the competitiveness of specialty crops by focusing all efforts solely on the marketing of Michigan Apples, as is the mission of the Michigan Apple Committee.

GOALS AND OUTCOMES ACHIEVED

In the Chicago market, MAC completed the following activities:

- Creative in-store activities –MAC completed 52 in-store chef demos from mid-January until March 31. MAC works with the retailers to secure a demo position near the Michigan apple display. Chefs estimate interacting with 20 – 60 shoppers per demo, meaning interaction about Michigan apples with, at minimum, 1,040 shoppers during that time frame. In addition,

four of Michigan's major apple shippers participated with Kwik-Lok bag tags that included messaging about the Healthy Living program and sweepstakes.

- Special events – MAC worked with WTMX and WILV (Hubbard Radio Group) in Chicago to promote locally grown Michigan apples at two chef demo events at retailers in the western suburbs. In addition, MAC partnered with the Chicago Wolves for "Michigan Apple Night" at a game on February 15. Five thousand apples and flyers with health information were distributed to fans upon exit of the arena.

- Radio/Video Use – MAC partnered with Pure Michigan to run radio ads in the Chicago market from mid-January to mid-February. As a part of this partnership, Pure Michigan matches MAC's ad buy commitment dollar for dollar, getting MAC $110,000 worth of radio ads in this market.

In regards to long term outcome measures, certainly past SCBG funds focused on the Chicago market have been helpful to us as we go forward. It takes years to achieve market penetration, but we are making headway each year. In 2012, some ground was lost due to the crop loss, but we believe the efforts described here have moved us forward in early 2014, by raising interest in the 2013 record-sized crop.

As a part of this grant, MAC hired Nielsen Perishables Group to analyze price and movement in during the time frame of this grant. You can see below that in the Feb/March period Michigan varieties did perform better than the rest of the category, in both dollars and volume for Roundy's and Meijer-Chicago, and just volume for Jewel.

		Feb/March	
Geography	Sub-Category2	Dollars % Change vs. YAGO	Volume % Change vs. YAGO
Roundys - Mariano's	Michigan Varieties	93.9%	79.8%
	All Others	50.0%	40.5%
Jewel	Michigan Varieties	30.8%	60.4%
	All Others	35.5%	26.9%
Meijer Chicago Stores	Michigan Varieties	6.7%	22.1%
	All Others	3.9%	14.0%
Total U.S.	Michigan Varieties	0.9%	3.9%
	All Others	1.1%	7.0%

This data sets a baseline for us to measure against in future years, and of course, it is a great increase in the amount that was distributed in 2012, which was basically zero.

Comparison of actual accomplishments and goals established:

- MAC established the goal of achieving placement of health information materials in 25 percent of targeted health clubs.
- MAC was able to place materials in all 42 health clubs located in the western suburbs of Chicago (100% placement).
- MAC also established the goal of placement of the program in 50 percent of the targeted grocery stores in the area.

- The shippers who participated with Kwik Loks communicating about the Healthy Living sweepstakes service at least 78 of the 176 stores in the western suburbs of Chicago, and in-store chef demos were conducted in 52 stores in that region, therefore, MAC placed the program in 74 percent of the retail grocery stores in the western suburbs of Chicago.

Again, the 2012 crop loss meant an absence from the marketplace for over a year. Therefore, the baseline data was zero. This project allowed us to gather new baseline data which we can utilize in future efforts.

BENEFICIARIES

The beneficiaries of this SCBG funded project are Michigan's 850 apple growers, as well as Michigan apple shippers.

Important quantitative data that concerns Michigan's apple growers and shippers would be data such as the Nielsen Perishables Group data that shows an increase in volume movement in the February/March time frame.

To put an economic impact on this project would be nearly impossible, since MAC is not a sales organization. That said, based on smaller-sized crops of the past, it has been estimated that the Michigan apple industry has had a $700 – 900 million economic impact on the state's economy, so it would stand to reason that with a 30 million bushel crop, that number would be higher.

LESSONS LEARNED

There are many lessons learned with a project such as this. We continue to find that in-store efforts and special events are received well by consumers. They particularly like the face-to-face engagement of the in-store chef demos. We have also found that an in-store presence such as Kwik-Loks and other signage helps to differentiate Michigan product from apples from outside Michigan. Our consumer research continues to show that consumers want apples to be clearly marked as grown in Michigan.

Some challenges we encountered included in-store execution of the program. As may be expected, it can sometimes be difficult to rely on someone from outside your organization to implement a portion of your program, who may have little interest or investment in the program.

This project was the first time we have tried to collaborate with health clubs and other family activities. We are unsure if the information and materials were well received by patrons of the health clubs. Also, we do not know if consumers we reached through the partnership with Chicago Parent magazine were impacted by our messaging. The Chicago Wolves partnership seemed to generate a great deal of excitement, and because there was a retail partner piece, it was an attractive partnership for us. Participation in the Chicagoland Kids Expo was another way we felt we could reach families, however it may not be an event in which we will participate in the future.

CONTACT INFORMATION

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ADDITIONAL INFORMATION

Program Development – MAC used the grant funds for many activities under program development. For art development for the posters, handouts and table tents, in a partnership with Chicago Parent magazine, and with the Chicago Wolves for Michigan Apple Night. An

investment of grant funds was made in the Chicagoland Kids Expo, marketing information, marketing consultant to help with placement of materials and planning.
MAC used grant funds to print health message materials that were distributed to health clubs in the western suburbs of Chicago as well as healthy family activities and partners. MAC provided a match. MAC also used grant funds to pay for 1.5 million Kwik-lok bag tags that were distributed to retail customers, communicating about the program.

Radio/Video Use - MAC participated in remote broadcast events with Hubbard Radio Stations WTMX and WILV, who broadcasted from stores where chef demos were taking place, and purchased radio time during this time frame in Chicago for the Pure Michigan Apples radio commercial. All radio buys through Pure Michigan are matched dollar for dollar by Pure Michigan, which made our total radio buy during the period worth $110,000. MAC provided match in the amount of $44,814.33.

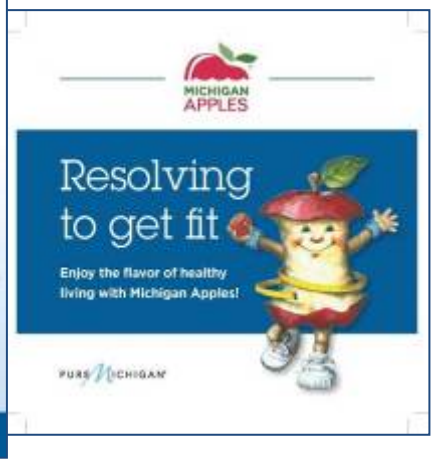
In-store chef demos – MAC used grant funds to cover the cost of in-store chef demos in Chicago area stores from mid-January through March, 2014. The demos were in 52 stores in the western suburbs of Chicago.

Nielsen Data – MAC hired Nielsen Perishables Group to analyze data and movement numbers in targeted retailers in the western suburbs of Chicago.

Healthy Living Program – MAC implemented the Healthy Living program from January through March in this target market.

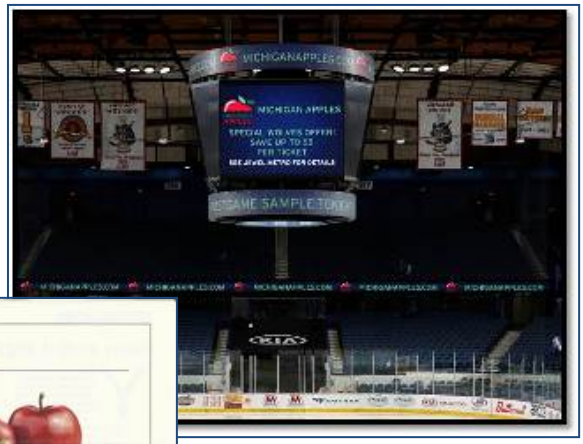
Photos from Creative In-Store Activities, Special Events
Healthy Living Kwik Lok Bag Tag

In-Store Chef Demos



Healthy Living Message Materials (poster, table tent, handout)

Michigan Apple Night with the Chicago Wolves



Chicago Parent magazine ad

PROJECT TITLE	Michigan Asparagus Advisory Board, Developing an Integrated Pest Management Program for the Asparagus Miner in Michigan - FINAL

PROJECT SUMMARY

The Michigan Asparagus Advisory Board in conjunction with Michigan asparagus growers listed the development of an effective asparagus miner management strategy as one of their three top industry priorities in 2011. Previously, asparagus growers do not have a management plan for the asparagus miner; their insect control program consisted of multiple broad-spectrum insecticide sprays applied at various times in the season. The goal of this project was to take an integrated pest management approach to build a long-term, economically and ecologically sustainable asparagus miner management strategy. This was achieved through developing a degree-day model, a new population-monitoring tool, identifying biological control agents, and evaluating chemigation to suppress larval populations of this pest. Results of the research were communicated to growers through oral and written format. Short-term outcomes of this project were that growers are now able to use the degree-day model for predicting asparagus miner population abundance in the field, and they have increased understanding of the pest's biology as well as the natural enemies that kill the insect. The long-term outcomes of this project will improve cost benefit for asparagus growers, decrease risks on human health and non-target impacts through a reduction in the number of tractor trips, the number of insecticide applications, and the total amount of insecticides applied. Better monitoring and population prediction tools allow growers to time management actions, thereby maximizing the impact of pest management inputs over their cost and minimizing harmful environmental effects.

PROJECT APPROACH

The asparagus miner is the most important insect pest of asparagus, not only due to the direct damage it causes to stems, but also because of its ability to facultatively vector pathogenic species of *Fusarium* (Tuell and Hausbeck, 2008). Infection by this fungus can reduce the productivity of asparagus fields by 5-9 years (Grogan and Kimble, 1959, Elmer et al., 1996), and while there has been much research into its control (e.g. Reid et al., 2002), the research on the management of the insect vector has been lacking (Morrison et al., 2011). There are no effective control strategies for the asparagus miner, because larvae remain protected from pesticides within the stem, thus currently registered selective insecticides in asparagus fail to reduce adult population levels (Z. Szendrei, unpublished data, Morrison et al., 2011). Successful integrated pest population suppression depends on the concerted use of multiple management strategies, better population prediction, and the incorporation of ecosystem services such as biological control. The goal of this project was to take an integrated pest management approach to develop a long-term, economically and ecologically sustainable asparagus miner management strategy. This was achieved through developing a degree-day model, a new population-monitoring tool, identifying biological control agents, and evaluating chemigation as a tool to suppress larval populations.

Biological control can be a valuable part of integrated pest management programs (Orr, 2009), because its compatibility with other management strategies, its contribution to a reduction or change in pesticide use (Ruberson et al., 1998), its effect on insecticide resistant pests (Foster et al., 2007), and its environmental sustainability (Quimby et al., 2002). To date, surveys of asparagus miner natural enemies in North America have been completely lacking. According to a study from the United Kingdom (Barnes, 1937), the following parasitoids attack asparagus miner pupae: *Dacnusa rondanii* (Braconidae), *Sphegigaster* sp. (Pteromalidae), and *Pleurotropis epigonus* (Eulophidae). It is unclear if the same species are present in North America, so learning the species identity and abundance under field conditions as well as dietary preferences will form the basis for future conservation biological control efforts.

The importance of plant volatiles in mediating plant-insect interactions has been recognized and studied for over 80 years (Kennedy, 1965; Visser, 1986; Paré and Tumlinson, 1999; Turlings and Ton, 2006). Understanding the role plant volatiles play in trophic interactions is not only important from an ecological and evolutionary perspective (Dicke and Baldwin, 2010), but also for the development of novel crop protection strategies. Examples of plant volatile use in agriculture includes lures manufactured to monitor insect pests (Light et al., 2001), spraying a plant to increase its attractiveness in trap cropping (Martel et al., 2005), or making a crop less attractive by the application of repellent plant volatiles (Pickett et al., 2006). Little is known about the volatiles that asparagus emits into the environment. A study performed by Sun et al. (2001) found that there were over 100 compounds emitted by asparagus, however, this study analyzed ground-up frozen asparagus, not the volatiles that are actually constitutively expressed or induced. To date, nothing is known about the type and quantity of volatiles emitted into the headspace and how these may affect other organisms, such as the asparagus miner. This could be a potentially effective method to manipulate the behavior of the asparagus miner, since they are specialists and are highly mobile.

Degree-day modeling is a tool to help guide management decisions in integrated pest management strategies to better time pesticide applications (Dent, 2000). Degree-day models have been successfully developed for two related agromyzids, the vegetable leafminer (*Liriomyza sativae*; Petitt et al, 199 1) and, a pest of tomatoes (*Liriomyza trifolii*), (Schuster and Patel, 1985). A degree-day model would give asparagus growers a tool to time management efforts, saving money and reducing ecological costs. As effective management methods are identified, these were used with the help of the degree-day model to target them at the most vulnerable life stage of the asparagus miner. Specifically, insecticides that exhibit low toxicity to natural enemies and have low environmental impact were the best fit to an integrated control program.

Twelve species of pupal parasitoids of the asparagus miners have been identified from commercial asparagus fields and they parasitize about 30% of asparagus miner pupae. The two main parasitoids we found were *Thinodytes cephalon* and *Chorebus rondanii*. Sugar-rich diets are able to increase the lifespan of these parasitoids, indicating that they may be amenable to manipulation by supplementing fields with floral resources. Interestingly, parasitoids were found in higher abundance during the first generation of the asparagus miner when the miner was more abundant. Several plant-derived volatiles were tested as baits attached to monitoring traps in the field. One compound, “decanal” repelled asparagus miner adults from traps compared to the unbaited traps. An asparagus miner degree-day model was developed and is now available to growers on the MSU EnviroWeather website, through which growers can predict the appearance of different asparagus miner lifestages in the field. Chemigation to control asparagus miner larval stages was tested, and a neonicotioind insecticide “Platinum” reduced larvae in the asparagus stems by 20% relative to the control.

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GOALS AND OUTCOMES ACHIEVED

GOAL: 1) Evaluation of the parasitoid community of the asparagus miner in Michigan
Baseline data: prior to this project no information was available on asparagus miner and its natural enemies, such as parasitoids.

Methods and results: We found 12 parasitoids from five families of wasps that prey on the asparagus miner. Two of these parasitoids were found in higher abundance, and their names are *Chorebus rondanii* and *Thinodytes cephalon*. These two species contributed to most of the 30% parasitization of asparagus miner pupae in commercial fields. On average, parasitoids were more abundant during the first generation of asparagus miners. Research indicates that the lifespan of the parasitoids can be greatly extended (up to 8 times) by providing sugar-rich resources. The lifespan of the asparagus miner can also be increased by sugar-rich resources, so in a field setting, it is important to provide floral resources in the margins that benefit the natural enemies, but not the pest. We found that the asparagus miner cannot use buckwheat and fava bean flowers as food to extend its lifespan. The plants could be sowed in the margins of asparagus fields to increase pest suppression of the asparagus miner.
Measurable outcome: 12 species of parasitoids were discovered, 30% of asparagus miner pupae are killed by these parastioids in commercial fields.
Long-term outcome: Addition of flowers next to asparagus fields will increase the parasitization rate further.

GOAL: 2) Identification of asparagus volatiles that attract the asparagus miner for use in monitoring baits
Baseline data: prior to this project no information was available on asparagus chemical ecology.
Methods and results: We examined how the abundance of the asparagus miner is affected by baits composed of different volatile compounds derived from plants. We found that in methyl salicylate-containing baits, there was an average of 20-30% greater abundance of asparagus miners compared to baits without methyl salicylate. On a far weaker level, we found that methyl salicylate increased the abundance of parasitoids in the field. Methyl salicylate baits are often advertised as increasing the abundance of natural enemies in gardens. However, for asparagus, we would recommend avoiding the use of baits containing methyl salicylate. In contrast to the asparagus miner, we found that other pests were most attracted to baits composed solely of cis-3-hexen-1-ol. As a result, formulations with this compound should also be avoided. The bait that contained decanal decreased asparagus miner abundance by about 25% on the traps.
Measurable outcome: baits composed of “decanal” reduce asparagus miner abundance by 25%
Long-term outcome: chemicals identified from asparagus plants will be used in baits attached to traps to monitor asparagus miners in the field (i.e.: detect when asparagus miners first appear in the season) and also to manage these insects (i.e.: attract and kill).

GOAL: 3) Development of a degree-day model for the asparagus miner
Baseline data: prior to this project no degree-day model was available for the asparagus miner
Methods and results: We determined that the beginning of adult flight occurred around 100 Growing Degree Days (GDD), with the first adult population peak at 490 GDD and second population peak at 1530 GDD. The first pupae and larvae appeared about 280-390 GDD after the beginning of adult flight. It then took another 360-450 GDD before the immature stages reached peak abundance in the field. As a reference, asparagus harvesting took place between

222-666 accumulated GDD, depending on the field and grower. Asparagus miner adult flight ended at 1850 accumulated GDD. The lower developmental threshold (12.1ºC) was discovered and the degree-day model has been completed. The degree-day model is available to growers through MSU's EnviroWeather website.
Measurable outcome: degree-day model on MSU EnviroWeather website available to growers.
Long-term outcome: growers will increasingly use the degree-day model to manage asparagus miners.

GOAL: 4) Evaluate chemigation as a new strategy to manage asparagus miner
Baseline data: prior to this project no chemigation method was tested to control asparagus miners
Methods and results: Seven insecticides were delivered using drip irrigation system in an experimental asparagus field. Among the seven drip treatments, Platinum performed the best and consistently reduced the percent number of damaged stems, compared to the untreated control. On June 18, 2013 visible signs of miner damage were relatively low across treatments and there were no significant differences among the treatments. On June 25, all of the drip insecticide treated plots had significantly less damage than the untreated control. On July 2, only the Platinum treatment was significantly less damaged than the untreated control, all other treatments were not significantly different from the control. On July 9, Platinum and Durivo were the only two treatments that significantly reduced the percent damaged stems relative to the untreated control. On July 16, none of the insecticide treated plots were significantly different from the untreated control. Overall, asparagus miner damage was reduced from 50% in the control plots to about 30% in Platinum treated plots. The longevity of the Platinum in the asparagus stems was about 8 weeks.
Measurable outcome: 20% reduction in asparagus miner larval damage
Long-term outcome: growers will increasingly adopt systemic insecticides post-harvest to manage asparagus miner larvae

OUTREACH: All of the data generated in this project was shared widely with asparagus growers across Michigan at the Great Lakes Expo in Dec., 2013 and at the Annual Oceana Asparagus Growers' Meeting. We also published our results in the Great Lakes Expo Proceedings, on the MSU Extension News for Agriculture website in two articles, and in 3 scientific publications.

BENEFICIARIES

We conducted an asparagus grower survey in 2013 and 2014 to determine the way asparagus miner management changed over the grant period. In 2013, 40 and in 2014, 51 surveys were filled out and returned; surveys were handed out at the annual Oceana Asparagus Day and collected at the end of the meeting, they were anonymous.

Overall, we asked growers about the way they perceive asparagus miner as a problem in their current production, how they deal with managing its populations, and the tools that they would like to use in the future. We found that in 2013 and 2014 growers who participated in the survey grew 107.5 (range: 0-600) acres of asparagus on average, and these growers have been growing asparagus on an average of 29 years (range: 0-60). The yearly crop loss due to asparagus miner damage was estimated to be about $1/acre in 2013 and $46/acre in 2014. The yearly per acre cost of the asparagus miner management program was estimated at $15 (range: $2-500) in 2013 and this increased to $40 (range: $10-500) in 2014. In both years, about 45% of respondents rated the importance of crop advisors in their pest management decisions as 'extremely important'.

In 2013, 10% of growers applied insecticides targeted at the asparagus miner, 32% applied insecticides on a calendar basis and the majority (62%) did not specifically target this pest with

insecticide applications. In 2014, 21% said that they timed their insecticide sprays for the asparagus miner, 43% said they used calendar insecticide sprays, and only 37% said they did not manage this pest specifically. Thus, from 2013 to 2014 the proportion of growers who targeted insecticide applications to asparagus miner increased by 22%, and awareness to manage this pest overall also increased by 25%. In both years 62% of growers said they were satisfied with their asparagus miner management program.

In 2013, 82% and in 2014, 86% said that they would like to use a degree-day model online to guide their management decisions for targeting insecticide applications against the asparagus miner adults. In general growers were not interested in using systemic insecticides applied through drip tubes (none in 2013 and three growers in 2014 said they would use it), but about 22% of the growers were interested in applying systemic insecticides in other ways to target the larval stages of the asparagus miner.

LESSONS LEARNED

We have learned that asparagus miners have pupal parasitoids in commercial asparagus fields in Michigan. These can be manipulated with flowers in the future to increase their efficacy. We also made progress in determining volatile bait for population suppression of the asparagus miner. We found that the degree-day model will be used by many growers to determine when to spray insecticides for asparagus miners. Although growers in general are interested in using systemic insecticides to kill asparagus miner larvae, we need to find other ways to deliver systemic insecticide applications other than drip tubes.

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ADDITIONAL INFORMATION

1. Asparagus miner degree-day model: http://www.enviroweather.msu.edu/homeMap.php
2. Article on asparagus miner degre-day model:
http://msue.anr.msu.edu/news/asparagus_miner_degree_day_model_now_available_on_msu_enviro_weather
3. Article on asparagus miner chemical ecology:
http://msue.anr.msu.edu/news/odious_asparagus_miner_and_odorous_asparagus
4. Insecticide reports, other information and photographs on asparagus miner for growers:
http://vegetable.ent.msu.edu/extension/bulletins/asparagus/

PROJECT TITLE	Michigan State University, Innovative Fruit Plantings: Keeping Michigan Fruit Producers Competitive by Establishing Research Plots - FINAL

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.

PROJECT APPROACH

The Michigan State Horticultural Society, The Michigan Cherry Committee, The Michigan Apple Committee, The National Grape Co-Op and The Michigan Peach Sponsors have acted in advisory capacities to development of the project work plan and provided significant contributions to help this project succeed.

Plantings and technology activities were conducted in 2012-13 according to the work plan, including maintenance of plantings established in year 1 & 2 of associated funded projects Table 1).

Table 1. Summary of plantings and technology activities (years 1-3) 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)	0.5 acre (HTRC 2011)				high tunnel for raspberries (2010); high tunnel for sweet cherries (2010)

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.

GOALS AND OUTCOMES ACHIEVED

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.

Activities completed:

Trevor Nichols Research Center (TNRC)

Grape vineyard: A hybrid grape vineyard composed of Chancellor, Foch & Aurora vines and trellis was established, along with drip irrigation. Season-long vineyard maintenance, including weed control, mouse guards and pest control was conducted to ensure optimal growth.

Peach orchard: Field-season preparations were made for a fall planting of peaches, including soil tilling, fertilizer amendments, weed control, and planting and irrigation layout. Peach trees were ordered for later deliver.

Cherry orchard: Season-long orchard maintenance of the cherry orchard, including re-plants, weed control, and pest control was conducted in 2013. Portions of the Balaton orchard that held sufficient fruit were used for the IR-4 field residue program, with placement of two 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: Season-long maintenance of the blueberries, including re-plants, weed control, and pest control was conducted in 2013. 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: Season-long orchard maintenance of the apple orchard, including re-plants, weed control, and pest control was conducted in 2013. The planting is expected to be mature enough to host research in 2014.

Southwest Michigan Research and Extension Center (SWMREC)
Concord Grape Vineyard: Development of a five-acre Concord vineyard at the MSU Southwest Michigan Research Center continued through the 2013 growing season. The approximately 4000 vines in this project were pruned and tied to the trellis in Jan. to April, 2013. Vine replacements for missing vine spaces were planted in May, 2013. Trickle irrigation was installed for all vineyard rows of this project. Weed control and fertilization of vines was performed in May, 2013. Spot-spraying of herbicides to control weeds occurred throughout the growing season. The crop on these vines was removed in June, 2013 to promote the growth of these vines. 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. Replacement vines for use in 2014 were propagated and grown in a nursery.
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 2013 growing season for mechanical shoot positioning work that is a part of this project.

Peach: - In spring 2013 we switched equipment from the lift-tractor mounted PT200 blossom thinner to a hedger arm mounted Darwin Solo. The hedger–mounted Solo is more maneuverable, and eliminates the need for a lift tractor with additional hydraulic systems. Tree pruning was done in mid-April and mechanical blossom thinning was done on May 1st, 2013. 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 an August 27, 2013, peach & plum industry meeting. MSU peach specialist Bill Shane showed approximately 40 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.

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.

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 2013, 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 two-acre planting in 12 seconds compared to tractor pulled sprayer for the same area at 30 minutes. On July 23, 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.

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". The first significant harvest from the NC-140 intensive training systems trial was accomplished, although yields were lower than anticipated due to the loss of fruiting spurs from the 2012 early bloom/multiple freeze events disaster and to the 12 May 2013 frost event.

Nevertheless, since protective covering systems were installed in summer 2012 for evaluation as part of this project, one covering system protected well against the 2013 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 4th 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: In 2013, electrical wiring, irrigation lines, and irrigation control systems were updated from what was set up in 2009. In addition, a high-density apple plot was planted to test different amounts of water and fertilizer that will be dispensed through the irrigation system. This new test plot will provide the empirical data on irrigation and fertigation strategies to help growers to transition to more economically desirable high-density apple systems.

Honeycrisp apple trees on Nic 29 (dwarfing rootstock) were planted at the NWMHRC in 2013. 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 10 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.

The two-acre Montmorency block at the NWMHRC was used for fungicide efficacy screening in spring 2013. These trees were planted at a traditional spacing of 20'x20' on standard Mahaleb rootstock. In addition, other plots established in years 1 and 2 were trained and maintained according to protocol.

Fruit production measures were collected in the high-density tart cherry block in July 2013, which was our first yield evaluation since the trees were planted in May 2010, due to the crop loss in 2012. 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 in spring 2012 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
A 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 2013. The MSU campus apple planting should produce fruit beginning next year. This summer the orchard was used for pheromone aging studies. Plans are in the works for research trials on organic apple production and pheromone-based mating disruption in 2014.

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 first minor fruiting occurred in the organic high tunnel sweet cherry plot (2013 was the 3rd year after planting), but yields were insufficient to warrant harvest for data. Unlike 2012, black cherry aphid populations were not controlled sufficiently by natural predators (such as lacewings and ladybird beetles), and tree growth was negatively impacted. However, due to the high planting density, the trees are close to filling their allotted orchard space on schedule and begin significant fruiting in 2014. 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.

"A grower meeting was held at the location of the Model Concord Vineyard, which is under development as a part of this grant. Grower 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*)

“Platforms have really taken off over recent years. We have demonstrated the Phil Brown Welding platforms over the past three years. Four 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*)

Further long-term outcomes will be quantified in terms of increased implementation or acceptability of new technologies, and new cultivars to growers. Growers will be surveyed via Turning Point surveys or paper questionnaires at grower to determine implementation and impact of crop-specific technologies (like dwarfing rootstocks in cherries, adoption of the tall spindle training system in apples, improved vineyard design and/or mechanization strategies in juice grapes, or shifts in new orchards away from traditional open center training to canopy structures conducive to mechanical thinning in peaches).

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 will be 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. 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 posivitanna*; summer fruit tortrix, *Adoxophyes orana*; and spotted wing Drosophila, *Drosophila suzukii*. Only *D. 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. Several websites and annually updated reports are quantifying emerging and invasive insect and disease pests in Michigan. Three MSU labs, including the Small Fruit Entomology lab, Small Fruit Plant Pathology lab and Tree Fruit Entomology lab, are utilizing fruit plantings from this project to conduct these surveys of important new pests. The outcomes of their research are posted on various websites, including MSU IPM website: www.ipm.msu.edu/SWD.htm. Best Management Practices are reported on the MSU Fruit Management Guide (E0154), http://www.bookstore.msue.msu.edu/ . Dr. Gut also conducted control monitoring/detection studies for Brown Marmorated stink bug in the TNRC stone fruit planting funded by SCBG in 2010, leading to grower control recommendations (E0154).

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.

Outcomes were quantified in terms of IR-4 “A” priorities, which in 2013 included six new compounds for fruit crop disease and insect pest management, resulting in 19 field residue trials conducted on research center fruit orchards. An “A” priority guarantees IR-4 to begin the field residue program during the following season and complete it within 30 months, with the expectation that a complete data package be submitted to the EPA thereafter. The current status of IR-4 projects can be found at the IR-4 Project website, http://ir4.rutgers.edu/index.html. These new “reduced-risk tools” for Michigan fruit growers will be accompanied with new IPM recommendations in MSU’s Fruit Management Guide (E-154), based on data from field performance studies conducted in the new research plantings. IPM recommendations are made annually in the MSU Fruit Management Guide (E154), http://www.bookstore.msue.msu.edu/.

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

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ADDITIONAL INFORMATION

PROJECT TITLE Western Michigan University: Analytical Testing for Michigan Hops and Metabolome Driven Breeding Program - FINAL

PROJECT SUMMARY

The purpose of this project was to provide standardized, quality testing services for hop farmers to promote wide scale adoption of the use of Michigan grown hops by the brewing industry. Novel methods of analysis were investigated for early disease detection as well. A high throughput method to quantitate the α- and β-acid content in hops using direct analysis electrospray ionization mass spectrometry has been developed and is currently being validated.

Seven activities were proposed to achieve three expected outcomes in the proposed project. The responsibilities of activities 1,2,3,7 were allocated to the Venter laboratory while responsibilities for activities five and six were shared with the Barkman laboratory.
The actions completed for each proposed activity are summarized below. A more detailed discussion for Activities one, and seven are also provided in subsequent pages.

PROJECT APPROACH

An analytical quality testing facility for the testing of hops from Michigan farmers was established at Western Michigan University. Official methods for the analysis of the α- and β-acid content in

hops for high pressure liquid chromatography (HPLC), ultraviolet/visible spectrophotometry (UV/VIS), steam distillation of hop essential oils, and the analysis of the essential oil profile by gas chromatography coupled with a mass spectrometer (GC/MS) were used to develop standard operating procedures for the standardized chemical testing of hop samples. A high throughput method for the analysis of the α- and β-acid content in hops using direct analysis electrospray ionization mass spectrometry has been developed and is currently being validated. A novel, high throughput method for the analysis of the α- and β-acid content in hops by paper spray ionization mass spectrometry is currently in development.

The following is a breakdown of the actions for each activity that occurred during the initial phase of the grant:

I. Activity 1: Set-up and validate experimental procedures for standard chemical testing of hops
    a. Official methods for the analysis of the α- and β-acid content in hops for high pressure liquid chromatography (HPLC), ultraviolet/visible spectrophotometry (UV/VIS), steam distillation of hop essential oils, and the analysis of the essential oil profile by gas chromatography coupled with a mass spectrometer (GC/MS) have been used to develop standard operating procedures for the standard chemical testing of hops samples.
II. Activity 2: Create website
    a. A website was developed to provide a means of hops sample submission for local farmers, coops, and brewers which includes a description of all testing methods, instructions regarding hops sample transportation, as well as sample logging and payment option pages.
III. Activity 4: Provide quality testing of Hops based on American society of Brewing Chemists specified methods
    a. A standard operating procedure was developed to analyze the α- and β-acid content in hops using HPLC by modifying the procedure for the ASBC official method of analysis Hops-14 entitled “α-Acids and β-Acids in Hops and Hop Extracts by HPLC”.
    b. A standard operating procedure was developed to analyze the α- and β-acid content in hops using UV/VIS but instead following the procedure for the ASBC official method of analysis Hops-6a entitled “α- and β-Acids by Spectrophotometry”.
    c. A standard operating procedure for the analysis of the essential oil profile utilizing GC/MS was developed following the procedures of Hops-13 and Hops-17 entitled “Total Essential Oils in Hops and Hop Pellets by Steam Distillation” and “Hop Essential Oils by Capillary Gas Chromatography-Flame Ionization Detection”, respectively.
IV. Activity 6: Development of methods to detect powdery mildew
    a. Methods to detect powdery mildew and downy mildew were developed utilizing polymerase chain reaction (PCR) primers. These methods have not yet been validated by analyzing infected hops samples.
V. Activity 7: Development of new analysis methods to improve sample throughput and quality
    a. A novel, high throughput method for the analysis of the α- and β-acid content in hops utilizing paper spray ionization mass spectrometry is currently in development as stated above.

A standardized hop testing facility has been launched at Western Michigan University that currently provides analysis methods for hops that includes the α- and β-acid content using UV/Vis and HPLC as well as analyzing the essential oil profile of hops by GC. The purpose of

launching the hop testing facility is to promote the growth of the hop industry in Michigan by providing quality assurance testing to help farmers guarantee the components of the hops. Twelve growers have requested more than 50 hop analysis tests between July and present. Hops growers in Michigan used to have testing performed by out-of-state laboratories. The planned in-state testing service outlined in our initial proposal has officially been launched. The provided services address the typical needs for hops farmers including the analysis of the α- and β-acid content in hops and essential oil analysis for hops growers.

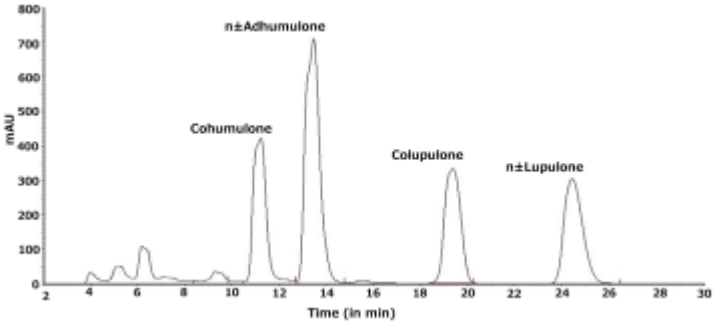
GOALS AND OUTCOMES ACHIEVED

Activity 1 Setup of hops testing facility

Selected methods offered by The American Society of Brewing Chemists (ASBC) were used as guidelines to create standard operating procedures for the hop testing facility at Western Michigan University for α- and β-acid percentages, essential oil content, hops storage index, etc.

1) *Methods of Analysis*
   a) α- and β-acid analysis
      i) HPLC
         (1) The Hops-14 ASBC method of analysis was used to develop a modified HPLC method for the quantitation of the α- and β-acid content of hops.
         (2) Reversed phase HPLC using UV detection provides quantitative analysis of the following compounds: cohumulone, n-humulone + adhumulone, colupulone, and n-lupulone + adlupulone.
         (3) Quantitation is calculated through an external calibration method utilizing International Calibration Extract #3 (ICE-3) according to the method described in Hops-14 performed with HPLC analysis.

Figure 1: Typical HPLC Chromatogram for Hops



         (4) The sample preparation procedure requires about one hour for completion. Each HPLC analysis requires 28 minutes according to the Hops-14 ASBC method of analysis. This method was improved by using a more efficient chromatographic column, a higher linear flow rate, and a different mobile phase composition. This resulted in quantitative chromatographic separation in less than 15 minutes. The ICE-3 standard needs to be analyzed four times for the average response factor and each hops sample should to be analyzed in duplicate. Setup and preparation time for Hops-14 requires two hours for calibration and an additional hour per hops sample. The modified method requires only one hour for calibration and a half hour per hops sample.
      ii) UV/VIS

(1) The Hops-6a ASBC method of analysis was used as the standard operating procedure for the quantitation of the total α- and β-acid content of hops. This method does not differentiate between the individual congeners of the α- and β-acids respectively but rather yields the total amounts of each class. UV/Vis is a high throughput method of α- and β-acid quantitation but lacks the detail of the HPLC method of analysis. The sample preparation procedure requires about one hour and each analysis a further five minutes, producing a full experiment time of approximately 75 minutes.

b) Essential Oils Analysis

i) Total oil content

(1) The total amount of essential oils, expressed as a percentage of the dry hops mass, is obtained through the steam distillation of a hops sample over a period of approximately six hours. The procedure for Hops-13, "Total Essential Oil in Hops and Hop Pellets by Steam Distillation", was used as a guideline to create a standard operating procedure for the essential oil collection.

ii) Essential oil profile

(1) The oils collected from the modified Hops-13 procedure are analyzed on a GC/MS for the essential oil profile. The sample is separated via gas chromatography and the individual components are identified and quantitated by mass spectrometry.

2) *Performance evaluation of testing facilities*

a) Internal reproducibility

(1) The relative standard deviation of the HPLC analysis for check samples is less than 5% between the employees of the testing facility.

(2) The relative standard deviation of the UV/Vis analysis for check samples is less than 5% for the α-acids and less than 7.5% for the β-acids.

b) Comparison to external laboratory check sample program

i) ASBC offers a check sample program for testing facilities to determine the deviation of the α- and β-acid content of one hops sample between facilities.

ii) Once a month, an identical hops sample in the form of powder, pellets, or extract is sent to each of about 20-25 independent participating testing facilities. The sample is analyzed by each testing facility using their methods for α- and β-acids determination by HPLC and/or UV/Vis and the national averages are used to determine if individual facilities are providing accurate results.

iii) The national results for the check samples HPW-4, HPL-5, HPE-6, HPW-7, HPL-8, HPE-9, HPW-10, HPL-11, HPE-12, HPW-1, HPL-2, HPE-3, and HPW-4 have been released and the results obtained at the Western Michigan University testing facility were usually within acceptable ranges as summarized in Table 1 and 2 below

iv) See appendix C for typical check sample testing results.

The Western Michigan University testing facility is subscriber number 184 for the ASBC check sample program.

Table 1: ASBC Check Sample Results for HPLC Analysis

Sample ID	Total % α-acids		Total % β-acids	
	Sub # 184	Nat. Avg.	Sub # 184	Nat. Avg.
2013 HPW-4	12.25	12.43±0.38	4.63	4.60±0.06
2013 HPL-5	10.74	12.10±0.57	3.35	3.68±0.14
2013 HPE-6	52.93	53.01±1.85	18.12	18.60±0.47
2013 HPW-7	11.42	11.74±0.43	4.43	4.64±0.15
2013 HPL-8	5.77	14.72±0.63	2.22	5.73±0.20
2013 HPE-9	59.42	60.04±1.56	16.11	16.31±0.37

2013 HPW-10	7.57	9.31±0.77	3.97	4.77±0.34
2013 HPL-11	11.60	11.81±0.44	2.63	2.65±0.09
2013 HPE-12	58.94	59.11±1.45	20.63	20.26±0.41
2014 HPW-1	10.92	10.98±2.34	5.08	5.04±0.41
2014 HPL-2	15.49	15.81±0.53	5.72	5.72±0.44
2014 HPE-3	55.90	56.26±0.86	14.81	14.61±0.27
2014 HPW-4	13.61	13.73±0.39	4.31	4.31±0.17
2014 HPL-5	10.52	Not released	2.74	Not released

Table 2: ASBC Check Sample Results for UV/Vis Analysis

Sample ID	Total % α-acids		Total % β-acids	
	Sub # 184	Nat. Avg.	Sub # 184	Nat. Avg.
2013 HPW-4	12.66	13.61±0.61	4.25	4.87±0.28
2013 HPL-5	13.75	13.17±0.90	3.16	4.02±0.67
2013 HPE-6	54.73	56.86±4.07	18.63	19.64±1.68
2013 HPW-7	12.58	12.82±.68	4.77	4.96±0.43
2013 HPL-8	15.90	16.71±0.44	5.40	5.82±0.50
2013 HPE-9	57.73	65.28±1.79	14.21	16.21±0.94
2013 HPW-10	7.78	9.64±0.88	4.28	5.26±0.41
2013 HPL-11	11.56	12.05±0.68	2.81	3.05±0.38
2013 HPE-12	51.86	65.09±1.41	20.53	20.55±1.71
2014 HPL-2	16.35	17.54±0.62	4.84	5.78±0.76
2014 HPE-3	55.79	60.38±1.97	11.19	14.94±0.70
2014 HPW-4	11.93	14.09±0.56	4.92	4.85±0.29
2014 HPL-5	11.54	Not released	3.01	Not released

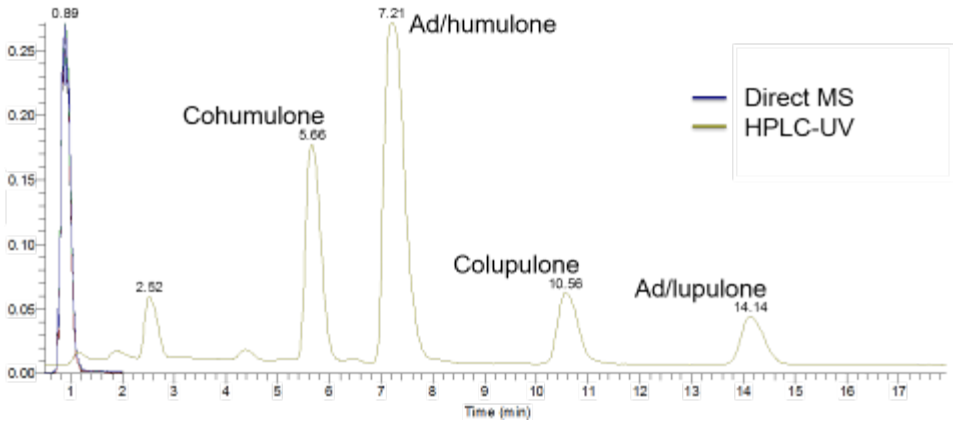
c) Validation of Standard ASBC Methods
   i) HPLC
      (1) The precision of the analysts and the results from Table 1 of the national check sample program verify that the Western Michigan University hop testing facility operates within acceptable experimental output and is confident in customer analysis results.
      (2) The results for HPL-8 were outside acceptable boundaries for variation between laboratories due to an equipment failure.
      (3) After HPLC refurbishment, the results for HPE-9 were well within acceptable boundaries for laboratory variation between laboratories.
   ii) UV/VIS
      (1) The precision of the analysts and the results from Table 2 of the national check sample program verify that the Western Michigan University hop testing facility operates within acceptable experimental output and is confident in customer analysis results.
      (2) α-acid content results for HPE-9 were outside acceptable boundaries for variation between laboratories.
      (3) The variation between the results of the Western Michigan University hop testing facility and the national average for 2013 HPE-12 and 2014 HPE-3 were determined to be from a faulty UV/VIS spectrophotometer.
      (4) A UV/VIS spectrophotometer with a new deuterium source is currently in use that operates within acceptable laboratory output as seen by the results of 2014 HPL-5 (national results not yet released) coinciding with the HPLC results for 2014 HPL-5.

Activity 7 Development of new methods to improve sample throughput and quality

Two methods for direct analysis of α- and β-acids in hops were developed. The first method uses flow injection analysis to introduce an unseparated hops extract to the mass spectrometer for analysis. The second method is similar, but instead of presenting the hops sample to the instrument as a liquid pumped through a capillary, the extract is applied to a paper triangle from which an electrospray is generated. These methods are capable of providing the detailed analyses achievable HPLC-UV but on a much faster timescale, rather than 15-30 minutes, each analysis takes only a minute or less as shown in Figure 2 for direct mass spectrometric analysis by flow injection.

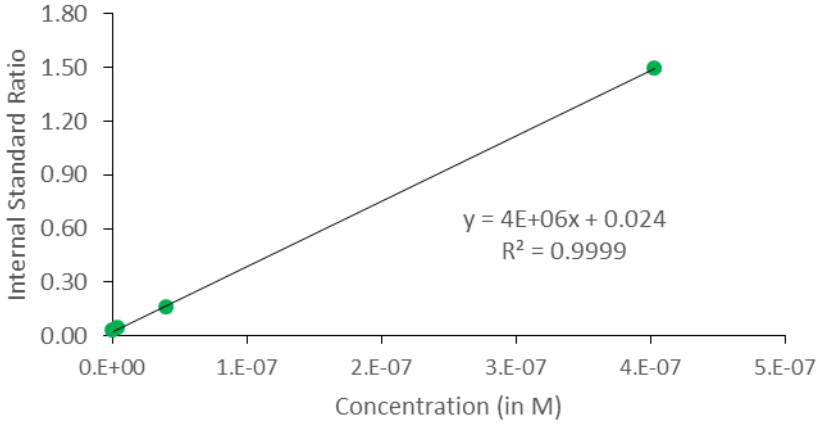
1. Direct analysis by flow injection analysis

Figure 2: Extraction ion chronograms of HPLC and direct analysis by flow injection



The method provides a linear dynamic range between 3 pMol/L to 5 μMol/L total bittering acid concentration. This is demonstrated for cohumulone in Figure 3.

Figure 3: Internal standard calibration curve for cohumulone using flow injection analysis electrospray ionization mass spectrometry



Above a certain concentration, charge competition can begin to affect the ionization of an analyte. The β- acids are more hydrophobic than the α- acids due to the addition of a nonpolar prenyl side chain. The additional hydrophobicity causes the β- acids to be more surface active during ionization and the β- acids ionize more efficiently than the α- acids due to this electromagnetic repulsion. Thus, β- acids can suppress the signal of α- acids at higher concentrations. By comparing the results obtained for HPLC separated bittering acids versus

direct analysis for increasing concentrations of total bittering a limit of 5 μMol/L was established before ion suppression effects on the alpha acids by the beta acids leads to a loss of linearity.

Experimental conditions for HPLC separation and mass analyses used in this study are presented in Appendix B

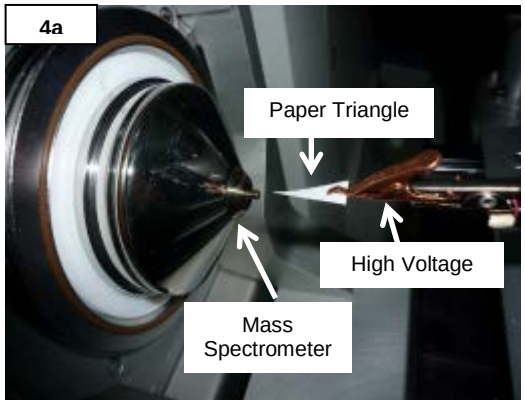
The accuracy of the method was evaluated by comparing the results obtained for analyses of the check samples provided by ASBC as part of the monthly international check sample service. When an internal standard is added to the sample extracts excellent accuracies were obtained as summarized in Table 4. The internal standard used was Tetrahydroiso-α-acids (ICS-T3, or tetra)

Table 4: 2014 ASBC Check Sample Results for Direct Analysis Electrospray Ionization Mass Spectrometry using Internal Calibration Methods

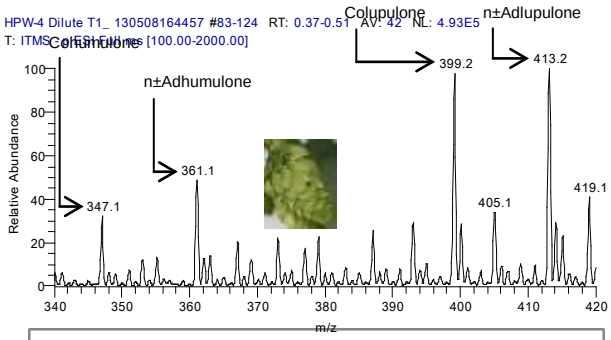
Sample ID	Total % α-acids			Total % β-acids		
	Direct ESI-MS	UV-Vis Nat. Avg.	HPLC Nat. Avg.	Direct ESI-MS	UV-Vis Nat. Avg.	HPLC Nat. Avg.
HPW-1	10.94	11.36±0.52	10.98±2.34	5.25	5.52±0.26	5.04±0.41
HPL-2	16.15	17.54±0.62	15.81±0.53	6.33	5.78±0.76	5.72±0.44
HPE-3	56.94	60.38±1.97	56.26±0.86	15.24	14.94±0.70	14.61±0.27
HPW-4	13.61	14.09±0.56	13.73±0.39	5.31	4.85±0.29	4.31±0.17

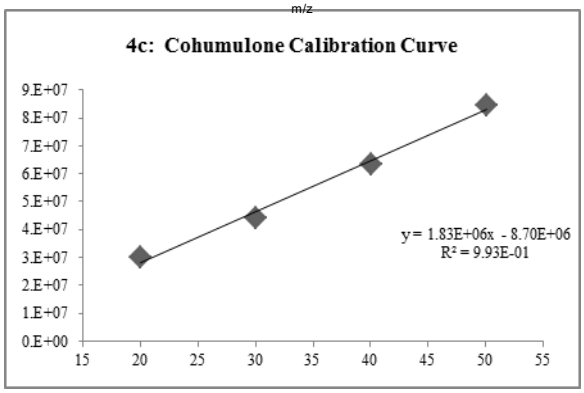
2) Direct analysis of hops bittering acids by paper spray ionization mass spectrometry
Similar to the direct analysis by flow injection method just described, paper spray mass spectrometry offers advantages over lengthy HPLC analyses. In addition, this method promises to be even faster than flow injection analysis and reduce potential carry over problems and the need to clean injector ports and lines between analyses. Sample preparation is also simplified with no need to filter samples prior to analyses. Beer samples can potentially be analyzed without any sample preparation. Figure 4a shows the instrumental configuration for the analysis and 4b a typical mass spectrum obtained by paper spray MS.

Figure 4a: Paper spray ionization mass spectrometry setup. Figure 4b: Mass spectrum for the HPW-4 check sample. 4c: Paper spray ionization calibration curve for cohumulone. (Next page)



4b: Paper Spray Mass Spectrum of HPW-4





A quantitative method is nearly complete. As seen in Figure 4c, a viable calibration curve using ICE-3 as an external standard has been constructed. However, the preliminary data features α- and β-acid content that is inconsistent with the HPLC and UV/Vis results.

There were three main expected outcomes/goals in the original hops proposal submitted to the USDA:

1. More breweries buy and use Michigan grown hops in specialty beers.
2. Increased acreage of hops grown in Michigan and the number of hops growers.
3. Develop a database containing chemical, genetic and environmental information for samples submitted for testing or otherwise sourced from growers. Make this information available to breeders to cultivate improved hops cultivars with distinctive Michigan qualities.

Michigan brewed beer has grown by 21.6% between 2012 and 2013 according to the Michigan Beer Guide May-June 2014 Volume 18 Issue 132. While there were 59 acres of hops grown in Michigan in 2012 (Michigan State and County Data Volume 1, Geographic Area Series, Part 22 AC-12-A-22 Issued May 2014), this has increased to over 200 acres of commercial hops grown in Michigan in 2013, with over 100 more acres expected in 2014. (According to MSU-Ext http://msue.anr.msu.edu/news/interested_in_learning_more_about_hops_production) "Most" of the hops harvested were sold to Michigan breweries, but the exact amount could not be found. The Hop Growers of America and the USDA National Agriculture Statistics Service (USDA-NASS) has reported on the growing acreage of hops in areas outside the traditional growing regions for 2014. Currently, there has only been approximately 300 acres of hops strung in the state of Michigan. (http://www.usahops.org/userfiles/image/1403128582_2014%20June%20US%20Hop%20Acreage%20HGA.pdf)

The total acreage of hops grown in Michigan has drastically increased by over 500% in just two years, but the target was not met for the expected measurable outcome 2.

BENEFICIARIES

The largest beneficiaries for this project were the Michigan hop farmers. These farmers were offered standardized, quality analytical testing for their hop harvest for a reduced rate compared to other Michigan analytical testing facilities. Recently a survey was sent out as part of the activities of this project. While responses are still only slowly incoming, a few responses have been received to date, 5/38 hops growers contacted responded. Four out of five respondents had their hops chemically analyzed. Two respondents identified Michigan based laboratories were used. 3/ 4 respondents indicated that having their hops tested directly influences their ability to sell their crops. 3 /4 respondents indicated that 100% of their crop was sold while another indicated zero being tested and sold. 4/5 respondents indicated that their hops acreages increased over the last two years.

LESSONS LEARNED

There were a few lessons learned as a result of undertaking this project. When running an analysis for a farmer, a control sample, such as the month's prior ASBC Check Sample, should be analyzed on the same day to ensure chemical quality and to validate the functionality of all equipment and instruments. If the ASBC Check Sample analysis does not correlate with the national average for that ASBC method of analysis, then we could take immediate action and reanalyze the farmer's sample. It has been determined that the results for the UV-Vis of hops is far too variable and can have a large fluctuation between instruments. The hop acid extraction method for Hops-6a (UV-Vis) does not seem to be nearly as reliable as the Hops-14 (HPLC) extraction method.

For the ITS molecular screening of pathogens, a significant delay arose from the application process required in order to possess the pathogens and work with them. Although we were eventually granted permission in June 2013, we were never approved to work with live pathogens for experimental inoculations. Such permission will really need to be attained to carry out this process on living plants infected with living pathogens.

CONTACT INFORMATION

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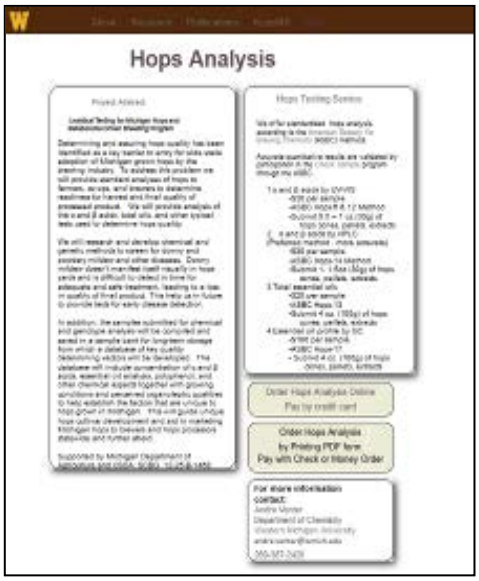
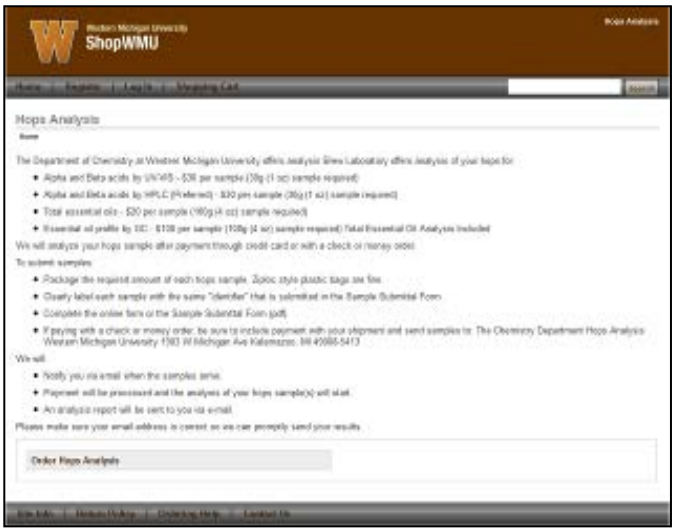
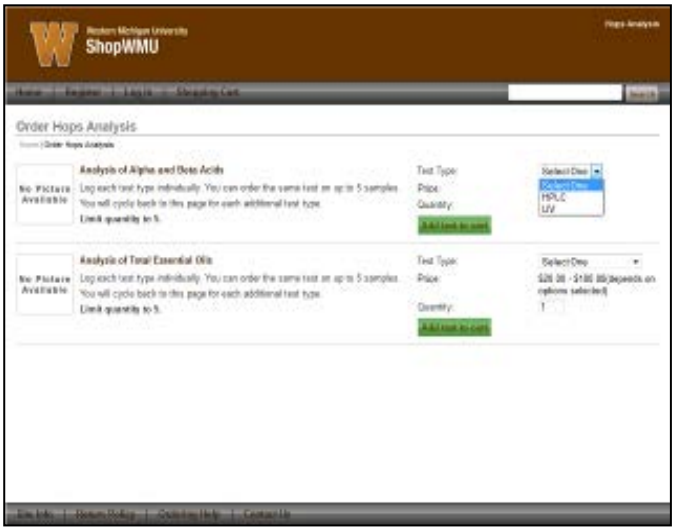
ADDITIONAL INFORMATION

Appendix A

Western Michigan University Hops Analysis Website:
http://homepages.wmich.edu/~gzt8940/andre_venter/Hops.html


Hops Analysis
Order Hops Analysis Online
Pay by credit card
Order Hops Analysis
by Printing PDF form
Pay with Check or Money Order


ShopWMU
Hops Analysis
Order Hops Analysis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Analysis of Total Essential Oils
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Price
Quantity
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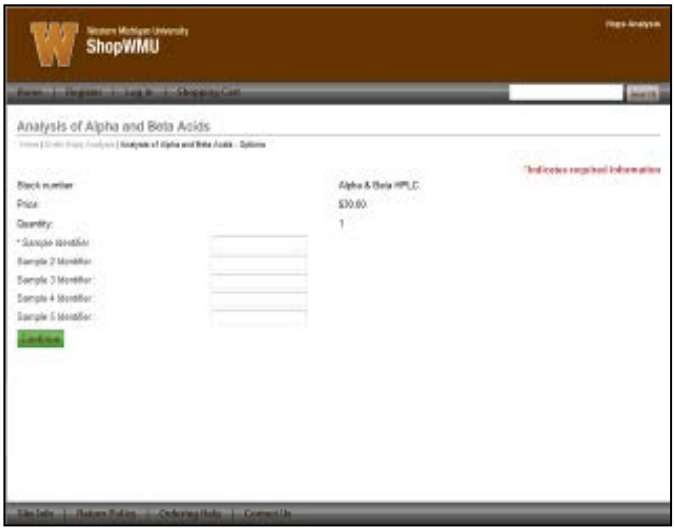
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Price
Quantity
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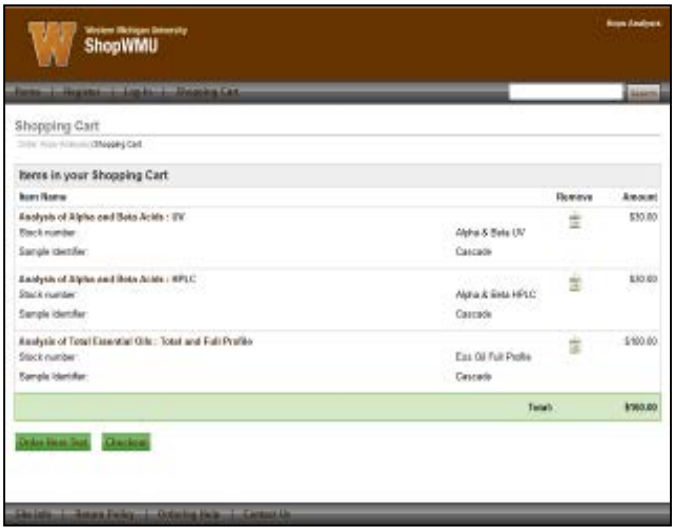
ShopWMU
Shopping Cart
Items in your Shopping Cart
Item Name
Remove
Amount
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Analysis of Alpha and Beta Acids : HPLC
Analysis of Total Essential Oils : Total and Full Profile
Stock number
Sample identifier
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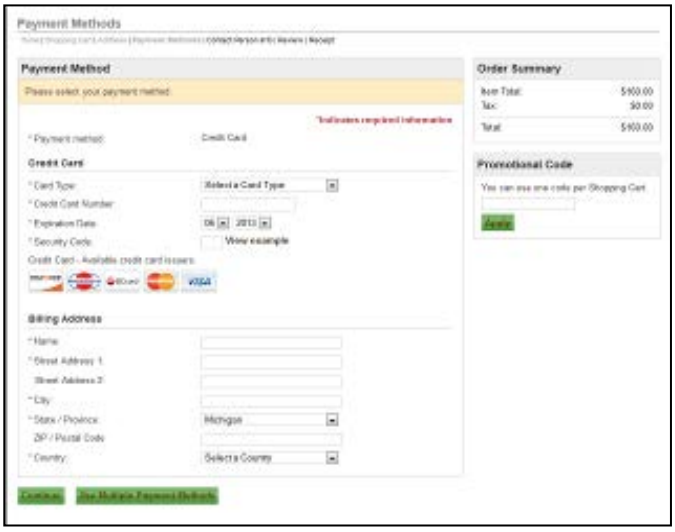
Total:
Order More Test
Checkout


Payment Methods
Payment Method
Please select your payment method
Credit Card
Billing Address
Order Summary
Item Total:
Tax:
Total:
Promotional Code
Apply
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Appendix B

Table 3: Waters Synapt experimental conditions

Waters Synapt Mass Spectrometer Conditions	
Spray Voltage	-3 kV
Sampling Cone Voltage	26 V
Extraction Cone Voltage	5.0 V
Source Temperature	135°C
Desolvation Gas Temperature	300°C
Desolvation Gas Flow Rate	700 L/hour

Table 4: Waters Acquity UPLC experimental conditions

Waters Acquity UPLC Conditions	
Chromatography Column	Phenomenex Kinetex XB-C18 1.7µm, 2.1 mm x 50.0 mm, 100 Å
Mobile Phase Composition	Methanol:Water:Formic Acid
Mobile Phase Condition	Isocratic at 80:20:0.1
Flow Rate	0.500 mL/min
Injection Volume	5.0 µL

The hop acids were extracted from hops by means of the Hops-14 American Society of Brewing Chemists Hops-14 official method of analysis. Approximately 15g of hops is ground into hop powder using a coffee grinder. 10g of ground hops is transferred to a 250mL bottle. 20mL of methanol and 100mL of diethyl ether is added into the bottle. The bottle is stoppered and stirred for 30 minutes with a stir plate and stir bar. 40 mL of 0.1M hydrochloric acid is added to the bottle and stirred an additional 10 minutes. The solution is allowed to rest for 10 minutes to separate the organic and aqueous layer. A volumetric pipette is used to transfer 5.0 mL of the organic ether layer into a 50 mL volumetric flask and filled to volume with methanol. This diluted extract is centrifuged prior to injection into an HPLC. A varying concentration range of ICE-3 is used for the external standard calibration curves. Tetrahydroiso-α-acid standard is added to the ICE-3 standards and the hop extract samples at a concentration of 500 nM for the internal standard calibration curves.

Appendix C

Special Thanks

Supported by Michigan Department of Agriculture and USDA: SCBG 12-25-B-1468

Standardized hops analysis according to the American Society for Brewing Chemists (ASBC) methods.

Accurate quantitative results are validated by participation in the Check Sample Program through the ASBC

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Western Michigan University
Hops Testing Facility

Analytical Testing for Michigan Grown Hops

Product/Service Information

Tel: (269) 387-2420

Hops Analysis

Determining and assuring hops quality has been identified as a key barrier to entry for wide scale adoption of Michigan grown hops by the brewing industry. To address this problem we will provide analysis of the α and β acids, total oils, and other typical tests used to determine hops quality.

Quality Assurance

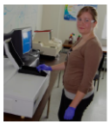
To assure the accuracy of our services we participate in the American Society of Brewing Chemists (ASBC) Check Sample Program. Single-blind unknown samples are sent to participating labs for quantitative analysis each month. These samples can include hops cones, pellets or extracts. Each lab sends their results in and they are compiled and made public so that we can compare our results to other labs providing the same services. This service allows us to validate the accuracy of our services and make changes to our methods if necessary.

How to Sample

Sample size requirements are listed as dry sample weights. Wet samples should be at least 3 times the required weight to allow for loss during drying. Wet samples will also require an additional day to process due to drying. The required sample size of hops should be placed in a bag preferable vacuum sealed or zip locked. For small samples one bag should be used but for larger sample sizes, like that of the Total Essential Oils method, will require multiple bags depending on the size of bag used. Upon sealing of the bag excess air should be expelled and samples should be kept cool to deter the growth of mold. Samples should be shipped to the lab as quickly as possible for the most accurate results.

Services

High Performance Liquid Chromatographic analysis of hops offers excellent quantitation of the major components of hops. With this method the percent compositions of Alpha Acids, Beta Acids, Cohumulone and Colupulone can be obtained. For this technique we utilize the American Society of Brewing Chemists (ASBC) Hops-14 HPLC method.



Using UV/VIS spectrophotometry we can obtain the total percent composition of Alpha Acids and Beta Acids in a sample of hops as well as the Hops Storage Index (HSI). For this technique we utilize the ASBC Hops-6 UV/VIS method.

The Total Essential Oils in a sample can be obtained through a steam distillation utilizing the ASBC Hops-13 method.

An Essential Oil Profile by gas chromatography allows growers and brewers to see what important flavor components are present in a particular variety of hops. For this technique we utilize the ASBC Hops-17 Method.

Price List

α and β by UV-VIS $30.00
- ASBC Hops –6 & 12 Method
- Submit 0.5-1 oz. (~30g) of dry hops cones, pellets, extracts

α and β by HPLC $30.00
- ASBC Hops-14 Method
- Submit 0.5-1 oz. (~30g) of dry hops cones, pellets, extracts

Total essential oils $20.00
- ASBC Hops-13 Method
- Submit 4 oz. (100g) of dry hops cones, pellets, extracts

Essential oil profile by GC $100.00
- ASBC Hops-17 Method
- Submit 4 oz. (100g) of dry hops cones, pellets

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Appendix D

The following is an example of monthly ASBC check sample results. The Western Michigan University hop testing facility is subscriber number 184.

HPL-8

American Society of Brewing Chemists
HOPS CHECK SERVICE

8/31/2013

	Spectrophotometric Methods			Conductometric Methods			HPLC Method				
Subscriber Number	Alpha Acids (%)	Beta Acids (%)	Hop Storage Index	ASBC C.V. (%)	EBC LCV (%)	MEBAK LCV (%)	Alpha Acids (%)	Beta Acids (%)	Cohumulone (% of total)	Colupulone (% of total)	Standard
B 6	17.08	5.45	0.347				14.94	5.61	24.03	52.080	ice3
B 8	17.17	5.90	0.349		15.42	16.81	15.13	5.68	24.03	51.800	ice3
B 10	16.77	6.64	0.331			16.74	15.13	6.00	* 34.20	50.830	ice3
B 15	16.10	5.50	0.344								
B 17	16.40	5.50	0.385								
B 18							14.78	5.52	24.47	50.950	ICE-3
B 95	16.97	6.20	0.380				13.28	5.44	24.02	49.980	ice3
B 99	16.90	6.20	0.338		15.00	15.96					
B 115	17.17	6.17	0.342			17.40	15.25	5.64	24.10	52.300	ice3
B 127	16.23	5.66	0.366		15.16	17.06	15.01	5.82	24.92	49.830	ice3
B 140	16.21	4.96	0.340		15.14		15.56	6.00	25.17	52.580	ice3
B 142	16.80	6.01	0.391				14.51	5.84	24.89	51.350	
B 163							14.10	5.70	24.93	49.960	ice3
B 164					15.50						
B 174	17.50	6.80									
B 178	16.60	5.35	0.313				14.14	5.48	23.93	51.060	ice3
B 182	16.79	5.82	0.363				14.80	6.01	* 26.96	50.492	ice3
B 184	15.90	5.40	0.352				* 5.77	* 2.22	24.52	51.460	ice3
B 186	16.71	5.50	0.370								
N	16	16	15		5	5	12	12	11	13	
Mean	16.71	5.82	0.354		15.24	16.79	14.72	5.73	24.46	51.129	
Min	15.90	4.96	0.313		15.00	15.96	13.28	5.44	23.93	49.830	
Max	17.50	6.80	0.391		15.50	17.40	15.56	6.01	25.17	52.580	
Std	0.44	0.50	0.021		0.21	0.53	0.63	0.20	0.46	0.908	

** Not included in mean.*

Confidentiality Notice: The data contained herein are confidential and intended for subscriber use only. Data from other subscribers are included for comparison purposes only.

PROJECT TITLE: Michigan Vegetable Council, Inc.: Identifying Tools to Manager Phytopohthora Root, Crown, and Fruit Rot of Winter Squash and Pumpkins - FINAL

PROJECT SUMMARY

Michigan is the largest producer of squash and the sixth largest producer of pumpkins for the fresh and processing market in the U.S. Recently, Nestle has contracted with growers in western Michigan to produce 'Dickinson Field' processing pumpkins for Libby's canned pumpkin. This was initiated due to yield losses caused by *Phytophthora capsici* in Illinois leading to production shortages there. Winter squash is grown commercially in Michigan for use in baby food purees and also for the fresh market.

Root, crown, and fruit rot caused by *P. capsici* is a major constraint to cucurbit production. Phytophthora fruit rot can cause complete crop failure. In Mason County, MI, an individual grower lost more than 90% of his winter squash (80 acres) due to Phytophthora fruit rot in 2010 (M. Meyer and M. Hausbeck, *personal observation*).

Production of winter squash and processing pumpkins can be especially challenging as fruits have a long maturation time, increasing the contact time between the susceptible fruit and soil containing spores of *P. capsici*. Differences in susceptibility have been observed between butternut squash cultivars to Phytophthora root and crown rot (Enzenbacher and Hausbeck, unpublished), but variations in cultivar susceptibility to fruit rot have not been previously investigated. Age-related fruit resistance varied widely between the processing pumpkin and squash cultivars used in a Meyer and Hausbeck study. The relatively low profit margin of squash and pumpkins produced for the processing market and use of mechanical harvesters do not allow for use of cultural techniques (raised beds, black plastic mulch, trickle irrigation, trellising) that have proven helpful in reducing Phytophthora rot of cucurbits and peppers produced for the fresh market. Hence, Phytophthora rot of winter squash and processing pumpkin is primarily managed with fungicides and crop rotation.

Most growers use foliar fungicide applications exclusively, and fungicides need to be applied preventively and before and after a rain event to reduce Phytophthora rot. Foliar fungicide applications may not reduce fruit rot when the crop canopy prevents coverage of the fruit or when applications do not reach the undersides of fruit that are in direct contact with the soil. In addition, foliar fungicide applications may not provide adequate protection to crown and root tissue. Michigan research has shown that soil application of fungicides has been shown to be more effective than foliar application to manage crown and root rot of yellow squash and bell pepper. Currently, only two fungicides (fluopicolide and mefenoxam) are registered for drip application to reduce disease caused by *P. capsici*. Resistance to mefenoxam (metalaxyl-M) is widespread in *P. capsici* populations from the primary vegetable growing regions in Michigan and we do not recommend its use in these regions. Hence, additional products that can be rotated with fluopicolide for drip applications need to be identified, which will need to be labeled for this use in the future.

Michigan growers need a management plan that allows for the consistent production of a high quality product to fulfill contractual obligations and remain competitive. To provide growers with an economically viable management program that limits diseases caused by *P. capsici*, research is needed to determine the most effective fungicides and fungicide application methods. An effective management scheme that includes less susceptible cultivars and effective fungicides is essential to reduce losses caused by *P. capsici* and increase the economic viability of the winter squash and processing pumpkin producers in Michigan.

PROJECT APPROACH

Research addressed the Michigan Vegetable Council's first research and extension priority (www.greeen.msu.edu): 'Control of *Phytophthora capsici* . . . on vegetable crops.

Research evaluated susceptibility of hard squash types/cultivars, effects of fruit age on disease, efficacy of fungicides and application methods, and whether treatments needed to be continued once fruits reach maturity. Squash fruit types (acorn, pumpkin, etc.) differed in disease susceptibility as did cultivars within a type. Resistance increased with maturity, but rind hardness was not the main factor in age-related resistance. Disease intensity over the season (AUDPC) was decreased by in-furrow/drench applications of DPX-QGU42 and Ridomil Gold to 'Dickinson Field' pumpkin and DPX-QGU to 'Golden Delicious' squash. Revus increased pumpkin yields. No differences occurred among treatments of registered and new fungicides whether they were applied until fruit were mature or until harvest. Lower AUDPC values occurred for drench/drip applications of conventional fungicides than biopesticides on squash cultivars; however, there were no differences for varying intervals. Conventional fungicides applied to 'Table Ace' every 14 days yielded more than 21 day intervals. Results prove that a generic management program will not be effective for all types and cultivars of pumpkins and hard squashes.

GOALS AND OUTCOMES ACHIEVED

Table 1. List of fungicides and biopesticides tested in this research project.

Product	Active ingredient	Labeled
Actinovate AG*	*Streptomyces lydicus*	yes
Bio-Tam*	*Trichoderma asperellum*, *T. gamsii*	yes
DPX-QGU42	oxathiopiprolin	no
Forum 4.1SC	dimethomorph	yes
Presidio 4FL	fluopicolide	yes
Revus 2.08SC	mandipropamid	yes
Ridomil Gold**	mefenoxam	yes
Serenade Soil*	*Bacillus subtilis*	yes

*Classified by the EPA as a biopesticide.
**Classified by the EPA as a reduced risk fungicide.

1. Investigate differences in susceptibility to *P. capsici* for various hard squash types (butternut squash and pie pumpkins) and determine the effects of fruit age on disease development. The experiment was conducted at the Plant Pathology Farm in Lansing, MI. On 12 June, 3-week-old transplants of 12 commercial fresh market squash and pumpkin cultivars were transplanted into 6-inch raised beds. The beds were mulched with black polyethylene plastic, irrigated with drip irrigation, and fertilized according to local commercial standards. The rows were 50 feet in length, with 2-feet spacing between transplants within row. Beds were spaced 12 feet apart. After initiation of flower production in early July, male flowers were removed and used to pollinate female flowers. The female flowers were tagged with the date and target harvest age. After 7, 14, 22, and 56 days post pollination, the fruits were harvested and brought to the lab. Fruits were washed in 10% bleach for five minutes and rinsed in tap water. Fruits were inoculated with *P. capsici* in the middle of the fruit, and placed into plastic bins lined with moist paper towels under constant fluorescent light. *P. capsici* isolates OP97 (A1 mating type, sensitive to mefenoxam, isolated from pumpkin) and 12889 (A1 mating type, insensitive to mefenoxam, isolated from pepper) were used to inoculate the fruits. Fruits were incubated 4 days at ambient temperature, pathogen growth was measured and rated on a 0-4 scale (0=no growth, 1=water soaking only, 2=light pathogen growth, 3=moderate pathogen growth, 4=dense pathogen growth). Temperature and humidity were measured in the bins with Watchdog data loggers (Spectrum Technologies, Inc., Aurora, IL). Average temperature was

75.2°F and average relative humidity was 99.7 during incubation. After the experiment, pericarp and excerpt firmness were measured with a fruit penetrometer (model FT 327, QA Supplies LLC, Norfolk, VA). Data were analyzed using SAS Proc Mixed and Proc Corer, and statistical differences were compared using the Fisher's Least Significant Differences test (P=0.05).
All cultivars gained resistance to fruit rot as they matured from seven to 56 days post pollination (P<0.001) (see Fig. 1 under Additional Information). The cultivar Vegetable Spaghetti was most resistant at the 7, 14, and 22 day age ranges (*data shown only for 22 days post pollination*), exhibiting no pathogen growth at 22 and 56 days post pollination. 'Chucky' pumpkin had significantly more *P. capsici* growth than all other cultivars. Excerpt and pericarp (*data not shown for pericarp*) firmness were negatively correlated with pathogen growth rating and disease incidence (P<0.001) for all cultivars analyzed. The general trend for all cultivars was that the excerpt became harder and resistance increased as cultivars matured, and concurrently, pathogen growth decreased. However, at 22 days post pollination, excerpt firmness and disease incidence did not correlate (P=0.85) among cultivars. Gold Dust, which had the hardest excerpt, had the second highest number of fruits infected at this age. Thus, excerpt firmness does not appear to be the main factor in age-related disease resistance in hard squash. Three cultivars, Lumina, Hubal, and Diablo had pathogen growth on a small percentage of fruit at 56 days post pollination.

Table 2. Effect of cultivar on susceptibility to *Phytophthora* infection and rind hardness.

Cultivar (squash type, *Cucurbita* sp.)	Days to harvest	*P. capsici* growth[s]	Infected fruit (%)	Excerpt firmness (kg)[y]
Autumn (acorn, *C. pepo*)	90	0.2 d[x]	6	10.2 c
Table Ace (acorn, *C. pepo*).....	70	0.2 d	6	11.9 ab
Table Gold (acorn, *C. pepo*)	80	0.4 b-d	25	11.1 b
Avalon (butternut, *C. moschata*)	90	0.2 d	19	8.5 ef
Early Butternut (butternut, *C. moschata*).....	82	0.2 d	19	9.0 e
Waltham (butternut, *C. moschata*)	110	0.4 b-d	44	9.1 de
Hubba Hubba (hubbard, *C. maxima*)	95	0.9 bc	31	7.2 g
Chucky (pumpkin, *C. pepo*)	85	2.3 a	75	10.0 cd
Diablo (pumpkin, *C. pepo*)	100	0.4 cd	19	8.0 fg
Gold Dust (pumpkin, *C. pepo*)	95	1.1 b	63	12.7 a
Lumina (pumpkin, *C. maxima*)	100	0.9 bc	56	6.0 h
Vegetable Spaghetti (spaghetti, *C. pepo*)	100	0.0 d	0	10.0 cd

[z]Rated on a scale of 0-4, where 0=no growth, 1=watersoaking only, 2=light pathogen growth, 3=moderate pathogen growth, 4=dense pathogen growth. Taken 22 days postpollination.
[y]Measurement made using fruit penetrometer.
[x]Column means with a common letter are not significantly different (Fisher LSD test; P=0.05).

2. Test soil application of fungicides (in-furrow/drench applications) to control Phytophthora crown and root rot of processing pumpkin. The experiment was conducted at the Southwest Michigan Research and Extension Center in Benton Harbor, MI on fine loamy sand. On 10 June, seeds of 'Dickinson Field' pumpkin and 'Golden Delicious' squash were sown using a mechanical seeder into a field arranged in a split plot design. During sowing, fungicide treatments were applied into the furrow using a backpack sprayer equipped with a hand wand and 8003XR nozzle at 50 GPA on 13 June. Five fungicides and one biological control (Bio-Tam) were applied using labeled rates and each treatment was blocked and replicated within a plot (randomized complete block design). Ten days after the seedlings emerged, *P. capsici*-infested

millet was inserted into the soil 0.5 inch from the crown of each seedling. *P. capsici* isolates 12889 (A1 mating type, insensitive to mefenoxam, isolated from pepper), and SP98 (A2 mating type, sensitive to mefenoxam, isolated from pumpkin) were used to infest the millet (100 g sterilized millet, 72 ml distilled water, 0.08 g asparagine). Subsequent fungicide treatments were applied as foliar sprays on 27 June and 11 July (14 and 28 days after sowing, respectively) using a backpack sprayer equipped with a 3-nozzle boom and 8003XR nozzles. Nozzles were spaced 18 inches apart with the outer two nozzles directed at a 45° angle towards the seedling crowns. Healthy, wilted, and dead plants were counted weekly to obtain an area under the disease progress curve (AUDPC) and plant death value (%). AUDPC is a quantitative summary of disease intensity over the growing season. At the end of the season, on 13 September, fruits were harvested and weighed, and final disease incidence was calculated. Data were analyzed using SAS Proc Mixed and statistical differences were compared using the Student Newman Keuls procedure.

Disease pressure was significant, resulting in 75% and 100% death of untreated inoculated 'Dickinson Field' pumpkin and 'Golden Delicious' squash plants, respectively. Compared with the inoculated control plants, disease intensity over the growing season (AUDPC values) were significantly lower for 'Dickinson Field' plants treated with DPX-QGU42 and Ridomil Gold. Treatments of Revus produced significantly higher yield of 'Dickinson Field' than the inoculated control.

'Golden Delicious' had a lower AUDPC value when treated with DPX-QGU than the inoculated control; however, plant death of DPX-QGU-treated plants still reached an unacceptable high of 75%. Yields of all fungicide treatments of 'Golden Delicious' were similar to that of the untreated inoculated plants.

Table 3. Evaluation of in-furrow/drench fungicides on Phytophthora of processing pumpkin.

Treatment and rate/A	Plant death (%)	AUDPC*		Yield (lb/100 ft row)	
'Dickinson Field' pumpkin					
Uninoculated control	20.0	761	a**	699	a
Inoculated control	75.0	5339	c	185	c
DPX-QGU42 9.6 fl oz	42.5	1689	ab	376	a-c
Ridomil Gold 1 pt	48.5	2283	ab	407	a-c
Presidio 4 fl oz	52.5	3098	bc	287	c
Revus 8 fl oz	54.0	3140	bc	660	ab
Forum 6 fl oz	72.5	4380	c	317	bc
Bio-Tam 2.2 lb	72.5	4583	c	272	c
'Golden Delicious' squash					
Uninoculated control	10.0	704	a	401	a
Inoculated control	100.0	6411	c	0	b
DPX-QGU42 9.6 fl oz	75.0	3703	b	112	b
Ridomil Gold 1 pt	92.0	5510	bc	13	b
Revus 8 fl oz	90.0	5645	bc	40	b
Forum 6 fl oz	92.5	5786	bc	80	b
Presidio 4 fl oz	95.0	5998	c	42	b
Bio-Tam 2.2 lb	95.0	6068	c	17	b

*Area under disease progress curve.

**Column means with a common letter are not significantly different (Student-Newman-Keuls; *P*=0.05).

3. Test registered and new fungicides to reduce Phytophthora crown and fruit rot of processing pumpkin fruits. This trial was conducted at the Southwest Research and Extension Center. On 13 June, seeds of 'Dickinson Field' pumpkin were sown into a field

organized in a split plot design. The first fungicide applications were made on 30 July after initiation of fruit growth. Fungicide treatments consisted of alternations of two fungicides sprayed at labeled rates, using a CO_2 backpack sprayer with a three nozzle boom (8003XR nozzles). Plot one was sprayed weekly until harvest and plot two was sprayed weekly until physiological maturity (~75% of fruit were at full size or >21 days postpollination). Both plots were sprayed with the same treatments. Nine total sprays were made to the plots treated until harvest on 1, 8, 12, 19, 26 and 30 August; 4, 11 and 16 September; four sprays were applied to plots treated until fruit maturity on 1, 8, 12, 19 August. Treatments were blocked and replicated four times within a plot, with a 20-foot row consisting of one replication. Once pumpkin fruits were ~ 25-35 days postanthesis, they were tagged in the field, harvested (12 fruits per treatment per plot), and brought to the MSU Plant Pathology Farm in Lansing for inoculation. Pumpkins were placed in crates, randomized, measured (*data not shown*) and inoculated with a virulent *P. capsici* isolate on 7 September. *P. capsici* isolate 12889 (A1 mating type, insensitive to mefenoxam, isolated from pepper) was grown on V8 juice agar, and a 7-mm plug from an actively growing colony was used to inoculate the fruits. All inoculations were made in the middle of the fruit, and uncolonized agar was used to inoculate control fruits. The agar plugs were covered with a plastic screw cap (Axygen Inc, Union City, CA) affixed to the fruit with petroleum jelly to prevent desiccation. Wet paper towels were spaced among the crates and the crates were covered with a large clear plastic tarp to maintain high humidity. After 7 days, fruits were rated for pathogen growth on a 0-4 scale (0=no growth, 1=watersoaking only, 2= light pathogen growth, 3=moderate pathogen growth, 4=dense pathogen growth) and lesions were measured. Temperature and humidity were measured during the experiment using WatchDog Data Loggers; average temperature during the study was 72.0°F and average relative humidity was 80.5. Data were analyzed using SAS Proc Mixed and statistical differences were separated using the Fischer Least Significant Differences test (P = 0.05).

When the data were analyzed together there were no significant differences among treatments, and the fungicide by plot interaction was not significant (P=0.78). Although there were no statistical differences, some trends were observed. When treatments were applied to harvest, Forum alternated with DPX-QGU resulted in the lowest disease rating and fruits with lesions (%) and the smallest lesion diameter. When treatments were applied until maturity, Presidio alternated with Forum resulted in the lowest numbers for all parameters measured. An assay was completed in the MSU greenhouse using pumpkins from the same field plots at the 10-15 days postpollination age range; however, due to excessively high greenhouse temperatures (>110°F), data were inconsistent and not reported.

Table 4. Evaluation of fungicides applied until fruit maturity or until harvest on Phytophthora of processing pumpkin.

Treatment and rate/A[z]	**Average rating[y]**	**Average lesion diameter (cm)**	**Fruits with lesions (%)**
Sprayed until harvest			
Unsprayed control.....	0.45[x]	1.83	25
Presidio 4FL 4 fl oz -*alt*- Revus 2.08SC 8 fl oz.....	0.28	0.67	17
Presidio 4FL 4 fl oz -*alt*-Forum 4.1SC 6 fl oz.....	0.61	2.25	42
Presidio 4FL 4 fl oz -*alt*- DPX-QGU42 4.8 fl oz	0.11	1.00	17
Revus 2.08SC 8 fl oz -*alt*-DPX-QGU42 4.8 fl oz	0.45	1.38	17
Forum 4.1SC 6 fl oz -*alt*- DPX-QGU42 4.8 fl oz	0.04	0.34	8
Sprayed until maturity			
Unsprayed control.....	0.17	0.98	17
Presidio 4FL 4 fl oz -*alt*- Revus 2.08SC 8 fl oz.....	0.17	1.30	17
Presidio 4FL 4 fl oz -*alt*-Forum 4.1SC 6 fl oz.....	0.08	0.13	8

Treatment and rate/A[z]	Average rating[y]	Average lesion diameter (cm)	Fruits with lesions (%)
Presidio 4FL 4 fl oz -*alt*- DPX-QGU42 4.8 fl oz	0.08	0.58	8
Revus 2.08SC 8 fl oz -*alt*-DPX-QGU42 4.8 fl oz	0.50	1.75	25
Forum 4.1SC 6 fl oz -*alt*- DPX-QGU42 4.8 fl oz	0.08	0.54	8

[z]-*alt*- = alternating program.
[y]Pathogen growth ratings calculated on 0-4 scale.
[x]There were no significant differences among treatments.

4. Determine the optimal fungicide application interval for fungicides applied through the drip irrigation system to manage Phytophthora crown and root rot of fresh market winter squash. The experiment was conducted at the Southwest Michigan Research and Extension Center on fine loamy sand. Seedlings were grown in 72-cell flats at the MSU Plant Pathology Farm for 3½ weeks. On 17 June, fresh market squash cultivars Table Ace acorn and Chieftain butternut squashes were transplanted into six-inch raised beds covered with black polyethylene mulch. Beds were spaced 5½ feet on center, and rows were 25 ft in length. The field was organized in a split-plot design, with cultivar as the main effect. The trial was arranged with 6 treatments, consisting of three biopesticides (Serenade Soil, Bio-Tam, Actinovate AG) or three conventional fungicides (Presidio, Revus, DPX-QGU42) applied on 7-, 14-, or 21-day rotations. After transplanting, the first fungicide in the drip alternation sequence was applied using a backpack sprayer equipped with a TeeJet 8002 flat fan nozzled hand wand, and calibrated to 30 GPA. The application was made as a soil drench directed to the crown-soil interface on 19 Jun. All other applications were made with CO_2 pressurized canisters applied using labeled rates via drip irrigation on 27 Jun; 1, 8, 15, 22 and 29 Jul; 4, 12, 19 and 26 Aug. Five days after the first treatment application, the plants were inoculated with *P. capsici*-infested millet (100 g sterilized millet, 72 ml distilled water, 0.08 g asparagine). Holes were made 1 cm from the plant crown and 1 g of millet was inserted. *P. capsici* isolates 12889 (A1 mating type, insensitive to mefenoxam, isolated from pepper), and SP98 (A2 mating type, sensitive to mefenoxam, isolated from pumpkin) were used to inoculate the study. Healthy, wilted, and dead plants were counted weekly to obtain a disease progress curve and incidence of plant death value. At the end of the season on 6 Sep, fruits were harvested and weighed. Data were analyzed using SAS Proc Mixed and statistical differences were compared using the Student Newman Keuls procedure.

Disease pressure on ‘Chieftain’ squash was significant, with 72.5% of the inoculated plants dead by the end of the season. ‘Chieftain’ plants treated with the three Presidio fungicide rotations, regardless of application interval, had significantly lower plant death and AUDPC than the inoculated control (P=0.05); there were no differences among yield (see Fig. 2 under Additional Information). When compared with the uninoculated plants, the biopesticide program applied at 14-day intervals yielded significantly less.

Disease pressure was severe on ‘Table Ace’ squash; all inoculated and biopesticide-treated plants were dead by the end of the season. Plants treated with Presidio programs resulted in significantly more dead plants than uninoculated plants, while AUDPC values were similar for Presidio programs and the uninoculated. Plants treated with the Presidio program applied at 14-day intervals yielded similar to the uninoculated plants, while 21-day intervals resulted in significantly lower yields when compared to the uninoculated plants.

Table 5. Evaluation of varying application intervals of fungicides for control of *Phytophthora* on two squash cultivars.

Treatment and rate/A	Application intervals	Plant death (%)[y]	AUDPC[x]	Yield (lb/100 ft row)
'Chieftain' acorn squash				
Inoculated control	--	72.5 c[w]	4238 d	63 ab
Uninoculated control	--	10.0 ab	394 a	140 a
Presidio 4 fl oz -*alt*- Revus 8 fl oz -*alt*- DPX-QGU42 9.6 fl oz	7 day	7.5 a	410 a	131 ab
Presidio 4 fl oz -*alt*- Revus 8 fl oz -*alt*- DPX-QGU42 9.6 fl oz	14 day	12.5 ab	520 ab	118 ab
Presidio 4 fl oz -*alt*- Revus 8 fl oz -*alt*- DPX-QGU42 9.6 fl oz	21 day	10.0 ab	350 a	128 ab
Serenade Soil 2 qt -*alt*- Bio-tam 2.2 lb -*alt*- Actinovate AG 0.75 lb	7 day	67.5 c	3680 cd	74 ab
Serenade Soil 2 qt -*alt*- Bio-tam 2.2 lb -*alt*- Actinovate AG 0.75 lb	14 day	75.0 c	3888 d	53 b
Serenade Soil 2 qt -*alt*- Bio-tam 2.2 lb -*alt*- Actinovate AG 0.75 lb	21 day	57.5 c	3208 cd	72 ab
'Table Ace' butternut squash				
Inoculated control	--	100.0 c	6221 d	0 d
Uninoculated control	--	5.0 a	298 a	140 a
Presidio 4 fl oz -*alt*- Revus 8 fl oz -*alt*- DPX-QGU42 9.6 fl oz	7 day	45.0 b	2363 ab	93 bc
Presidio 4 fl oz -*alt*- Revus 8 fl oz -*alt*- DPX-QGU42 9.6 fl oz	14 day	22.5 b	955 a	119 ab
Presidio 4 fl oz -*alt*- Revus 8 fl oz -*alt*- DPX-QGU42 9.6 fl oz	21 day	50.0 b	2374 ab	71 c
Serenade Soil 2 qt -*alt*- Bio-tam 2.2 lb -*alt*- Actinovate AG 0.75 lb	7 day	100.0 c	6251 c	0 d
Serenade Soil 2 qt -*alt*- Bio-tam 2.2 lb -*alt*- Actinovate AG 0.75 lb	14 day	100.0 c	6208 c	0 d
Serenade Soil 2 qt -*alt*- Bio-tam 2.2 lb -*alt*- Actinovate AG 0.75 lb	21 day	100.0 c	6278 c	0 d

[z] -*alt*-=alternate.
[x]Calculated as % plant death 78 days after planting
[y]Area under disease progress curve.
[w]Column means with a common letter are not significantly different (Student-Newman-Keuls; *P*=0.05).

BENEFICIARIES

If *P. capsici* is not controlled, the 90% winter squash loss suffered by a grower in 2010 has the potential of costing Michigan squash growers up to $18 million in the 2013 market. Due to the ability of *P. capsici* to survive for many years in soil, losses would recur every year a susceptible crop is grown. *P. capsici* infects many vegetables, as well as squash and pumpkin. Michigan ranks among the top 11 states in the U.S. for production of *P. capsici*-susceptible fresh market and processing snap bean, cucumber, pepper, tomato. Along with squash and pumpkin, these crops are grown on 74,700 acres and are worth $153.5 million to Michigan growers. This research benefits growers of all susceptible crops and allied agricultural businesses by maintaining the sustainability of these industries. Results were presented at the Vine Crops Session of the Great Lakes Fruit, Vegetable and Farm Market Expo in December 2013.

LESSONS LEARNED

Conventional fungicides (Presidio, Revus and DPX-QGU42) appeared more effective than biopesticides at limiting disease. Widespread use of mefenoxam (Ridomil Gold) has resulted in development of mefenoxam resistance in some populations of *P. capsici* isolates. Rotating products with different modes of action will help delay the development of fungicide resistance in *P. capsici*. Fluopicolide (Presidio) and mandipropamid (Revus) have proved effective in this research and are good rotation products to use with mefenoxam. Oxathiopiprolin (DPX-QGU42) is an experimental product proved effective in this research. Speedy registration of this product with labeled treatments as a foliar spray and soil application would give growers another tool against *P. capsici*.

Susceptibility of fruits varied among different types of squashes and pumpkin, among cultivars of a particular type, and also was affected by fruit age. The experiment comparing fungicide treatments applied until fruit maturity versus harvest did not produce significant data. More research is needed to clarify how crop type/cultivar and fruit age may affect disease management recommendations for pumpkin and squash crops.

While varying fungicide application intervals from 7 to 14 or 21 days did not affect the amount of disease on two types of squash, 14-day treatments significantly increased yield compared with 21-day treatments for only one cultivar. Identification of effective fungicide application intervals is likely to be influenced by the squash type and cultivar grown.

CONTACT INFORMATION

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ADDITIONAL INFORMATION

Figure 1. 'Table Gold' acorn squash fruits inoculated with *P. capsici* at 7, 14 and 22 days (left to right) postpollination. Note that the fruit inoculated at 14 days had a smaller lesion than the fruit inoculated at 7 days; inoculation at 22 days did not result in infection.

Figure 2. Regardless of Application interval, conventional fungicides (Presidio alternate Revus alternate DPX-QGU42) applied through drip irrigation to 'Chieftain' butternut squash significantly reduced Phytophtohora disease (left). There were no differences among treatments for yield (right).

PROJECT TITLE: Michigan Food and Farming Systems: Enhancing the Profitability of Michigan's Specialty Crops Growers through Retail, Wholesale and Institutional Channels and Continuous Improvement of Food Safety Plans - FINAL

PROJECT SUMMARY

Michigan's specialty crop growers have witnessed increased demand for their crops and increased food safety requirements from regional buyers. Increased demand is due to growing consumer interest in purchasing local food and from Michigan retailers and wholesalers working to source more local fruits and vegetables to meet that consumer demand.

This project builds on successful partnerships MIFFS has previously established with governmental agencies, buyers of regional specialty crops, and agriculture groups across Michigan to help farmers find new, fresh markets and to improve their on-farm food safety plans. MIFFS conducted two educational sessions teaching participants how to develop farm food safety plans focusing on traceability plans and three food safety updates based on the rules released for the Food Safety Modernization Act. MIFFS also conducted a statewide Meet the Buyers Event and two regional events that provided nearly 350 farmers the opportunity to meet with retail and wholesale specialty crop buyers.

MIFFS has previously been awarded grants to support efforts towards educating growers about food safety risks. We have attracted more than 800 producers to sessions highlighting the importance of GAP/GHP, enabling them to create farm food safety plans and enhance their traceability efforts.

There is a consistent demand from retail, wholesale and institutional buyers that are interested in attending a Meet the Buyers event. In 2011, 15 buyer organizations and around 400 people attended the event. In addition, 75% of buyers who were surveyed purchase their produce from 20-25 Michigan specialty crop growers annually.

PROJECT APPROACH

Meet the Buyer Events were completed from December through March in diverse geographic regions and with new partnerships. The purpose of these events was to give farmers the opportunity to meet with retail, wholesale and institutional buyers of specialty crops. According to

surveys and interviews in previous years, one of the barriers that farmers encounter is not being able to find contacts within large institutions to develop necessary relationships and initiate critical conversations. The Meet the Buyers event held for the past five years during the Great Lakes Fruit, Vegetable and Farm Market Expo (GLExpo) continues to help introduce specialty crop growers to potential fresh market retail, wholesale and institutional buyers, and smaller scale "Meet and Greet" events help growers forge relationships with schools and institutions. Four educational workshops were conducted in various geographic locations, the food safety website was updated, and numerous communication updates were sent to members via e-newsletters, list serves, etc.

Our partner contributions for Meet the Buyer/Meet and Greet events included:

- MSU Product Center - registration and event promotion along with staffing an informational booth for Market Master, an online food directory and ecommerce site
- MSU Product Center – event promotion and registration
- MIFMA – event promotion on MIFMA.org and via member newsletters
- Michigan Vegetable Council – event promotion
- Great Lakes Fruit, Vegetable & Farm Market Expo – event promotion
- Michigan Department of Agriculture & Rural Development (MDARD) – event promotion and volunteer staffing at GLExpo
- MSU Farm to School – co-sponsor of Farm to School Meet and Greet events
- Southern Clinton County Food & Farming Council – sponsor and host of "Meet the Buyer" session at EE 2.0
- Everybody Eats 2.0 Conference Regional Planning Committee – promotion and coordination
- Michigan State University's Center for Regional Food Systems - coordination
- Food System Economic Partnership (FSEP) – coordination and promotion
- Detroit Eastern Market Corporation - host and promotion

Our partner contributions for the traceability and FSMA workshops were workshop announcements posted on MIFMA list serve (over 1,000 subscribers) by MIFMA (Michigan Farmers Market Association).

In refining food safety educational materials, MSU Extension was a major contributing partner, and in particular, Phil Tocco, Extension Educator, who is considered the Subject Matter Expert on food safety for Michigan. Additionally, several partner organizations led efforts to encourage specialty crop producers to comment on the FSMA proposed changes. By utilizing the National Sustainable Agriculture Coalition templates and robust group collaboration, comment sessions were held in the Southeast, Northwest and mid-Michigan regions of the state. These extended outreach and communication efforts enabled growers to submit additional feedback on what is needed to strengthen farm food safety practices in the future. These aggregated comments were submitted to MIFFS council, staff and affiliates for review and consideration.

Significant results, accomplishments, conclusions and recommendations:

Anecdotal feedback from GLExpo included requests from Michigan processors to be included in future Meet the Buyer events. This interest could signal a need to secure a larger space, extend the timeframe allocated for the event, or make additional adjustments as necessary to accommodate new participants. Growers indicated that there wasn't enough time or room to initiate a new buyer relationship. This finding supports the assumption that a larger venue will be needed, however, these comments were not substantiated in the buyer survey, where 100% responded Excellent to the "ability to meet producers" and "ability to have meaningful discussions with producers" at the event. MIFFS has finalized a new location for the 2013 event that will improve traffic flow and encourage additional one-on-one conversations.

Dot Survey questions were revised for the 2012 event in an effort to more accurately assess the demographics of the audience, the usefulness of the event, and the impact of the event on the sales of specialty crops. The revised questions and new methodology (surveying producers as they left the venue) allowed MIFFS to gather more targeted feedback that was linked directly to project goals.

The low return rate on buyer surveys indicates a need for stronger action in upcoming years. For instance, MIFFS could solicit previous year evaluation data with current year registrations and advocate for a greater commitment from buyers to participate in the data collection as they solicit participation and process registrations. It is interesting to note that in addition to overall response rates diminishing, the number of buyers who shared specific purchasing data also dropped substantially. We can assume that the drought impacted quantity and quality, and therefore overall purchases, so we should not expect to see an increase in purchases of specialty crops from last year.

GOALS AND OUTCOMES ACHIEVED

I. Meet the Buyer Events

At the Fruit, Vegetable and Farm Market Expo (GLExpo) conducted December 3, 2012, Grand Rapids, MI
A Meet the Buyer Workshop conducted at Everybody Eats 2.0 Conference, February 23, 2012 in Lansing.
A Farm to Institution Meet and Greet conducted in Battle Creek on March 6, 2013.

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.
PERFORMANCE MEASURE: Post-performance survey of producers and buyers to see if there is an increase of Michigan specialty crops sold to the buyer institutions who attended GLExpo.
MONITORING - Survey the buyers post event and conduct a case study with a statistical sampling of attendees that are currently selling, or plan to start selling more specialty crops to the buyers in attendance.
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:

- 400 specialty crop producers at GLExpo
- 15+ buyer organizations at GLExpo
- 50% of specialty crop producers enhance their relationship with buyers
- 15% of specialty crop producers increase their sales to the buyer institutions
- Expand the Meet the Buyers model by adapting it to two or three smaller-scale events
- Assess the adaptability of this model to a variety of venues
- Engage more beginning and micro-scale farmers in business development and regional food systems

FINAL OUTCOMES:
OUTCOME A: Data from Regional and Small Scale Events

- Approximately 340 growers and 67 buyer representatives attended the GLExpo. Over 50% of producers attended for the first-time.
- Six buyer organizations and six beginning growers attended the Meet the Buyer workshop at Everybody Eats 2.0 Conference. No formal evaluation was conducted.

- Lessons learned from the Farm to Institution Meet and Greet (Battle Creek, March 6, 2013) and other small scale events included a) the realization that this is a very new process for most farmers, but they are eager to learn the necessary skills, b) guidance is needed for growers to initiate and sustain essential relationships with buyer institutions, c) the language used by people in varying positions and roles in the local food system creates barriers to progress; a common vocabulary for food safety is needed, and d) the use of small scale events that bring growers and buyers together in a common venue is effective for identifying stakeholders with dual roles in the food system, i.e. a food hub representative could represent either grower or buyer interests. Overall, the expansion of "Meet the Buyer/Meet and Greet" events increases the likelihood that a higher number of Michigan specialty crops will enter the local food system.

OUTCOME B – Producer Data
From the Dot Survey (Attachment A, survey questions; Attachment B, survey responses), we learned that:

- Approximately 15% of producers had a 1-7% increase in sale of produce from December 2011 to December, 2012
- Approximately 47% of the producers in attendance met 3-5 buyers
- Twenty seven percent (27%) noted that the most valuable aspect of this event is the opportunity to strengthen relationships with buyers

OUTCOME C- Buyer Data:
From the Meet the Buyer Survey (GLExpo) —Attachment C, survey questions; Attachment D survey responses), we learned that:

- 100% of buyers indicated that they expect to increase the number of MI fruit and vegetable producers with whom they do business
- 100% of buyers indicated that they expect to increase purchases of MI fruit and vegetables in the upcoming year
- 100% of buyers indicated that because of this event, MI fruit and vegetable producers have increased market share

II. Workshops on Traceability

Workshops were conducted on March 12, 2013 in Detroit and on March 27, 2013 in Kalamazoo.
OVERALL GOAL: To increase the number of specialty crop producers that have traceability plans.
BENCHMARK: When this grant proposal was submitted, the number of producers who have a traceability plan was unknown. Aggregated data from the post workshop surveys have established the following baselines for this outcome:

1. Do you currently have a food safety plan? Yes (8) No (29)
2. Do you currently have a traceability plan? Yes (5) No (32)
3. Have you already started adopting some food safety practices? Yes (24) No (8)
4. Have you had a third party audit? Yes (5) No (26)

PERFORMANCE MEASURE: Pre and post participant surveys were completed. The post workshop survey provided an approximate number of producers who plan to create traceability plans, or enhance their existing plans because of the information provided:
MONITORING: We will determine the number of specialty crop producers who completed new or enhanced traceability plans via follow up correspondence using email addresses collected at registration. We set a baseline from the workshops (see above) and our follow up began approximately December 1, 2013 (post-harvest season). During this process, we determined a) what else was implemented, b) what was especially helpful in that implementation, and c) what is needed next to strengthen future practices.

TARGETS:
- 70 specialty crop producers will receive training on farm food safety traceability planning
- 80% of the participants will establish or enhance their food safety traceability plan.

FINAL OUTCOMES:
A. Workshop Evaluation
See Attachment E- Traceability Workshop Evaluation Summary

- 37 producers attended the workshops
- 85% of producers feel comfortable writing a food safety plan, tailored to their commodity, within a year
- 78% of producers feel comfortable completing a food safety self-audit within a year
- 59% of producers feel they can complete a 3rd party food safety audit within a year

B. Monitoring Progress
100% of participants that responded to the follow-up survey had a food safety plan in progress or created one after attending the workshop.
50% of participants that responded to the follow-up survey added a traceability component to an existing farm food safety plan after attending the workshop.
100% of participants that responded to the follow-up survey conducted a self-audit after attending the food safety traceability workshop.
50% of participants that responded to the follow-up survey conducted a third party audit after attending the food safety traceability workshop.

Participants responses to, "What is needed next to strengthen your farm food safety practices in the future?" were:
- Updates!
- Scaling up infrastructure needs to meet requirements of food safety, i.e. refrigerated vehicles, cold storage, etc.
- Better traceability that is easy to understand

Participant's responses to, "what was especially helpful in the implementation of any new food safety practices on your farm?" were:
- Having the law explained
- Recognizing weaknesses and possible points of entry for food safety concern
- Knowing that there is assistant means a lot. We are looking to hire a volunteer coordinator who will need to know safety practices.

III. Workshops on Food Safety Modernization Act (FSMA)
Workshops were conducted in Detroit on March 1, 2013 and Battle Creek on March 21, 2013.
OVERALL GOAL: To increase the number of specialty crop producers that will be able to make changes to their food safety plans.
BENCHMARK: N/A - this is new training on this topic
PERFORMANCE MEASURE: Conduct a post workshop evaluation asking for the change in attitudes toward updating food safety plans.
MONITORING: assessing the number of specialty crop producers who complete new or enhanced food safety plans will be accomplished via email correspondence post-harvest season.
We videotaped one Food Safety modernization Act meeting and edited it for posting to the www.mifarmfoodsafety.org website.

TARGETS:

- Approximately 90 specialty crop producers will receive updated information on the rules of FSMA
- 50% of participants will feel that they are comfortable making changes to their food safety plan based on the new rules
-

FINAL OUTCOMES:

A. Workshop Evaluation - See Attachment F - FSMA Workshop Evaluation Summary

- 22 producers attended the workshops.
- Google Analytics reported 624 visits to www.mifarmfoodsafety.org (77.4% new visitors) and 159 page views on **www.miffs.org/gapghp** (food safety pages) in that same time frame. Producers were able to download updated information on FSMA from both of these sites.
- Approximately 71% of workshop participants responded that they feel comfortable writing a food safety plan according to the new rules.
- A video about FSMA that was posted to YouTube.com has received 33 views to date.
    - This medium was selected to replace a video on www.mifarmfoodsafety.org because of the popularity of YouTube and the ability to create a better product.

B. Monitoring Progress

100% of participants that responded to the follow-up survey had a food safety plan in progress or created one after attending the workshop.
80% of participants that responded to the follow-up survey modified their existing food safety plan after attending the workshop.
80% of participants that responded to the follow-up survey visited <www.mifarmfoodsafety.org> for food safety tools and resources or for updates on FSMA.
80% of participants that responded to the follow-up survey commented on the Food Safety Modernization Act legislation. Specifically, the areas of "manure usage, the lack of scientific base for requirements, and the lack of improved food safety based on increased paperwork demands" were mentioned.

IV. Food Safety Traceability Materials -developed and made available to producers via MIFFS and partners websites.

OVERALL GOAL: Make the food safety traceability plans available to producers that are not able to attend the two educational sessions.
BENCHMARK: We will have a baseline of zero producers visiting the site and will be able to track the number of visits to the website.
PERFORMANCE MEASURE: Use Google Analytics to track the number of visits to the MIFFS Food Safety website traceability section
TARGET:

- 75 additional producers will visit the MIFFS Food Safety website to learn about traceability

MONITORING- MIFFS will track the number of visits to the MIFFS Food Safety website monthly.
FINAL OUTCOMES (Google Analytics for <www.mifarmfoodsafety.org> for the full length of the grant, Oct 1, 2012 – March 31, 2014)

- Google Analytics reported 1249 visits, (78% new visitors), 2.41 page views/visit and 3,000 total page views
- Food safety updates were sent out in 10 issues of the MIFFS Minute e-newsletter to approximately 300 subscribers in April, July, August, 2012 and February, March, April, May, July, August, October, 2013 (http://us2.campaign-archive2.com/home/?u=95829a275d7e3470bc0f9f24b&id=e4b38a2d46)

- Identical information is typically posted to Facebook (458 followers)
- About a dozen updates were posted to the MIFFS listserv on workshops, webinars etc. (202 subscribers) and on the MIFMA listserv (over 1,000 subscribers)

V. Refine Food safety Training Materials

OVERALL GOAL: MIFFS will continuously improve the material that we provide to specialty crop producers based on feedback from producers, auditors, Michigan State University food safety experts, industry representatives, and new technology made available.

BENCHMARK: N/A

PERFORMANCE MEASURE: Unknown until materials used in 2013. At that time, a determination could be made if content changes were an improvement for the learners/participants (producers).

TARGETS:

- Continuous improvement of the information that we provide to producers
- Timely communication of food safety issues to producers

MONITORING- MIFFS will continually identify and communicate changes in information, technology, and food safety laws for their target audience.

FINAL OUTCOMES:

From participants (Kirkpatrick Level 1) evaluation forms we learned that the most useful aspects of the workshops on food safety include the following:

- *Info and conversation on traceability"*
- *Being able to listen to people who have experience with food safety*
- *It was mostly new info for me, so it was all useful*
- *Labeling, broke it down into something I can use—I was finally given a reason to excite me about traceability, marketing and sell, sell, sell*
- *How to code*
- *Thinking: 1 step forward and backward. Example of stamp to put code on.*
- *Setting up the code and ways to create label*
- *Just learning more about what is coming for the farmers of the future*
- *Presented simple way of tracing for various sizes*

BENEFICIARIES

- The core beneficiaries were specialty crop growers who attended GLExpo or a regional "Meet the Buyer" event. Buyers of specialty crops, including Food Service Director's, also benefitted from this project's activities. The potential economic impact is hard to define because buyers and growers will only answer survey questions with a percentage of anticipated change.
- These two new workshops complemented the 16 workshops already conducted for more than 800 farmers about food safety plans/audits. MIFFS also continued to improve and update the www.mifarmfoodsafety.org website with educational materials on both topics.

LESSONS LEARNED

1. Meet the Buyer events continue to be popular and beneficial venues for specialty crop growers to connect with buyers and launch crucial conversations. Launching these relationships in a safe environment is key to growers' ongoing success in the marketplace.
2. Collecting useful data from buyers is difficult because it is often considered proprietary information by the food companies. Even with a strong relationship built over the past 5 years, MIFFS still struggles to collect meaningful feedback that demonstrates behavioral change. This activity could be tied to the event registration process, requiring buyers to provide feedback about their buying habits from the past year in exchange for the opportunity to meet growers.

3. Growers are hungry for new knowledge. Interest at regional events was noted by attendees.
4. Lessons learned from the Farm to Institution Meet and Greet (Battle Creek, March 6, 2013) and other small scale events included a) the realization that this is a very new process for most farmers, but they are eager to learn the necessary skills, b) guidance is needed for growers to initiate and sustain essential relationships with buyer institutions, c) the language used by people in varying positions and roles in the local food system creates barriers to progress; a common vocabulary for food safety is needed, and d) the use of small scale events that bring growers and buyers together in a common venue is effective for identifying stakeholders with dual roles in the food system, i.e. a food hub representative could represent either grower or buyer interests. Overall, the expansion of "Meet the Buyer/Meet and Greet" events increases the likelihood that a higher number of Michigan specialty crops will enter the local food system.
5. Growers experienced with doing their own food safety plans are the most credible teachers for other growers who are seeking this knowledge.

We need to use social media to expand our efforts. The food safety video that was planned for a food safety website was posted on YouTube instead. We believe it will be more convenient for growers to access YouTube and we'll continually monitor views.

CONTACT INFORMATION

Michelle Napier-Dunnings, Executive Director
(B): 517-432-0712
michelle@miffs.org

ADDITIONAL INFORMATION

ATTACHMENT A: 2012 Meet the Buyers Dot Survey

Note: Questions will be written on flip charts near the exit door and two people will be posted there at all times to pass out dots and direct growers to the survey.

1. How many buyers did you meet today?
   a. None;
   b. 1-2
   c. 3-5
   d. More than 5

2. If not for this event, how would you have had access to these buyers?
   a. Would not have access
   b. Would have hired a broker
   c. Would have tried personally

3. What is the most valuable aspect of this program?
   a. Meet a specific buyer
   b. Strengthen relationships with a current buyer
   c. Network with other producers
   d. Learn how to sell my produce (as Beginning Farmer)

4. How many times have you attended this event?
   a. First time
   b. 2 or 3 times
   c. More than 3 times

5. After attending last year, how did these buyers impact your produce sales?
   a. Did not attend last year
   b. 1-7% increase
   c. 8+ increase
   d. No increase

ATTACHMENT B: Meet the Buyers Dot Survey – Aggregated Data
Methodology: Post event surveys. Growers completed a Dot Survey as they were exiting the event and buyers completed a survey administered electronically.

A. Grower Dot Survey results:

1. How many buyers did you meet today? N=79
   a. None = 6 <1%
   b. 1-2 – 30 38%
   c. 3-5 – 37 47%
   d. More than 5 – 6 <1%

2. If not for this event, how would you have had access to these buyers? N= 70
   a. Would not have access -17 10%
   b. Would have hired a broker – 4 <1%
      i. We have learned through this process that the wording of this question needs to change.
      ii. We are considering in 2013 to change "broker" to "sales agent"
   c. Would have tried personally – 49 70%
3. What is the most valuable aspect of this program? N = 90
   a. Meet a specific buyer – 31 34%
   b. Strengthen relationships with a current buyer- 24 27%
   c. Network with other producers- 22 24%
   d. Learn how to sell my produce (as Beginning Farmer) – 13 14%

4. How many times have you attended this event? N = 71
   a. First time 35 50%
   b. 2 or 3 times – 18 11%
   c. More than 3 times – 18 11%

5. After attending last year, how did these buyers impact your produce sales? N= 66
   a. Did not attend last year- 37 56%
   b. 1-7% increase -12 15%
   c. 8+ increase -1
   d. No increase -16 24%

ATTACHMENT C: MIFFS Buyer Survey – 2012
This survey is being used to gather feedback about our recent "Meet the Buyer" event. We are interested in your honest answers so we can improve this program for you and others in the future.

1. How would you rate each of the following aspects of the event?

	Excellent	Good	Fair	Poor	Don't Know
Promotion					
Registration					
Table Space					
Communication from MIFFS prior to event					
Ability to meet the producers.					
Ability to have meaningful discussions with the producers.					
Follow up from MIFFS after the event.					

The following list contains some behavioral changes you may or may not have experienced because you attended this event. Please indicate how much you agree or disagree with the following statements.

2. Because of this event, I/we…..

	Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**	**Don't Know**
Have increased access to Michigan fruit and vegetable producers.					
Expect to **increase** the **number** of Michigan fruit and vegetable **producers** with whom we do business in the upcoming year.					
Will increase the number of producers by (please highlight one choice) 0 1-5 6-10 10+					
Expect to increase **purchases** of Michigan fruits and vegetables in the upcoming year.					
Will increase purchases by (please highlight one choice) 1-5% 6-10% 11%+					
Have a stronger relationship with MIFFS.					
Have a stronger relationship with our fruit and vegetable producers.					

The following list contains some attitudinal changes you may or may not have experienced because you attended this event. Please indicate how much you agree or disagree with the following statements.

3. Because of this event, I now feel that…

	Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**	**Don't Know**
We are improving the economic viability of Michigan specialty crop producers.					
Michigan specialty crop producers have increased market share.					
We can offer fresher food to Michigan consumers.					

4. Are there any other ideas or feedback about this event that you would like to share with MIFFS?

<u>Buyer Demographics</u>

Your responses to the following questions will enable us to measure short and long term progress on grant-funded programs in support of Michigan specialty crop producers.

1. Number of years that your company has attended MIFFS "Meet the Buyer" event (1-5) _____.
2. Estimated **number** of Michigan specialty crop **producers** that your company purchases from _____
3. Estimated **increase in expenditures <u>over past 5 yrs.</u>** for Michigan specialty crops (highlight one) 1-5% 6-10% 11%+

Attachment D: MIFFS Buyer Survey, Annotated – December, 2012

This survey is being used to gather feedback about our recent "Meet the Buyer" event. We are interested in your honest answers so we can improve this program for you and others in the future. **NOTE: N=4 NR = No Response**

1. **How would you rate each of the following aspects of the event?**

	Excellent	**Good**	**Fair**	**Poor**	**Don't Know**
Promotion	50%	50%			
Registration	100%				
Facility	50%	50%			
Communication from MIFFS prior to event	100%				
Ability to meet the producers.	100%				

	Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**	**Don't Know**
Have increased access to Michigan fruit and vegetable producers.	25%	75%			
Expect to **increase** the **number** of Michigan fruit and vegetable **producers** with whom we do business in the upcoming year.	25%	75%			
Will increase the number of producers by (please highlight one choice) 0 1-5 25% 6-10 10+ NR= 75%					
Expect to increase **purchases** of Michigan fruits and vegetables in the upcoming year.	25%	75%			
Will increase purchases by (please highlight one choice) 1-5% 25% 6-10% 11%+ NR= 75%					
Have a stronger relationship with MIFFS.	25%	75%			
Have a stronger relationship with our fruit and vegetable producers.	25%	75%			

Ability to have meaningful discussions with the producers.	100%				
Follow up from MIFFS after the event.	75%	25%			

The following list contains some behavioral changes you may or may not have experienced because you attended this event. Please indicate how much you agree or disagree with the following statements.

1. **Because of this event, I/we…..**

The following list contains some attitudinal changes you may or may not have experienced because you attended this event. Please indicate how much you agree or disagree with the following statements.

2. **Because of this event, I now feel that…**

	Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**	**Don't Know**
We are improving the economic viability of Michigan specialty crop producers.	50%	50%			
Michigan specialty crop producers have increased market share	25%	75%			
We can offer fresher food to Michigan consumers.	25%	75%			

3. **Are there any other ideas or feedback about this event that you would like to share with MIFFS? "Cannot share demographic data"**

Buyer Demographics

Your responses to the following questions will enable us to measure short and long term progress on grant-funded programs in support of Michigan specialty crop producers.

4. Estimated **number** of Michigan specialty crop **producers** that your company purchases from ~ 25% responded with answer = 5 75% NR= no response
5. Estimated **increase in expenditures over past 5 years** for Michigan specialty crops (highlight one) 1-5% 25% 6-10% 11%+ 75% NR= no response

Thank-you! Please return this email survey to Kristine@knowledgenavigators.com. For questions or clarifications on this survey, please contact Kristine Ranger at Kristine@knowledgenavigators.com or call 517.974.5697.

Attachment E: Traceability Participant Post-Survey Template

This survey is being used to get your opinions on the Traceability Workshop conducted by MIFFS. We are interested in your honest answers so we can improve this program for you and others in the future.

1. **What was the most useful aspect of this workshop? Why?**
2. **What was the least useful aspect of this workshop? Why?**

The following list contains some **knowledge changes** you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Know more about the need for traceability in food safety					
Have a better understanding of the importance of record keeping on my operation.					
Have a better understanding of what changes I will need to make.					
Know where to obtain additional information about food safety.					
Know where to obtain additional help in writing food safety plans.					

The following list contains some **attitudinal changes** you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements. Use N/A if Not Applicable to your operation.

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know- N/A
Feel comfortable writing a food safety plan, tailored to my commodity, within a year.					
Feel comfortable completing a food safety **self-audit** within a year					
Feel that we can complete a 3rd party food safety audit within a year.					

Are there any other ideas or feedback about this topic that you would like to share with MIFFS?

Participant Demographics (required by MSUE)

County_____ Acres Farmed_____

Occupation

□Grower □Packer Shipper □Retailer

□Concerned Citizen □Agency □Other

My age is □Under 25 □25-35 □36-45 □46-55 □Over 55

How did you learn about the workshop?

□Mailing □E-mail Notice □Word of Mouth □Website

□Invitation from buyer

Have you already started adopting some food safety practices? Yes No

Have you had a third party audit? Yes No

MIFFS Tackling Traceability Workshop Pre-Survey Results

Tuesday, March 12, 2013 from 9 am - 12 pm

Sacred Heart Church Activities Building, 3451 Rivard St. Detroit, MI 48207

1. Do you currently have a food safety plan? **Yes (3) No (20**)
2. Do you currently have a traceability plan? **Yes (2) No (21)**
3. What type of farm do you have?
   - ❑ Fruit (1)
   - ❑ Vegetable (9)
   - ❑ Fruit and Vegetable (9)
   - ❑ Other: (5)
4. I'm attending this session:
   - ❑ To learn what traceability is and why it's important (19)
   - ❑ To learn how to create a traceability plan (14)
   - ❑ To improve my traceability plan (5)
   - ❑ Other: Helping out, to obtain knowledge, share, Be a part of this cause

Traceability Participant Post-Survey Results - Tuesday, March 12, 2013 from 9 am - 12 pm

Sacred Heart Church Activities Building, 3451 Rivard St. Detroit, MI 48207

This survey is being used to get your opinions on the Traceability Workshop conducted by MIFFS. We are interested in your honest answers so we can improve this program for you and others in the future.

1. **What was the most useful aspect of this workshop? Why?**

   "Better understanding of food safety and traceability" (4)

   "Traceability methods and requirements—this helps me plan for my situation." (2)

   "Learning about food safety"

   "Being taught the basics of food traceability. Followed by food safety info/education. Great info."

   "Food safety, because food safety is very important to the human body."

   "I am new to small gardening. Safety is the number one concern."

2. **What was the least useful aspect of this workshop? Why?**

   "none" (5)

The following list contains some **knowledge changes** you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements.

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	**Tally N=21**
Know more about the need for traceability in food safety	12	9				**100%**
Have a better understanding of the importance of record keeping on my operation.	10	11				**100%**
Have a better understanding of what changes I will need to make.	8	13				**100%**
Know where to obtain additional information about food safety.	8	14				**100%**
Know where to obtain additional help in writing food safety plans.	9	12				**100%**

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know-N/A	**Tally**
Feel comfortable writing a food safety plan, tailored to my commodity, within a year.	4	14			3	**18/21 or 86%**
Feel comfortable completing a food safety **self-audit** within a year	3	15			2	**86%**
Feel that we can complete a 3rd party food safety audit within a year.	2	11	1		7	**13/21 or 62%**

The following list contains some **attitudinal changes** you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements. Use N/A if Not Applicable to your operation.

Are there any other ideas or feedback about this topic that you would like to share with MIFFS?

Participant Demographics (required by MSUE) - 23 participants

County: **Wayne (18); Oakland (1); Macomb (1); Lapeer (1**) Acres Farmed: **0 (1); ½ (3); 1-1.5 (2); 2 (3); 3-10 (2); 100+ (1)**

Occupation: □Grower (12) □Packer Shipper (1) □Retailer (3) □Concerned Citizen (5) □Agency □Other (5)

My age is □Under 25 **(5)** □25-35 (**2**) □36-45 **(5)** □46-55 **(4**) □Over 55 **(4)**

How did you learn about the workshop? □Mailing- 2 □E-mail Notice- 7 □Word of Mouth (4) □Website □Invitation from buyer Other: Morse Brown; E.A.T. (2); Earthworks (3)

Have you already started adopting some food safety practices? Yes (15) No (4)

Have you had a third party audit? Yes No (19)

MIFFS Tackling Traceability Workshop Pre-Survey Results; Wednesday, March 27, 2013
Kalamazoo County MSU Extension Office, 3299 Gull Rd, Kalamazoo, MI 49048

1. Do you currently have a food safety plan? Yes **(5)** No **(9)**
2. Do you currently have a traceability plan? Yes (**3**) No **(11)**
3. What type of farm do you have?
   - ❑ Fruit **(2)**
   - ❑ Vegetable **(5)**
   - ❑ Fruit and Vegetable **(5)**
   - ❑ Other: **Native landscape; Kitchen; Community Garden (2); Non-farmer; MSUE Educator; Processor—Field rep**
4. I'm attending this session:
   - ❑ To learn what traceability is and why it's important **(7)**
   - ❑ To learn how to create a traceability plan **(9)**
   - ❑ To improve my traceability plan **(6)**
   - ❑ Other: **What is required and what is recommended; To help farmers with FSMA and traceability;**

Traceability Participant Post-Survey Results
Wednesday, March 27, 2013 from 9 a.m. - 12 p.m.
Kalamazoo County MSU Extension Office, 3299 Gull Rd, Kalamazoo, MI 49048

This survey is being used to get your opinions on the Traceability Workshop conducted by MIFFS. We are interested in your honest answers so we can improve this program for you and others in the future.

1. **What was the most useful aspect of this workshop? Why?**
   "Lee's metaphors and suggestions"
   "Info and conversation on traceability"
   "Being able to listen to people who have experience with food safety"
   "It was mostly new info for me, so it was all useful"
   "Labeling, broke it down into something I can use—I was finally given a reason to excite me about traceability, marketing and sell, sell, sell"
   "How to code"
   "Thinking: 1 step forward and backward. Example of stamp to put code on."
   "Setting up the code and ways to create label"
   "Just learning more about what is coming for the farmers of the future"
   "Presented simple way of tracing for various sizes"

2. **What was the least useful aspect of this workshop? Why?**
   "The QR Codes scanning info"
   "The group work"
   "I'm small gardening, not big farming—so big info wasn't relevant."
   "Group exercise—recall—groups too big"
   "High tech—computer type and equipment"
   "Using scanner in mock recall"

The following list contains some **knowledge changes** you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Know more about the need for traceability in food safety	**7**	**5**			
Have a better understanding of the importance of record keeping on my operation.	**6**	**6**			
Have a better understanding of what changes I will need to make.	**6**	**5**			
Know where to obtain additional information about food safety.	**8**	**3**	**1**		
Know where to obtain additional help in writing food safety plans.	**9**	**3**			

The following list contains some **attitudinal changes** you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements. Use N/A if Not Applicable to your operation.

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know-N/A	Tally
Feel comfortable writing a food safety plan, tailored to my commodity, within a year.	**4**	**6**	**1**		**1**	**10/12 = 83%**
Feel comfortable completing a food safety **self-audit** within a year	**4**	**3**	**3**		**2**	**7/12 = 58%**
Feel that we can complete a 3rd party food safety audit within a year.	**3**	**3**	**4**		**1**	**6/11 = 54%**

Are there any other ideas or feedback about this topic that you would like to share with MIFFS?
"It didn't stick because it wasn't relevant and too new"
"Keep up the good work with training sessions."

Participant Demographics (required by MSUE)—18 Participants
County: **Kent; Kalamazoo (3); Tuscola; Oceana (2); Berrien Van Buren; Chile; Allegan; Antrim/Charlevoix**

Acres Farmed: **0-5 (4)**
200-500 (1)
500+ (2)

Occupation
□Grower (**7**) □Packer Shipper (**3**) □Retailer (**2**) □Concerned Citizen□Agency (**1**) □Other (**4**) (Processor; Office for sustainability employee)

My age is □Under 25 **(2)** □25-35 **(1)** □36-45 **(5)** □46-55 **(3)** □Over 55 **(1)**

How did you learn about the workshop?
□Mailing **(6)** □E-mail Notice **(4)** □Word of Mouth **(1)** □Website **(1)**
□Invitation from buyer **(1)** □Other: **Student intern; Other MSUE workshop**

Have you already started adopting some food safety practices? Yes (**9**) No **(4)**
Have you had a third party audit? Yes **(5)** No **(7)**

Attachment F: Food Safety Modernization Act Update Participant Survey Template
This survey is being used to get your opinions on the FSMA update conducted by MIFFS. We are interested in your honest answers so we can improve this program for you and others in the future.

3. **What was the most useful aspect of this workshop? Why?**
4. **What was the least useful aspect of this workshop? Why?**

The following list contains some **knowledge changes** you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Know more about the proposed standards for produce safety					
Know more about the preventive controls for human food					
Know where to obtain additional information about food safety plans					
Know where to obtain additional help in writing food safety plans					
Have a better understanding of what changes will be needed in my operation					

The following list contains some **attitudinal changes** you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements. Use N/A if Not Applicable to your operation.

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know-N/A
Feel comfortable writing a food safety plan according to the new rules.					
Feel that we will need help in amending our food safety plan to comply with the new rules.					

Are there any other ideas or feedback about this topic that you would like to share with MIFFS?

Participant Demographics (required by MSUE)

County_____ Acres Farmed_____

Occupation

□ Grower □ Packer/Shipper □ Retailer
□ Concerned Citizen □ Agency □ Other

What is your age?

□ Under 25 □ 25-35 □ 36-45 □ 46-55
□ Over 55

How did you learn about the workshop?

□ Mailing □ E-mail Notice □ Word of Mouth □ Website □ Invitation from buyer

Have you already started adopting some food safety practices? Yes No

Have you had a third party audit? Yes No

Food Safety Modernization Act Update Participant Survey Results
March 1, 2013, SE Michigan

1. **What was the most useful aspect of this workshop? Why?**
   "Learning how small farmers, farmer's markets, and food hubs will be affected."
   "How it will affect small growers"
   "Key safety factors"
   "Explaining areas that will be regulated and how people can implement practices to comply."
   "Learn how it will affect farmers"

2. **What was the least useful aspect of this workshop? Why?**

"It was all very interesting."

Are there any other ideas or feedback about this topic that you would like to share with MIFFS?

The following list contains some **knowledge changes** you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	**Tallies**
Know more about the proposed standards for produce safety	4	2				**100%**
Know more about the preventive controls for human food	3	3				**100%**
Know where to obtain additional information about food safety plans	2	4				**100%**
Know where to obtain additional help in writing food safety plans	1	3	1		1	**66%**
Have a better understanding of what changes will be needed in my operation						**no responses given**

The following list contains some attitudinal changes you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements. Use N/A if Not Applicable to your operation.

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know-N/A	**Tallies**
Feel comfortable writing a food safety plan according to the new rules.	2	2	1		1	**4/6 = 66%**
Feel that we will need help in amending our food safety plan to comply with the new rules.	1	1			4	**1/3 = 33%, 66% don't know**

Participant Demographics (required by MSUE): 11 people present

County: Ingham (1); Wayne (3) Acres Farmed: 15(1); 0 (1)
Occupation
□ Grower (2) □ Packer/Shipper □ Retailer
□ Concerned Citizen (2) □ Agency (1) □ Other (2): Non-profit, Co-op developer
What is your age?
□ Under 25 (3) □ 25-35 □ 36-45 □ 46-55 (3)
□ Over 55
How did you learn about the workshop?
□ Mailing □ E-mail Notice (2) □ Word of Mouth (1) □ Website (1) □ Invitation from buyer

Have you already started adopting some food safety practices? Yes (1) No (5)
Have you had a third party audit? Yes (0) No (6)

Food Safety Modernization Act Update Participant Survey Results
March 21, 2013, SW Michigan

This survey is being used to get your opinions on the FSMA update conducted by MIFFS. We are interested in your honest answers so we can improve this program for you and others in the future.

1. **What was the most useful aspect of this workshop? Why?**
   "Increased understanding of expectations."
   "On-farm Food Safety presentation. It is what can be done in the most practical sense."
   "Learning about new requirements"
   "Policies and rules (very understandable)"
   "Water quality"
   "Modifications to Food Code"
   "To know what is coming at us"
   "I enjoyed the Fiddler's Green example."
   "It's hard to answer—I think we were looking at going to the Tackling Traceability workshop and I accidentally came to this. I did learn a lot though, thanks."
   "Handouts/slides"
   "Getting more information about FSMA and getting more websites to visit."
   "Water quality! Not educated on this subject"
   "All of it!"

2. **What was the least useful aspect of this workshop? Why?**
   "The state of FSMA because the rules are proposed and being developed."
   "Nothing! I was amazed in the rules and regs"
   "All useful—I will be providing training (MAEAP)."
   "Would like to see more interaction of farmers on real-life situations."
   "There was nothing I found to be un-useful. Just maybe an upgraded meeting for people who have started these programs with more direct topics."

The following list contains some **knowledge changes** you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements:

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Know more about the proposed standards for produce safety	8	8			
Know more about the preventive controls for human food	8	8			
Know where to obtain additional information about food safety plans	11	6			
Know where to obtain additional help in writing food safety plans	6	10			
Have a better understanding of what changes will be needed in my operation	6	8	1		

The following list contains some **attitudinal changes** you may or may not have experienced because you attended this session. Please indicate how much you agree or disagree with the following statements. Use N/A if Not Applicable to your operation.

Because I attended this session, I now…	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know-N/A	Tally
Feel comfortable writing a food safety plan according to the new rules.	3	8	2	1	1	11/15 = 73%
Feel that we will need help in amending our food safety plan to comply with the new rules.	4	6	2	1	1	10/14 = 71%

Are there any other ideas or feedback about this topic that you would like to share with MIFFS?
"I would like to see sessions like this promoted as beginner → advanced. Most of this was review for me."
"Let those that need assistance know about MAEAP techs and Food Safety Risk Assessment."

Participant Demographics (required by MSUE) – 19 Attendees
County: Kalamazoo (2); Ottawa (2); Allegan (1); Van Buren (6); Ingham (1); Berrien (2); Oceana (2); Tuscola (1)
Acres Farmed: 1-5 (4); 10+ (1); 40 (1); 100+ (7); 1000+ (1)
Occupation
□ Grower (19) □ Packer/Shipper (7) □ Retailer (4)
□ Concerned Citizen (1) □ Agency (1) □ Other (4)- MAEAP, Extension Staff
What is your age?
□ Under 25 □ 25-35 (1) □ 36-45 (5) □ 46-55 (6) □ Over 55 (5)
How did you learn about the workshop?
□ Mailing (9) □ E-mail Notice (5) □ Word of Mouth (4) □ Website (1) □ Invitation from buyer

Have you already started adopting some food safety practices? Yes (15) No
Have you had a third party audit? Yes (6) No (8)

PROJECT TITLE Michigan State University: Development of Poplar Plantations for Specialty Crop Processing Wastewaters - FINAL

PROJECT SUMMARY

Over 273×10^9 kg of fruits and vegetables were produced in the United States in 2011 for processing operations like canning, freezing and pickling [1, 2]. Processing fruits and vegetables produces large volumes of wastewater; for example, approximately every kg of potato processed produces approximately 8-28 L of wastewater [3]. Containing grams per liter concentrations of pollutants, food processing wastewaters are classified as "high-strength" [4-6]; concentrations can be as high as 8,537 mg/L biochemical oxygen demand (BOD), 12,230 mg/L chemical oxygen demand (COD), 9,993 mg/L total suspended solids, 1,514 mg/L total nitrogen, and 1,277 mg/L total phosphorous [7, 8]. A substantial portion of carbon in food processing wastewater can be recalcitrant, as BOD concentrations were only 74% of COD for fruit processing wastes [9]. Despite its high-strength, land application is commonly used to treat food processing wastewaters due to low cost – typically 30 to 50% less than discharging wastewater to conventional treatment plants [3-5, 10-12].

Land application of wastewaters is a reliable technology if application rates are lower than the waste assimilative capacity of the plant-soil ecosystem [3]. Differing state regulations limit nutrient and hydraulic loading of food processing wastewater during land application [5, 13]; for example, Michigan limits application to a maximum of 2.5 to15.4 mm/day or 1800 lb BOD/acre/day [14, 15]. Permissible hydraulic loading rates are calculated so that the field capacity of the soil is not exceeded after consideration of evapotranspiration and infiltration[12]. Crop selection can optimize nutrient uptake and evapotranspiration, increasing allowable loading. The ideal plant for land application of wastewater should uptake high levels of nutrients, grow rapidly, tolerate moisture, and evapotranspire extensively [3]. Dense grasses at land application sites, the status quo preference[16], require time to establish each spring [17] and are frequently outcompeted by local grasses and weeds with shallower roots and less evapotranspiration, leading to decreased effectiveness [18].

Soil redox potential, which characterizes the relative abundance of electron acceptors and donors, determines the stability, availability and solubility of redox sensitive metal(loid)s, such as iron, manganese and arsenic, and nitrate, in soils [22]. Soil redox conditions during land application fluctuate and both oxidizing and reducing conditions during land application of wastewaters can cause contamination of groundwater with pollutants that present human health concerns. Under <u>aerobic/oxidizing conditions</u>, ammonium and organic nitrogen is converted to nitrate, a highly mobile pollutant. Frequent drying and wetting of land application sites (e.g., 2-4 days wet /3-5 days dry [23] and 9 hours spraying/15 hr drying [24]) converted almost all nitrogen in influent water to nitrate. While increasing the period of flooding to 14 -21 weeks decreased nitrification by 50-80%, distinct peaks of nitrate occurred at the start of each flooding period [23]. Elevated levels of nitrate in groundwater can also occur when application of nitrogen exceeds plant uptake and denitrification [5, 17, 25]. In one study, approximately 76% of nitrogen from fruit and vegetable processing wastewaters applied to sandy loam soils contaminated groundwater [25]. In California, 42 of 47 facilities had polluted groundwater with nitrate [5]. Nitrogen contamination of groundwater from land application of wastewaters can be worse in cold-climates due to limited biological activity, freezing, and thawing during winter [17]. Under <u>anaerobic/reducing conditions</u>, nitrate is denitrified to nitrogen gas, minimizing the potential for groundwater contamination with nitrate. Degradation of wastewater BOD consumes limited oxygen in the soil, creating reducing, anaerobic conditions that facilitate mobilization of native soil metals [26], contributing to groundwater contamination with iron, arsenic, and manganese.

Utilization of metals as electron acceptors by microorganisms can reduce metal species to more mobile forms (e.g., Fe^{3+} to Fe^{2+}, Mn^{4+} to Mn^{2+}). Additionally, under reduced and moderately reduced conditions, iron and manganese oxyhydroxides formed in oxidizing conditions undergo dissolution and precipitates of metallic sulfides or pyrites formed in anaerobic conditions can undergo oxidation [28, 29], releasing iron and manganese. As iron oxides and hydroxides provide sorbing sites to arsenic, dissolution of these oxides also releases arsenic [30].

Phytoremediation has the potential to help balance soil redox conditions under realistic wastewater loadings to simultaneously prevent nitrate and metal pollution of groundwater. Poplar trees are widely used for phytoremediation due to rapid growth rates (e.g., up to 2 m per year [31]) and the ability to withstand high soil moisture [31], saline conditions [32, 33], high nutrient concentrations [34], and metal toxicity [35]. Phytoremediation with poplars has successfully remediated multiple wastes, including domestic wastewater effluents [36], landfill leachate [31], brownfields [37], and wood waste [38]. The processes through which phyto-processes are expected to influence soil treatment of food processing wastewaters are discussed in detail next.

Evapotranspiration. By evapotranspiring large volumes of water, poplar trees have the potential to reduce transport of metals and nitrogen to groundwater and decrease soil moisture, thereby increasing oxygen diffusion in soils [39]. Under ideal conditions, a 4-year old poplar tree can evapotranspire 81 - 91 cm water each year, with evapotranspiration coefficients as high as 4.2 [39, 40]. About 79% of 748 mm total precipitation and 84% of 996 mm total precipitation was removed as evapotranspiration by poplars used as evapotranspiration covers after one and two years of growth (respectively) [41].

Phytoextraction. Through uptake of metals and nitrogen, poplar plantations have the potential to decrease the mass of metals and nitrogen available to contaminate groundwater. Poplars uptake substantially more nitrogen than perennial grasses [42]. Average annual uptake of nitrogen by five-year old hybrid poplars can reach 155 kg/ha/yr in the Great Lakes region and 400 kg/ha/yr in the Western U.S. [43], as compared to 38.8 kg/ha/yr for reed canary grass and 125 kg/ha/yr for alfalfa[17]. Moreover, poplars can uptake high concentrations of metals, including arsenic, copper, and zinc, through roots and translocate them into shoots [35, 38, 44-48]. The presence of chelating agents like EDTA, common in food processing wastewaters [4-6], enhances phytoextraction of metals from contaminated soils [46]. Metal uptake by plants depends on the soil pH, chemical speciation, metal solubility and plant species [50, 51]. Additionally, interactions between nitrogen and metals during land application of wastewater are expected to affect nitrogen and metal uptake. For example, presence of nitrate increases arsenic accumulation by increasing pH [30]. Consequently, it is essential to examine phytoextraction of metals concurrently with nitrate studies.

Rhizostimulation. Through provision on oxygen and carbon in the rhizosphere, poplar trees have the potential to stimulate microbial growth and activity [39]. In wetland systems, the root aeration flux for emergent plants ranges from 0.5 – 12 $g/m^2/d$ [54]. In contrast, the BOD loading rate for food processing wastewaters is ~202 $g/m^2/d$, indicating that increased oxygen in the root zone would account for <5% of loaded BOD. The plant root-soil interface also contains root exudates with inorganic and organic molecules that influence microorganisms [55]. Roots can exude as much as 10-20% of total photosynthesis in the forms of sugars, alcohols, and acids [31]. Hybrid poplar exudates contain 10-120 mg/L dissolved organic carbon and 1-10 mg/L acetic acid [31]. In contrast, concentrations of BOD in food processing wastewater were much greater, ranging from 300 – 2,700 mg/L [4].

Phytosequestration. Roots can also produce exudates that sequester metals in soils, reducing the mass of metals available to contaminate groundwater [39]. Through sorption, precipitation, complexation and redox reactions, poplar roots can stabilize metals in soils [45, 55]. Root exudates (such as pectins) have the potential to bind 1.6-6.3% of Cu and 0.4-6.1% of Zn [45] in soils.

Poplars produce organic acids, such as oxalate, malate, citrate and formate, at elevated metal concentrations to withstand toxicity [56]. Consequently, extractability of Zn and Cd was reduced during a short-rotation poplar plantation at a brownfield site, indicating that the trees stabilized these metals [37]. Based on examining metal stabilization in uncontaminated and contaminated soils, poplar trees are expected to be the most effective at stabilizing metals at low concentrations [45]. Phytosequestration may also occur by oxidation metals by root-leaked oxygen, resulting in precipitation of metal oxyhydroxides [28].

Motivation

Metal and nitrate contamination of groundwater due to food processors is an ongoing threat to human health. Iron, manganese, arsenic, and nitrate concentrations have exceeded source drinking water standards in wells of many food processing facilities [15, 63, 64]. As more than 51% of the U.S. population and 99% of rural residents obtain their drinking water from groundwater [65], pollution of groundwater with metals and nitrates, which are primary drinking water contaminants [62], is a urgent health concern. Consequently, low-cost, sustainable solutions to nitrate and metal mobilization during land treatment of wastewaters are immediately needed. Adaption of current land application sites through poplar plantings has great potential to address this need; however, demonstration of the effectiveness of this technology is needed.

Each of these five processes could decrease metal mobilization at land application sites, allowing land application to continue at higher loading rates while remaining environmentally sustainable. However, phytoremediation studies utilize sites with extremely elevated metal concentrations, low soil organic matter, and rarely use continuous irrigation. In contrast, land application sites contain natural concentrations of metal, high concentrations of BOD, and are regularly saturated. Therefore, following research questions need to be answered:

(i) Do poplars grow well at land application sites?
(ii) Do poplar plantations decrease metal mobility in the soil at the field application rate of processing wastewater?
(iii) What transpiration rates can be expected for poplars grown under land application conditions?
(iv) Do poplar trees provide year-round benefits?

Enhancement of Previously Funded SCBGP-FB Grant

The project built on the previously funded SCBGP-FB project that established the field-site in Western Michigan by continued monitoring to determined treatment by poplar-planted versus control (non-planted) plots.

PROJECT APPROACH

Activities and Tasks Performed

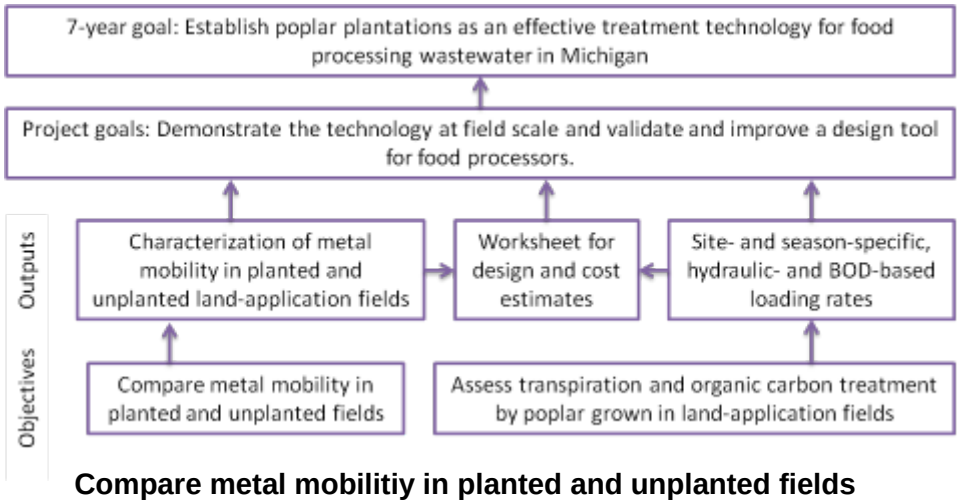
A field site to assess the benefits of poplar tree growth on land application of wastewater was established and instrumented in 2011 in southwest Michigan. The field site is planted with Hybrid poplar (*Populus deltoides* × *Populus nigra*) in two alternate sub-plots at the spacing of 10 ft×10 ft in a staggered pattern. This project monitored the field site continuously for temperature, soil moisture content, and volume of leachate produced, while regularly collecting leachate samples for COD and transition metals (i.e., iron and manganese). Data was analyzed to compare year-round treatment of food processing wastewater between the planted and unplanted plots, with the objectives of comparing metal mobility, transpiration, and organic carbon treatment. Initially, permissible hydraulic and organic loading rates and design guidelines were to be developed; however, the results from monitoring in 2012 and 2013 do not warrant these outcomes as no significant difference were observed between planted and unplanted plots.

Role of Project Partners

The main project partner was a food processing facility in West Michigan. This food processor has donated one acre of land for the field site and shares its wastewater application data with the project team.

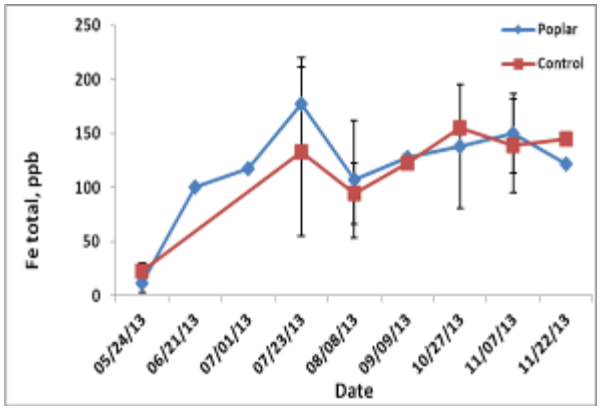
GOALS AND OUTCOMES ACHIEVED

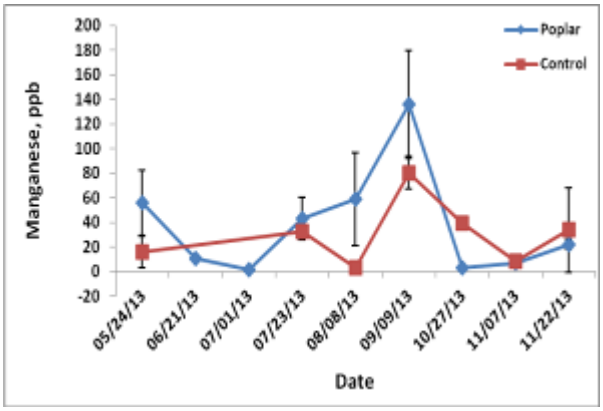
The goals, objectives, and outputs, as proposed initially, are summarized in the figure below:



Objective: Compare metal mobilitiy in planted and unplanted fields

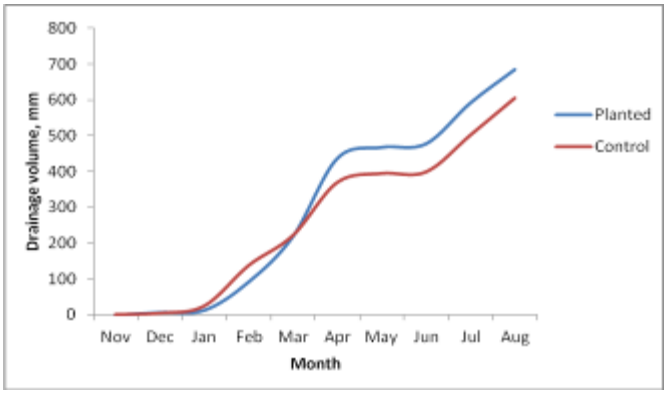
Water samples from lysimeters and draingauges were collected 10 times during 2013. These water samples were collected at approximately 6' deep. Sample number was less than expected due to a period of time where the food process was not applying wastewater, leading to the inability to collect samples. The concentrations of iron and manganese in the leachate are shown in the figures below.





Concentrations of iron and manganese in the leachate were similar for leachate collected from both planted and unplanted plots. Concentrations of iron were less than standards for drinking water (300 ppb Fe); however, concentrations of manganese frequently exceeded the drinking water standard of 55 ppb Mn. These results indicate that decrease in metal mobilization was not observed after two years of poplar tree growth. These results contradict those found in small column studies (see additional information), indicating that with tree growth and further root development, a decrease in metal mobilization due to poplar trees may be observed in the future. However, as the trees are already close in height to the bottom of the pivot used for irrigation of wastewater, further growth will require trimming the trees to have a shrub-like phenotype.

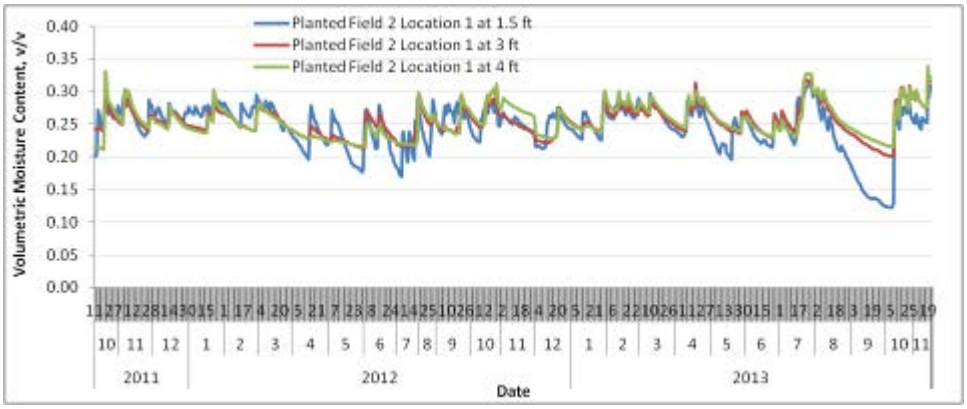
To finalize this analysis, the total mass of iron and managense will be calculated by multiplying the concentration of metal by volume of water drained. Difficulty with downloading the Drain Gauge data was recently resolved and this analysis will be finalized shortly. However, initial analysis indicates that the difference between leachate volume did not drastically differ. The figure below shows the cummulative volume of water leached from 11/2012 to 8/2013 in one planted (p2) and one control (c2) plot.

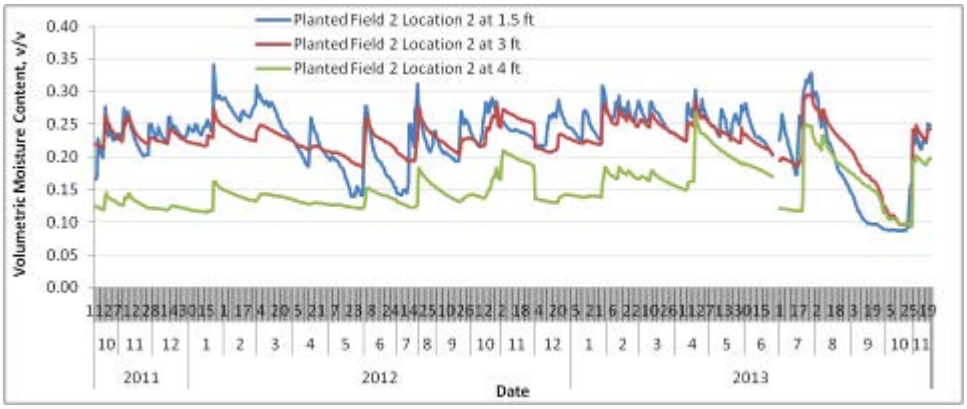


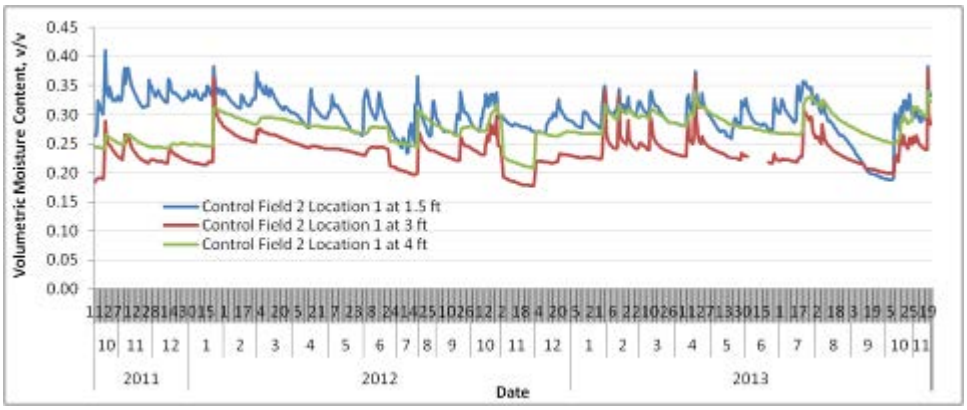
Therefore, it appears the poplar trees had little effect on the volume of water leached. Subsequently, it is probable that the mass of metals leached did not differ based on the presence of poplar trees.

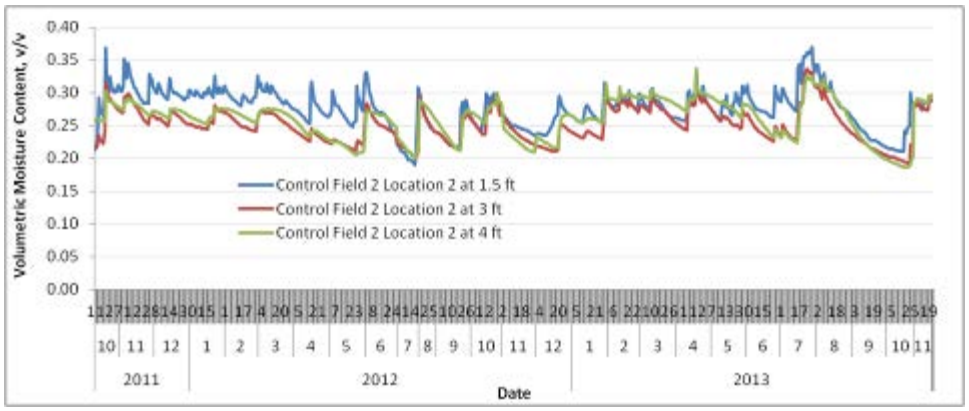
Objective: Assess transpiration by poplars grown in land application fields

Calculation of evapotranspiration coefficients has been delayed as the project team is waiting for the wastewater application data from the food processor. The plots for volumetric moisture content in one planted and one unplanted plot follow.





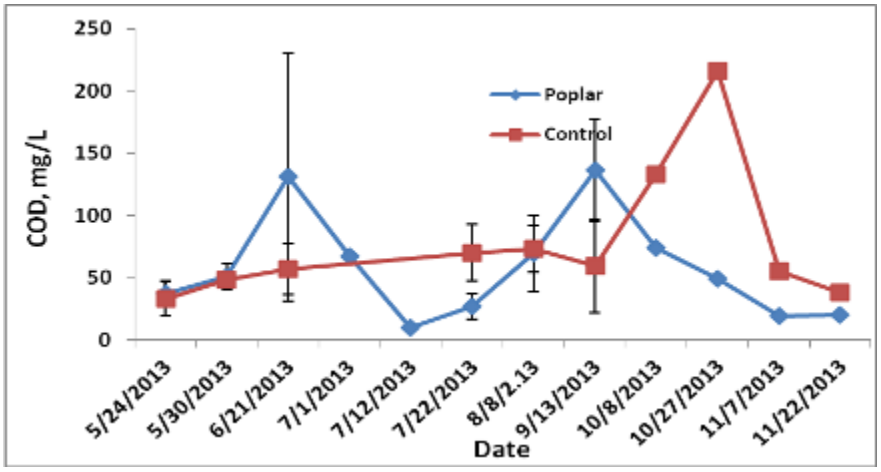




Moisture content in the soil ranged from 0.20 to 0.40. Moisture content was consistently higher at shallower depths. Statistical analysis indicates no difference in moisture content between the planted and unplanted plots. It is important to note that each plot did not receive an equal amount of water due to irregularity in wastewater application, which will be taken into consideration for the final analysis. However, as both the control two and planted two plots received similar wastewater application, it is expected that the evapostranspiration coefficients for the planted plots will be close to one, indicating no benefit. This is inconsistent with smaller scale, controlled studies where evapotranspiraiton coefficents were >3. This may be due in part to low wastewater application rates during 2012 and 2013 (associated with low production rates at the processing facility). Saturation for the given soil type is near a moisture content of 0.45, indicating that the soils were rarely to never saturated in the experimental plots.

Objective: Assess organic carbon treatment by poplars grown in land application fields

Organic carbon was measured using chemical oxygen demand (COD) as a proxy. Data for 2013 is summarized in the figure below.



Similar to metal concentrations, the leachate concentrations of COD did not differ between poplar and control plots.

Output: Hydraulic and BOD loading rates and worksheet for design

Based on the disappointing similarities between treatment of metals and COD by the control and planted plots, loading rate recommendations for sites planted with poplar trees different from those currently existing are not justified. In part, the lack of differences is likely due to the low wastewater application rates (which resulted from lower wastewater production by the processing facility). As evidenced by the moisture content data, the soils at the site were almost never saturated, maintaining volumetric moisture contents of approximately 25%. Consequently, the waste assimilative capacity of the native soil system was not likely exceeded. Further research and monitoring of the site, under stressed conditions, is needed for all the outcomes of this project to be achieved and/or to total discredit this technology as a viable solution for food processors (given the success of the technology at smaller scales under controlled conditions).

BENEFICIARIES

Ultimately, this project will benefit food processing facilities that are looking to improve their sustainability, both economically and environmentally. Currently, the benefit is limited to prevention of marketing an un-validated technology; however, if future studies indicate a benefit of poplar plantations under high wastewater loadings, the benefit will expand to creation of a low-cost solution to metal mobilization due to wastewater application. As such, the project has the long-term potential to benefit communities that rely on groundwater for drinking water that are near food processing facilities.

At this point, the potential economic impact of the project is unknown – further research is needed to determine whether poplar plantations for food processing wastewaters are a viable technology given the contradictory results from this field study and previous controlled, column studies.

LESSONS LEARNED

- The largest lesson learned in this project was close interaction between the food processor and the research team is needed to overcome economic realities that affect production. Production at the facility was low in 2012 and 2013, resulting in lower wastewater production. Per normal practice, the facility evenly applied the wastewater over all available sites. It was not until mid 2013 that the research team convinced the facility to concentration application on the experimental site, only shortly before winter set in. This may have contributed to the lack of differences that were observed between planted and control plots, as the system was not stressed. Additionally, acquiring wastewater application data from the food processor frequently took many months.
- Application of wastewater was very uneven. We are currently collecting additional data on the pattern of application to improve calculations for volume of water added to each plot. Additionally, the pivot system broke down twice during the experimental period. While working with an existing facilities provides a “real-world” context to the research, some things, such as motivation to fix a broken pivot systems that does not have to be used, are hard to control
- Rodents bring many types of problems. At the land application sites, rodents were found heavily likely due to dense grasses. Rodents chewed the bark of the tree in our previous year and the trees died. In 2013, rodents chewed on the cables and the data acquisition stopped working due to exposure of naked sensor wire to the soil. We had previously installed the cables underground. Therefore, fixing required to pull them out, fix them and put

them into the PVC pipe. Still, the portion of the cables that were not fully inside the PVC pipes were eaten by rodents.

- TDR sensors are more reliable, easier to install, and cheaper. In our experience, Enviroscan sensors were less reliable in moisture readings, malfunctioned often and large care was necessary in handling.

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ADDITIONAL INFORMATION

Results from our small-columns studies are currently in-press at the *Ecological Engineering.*

Aryal, N. and Reinhold, D.. (in review). "Reduction of metal mobilization by poplars during soil treatment of wastewaters: Small-scale proof of concept studies" Ecological Engineering.

PROJECT TITLE: Michigan State University/Crop and Soil Sciences: Lightweight Rolling Programs to Decrease Pesticide Inputs and Enhance Turfgrass Quality - FINAL

PROJECT SUMMARY

The Michigan turfgrass industry (golf courses, sod farms, and lawn care suppliers) contributes $1.86 billion to the state economy, employs 30,000 residents, spends $643 million in labor and services, and generates $52 million in sales of lawn care supplies. Our sod farms produce 24 million square yards of sod, and account for 21% of the total agricultural acreage; turfgrass coverage across the state equals 1.89 million acre. Moreover, Michigan ranks first in the nation for number of public golf courses (865), and the golf course industry is a direct supporter of lawn care suppliers and turfgrass growers, both sod and seed producers, throughout the nation (Turfgrass Producers International, 2011). Therefore, the importance of protecting turf from disease cannot be underestimated; loss of turf will result in loss of revenue, and thus will result in the cessation of business operation.

Dollar spot is a foliar disease of turfgrass that causes significant injury if left untreated. The causal pathogen, *Rutstroemia floccossum* syn. *Sclerotinia homoeocarpa* F.T. Bennett (Smiley et al., 1992), is particularly severe on Michigan athletic fields, home lawns, sod farms, and golf courses as a result of environmental conditions and turfgrass cultural regimes that favor disease outbreak. While dollar spot can be suppressed with fungicides, turfgrass managers commonly limit their use because of economic, environmental, and fungicide-resistance concerns (Delvalle et al., 2011). However, the rising cost and imminent ban of certain chemical pesticides have caused turf managers to clamor for effective yet inexpensive means to control turf diseases. One chemical slated for ban is chlorothalonil, the most commonly used fungicide in the turf

industry (McDonald et al., 2006), and currently one of 54 fungicides, insecticides, and herbicides listed in the lawsuit filed by several Northwest Pacific Environment Coalitions against the Environmental Protection Agency (National Marine Fisheries Service, 2011). The reason for the potential ban lies solely in the toxicity levels of chlorothalonil metabolites and degradation products, which adversely affect rainbow trout egg production and survival rate (Davies and White, 1985). Moreover, chlorothalonil is also known to adversely affect amphibian and mollusk populations (McMahon et al., 2012).

This contact fungicide is relatively inexpensive, provides broad-spectrum control of numerous foliar diseases, and is a favorite among turf managers because it is less likely to cause pathogen resistance, which often occurs in many of the systemic fungicide classes (Detweiler et al., 1983). Therefore, if recent plans from the EPA to ban chlorothalonil come to fruition then it is up to the turf research scientists to find effective and affordable alternatives for managing *S. homoeocarpa.* One method involves the use of integrated pest management (IPM), a system that combines cultural, biological, and chemical means of suppressing turf diseases. Although perhaps not as effective as conventional, chemical pest management systems, IPM still proves acceptable in terms of turf quality conditions (Rossi and Grant, 2009). Therefore, lightweight rolling and sand topdressing could be alternatives for managing turf diseases in lieu of chemical pesticide applications, and offer major advantages such as the following: they reduce the necessity for fungicides, extend the efficacy of fungicides, and reduce the possibility of human exposure to them (Giordano et al., 2012).

Sand topdressing enhances turfgrass vigor and reduces disease infection severity (Skorulski et al., 2010), and rolling improves turfgrass quality (Beard, 1982); therefore, plants will be healthier and withstand disease pressure more readily. Turf maintenance would benefit from lightweight rolling regimes that minimize both labor costs and fuel consumption; however, in terms of acceptable turfgrass conditions, this practice must also be effective at reducing dollar spot severity on turf swards. Golf course rolling and sand topdressing have become normal practice on putting; therefore, these procedures would likely have equal success on fairways, athletic fields, and sod farms. Instead of applying eight to nine fungicide treatments per season at a cost of $16,000-27,000 annually on fairways (Turf Producers International, 2011), lightweight rolling and sand topdressing may alleviate this annual expenditure, and possibly cut the cost per application by 25 to 50%.

We hypothesized *S. homoeocarpa* infection on turfgrass would be decreased by sand topdressing and by rolling, thereby reducing the need for frequent fungicide applications. Therefore, our objective was to examine dollar spot severity and turf quality responses on an *Agrostis stolonifera* and *Poa annua* fairway to sand topdressing and rolling with and without fungicides.

PROJECT APPROACH

The study was conducted at the Hancock Turfgrass Research Center at Michigan State University using a split block design with treatments consisting of sand topdressing, three rolling frequencies (1x, 3x or 5x weekly), controls, and three replications. In 2013 and 2014, fungicide treatments were introduced, and consisted of the following: different application rates of Emerald® fungicide (0.045, 0.090, and 0.180 oz/1000 ft^2), rolling 3x weekly, sand topdressing, and controls.

In August 2014, conditions conducive to disease outbreak were particularly severe, but sand topdressing (applied biweekly from May to September at 0.1346 yd^3/1000 ft^2) significantly

reduced the percentage plot surface area affected by dollar spot approximately 46% compared to the control (native soil)(Table1).

Table 1. Effects of sand topdressing on percentage plot surface area affected by dollar spot lesions. Means comparison; East Lansing, MI 2014.

Treatment	% Plot surface area affected by dollar spot lesions [y]
	August 25
Sand topdressed	6
Native soil (control) [z]	11

[y] Percentage of plot area affected by dollar spot lesions (visual estimation).
[z] Capac loam soil texture.

Turfgrass quality was visually assessed using methods established by the National Turfgrass Evaluation Program, Inc. (Beltsville Agricultural Center, Beltsville, MD); color, density, uniformity, texture, and biotic and abiotic stress constitute quality ratings. In 2014, lightweight rolling significantly affected turfgrass quality on different dates. Rolling 5x weekly resulted in the highest quality ratings (Table 2).

Table 2. Effects of rolling frequency on turfgrass quality. Means and LSD comparisons; East Lansing, MI 2014.

Treatment	Quality ratings [y]		
	July 28	August 4	August 18
1x/wk	6.7 ab [z]	5.7 ab	5.2 a
3x/wk	5.8 b	5.2 b	4.5 b
5x/wk	7.2 a	6.7 a	5.3 a
Not rolled (control)	6.2 b	5.2 b	4.5 b
LSD (0.05)	0.9	1.2	0.6

[y] Quality based on a 1 (dead or poor) to 9 (best) rating scale, with 6 indicating acceptable.
[z] Means followed by the same letter not significantly different within columns.

Sand topdressing treatment effect on turfgrass quality was significant on different dates in 2014 (Table 3).

Table 3. Effects of sand topdressing on turfgrass quality. Means comparisons; East Lansing, MI 2014.

Treatment	Quality ratings [y]	
	August 11	August 25
Sand topdressed	5.9	6.0
Native soil (control)	4.1	4.8

[y] Quality based on a 1 (dead or poor) to 9 (best) rating scale, with 6 indicating acceptable.
[z] Capac loam soil texture.

A chlorophyll meter (TCM 500, Spectrum Technologies, Inc. Aurora, IL) was used to quantitatively evaluate turfgrass quality response, because chlorophyll content is a good indicator of plant health. This instrument calculates an index value, whereas the higher the value the healthier the plant (Kruse et al., 2013). Compared to the control, rolling 5x weekly significantly affected normalized difference vegetation index (NDVI)(Table 4).

Table 4. Effects of rolling on turfgrass NDVI (normalized difference vegetation index). Means and LSD comparison; East Lansing, MI 2014.	
Treatment	**NDVI rating [y]**
	August 18
1x/wk	0.690 ab [z]
3x/wk	0.688 ab
5x/wk	0.706 a
Not rolled (control)	0.674 b
LSD (0.05)	0.02

[y] NDVI range from 0.000 to 1.000 with higher values indicative of healthier plants.
[z] Means followed by the same letter not significantly different within columns.

Fungicide (Emerald®) application rates, reduced by 50 to 75% of the full, recommended application rate, had a significant effect on the percentage plot surface area affected by dollar spot lesions (Table 5).

Table 5. Effects of different fungicide application rates on percentage plot surface area affected by dollar spot lesions. Means and LSD comparisons; East Lansing, MI 2014.

Treatment (oz/1000 ft^2)	% plot surface area affected by dollar spot lesions [x]								
	July 11	July 17	July 28	Aug. 4	Aug. 11	Aug. 18	Aug. 25	Sept. 2	Sept. 9
0.045 [y]	4.3 a[z]	4.0 a	1.9 a	1.0 a	1.8 a	4.0 a	6.3 a	2.8 a	7.6 a
0.090	2.2 b	2.0 b	1.5 a	1.0 a	1.1 a	1.8 b	3.7 b	1.6 b	3.3 b
0.180	1.0 b	1.1 b	1.0 a	1.0 a	1.0 a	1.1 b	1.8 b	1.1 b	1.2 b
No fungicide (control)	9.1 c	6.3 c	5.0 b	7.2 b	8.8 b	13.4 c	16.0 c	9.3 c	10.1 c
LSD (0.05)	1.8	1.5	1.0	0.5	0.9	1.1	2.0	0.9	2.2

[x] Percentage of lesions affecting turfgrass treatment plots.
[y] Based on label recommendation for preventative application rates of Emerald® (boscalid) fungicide.
[z] Means followed by the same letter not significantly different within columns.

In 2014, interaction effects of fungicide application rate and application interval on turfgrass quality response were observed. Moreover, lightweight rolling and sand topdressing significantly enhanced turfgrass quality (Figure 1). Finally, the interactions of sand topdressing and fungicide application rates differ as a function of the 3x weekly rolling treatment, whereas the effect of rolling greatly influenced fungicide efficacy (Figure 2).

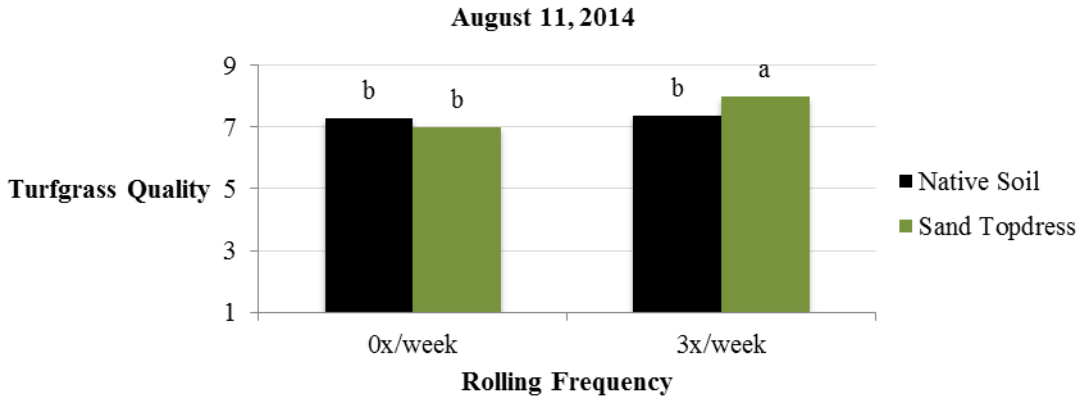

Figure 1. Effects of lightweight rolling and sand topdressing on turfgrass quality. East Lansing, MI.
Quality based on a 1 (dead or poor) to 9 (best) rating scale, with 6 indicating acceptable.
Columns with the same letter not significantly different (Pr > 0.05).

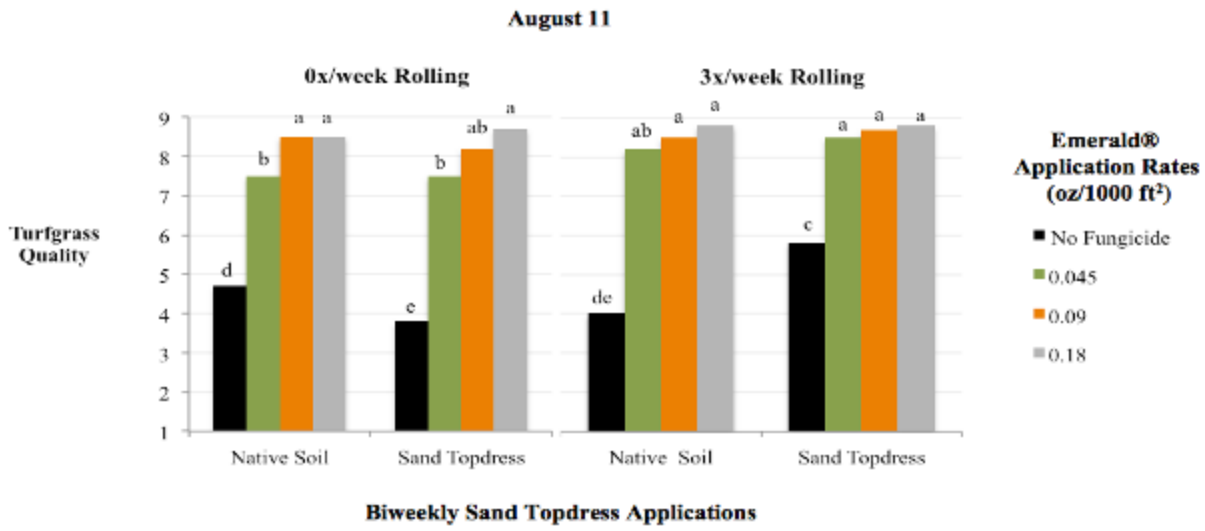

Figure 2. Effects of lightweight rolling, sand topdressing, and different fungicide application rates on turfgrass quality. East Lansing, MI.
Quality based on a 1 (dead or poor) to 9 (best) rating scale, with 6 indicating acceptable.
Columns with the same letter not significantly different (Pr > 0.05).

In 2014, significant interaction effects occurred between fungicide application rates and application intervals. The reduced application rates were more efficacious when applied at 15-d intervals, but regardless of the interval treatment, all fungicide treatment levels effectively controlled dollar spot compared to the control (Figure 3 and 4).

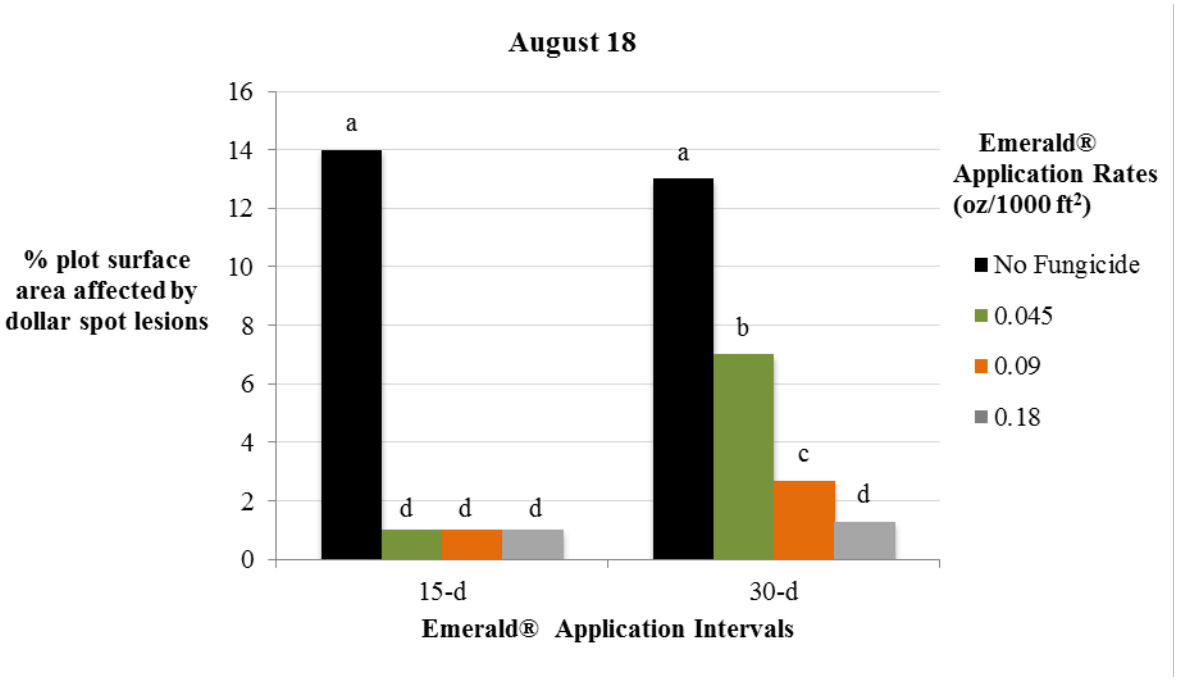

Figure 3. Effects of different fungicide application rates and application intervals on percentage plot surface area affected by dollar spot lesions. East Lansing, MI.
Columns with the same letter not significantly different (Pr > 0.05).

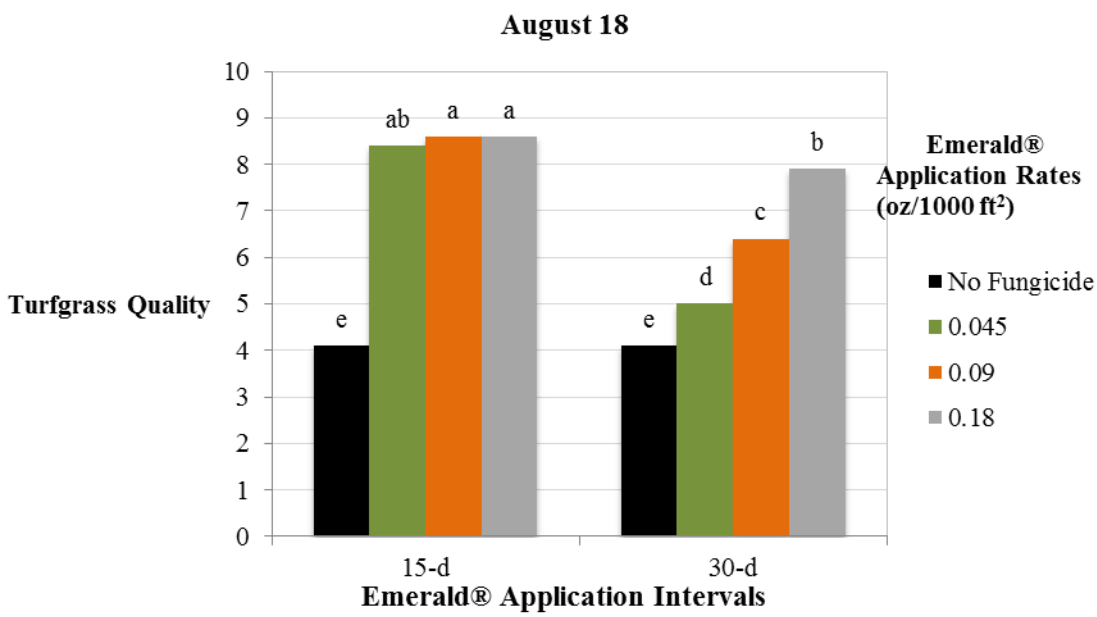

Figure 4. Effects of different fungicide application rates and application intervals on turfgrass quality. East Lansing, MI.
Quality based on a 1 (dead or poor) to 9 (best) rating scale, with 6 indicating acceptable.
Columns with the same letter not significantly different (Pr > 0.05).

A significant interaction effect occurred between rolling frequency and fungicide application rate on NDVI (normalized difference vegetation index) during one data collection period. Although no mean separation was observed between the application rates, a significant difference between application rates and control was observed (Figure 5). The 3x weekly rolling treatment increased

fungicide efficacy, whereas the interaction effects of fungicide application rates and intervals varied as a function of rolling, and no difference in response was noticed between the lowest and highest rates when applied at 30-d intervals (Figure 6).

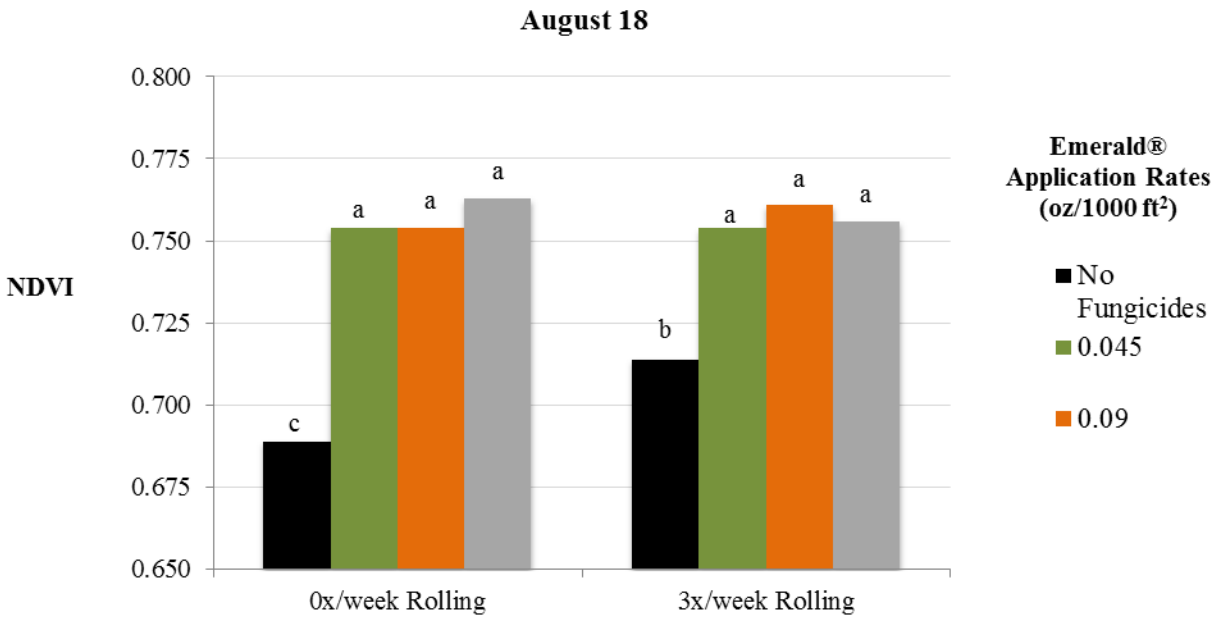

Figure 5. Effects of lightweight rolling and fungicide application rates on NDVI (normalized difference vegetation index). East Lansing, MI.
NDVI range from 0.000 to 1.000 with higher values indicative of healthier plants
Columns with the same letter not significantly different (Pr > 0.05).

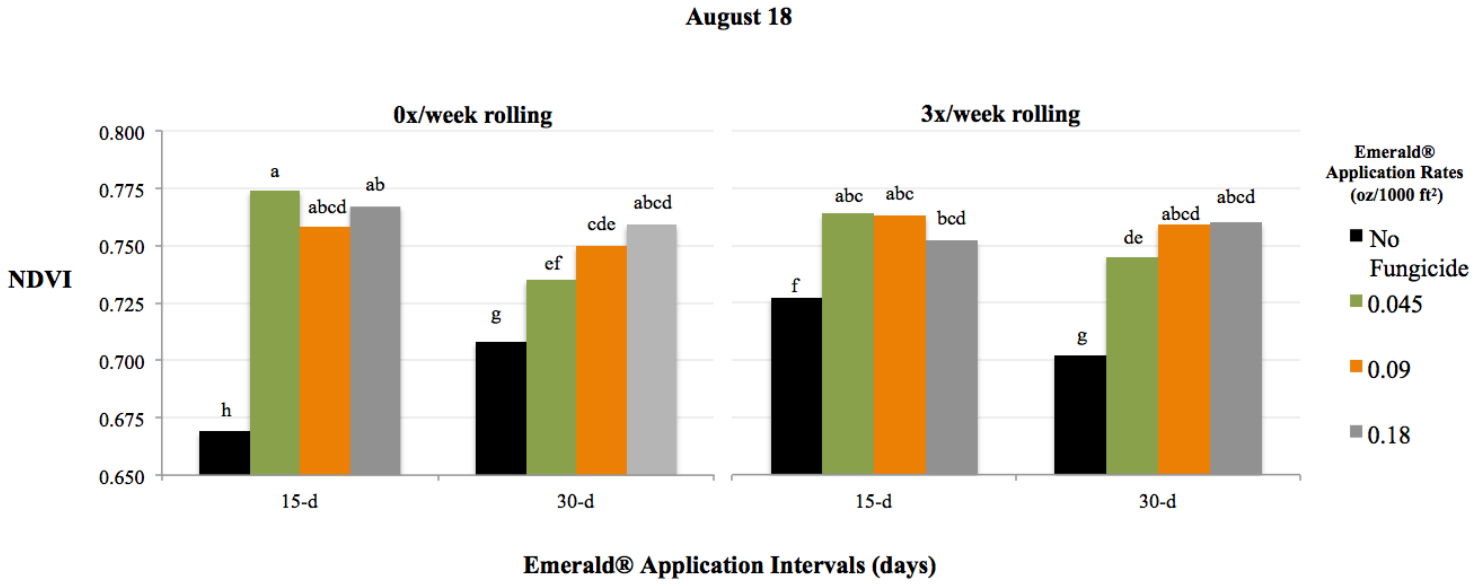

Figure 6. Effects of lightweight rolling, fungicide application rates, and intervals on NDVI (normalized difference vegetation index). East Lansing, MI.
NDVI range from 0.000 to 1.000 with higher values indicative of healthier plants
Columns with the same letter not significantly different (Pr > 0.05).

GOALS AND OUTCOMES ACHIEVED

The performance goals were achieved for the reporting period (Table 6 and 7).

Table 6. Goals and outcomes achieved for lightweight rolling and sand topdressing programs to decrease pesticide inputs and enhance turfgrass quality. East Lansing, MI 2014.

Activities Performed	Goals Achieved	Measurable Outcome
Lightweight rolling (1x, 3x, 5x weekly, and a control)	Reduced dollar spot severity, enhanced turfgrass quality and fungicide efficacy.	Visual estimate of percentage plot surface area affect by dollar spot lesions [w], visual assessment of turfgrass quality [x], and quantitative analysis of turfgrass chlorophyll content [y].
Sand topdressing [v]		
Lightweight rolling (3x weekly, and a control)		
Fungicide application rates [z] (0.045, 0.090, 0.180 oz/1000 ft^2, and a control)		
Sand topdressing [v]		

[v] Sand topdressing biweekly application rate: 0.1364 yd^3/1000 ft^2.
[w] Percentage of lesions affecting turfgrass treatment plots.
[x] Based on label recommendation for preventative application rates of Emerald® (boscalid) fungicide.
[y] Quality based on a 1 (dead or poor) to 9 (best) rating scale, with 6 indicating acceptable.
[z] NDVI range from 0.000 to 1.000 with higher values indicative of healthier plants.

Table 7. Comparison of goals established, and actual accomplishments of the study (lightweight rolling and sand topdressing programs to decrease pesticide inputs and enhance turfgrass quality). East Lansing, MI 2014.

Goals	Accomplishments
Reduce dollar spot severity and enhance turfgrass quality with a combination of lightweight rolling and sand topdressing [v] without fungicide applications.	Aug. 18: rolling 5x weekly increased turfgrass chlorophyll content, and enhanced turfgrass quality (Table 4). Aug. 25: sand topdressing reduced dollar spot lesions [w] by 46% (Table 1).
Reduce fungicide [x] use by 25 to 75% of the full, label recommendation application rate for the control of dollar spot with a combination of lightweight rolling and sand topdressing regimes.	Aug. 11: rolling and sand topdressing increased the efficacy for the lowest fungicide application rate (Figure 4). Aug. 18: rolling enhanced fungicide efficacy, reduced dollar spot lesions by 70% (Table 5), and increased turfgrass quality [y] and chlorophyll content [z] (Figure 2, 5, and 6).

[v] Sand topdressing biweekly application rate: 0.1364 yd^3/1000 ft^2.
[w] Percentage of lesions affecting turfgrass treatment plots.
[x] Based on label recommendation for preventative application rates of Emerald® (boscalid) fungicide.
[y] Quality based on a 1 (dead or poor) to 9 (best) rating scale, with 6 indicating acceptable.
[z] NDVI range from 0.000 to 1.000 with higher values indicative of healthier plants.

BENEFICIARIES

Turfgrass health is a critical concern for turfgrass managers in the upper Midwest. More money is expended trying to manage Dollar spot, caused by *Sclerotinia homoeocarpa* F.T. Bennett, than any other turf disease (Goodman and Burpee, 1991; Vargas, 2005). Chlorothalonil (tetrachloroisophthalonitrile) is a pesticide that provides broad-spectrum control of numerous pathogens, but is primarily used as a fungicide on crop and non-crop sites such as nurseries, home lawns, and golf courses (National Marine Fisheries Service, 2011). Moreover, on Michigan golf courses, it is the most frequently used pesticide (Smitley and Rothwell, 2003). In 1999-2000, the total domestic use exceeded 6.8 million kg active ingredient (a.i.) of chlorothalonil, with approximately 680,000 kg a.i. used on turf areas (EPA, 1999). In 2007, chlorothalonil was the most commonly used fungicide in the agricultural sector (3.6 million kg a.i.), and in the industry/commercial/government market sector (1.8 million kg a.i.) (EPA, 2011). A surveyed report of 49 Michigan golf course superintendents revealed that fairways averaged 1.8 applications of chlorothalonil per year while the greens received 4.4 per year (Smitley and Rothwell, 2003). Although dollar spot causes substantial turf injury and is particularly severe on fairways, fungicide use is often curtailed because of environmental, fungicide-resistance, and economic concerns with the latter related to the sheer size (12-16 ha) of fairway areas on golf courses (Devalle et al., 2011). These combined factors, in the minds of many turf managers, lend an intractable quality to dollar spot. The causal pathogen rarely kills the grass plant; however, the symptomatic lesions that appear on the turfgrass leaf blades affects the aesthetics as well as playability the golf course. If left untreated lesions quickly coalesce into an obstreperous matrix of turf, whereby the direction of travel of the golf ball upon the fairway becomes greatly impeded. Therefore, in an effort to combat the ravages of dollar spot, fungicides are often applied to maintain the playability and aesthetic appeal of the golf course. The popularity of chlorothalonil for use to control dollar spot can be attributable to the multi-site mode of action these contact fungicides possess, which make the development of pathogen resistance less likely to occur (Golembiewski et al., 1995). Another quality that makes the use of contact fungicides popular among turf managers is their relative low cost, particularly when compared to single-site mode of action systemic fungicides that are more expensive, and often promote the development of pathogen resistance. Dollar spot resistance has been noted in several classes of systemic fungicides: benzimidazoles, dicarboximides, and demethylation inhibitors (Warren, 1974; Detweiler et al., 1983; Golembiewski et al., 1995). Contact fungicides are often applied at preventative rates (reduced concentration) in anticipation of conditions conducive to dollar spot outbreak rather than at curative application rates (full concentration) when severe disease pressure is present (Williams et al., 1996). Nevertheless, the efficacy of contact fungicides is rather short lived (7-14 days) compared to systemic fungicides (21-28 days). Therefore, in light of EPA mandated pesticide use restrictions and environmental concerns, turf disease management strategies should include the use of cultural practices that promote plant health (rolling and sand topdressing) while being also antagonistic to the disease life cycle (Giordano et al., 2012). The implementation of the IPM approach is not only beneficial to the environment, but to the turf managers, residents of the state of Michigan, and populace of our nation. Moreover, the IPM approach is beneficial for our state economy as well as the national economy.

LESSONS LEARNED

The project results have shown that a combination of rolling and sand topdressing, with and without fungicides can significantly reduce the severity of dollar spot, and at the same time, improve turfgrass quality, reduce pesticide expenditures as well as reduce the possibility of human and animal exposure to pesticides.

CONTACT INFORMATION

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ADDITIONAL INFORMATION

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PROJECT TITLE: Lakeshore Environmental, Inc.: A Full-Scale Follow-Up Study to Assess the Effectiveness of Passive Aeration of Soils in a Food Processing Wastewater Treatment System – FINAL

PROJECT SUMMARY

Michigan's fruit and vegetable food processing industry produces a large amount of wastewater, much of which if treated and released to the ground surface through various means. This wastewater discharge has the potential to cause naturally-occurring metals in the soil to leach into groundwater at concentrations which may pose a risk to both human health and the environment. As a result, the Michigan Department of Environmental Quality (DEQ) has established conservative wastewater disposal standards. These generic standards do not often for actual site conditions, specifically the amount (or availability) of oxygen in the soils.
Soil aeration is a proven technology that provides oxygen to the soils regardless of natural site conditions. This method can be expensive to operate due to the electricity requirements to run the blowers and other operation and maintenance costs. LEI conducted a study from 2010 through 2012 and examined passive soil aeration methods to evaluate the feasibility of in-situ wastewater treatment technology ("pilot scale study"). The study also set out to determine the economic feasibility of this method for large food processing applications. The final performance report for that study (submitted in March 2012) concluded that although not as effective as active aeration, passive aeration was a successful treatment method for food processor wastewater. Passive aeration demonstrated the ability to reduce the concentration of key wastewater

contaminants and indicators by over 80% which translates into an increased ability of irrigation land to treat and assimilate food processing wastewater by five times.

While the results of the pilot scale study were conclusive and encouraging, some issues were encountered along the way, especially related to the installation of the system. To further elaborate on the conclusions of the 2010-2012 study, LEI proposed a full scale follow-up study to assess the effectiveness of passive aeration of soils in a food processing wastewater treatment system.

The purpose of this study was to determine if the success observed in the pilot scale study will translate into a full scale system. The effectiveness of the treatment method was compared to control (not aerated) and background (not irrigated or aerated conditions. This study was also designed to track and monitor the system's ability to accommodate various biochemical oxygen demand (BOD), chemical oxygen demand (COD), and hydraulic loading rates. The study continued through the winter months and assessed the effectiveness of passive aeration during extended periods of sub-freezing temperatures. Costs of the system were tracked throughout the study for comparison to other approved food processing wastewater treatment systems.

PROJECT APPROACH

The grant was issued in October 2012. LEI installed a full scale land application system at a food processing facility in Hartford, Michigan. The system was comprised of five fixed spray irrigation guns designed to apply wastewater to approximately 3.6 acres total. A full scale passive aeration system was installed in the western portion of the land application area (Passive Aeration Zone), while the eastern portion was left without aeration of comparison purposes (Non-Aerated Zone). Lysimeters and soil data sensors (moisture content and temperature) were installed in each zone for analysis of soil conditions and wastewater treatment capacity.
Irrigation to the study area began in late-July 2013 following the completion of the irrigation plumbing system. Wastewater and lysimeter samples were collected on a monthly basis (at a minimum). Wastewater effluent quality was compared to soil pore water quality (lysimeters) throughout the study to determine the level of treatment occurring within the soils after irrigation. Effective wastewater treatment was documented throughout the majority of this study: soil pore water samples collected from the 8' below ground surface (BGS) lysimeters contained little to none of the analytes found in the untreated effluent during typical loading conditions.
Similarly, the data collected by the soil sensors allowed LEI to observe the effects of the irrigation, especially with regard to soil moisture content. Any spikes or consistent increase in soil moisture would be linked to over application of wastewater and saturation of the treatment soils. Results concluded that soil moisture content was significantly lower in the Non-Aerated Zone than the Passive Aeration Zone, even prior to any wastewater land application. Both showed a clear reaction to land application or natural precipitation events with similar short and long term recovery times.
Burnette Foods – Hartford Facility played a key role in the project by providing the land for the study, performing routine system checks, operation and maintenance activities, and collecting wastewater samples throughout the project.

GOALS AND OUTCOMES ACHIEVED

Goal #1: Determine whether the success observed in pilot scale version of the study will translate into the full scale.

Conclusion: This goal was inconclusive. Overall, this study demonstrated that land application coupled with passive aeration is an effective treatment method for food processing wastewater. However, some anomalies were observed which prevent LEI from conclusively determining whether the success observed in the pilot scale version translated into the full scale. Furthermore, there was not a strong indication that the Passive Aeration Zone performed better

or worse than the Non-Aerated Zone. Further discussion of the analytical results gathered and evaluated throughout this study is included in the following goal evaluations.

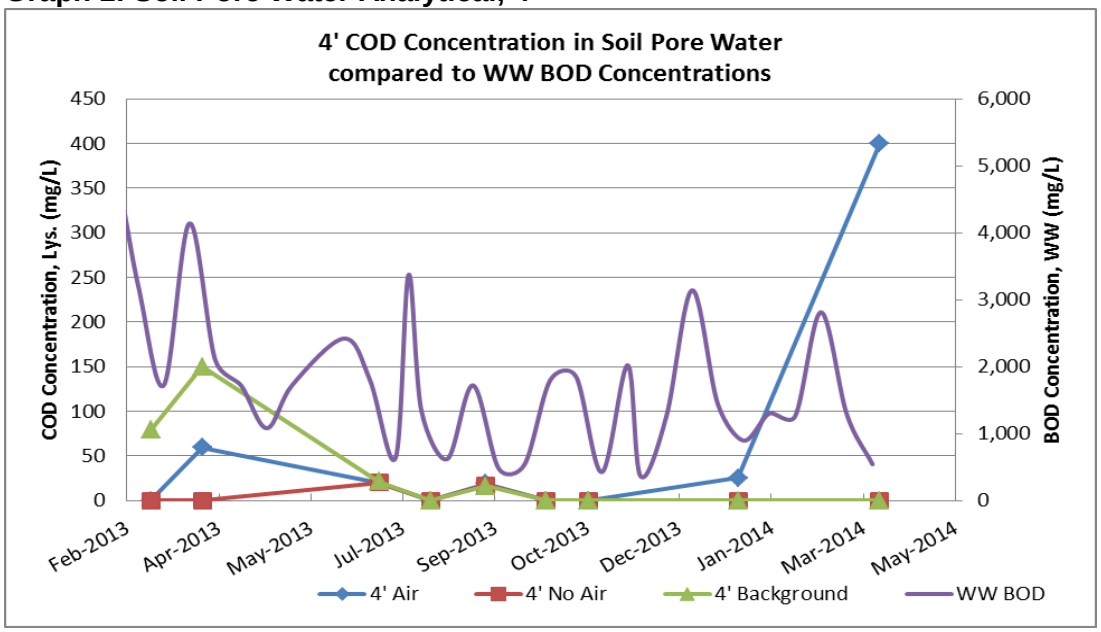
Goal #2: Determine the effectiveness of the treatment method compared to background/control conditions.

Conclusion: There was not a strong, demonstrable difference in the soils ability to treat specialty crop food processing wastewater by passive soil aeration when compared to the non-aerated soils.

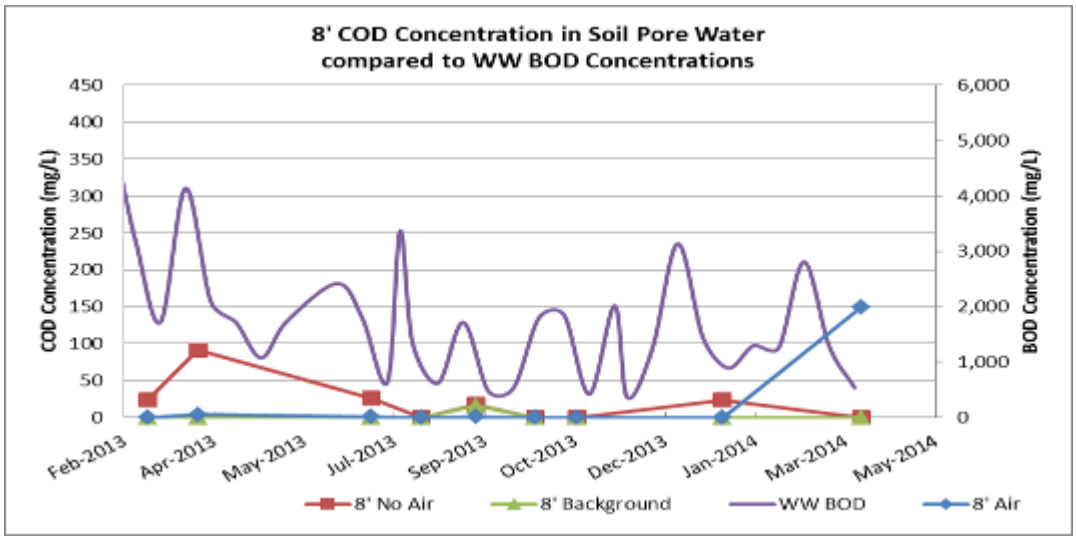
As mentioned in the project approach, monthly wastewater and lysimeter soil pore moisture samples were collected and compared throughout the study. Both zones (Passive Aeration and Non-Aerated) showed a similar reduction in key analytical parameters. Concentrations of iron and manganese were below laboratory detection limits throughout a majority of the study in both zones. Samples collected from lysimeters in Passive Aeration Zone showed better/more favorable treatment results at 4' BGS when compared to those collected from the Non-Aerated Zone. However, this observation was not consistent for samples collected from 8' BGS.

COD concentrations were similar in both zones at the same depth, indicating a similar amount of treatment capacity in both the Passive Aeration and Non-Aerated Zones.

Graph 1: Soil Pore Water Analytical, 4'



Graph 2: Soil Pore Water Analytical, 8'



Analytical results are summarized in the attached tables. Wastewater analytical data is provided in **Table 1**, *Wastewater Analytical Results*. As shown in **Table 2**, *Lysimeter Analytical Results*, many of the key analytical parameters present in the wastewater effluent were below laboratory detection limits at 4' and 8' BGS in both zones. Chloride concentrations in the irrigation zones increased throughout the study, acting as a tracer and confirming the presence of treated wastewater. This observation, coupled with the lack of metals mobilization or increased COD/TOC concentrations, demonstrated that the wastewater was in fact treated by the soils within each zone.

A spike in analytical concentrations was observed in the March 31st sample, particularly in the Passive Aeration Zone. COD and TOC increased in both the 4' and 8' lysimeter samples, with metals concentrations increasing as well. Some metals, primarily manganese, appeared in the soil pore moisture sample collected from the 4' BGS lysimeter in the Non-Aerated Zone as well. These increases occurred after nearly two months of constant wastewater irrigation, which is further discussed below ("Goal #3), and the spring thaw which provided greater than normal moisture input to the soil column.

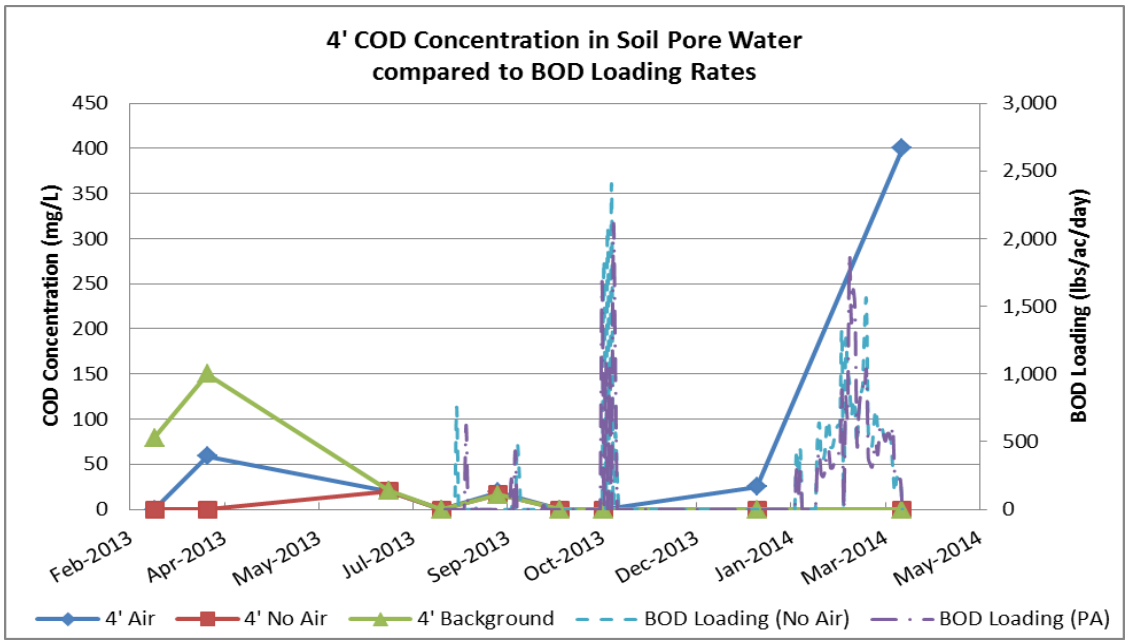
As expected, the control zone showed no statistical change throughout the study.

Goal #3: Track the effectiveness of the passive aeration system at various BOD/COD and hydraulic loading rates (inches of wastewater irrigated per acre per day).

Conclusion: The passive aeration treatment system was relatively effective at treating wastewater when BOD loading rates ranged from < 50 lbs./ac/day to 100+ lbs./ac/day. Decreased treatment efficiency was observed when consistent loading to the irrigation area over 100 lbs./ac/day occurred for nearly 45 consecutive days.

Similarly, soil moisture content and recovery time was consistent throughout the study at hydraulic loading rates ranging between 0.61 and 2+ inches/ac/day. Stable but increased soil moisture content was observed after nearly 45 days of consecutive wastewater loading of over 2 in./ac/day.

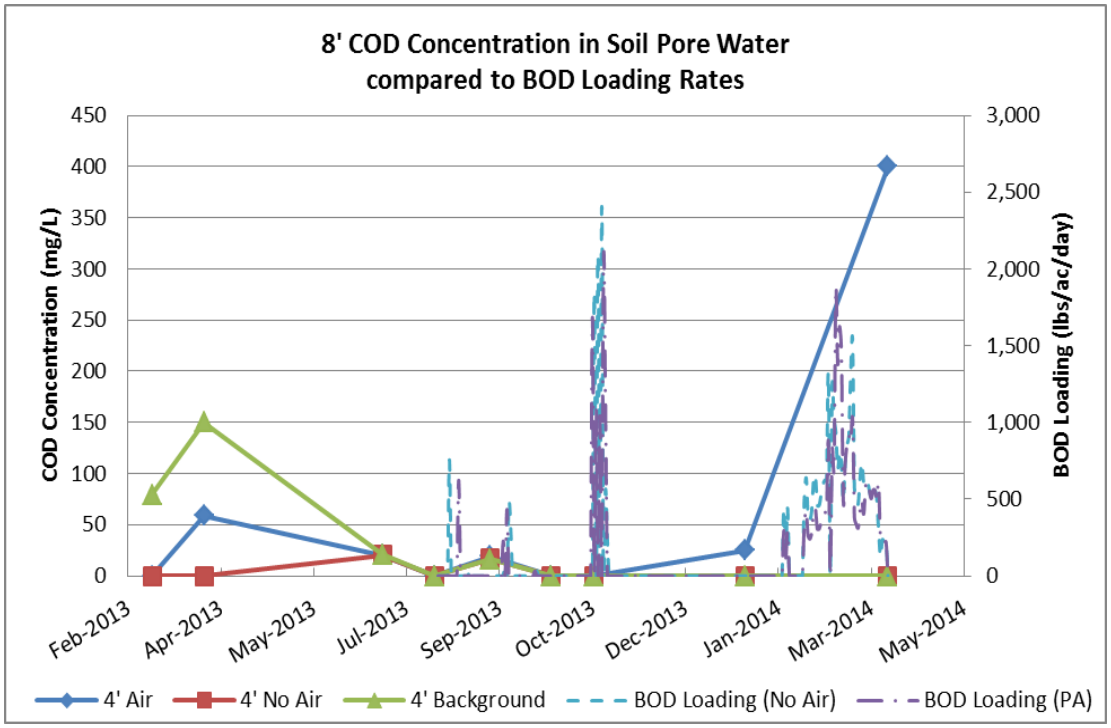
BOD loading to each zone varied throughout the study in order to determine effectiveness at the various loading rates. *In true application, BOD loading to a land application system is monitored on a 30-day (or monthly) average.* **Graphs 3** and **4** depict the COD concentration in the soil pore water at 4' and 8' BGS compared to the BOD loading rates to each zone.



Graph 3: BOD Loading and Soil Pore Water

Analytical, 4'

Graph 4: BOD Loading and Soil Pore Water



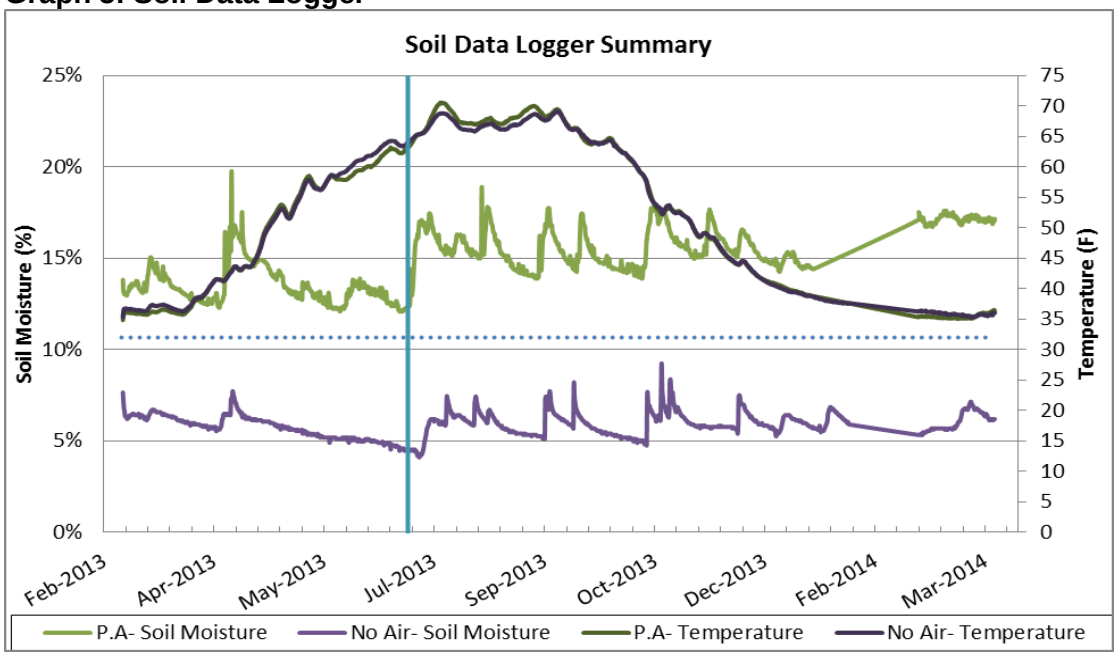
Analytical, 8'

As previously mentioned, a decrease in treatment capacity of the wastewater was observed when loading rates were purposely increased to greater than 100 lbs./ac/day over a period of nearly 45 days near the end of the study. This consistent increase in loading correlated with an increase of several key analytical parameters, primarily COD, TOC, iron, and manganese. This increase was observed in both zones; however concentrations in samples collected from the Passive Aeration Zone were slightly higher than those collected from the Non-Aerated Zone; as mentioned above, loading during this time was coupled with a significant spring thaw event, which may have added to the strain on the system.

The soil moisture sensors (installed at 4' BGS) in each zone were used to track the effects of increased loading throughout the study, specifically increased hydraulic loading. Small increases, or "spikes", were observed following an irrigation or natural precipitation event, as expected. This data indicated that the soil recovery time (i.e.: the time it took for soil moisture content to return to the level observed prior to the irrigation event) in both zones ranged from 12 to 30 days. Consistent loading without regular rest periods prevented adequate recovery time; this abnormally stressed condition resulted in a 5% increase of the soil moisture content "baseline" in both zones immediately following the loading strain study. Further evaluation was needed to establish whether the passive aeration tile may have acted to contain or accumulate partially-treated wastewater in the subsurface rather than allow it to transmit the water downward and keep the tile open for airflow.

Graph 5 shows soil data logger readings throughout the study. The vertical blue line indicates the start of irrigation activities.

Graph 5: Soil Data Logger



Summary
Soil moisture content in the Passive Aeration Zone was nearly 10% greater than moisture content observed in the Non-Aerated Zone throughout the study's duration, even prior to any irrigation activities. This natural difference between the zones could be a contributing factor to the reaction observed during and after the increased loading activities discussed above. If the Passive Aeration Zone receives and maintains a higher volume of natural surface water and/or is closer to the top of the groundwater aquifer, then the availability within the soil to receive and treat land applied wastewater is directly deceased.

Goal #4: Track the effectiveness of the passive aeration system during the winter months.
Conclusion: This goal was inconclusive. Based on the data collected during winter months, effectiveness of the passive aeration system neither increased nor decreased.
Based on the data collected during winter months, effectiveness of the passive aeration system neither increased nor decreased; however, minimal irrigation occurred between December 2013 and January 2014 due to freezing temperatures that caused the pump and gun nozzles to freeze. Additionally, lysimeter samples were limited during this time for the same reasons. Irrigation began again in mid-February and continued throughout the remainder of the study. The treatment efficiency of the Passive Aeration Zone did not decrease during periods of subfreezing temperatures, though treatment observed in each zone was similar. There was not a strong indication that Passive Aeration was more effective than No Aeration during winter months.

Goal #5: Provide real-world costs for use in system design and the comparison of food processing wastewater treatment systems.
Conclusion: The installation of passive aeration tile cost an additional $9,200 per acre above and beyond the cost of the land itself. This cost per-acre for the installation of tile for passive aeration would likely decrease as the overall acreage increased but, since there was not a demonstrable benefit over non-aerated soil, its use is not justified by this study.

Regardless of the additional cost or effectiveness of passive aeration, the value per acre of land application wastewater treatment is exceptional compared to other chemical and mechanical treatment methods (e.g.: dissolved air floatation, sequenced batch reactors, digesters, etc.) due to the lower operation and maintenance costs and ease of use.

BENEFICIARIES

Michigan's food processing and agribusiness represents the state's second largest industry (DEQ, Food Processing E2-P2 website, 6/22/09). Furthermore, according to the Michigan Department of Agriculture, food processing and agribusiness is the fastest growing industry in the State. The operating costs associated with environmental compliance for Michigan processors are significant. Annual costs associated with wastewater treatment, discharge, and discharge compliance can range from approximately $50,000 to over $1,000,000 for a single processor.

A number of processors have expressed the need to expand to meet market demand, but the current concentration and loading limits for wastewater prohibit such endeavors. Many specialty crop processors cannot expand their businesses, and thus the State's revenues, without dedicating a rapidly increasing amount of capital to meet wastewater discharge standards. Development or improvement of this technology for the treatment of wastewater may significantly reduce costs for the State's food processors, while protecting the State's water resources.

LESSONS LEARNED

Fixed Gun Installation: Fixed guns should be installed such that the base will not move during irrigation. Due to the dynamic rotational forces in effect during irrigation, the riser of each irrigation gun was allowed to slightly "wobble." This effect was magnified as the surrounding earth compacted when finally the movement overcame the tensile strength of the piping material and the base of several irrigation guns ruptured shortly after start up and immediate repair was required. Concrete was used to stabilize and secure the base of the guns after the necessary repairs were made. No other related issues occurred.

Winter Irrigation: Winter irrigation was limited during this study due to improper protection and maintenance of the equipment. At installation of a new irrigation system, a pump house must be constructed to protect the pump during periods of subfreezing temperatures. Similarly, the irrigation lines and fixed guns must be drained after each use during winter months. Failure to do so will result in broken guns and/or irrigation lines.
Plot Selection: Successful application of passive aeration techniques and in-situ soil monitoring with electronic environmental sensors is achieved in native, undisturbed soils or soils that are properly compacted.

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Ms. Erin Gerber: 616-844-5050

ADDITIONAL INFORMATION

Lakeshore Environmental | Environmental Engineering and Consulting, Grand Haven, MI

PROJECT TITLE Michigan State University/Plant Pathology: Enhancing the Sustainability of Small Fruit Crops in Michigan by Optimizing Fungicide Applications - FINAL

PROJECT SUMMARY

Small fruit crops like blueberries and grapes contribute significantly to the agricultural economy of Michigan. Growers rely primarily on chemical fungicides for control of fungal diseases to produce the high-quality fruit demanded by consumers; however, application timing could be optimized in response to weather variability. The specific objectives of this project were to: 1) Determine effects of rainfall, residue age and temperature on fungicide efficacy in blueberry 2) Determine effects of rainfall intensity and frequency on fungicide wash-off potential in grapes and blueberries; 3) Determine effects of application timing on fungicide efficacy against anthracnose in blueberries and Phomopsis in grapes; 4) Validate the SprayWeather-Wise decision support program. Trials were done with fungicide-sprayed potted plants and field-grown plants exposed to simulated rainfall and different environmental conditions. Residue analysis was conducted and correlated with fungicide efficacy data. Knowledge about the persistence and efficacy of fungicides in response to environmental variables helps to optimize fungicide timing. Improved fungicide timing will increase efficacy of applications and reduce unnecessary sprays, thereby improving economic and environmental sustainability of small fruit production.

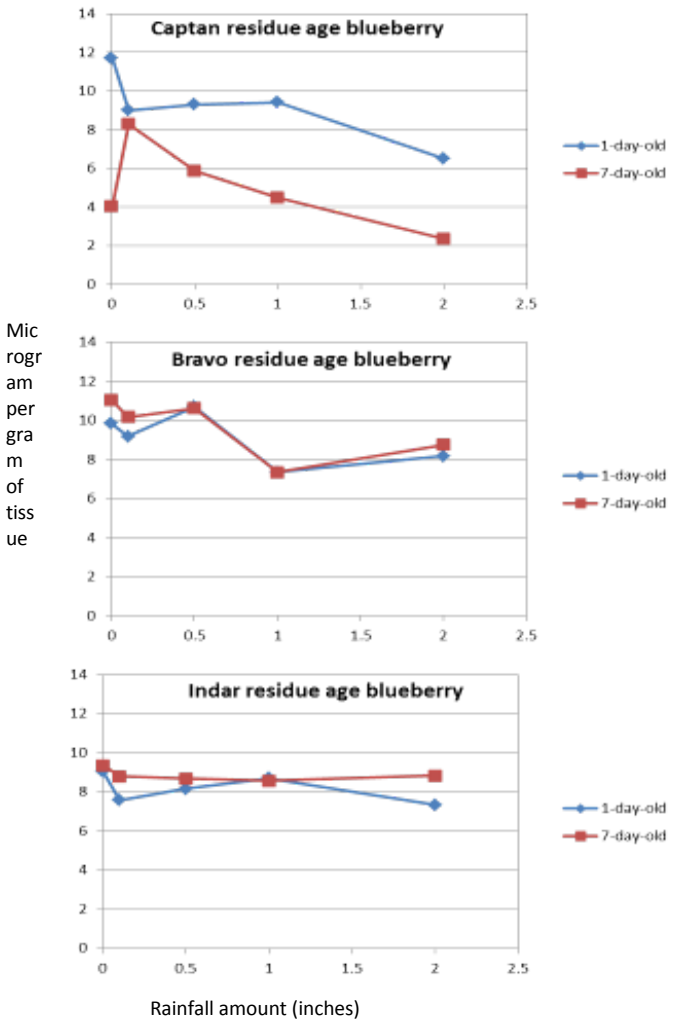
PROJECT APPROACH

1) Determine effects of rainfall, residue age and temperature on fungicide efficacy in blueberry

Three-year-old potted 'Bluecrop' blueberry plants were hand-pollinated at bloom and treated with the following five fungicide treatments at the green-fruit stage: 1) Captan (captan) 50 WP 2.5 lb/A; 2) Bravo WeatherStik (chlorothalonil) 4 pt/A, 3) Pristine (pyraclostrobin + boscalid) 20 oz/A, 4) Indar 2 F (fenbuconazole) 6 fl oz/A; and 5) Switch (cyprodinil and fludioxonil) 12 oz/A. Treated plants were allowed to air dry for 24 hours and divided into two groups: one group was exposed to rain treatments immediately and the other after seven days of weathering (solar radiation) outside. During the seven-day weathering period, the plants were placed under cover whenever there was an immediate threat of rain. Three replicate samples for each fungicide/rainfall/residue age treatment were used. Rain treatments were as follows: 0, 0.1, 0.5, 1.0, or 2.0 inches of rain performed in the rain simulation booth at the Trevor Nichols Research Center in Fennville, MI. The day following rain treatments, 10-g leaf samples were removed from each plant to be processed for fungicide residue analysis. At the end of the rain treatment, blueberry fruit were inoculated with 1 x 10^6 spores/ml of the anthracnose fungus *Colletotrichum acutatum*. Plants were bagged for 48 hr to keep them moist during the infection process and were then kept in the greenhouse to allow the green fruit to ripen. Ripe fruit was harvested every 10 days (4x) and incubated at 100% RH for 12 days at which time the fruit was examined for the presence of *C. acutatum*. All residue samples from leaves were stored in the solvent acetonitrile below 0°C and analyzed by HPLC and GC-MS in the MSU Pesticide Analysis Lab. Data showed that Captan and Bravo were somewhat more sensitive to wash-off than Indar, which was to be expected because Indar is a systemic fungicide and gets taken up into leaf tissues while Captan and Bravo are surface protectants (Fig. 1). Among these, the effect of residue age was most noticeable for Captan, in which case seven-day-old residue was reduced and removed by rainfall more than 1-day-old residue. In the latter case, we also noticed that a light rain (0.1 inch) apparently increased recovery of seven-day-old captan residues, which may be due to fungicide redistribution by water applied. Among the systemic fungicides, both components of Pristine (pyraclostrobin and boscalid) were relatively rainfast when 1-day-old residues were exposed to simulated rainfall, but less so when the residues were seven days old. In the case of Switch,

one-day-old residues were lost more rapidly to rain than expected, and seven-day-old residues were detected at only very low levels even without rain, suggesting that they may have broken down due to UV light or microbial activity on the leaf surface.

Based on disease incidence, Indar and Switch were inherently less effective against the pathogen than the other fungicides and their efficacy was further reduced after rainfall (Fig. 2A). The other fungicides were very effective in the absence of rain, but Pristine appeared more sensitive to wash-off by rain than Captan and Bravo (as measured by infection incidence). Aged (7-day-old) residues of Bravo also were more sensitive to rainfall, especially low amounts of rain such as 0.1 and 0.5 inches, than 1-day-old residues as measured by disease incidence (Fig. 1B). When comparing residue levels with relative disease control efficacy, we have to keep in mind that residue levels were measured on leaves and disease incidence was measured on fruit. There may be differences in adherence and uptake in fruit versus leaves due to variation in cuticular waxes and other surface features. Fungicide residues were positively correlated with level of disease control, however most correlations were not very strong. The correlation between captan and disease control level was the strongest and leveled off as fungicide dose increased (R^2=0.7898) (Fig. 3A). The relationship between boscalid and % control could be described by a power relationship. The R^2 value was more typical of the rest of the fungicides.



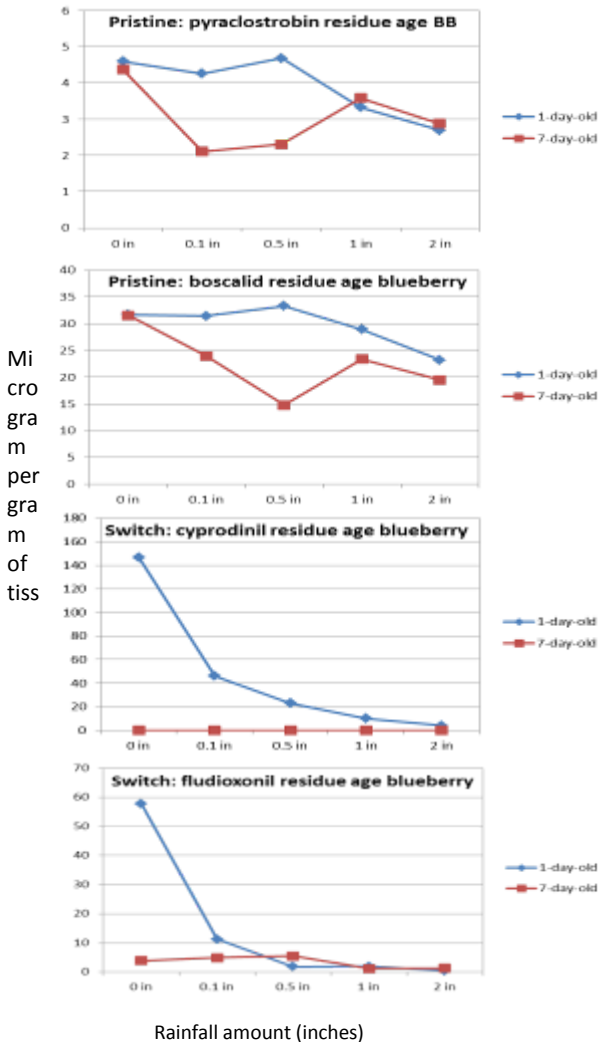


Fig. 1 . Susceptibility of 1-day-old and 7-day-old fungicide residues on blueberry leaves to wash-off by increasing amounts of rain.

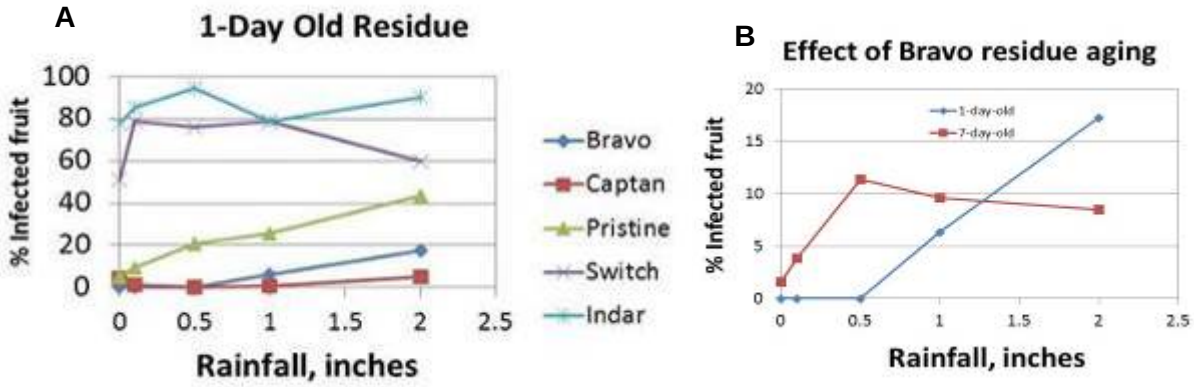


Fig. 2 A) Susceptibility of different fungicides to wash-off by rain as measured by the level of anthracnose infection in blueberry fruit. **B)** Susceptibility of 1-day-old and 7-day-old Bravo residues to wash-off by rain as measured by the level of anthracnose infection in blueberry fruit.

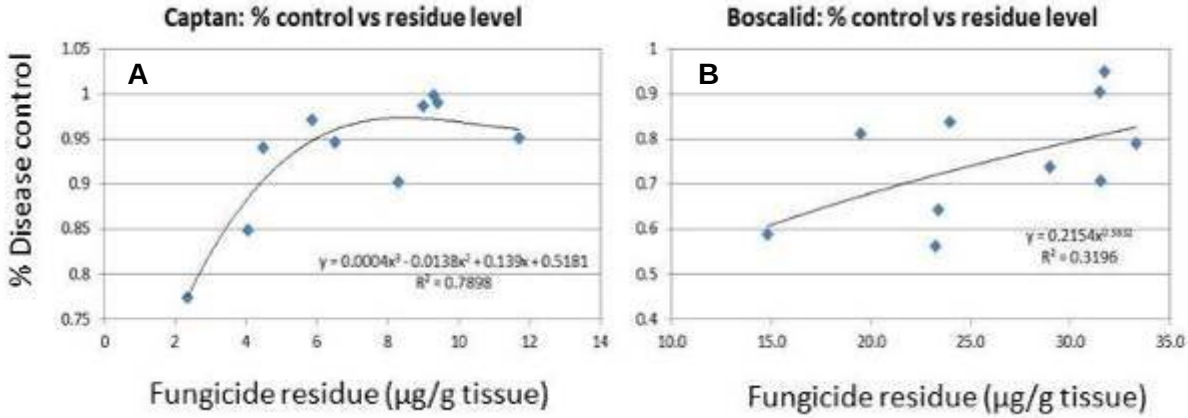


Fig. 3 A) Regression of the level of disease control versus captan residues, showing a polynomial relationship. **B)** for boscalid (one of two ingredients in Pristine), showing a power relationship. The R-squared value indicates the regression coefficient, an indicator of the strength of the relationship.

For validation of wash-off by rain under natural field conditions, field-grown blueberry plants on the Plant Pathology Farm at Michigan State University were sprayed with Ziram (ziram: a protectant fungicide), Ziram + Nu-Film P (a sticker-extender), or Abound (azoxystrobin; a systemic fungicide) on Aug 19 and on Aug 29. The maximum temperature was fairly similar on

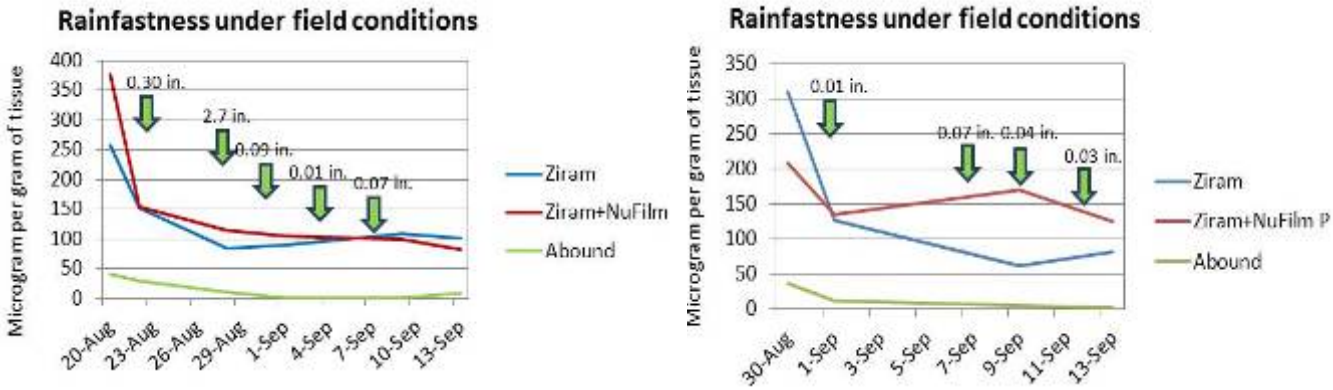


Fig. 3 above. Rainfastness of fungicides applied to blueberries under field conditions in two experiments.

the day of application (81°F on Aug 19 to 87°F on Aug 29). Leaf samples were taken within 24 hours after application and then repeatedly after rainfall events. For the first set, samples were taken on 20, 22, 28 Aug, and 1, 9, 13, and 17 Sep. In that period there were seven rain events for a total of 3.4 inches of rain. For the second set, samples were taken on 30 Aug, and 1, 9, 13, and 17 Sep. All residue samples were maintained in the solvent acetonitrile and stored below 0°C until extraction and analysis. Abound residues overall appeared lower than those of Ziram even before rain because Abound is applied and effective at much lower rates than Ziram. However, we decided to show them in the same graph. We observed that relatively low amounts of rain (0.30 and 0.01 inches, respectively) removed a substantial portion of Ziram, which subsequent rain events removing relatively less of the active ingredient. Abound was relatively more rainfast. Addition of the sticker-extender Nu-Film P (a pine-based product which is approved for organic production) led to better retention of Ziram during exposure to rainfall.

Based on this grant, we started a collaborative project with Bryan Hed, grape pathology researcher at the Pennsylvania State University, on the utility of mineral analysis (ICP-MS: inductively-coupled plasma mass spectrometry) for manganese, a component of the fungicide mancozeb, in comparison with the more laborious and costly 2-step procedure used for HPLC analysis of mancozeb residues in the MSU pesticide residue lab. The correlation between both methods was very close (Adj R^2=0.96) (Fig. 2). It was assumed that this also applied to zinc in the fungicide ziram. Therefore, we chose ICP analysis for all future experiments, subtracting out background levels of zinc in plant tissues. Another benefit of this method is that the leaves can be dried and stored or easily sent by regular mail. In addition, Fig. 3 shows that under field conditions, 0.17 inch of rain washed off about 60% of the mancozeb, and that additional rainfall (0.52 inch and 0.91 inch) only washed off an additional 10% approximately. A similar trend can be seen after the second spray, which suggests that after the easily dislodgeable portion is lost, the remaining mancozeb fungicide tightly adheres to the leaf. These results are very similar to those observed in blueberries in the experiment described above.

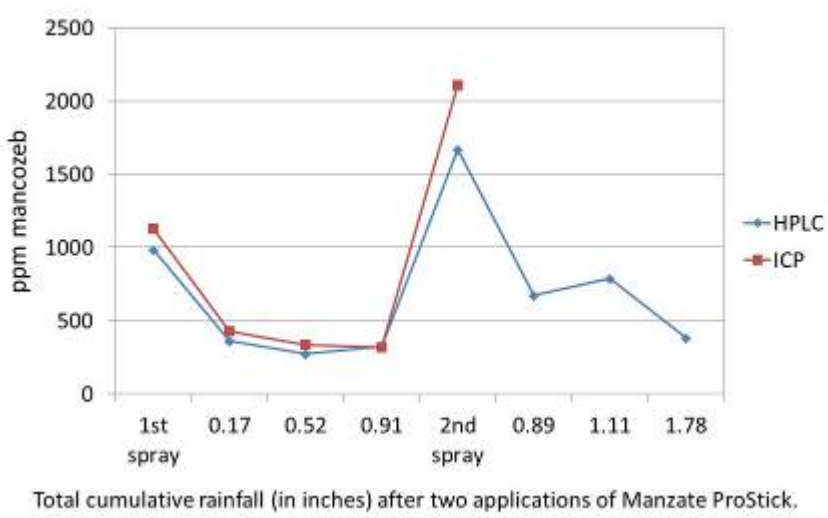


Fig. 4. Wash-off of mancozeb by rain from 'Chardonnay' grape leaves under field conditions, as measured by HPLC/GC/MSD and ICP (mineral Mn) analysis of manganese levels (data from Bryan Hed, the Pennsylvania State University and Christine Vandervoort, MSU).

To study the effect of temperature on fungicide efficacy, potted blueberry plants were treated with Captan, Indar or Pristine. Instead of drying at room temperature for 24 hours, the plants were place in growth chambers at either 40°F, 65°F or 90°F for 24 hr. At the end of that

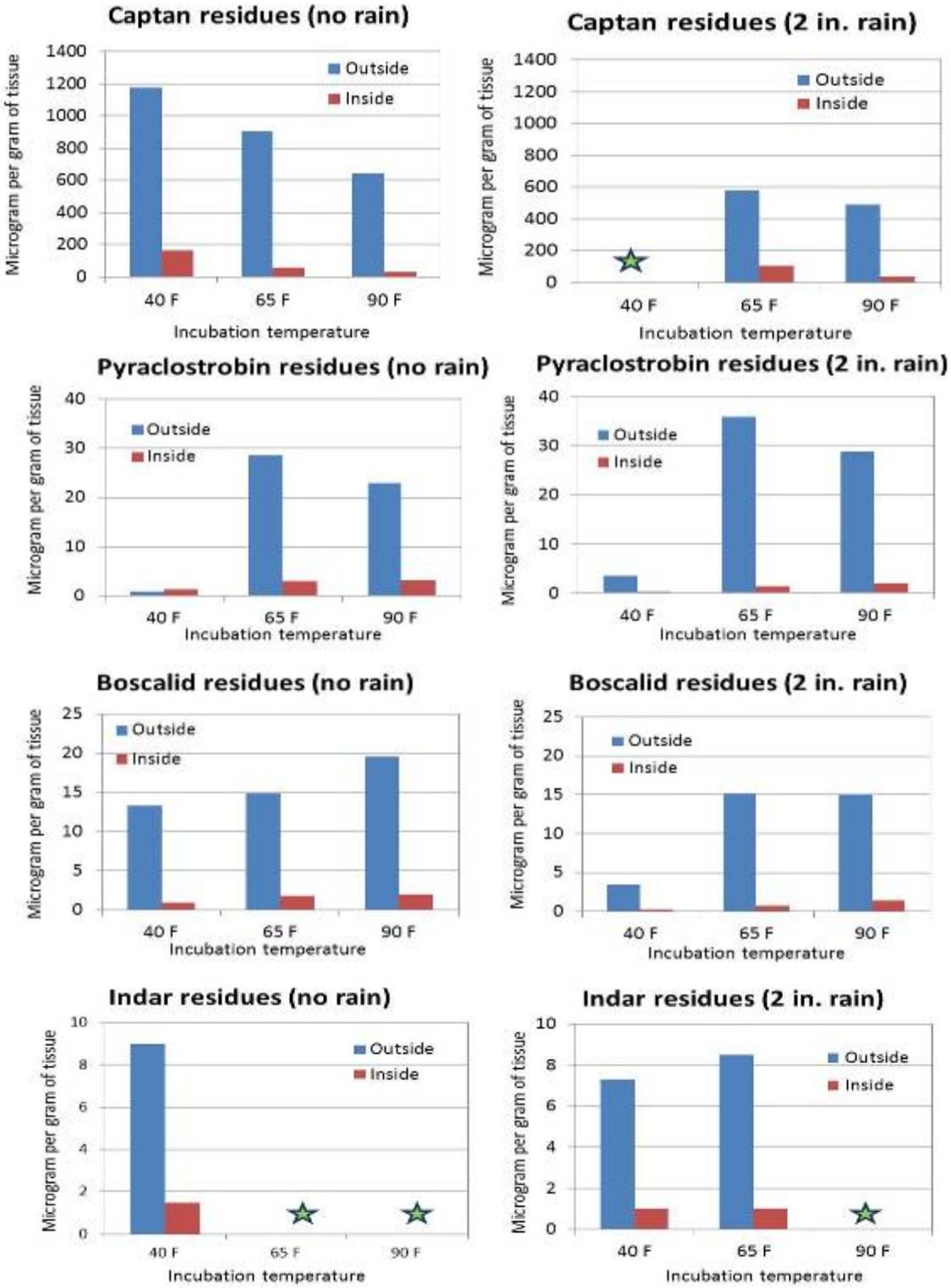


Fig. 5. Effect of incubation temperature after fungicide application on fungicide adherence/uptake on blueberry leaves and persistence after exposure to 2 inches of rain. Stars indicate samples were lost.

time, the plants were subjected to 0 or 2 inches of rain. Leaf residue samples were taken immediately. All samples were kept in the solvent acetonitrile and stored below freezing until analysis. All treatments were run in triplicate.

Unfortunately, due to personnel problems in the MSU Pesticide residue analysis lab, some samples were lost as indicated by green stars in Fig. 5. For all products, most of the fungicide active ingredient was recovered from the "outside" of the leaves, while only a small portion was "inside". Some of this may be due to the extraction procedure; the outside portion may include part of the waxy cuticle. Indar (a systemic fungicide) shows somewhat more internalization of the product than boscalid and pyraclostrobin, which have higher affinity for the waxy cuticle. Temperature affected adherence of captan as more captan was recovered after incubation at 40°F than at 65° and 90°F. Two inches of simulated rainfall reduced the amount of fungicide by 25-35% in this case. Pyraclostrobin was highly affected by temperature, as the fungicide was almost not recoverable after the 40°F incubation, which suggests that it may break down at low temperatures. Recovery was also lower at 90°F; and 65°F appeared to be the most conducive. This supports field observations in blueberries that strobilurin fungicides were not very effective against mummy berry in early spring in Michigan while they were more effective in Georgia. Rainfall did not reduce "outside" residue levels but appeared to reduce "inside" levels of both pyraclostrobin and boscalid, suggesting a dynamic equilibrium. Retentio of boscalid was best at 90°F and lowest at 40°F, at which temperature the fungicide was also washed off more readily by simulated rain. Unfortunately, some of the Indar samples were lost but Indar did not appear as sensitive to low temperatures, showing a slight reduction in the amount of product recovered after the 40°F incubation compared to the 65°F incubation. This experiment suggests that temperature during the uptake/adherence stage can indeed affect fungicide levels in/on the plant. This needs to be taken into account, especially for the strobilurins.

2) Determine effects of rainfall intensity and frequency on fungicide wash-off potential in grapes and blueberries

Ziram 76DF (3 lb/acre) was applied to additional 'Bluecrop' plants that had been hand pollinated to ensure fruit production. The same was done for potted "Vignoles" grapevines. Different rain intensities and frequencies were compared. The same total amount of rain was applied, namely 1 inch, but apportioned differently. The treatments were evenly applied by hand using a watering hose with different nozzles: 1): 1 inch of rain in short, intense rainfall, 2) 1 inch of rain in extended, mild rainfall; 3) 1 inch of rain in 2 discrete events of 0.5 inch each; 4) 1 inch of rain in 5 discrete events of 0.2 inch each; and 5) 1 inch of rain in 10 events of 0.1 inch each. A Fogg-It Low Volume nozzle was used to simulate light (mist-like) rainfall treatments for the low-intensity events. Rain gauges were used to estimate when a total of 1 inch of rain was reached. Residue sampling, inoculation with *Colletotrichum acutatum*, and evaluation of ripe fruit were conducted as described in Objective 1. Grapevine leaves were spray inoculated with the fungus *Phomopsis viticola* at 10^6 conidia/ml and kept moist by bagging them for 72 hours.

All simulated rain events reduced fungicide residues and efficacy, with a trend towards lower residues and higher disease levels (indicative of more fungicide wash-off) after more intense rain events versus light rain events (Fig. 6). Similar trends were seen in blueberries and grapes, but more residues were retained in grapes, which may be related to grape leaf surface properties and architecture (Fig. 6 A). Ziram controlled Phomopsis well and there was a logarithmic relationship between the amount of ziram retained and disease severity (Fig. 7A). Unfortunately, ziram did not control blueberry anthracnose very well, even when no rain was applied (Fig. 6B). The relationship between ziram levels and anthracnose was linear with a fairly shallow slope (Fig. 7B). These experiments suggest that growers should take rainfall intensity into account when considering when to reapply a fungicide after rain.

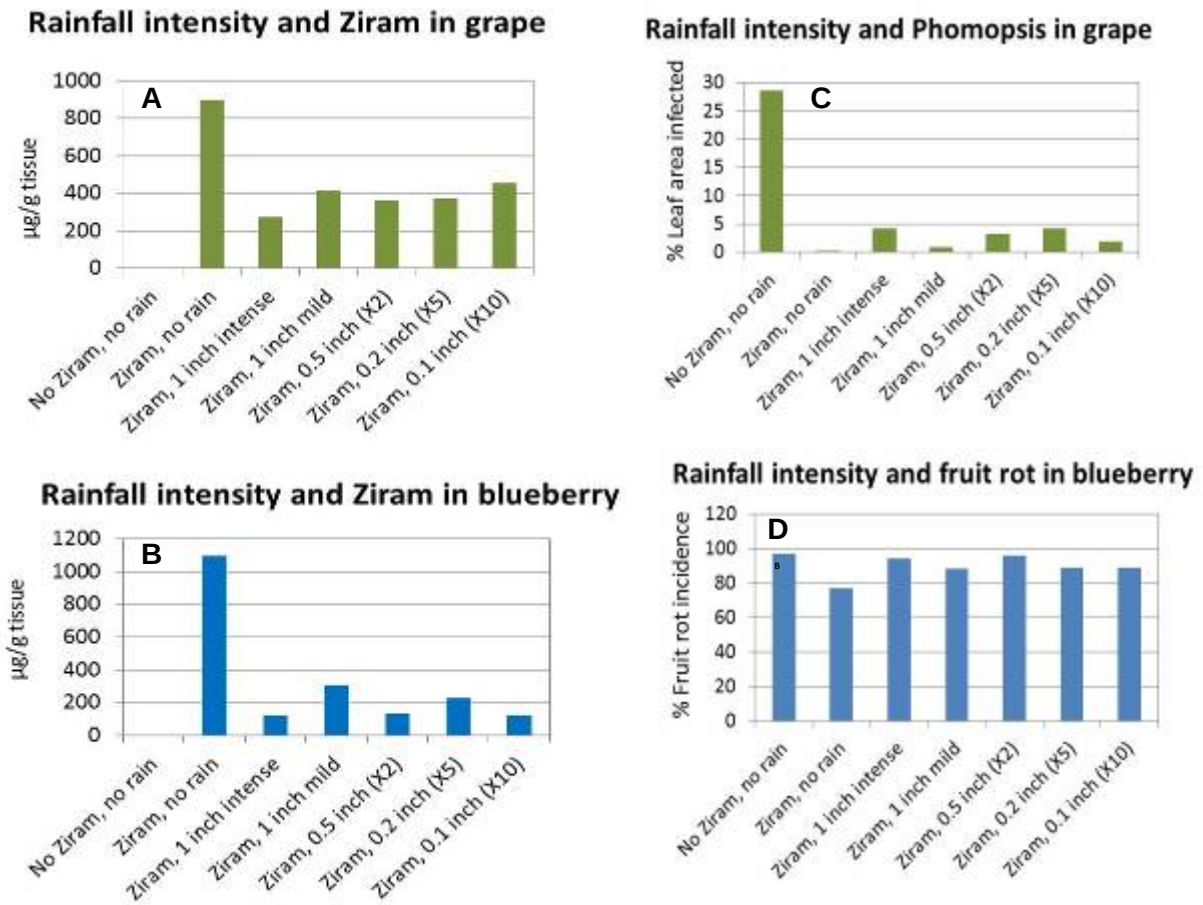


Fig. 6. Effect of rainfall intensity on ziram residues in A) grape and B) blueberry; and on corresponding disease levels in C) grape and D) blueberry.

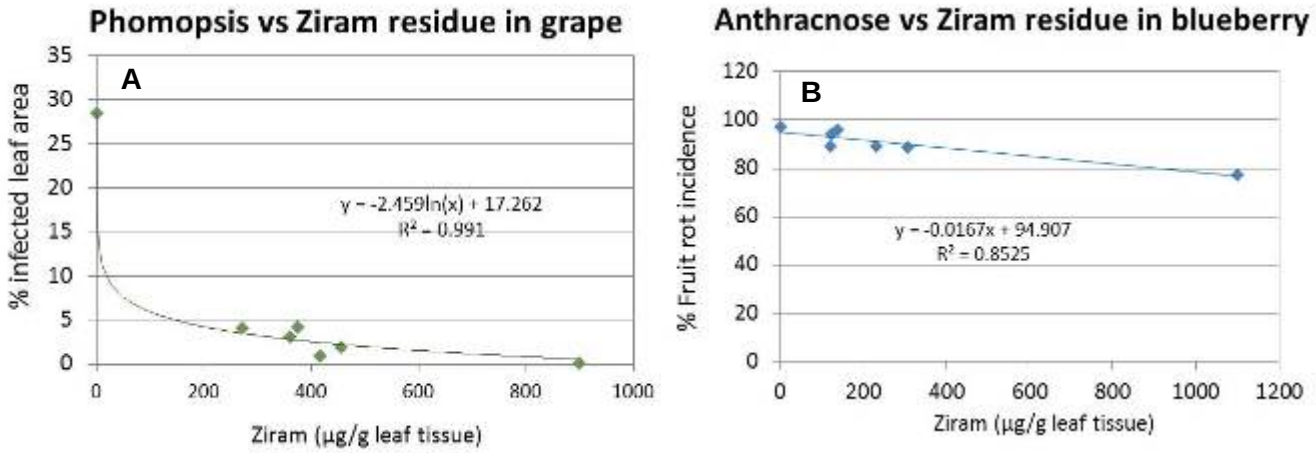


Fig. 7. **A**) Correlation between Phomopsis severity and ziram residues in grape, and **B**) Correlation between anthracnose fruit rot incidence and ziram residues in blueberry.

3) Determine effects of application timing on fungicide efficacy against anthracnose in blueberries and Phomopsis in grapes

For blueberries, green and blue fruit was obtained from a commercial farm in Traverse City and tested for background infection by *Colletotrichum acutatum*. No background infection was detected. To determine the effects of application timing of fungicides in blueberries, the following fungicides were applied: 1) Water (control treatment), 2) Abound 2.08SC at 10 fl oz/A, 3) Captec 4L at 2 qt/A, 4) Phostrol at 3 pt/A, 5) Pristine 38WG at 23 oz/A, and 6) Switch 62.5WG at 14 oz/A. Fungicides were applied at 1, 3, 5, 7 and 10 days before inoculation with *C. acutatum* to test protective (forward) activity. Fungicides were also applied 1, 3, and 5 days after inoculation with *C. acutatum* to test backward (curative) activity. To test forward activity, green and ripe blueberries were divided into four replicates and gently agitated for 30 seconds in a fresh solution of one of the fungicides listed above and allowed to air-dry for 2 hours. Berries were kept on metal racks suspended over water for 10, 7, 5, 3, or 1 day(s) to keep the berries turgid. At the appropriate time, berries were inoculated with a fresh *C. acutatum* spore suspension (1×10^6 spores/ml). Berries were kept moist for 24 hours, followed by drying for 24 hours. In the case of blue fruit, moisture was reintroduced and the berries incubated for 10 days to allow infection to develop. In the case of green fruit, berries were surface sterilized with bleach, cut in half, and placed on potato dextrose agar to look for disease development. To test backward (curative) activity, green and ripe berries were inoculated as described above with 24 hours of moisture to allow infection followed by 24 hours of dry time to stop infection. At that time, berries were placed in moisture again and treated with fungicides 1, 3, 5, or 7 days after the infection period. The efficacy of fungicides was determined for blue and green fruit as described above.

Results in blueberries showed that the following fungicides had excellent protective activity (Captan and Abound) on green fruit (Fig. 8). Switch and Pristine were also very good. The best protective activity of the latter two products was when applied 1-2 days ahead of infection. Phostrol did not have much protective activity but became somewhat more effective when applied 1-3 days before infection. On ripe (blue) fruit, in which infection proceeds much more rapidly, Captan had the most protective activity, followed by Switch (Fig. 9). Switch was more effective when applied within 1-3 days before infection than at other times. Interesting, Pristine and Abound were not very effective as protectants on ripe fruit. The reason for this is not known, but there may be some level of fungicide resistance present in the fungus, which is what we have observed in some isolates. Most fungicides had some level of curative activity on green fruit (Pristine the most) (Fig. 10) but the level of efficacy declined when sprayed more than one day after inoculation. On blue fruit, none of the products had much curative activity. Interestingly, Captan appeared to have some post-infection activity, which indicates that it may be lethal to appressoria which are superficial on the surface of the fruit.

In grapes, we evaluated the pre- and post-infection activity of ProPhyt (3 pt/acre equivalent), Abound (12 fl oz/acre equivalent) against *Phomopsis viticola* using Manzate (3 lb/acre) as a protectant for comparison. These fungicides were sprayed on detached shoots of the cultivar Vignoles placed in test tubes with water. Applications were made 10, 7, 5, 3, 1 days before inoculation and 1, 3, 5, and 7 and 10 days post-inoculation to determine residual and curative activity against the disease. Plants were inoculated with *Phomopsis viticola* inoculum (1×10^6 spores/ml) and bagged to keep them moist for 72 hours. There were three replicates. Disease severity was evaluated as the number of leaf spots per leaf after two weeks and the number of necrotic internodes per shoot.

Results in grapes were a little more difficult to interpret due to the relatively low number of leaf spots and the fact that the tops of shoots also started dying back as a result of the infection or due to phytotoxicity in the case of Phostrol. All fungicides had good protective activity, with

Abound being the most efficacious. Manzate efficacy improved closer to the inoculation time as well, whereas Phostrol appeared most effective at seven and ten days before inoculation.

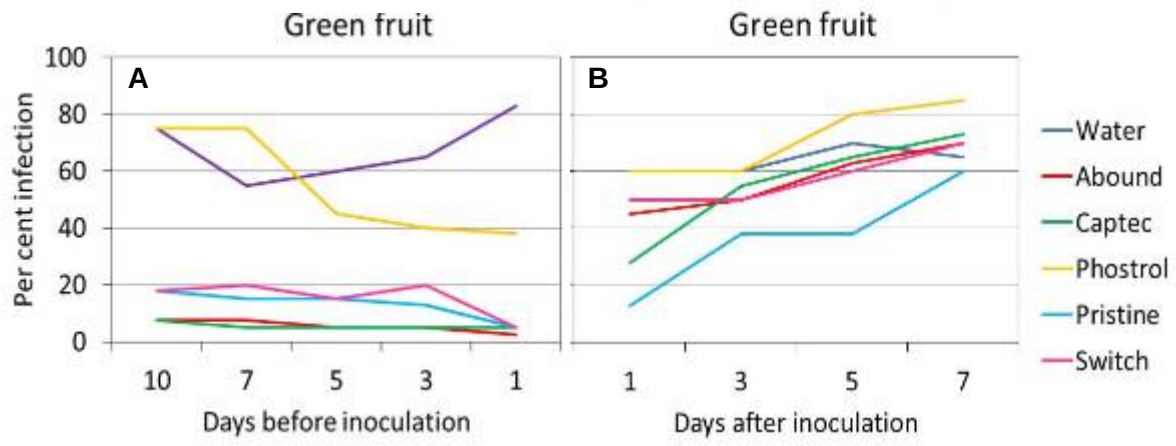


Fig. 8. Effect of application timing of various fungicides on their level of A) forward (protective) and B) backward (curative) activity against anthracnose fruit rot in green (unripe) blueberries.

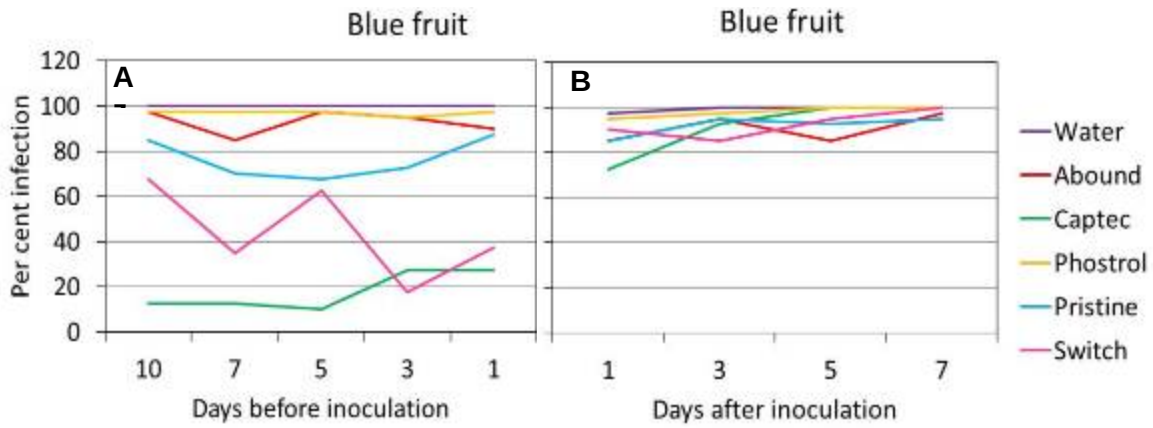


Fig. 9. Effect of application timing of various fungicides on their level of A) forward (protective) and B) backward (curative) activity against anthracnose fruit rot in ripe blueberries.

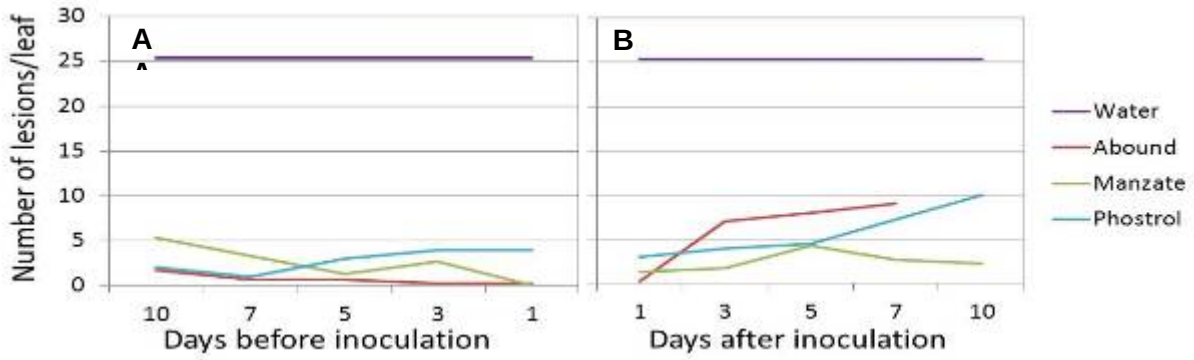


Fig. 10. Effect of application timing of various fungicides on their level of A) forward (protective) and B) backward (curative) activity against Phomopsis leaf spot in grapes.

When considering applications after inoculation, Abound became less effective when applied more than one day after the inoculation. This makes sense as Abound is known to have limited curative activity, although it is considered more systemic than other strobilurins, such as Sovran. Phostrol also became a bit less effective with time after inoculation. The Manzate results are a little puzzling, as Manzate being a protectant fungicide is not supposed to have any curative activity. The data merit additional experiments to confirm the results using potted and/or field-grown plants.

4) Validate the SprayWeatherWise decision support program in Enviro-weather.

The "Spray Weatherwise" program by Erno Bouma and Joost Nieveen of Agro-Meteorological Consulting in The Netherlands was made available on a trial basis in 2013. An experiment was conducted in which Rally (myclobutanil) was applied to "Niagara" grapevines on the MSU Plant Pathology Farm according to "good" and "poor" weather conditions for fungicide uptake as predicted by the "Spray Weatherwise" program. Residues on the outside and inside of the leaves were separated to determine uptake efficiency under different weather conditions. Unfortunately, the residue samples were lost in the MSU Pesticide residue analysis lab and were not retrievable. We have repeated this experiment in September 2014 and are awaiting the sample results.

GOALS AND OUTCOMES ACHIEVED

Significant contributions of the project are new information on the effects of rain parameters, temperature and application timing on performance of fungicides on grapes and blueberries, which will assist growers in decision making with respect to spray timing and fungicide choice. We learned that fungicide behavior on and in plants is more nuanced than we typically assume. One major conclusion is that fungicides are more effective on green blueberry fruit than on blue fruit, most likely because infections on green fruit are more superficial and do not progress as quickly as in blue fruit due to the latency phase. Another important finding is that aged, sun-exposed (7-day-old) residues may not be as robust when it comes to rainfastness as younger (1-day) residues for some fungicides. Also, the addition of Nu-Film P sticker-extender can enhance rainfastness of protectant fungicides. Temperature right after fungicide application is an important determinant of fungicide uptake and/or retention, with strobilurins most affected, particularly at 40°F. Furthermore, rainfall intensity and frequency do affect fungicide efficacy, and growers may need to reapply fungicides sooner after heavy rains than light rains. We also demonstrated that nutrient analysis for manganese (or zinc) can be used instead of conventional fungicide residue analysis; this is more cost-effective and convenient. The information obtained in this project was shared with growers at extension meetings and was directly applicable to anthracnose fruit rot control during the 2014 season. A long-term goal is to use the results from these rainfastness studies to develop fungicide 'decay' models and applications for the MSU automated weather network (EnviroWeather) which will predict if a repeat spray is needed after a rain event. Some of the findings from this project will also be incorporated in a new book entitled: "Weather and Crop Protection" to be published in 2015.

Since most of our data were not complete until recently due to the delayed analysis of our pesticide residue samples at the MSU, we have not been able to share the full set of results of this project with Michigan small fruit growers. However, we will do so at upcoming winter and spring meetings and will conduct a questionnaire or clicker-based survey to determine gains in knowledge and potential changes in grower behavior. As for the data we were able to share at grower meetings, we have received positive responses from extension personnel and growers. Based on a presentation at the IPM Academy on impacts of weather on fungicides in Feb 2014, I was invited to make a presentation at the annual Christmas Tree Association meeting in Grand Rapids and to write a related article for the Christmas Tree Journal. Our work has also garnered the attention of other researchers working on small fruits and we have established research collaboration with a grape researcher at The Pennsylvania State University.

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In a blueberry trial where we evaluated spray timing in response to the blueberry anthracnose disease forecast model, we observed improved disease control when weather predictions were considered in the fungicide spray timing. We have requested verbal feedback from blueberry growers on how to best present the outputs of these models. However, the Spray-Weatherwise model that we evaluated was not accepted by MSU for incorporation into the Enviro-weather system due to the fact that it is a commercial product. Therefore we have not pursued further evaluation of this model.

BENEFICIARIES

The main beneficiaries of this research project are Michigan blueberry and grape growers, although the results are potentially applicable to other crops as well. Researchers and extension agents also benefit by increased understanding of the connection between fungicide persistence and environmental variables. Improved management of small fruit diseases using accurate and more precise knowledge of fungicide behavior in relation to environmental factors will limit unnecessary or poorly timed fungicide applications and will improve disease control. This will reduce production costs and environmental and worker exposure to fungicides, thereby enhancing environmental and economic viability of the small fruit industry in Michigan. While it may be more difficult to demonstrate environmental impacts of this project, improved fungicide uptake should reduce fungicide wash-off and leaching into ground and/or surface water.

LESSONS LEARNED

We have learned that fungicides containing metals (e.g., ziram, mancozeb) can be quantified using nutrient tissue analysis, which is more cost-effective than the 2-step procedure normally used to quantify these fungicides. We also learned that detached shoots of cv. Vignoles can be used for inoculation experiments, but those of cv. Niagara tend to wilt too quickly. Detached shoots do appear more sensitive to burning by phosphite fungicides. Another lesson was that ziram does not have much innate efficacy against anthracnose fruit rot in blueberries; therefore when repeating the rain intensity trial it would be important to use another product. Studies on fungicide-environmental interactions take a lot of coordination and flexibility, especially when relying on weather conditions to apply sprays. Rainfall in particular can be unpredictable. Having movable tunnels or plastic roofs would be desirable to protect (control) plants from rain during fungicide weathering periods. Rooted cuttings may also be more manageable than large potted plants.

CONTACT INFORMATION

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ADDITIONAL INFORMATION

Publications:

Wise, J. C., Gut, L. J., Isaacs, R., Schilder, A. M. C., Sundin, G. W., Zandstra, B., Hanson, E., and Shane, B. 2013. Michigan Fruit Management Guide 2014. Extension Bulletin E-154. Michigan State University, East Lansing, MI.

Wise, J. C., Gut, L. J., Isaacs, R., Schilder, A. M. C., Sundin, G. W., Zandstra, B., Hanson, E., and Shane, B. 2014. Michigan Fruit Management Guide 2015. Extension Bulletin E-154. Michigan State University, East Lansing, MI.

Bouma, E., Andresen, J., Schilder, A., Wise, J. 2014. Weather and Crop Protection, US Edition. Roodbont Publishers, Zutphen, The Netherlands (in press)

Schilder, A. 2014. Fungicides and weather conditions. Great Lakes Christmas Tree Journal, March edition.

We will prepare two scientific publications from this work for the journal Plant Disease and/or Plant Pathology.

Research and Extension Presentations

The results were presented at the Michigan Christmas Tree Association Meeting (Feb 2014), Blueberry Pre-harvest meeting Van Buren County (June 18, 2014), Blueberry Pre-harvest meeting Ottawa County (July 2, 2014), Viticulture Day (July 31, 2014), NW Grape Meeting (July 11, 2014). Results will also be presented at the Great Lakes Expo (December, 2014), Journées Horticoles (Quebec, December 2014) and Southwest Horticulture Days (Feb., 2014) and extension meetings during the 2015 growing season. We will also present this research at the American Phytopathological Society meeting in Pasadena, CA in Aug. 2015.

Matching funds

Matching funds of $72,000 were obtained from MSU Project GREEEN. Furthermore, we were able to also get matching funds ($4,200) from the Pennsylvania Department of Agriculture as part of our collaboration with Bryan Hed at the Pennsylvania State University on this project.

PROJECT TITLE Michigan State University/Horticulture: Improving Fruit Quality in Concord Grapevines for Sustainable and Economical Production of Juice Grapes in Michigan - FINAL

PROJECT SUMMARY

In Michigan, 82% of the total grape acreage is dedicated to juice grapes. Concord is the most widely cultivated juice grape variety in Michigan, where it accounts for 60% of the total area and 80% of production, respectively. For the National Grape Coop and the Welch's, the production of higher quality grapes is a pivotal priority to compete on the global market. Recent discoveries of significant quantities of antioxidant in red grapes is helping the growing image of juice grapes as healthful food in the US market. Information on antioxidant content of grapes grown in Michigan were not available 3-years ago, at the beginning of this project. There weren't any studies also on viticultural and environmental impacts on fruit quality of Concord grapes. Therefore, the focus of this proposal was to investigate the effects of temperature, light and yield on fruit antioxidant

capacity and accumulation of polyphenols. The specific objectives were to evaluate the effect of canopy management techniques on basic fruit chemistry composition, total phenolics, total anthocyanins and antioxidant capacity in berries.

The juice grape industry is currently experiencing an oversupply of Concord grapes and consequently the price of juice grapes has been declining steadily from the mid 1970's (in the last decade the price dropped from $280 a ton in 2001, to $170 a ton last year). Cost of production is estimated at $220 a ton, and currently grape prices are below the break-even point for several Michigan growers. These numbers suggest that the future of the juice grape industry in Michigan will be probably linked to (1) consolidation of farms in more efficient enterprises, (2) elimination of acreage of marginal productivity and above all (3) production of higher quality fruit to increase market opportunities and profit for Welch's and National Grape Coop growers (3) was the focus of our research.

Price of grapes for juice production is based on yield and concentration of soluble solids (Brix), namely sugars. A premium is paid for grapes with more than 16% Brix, whereas the price of grapes with less than 14% Brix does not justify the harvesting cost. Because of the limitation of price changes with soluble solids concentration, grower revenues are maximized when high yields above the minimum acceptable juice soluble solids are obtained. Titratable acidity and pH, like color and flavor are important for quality grape production and they will be directly related to grape premium price in the near future.

Commercial juice products from Concord grapes have been used in several medical research studies. The studies indicate that the juice has potential benefits against cancer, atherosclerosis and may help preventing loss of physical and mental performance during aging and hypertension. The presumption is that certain antioxidants, e.g., phenolics, anthocyanins, and compounds like resveratrol, are responsible for these effects. Unfortunately, information on antioxidant capacity in berries grown under Michigan conditions were not available before this project that focused on (1) viticultural and (2) environmental effects on fruit quality at harvest.

The juice grape industry in Michigan in its effort to produce quality products is often limited by a growing season that is often too short, leading to incomplete ripening of the fruit, especially when vine canopy management is not performed. The specific objectives of this study are to analyze the effect of canopy management techniques (e.g. shoot positioning) on (1) basic fruit composition, (2) total phenolics, total anthocyanins, antioxidant capacity, and (3) total resveratrol content (trans- and cis-isomers and their glycosides) in berries for three growing years in Michigan. The focus of this proposal is to investigate the effect of (a) temperature, (b) light and (c) cluster thinning (crop control) on total fruit antioxidant in Concord vines around the veraison phenological stage, the first signal of the on-set of berry maturation.

This project was not build on previously funded SCBGP or SCBGP projects, but was able to leverage 2-years of matching funds from Project GREEEN at Michigan State University.

PROJECT APPROACH

This project helped juice grape growers to better understand practical vineyard strategies that impact fruit quality. Detailed information to optimize crop and vine management was provided to growers. The objectives of the research was to investigate the effect of (a) temperature, (b) light and (c) cluster thinning on quality and antioxidant capacity in Concord berries grown in Michigan.

Results showed that shaded fruit at harvest had lower sugar accumulation than the sun exposed clusters (8-10%). This difference was also reflected in higher pH and lower acidity, index of poor fruit quality. Selected shoot positioning was performed four times during the seasons to establish

levels of cluster exposure. Interestingly, the time of cluster exposure did not impact the fruit quality as did the sun exposure level. This seems to suggest the relative sensitivity of *Vitis Labrusca* to canopy microclimate changes and its importance for reaching high quality fruit standards. However, light exposure influenced the total antioxidant capacity showing a higher concentration at the highest levels of cluster exposure (+15.20%). Results from this project were presented at the Viticulture Field Day at the Great Lakes Expo, South West Horticultural Days and at the North West Michigan Orchard and Vineyard show.

This project had a team of scientist and extensions leaders optimized to adapt and deliver practical applications of new scientific discoveries directly to growers. Our close interaction with Michigan juice grape growers was pivotal to deliver viticultural data-driven research generating a potential competitive advantage with early adoption of MSU research on improving fruit quality.

Paolo Sabbatini, Associate Professor of Horticulture, Department of Horticulture, MSU

- Supervisor of vineyard and laboratory research. Responsible for experimental design, data collection and data elaboration and for delivery of the information to the growers.

Paul Jenkins, MSU Grape and Wine Integrator, MSU.

- Responsible for organizing extension meetings for Paolo Sabbatini.

Wayne Loescher, Professor of Horticulture, Department of Horticulture, MSU.

- Advising on chemical laboratory analyses and data interpretation.

Randy Beaudry, Professor of Horticulture, Department of Horticulture, MSU.

- Advising on chemical laboratory analyses and data interpretation.

Terry Holloway, National Grape Cooperative, Welch's.

- Responsible for delivering information generated by this project to the Grape National Coop growers and to the Welch's.

Bob Dongvillo, Dongvillo's Vineyards.

- Grower collaborator on this project, responsible for experimental plot maintenance.

GOALS AND OUTCOMES ACHIEVED

Performance goals and outcomes of this project were:

1. Develop viticultural practices that will increase the quality of the fruit and overall the sustainability of growing juice grapes in Michigan.
2. Involve our grape growers in adopting new viticultural techniques in their enterprises.
3. In five years, improved fruit quality will results from better growing practices and in the long-term Michigan juice grape growers will transition from a "break-even' status to 'sustained profitability' of their enterprises.

We provided innovative vineyard management strategies that can hasten fruit development and maturation for improved and more consistent high quality juice grape production in Michigan. This project involved our 320 Concord and Niagara juice grape growers in Michigan through timely oral and written communication of Dr Sabbatini with Terry Holloway, viticulturist for the National Grape Coop. Information were shared with growers and extension personnel at our annual extension meetings, such as the Great Lakes Expo, Viticulture Day, Southwest Horticultural Days, and other in-season meetings. Information was also distributed via extension and crop-related websites. Research presentations were also made at scientific conferences, informal scientific meetings, and published on trade journals.

1. Sabbatini P, Tozzini L and Murad P., 2011. Relationship between yield and fruit quality in Concord vines. Michigan Horticultural days. Lake Michigan college, Mendel Center, Benton Harbor, MI, February 4-5.
2. Sabbatini P. 2011. Increasing fruit quality and antioxidant capacity of Concord fruit. Great Lakes Fruit, Vegetable and Farm Market EXPO, Grand Rapids, MI, December 6-8.
3. Sabbatini P. 2013. Impact of Light and Temperature on Fruit Quality of Concord Grapevines. SW Michigan Horticultural Days (Benton Harbor, MI), February 7th.
4. Sabbatini P., Tozzini L., Zhuang S. and Murad P. 2014. Effects of canopy management on fruit quality of Concord grapevines. Southwest Michigan Horticultural days, Benton Harbor (MI), February 5.6, 2014
5. Sabbatini P., 2011. MSU studies the health benefits of concord grapes. Fruit Growers News, Vol 50, n.11: pp 33-34.
6. Sabbatini P., 2014. Control of grape maturation pegged in Concords. Fruit Growers News, February 2014, Vol 53 n 2; pp 30-31.

A summary of data generated by the project was given to Terry Holloway (National Grape Coop) in February 2014 to be distributed to the 320 Welch's growers in MI. The document is a cumulative data-set describing the viticultural practices developed by this project. The National Grape Coop will be measure the impact of the new strategies during harvest 2014, and this will give them the opportunity to overall evaluate vineyard management strategies on the entire industry.

The first step of this project was the development of a specific recommendation practices through the data-driven results of this research. The long term goal is to survey of how many growers are adopting new viticultural strategies and finally it will be followed by gathering quality parameters data at harvest using the National Grape Cooperative database. This second part of the project will be started in June 2014 with Terry Holloway of the National Grape Cooperative, financially supported by the Welch's.

The goal of this research is to provide vineyard management strategies that can hasten fruit development and maturation for improved and more consistent high quality juice grape production in a highly variable climate, characteristic of MI. We strongly believe that our research results and timely dissemination of the information have provided answers and significant benefits to our 320 Concord and Niagara juice grape growers in Michigan. Research results are new and innovative and data coupled with applied demonstrations in vineyards of collaborators tied with specific extension meetings were well received by our industry.

This work timely informed grape growers about practices in order to produce quality fruit, both consistently and economically. Now, starting with Spring 2014, growers, processors and extension educators will be able to make informed choices guided by data-driven results to improve the quality of fruit produced in Michigan juice grape vineyards. At the end of the 3-year project a survey was created to solicit feedback and to identify how the project was conducted. The results were compiled and discussed in detail with a specific post-project meeting with the Welch's.

BENEFICIARIES

The juice grape industry in MI. 320 Concord and Niagara juice grape growers. Our presentations at several meetings and extension demonstrations (the Great Lakes Expo, Viticulture Day, Southwest Horticultural Days, and other in-season meetings) were well attended as described in the annual progress of this project.

Our MSU Grape Team field days or extension meetings were attended by an average of 35-45 juice grape growers. Those growers are only 10-20% of the total number of juice grape growers in Michigan, but they are representing more than 60% of the total acreage of juice grape vineyards. Our survey showed that (1) our activities to target juice grape growers leaders with on site demonstration workshops during the growing season were very successful, (2) basic information on canopy management were needed, (3) data-driven research results on strategic approach towards vineyard management will be implemented by our industry as revealed by several discussion with Terry Holloway of the Welch's National Grape Cooperative.

LESSONS LEARNED

Applied research with fruit crops, requires 5-10 years to be developed and 15-20 years to be applied by the industry. For grapes the time scale of research activity, commercialization of new ideas and adoption is at least a decade, with complete adoption often taking from 20 to 30 years (Boulton, R., 2012). In the interest of thoroughness, this project must assess the impact of alternative canopy management techniques for at least 4-5 years over different growing seasons. This will provide valuable information on the appropriateness of the technique given the particular seasonal characteristics. This should be explored for several years to determine that there are no long-term adverse effects on overall vine health before it is rolled out as a recommended practice for juice grape growers in Michigan. However, we strongly believe that this project had a high level of success because according to Franz et al. (2010), modern agricultural producers want to be engaged with the university research teams to learn new ideas and promote innovation between industry members; this is the way we designed the project. Moreover, our project was in alignment with the new generation of the land grant university, encouraging innovation through direct engagement of industry members (Blewett 2008).

Most of juice growers, planning to improve fruit quality were concerned to the increase cost of production. Juice grapes have a lower cost of production that wine grapes in Michigan. Therefore juice grape growers planning to switch to wine grapes, had the opportunity to face the reality of the tied connection between increasing fruit quality in the vineyard but and the same time increasing the cost of production.

The terrible frost experienced last year (2012) pose a challenging environmental condition with the potential to affect the proposed plan of work. However, all the members of our team have a very good relationship with our fruit industry, it was simple to identify vineyards not compromised by the frost, and all the experiments were conducted as delineated in the proposal.

CONTACT INFORMATION

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ADDITIONAL INFORMATION

PROJECT TITLE: National Grape Cooperative Association, Inc.: A Proactive Approach for Helping Michigan Grape Growers Improve Economic Viability and Environmental – FINAL

PROJECT SUMMARY

Objective 1. Provide Michigan grape growers with resources to help increase the sustainability score of their farms, and meet the verification requirements of the Michigan Agriculture Environmental Assurance Program.
Objective 2. Develop a web-based sustainability program to streamline efficiency of data collection, reporting, and action plans for growers.

National Grape identified soil and petiole samples as well as spill kits as the biggest obstacle to improving our member's sustainability scores. All members filled out initial sustainability workbooks to establish a baseline score.

National Grape felt without the assistance, few growers would improve their sustainability efforts., so it was important to provide spill kits, soil kits, and petiole nutrient sampling kits. Growers were then encouraged to adopt one of these practices. We will be requiring all members to fill out the sustainability worksheet again in 2015 to quantify improved scores.

PROJECT APPROACH

Soil and leaf petiole nutrient sampling. To accomplish this objective, growers were notified that up to four soil samples and up to four leaf petiole samples would be paid for by funds from the SCBGP and National Grape Cooperative. Growers were instructed on how to collect field samples, where to send them (MSU Soil and Plant Nutrient Laboratory, East Lansing), and how to fill out information sheets.

A web-based sustainability program has been developed for our National Grape Cooperative website and will soon be available to all members of the National Grape Cooperative. A database was created for grower scores and for the purpose of generating reports by stakeholders. The web-based program will be hosted on a website for National Grape and information of individual growers will be kept confidential. As part of the web-based system, action plans for growers to improve the sustainability on their farm(s) are being integrated. Growers will be presented with options at the end of program completion and ranked for priority.

Dr. Roger Brook of Running Water Publishing (Hillsdale, MI) is the developer of the web-based program, under the guidance of National Grape IT personnel, John Jasper and Terry Holloway.

Significant contributions in this project were made by Dr. Roger Brook of Running Water Publishing (Hillsdale, MI) as the developer of the web-based program, under the guidance of National Grape IT personnel, John Jasper and Terry Holloway.

GOALS AND OUTCOMES ACHIEVED

As a result of this project, we have made great progress toward improving the sustainability of juice grape production in Michigan. As a result of soil testing and leaf petiole testing, growers are more knowledgeable about fertilizer needs of their vineyards, saving money (becoming more economically sustainable) and reducing chemical inputs on their farms (becoming more environmentally sustainable). Based on our success in Michigan we are coordinating this effort with our other growing regions. We are also in the process of creating a national sustainability program, which is based on the success of the Michigan program. We are creating action plans for our members to improve the sustainability of their farms. No changes are anticipated in the project.

As a result of this project, we have made great progress toward improving the sustainability of juice grape production in Michigan. As a result of soil testing, growers are more knowledgeable about fertilizer needs of their vineyards, saving money (becoming more economically sustainable) and reducing chemical inputs on their farms (becoming more economically sustainable). Based on our success in Michigan we are coordinating this effort with our other growing regions. We are also in progress of creating a national sustainability program, which is based on the success of the Michigan program. We are creating action plans for our members to improve the sustainability of their farms.

National Grape purchased 1,204 soil samples and 852 petiole plant tissue samples. 170 growers have taken soil tests, and 94 growers have petiole nutrient samples. This represents 60 percent of the 282 total growers. Over 7000 acres of grape productions were sampled. All remaining samples will be distributed to our growers for completion. We are hopeful that all will be completed in 2015. National Grape will be requiring all producers to complete the web based sustainability program again in 2015. This will allow National to verify the progress made by our growers. National Grape originally projected 75% of our growers would participate.

BENEFICIARIES

We have continued to pass out soil testing kits and growers were provided with analyses from the lab, and they were able to use these results to fine tune their fertilizer program and reduce chemical inputs on their farms. 105 growers attended the grower workshops. 170 members took soil tests and 94 growers have taken petiole nutrient samples. National Grape Cooperative will continue to provide soil and petiole sampling on an ongoing basis.

LESSONS LEARNED

The process of applying the correct nutrient amounts to grape crops is increasing on our members farms. More of our growers are realizing the importance of becoming MEAP certified.

It is hard to encourage growers to voluntarily participate. We found they are more likely to participate when it is mandatory. You also need a core group of growers to be successful examples for others to follow and implement.

We have continued to pass out soil testing kits and growers were provided with analysis from the lab, and they were able to use these results to fine tune their fertilizer program and reduce chemical inputs on their farms. 105 growers attended grower workshops. 170 members took soil tests and 94 growers have taken petiole nutrient samples. The reduced fertilizer input costs and knowledge gained from sampling gave growers confidence not the follow industry consultants recommended application rates.

CONTACT INFORMATION

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ADDITIONAL INFORMATION

PROJECT TITLE: Michigan Nursery and Landscape Association: Weed Control in Specialized and Traditional Michigan Nursery Crops - FINAL

PROJECT SUMMARY

The 2012-13 project had four objectives dealing with three issues in the industry:

- **A.** Loss of Methyl Bromide soil fumigant
- **B.** Liner bed weed control with pre- and post-emergence herbicides for difficult weeds ex. *Rorippa sylvestris*
- **C.** Liverwort control

The fourth objective propagule bank evaluation was connected with issue (**A**) (listed above). All the seedlings nursery fields we worked with in 2013 had been treated with MeBr before our evaluations (see below). This rendered the work for objective four inapplicable and irrelevant to conduct.

The SCBG: 12-25-B-1468 project built on previous SCBGs we had conducted regarding liverwort control in propagation nurseries. However, via our previous SCBGs we gained an appreciation of the size and scope of the propagation nursery sector in MI and how important it was to the entire industry and state's economy. Therefore, the 12-25-B-1468 SCBG came out of previous SCBGs and specially targeted the propagation nursery sector. Although liverwort controls are critical, the issues surrounding the economic success of this vital propagation sector go well beyond liverwort controls. Using the definition of the USDA, *Propagative Nursery Materials or Lining-Out Stock*, includes unfinished plants of nursery crops such as lining-out stock, root stock, rooted cuttings, seedlings, and tissue-cultured plantlets. In the last USDA *Agriculture Statistics Nursery Summary,* propagative nursery materials in MI were worth $36,847,000 million. Michigan ranks fourth in the nation in the economic worth of this sector and is only surpassed by FL, OR and CA. Michigan is the only major propagation state in the North Central or North Eastern region and is thus extremely important not only to the Michigan nursery and landscape industries success but also to the entire region.

We achieved the three successes (A-C) in our initial purpose to reduce weed control costs for propagation nursery growers and based on stock worth of this sector estimate the total savings achieved from these three (A-C) successes is **$5.5 Mn or a 30% reduction** in previous weeding costs.

Motivation Objective A

Forests are increasingly important, for mitigating global environmental challenges. The first step in forest establishment is the production of tree seedlings by forest tree nurseries. These nurseries provide healthy starting material for reforestation. Direct yield losses, in terms of seedlings/hectare, may not be large on average with improper pest control; intensive seedling production relies on the ability of nursery managers to meet quality and yield goals as well as certification that plants are essentially pest-free.

Methyl Bromide (MeBr) has been used extensively as the soil fumigant of choice to manage fungal pathogens (e.g., *Fusarium*, *Alternaria*, *Phytophthora*, *Pythium, Rhizoctonia*, *Cylindrocladium* spp., *Cylindrocarpon*, and *Macrophomina*), nematodes (e.g., *Circonemoides*, *Helicotylenchus*), and yellow and purple nutsedges (species of *Cyperus*) in forest and herbaceous seedling nurseries in MI and the rest of the US. In 1994, the Clean Air Act mandated 100% phase-out of MeBr by 2001. MeBr was being phased out internationally because it depletes stratospheric ozone, which protects life on Earth from the harmful effects of the sun's ultraviolet radiation. In 1998, the phase-out schedule was revised. The U.S. Congress

amended the Clean Air Act to synchronize it with the Montreal Protocol. The 1998 phase-out planned for developed countries reduced production and import of methyl bromide by the following percentages of the 1991 baseline amounts: 25% in 1999, 50% in 2001, 70% in 2003 and 100% in 2005. By 2015, MeBr will be gone.

Motivation Objective B
Creeping yellow cress also known as Kik and yellow cress, is a major nuisance weed in nurseries. *Rorippa* is a member of the mustard family and forms dense stands. Creeping yellow cress has roots that spread widely and can be propagated by small pieces of the roots. Stands of creeping yellow cress cover the ground and choke the life out of any plants around. *Rorippa sylvestris* is the most rapidly dispersing invasive weed in MI and most efforts to control its spread have been ineffective.
Motivation Objective C
Michigan propagation nurseries have severe issues with liverwort infestations in their nursery containers. Crop phytotoxicity occurs with current controls; alternative non-phytotoxic controls are critical. In previous Specialty Crop Block Grants (SCBGs) we have identified potential bio-rationale products for utilization in these MI nurseries; however, these nurseries also grow many new and unusual plants. Further evaluation of potential products on a range of new plant species and evaluation of new products suggested by IR-4 is required to keep these high value nurseries economically viable.

Problems Objective A: Our objective in addressing the issue of Methyl Bromide (MeBr) loss in this 12-25-B-1468 project was to test two MeBr alternative fumigants, Chloropicrin and Basamid with supplemental low-rates of preemergence herbicides for weed control in forest and herbaceous seedling nurseries in MI. However, before beginning the studies, in the spring of 2013, additional regulations were placed on the use of Chloropicrin in 2012 that made the use of this product impossible. Chloropicrin is a powerful tear gas; it is one of the most toxic to insects of the fumigants. Chloropicrin is a highly hazardous material and can be handled and used only by those who are specially trained. The additional restrictions placed on Chloropicrin in 2012 also made this MeBr alternative extremely restrictive for seedling growers to consider. The industry had no desire to test Basamid (e.g. metam-sodium and dazomet) due to inconsistent pest management performance in previous studies. Since 2005, forest nurseries and other seedling growers have made nominations for critical use of MeBr in those nurseries where registered alternatives are not effective or sufficiently tested to enable commercial use. The use of MeBr is considered critical where alternatives are not suitable because of regulatory, economic, or technical constraints. Instead of supplementing the use of low rates of preemergence herbicides with Basamid or Chloropicrin (as planned) the herbicides in this project were tested as supplements to MeBr applications. All except *Picea abies* fields at New Life in this study were treated with MeBr either in the fall or spring before planting.

Problems Objective B: Between 5 and 6 WAT, in the preemergence study, Berry Family Nursery employees mistakenly went through the plots and applied glyphosate (Round up) as a directed spray onto the creeping yellow cress. This, plus the high rains of April, caused high phytotoxicity ratings in the untreated plots of the efficacy study (Table 6). However, differences could still be distinguished between treatments. Working at nursery sites is a great way to reach the industry with these trials; however, worker error always seems to be a problem.

In the original proposal, we were going to evaluate preemergence efficacy trials for mugwort (*Artemisia vulgaris* L), creeping yellow field cress (*Rorippa sylvestris)*, Red Stem Filaree (*Erodium cicutarium),* Wild Garlic *(Allium vineale)* and marestail *(Conyza canadensis).* In this project, we only did the *Rorippa*; however, we also did a postemergence trial. We used a

broader range of pre- and post- emergence products than originally planned and it was the post-trial that accomplished our target.

Problems Objective C: There was little liverwort present at Northland Farms making it difficult to find enough plants to do several treatments and species. Northland Farms is using some of the controls we have advocated in previous SCGBs and thus their liverwort pressure has decreased significantly.

PROJECT APPROACH

Addressing objective A, the preemergence herbicides that we found to be effective in this project cost less than $35.00/ ac. Products such as Treflan 1 pt/ac rate and Barricade 10 oz/ac could be used for herbaceous seedlings and Pendulum 2G in some crops. Treflan, Barricade and Pendulum 2G were also found to be acceptable for woody plant seedlings. We targeted to cut forest and herbaceous seedling growers weed control program cost by 30%. Using the herbicides listed above we have accomplished this target. We recommend more work is needed with preemergence herbicides in these industries due to the total phase out of MeBr by 2015. The lack of alternative soil fumigants and this being the first study of preemergence herbicide use in these industries also confirms the importance of this work and its timeliness. The contributions of Walter's Gardens and New Life Nursery, due to the primary nature of these studies, were substantial. Many plants were severely injured and killed in these trials; however, the partners understood the importance of this research and were willing to accept these losses in order to find a possible solution.

Addressing objective B, in pre- project start surveys we found that liner bed growers in MI were using the following herbicides, Rout, Barricade, Snapshot, SureGuard, Pendulum, Round up, Goal, Tower, Lontrel and 2, 4-D. On average, they were spending $2300.00/ ac to hand weed problem areas with difficult weeds such as *Rorippa.* We had targeted to reduce their weed program cost by 30%. We accomplished this goal. The acceptable use of Lontrel in this study provided 35% control, thus reducing hand weeding costs by 35%. We recommend more work with Lontrel on more species and with lower rates to reduce phytotoxicity. The contributions of BFN, due to the primary nature of these studies, were substantial. Many plants were severely injured and killed in these trials; however, the partner nursery was willing to accept these losses in order to find a possible solution.

Addressing objective C, SureGuard at 3 or 4 oz/ ac were found to be excellent choices for liverwort control in dormant species. There was no significant difference between the 3 and 4 oz rates for control and phytotoxicity was less with the 3 oz/ac rate. We recommended the 3 oz/ ac rate be used as it is more economical. Marengo was also an excellent choice for liverwort control if applied dormant and provides residual control up to 8-10 weeks much like the SureGuard. We recommend either of these two herbicides could be applied dormant and supplemented with either baking soda or potassium bicarbonate applications in the growing season. Work with sequence of application needs to be done.

GOALS AND OUTCOMES ACHIEVED

A) Loss of Methyl Bromide:

From our pre-project start surveys, we learned that forest and herbaceous seedling growers currently use no herbicides and their MeBr applications cost approximately $1700.00/ ac. Additionally, weekly hand weeding, costs the grower over $600.00/ ac on average, over the growing season. Therefore, their total cost of weed control before this project was $2300.00/ ac.

Walters Gardens is a 385 acre nursery. The preemergence herbicides found to be effective in this project cost less than $35.00/ ac. We targeted to cut their weed control program cost by

30%. Using the herbicides we found effective accomplished this target. Much more work is needed in this area due to the total phase out of MeBr by 2015, the lack of alternative fumigants and this being the first study of preemergence herbicide use in these industries.

Trials with supplemental preemergence herbicides were conducted on three growth stages of deciduous, coniferous or herbaceous seedlings. The three growth stages are listed below in order of highest to lowest potential to cause injury and death:

1) Before the seed emerged in seedling beds
2) Two to six weeks after the seedlings had emerged
3) Transplant beds, two weeks after two year old seedlings were transplanted from seedbeds to the transplant beds.

Stage 1& 2 trials were conducted at Walters Gardens, Inc., at their 400 80th Ave, Zeeland, MI location. The soils are a Gladwin Series sandy loam with low fertility and available water capacity. Gladwin Series soils are moderately permeable. Applications were made on the morning of May 22, 2013. There was a light rain, cloudy skies and the temperature was 63°F. For Stage 1 and 2 trials, nine treatments were applied with four replications of 3 ft. X 3 ft. sections of beds and one ft. buffers between each (Fig. 1 A). The nine treatments and replicates were randomized within each bed/ species. Chemical treatments included trifluralin (Treflan 4 EC) (Helena Chemical Company, Collierville, TN, 38017) applied at (1/2 rate) 1qt and (1/4 rate) 1 pt. per acre; prodiamine (Barricade 4FL) (Syngenta Crop Protection, LLC, Greensboro, North Carolina, 27419) applied at (1/2 rate) 10 oz./ac; Barricade 4FL (1/4 rate) (5 oz./ac) plus Treflan 4EC (1/4 rate) (1pt/ac); oxyfluorfen + prodiamine (Biathlon) (OHP, Inc., Mainland, PA, 19451) applied at (1/4 rate) 50 lb./ac; pendimethalin (Pendulum 2G) (BASF Corporation, Research Triangle Park, NC 27709) applied at (1/2 rate) 100lb./ac and oxadiazon + pendimethalin (Jewel) (Scotts-Sierra Crop Protection Company, Marysville, OH 43041) applied at (1/2 rate) 50 lb./ac. The remaining two treatments to total nine were an untreated weeded check and an untreated weedy check.

The three species used in Stage 1 trials at Walters Gardens were Beard tongue, *Penstemon barbatus* 'Coccineus'; Swamp milkweed, *Asclepias incarnata* 'Cinderella,' and Rhubarb, *Rhubarb* 'Victoria.' These species had been seeded on May 20, 2013 only two days before we treated the beds with the herbicides listed above. The beds were weed free at time of application with no seed germination occurring (Fig. 1 A and B). The three species used in Stage 2 trials at Walters Gardens were Oriental poppy, *Papaver orientalis 'Queen Alexander'; Columbine, Aquilegia* 'Dorothy Rose'; and, Perennial larkspur and *Delphinium* x *cultorum* 'Round Table Mix'. These species had been seeded on April 29, 2013 approximately 3 weeks prior to treatment. *Papaver* 'Queen Alexander' was just emerging at the time of application on May 22, 2013. *Aquilegia* 'Dorothy Rose' was germinated but barely emerged from the ground. *Delphinium* ' Round Table Mix' was the most advanced of the three stage 2 species used at Walters with cotyledons emerged but no true leaves (Fig 2 A and B). Weeds were already emerging in these stage 2 fields with a heavy infestation of white clover (*Trifolium repens*) at the north end of the field.

Fig. 1. A and B. (Left) Stage 1 trials at Walters Gardens, Zeeland, MI on Gladwin Series soils were conducted on Beard tongue, Swamp milkweed and Rhubarb **(A).** These species had been seeded on May 20, 2013 two days before treatments were applied (**B)**.

Fig. 2. A and B. (Left) The Stage 2 species at Walters Gardens, Zeeland, MI were Oriental poppy, *Columbine a*nd Delphinium. Delphinium was the most advanced of these with cotyledons emerged but no true leaves **(A).** Stage 2 species were seeded on April 29, 2013 approximately 3 weeks before applications on May 22, 2013 and were barely emerged from the soil **(B)**.

Stage 2 and 3 trials were conducted at New Life Nursery, 3720 64th St. Holland, MI on deciduous and coniferous seedlings. Applications were applied in the early afternoon of May 22, 2013. There was a moderate rain, cloudy skies and the temperature was 55°F. Stage 2 trials consisted of the same nine treatments applied at Walters Gardens, with four replications of 3 ft. X 3 ft. sections of beds and one ft. buffers between each. The nine treatments and replicates were randomized within each bed/ species. For Stage 3 trials, 12 treatments were conducted: dimethenamid-P + pendimethalin (FreeHand 1.75G) (BASF Corporation, Research Triangle Park, NC 27709) applied at (normal rate) 150 lb./ac; indaziflam (Marengo G) (OHP, Inc., Mainland, PA, 19451) applied at (½ rate) 50 lb./ac and (normal) 100lb./ac; oxyfluorfen + prodiamine (Biathlon) (OHP, Inc., Mainland, PA, 19451) applied at (3/4 rate) 150 lb./ac and (1/3 rate) 75 lb./ac; pendimethalin (Pendulum 2G) (BASF Corporation, Research Triangle Park, NC 27709) applied at (1/2 rate) 100lb./ac; oxadiazon + pendimethalin (Jewel) (Scotts-Sierra Crop Protection Company, Marysville, OH 43041) applied at (normal rate) 100 lb./ac; Barricade 4FL (1/4 rate) 5 oz/ac plus Treflan 4EC (1/2 rate) 1qt/ac; dimethenamid-P (Tower) + pendimethalin (Pendulum Aqua Cap) (BASF Corporation, Research Triangle Park, NC 27709) applied at (normal rates) 1 qt/ac + 1 qt/ac; and, isoxaben (Gallery) (Dow Agro Sciences, LLC, Indianapolis, IN 46268) applied at (1/3 rate) 0.65 lb.ac + Barricade 4FL (½ rate) 10 oz./ac. The remaining two treatments to total 12 were an untreated weeded check and an untreated weedy check.

The Stage 2 trials at New Life were conducted on common lilac, *Syringa vulgaris;* Black walnut, *Juglans nigra;* and, Bur oak, *Quercus macrocarpa*. Soils at New Life are Saugatuck series sands. They are very deep and somewhat poorly drained soils with cemented subsoil. Saugatuck Series soils were formed in sandy glaciofluvial deposits on lake plains, till plains, and outwash plains (Fig. 3 and 4). The lilac field had been fumigated prior to fall planting with MeBr at 400 lb. /ac. Post planting, a thin layer of pine mulch was applied to the lilac field to decrease wind erosion of the sandy soils. The walnut and the bur oak were also fumigated with MeBr at 400 lb. /ac prior to fall planting. Lilac had emerged approximately ¼ inch above the ground at time of application on May 22, 2013. Cotyledons were presented and some seedlings had their first true leaves just expanding (Fig. 3 A and B). Applications to the oak and walnuts were conducted on June 19, 2013 due to rain on May 22, 2013 and thus they were more advanced in growth having been emerged for approximately 3 weeks. The Stage 3 trials were conducted using Norway spruce, *Picea abies* that were being grown as 2+1 transplants (2 years in the seedbed) and transplanted two weeks before on May 8, 2013. They were approximately six inches tall at time of application (Fig. 4). The spruce fields had not received MeBr prior to planting nor mulch post planting. Data was analyzed using SAS® GLM. Phytotoxicity effects of treatments were compared to the controls using Dunnett's t-test (α = 0.10 and 0.05). Efficacy treatments were compared to each other using least significant difference (ls means). Evaluations were conducted every two weeks after application for 3 months or 12 WAT, unless otherwise stated.

Fig. 3. A and B. (Left) New Life Nursery, Holland, MI, lilac seeded fall of 2012 just beginning to emerge at time of herbicide applications, May 22, 2013 **(A).** (Below) Note the fine layer of mulch applied post planting **(B)** on top of Sagatuck Series soils.

Fig. 4. (Left) Norway spruce fields at Walters Gardens, Holland, MI. Two year old seedbed spruce (approximately six inches tall) was transplanted into beds on May 8, 2013, two weeks prior to herbicide applications on May 22, 2013.

Stage 1 trials at Walter's Gardens have never been tried anywhere before. Placing a preemergence herbicide, which inhibits germination, over seedbeds before any plants have emerged is problematic at best. However, all herbicides have selectivity and some selectivity was found in these trials (Table 1). With no information available regarding herbaceous perennial seed susceptibility to herbicides, the species chosen for this trial were those with the largest market share for Walters Gardens. The results indicated that for most perennial species tested and treatments used, severe injury and death occurred (Table 1). However, the Treflan 1 pt rate (Fig. 5A), the Barricade 10 oz. rate and the Biathlon 50 lb./ac rate (Fig. 5B) on milkweed (*Asclepias*) provided near commercially acceptable phytotoxicity at most evaluation dates including 12 WAT. If Barricade had not been reapplied at 8 WAT to milkweed, it would have caused very low phytotoxicity and been more than commercially acceptable. The Barricade was reapplied at 8 WAT in the hopes of picking up additional weed control. The results for Rhubarb, which was also a Stage 1 plant used at Walters Gardens, are not presented. Following treatment application none of the Rhubarb emerged in any of the treatment plots. The results at 2 WAT show high values indicative of high phytotoxicity (Table 1); however, at this stage few plants had emerged and thus were scored as non- or barely existent. The *Penstemon*, another Stage 1 plant, had high phytotoxicity ratings especially in the weedy check 2 WAT (Fig. 6) to 10 WAT (Table 1). We believe that much of the *Penstemon* seed was non-viable. Therefore treatment impacts were difficult to interpret for this species. Treflan at 1 qt. /ac (2 WAT) had low germination; however, in the control, germination was no better (Fig. 6) with ratings of 9.5 and 9.8, respectively (Table 1). We recommend that Treflan, Barricade and Biathlon be tried again at even lower rates and not reapplied for *Penstemon* and *Asclepias*. Further studies with more species are also warranted. These three treatments do seem to show promise on Stage 1 plants.

We had hypothesized that Stage 1 treatments would cause more phytotoxicity than Stage 2 treatments at Walters Gardens. This was not the case. Treatment impacts were equal to or more severe on Stage 2 plants (Table 2) than on Stage 1 plants (Table 1). The results for the poppy are not presented. As with the Stage 1 Rhubarb, all treatments on Stage 2 *Papaver* caused death, at all evaluation dates (Fig. 7 A and B). Again, however, the Barricade 10 oz./ac rate seemed to show promise with low phytotoxicity at 6 WAT on *Delphinium* (Fig. 8) and *Aquilegia* (Fig. 9 A and B). Even with reapplication of Barricade at 8 WAT on *Aquilegia* 'Dorothy Rose,' phytotoxicity was below commercial acceptable levels and not different than the control

(Table 2) (Fig. 9 B and C). The *Delphinium* x *cultorum* 'Round Table Mix' would have also had commercially acceptable phytotoxicity with Barricade 10 oz. /ac if it had not been reapplied at 8 WAT (Table 2). The *Delphinium* x *cultorum* 'Round Table Mix' also seemed to show some promises with Pendulum 2G at 100 lb. /ac (Fig. 10 A). The Pendulum 2 G rating at 12 WAT of 6.5 was statistically equivalent to the two controls (Fig. 10 B and C) and the photos (Fig. 10 A, B and C). Unlike with Stage 1 trials, Biathlon 50 lb. /ac was very phytotoxic to Stage 2 plants. Biathlon contains oxyfluorfen which has some postemergence potential on very small seedlings. Because the Stage 2 trials were on very small seedlings, any product containing herbicides other than mitosis inhibitors MoA (i.e., Jewel and Biathlon) caused severe injury to total kill.

We recommended in future trials using a larger buffer zone between treatments. In the sandy soils at Walters Gardens, there was more leaching than usual in our trials. Some of the treatments leached into adjacent plots (Fig. 11). This was demonstrated by the high phytotoxicity ratings of the untreated plots (Table 1 and 2). We also recommend for future trials that the perennial seed be planted deeper. This recommendation is based on observations of the rows closest to the tractor tire. The rows immediately adjacent to the tractor tire were unaffected by the herbicides; however, the rows next to these were damaged (Fig. 5 A) or dead (Fig. 8). The tractor tire created a berm and thus the seed was planted deeper in the adjacent row. In row crops, such as corn, the Pendimethalin (Prowl) label specifies the seeding depth needs to be at least 1.5" deep. At Walters Gardens, fields were weeded almost every week as normal practice; therefore, all treatments had very high efficacy ratings (Table 3).

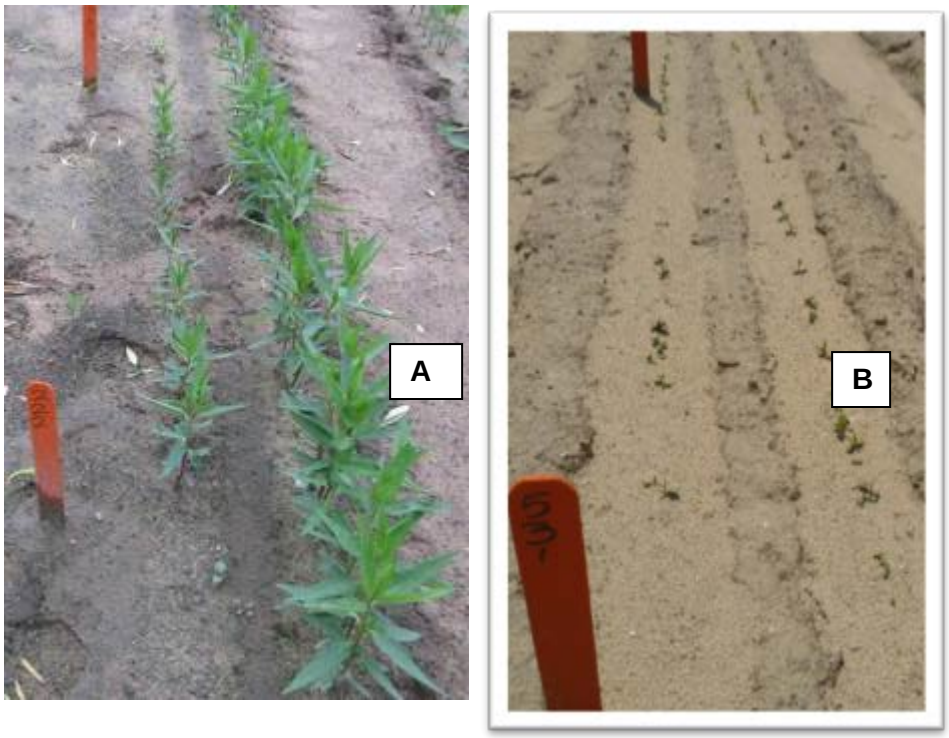

Fig. 5. A and B. (Left) Stage 1 *Asclepias incarnata* 'Cinderella' at Walters Gardens, Zeeland, MI at 6 WAT with Treflan 1 pt/ac (rating 2.5) (**A**). Biathlon 50 lb. /ac at 2 WAT (**B**) showing little injury.

Fig. 6. (Above) Stage 1 *Penstemon coccineas* at 2 WAT at Walters Gardens, Zeeland, MI. The stake in the foreground marks the beginning of the Treflan 1 qt. /ac plot. The stake in the background marks the beginning of the untreated weedy check 2 WAT (phytotoxicity ratings 9.5 and 9.8, respectively).

Fig. 7. A and B. (Left) Stage 2 *Papaver orientalis 'Queen Alexander' at Walters Gardens, Zeeland, OH The second row from the left of the photo* ***(A)*** *just to the right of the blue line was the treated row at 6 WAT. Note the stakes that start the various treatment plots and the death in most of these* ***(A).*** *At 2 WAT also no germination occurring in any treated plot* ***(B)*** *(above).*

Fig. 8. (Left) Stage 2 Delphinium 'Round Table Mix' at Walters Gardens 6 WAT. Stake in foreground marks the beginning of the Barricade 10 oz. /ac (rating 4.0). Note the row adjacent to the tire track is fine; however the row to the left of that is almost all dead. The tire track is denoted by a black line.

Fig. 9. A, B and C. (Above) Stage 2 *Aquilegia* 'Dorothy Rose' at Walters Gardens, Zeeland, MI 2 WAT with Barricade 10 oz./ac (**A**), at 12 WAT with Barricade 10 oz./ac (rating 1.8) (**B**) compared to the Control at 12 WAT (rating 1.8) (**C**).

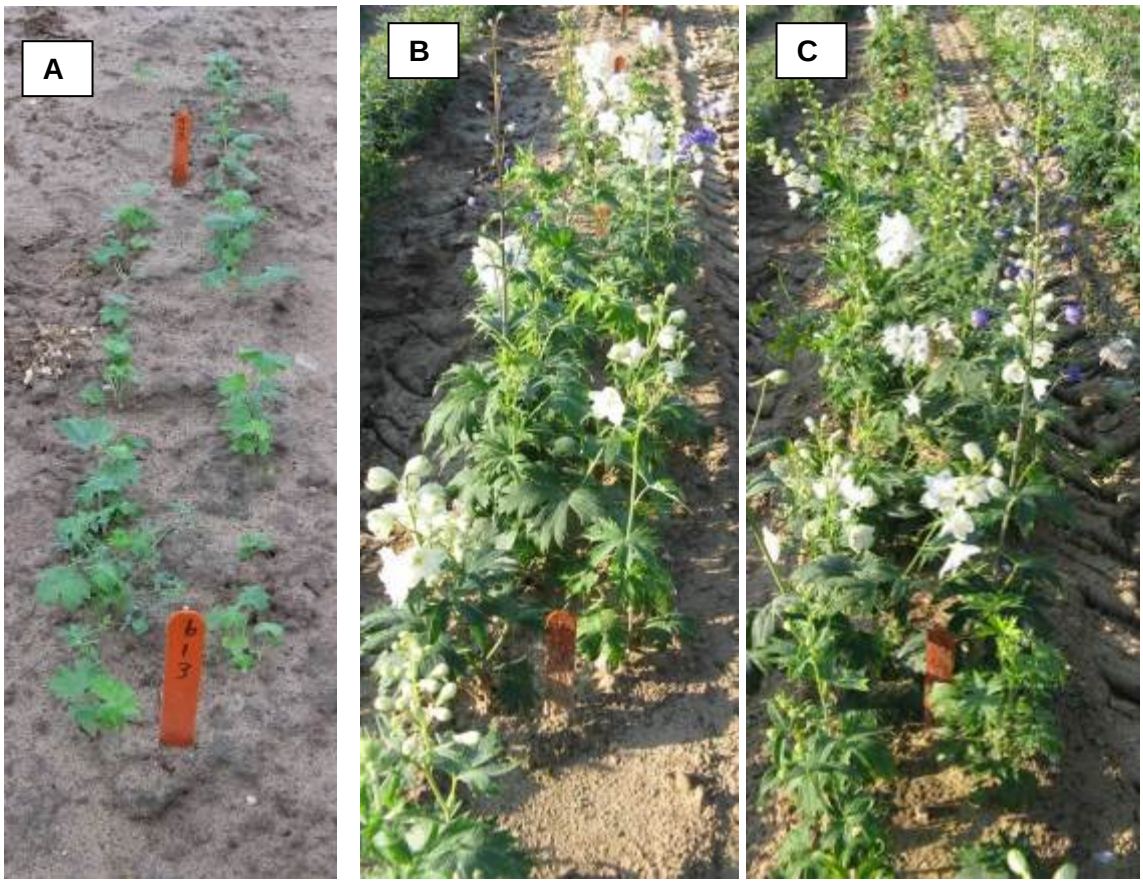

Fig. 10. A, B and C. (Above) Stage 2 *Delphinium* 'Round Table Mix' at Walters Gardens. Stake in foreground marks the beginning of the Pendulum 2G at 100 lb./ac (rating of 5) and stake in background the weedy check (rating 4.5) at 6 WAT **(A).** *Delphinium* 'Round Table Mix' at Walters Gardens 12 WAT with Pendulum 2G at 100 lb. /ac (rating 6.5) **(B)** compared to untreated weeded control **(C)** (rating 3.5).

Fig. 11. (Left) Stage 1 Swamp milkweed, *Asclepias incarnata* 'Cinderella, at Walters Gardens 6 WAT. Stake in foreground is start of the untreated check (rating 2.5) and the stake in start of the background is the start of Jewel at 50 lb. /ac (rating 9.8). Note the herbicide leaching that has occurred from the Jewel plot into the buffer between the plots (causing death) and into the control plot (especially along the right row nearest the tire track, denoted by a black line).

Table 1. Stage 1, phytotoxicity of several ornamental herbicides on selected herbaceous perennials at Walters Gardens Zeeland, MI.

Penstemon coccineas

Treatment	Rate/ac	2 WAT[z]	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT
Treflan	1 qt	9.5 [y x]	8.0	7.5 *	7.8 **	7.5	8.0 **
Treflan	1 pt	9.8	7.5	6.8	6.5	6.5	6.5 *
Barricade 4FL	10 oz	9.3	7.3	7.8 *	8.8 **	5.8	8.5 **
Barricade 4FL + Treflan	5 oz + 1 pt	9.8	8.5	9.0 **	8.5 **	8.5 *	8.8 **
Biathlon	50 lb	10.0	10.0 **	9.8 **	9.8 **	9.8 **	9.8 **
Pendulum 2G	100 lb	9.5	9.5 **	9.0 **	8.5 **	8.3 *	8.0 **
Jewel	50 lb	10.0	10.0 **	10.0 **	10.0 **	10.0 **	10.0 **
Untreated weeded	--	9.3	5.8	4.0	4.0	3.8	3.3
Untreated	--	9.8	7.3	6.0	5.3	5.0	2.8

Asclepias incarnata

Treatment	Rate/ac	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT
Treflan	1 qt	9.3 **	4.0	4.8	5.0 *	4.5	5.3
Treflan	1 pt	8.3	4.0	2.5	2.0	2.5	2.8
Barricade 4FL	10 oz	8.3	3.5	4.0	3.0✓ [w]	3.3	**4.3**
Barricade 4FL + Treflan	5 oz + 1 pt	8.3	4.3	5.0	5.0	4.8	**6.5 ****
Biathlon	50 lb	9.5 **	4.0	4.3	4.4	3.0	3.5
Pendulum 2G	100 lb	8.0	7.0 **	9.0 **	9.8 **	9.5 **	9.3 **
Jewel	50 lb	10.0 **	9.5 **	9.8 **	9.5 **	9.8 **	9.5 **
Untreated weeded	--	6.3	1.0	1.3	1.0	1.0	1.3
Untreated	--	7.8	0.5	2.5	2.5	1.8	3.0

z = weeks after treatment (WAT)

y = Visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = Treatment means followed by *, ** are significantly different from the untreated weeded control based on Dunnett's t-test (α = 0.10 and 0.05, respectively

w = ✓ indicates treatment was reapplied on this date

Table 2. Stage 2, phytotoxicity of several ornamental herbicides on selected herbaceous perennials at Walters Gardens, Zeeland, MI.

Aquilegia 'Dorothy Rose'

Treatment	Rate/ac	2 WAT[z]	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT
Treflan	1 qt	8.2[yx]	9.0 **	8.3 **	8.0 **	8.3 **	8.5 **
Treflan	1 pt	7.8	7.8 **	4.8 *	5.3 **	6.8 **	5.5 **
Barricade 4FL	10 oz	8.0	1.3	1.0	1.2□[w]	2.3	1.8
Barricade 4FL + Treflan	5 oz + 1 pt	8.5	8.0 **	5.5 **	5.5 **	5.8 **	5.3 **
Biathlon	50 lb	9.8 **	9.8 **	7.0 **	9.8 **	9.8 **	9.8 **
Pendulum 2G	100 lb	8.3	5.5 **	6.0 **	7.0 **	7.0 **	6.8 **
Jewel	50 lb	9.5 **	6.3 **	4.8 *	5.3 **	7.0 **	5.5 **
Untreated weeded	--	7.8	0.0	0.3	0.3	0.3	0.0
Untreated	--	8.8 *	2.3	2.3	1.8	2.3	1.8

Delphinium 'Round Table Mix'

Treatment	Rate/ac	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT
Treflan	1 qt	8.3	8.0 **	7.8 **	8.5 **	8.3 **	8.0 **
Treflan	1 pt	7.5	5.3	4.3	4.3	5.3	6.0
Barricade 4FL	10 oz	7.8	7.0 **	4.0	6.3□	5.5	6.3
Barricade 4FL + Treflan	5 oz + 1 pt	8.3	7.0 **	6.0	7.3 **	7.5 **	7.0 *
Biathlon	50 lb	10.0 **	10.0 **	10.0 **	10.0 **	10.0 **	10.0 **
Pendulum 2G	100 lb	7.8	5.0	5.0	5.8	6.0 *	6.5
Jewel	50 lb	9.8 **	8.8 **	7.5 **	8.0 **	8.8 **	8.5 **
Untreated weeded	--	7.3	3.3	2.8	2.8	2.8	3.5
Untreated	--	8.0	5.0	4.5	4.5	3.8	4.5

z = weeks after treatment (WAT)

y = Visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = Treatment means followed by *, ** are significantly different from the untreated weeded control based on Dunnett's t-test (α = 0.10 and 0.05, respectively

w = □ indicates treatment was reapplied on this date

Table 3. Efficacy of several ornamental herbicides in liner beds at Walters Gardens, Zeeland, MI and New Life Nursery, Holland, MI

		Walters Gardens[z]				New Life[y]			
Treatment	Rate/ac	4 WAT[x]		6 WAT		4 WAT		6 WAT	
Treflan	1 qt	9.6[wv]	abc	9.2	abc	8.3	b	7.8	bc
Treflan	1 pt	9.6	abc	9.2	abc	7.5	b	7.6	cd
Barricade 4FL	10 oz	9.3	c	8.8	cd	8.0	b	7.6	cd
Barricade 4FL + Treflan	5 oz + 1 pt	9.6	abc	9.1	abcd	7.8	b	7.3	cd
Biathlon	50 lb	9.8	a	9.4	ab	8.5	b	8.4	ab
Pendulum 2G	100 lb	9.8	a	9.5	a	8.3	b	7.3	cd
Jewel	50 lb	9.7	ab	9.6	a	9.8	a	8.9	a
Untreated weeded	--	9.3	c	8.6	d	6.3	c	7.0	d
Untreated	--	9.4	bc	8.9	bcd	6.0	c	6.1	e

z = treatment means were averaged over liner beds of *Papaver, Aquilegia, Delphinium, Penstemon, Asclepias and Rhubarb* varieties

y = treatment means were taken from a *Syringa* liner bed

x = weeks after treatment

w = visual ratings based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercially acceptable

v = treatment means followed by the same letter in the same column are not significantly different, based on ls means (α = 0.05)

The Stage 2 trials at New Life on woody plant seedlings had very different results than on the herbaceous seedlings at Walters Gardens. At 12 WAT, all treatments were providing low phytotoxicity on the *Juglans* and the *Quercus* (Table 4). The damage on these species had been either passing on the *Quercus* as with Treflan 1 qt./ac and Biathlon 50 lb./ac (Fig. 12 A and B, respectively) or non-existent with the *Juglans* (Table 4).

Averaged across all dates of evaluation, there were four treatments that provided commercially acceptable phytotoxicity with the Lilacs, Treflan 1pt./ ac, Treflan 1qt./ ac, Barricade 10 oz./ ac and Pendulum 2G (data not shown). At 8 WAT the Barricade and the Pendulum picked up phytotoxicity and exceeded commercially acceptable (Table 4). The best treatments for reduced phytotoxicity at New Life Nursery for Lilac were Treflan 1pt./ac and Treflan 1 qt./ac. (Fig. 13 A and Fig. 14 B, respectively). Jewel at 50 lb. /ac was the most phytotoxic (Fig. 13 and 14 D).

The un-weeded control at New Life had significantly lower efficacy than Treflan 1pt./ ac, Treflan 1qt./ ac, Barricade 10 oz./ ac and Pendulum 2G (Fig. 14 A, B and C and Table 3). At New Life, managers were also concerned about weeds, so we ended the efficacy trial at 6 WAT, due to weeding (Table 3). Also, the people weeding picked out the plot markers at 8 WAT in the lilac and thus ended the trial. We recommend that trials on woody plant seedlings be continued with Treflan, Barricade and Pendulum 2G at lower rates in further studies and on more species. The low phytotoxicity levels demonstrated with these products are of tremendous value to the forest seedling industry.

Table 4. Phytotoxicity of several ornamental herbicides in Stage 2 (emerged two to six weeks) seedling beds of *Syringa vulgaris*, *Juglans nigra,* and *Quercus macrocarpa*

Syringa vulgaris

Treatment	Rate	2 WAT[z]	4 WAT	6 WAT	8 WAT
Treflan	1 qt	2.0[yx]	1.0	0.8	2.0
Treflan	1 pt	2.8	1.0	0.8	1.0
Barricade 4FL	10 oz	3.5	0.5	1.5	3.5 **
Barricade 4FL + Treflan	5 oz + 1 pt	4.0	3.0 **	1.8 *	4.0 **
Biathlon	50 lb	5.0 *	2.0 **	2.0 **	3.5 **
Pendulum 2G	100 lb	3.8	2.0 **	1.0	4.3 **
Jewel	50 lb	8.3 **	5.3 **	5.5 **	6.3 **
Untreated weeded	--	2.0	0.0	0.0	0.0
Untreated	--	1.5	0.0	0.0	1.0

Juglans nigra

Treatment	Rate	2 WAT	4 WAT	6 WAT	8 WAT
Treflan	1 qt	1.0	0.0	1.0	0.5
Treflan	1 pt	0.8	0.3	0.8	1.3
Barricade 4FL	10 oz	0.5	0.5	0.3	0.5
Barricade 4FL + Treflan	5 oz + 1 pt	0.8	0.3	0.5	0.3
Biathlon	50 lb	0.3	0.0	0.3	0.3
Pendulum 2G	100 lb	0.0	0.3	0.5	1.0
Jewel	50 lb	0.3	0.3	0.3	0.5
Untreated weeded	--	0.3	0.3	1.5	0.8
Untreated	--	0.8	0.0	1.3	1.3

Quercus macrocarpa

Treatment	Rate	2 WAT	4 WAT	6 WAT	8 WAT
Treflan	1 qt	2.8	0.8	1.8	2.8
Treflan	1 pt	1.5	0.3	0.5	0.0
Barricade 4FL	10 oz	1.3	0.3	0.5	0.0
Barricade 4FL + Treflan	5 oz + 1 pt	2.3	0.5	0.5	0.8
Biathlon	50 lb	2.0	0.5	2.0	1.0
Pendulum 2G	100 lb	0.3	0.0	0.8	0.0
Jewel	50 lb	1.3	0.5	1.5	0.3
Untreated weeded	--	0.0	0.0	0.0	0.0
Untreated	--	0.3	0.5	0.0	0.0

z = weeks after treatment (WAT)

y = Visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = Treatment means followed by *, ** are significantly different from the untreated weeded control based on Dunnett's t-test (α = 0.10 and 0.05, respectively

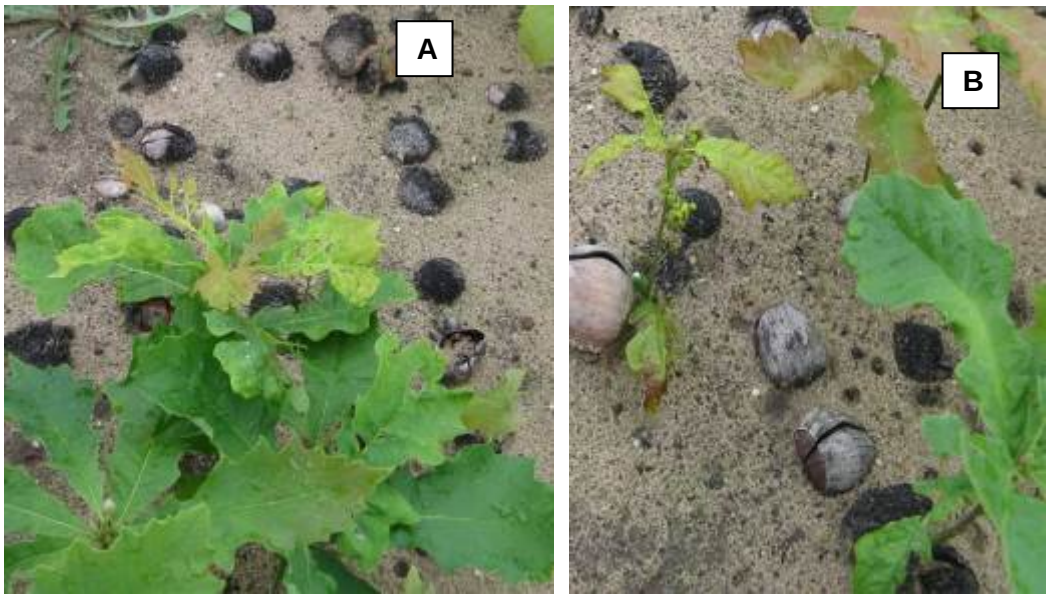

Fig. 12. A and B. Damage on Stage 2 Oaks at New Life Nursery, Holland, MI from Treflan 1 qt./ ac (**A**) and Biathlon 50 lb./ac (**B**) 2 WAT. By 8 WAT, all the oaks had grown out of any phytotoxicity.

Fig. 13. A, B, C and D. Stage 2 *Syringa vulgaris* seedlings at New Life Nursery, Holland, MI 2 WAT with Treflan 1 qt. /ac (**A**), Barricade 10 oz. /ac (**B**) versus the weeded control (**C**) and the most phytotoxic treatment Jewel 50 lb. /ac (**D**).

Fig. 14. A, B, C and D. Stage 2 *Syringa vulgaris* seedlings at New Life Nursery, Holland, MI 6 WAT with Treflan 1 qt. /ac (**A**), Treflan 1 pt. /ac (**B**) versus the un-weeded control (**C**) and the most phytotoxic treatment Jewel 50 lb. /ac (**D**). Note more weeds are in **B** versus **A,** but far less than in **C**.

Table 5. Phytotoxicity of several ornamental herbicides on Stage 3 *Picea abies* seedlings at New Life Nursery, Holland, MI.

Treatment	Rate	2 WAT[z]	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT
FreeHand	150 lb	0.8[yx]	0.0	0.8	1.8	1.8	1.5
Marengo	50 lb	0.0	0.0	0.8	0.8	1.3	1.3
Biathlon	150 lb	1.5	0.0	0.3	0.3	0.3	0.3
Pendulum 2G	100 lb	0.8	1.5 **	1.8	2.8 **	3.0 **	2.3 *
Biathlon	75 lb	2.5	0.0	0.5	0.8	0.5	0.3
Marengo	100 lb	1.0	1.0	1.5	3.0 **	2.8 **	2.8 **
Jewel	100 lb	0.5	0.0	0.5	1.0	0.0	0.0
Barricade + Treflan	5 oz + 1 qt	2.0	0.8	1.3	2.5 [*	2.0	2.8 **
Tower + Pendulum	1 qt + 1 qt	0.8	0.3	0.3	0.8 [	1.3	1.8
Gallery + Barricade	0.65 lb +10 oz	1.0	0.5	1.5	1.8 [	1.5	1.3
Untreated	--	0.5	0.0	0.3	0.0	0.0	0.0
Untreated weeded	--	0.5	0.0	0.3	0.8	0.0	0.3

z = weeks after treatment
y = Visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable
x = Treatment means followed by *, ** are significantly different from the untreated weeded control based on Dunnett's t-test (α = 0.10 and 0.05, respectively.
w = [indicates treatment was reapplied on this date

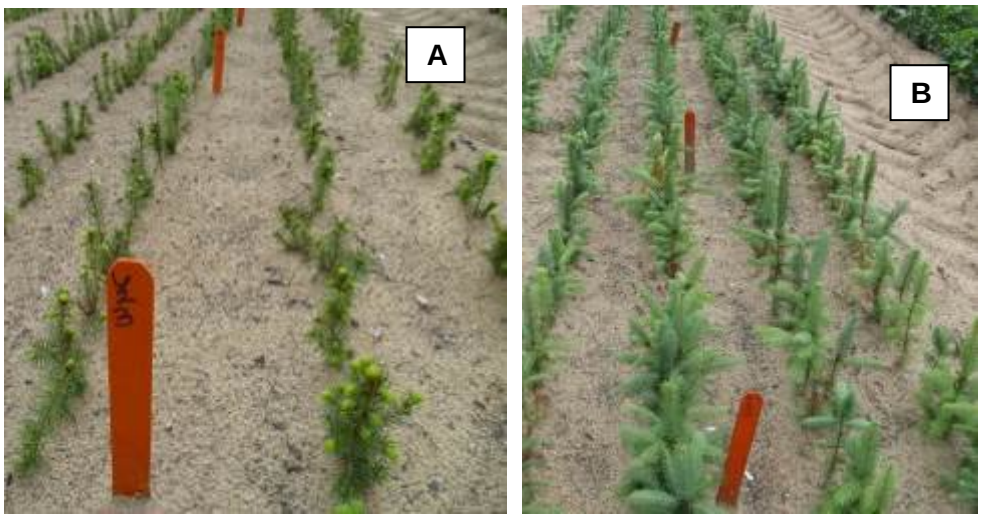

Fig. 15. A and B. Stage 3 *Picea abies* seedlings at New Life Nursery, Holland, MI 2 WAT with Marengo G 100 lb./ac (**A**) and at 6 WAT (**B**). At 2 WAT, there was no phytotoxicity, but at 6 WAT, there was phytotoxicity greater than the control but still commercially acceptable (2.8 rating).

Fig. 16. A and B. Stage 3 *Picea abies* seedlings at New Life Nursery, Holland, MI 2 WAT with Barricade + Treflan (5 oz./ac + 1 qt./ac **(A)** (above) showing no injury and at 6 WAT **(B)** (left). By 6 WAT, there was phytotoxicity greater than the control but still commercially acceptable (2.8 rating).

B) Liner Bed Pre- and Post- Emergence Herbicides for Controlling Creeping Yellow Field Cress (Rorippa sylvestris):

Two trials were conducted in Berry Family Nurseries, Grand Haven, MI fields, one as a preemergence study, and the other a postemergence study. Evaluations for the pre- and post-emergence trials consisted of visual ratings of weed control and phytotoxicity to crop species. Visual ratings of weed control were based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercially acceptable. Visual ratings of phytotoxicity were based on a scale of 0-10 with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable. Data was analyzed using SAS® GLM. Phytotoxicity effects of treatments were compared to the controls using Dunnett's t-test (α = 0.10 and 0.05). Efficacy treatments were compared to each other using least significance difference (ls means).

The preemergence trial was started on April 4, 2013 in a liner bed of Common purple lilacs (*Syringa vulgaris*) that had not yet broken dormancy and were approximately 6" (15 cm) tall. Weather at time of application was sunny, approximately 40 °F with no dew present. Six herbicides and one herbicide + mulch were compared to an untreated control. Herbicides included Corsair (chlorsulfuron, Nufarm Americas, Inc.) at 5.3 oz/ac, Certainty (sulfosulfuron, Monsanto Corp.) at 1 oz/ac, SedgeHammer (halosulfuron, Gowan Co.) at 2 oz/ac, Lontrel (clopyralid, Dow Agro Sciences) at 1 pt/ac, V-10336 (no trade name yet, flumioxazin + pyroxasulfone, Valent U.S.A.) at 15 oz/ac, and Diuron 80 (diuron, Drexel, Inc.) at 3 lb./ac. For the herbicide + mulch treatment, Casoron CS (dichlobenil, Chemtura Corp.) at 3 gal/ac was applied just prior to application of 2 inches of pine nugget mulch. The herbicides were applied with a CO_2 backpack sprayer delivering 25 gal/ac. The creeping yellow cress was just beginning to green below the soil surface (Fig 17). Plots were approximately 3' x 3' with approximately 1-2' between plots.

Fig 17. Creeping yellow cress at time of application at Berry Family Nursery on April 4, 2013.

The postemergence trial treatments were also conducted on Common purple lilacs (*Syringa vulgaris*); however, unlike the preemergence trial, the lilacs had broken dormancy at the time of application and were approximately 7" (17.5 cm) tall. Applications were made on May 16, 2013. Weather was approximately 65 °F, 5 mph wind, sunny. Herbicides included: Corsair (chlorsulfuron, Nufarm Americas, Inc.) at 5.3 oz/ac, Certainty (sulfosulfuron, Monsanto Corp.) at 1 oz/ac, SedgeHammer (halosulfuron, Gowan Co.) at 2 oz/ac, Lontrel (clopyralid, Dow Agro Sciences) at 1 pt/ac, V-10336 (no trade name yet, flumioxazin + pyroxasulfone, Valent U.S.A.) at 15 oz/ac, Diuron 80 (diuron, Drexel, Inc.) at 3 lb/ac, Classic (chlorimuron, Dupont Crop Protection) at 2/3 oz/ac, and Marengo SC at 9 oz/ac. All treatments included the addition of nonionic surfactant at 0.25% v/v. Herbicides were applied with a CO_2 backpack sprayer delivering 25 gal/ac.

Achieved Outcomes

Preemergence trial. In the weeks following the preemergence applications, there was considerable in Grand Haven, MI. Rainfall in 2013 set a new record for April, measuring 11.10", 7.75" more than usual, and 8.12" more than last year (2.98"). 11.10" total rainfall broke the previous April record of 8.29" set in 1909. April 2013 is now the third wettest month on record after June 1892 (13.22") and September 1986 (11.85") in Grand Haven. In April 2013, 18 days

received measurable precipitation, five days more than average. This abnormally high rainfall caused leaching of the treatments into adjacent plots. Some of the control plots demonstrated higher phytotoxicity than normal (Fig. 18, Table 6).

Fig. 18. (Left) Untreated control showing phytotoxicity due to herbicide leaching from adjacent treatments in Lilacs at Berry Family Nurseries, Grand Haven, MI

Corsair, Certainty, and SedgeHammer provided perfect efficacy through 8 WAT. Corsair provided the highest efficacy at 11 WAT and was the only treatment that was significantly better than the untreated controls (Table 6). Lontrel provided little to no preemergence efficacy for creeping yellow cress. This is not surprising, as Lontrel is not labeled as a preemergence herbicide. V-10336 provided excellent control through 5 WAT; however, by 6 WAT, efficacy decreased to a rating of 5.5, only slightly better than untreated (Table 6).

Phytotoxicity varied among the treatments (Table 5). Corsair, although extremely efficacious, was also extremely phytotoxic. BY 11 WAT, all the lilacs were dead in the Corsair plots (Table 5). V-10336 at 15 oz/ac was also very phytotoxic to lilac by 11 WAT (Table 5). V-10336 became more phytotoxic as the trial progressed (Table 5), even though it was applied during dormancy. Casoron also became increasingly phytotoxic over time and significantly so by 11 WAT (Table 5). We recommend Certainty and SedgeHammer be used in further studies for preemergence control of *Rorippa* in lilacs and other species as both showed promise in efficacy and reduced phytotoxicity.

Table 5. Phytotoxicity to *Syringa vulgaris* from selected preemergence applications at Berry Family Nurseries, Grand Haven, MI.

Phytotoxicity

Treatment	Rate/ac	4 WAT[z]	5 WAT	6 WAT	8 WAT	11 WAT
Corsair	5.3 oz	7.5[yx]	8.3 **	9.0 **	9.3 **	10.0 **
Certainty	1 oz	4.5	4.5	5.5	6.5	5.0
SedgeHammer	2 oz	5.3	5.3	6.3 *	6.0	4.8
Lontrel	1 pt	3.3	3.5	4.8	4.5	4.3
V-10336	15 oz	3.8	4.3	5.0	7.3	7.0 **
Diuron	3 lb	2.0	3.0	4.5	5.8	5.8
Casoron + PN	3 gal	3.5	4.8	5.3	6.3	8.0 **
Untreated	--	2.3	1.5	2.5	3.5	2.5

Table 6. Efficacy in *Syringa vulgaris* fields for *Rorippa sylvestris* (creeping yellow cress) from selected preemergence applications at Berry Family Nurseries, Grand Haven, MI.

Creeping yellow field cress control

Treatment	Rate/ac	4 WAT	5 WAT	6 WAT	8 WAT	11 WAT

Corsair	5.3 oz	9.0[wv]	a	9.3	a	10.0	a	10.0	a	9.8	a
Certainty	1 oz	10.0	a	9.5	a	10.0	a	10.0	a	8.8	ab
SedgeHammer	2 oz	10.0	a	9.8	a	10.0	a	9.8	a	8.5	abc
Lontrel	1 pt	2.8	c	3.3	d	6.8	bcd	7.0	bc	6.8	bc
V-10336	15 oz	9.5	a	7.5	ab	5.5	cd	2.5	d	5.8	c
Diuron	3 lb	4.3	bc	6.3	bc	7.5	bc	7.8	ab	8.3	abc
Casoron + PN	3 gal	6.3	b	8.0	a	7.8	ab	7.0	bc	9.0	ab
Untreated	--	3.5	c	4.0	cd	5.0	d	4.8	cd	6.0	bc

z = weeks after treatment

y = Phytotoxicity ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = Treatment ratings followed by *,** are significantly different from the control, based on Dunnett's t-test (α = 0.10 and 0.05, respectively)

w = Control ratings are based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercially acceptable

v = Treatment ratings followed by the same letter in the same column are not significantly different based on lsmeans (α = 0.05)

Postemergence trial. Although April had record rainfall, May 2013 had normal rainfall. All the rains of April did bring “lots of flowers” and weeds for this postemergence trial. Unfortunately, all of the treatments caused greater phytotoxicity than the control (Table 7). Lontrel, however, was the only treatment where the injury was near commercially acceptable (Table 7, Fig. 19). More work and trials need to be conducted to determine the best option for control of creeping yellow field cress in field situations.

Fig. 19. (Left). Injury on lilac at 11 WAT from Lontrel applied postemergence on May 16, 2013 at Berry Family Nurseries, Grand haven, MI. Note stunting and leaf distortion typical of Lontrel injury.

Excellent efficacy was achieved with six of the eight treatments; Marengo SC and Lontrel were the only two treatments not providing acceptable control at 5 WAT (Table 8). Marengo was significantly better than the control at 2 WAT, but not 5 WAT (Table 8). Lontrel, although not commercially acceptable, provided better control than Marengo and the untreated plots and was similar to Diuron at 5 WAT (Table 8) Corsair, just like in the preemergence trial, provided the best control of *Rorippa* through 5 WAT (Fig. 20).

We recommend Lontrel be further studied for control of *Rorippa* as it was the only product to provide near acceptable phytotoxicity and some level of weed control. Although Lontrel's efficacy was not as high as some of the other products, it seems to be the only one with promise. We recommend there be much more work and trials conducted to determine the best option for control of *Rorippa* in various liner bed species in MI due to the rapid dispersion of this weed.

Table 7. Phytotoxicity to *Syringa vulgaris* from selected postemergence herbicide applications at Berry Family Nurseries, Grand Haven, MI.

Phytotoxicity

Treatment	Rate/ac	2 WAT[z]		5 WAT	
Corsair	5.3 oz	6.0[yx]	**	9.8	**
Certainty	1 oz	4.8	**	6.3	**
SedgeHammer	2 oz	6.0	**	7.3	**
Classic	2/3 oz	6.5	**	8.8	**
Lontrel	1 pt	3.8	**	3.3	**
V-10336	15 oz	9.0	**	7.8	**
Diuron	3 lb	7.5	**	7.5	**
Marengo SC	9 oz	4.3	**	6.0	**
Untreated	--	1.0		0.8	

Table 8. Efficacy in *Syringa vulgaris* fields for *Rorippa sylvestris* (creeping yellow cress) from selected preemergence applications at Berry Family Nurseries, Grand Haven, MI.

Creeping yellow field cress control

Treatment	Rate/ac	2 WAT		5 WAT	
Corsair	5.3 oz	9.0[wv]	a	9.8	a
Certainty	1 oz	9.0	a	9.5	a
SedgeHammer	2 oz	8.8	ab	9.0	a
Classic	2/3 oz	9.0	a	9.5	a
Lontrel	1 pt	6.0	c	6.5	b
V-10336	15 oz	9.0	a	9.0	a
Diuron	3 lb	6.5	bc	7.8	ab
Marengo SC	9 oz	6.8	abc	5.5	bc
Untreated	--	3.0	d	2.3	c

z = weeks after treatment

y = Phytotoxicity ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = Treatment ratings followed by *,** are significantly different from the control, based on Dunnett's t-test (α = 0.10 and 0.05, respectively)

w = Control ratings are based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercially acceptable

v = Treatment ratings followed by the same letter in the same column are not significantly different based on lsmeans (α = 0.05)

Fig. 20. (Left) Control of creeping yellow cress at Berry Family Nurseries, Grand Haven, MI at 11 WAT of Corsair postemergence on May 16, 2013. Although weed control is perfect, injury to the crop is also complete death (rating 9.8).

From our pre- project start surveys we found that liner bed growers in MI were using the following herbicides, Rout, Barricade, Snapshot, SureGuard, Pendulum, Round up, Goal, Tower, Lontrel and 2, 4-D. On average, they were spending $250.00/ac to hand weed problem areas with difficult weeds such as *Rorippa.* We had targeted to reduce their weed program cost by 30%. We accomplished this goal. The acceptable use of Lontrel in this study provided 35% control, thus reducing hand weeding costs by 35%.

C) Liverwort Control:

Trials were initiated in late February, 2013 at two Michigan nurseries to determine liverwort efficacy and ornamental phytotoxicity from selected herbicide treatments. Seven treatments were evaluated at Spring Meadow Nursery, Grand Haven, MI: SureGuard (flumioxazin, Valent U.S.A.) at 3 and 4 oz/ac, baking soda (for this treatment, Arm and Hammer, Church and Dwight Co, Inc.) at 2.24 g/ft2, MilStop (Potassium bicarbonate, BioWorks, Inc.) at 2.24 g/ft2, WeedPharm (Pharm Solutions, Inc.) at 10% v/v, Marengo SC (indaziflam, Bayer Crop Science) at 9 oz/ac, and the untreated control. Liquid applications were applied with a CO2 backpack type sprayer set to deliver 50 gal/ac with 8004 VS Teejet nozzles. Protocol required 100 gal/ac, so two passes were made to deliver the required volume. Species selected for phytotoxicity trials at Spring Meadow included *Hydrangea paniculata* 'Limelight', *Hibiscus* 'Satin blue', *Forsythia* 'Show off Sugar Baby', *Viburnum dentatum* 'Blue Muffin', and *Physocarpus* 'Summer Wine'. Reagent grade potassium bicarbonate (Sigma-Aldrich) at 2.24 g/ft2 was also trialed at Spring Meadow, on one species, *Hydrangea paniculata* 'Limelight.' All species at Spring Meadow were just coming out of dormancy, i.e. bud swell. The *Physocarpus,* however, was more advanced with small leaves on the majority of plants. Four treatments were evaluated at Northland Farms Nursery, West Olive, MI: SureGuard at 4 oz/ac, MilStop at 2.24 g/ft2, Marengo SC at 9 oz/ac and the untreated control. Species selected for phytotoxicity evaluations at Northland Farms included *Syringa* 'Miss Kim', *Cotoneaster apiculata*, *Euonymus* 'Blondie', *Syringa meyeri* 'Paliban', *Salvia* 'East Fryland', *Pachysandra* 'Green carpet', and *Vitis labrusca*. *Syringa* and *Vitis* were dormant; *Cotoneaster, Pachysandra,* and *Euonymus* were at bud swell; and *Salvia* was actively growing with rosettes of leaves approximately 3-4" in diameter at time of application.

Applications were applied on February 28, 2013 at both sites. Spring Meadow is a propagation nursery, so the environment was highly regulated. Northland Farms does propagation but is not

exclusively a propagation nursery. The first applications at Spring Meadow was made in a vented- roof greenhouse that was 60 °F with high humidity. At Northland Farms the first applications were made in a covered polyhouse at 45 °F and high humidity. SureGuard at 4 oz/ac and the WeedPharm at 10% v/v were reapplied on May 2, 2013 [8 WA1T (weeks after first treatment)] at Spring Meadow only in accordance with IR-4 protocols. Evaluations consisted of visual ratings of efficacy and phytotoxicity. Visual ratings of liverwort efficacy were based on a 0-10 scale with 0 being no control, 10 perfect control and ≥7 commercially acceptable. Visual ratings of phytotoxicity were based on a scale of 0-10 with 0 being no phytotoxicity, 10 death and ≤3 commercially acceptable.

Achieved Outcomes:
Phytotoxicity. At Spring Meadow, SureGuard at 3 oz/ac caused some temporary injury but by 12 WAT all species were commercially acceptable (Table 9). The SureGuard at 4 oz/ac, on four of five species evaluated, caused greater phytotoxicity than commercially acceptable at 12 WAT (Table 9). However, the SureGuard 4 oz.ac injury occurred after the first application and persisted as delayed growth compared to the control. All five species had commercially acceptable injury at 8 WAT before reapplication. The second application, at 4 oz/ac SureGuard, caused significantly more injury than the controls (Fig. 21 A and B) (Table 9). SureGuard injury on actively growing plants is well documented and our results concur. *Physocarpus*, which was leafed out at the first application, also indicates SureGuard needs to be applied dormant or just at bud-break to prevent injury (Table 9). The first application of Marengo also caused significant delays in bud break with *Hibiscus, Forsythia,* and *Viburnum.* However the impact was more severe and longer term on *Hydrangea* (Fig. 22), up to 8 WAT with *Hydrangea* (Table 9) and through to 12 WAT with *Physocarpus* (Table 9). Marengo also impacted the roots of *Hibiscus* causing a significant reduction in root development at 6 WAT (Fig. 23) and was gone by 9 WAT (Table 9). WeedPharm was not injurious when applied at bud swell. WeedPharm applied to active growth ex. *Physocarpus* initially, or as a second application (Fig. 24), to other species did cause significant injury (Table 9. MilStop and baking soda were not injurious on any species. Potassium bicarbonate reagent, which was applied once at a later date on *Hydrangea,* caused significant leaf burn and injury. However, by 9 WAT the injury had decreased to commercially acceptable (Table 9).

Phytotoxicity at Northland Farms used only the 4 oz/ac rate of SureGuard and as at Spring Meadow it caused some delay in bud break and injury (Table 10). However, only *Pachysandra* by 8 WAT, had injury that was greater than commercially acceptable (Table10, Fig. 25). Bud break occurred much later at Northland Farms as the plants were in unheated polyhouses. All treatments at Northland were applied later and were not evaluated as long (Table 10). SureGuard 4 oz/ac on *Salvia* did cause initial burn and stunting (Fig. 26) that decreased to commercially acceptable by 8 WAT (Table 10). The Marengo also delayed bud break and growth, but not to the extent of the SureGuard. *Cotoneaster* had the most injury from Marengo (Table 10 and Fig. 27).

Efficacy. At Spring Meadow, all treatments provided some level of control; however, baking soda, MilStop, and K-bicarbonate all failed to provide commercially acceptable control at any date (Table 11). The MilStop was applied at ½ the rate of 2012 trials when it was exceptional in its control. SureGuard 3 oz (Fig. 28) and 4 oz/ac, and WeedPharm provided excellent control of liverwort throughout the experiment (Table 11). However, if the Weed Pharm had not been reapplied at 8 WAT, its control would not have been commercially acceptable. At 6 WAT WeedPharm efficacies was decreasing (Fig. 29) and was significantly worse than the other two treatments listed above and the control. Even though the 4 oz/ac rate was reapplied at 8 WAT, the 3 oz/ac rate clearly suggested it was sufficient for liverwort control out to 10 WAT combined across species (Table 11). The duration of control from 3 oz/ac rate did seem dependent on the

level of infestation at time of application. Some species that had very high initial infestations of liverwort were waning in control at 6 WAT (Fig. 28) and 8 WAT (data not shown). Marengo surprisingly provided excellent control of liverwort throughout the trial, although death of the liverwort was slow (Table 11). The MilStop did provide some efficacy, but not commercially acceptable. Also the MilStop control was achieved quickly after application and decreased over time.

At Northland Farms, the environment was much different than at Spring Meadow and efficacy was not as high with SureGuard at 4 oz/ac, MilStop, or Marengo compared to Spring Meadow (Tables 12 and 11, respectively). Also there was less liverwort present at Northland Farms, which is evident with the control ratings (Tables 12) versus (Table 11). MilStop and Marengo (Fig. 27) did achieve significantly efficacy than the untreated controls (Table 12). Perhaps the lack of efficacy at Northland was due to the cooler environment at this location.

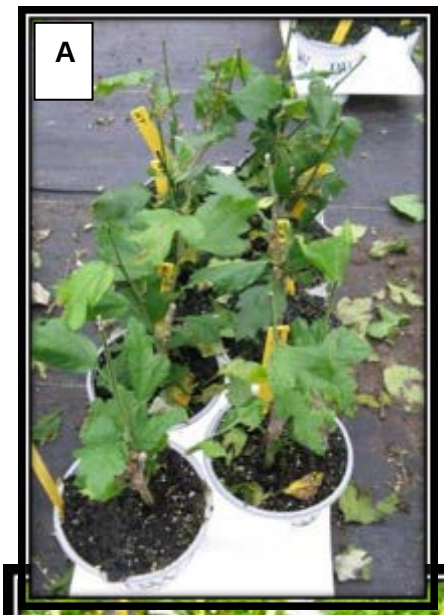

Fig. 21 A and B. (Left) SureGuard 4 oz/ac on Hibiscus at Spring Meadow Nursery 9 WAT with greater than commercially acceptable injury (phytotoxicity 3.9 rating). The first application was Feb. 28, 2013 the second application was at 8 WAT or one week before photo **(A)**. (Below) Hibiscus control at 9 WAT (rating 0) (**B**).

Fig. 22. (Left) Injury on *Hydrangea paniculata* caused by Marengo SC at 3 WAT (phytotoxicity rating 6). Many of the buds failed to emerge and the plants were retarded versus the control plants.

Fig. 23. (Left). *Hibiscus* 'Satin blue' at Spring Meadow Nursery, Grand Haven, MI, 6 WAT with (Left to right) Marengo 3SC (phytotoxicity 2.2 rating), Control (O rating), and SureGuard 3 oz/ac (0.9 rating). Note reduction in root growth in the Marengo #SC versus the SureGuard 3 oz/ac.

Fig. 24. (Right) *Hibiscus* 'Satin blue' at Spring Meadow Nursery, Grand Haven, MI, 9 WA1T or 1WA2T WeedPharm (3.1 phytotoxicity rating). Note loss of terminal growth.

Fig. 25. (Left) Pachysandra 'Green Carpet' at Northland Farms, West Olive, MI Control (left) at 8 WAT (phytotoxicity rating 0) versus treated with SureGuard 4 0z/ac (right) (rating 3.8).

Fig. 26. (Above) *Salvia* 'East Fryland' at Northland Farms, West Olive, MI at 4 WAT with SureGuard 4 oz/ac (left) (phytotoxicity rating 3.5) versus control (right) (rating 0).

Fig. 27. (Above) *Cotoneaster apiculata* at Northland Farms, West Olive, MI applied with Marengo 3 SC (left) (phytotoxicity rating 1) versus Control at 4WAT (rating 0).

Fig. 28. (Above) *Physocarpus* 'Summer Wine' at Spring Meadow Nursery, Grand Haven, MI, 6 WAT with SureGuard 3 oz/ac (efficacy 9.6 rating).

Fig. 29. (Above) *Hydrangea paniculata 'Limelight'* at Spring Meadow Nursery, Grand Haven, MI, 6 WAT with WeedPharm (Left) (efficacy rating 7.9) compared to control (right) (efficacy rating 0). Note the liverwort is starting to reemerge following the first application of WeedPharm shown with red lines.

Table 9. Phytotoxicity on ornamentals at Spring Meadow Nursery, Grand Haven, MI with selected products.

Hydrangea paniculata 'Limelight'

Treatment	Rate	1 WAT[z]	2 WAT	4 WAT	6 WAT	8 WAT	9 WAT	10 WAT	12 WAT
SureGuard	3 oz/ac	0.3[yx]	0.0	0.0	0.6	0.0	1.0	0.0	0.0
SureGuard	4 oz/ac	0.1	0.2	0.0	0.0	0.0 □	5.6 **	4.9 **	2.7 **
Baking Soda	2.2 g/ft^2	0.0	0.1	0.4	1.0	0.0	0.6	0.0	0.5
MilStop	2.2 g/ft2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WeedPharm	10% v/v	0.0	0.1	1.8	0.6	0.0	3.4 **	3.6 **	2.5 **
Marengo	9 oz/ac	3.3 **	6.0 **	7.0 **	4.0 **	4.4 □ **	1.2	0.9	1.3 **
Untreated	--	0.0	0.2	0.0	0.0	0.0	1.7	1.2	0.0

Hibiscus syriacus 'Blue Satin'

Treatment	Rate	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	9 WAT	10 WAT	12 WAT
SureGuard	3 oz/ac	1.2 **	0.9 **	1.3 **	0.9 **	1.7 **	0.0	0.0	0.0
SureGuard	4 oz/ac	2.1 **	2.1 **	2.1 **	1.2 **	1.5 □ **	3.9 **	4.3 **	5.5 **
Baking Soda	2.2 g/ft^2	0.2	0.0	0.1	0.3	0.3	0.0	0.0	0.0
MilStop	2.2 g/ft2	0.0	0.0	0.0	0.3	0.5	0.0	0.0	0.0
WeedPharm	10% v/v	0.1	0.2	0.4	0.9	1.1 □ **	3.1 **	1.5 **	2.5 **
Marengo	9 oz/ac	2.2 **	3.0 **	3.4 **	2.2 **	2.3 **	0.0	0.0	0.0 **
Untreated	--	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0

Forsythia 'Show Off Sugar Baby'

Treatment	Rate	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	9 WAT	10 WAT	12 WAT
SureGuard	3 oz/ac	2.7 *	2.0	2.3	3.3	3.0	2.0	3.0	3.0
SureGuard	4 oz/ac	3.1 **	2.1	1.9	2.3	2.0□	5.0	5.6	5.2
Baking Soda	2.2 g/ft^2	2.0	2.7	2.0	2.8	2.0	2.0	2.0	3.0
MilStop	2.2 g/ft2	0.0	0.2	0.6	3.0	5.2	4.0	4.2	4.7
WeedPharm	10% v/v	0.0	0.5	0.4	0.3	0.0 □	4.2	4.2	3.9
Marengo	9 oz/ac	2.1	1.2	0.3	0.2	0.0	0.0	0.0	0.0
Untreated	--	0.0	1.0	1.4	2.3	1.4	2.2	2.0	2.0

Viburnum dentatum 'Blue Muffin'

Treatment	Rate	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	9 WAT	10 WAT	12 WAT
SureGuard	3 oz/ac	1.1 **	0.8	0.0	0.1	0.0	0.0	0.1	0.0

SureGuard	4 oz/ac	2.1 **	2.5 **	1.5 *	0.8 **	0.4□	2.8 **	3.9 **	3.3 **
Baking Soda	2.2 g/ft^2	0.0	0.3	0.0	0.1	0.3	0.1	0.0	0.0
MilStop	2.2 g/ft2	0.1	0.1	0.0	0.0	0.3	0.0	0.0	0.0
WeedPharm	10% v/v	0.1	0.0	0.0	0.1	1.1 □ **	3.4 **	2.1 **	2.6 **
Marengo	9 oz/ac	1.7 **	2.8 **	2.0 **	1.5 **	1.2 **	0.2	0.3	0.2
Untreated	--	0.0	0.3	0.3	0.0	0.0	0.0	0.2	0.1

Physocarpus opulifolius 'Summer Wine'

Treatment	Rate	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	9 WAT	10 WAT	12 WAT
SureGuard	3 oz/ac	3.8 **	4.0 **	3.1 **	2.0 **	1.5	1.3	1.0	0.8
SureGuard	4 oz/ac	4.0 **	3.9 **	2.6 **	2.6 **	2.2□ **	5.0 **	4.6 **	4.7 **
Baking Soda	2.2 g/ft^2	0.0	0.3	0.3	0.1	0.2	0.5	0.0	0.0
MilStop	2.2 g/ft2	0.0	0.1	0.3	0.3	0.6	0.5	0.0	0.0
WeedPharm	10% v/v	3.4 **	2.1 **	1.8 **	1.0	1.4 □	6.1 **	4.7 **	3.7 **
Marengo	9 oz/ac	6.3 **	6.7 **	7.2 **	5.3 **	4.5 **	5.5 **	3.9 **	3.6 **
Untreated	--	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3

Hydrangea paniculata 'Limelight'

Treatment	Rate	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	9 WAT	10 WAT	12 WAT
K-bicarbonate	2.2 g/ft2	--	--	--	6.6 **	5.6 **	1.7 **	1.2 **	0.8 *
Untreated	--	--	--	--	0.0	0.0	0.0	0.0	0.0

z = weeks after treatment

y = Phytotoxicity Ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable.

x = Phytotoxicity ratings followed by *,** are significantly different from control based on Dunnett's t-test (α = 0.10, 0.05, respectively).

Table 10. Phytotoxicity on ornamentals at Northland Farms, West Olive, MI with selected products.

Pachysandra 'Green Carpet'

Treatment	Rate	1 WAT[z]	2 WAT	4 WAT	6 WAT	8 WAT
SureGuard	4 oz/ac	--[yx]	--	4.0 **	4.0 **	3.8 **
MilStop	2.2 g/ft2	--	--	0.0	0.0	0.0
Marengo	9 oz/ac	--	--	0.0	0.3	1.5 **
Untreated	--	--	--	0.0	0.0	0.0

Syringa meyeri 'Paliban'

Treatment	Rate	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT
SureGuard	4 oz/ac	--	--	--	0.8	0.0
MilStop	2.2 g/ft2	--	--	--	0.0	0.0
Marengo	9 oz/ac	--	--	--	0.5	0.0
Untreated	--	--	--	--	0.0	0.0

Euonymus 'Blondie'

Treatment	Rate	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT
SureGuard	4 oz/ac	--	--	--	2.0 **	2.3 **
MilStop	2.2 g/ft2	--	--	--	0.0	0.0
Marengo	9 oz/ac	--	--	--	0.8	0.5
Untreated	--	--	--	--	0.0	0.0

Cotoneaster apiculata

Treatment	Rate	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT
SureGuard	4 oz/ac	--	1.5 **	0.0	0.8 **	1.5 **
MilStop	2.2 g/ft2	--	0.0	0.0	0.3	0.0
Marengo	9 oz/ac	--	2.8 **	1.0 **	1.0 **	1.0 **
Untreated	--	--	0.0	0.0	0.0	0.0

Syringa 'Miss Kim'

Treatment	Rate	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT
SureGuard	4 oz/ac	--	--	--	0.0	1.8 **
MilStop	2.2 g/ft2	--	--	--	0.0	0.0
Marengo	9 oz/ac	--	--	--	1.3	0.3
Untreated	--	--	--	--	0.0	0.0

Salvia 'East Fryland'

Treatment	Rate	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT
SureGuard	4 oz/ac	4.2 **	4.0 **	3.5 **	2.5 **	1.5 **
Untreated	--	0.0	0.0	0.0	0.0	0.0

z = weeks after treatment
y = Phytotoxicity Ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable.
x = Phytotoxicity ratings followed by *,** are significantly different from control based on Dunnett's t-test (α = 0.10, 0.05, respectively).

Table 11. Efficacy at Spring Meadow Nursery, Grand Haven, MI for liverwort with selected products.

Treatment	Rate	1 WAT[z]	2 WAT	4 WAT	6 WAT	8 WAT	9 WAT	10 WAT	12 WAT
SureGuard	3 oz/ac	7.4[wv] b	9.8 a	9.6 a	9.6 a	9.6 a	9.7 a	9.7 a	9.7 a
SureGuard	4 oz/ac	7.5 b	9.8 a	9.5 a	9.6 a	9.8 □ a	9.9 a	9.8 a	9.9 a
Baking Soda	2.2 g/ft^2	5.8 c	5.3 b	3.5 c	3.8 c	4.0 c	4.3 c	5.3 b	4.9 b
MilStop	2.2 g/ft2	4.4 d	3.7 c	2.3 d	2.5 d	2.3 d	3.6 d	4.4 bc	4.5 b
WeedPharm	10% v/v	9.8 a	9.5 a	8.6 b	7.9 b	7.5 □ b	8.6 b	9.0 a	9.0 a
Marengo	9 oz/ac	6.2 c	9.4 a	9.4 a	9.8 a	9.5 a	9.7 a	9.8 a	9.7 a
Untreated	--	0.0 e	0.0 d	0.0 e	0.0 e	0.0 e	1.1 e	3.7 c	3.4 c
Treatment	**Rate**	**1 WAT**	**2 WAT**	**4 WAT**	**6 WAT**	**8 WAT**	**9 WAT**	**10 WAT**	**12 WAT**
K-bicarbonate	2.2 g/ft2	--	--	--	5.2 a	3.1 a	2.5 b	2.6 b	3.6 b
Untreated	--	--	--	--	0.0 b	0.0 b	8.7 a	9.6 a	9.7 a

z = weeks after treatment

w = Liverwort control ratings followed by the same letter in the same column are not significantly different, based on lsmeans (α = 0.05)

v = Liverwort control ratings based on a 0-10 scale with 0 being no control, 10 perfect control and ≥7 commercially acceptable.

Table 12. Efficacy at Northland Farms, West Olive, MI for liverwort with selected products.

Treatment	Rate	1 WAT[z]		2 WAT		4 WAT		6 WAT		8 WAT	
SureGuard	4 oz/ac	7.5[wv]	bc	7.3	ab	7.9	a	7.3	b	6.2	bc
MilStop	2.2 g/ft2	8.7	a	8.6	a	9.0	a	8.4	a	7.4	ab
Marengo	9 oz/ac	6.6	cd	6.5	b	8.1	a	8.9	a	8.8	a
Untreated	--	5.5	d	4.2	c	4.8	b	5.7	c	5.0	c

z = weeks after treatment
w = Liverwort control ratings followed by the same letter in the same column are not significantly different, based on lsmeans (α = 0.05)
v = Liverwort control ratings based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercially acceptable.

SureGuard at either 3 or 4 oz is an excellent choice for liverwort control in dormant species. There was no significant difference between the 3 and 4 oz rates for control and phytotoxicity was less with the 3 oz/ac rate. We recommended the 3 oz/ ac rate be used as it is more economical. Marengo is also an excellent choice for liverwort control if applied dormant and provides residual control up to 8-10 weeks much like the SureGuard. WeedPharm also provided excellent control. WeedPharm has no residual control unlike SureGuard and Marengo and required reapplication which was phytotoxic to several species. The baking soda and MilStop did not provide the level of control that we had seen in previous SCBGs, this was probably due to the rate being too low and half of other years. Some of the containers did show excellent control, indicating rate is important for controlling liverwort with these products. More work needs to be done with SureGuard and Marengo on dormant plants, with follow up applications of baking soda, once active growth occurs.

BENEFICIARIES

Beneficiaries from these trials were obviously the nursery managers and staff that were involved in the trials at the five sites in MI. Also the over 100 participants that were involved in the weed workshop and survey classes held in MI during 2013. However, in 2013, 27 extension/ research presentations were also given with results from these trials. One was at an international conference, eight at national, nine at regional and another nine at state conferences benefiting over 700 MI attendees and over 2000 attendees in four other states and one other country. 25 of the 27 presentations were invited and were for industry organized events. This indicates the value and demand for this information to industry members. One bulletin chapter, two contributed articles, two technical reports and two invited articles were also completed in association with this project. Three papers in proceeding were also published using information obtained from this project. It is estimated that between the 27 presentations and articles published we reached over 6000 people in the MI ornamental industry.

LESSONS LEARNED

We did not recommend any seedling depth in the pre-emergence herbicides trials; however, we found that in rows were seeds had been pushed to lower depths less injury occurred. In the future we will recommend the seed be planted at least 1 inch deep before applications are applied. Also at New Life there was less injury perhaps due to the layer of mulch they apply over the seedbeds. Therefore, possible, mulch or soil could be used to cover the seeds pre - applications.

In the proposal there was $26,120.00 for a flat rate contractor James Beaver who works for MESS. Mr. Beaver was unable to work on this project in 2013, and this portion of the project was allocated to Dr. Mathers also of MESS in a consulting capacity and the remainder went to Luke

Case of OSU. In the proposal there was $5,640.05 for travel; however, due to the extensive number of trials that we did in this project the number of evaluations required was more than expected. We actually spent less in salary and more in travel than proposed.

CONTACT INFORMATION

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ADDITIONAL INFORMATION

PROJECT TITLE Western Michigan University: Enhancing Competitiveness for Specialty Crop Producers in Michigan through Agri-Tourism and Other Direct Retail Sales Options - FINAL

PROJECT SUMMARY

The purposes of the project included: 1) a determination of the types of consumer marketing and retail activities conducted by specialty crop producers in Michigan, 2) an estimate of economic impacts of these activities for the agri-tourism operations that participated in the survey, 3) qualitative work establishing the importance of these operations, economically and culturally to tourism, to the state, and to the specialty crop operations that participate in agri-tourism activities, and 4) finally, to determine how the existing agri-tourism and state agencies associations might help improve the business climate related to the agri-tourism sector. The objective of the completed research was to identify best marketing practices for specialty crop growers and identify issues and concerns related to the consumer marketing of specialty crop products. The completed project intended to adopt a multi-method research approach, including the development of a GIS-platform data base of just over 2,800 agricultural tourism operations throughout the state, three regional focus groups composed of specialty crop growers, a survey of specialty crop producers participating in retail activities, and extensive interviews and site visits to dozens of agri-tourism operations. The results of the study will allow us to generate a reliable estimate of the actual numbers of these businesses in Michigan, and offer recommendations for how the state and growers' associations might provide greater support for these operations. The Michigan Agri-Tourism Association (MATA) can grow as an organization through efforts to expand membership by contacting the newly developed mailing list of operations we developed in the course of this project. The database is also "geo-referenced" to show the locations of operations, by type of activities and by economic region. In addition, analyses of findings can provide an accurate assessment of the economic contributions of these growers to the state, to state tourism, and to the rural economy.

Motivation of the project: The importance of specialty crop producers to the agricultural and rural economy of Michigan has long been recognized. Producing more than 300 different agricultural commodities, Michigan is the nation's second most agriculturally diverse state. In Michigan, as in most states, the past two decades have seen greater attention to direct consumer sales by specialty crop growers through farm markets, Consumer supported agricultural (CSA) production, on-line sales, and agri-tourism operations. The growth of agri-tourism coincides with an increase in small-scale farms in America. Turning quickly to the overall general importance of small farms in US agriculture, according to the 2007 US farm survey, 72.6 of US farms currently manage only 9.53% of US cropland (USDA 2008). Many of these small

farms report sales of under $10,000/year, but account for a growing number of specialty crop agri-tourism operations throughout the nation. Small farms and the diverse products they produce matter not only in economic terms but also because they represent potential engines of change with respect to ecological and economic practices in agriculture and are vitally important to the culture of rural America as well (Che, Veeck, and Veeck 2005).

A second important trend is the rapid growth of small-scale farms associated in some way with agri-tourism operated by women. The number of US farm operations run by women as of 2007 increased by 19% from 2002, compared to 7% increase in farmers overall. Women are "principal operators" of 14% of US farms (USDA 2008). This is an increase of 30% to 306,209 farms and in the 2012 farm census; this is expected to be over 15%. Statistically, women support consumption of organic produce as a means of protecting family health at higher rates than men (21% higher) (Curl et al 2013), and it may well be that women farmers with agri-tourism operations are cognizant of this trend and will be the first to take advantage of it!

Previous Funding: This project does NOT build on a previously SCBGP or SCBGP-FB funded project.

PROJECT APPROACH

Activities Summary: This mixed methods project had five major components that incorporated both qualitative and quantitative methods of data collection conducted over the course of the year-long research period. The first (1) was the development of a comprehensive list, or census, of specialty crop producers in the state of Michigan which than became the mailing list (paper and e-versions) of the *Michigan Specialty Crop Farm Retail Sales Survey*. In the second stage (2) we conducted a set of three focus groups with specialty crop growers (6-9 participants per focus group), in three distinct agricultural regions, directed at identifying current issues and concerns with respect to the retail marketing of the state's specialty crops and how the state might help growers continue to operate successful agri-tourism operations. Results from the qualitative focus groups led to the development and distribution of (3) a systematic quantitative survey distributed to over 2800 specialty crop agri-tourism operations throughout the state (again—component #1 resulted in this geo-coded data base and address and/or e-mail list). Concurrent with the distribution of the survey, (4) site visits were made to dozens of operations where formal and informal interviews with operators were conducted to clarify or build upon issues raised by focus group participants and survey respondents. Finally (5) survey data were analyzed and results have already been reported at three professional meetings (see below). The development of research publications to major journals is currently underway.

Significant contributions and the roles of project participants:

Project partners: Western Michigan University – Departments of Geography and Marketing. Provided support, facilities and staff, including research undergraduates and graduates.

Michigan Agri-Tourism Association: provided access to email lists, membership files and facilitated focus group participation. Past president's Steve Tennes, Charles Goodman and current president Beth Hubbard were vital in providing access to members and information.

Michigan Farmers Market Association (MIFMA) provided access to membership files, access to location and market managers and general enthusiasm.

GOALS AND OUTCOMES ACHIEVED

Activities - With no current reliable estimate of the actual numbers of specialty crop growers in Michigan who engage in retail sales, our first step was to develop a database of specialty crop growers and determine how many of these producers currently, or have future plans to, sell directly to consumers. Using undergraduate and graduate student researchers all available data sources such as telephone books, internet lists, webserver mailing lists and specialty crop

membership lists were searched (n=2,800). Three focus groups, facilitated through MATA in three regions of Michigan (Kalamazoo, Lansing, and Traverse City), were created using 26 specialty crop agri-tourism operators. These groups identified concerns, issues and activities associated with their operations. A multi-media (paper and on-line) survey was designed based on these results, and distributed to the 2,800 agri-tourism operations identified in the first phase of our work. The survey served as a follow-up to a comprehensive survey of agricultural producers conducted ten years ago by the same research team. Two reminder mailers were sent later in the summer of 2013 to follow up. Findings generated by the survey data allow the research team to assess the economic contributions of specialty crop growers to the state, state tourism, and to the rural economy, as well as to identify effective retail marketing strategies that can be promoted through our colleagues in (MATA) who worked closely with the principal investigators to distribute the survey and promote results and action items to a larger audience.

1) GEO-CODED DATA BASE OF AGRI-TOURISM OPERATIONS: As noted above, initially, a comprehensive list of 2800 specialty crop producers in Michigan engaging in some form of agri-tourism was developed and "geo-coded" for subsequent use in a geographic information system (GIS) of all specialty crop growers, and those participating in the survey. Both the comprehensive list (in an Excel format) and the map (a .kmz document that requires Google Earth to open and operate) has been made available to the Michigan Agri-tourism Association (MATA) Board of Advisors, to MIFMA, and may be further accessed by emailing Dr. Hallett at luicus.hallett@wmich.edu.

2) FOCUS GROUPS WITH AGRI-TOURISM OPERATORS: Three focus groups, each consisting of six to nine owners of specialty crop agri-tourism operations, were conducted so as to explore issues related to the objectives of the study and to assist in the development of the survey. The focus groups were held in three diverse areas of the state, tentatively identified as the Southwest Michigan area (Kalamazoo) the Northwest LP area (Traverse, Ellsworth), and the Lansing/ Flint area (East Lansing). Areas of content covered in the focus groups include products and services offered by the participant's business; extent to which their business markets directly to consumers; benefits and drawbacks of marketing directly to consumers; types of promotion and publicity used; impact of these activities on these farm operations, to consumers, and to the state of Michigan. The recorded tapes for all three focus groups—over 6.5 hours in total—were transcribed and made available to MATA as well as the PIs for use in trade publications and academic research articles. These are available in CD format for anyone wishing to investigate further.

3) MULTI-MEDIA SURVEY DEVELOPED, DISTRIBUTED, AND ANALYZED: Based on the focus group transcripts –as well as site visits and discussions with other agri-tourism operators, a survey was developed and distributed both electronically and in hard copy form to 2,800 addresses (standard addresses and/or e-mails when available). A minimum sample size of 350 completed surveys was set as the goal, but only 252 "usable" surveys were returned (more on this later). This data base, with the names and addresses of the operations removed for privacy was also made available to MATA as well as the PIs for use in trade publications and academic research articles.

4) IN-DEPTH INTERVIEWS WITH SELECT AGRI-TOURISM OPERATORS: Collectively, site visits were made by all four PIs to agri-tourism operations in all three areas where focus groups were conducted for the purpose of observing actual operations and discussing main issues with operators. Fourteen in-depth producer interviews were conducted by Dr. Deborah Che in August and September regarding customer demographics, issues of scale/consolidation, linkages with other agri-tourism businesses, links with restaurants and culinary tourism more generally, involvement in food/wine trails,

advertising/cross promotion strategies, opportunities and challenges in direct marketing, the role of the state of Michigan and 'Pure Michigan' in particular in driving visitors to their site, outlets for their specialty crop products (on-site, at other sites such as farmers markets, on-line), donations and work with charities, and involvement with food assistance programs (i.e., Double Up Food Bucks). For producers who participated in the focus groups ten years ago, further information was sought in these interviews regarding changes in their agri-tourism business over that period of time, agri-tourism and direct marketing of specialty crops as a family farming/survival strategy, and the role of women producers. Additionally, six in-depth interviews were conducted by Dr. Che with managers of key Michigan farmers markets regarding the issues outlined above as well as the role of the farmers market as a tourist attraction/destination. In addition to the in-depth producer and farmers' market manager interviews, information was gathered from individual farmers' market vendors, wineries and restaurants. Audio CDs of these in-depth interviews were made available to the PIs for use in trade publications and academic research articles.

Progress with long-term outcome measures

Actual Accomplishments versus Project Goals: As a research unit we feel that we realized all of the project goals. Obviously we have not successfully published our four journal articles yet, but we have initiated the process of that and will have submitted the articles for consideration in the next few months.

Evidence of Completed Outcomes:

BENEFICIARIES

The Michigan Agricultural Tourism Association (MATA) has been provided with an analysis of the issues and results with the hopes that membership can be increased through targeted outreach to specialty crop growers that participate in some form of retail activity related to their specialty crops. The Michigan Famers Market Association has been provided with the results, as well, in hopes that their best marketing practices will improve sales of Specialty Crops. Of course, ultimately, we show that evidence we provide related to the benefits of agri-tourism to the Michigan Department of Agriculture & Rural Development and *Pure Michigan (*Michigan Economic Development Corporation) will raise the profile of agri-tourism in the state and help the specialty crop producers engaged in agri-tourism.

Quantitative Data Collection

A wide range of quantitative data was collected through the survey. The low response rate, discussed below, is a concern, but still data were collected for 152 agri-tourism operations related to employment, gross and net revenues, advertising costs, wage rates, and many other micro-economic variables related to the operation of individual specialty crop agri-tourism firms. Appendix I is a copy of the PowerPoint presentation that incorporates this micro-economic data along with many other types of systematic data collected by the surveys and the focus groups. Of course, these data will all be used in subsequent reports and research articles as well.

LESSONS LEARNED

Agricultural tourism is an increasingly important segment of Michigan's farm sector and economy. Agricultural tourism enhances Michigan's reputation as a tourist destination, as well as provides residents with great, fresh food, recreational and educational opportunities, and a source of both employment, and revenue. Additionally, agri-tourism provides farm visitors with the cultural and outdoor experiences that are a hallmark of Michigan's past and present. There is no qualitative measure, or set of facts, that can over-estimate the important contributions that these farms and their families provide to Michigan's life and culture. Michigan's specialty crop growers selling on-farm and at other emerging market options have invigorated many rural areas in Michigan, while providing employment, tax revenues, economic development, and memories!

Completing this project generated both the quantitative data discussed above and shared with the Michigan Agri-tourism Association, as well as, a set of macro-issues that we summarize below.

1) Agri-tourism is an important economic activity in many rural and peri-urban areas of Michigan: Many of the rural places where Michigan's agri-tourism operations are located have experienced out-migration of youth and corresponding high unemployment rates. As the quantitative results of our survey show, some of these operations provide full-time and part time jobs to thousands of Michigan residents. These wages are often spent locally, shoring up rural economies throughout the state and providing a sense of local identity and attracting tourists from throughout the US Midwest and Canada.

2) Hard lesson: Estimating the number of Agri-tourism Operations is difficult: While every effort was made to identify as many operations as possible, there is little doubt in our mind after completing the project that while we identified almost 2,000 farms with specialty crop agri-tourism operations in 2013, we probably missed at least another 1,000 simply because these firms, smaller in scale, did not have a website, or were not registered with their local Chamber of Commerce or specialty crop growers association. Lately, a simple drive around the state reinforces this problem. Those we missed are probably smaller in scale of operation, but that is really the point of our inquiry- where and how can we find these operations? Additionally, there is no reason to believe that this is always the case, many larger operations did not respond to our survey. All of these operations that we missed provide the same cultural benefits and, at the least, provide partial employment to one or two people.

3) More large operations, more small operations, fewer mid-size agri-tourism operations: What is patently clear from our survey results is that, as the industry matures, there is a growing gap between a limited number of larger operations, such as, many of the wineries or blueberry operations, or some of the more sophisticated "farm experience" and "farmers market" operations that are open year round, and the smaller operations where agricultural tourism provides a secondary source of income during a very limited portion of the year. Adding to this complexity is the fact that a growing number of the smaller operations not only welcome on-farm visits, but also opt to maintain a regular presence at the growing number of farmer's markets throughout the state. This growing heterogeneity presents some important challenges to umbrella organizations, such as, the Michigan Agricultural Tourism Association. As if this divergence in the types of agricultural tourism operations in Michigan is not enough, the strong and effective role that specialty crop growers associations play in Michigan means that farmers, to some extent, are challenged to divide their attention between the state's agricultural tourism association (MATA) and their specific specialty crop associations or boards. Based on our review of literature from other states, we do not believe that Michigan is unique in this regard. Still, the departments of agriculture in most other states with a diverse product base have dedicated personnel supporting agricultural tourism. States such as New York, New Hampshire, Vermont, New Jersey and Wisconsin all have staff that serve as clearinghouses for information to family farms operating, or considering operating, agri-tourism operations but also as advocates presenting industry concerns to other state agencies and state legislatures and congress-persons. Just as the industry matures, on the surface, "common ground" for these businesses may appear more difficult to find given the divergence in scale and the greater range of products involved in agri-tourism operations. A farm producing lavender and other essential oils that invites visitors to learn to make soap or perfume at first glance appears quite different from a u-cut Christmas tree farm. Certainly, every operation is wonderfully unique, that is part of the appeal of these businesses to the customer base that has grown increasingly diverse. On the other hand, all agricultural tourism operations continue to have common interests related to on-farm liability, state-led promotional efforts, and pro-agri-tourism legislation with respect to

signage, insurance, health regulations and the like. So, there is no lack of shared interest, but with the great breadth of agri-tourism operations in the state of Michigan, with respect to size and revenues, it is difficult to get all of these businesses on the "same page". Dues of one or two hundred dollars are inconsequential for the large operations that participated in our survey, but for a short season raspberry u-pick, the dues are still real money. Based on dozens of hours of interviews and countless visits to individual farms (the fun part), we think that state must take a greater role. A dedicated MDARD liaison officer working with MATA to coordinate policy development and promotion would be invaluable.

4) **The definition of "agri-tourism" seems to be shifting**: Quite surprising and interesting in terms of an outcome, as well as a reason for non-participation, we were informed by several operations that mailed the survey back but did not complete the survey that they did not think of their operations as "agri-tourism", despite the fact that they sold specialty crops at their farms. It seems we did not anticipate that confusion of what constitutes "agri-tourism" is not only common among consumers and members of the Michigan legislature, but also among firms selling specialty crops and other products on-site as well. One member of MATA confirmed this when she told us that she believed the agri-tourism in Michigan has an "identity problem". The lack of a shared understanding among different stakeholder groups of what agri-tourism is has been found to hamper technology transfer, producers' ability to reach their target market and increase revenues, and consumer awareness about the activities offered (Arroyo et al., 2012).

5) Challenges to MATA (Michigan Agri-tourism Association): There are numerous concrete steps that MATA can take to extend their influence and support roles both in terms of specialty crop agri-tourism operators AND the Michigan Department of Agriculture & Rural Development (MDARD), and the Michigan State legislature. 1) Expand membership— and prove the benefits of membership. This is complex given the growing diversity of firms in terms of products, services, AND scale, but lies at the core of MATA as a service organization. WMU Geography currently has a viable mailing list of 1,793 firms that we provided to MATA for their use in membership appeals. 2) Publically address the "disconnect" between CSA's, Farmers' markets, local food movement, AND agri-tourism (MATA). Many respondents feel no relationship among these interest groups despite what we (WMU/MATA) might think. What is MATA's position? 3) Maintain relevance: Create and promote help with legal issues such as liability, signage, permits, health department issues (toilets; kitchen equipment/inspections), unemployment issues associated with seasonal labor, and others. Seminars on these issues and others such as applying for licenses, tax issues, marketing, out-of-state sales etc. are recommended. 4) MATA as a leading proponent of the integration of Michigan specialty crop agriculture and agri-tourism in the successful "Pure Michigan" campaigns. Leadership here is essential and may well be a most effective means of increasing membership. This goal is consistent with the 2012-2017 Michigan Tourism Strategic Plan.[1]

Goals NOT Achieved

As the researchers on this project we always would feel that there are multiple things we have not achieved or would like to re-do. The primary concern for us as we look to investigate this process in the future is one of timing. 1) There are multiple suggestions that our survey would have been more effective if it had arrived earlier in the year. The process of gathering the focus groups, consolidating the results, initiating the printing company for mailing lists, survey size, survey length and mailing costs pushed the mailer into the time frame where specialty crop producers were either in the field or in the process of initiating growth of their products. And

[1] See Objective # 2 under the Resources and Environment Goal (Objective 2: Support and expand efforts to inventory resources critical to Michigan tourism and communicate results to relevant entities) http://www.michigan.org/lib/files/Industry/Tourism_Strategic_Plan/Tourism_Strategic_Plan.pdf

second, but most important: 2) Survey fatigue! We had expected a higher response rate, particularly given the use of an i-pad incentive (awarded via a MATA drawing after we provided cards with all respondent addresses –value $500.00—not covered in the grant). We were told by a number of non-respondents—after the fact—that they felt "over-surveyed", especially given that they had just completed the 2012 USDA Farm Survey and had also gotten a variety of other on-line and paper surveys at the same time as our survey was being conducted. In addition, frost in 2012 required that we collect data on both 2011 AND 2012 for all econometric data which was not originally conceptualized. This lengthened the survey and may have discouraged some respondents. We felt we needed the two years of data given that revenue, advertising, employment, etc. all dropped due to the severe spring frost. And last, the goal to increase membership in the Michigan Agri-tourism Association from 270 current members to 400 members (approx. 50% increase) is one that currently cannot be measured. This will need to be addressed at a later date with further research.

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Curl C.L, S. A. A. Beresford, A. Hajat, J. D. Kaufman, K. Moore, J. A. Nettleton, A. V. Diez-Roux. 2013. Consumption with Socioeconomic Status and the Local Food Environment: Multi-Ethnic Study of Atherosclerosis (MESA), PLOS, http://www.plosone.org/article/info%3Adoi%2F10.1371 %2Fjournal.pone.0069778
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CONTACT INFORMATION

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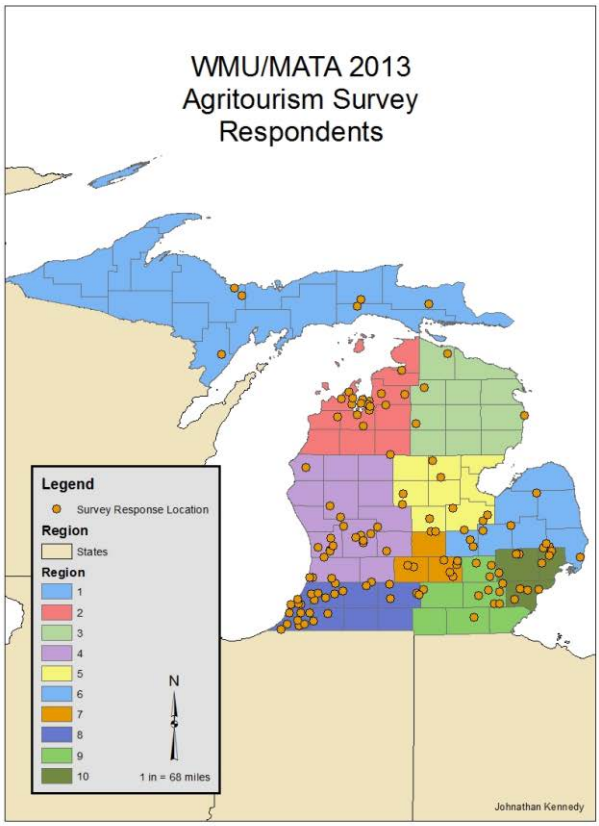
ADDITIONAL INFORMATION

Appendix 1


WMU/MATA 2013
Agritourism Survey
Respondents
Legend
Survey Response Location
Region
States
Region
1
2
3
4
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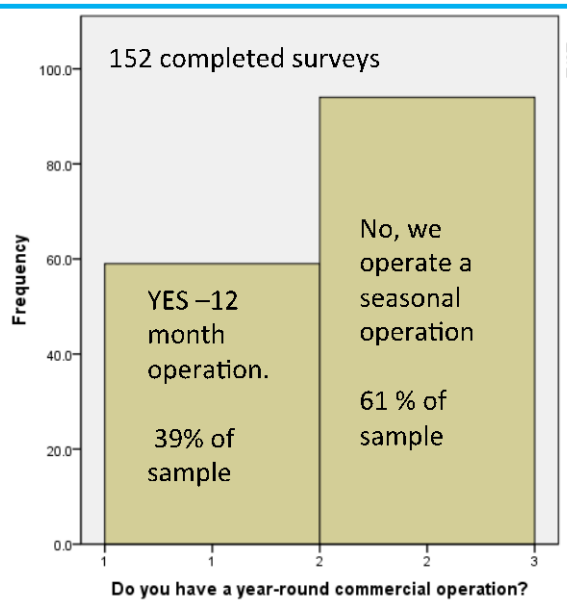
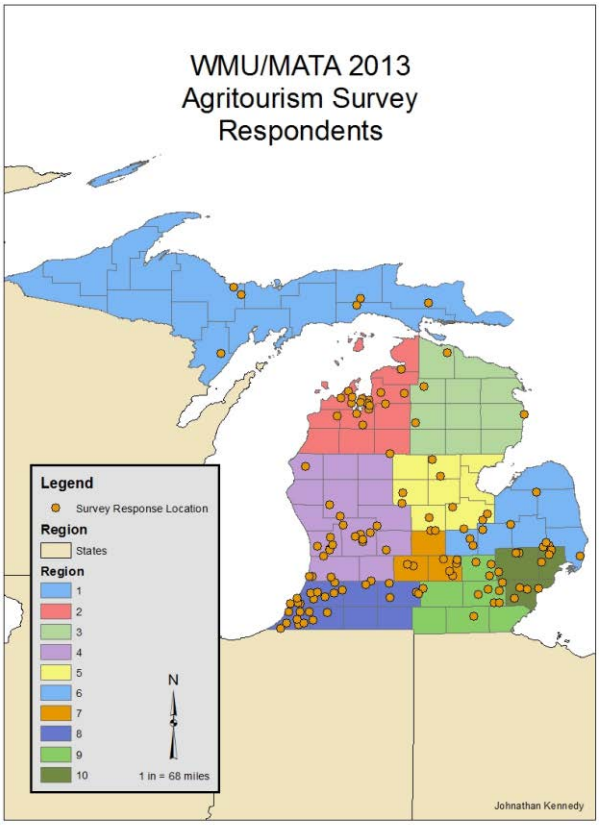
8
9
10
N
1 in = 68 miles
Johnathan Kennedy

Survey Response Rate by Self-reported Period of Operation



The response rate is very low. Typically, we would expect 10-15% for a two-media survey (on-line and paper options).

Low response rate due to :
#1: "Survey exhaustion"
2: Privacy concerns i.e. "I am uncomfortable providing WMU/ MATA with this information"
3: anti-government sentiments i.e. "Stay out of our business"
4: "disconnect between term "Agritourism" and the activities of their businesses (CSA, growing vegetables to "sell local" etc. Many did not see how their activities were "agritourism" despite on-farm sales!!



Categories of Firms: **2013** Agritourism Survey—Two New!

- 1) Animal-related Firms (18.4%)
- 2) Berry-based Firms (4.6%)
- 3) Christmas Centered (3.3%)
- 4) Fall Harvest Firms (9.2%)
- 5) Farm Markets (33.3%)
- 6) Farm "Experience" (5.2%)
- 7) Honey/Maple Based (5.2%)
- 8) Nurseries (3.3 %)
- 9) Orchards (12%)
- 10) Vineyards (3.3%)
- 11) Hops/Essential Oils (1.3)
- 12) Fish/Fish ponds (0.7%)

Categories of Firms: **2002-2003** Agritourism Survey Participants by

- 1) Animal-related Firms (6.3 %)
- 2) Berry-based Firms (12%)
- 3) Christmas Centered (11 %)
- 4) Fall Harvest Firms (11.3%)
- 5) Farm Markets (18%)
- 6) Farm "Experience" (3.3%)
- 7) Honey/Maple Based (3.3%)
- 8) Nurseries (12 %)
- 9) Orchards (18.3%)
- 10) Vineyards (4.7%)

Comparison of Survey respondents by year and categories of Firms: 2003 and 2013

- 1) Animal-related Firms (6.3 %)
- 2) Berry-based Firms (12%)
- 3) Christmas Centered (11 %)
- 4) Fall Harvest Firms (11.3%)
- 5) Farm Markets (18%)
- 6) Farm "Experience" (3.3%)
- 7) Honey/Maple Based (3.3%)
- 8) Nurseries (12 %)
- 9) Orchards (18.3%)
- 10) Vineyards (4.7%)

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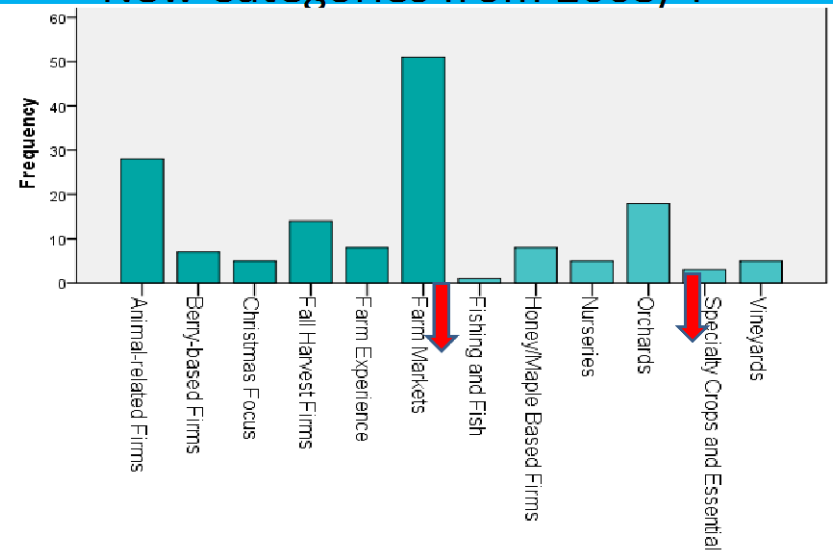
- 9) Orchards (12%)
- 10) Vineyards (3.3%)

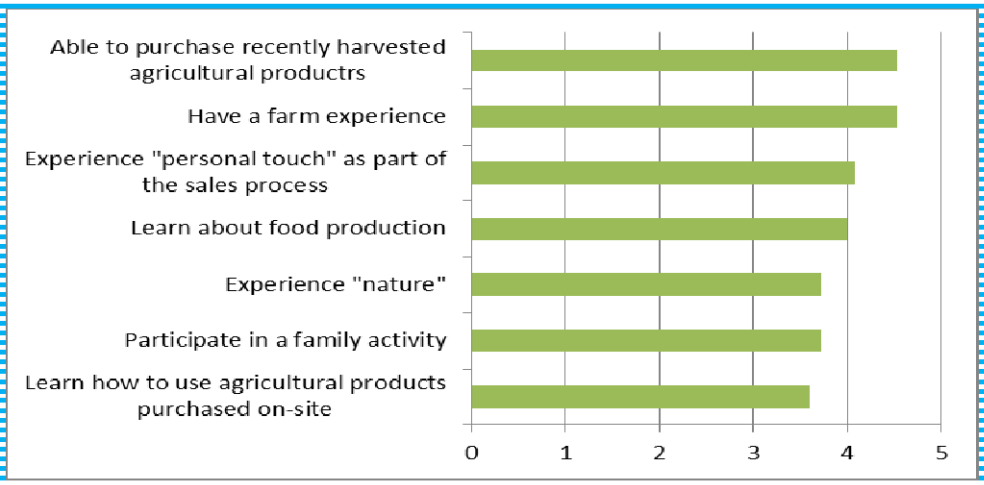
11) Hops/Essential Oils (1.3) and 12) Fish/Fish ponds (0.7%)= 2.0% in 2013

Categories of Firms: 2013 Agritourism Survey—Two New Categories from 2003/4



Take-away: Needs broader membership appeal to these new types of operations.

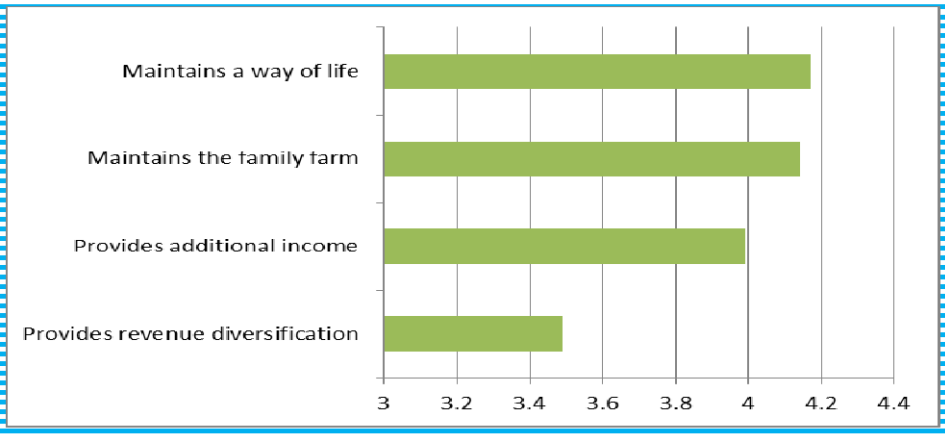
Benefits of Agritourism to Consumers*



*Scale of 1 to 5, with 1 =“no benefit at all” and 5=“strong benefit”

- Top perceived benefits are 1) the ability to purchase recently harvested agricultural (4.54) products and 2) the ability the have a farm experience (4.53).

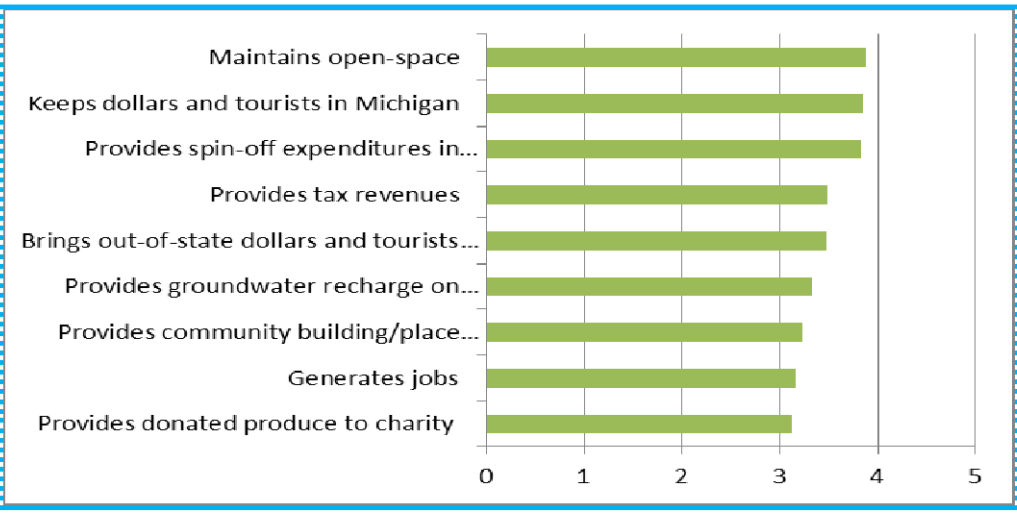
Benefits of Selling Directly to Consumers for Farmers*



*Scale of 1 to 5, with 1 =“no benefit at all” and 5=“strong benefit”

- Top perceived benefits are 1) Maintains a way of life (4.17) and 2) Maintains the family farm (4.14).

Benefits to Michigan - Agritourism Operations*



*Scale of 1 to 5, with 1 =“no benefit at all” and 5=“strong benefit”

- Strongest perceived benefits are: 1) Maintains open-space (3.88), 2) Keeps dollars and tourists in Michigan (3.87), 3) Provides spin-off expenditures for local business (3.83) money.

We cannot live in the past but a look or two over our shoulder can be useful!

Reasons for operating agritourism operation are unchanged.

Several times in the presentation, we compare responses from 2003 and 2013 survey.

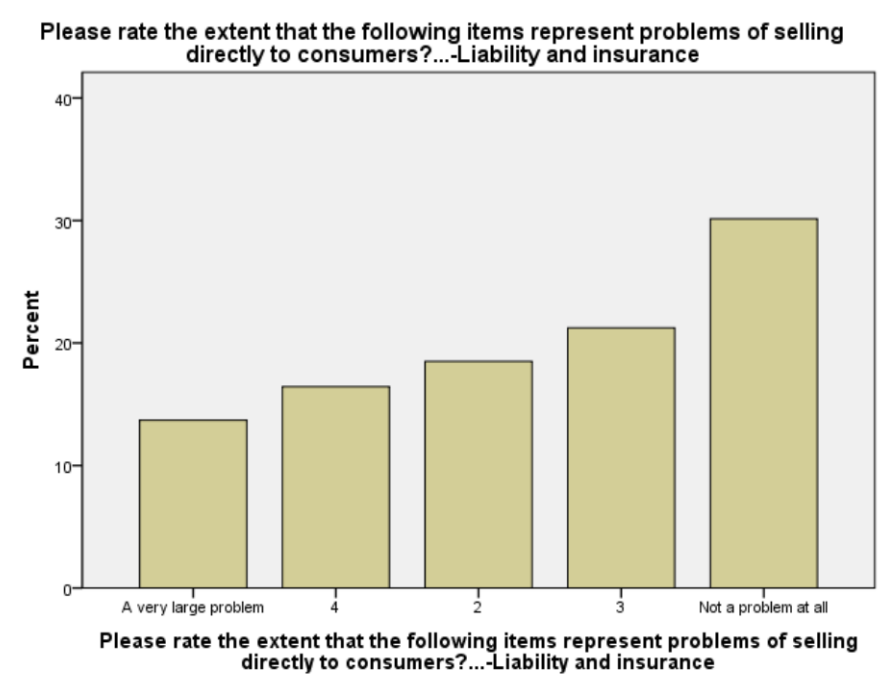
On our FIVE point scales:	2003	2013
• Maintains a way of life	4.27	4.17
• Maintains the family farm	4.21	4.14
• Provides additional income	4.15	3.99
• Revenue diversification	3.83	3.49

A comparison of reasons why OPERATORS feel agritourism is increasingly popular

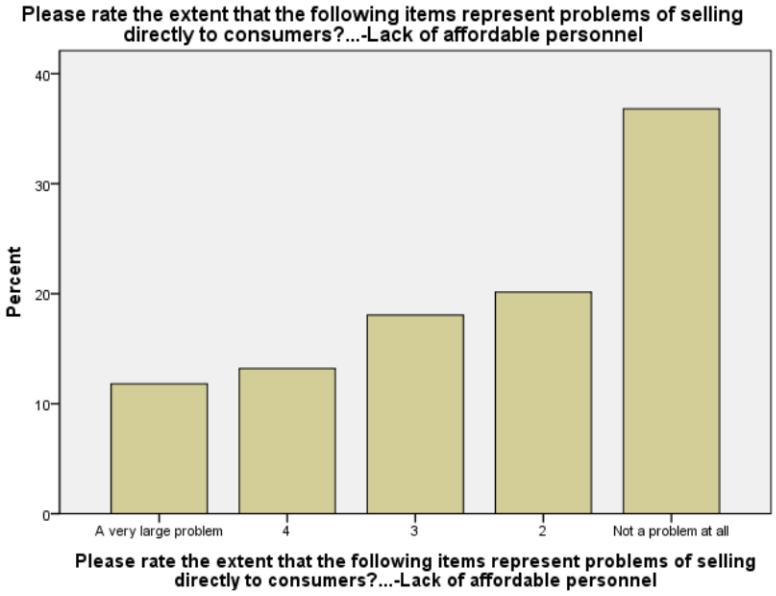
	2003	2013
Chance to meet growers	4.37	4.08
Purchase fresh agricultural products	4.25	4.54
Participate in a family activity	4.22	3.72
Have a farm experience	4.09	4.53
Experience "nature"	4.04	3.72
Learn how to use agricultural products	3.71	3.6
Revisit farm lifestyle of family or friends	3.64	3.6
Learn about food production	3.44	3.99
Farm setting for special events		2.06
Experience nostalgia		3.5
Try new products		3.69

We can return to these issues later—but there is a link here to new promotion/advertising efforts.

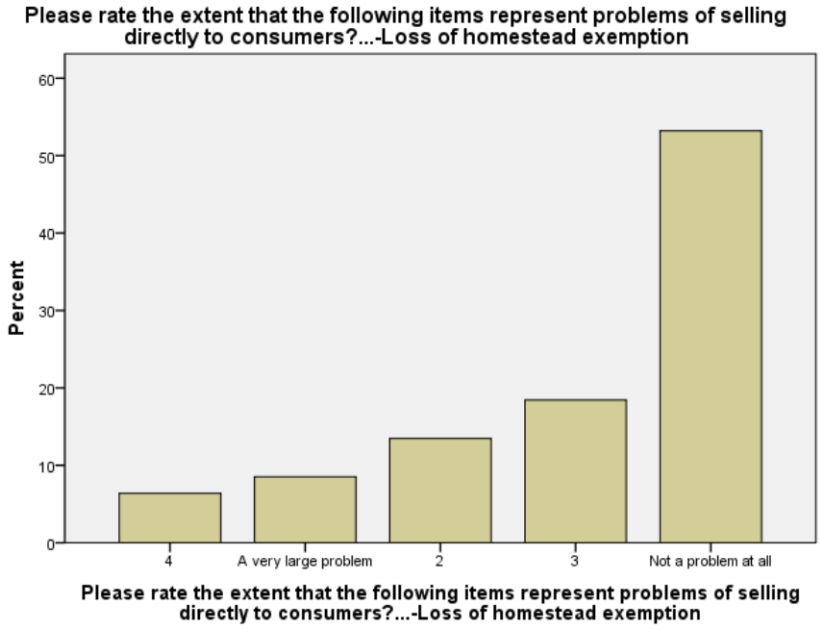
Liability and Insurance?



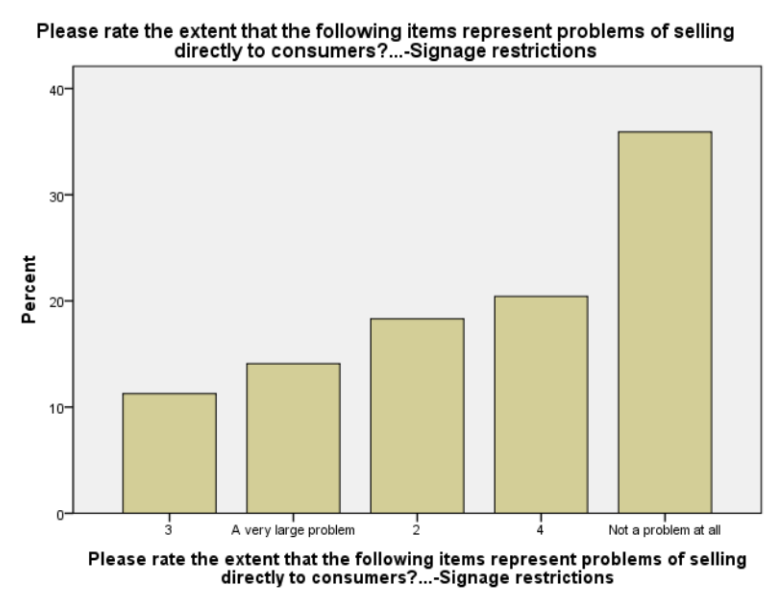
Lack of Affordable Workers?



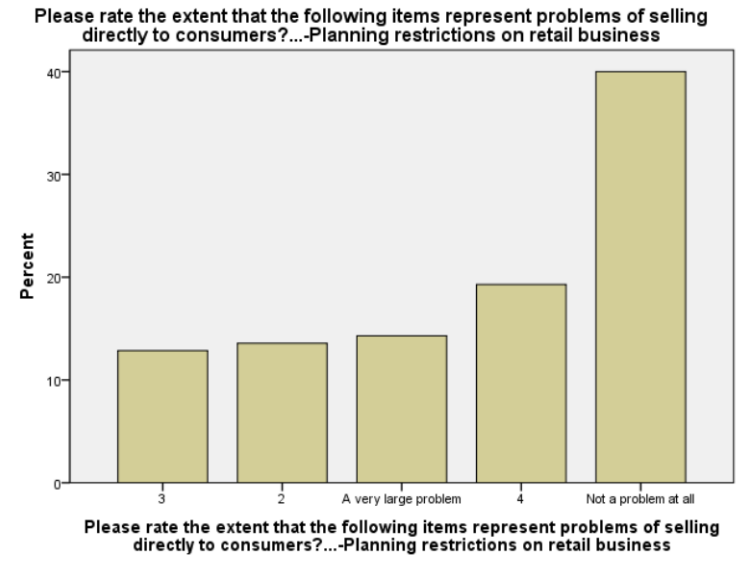
Loss of Homestead Exemption?



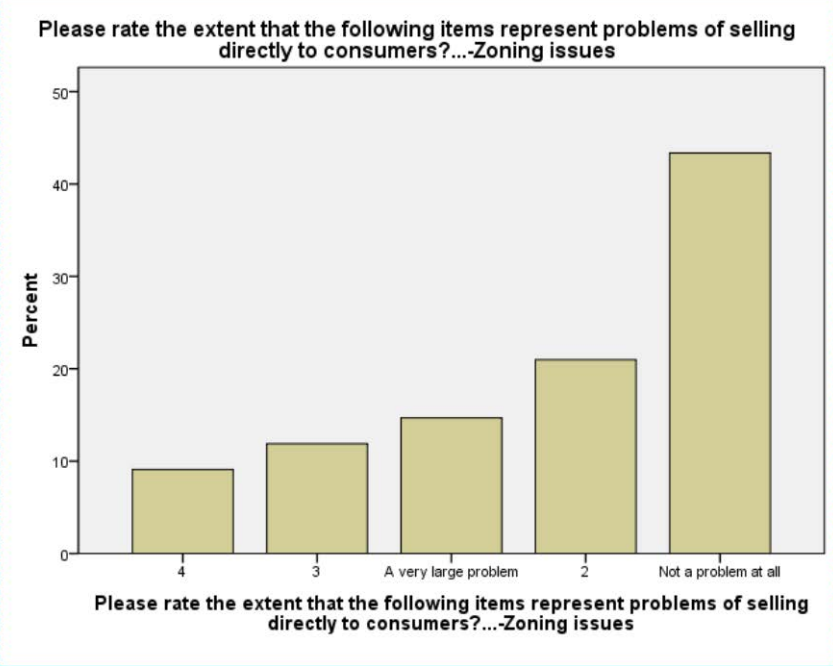
Restrictions/ Regulations related to Signage?



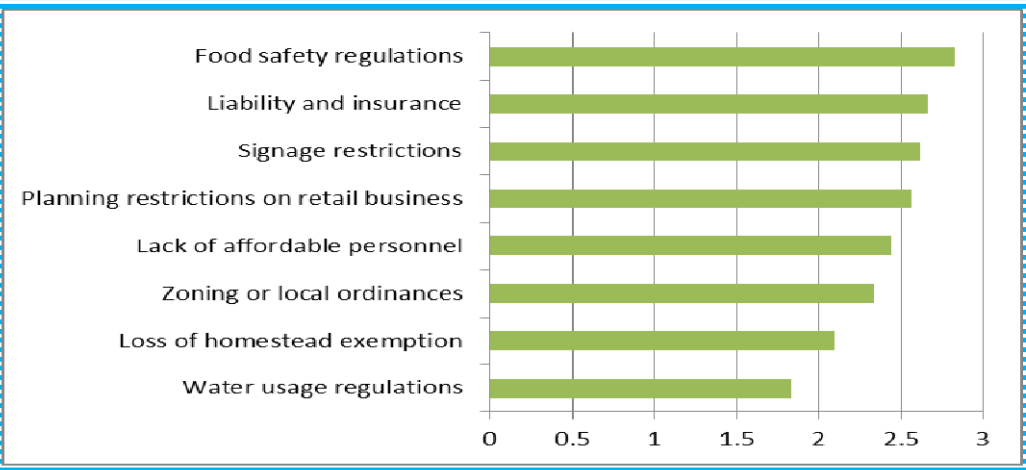
Planning Restrictions related to on-farm retail?



Zoning Issues?



Problems of Selling Directly to Consumers*



*Scale of 1 to 5, with 1 =“not a problem at all” and 5=“very large problem”

- The largest perceived problem is food safety regulations (2.83).
- No problem received a mean average in the category of “large” or “very large” problem.

Severity of Problems faced by agritourism operators completing the survey—5 point scale with 5 being most important

	2003	2013
Loss of homestead exemption	4.38	2.09
Zoning or local ordinances	4.38	2.33
Liability and insurance	4.37	2.66
Signage restrictions	4.16	2.61
Lack of affordable personnel	3.89	2.44
Food safety regulations		2.83
Water usage regulations		1.83
Planning restrictions on retail business		2.56

TAKE-AWAY: We added some new issues that emerged from focus group discussions in 2013, but importantly PREVIOUS issues including homestead exemption, zoning, insurance and signage issues seem to have decreased as concerns!

Other Concerns-Written Comments

- High taxes
- Local government is exceptionally rigid and controlling not willing to work with farmers
- Cost of advertising
- Unpredictability of number of farm visitors on a daily basis
- Age of Owners—"We are getting older"
- Meat processing laws that require USDA processing for beef, pork, lamb
- My issue is a zoning issue/ zoning issues are complicated and difficult to address
- We need agritourism insurance liability reform

Other Concerns-Written Comments

- It would help to change official definition of "locally grown" to 75 mile radius!
- State should include farmers markets in "Pure Michigan" materials
- Local politics affecting current location
- Insufficient labor willing to work on farm
- Problems with distribution
- We need more skilled labor
- The state needs to make CSA application easier
- Please work to reduce the costs associated with MDOT signage
- Unsupervised children, "parasites" who want to suck all the knowledge out for free, loss of home privacy
- Conflicts with neighbors

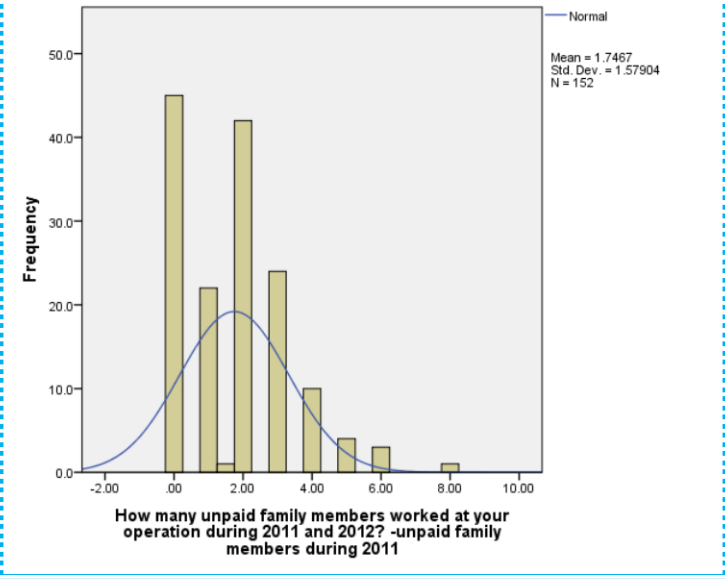
On-line Promotion Activities

Promotion Activity	DOES NOT USE (%)	DOES USE (%)
Farm Business Website	30.3	57.2
Facebook	36.2	50.7
Personal Firm Website	38.2	48.0
Twitter	73.0	13.8
E-mail list for customers	43.4	43.4
Cell phone application	82.9	3.9

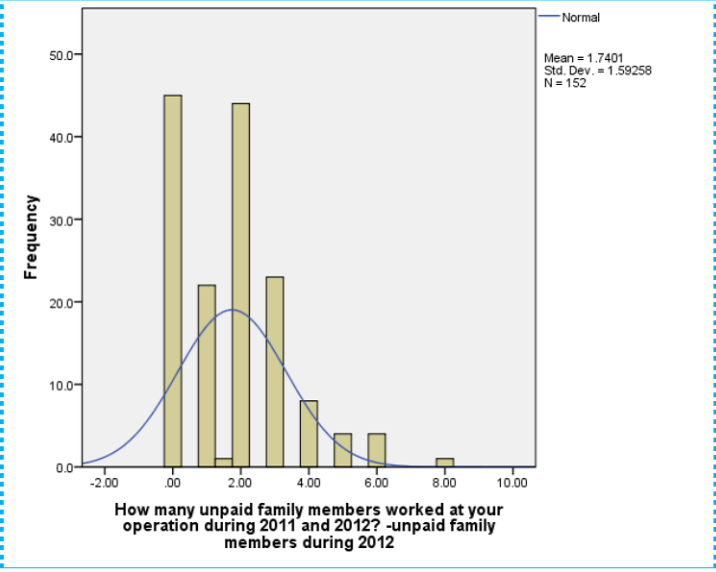
Media Promotional Efforts

Promotion Activity	DOES NOT USE (%)	DOES USE (%)
Newspaper Stories	52.6	34.9
Television Commercial	84.2	2.6
Mailing—Brochure direct	63.8	23.0
MDOT-dist. brochure	71.1	15.8
Recipe Book	78.9	7.9
Agritourism Guide	51.3	35.5
Newspaper Inserts	83.6	3.3
MDOT sign	80.9	5.9
Billboard	78.9	7.9
Sponsor Community Events	65.1	21.7
Press releases	70.4	16.4

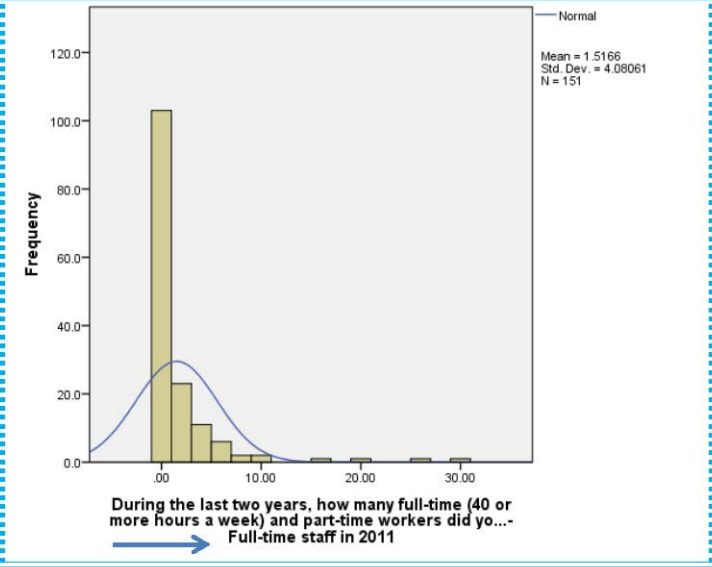
Unpaid Family Members in 2011



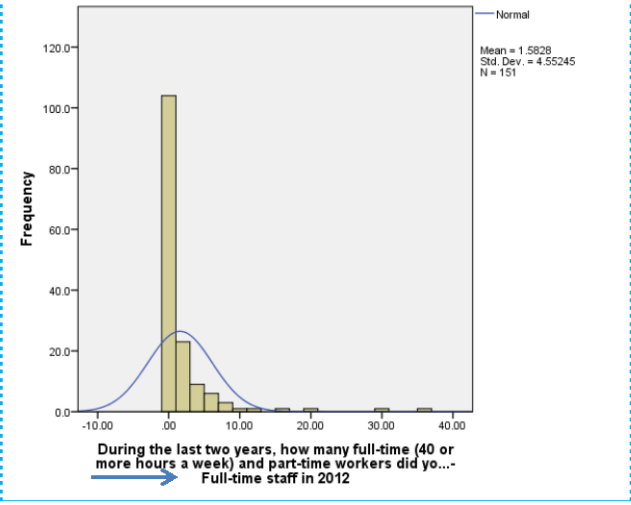
Unpaid Family Members in 2012



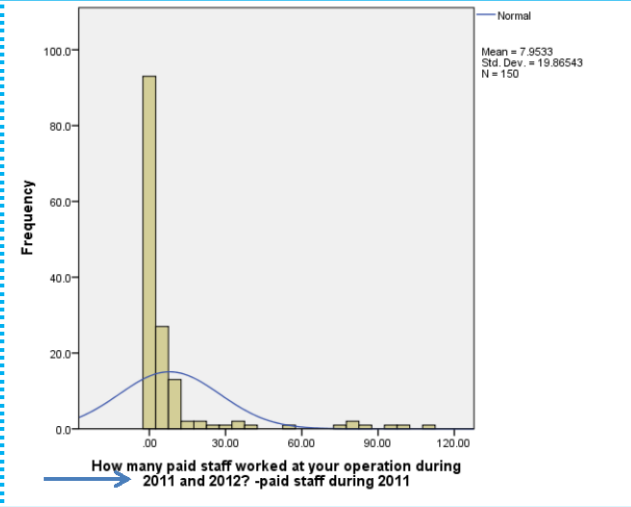
Full Time Employees: 2011



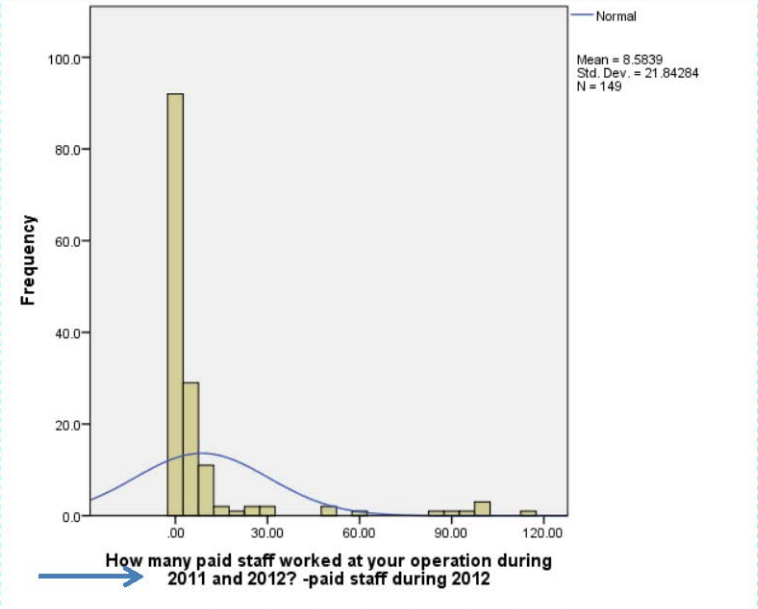
Full Time Employees: 2012



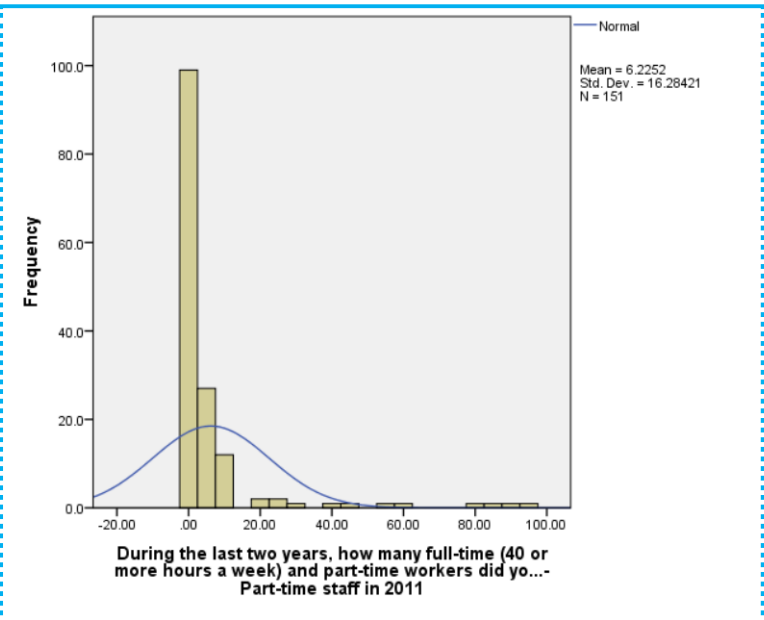
Mean Number of Paid Staff for 2011



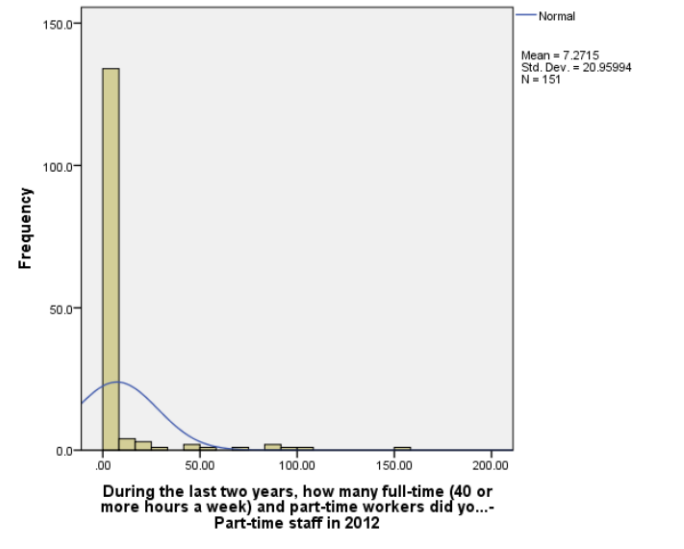
Mean Number of Paid Staff for 2012



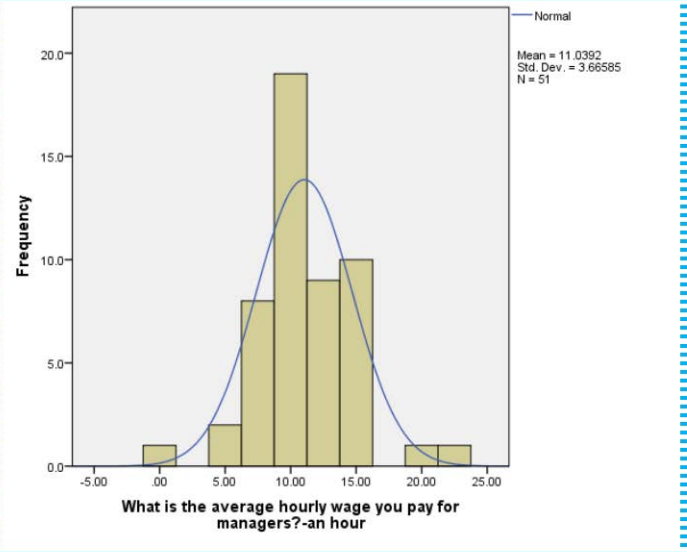
Number of Part-time Staff in 2011



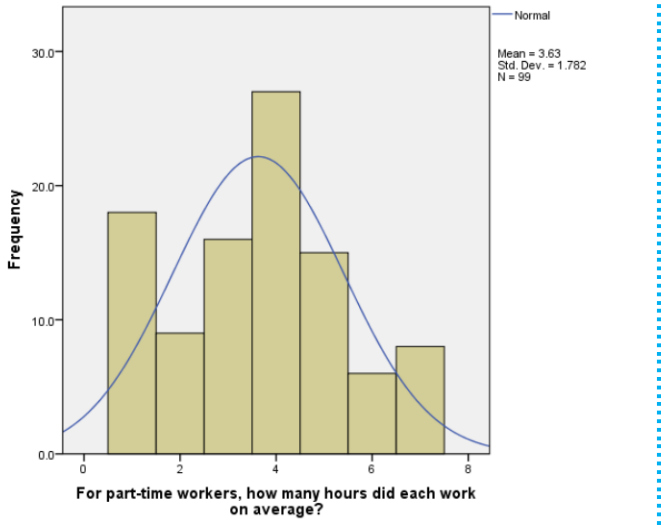
Number of Part-time Staff in 2012



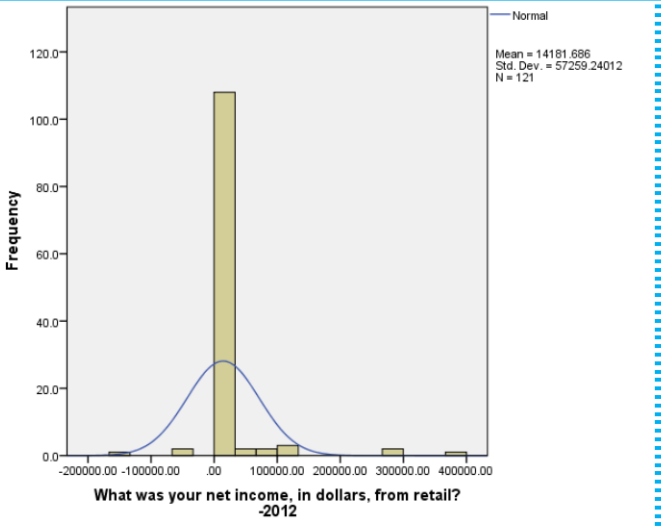
Manager's Hourly Wage in 2012



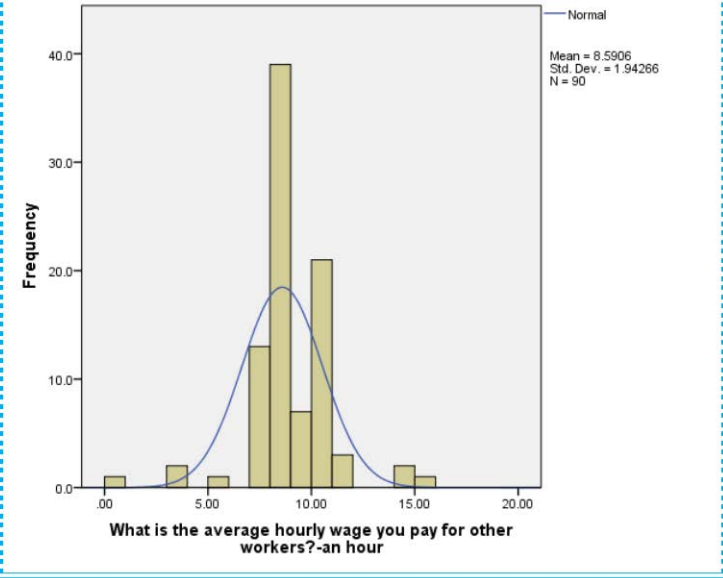
Hours worked per day for part time workers



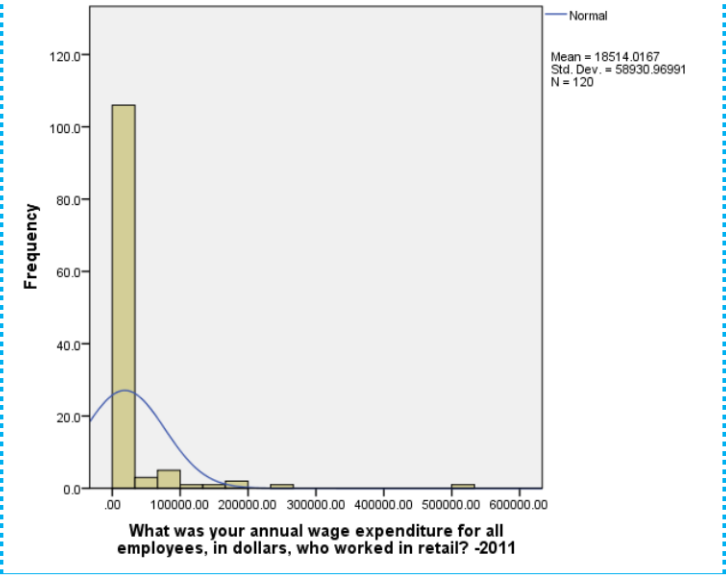
Retail Income: Why the AVERAGE is not accurate!!



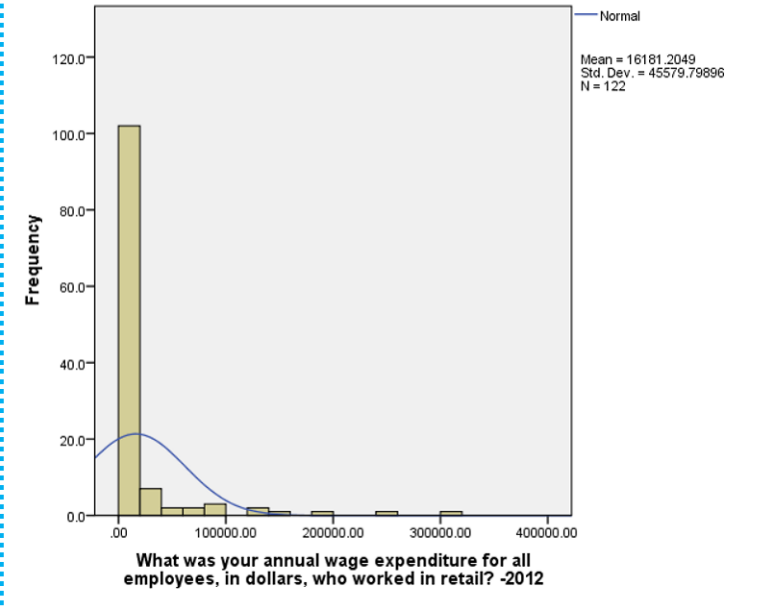
Hourly Wages paid to Non-managers



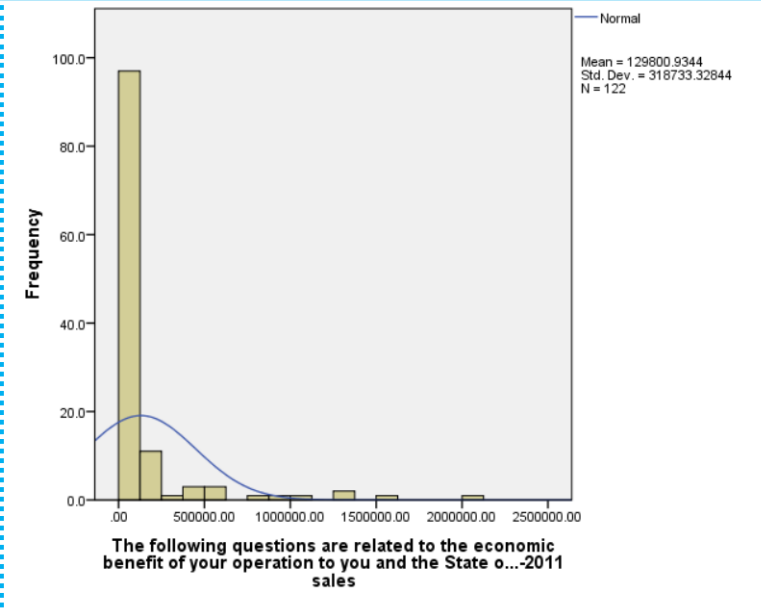
Total Value of Wages Paid in 2011



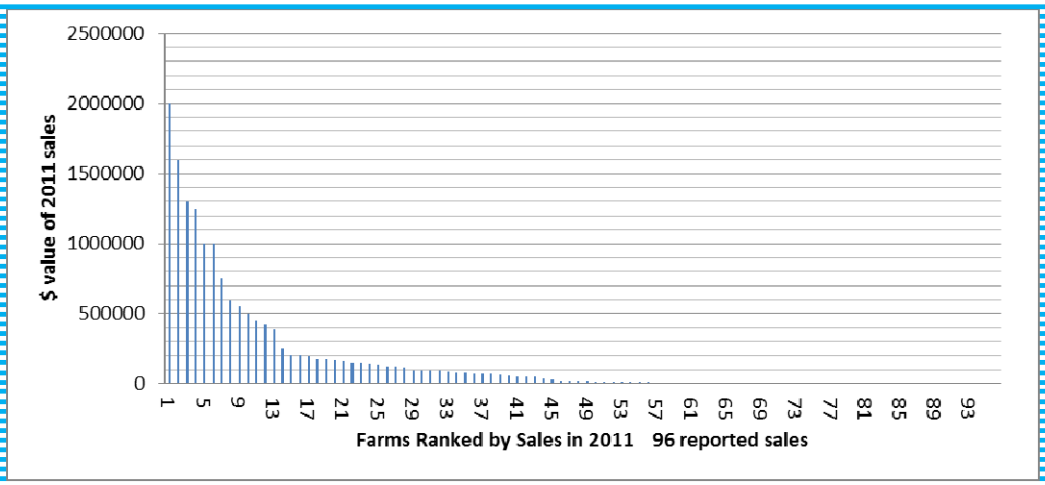
Total Value of Wages Paid in 2012



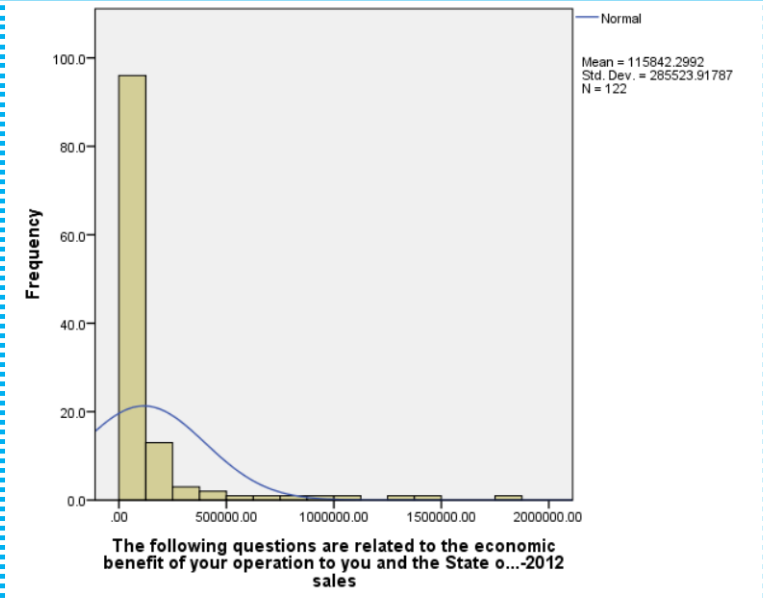
FULL SAMPLE: Gross Sales in 2011



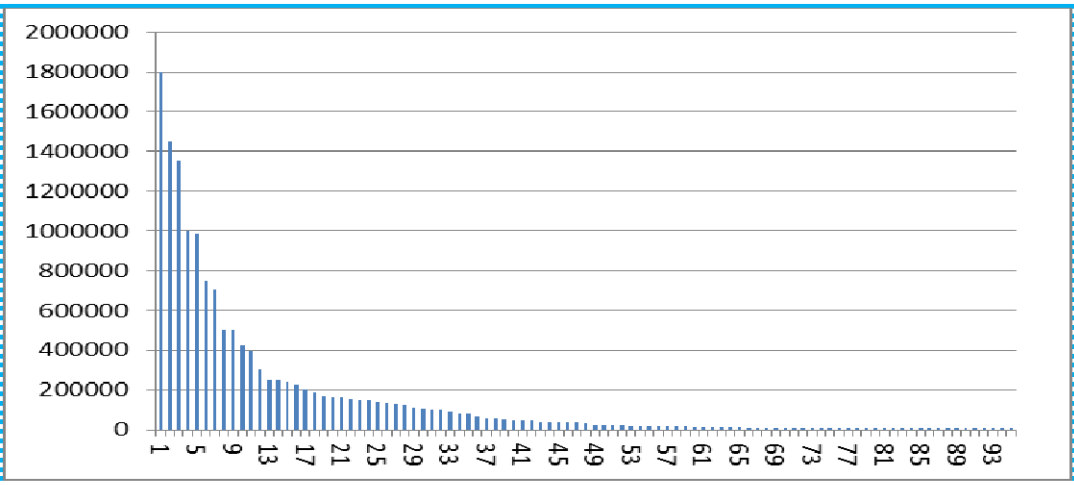
Partial SAMPLE: Operations with Gross Sales over $1.00 in 201



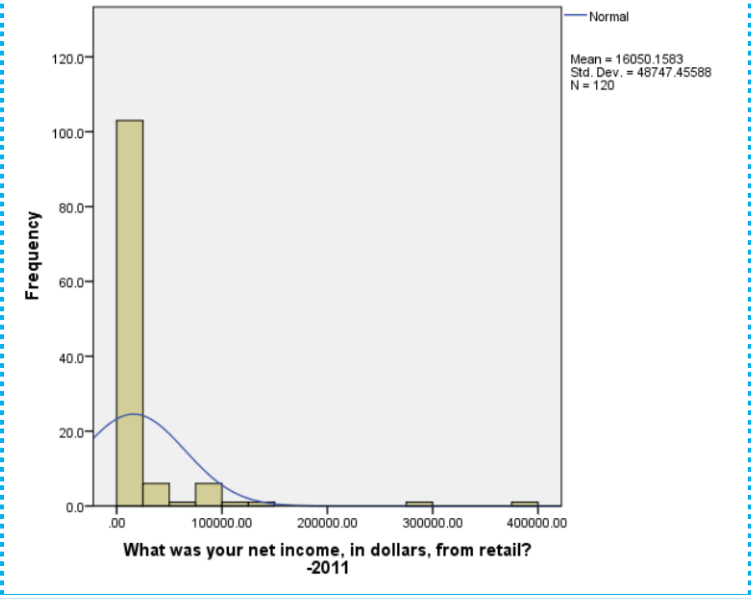
FULL SAMPLE: Gross Sales in 2012



Partial SAMPLE: Operations with Gross Sales over $1.00 in 2012



FULL SAMPLE: Net Income from Agritourism retail: 2011



SAMPLE with FIVE Operations with highest sales removed: Net Income from Agritourism retail: 2011

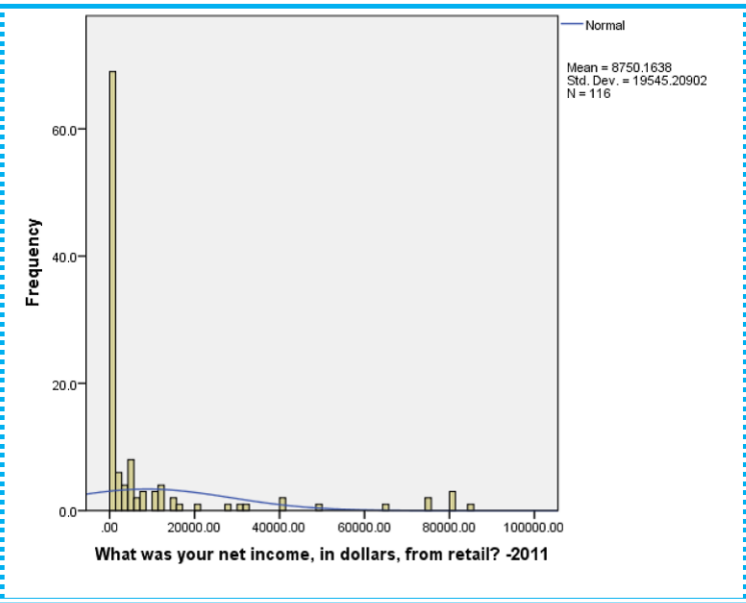
FIVE OPERATIONS REMOVED with net sales of:

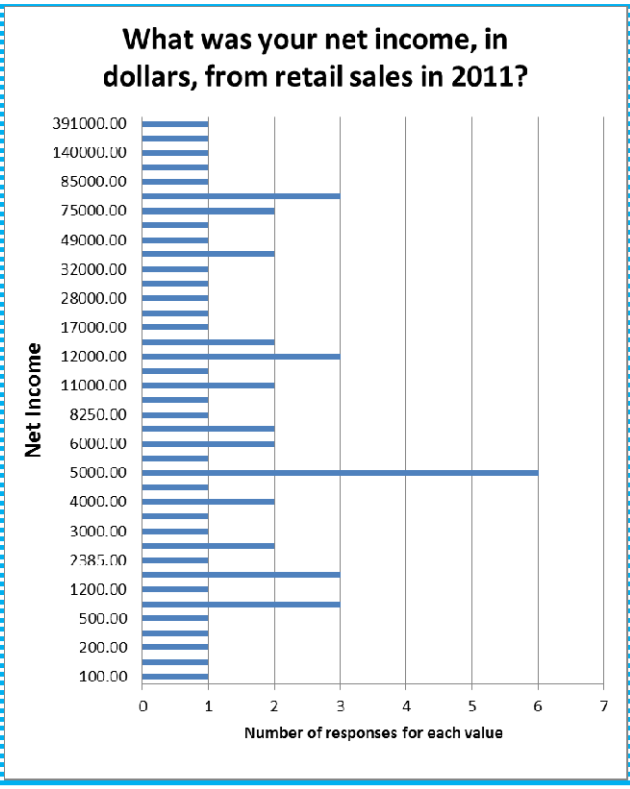
$391,000.00

$280,000.00

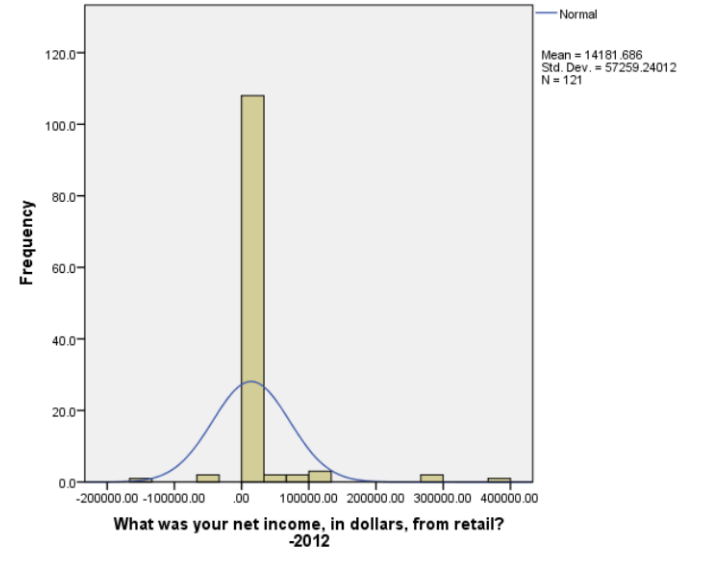
$140,000.00

2 X $100,000.00



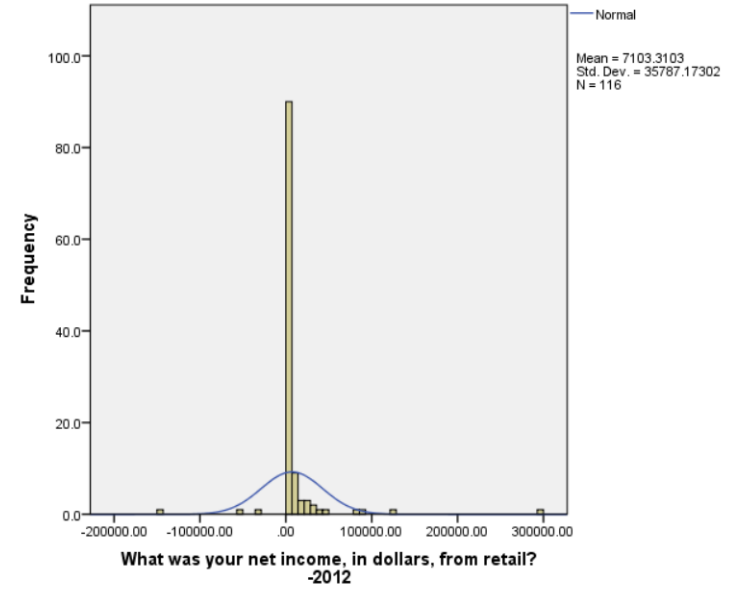


FULL SAMPLE: Net Income from Agritourism retail:2012

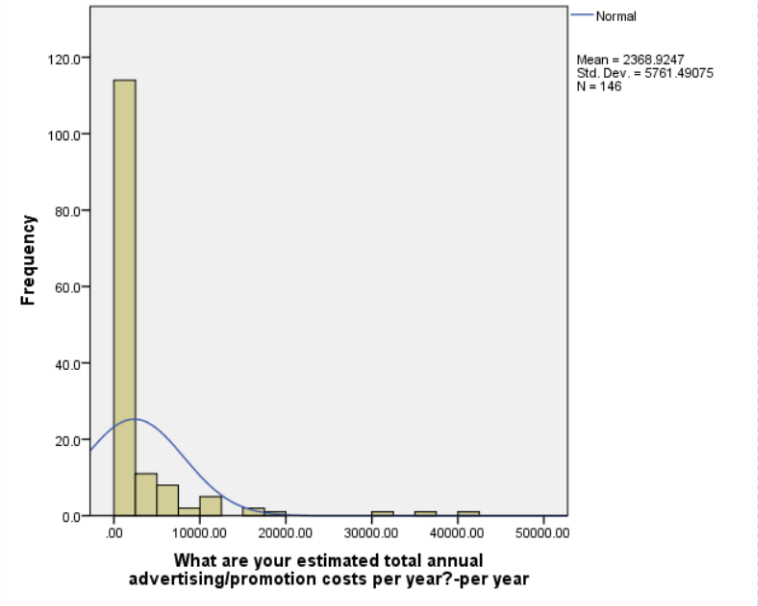


SAMPLE with FIVE Operations with highest sales removed: Net Income from Agritourism retail: 2012

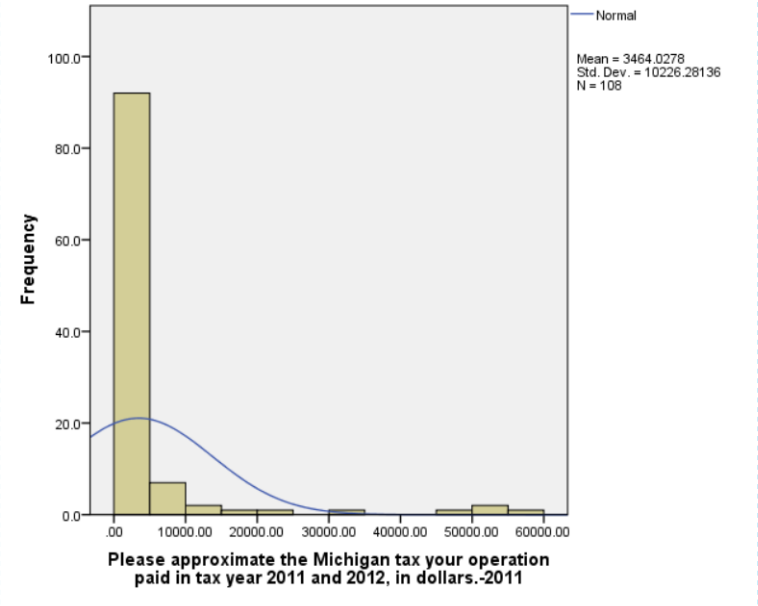
FIVE OPERATIONS REMOVED with net sales of:
$397000.00
$295000.00
3 X $100000.00



FULL SAMPLE: Annual Advertising Costs —Huge Range!



FULL SAMPLE: Michigan Tax paid in 2011?



PROJECT TITLE - Michigan Vegetable Council – Developing Tools for Michigan's Pickling Cucumber Industry to Combat Disease **FINAL**

PROJECT SUMMARY

Downy mildew (DM) is a severe foliar disease of cucurbits (cucumber, melon, squash, pumpkin, zucchini) caused by *Pseudoperonospora cubensis*, a fungal-like plant pathogen. Michigan is the #1 producer of cucumbers for pickling in the U.S. Until 2005, DM was controlled by the use of resistant cultivars, and the disease had not been reported in Michigan for more than 25 years. However, in 2005, a new isolate of DM swept across the state causing widespread losses of cucumber crops. Cucumbers and melons are especially susceptible to this new isolate of DM and have needed an aggressive fungicide program since DM re-emerged in 2005. Michigan research trials conducted in 2014 showed that the DM pathogen is now resistant to key fungicides that were once relied upon by growers, leaving the industry vulnerable. In this proposed project, new management tools were developed to ensure the future of the Michigan pickling cucumber industry.

PROJECT APPROACH

Research was carried out by Dr. Mary Hausbeck of Michigan State University (MSU). Replicated field trials for testing alternatives to registered pesticides were established at the MSU Plant Pathology Farm in Lansing, MI. Cucumber seeds were sown after DM had been confirmed in the county. Treatments were applied at five- to seven-day intervals. DM severity on the foliage was evaluated, fruits were harvested and weighed, and data analyzed. A newly registered product, Zing!, and some unregistered experimentals, including V-10208 and Orondis, proved effective in 2015 trials. Spore traps were operated and weather monitored from May to August 2015 in fields in Michigan's lower peninsula in areas of cucurbit production. Daily numbers of spores were quantified and continually uploaded to Dr. Hausbeck's 'For Growers' webpage. Confirmation by county of cucurbits infected with DM were uploaded to a Michigan map at Dr. Hausbeck's webpage. Spores were detected by trap before disease was confirmed in the county. Grower recommendations based on this research were published in articles at the MSU Extension News website with links on Dr. Hausbeck's 'For Growers' webpage.

GOALS AND OUTCOMES ACHIEVED

Field research

Researchers waited until DM was confirmed in Michigan to begin the fungicide trials. Trials were established in a field of Capac loam soil previously planted to cucumber. Roundup PowerMax 1 qt/A was applied in early spring for weed control, and the field was plowed and disced. Ammonium nitrate at 100 lb/A was applied preplant. Raised beds were formed and covered with black plastic and drip tape established for irrigation. Cucumber 'Vlaspik' seeds were sown spaced 12 inches apart within a row and 5.5 feet between rows measured at row center. The experiment was arranged in a completely randomized block design, and four replicates were established for each treatment. Each treatment replicate consisted of a 20-foot row with a two-foot buffer zone between replicates within a row. Insects were controlled with Admire Pro (8 fl oz/A) applied through the drip four weeks after plant emergence. The plots were fertilized weekly throughout the growing season with applications of 20-20-20 via drip tape at 2.5 lb/A. Weed control was performed by hand. Treatments were applied as a foliar spray at five- to seven-day intervals using a CO_2 backpack sprayer and a broadcast boom equipped with three XR8003 flat-fan nozzles calibrated at 50 psi and delivering 50 gal/A. Cucumber leaves were rated for DM severity using the Horsfall-Barratt scale. Fruit were harvested from the entire row of each replicate and weighed. Data were analyzed using an analysis of variance (ANOVA), with means separation performed using Fisher's protected least significant difference (LSD).

MSU Trial #1: Seeds were sown on 24 July. This study included 17 fungicides and an untreated control. Five treatments were applied on 7, 14, 21, 28 August; and 4 September.

Rating #1: At the first evaluation of disease on 19 August, DM had become established on the untreated control but was at a relatively low level. Several treatments were significantly better in protecting the plants from DM than the untreated control and included the following: Bravo Weatherstik SC, Ranman SC, Zampro SC, Gavel DF, Omega SC, Orondis, and V-10208. Fungicides including Presidio SC, Previcur Flex, and Tanos had the same disease level as the untreated control that did not receive any fungicides. Historically, Presidio, Previcur Flex, and Tanos, had been included in recommendations for DM. While Presidio and Tanos had been dropped from the 2015 recommendations, Previcur Flex had remained based on 2014 field trial results.

Rating #2: DM progressed significantly from the first to the second rating that was taken on 31 August; the untreated control received a disease rating of 7.3 (50 to 75% disease). Standout treatments included Orondis (1.0 = 0% plant tissue diseased), and V-10208 (2.3 = 0 to 3% disease). Other effective products included Zampro SC, Omega SC, and Koverall (mancozeb) with ratings of 3.3 to 3.5 (3 to 6% disease). A moderate level of control was observed with Ranman SC and Gavel DF (4.0-4.3 = 6 to 12% disease). While several other fungicides were determined to be better than the untreated control, the amount of disease observed on the tissue was unacceptable with ratings of five or higher indicating at least 12% of the foliage was infected with a maximum of 50% disease assessed. Fungicides that did not protect the plant any better than the untreated control included the following: Cueva, Cabrio DG, Previcur Flex SL, Revus SC, Forum SC, and Priaxor SC.

Rating #3: The final rating was taken following a period of unseasonably warm weather that prompted plant growth resulting in a decrease in the overall appearance of DM symptoms. As a result, the rating of the untreated control was 6.5 (25 to 50% disease) that indicated less disease than what was observed at the previous rating. The only fungicide treatment that scored a disease rating of 2 (0 to 3% disease) was Orondis. However, several treatments kept DM limited to 3 to 6% disease and included Koverall DG, Ranman SC, Zampro SC, Gavel DF, and V-10208. Presidio SC, Omega SC, and Bravo WeatherStik SC were similar in their level of protection and resulted in disease ranging from 6 to 25%. Treatments that were not effective and were similar to the untreated control included the following: Priaxor SC, Forum SC, Revus SC, Tanos DF, Previcur Flex SL, Cabrio DG, Omega SC, and Cueva.

Yield: The fruit yield did not separate out cleanly but the highest yields were obtained with Koverall DG and Presidio SC; these treatment yields were statistically similar to several other treatments including Ranman SC, Zampro SC, Gavel DF, Bravo WeatherStik SC, Omega SC, Curzate DG, V-10208 SC, and Priaxor. Many treatments produced reduced yields similar to the untreated control and included the following: Bravo WeatherStik SC, Cueva SC, Cabrio DG, Previcur Flex SL, Tanos DF, Curzate DG, Omega SC, Revus, SC, Forum SC, and Orondis SC.

Treatment and rate/A, applied at 5- to 7-day intervals	Disease severity*			Yield (lb/20 ft of row) 9/10
	8/19	8/31	9/4	
Untreated control	2.8 cd**	7.3 g	6.5 hi	10.5 e
Bravo WeatherStik SC 2 pt ..	1.3 ab	5.3 e	4.3 c-e	15.0 a-e
Koverall DG 2 lb.....	2.0 bc	3.5 cd	3.5 b-d	19.7 a
Cueva SC 2 qt.....	2.5 cd	7.0 g	6.3 hi	12.6 c-e
Cabrio DG 12 oz	2.8 cd	7.0 g	6.8 i	11.8 c-e
Presidio SC 0.25 pt.....	2.3 c	6.0 ef	5.0 e-g	19.6 ab
Previcur Flex SL 1.2 pt.....	2.8 cd	6.8 fg	6.5 hi	13.6 c-e
Ranman SC 0.17 pt	1.3 ab	4.3 d	3.3 bc	15.5 a-d

Treatment and rate/A, applied at 5- to 7-day intervals	Disease severity*			Yield (lb/20 ft of row) 9/10
	8/19	8/31	9/4	
Zampro SC 0.88 pt.....	1.3 ab	3.3 c	3.3 bc	16.4 a-c
Gavel DF 2 lb.....	1.3 ab	4.0 cd	3.3 bc	15.7 a-c
Tanos DF 0.25 lb	2.3 c	5.8 e	5.5 f-h	14.2 c-e
Curzate DG 5 oz	2.0 bc	5.8 e	4.5 d-f	14.7 b-e
Omega SC 1 pt	1.3 ab	3.3 c	3.0 ab	14.9 a-e
Revus SC 8 fl oz	2.8 cd	6.8 fg	6.0 g-i	10.8 de
Forum SC 6 fl oz	3.3 d	7.0 g	6.3 hi	14.1 c-e
Orondis SC 1.64 fl oz	1.0 a	1.0 a	2.0 a	13.1 c-e
V-10208 SC 8 fl oz.....	1.3 ab	2.3 b	3.0 ab	16.1 a-c
Priaxor SC 8 fl oz	2.5 cd	7.0 g	6.0 g-i	15.7 a-c

*Rated on the Horsfall-Barratt scale of 1 to 12, 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.
**Column means with a letter in common are not significantly different (LSD t Test; *P*=0.05).

MSU Trial #2: Seeds were sown on 16 July. Nine treatments and an untreated control were included in this study. Six treatments were applied on 31 Jul; 6, 13, 20, 27 Aug; and 4 Sep.

Rating #1: At the first rating conducted on 24 August, the untreated received a rating of four (6 to 12%) and nearly all treatments provided complete DM control. Zing! SC and Ranman SC were excellent fungicides when used alone or in alternation with other materials.

Rating #2: On 14 September, a second disease rating was assessed, and disease had progressed in both the untreated and all treatments. The trend was similar as that seen in rating #1 where Zing! SC and Ranman SC either alone or in alternation, limited disease to commercially acceptable levels.

Yield: Two harvests were combined for a total yield; the untreated control yielded a lower amount of fruit. Zing! SC 32 fl oz yielded significantly greater than the untreated control.

Treatment and rate/A, applied at 5- to 7-day intervals, *application schedule*	Disease severity[2]		Yield (lb/20 ft of row)		
	8/24	9/14	9/2	9/10	Total
Untreated control.....	4.3 c[3]	5.5 c	3.5	12.4 c-e	15.9 b-e
Ranman SC 2.75 fl oz.....	1.5 a	2.3 ab	3.0	19.3 ab	22.3 ab
Zing! SC 32 fl oz.....	1.3 a	2.8 ab	3.5	21.0 a	24.5 a
Zing! SC 36 fl oz.....	1.3 a	2.3 ab	3.0	18.2 a-c	21.2 a-c
Ranman SC 2.75 fl oz + Koverall DF 2 lb + Act. 90, *app 1* Zing! SC 36 fl oz, *apps 2,4,6* Previcur Flex SL 1.2 pt + Bravo WS SC 1.5 pt, *app 3* Orondis OD 1.64 lb + Koverall DF 2 lb, *app 5* Zampro SC 14 fl oz + Bravo WS SC 1.5 pt, *app 7*	1.8 a	3.0 b	2.6	19.3 ab	21.9 ab
PeKacid DG 1% v/v + Act. 90 SL.....	3.8 bc	5.8 c	2.2	9.6 e	11.8 e
PeKacid DG 1% v/v + Act. 90 SL + Ranman SC 2.75 fl oz.....	1.3 a	2.0 a	3.9	16.3 a-d	20.2 a-d
PeKacid DG 1% v/v + Act. 90 SL + Ranman SC 1.9 fl oz	1.0 a	2.3 ab	3.6	14.8 b-e	18.4 a-e
TKPP WP 1% v/v + Act. 90 SL	3.0 b	5.5 c	2.8	10.6 de	13.4 de
PeKacid DG 1% v/v + Act. 90 -*alternate*- TKPP WP 1% v/v + Act. 90	4.0 c	6.3 c	4.1	10.3 de	14.3 c-e

[1]Bravo WS=Bravo WeatherStik.

[2]Rated on the Horsfall-Barratt scale of 1 to 12, 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.
[3]Column means with a letter in common or with no letter are not significantly different (LSD t Test; *P*=0.05).

MSU Trial #3: Seeds were sown on 16 July. This trial included seven treatments and an untreated control. Six sprays were applied on 30 July; 6, 13, 18, 25 August; and 1 September.

Ratings #1 and #2 and yield: For the first rating conducted on 25 August, disease in the untreated control had reached a rating of 4 (6 to 12% disease). All fungicide programs were effective in keeping DM nearly completely controlled. The same trend was observed for the second rating on 4 September. It was notable that treatment with Bravo WeatherStik SC applied alone was comparable to other alternating fungicide programs that included Ranman SC, Gavel WG, Presidio, Zampro, and V-10208.

Treatment[1] and rate/A, applied at 7-day intervals, *application schedule*	Disease severity[2]		Yield (lb/20 ft of row)		
	8/25	9/4	9/2	9/10	Total
Untreated control	4.5 c[3]	6.0 b	4.2	15.3 a	19.4 d
V-10208 SC 8 fl oz + Bravo WS SC 2 pt + Act. 90	1.5 ab	2.0 a	4.5	23.0 b-d	27.4 a-c
Ranman SC 2.75 fl oz + Bravo WS SC 2 pt + Act. 90, *apps 1,3,5* V-10208 SC 8 fl oz + Bravo WS SC 2 pt + Act. 90, *apps 2,4* Zampro SC 1.2 pt + Bravo WS SC 2 pt + Act. 90, *app 6*	1.0 a	2.0 a	4.0	21.2 bc	25.2 bc
Ranman SC 2.75 fl oz + Bravo WS SC 2 pt, *apps 1,3,5* *-alternate-* Zampro SC 1.2 pt + Bravo WS SC 2 pt, *app 2,4,6*	1.5 ab	2.0 a	4.6	24.9 cd	29.5 ab
Ranman SC 2.75 fl oz + Bravo WS SC 2 pt + Act. 90, *apps 1,3,5* Gavel WG 2 lb + Bravo WS SC 2 pt + Act. 90, *apps 2,4* Zampro SC 1.2 pt + Bravo WS SC 2 pt + Act. 90, *app 6*	1.0 a	2.0 a	4.0	19.1 ab	23.1 cd
Presidio SC 45 fl oz + Bravo WS SC 2 pt, *apps 1,3* Ranman SC 2.75 fl oz + Bravo WS SC 2 pt, *apps 2,4,6* Zampro SC 14 fl oz + Bravo WS SC 2 pt, *app 5*	1.0 a	2.0 a	4.6	24.4 cd	29.0 ab
Zampro SC 14 fl oz + Bravo WS SC 2 pt, *apps 1,3,5* *-alternate-* Ranman SC 2.75 fl oz + Bravo WS SC 2 pt, *apps 2,4,6*	1.5 ab	2.0 a	4.9	27.2 d	32.1 a
Bravo WS SC 2 pt	1.8 b	2.3 a	3.6	26.2 d	29.8 ab

[1]Bravo WS= Bravo WS.
[2]Rated on the Horsfall-Barratt scale of 1 to 12, 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.
[3]Column means with a letter in common or with no letter are not significantly different (LSD t Test; *P*=0.05).

MSU Trial #4: Seeds were sown on 16 July. This trial included eight treatments and an untreated control. Five treatments were applied on 6, 13, 20, 27 August; and 4 September.

Rating #1: During the first rating, disease ranged from >25 to 50% on the untreated control. The following treatments provided exceptional control and included the following: experimental fungicides (2) from Valent, Ranman SC, Zampro SC, Gavel DF, and Orondis SC. Previcur Flex failed in limiting disease and was similar to the untreated control. While Presidio was better than the untreated control, the level of disease was not acceptable.

Rating #2: Disease was reduced in the untreated control compared to the first rating due to the unseasonably high temperatures that spurred growth of new foliage. The pattern of treatment efficacy observed in Rating #1 was observed in Rating #2. It was interesting to note that both Presidio SC and Previcur Flex SL were statistically similar to the untreated control and did not limit DM disease.

Yield: Differences in yield were not noted although the lowest yield was observed in the untreated control.

Treatment and rate/A, applied at 5- to 7-day intervals	Disease severity* 8/27	Disease severity* 9/4	Yield (lb/20 ft of row) 9/10
Untreated control	6.3 d**	5.5 c	9.4
Experimental SC 9.7 fl oz	2.0 ab	2.0 a	12.1
Presidio SC 0.25 pt	4.5 c	4.5 bc	10.8
Previcur Flex SL 1.2 pt	5.5 cd	5.5 c	12.1
Ranman SC 0.17 pt	1.0 a	2.0 a	10.1
Zampro SC 0.88 pt	2.3 b	2.3 a	11.1
Gavel DF 2 lb	2.3 b	3.0 ab	12.5
Orondis SC 1.64 fl oz	1.0 a	2.0 a	11.0
V-10208 SC 8 fl oz	1.8 ab	2.3 a	11.5

*Rated on the Horsfall-Barratt scale of 1 to 12, 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.
**Column means with a letter in common or with no letter are not significantly different (LSD t Test; *P*=0.05).

Spores and weather. Sporangial counts were especially high during the course of the season in Allegan County (Fig. 1) and peaked during mid-August. Rainfall was more prevalent in this growing region and temperatures were favorable for disease development. Sporangia were identified in the atmosphere prior to the confirmation of disease symptoms in the county. In Arenac County (Fig. 1), sporangial counts were significantly lower than those observed in Allegan County. The number of rainfall events and the total amount of rain in Arenac County were also significantly less. In Bay County (Fig. 1), the sporangial counts also increased in mid-August similar to Allegan County. Sporangia were detected prior to the confirmation of disease in this county. Rainfall was moderate in Bay County. In Berrien County (Fig. 2), sporangial counts were lower overall compared to other monitored areas. Spore concentrations were detected prior to the disease confirmation. In Gratiot County (Fig. 2), very high sporangial concentrations were detected beginning in early August despite moderate rainfall. As in the other counties, sporangia were detected prior to disease confirmation. In Muskegon County (Fig. 2), sporangial counts overall were very low despite adequate rainfall. In Saginaw County (Fig. 3), sporangial counts did not increase until mid-August and remained moderate throughout the monitoring period. In both Ingham (Fig. 3) and Monroe (Fig. 3) Counties the monitoring was established after disease was confirmed to provide additional spore counts and environmental data.

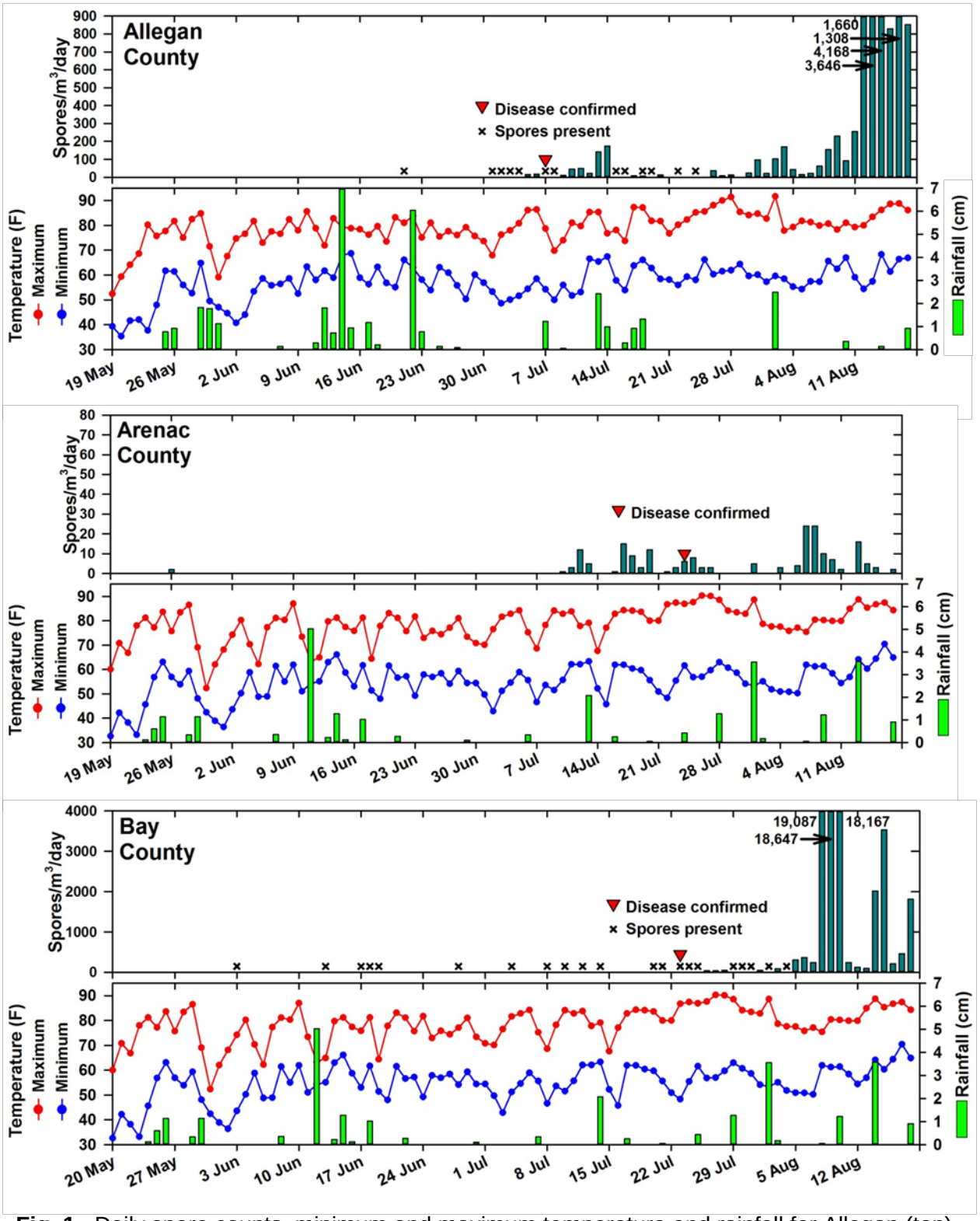


Fig. 1. Daily spore counts, minimum and maximum temperature and rainfall for Allegan (top), Arenac (middle), and Bay (bottom) Counties during the 2015 growing season.

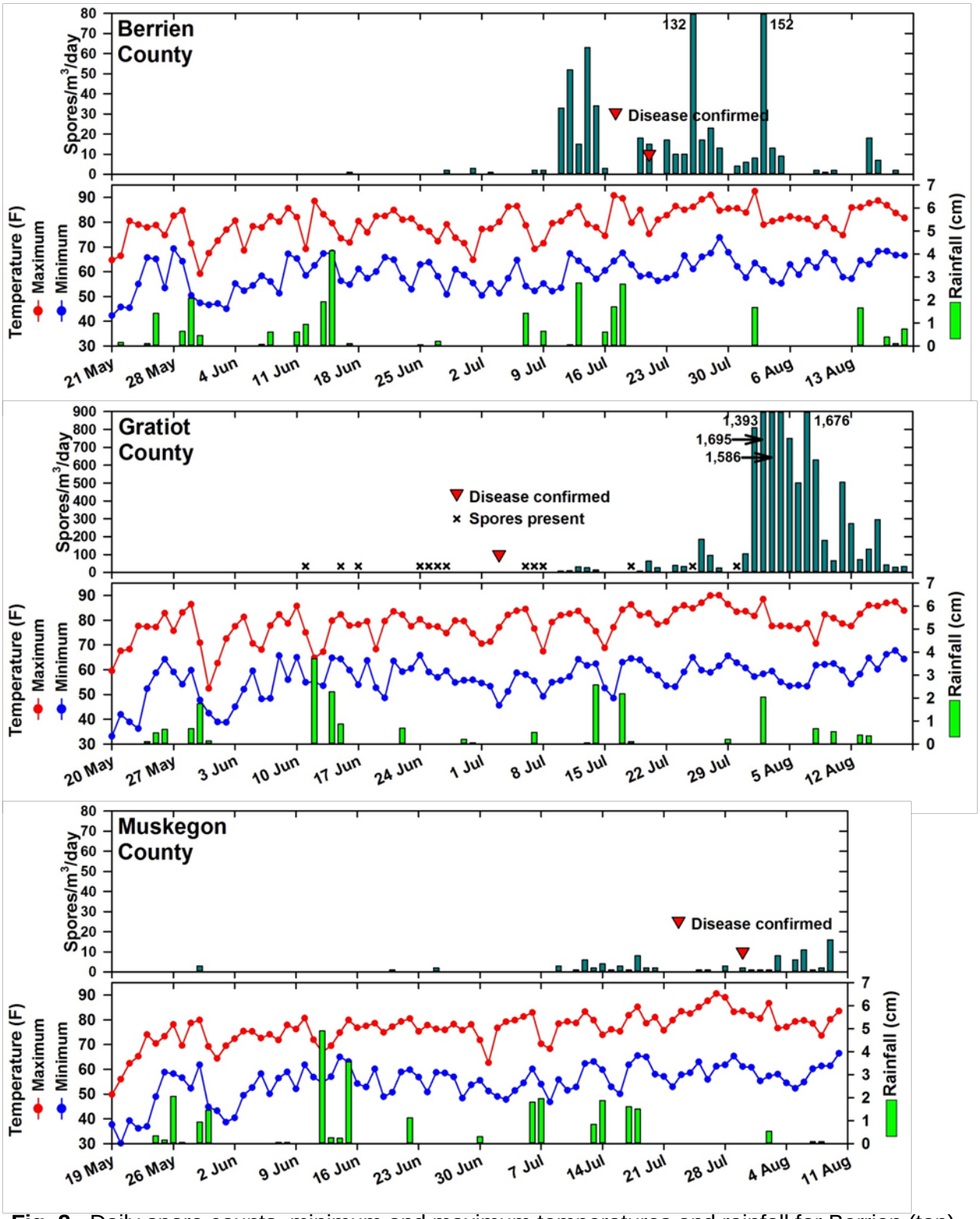


Fig. 2. Daily spore counts, minimum and maximum temperatures and rainfall for Berrien (top), Gratiot (middle), and Muskegon (bottom) Counties during the 2015 growing season.

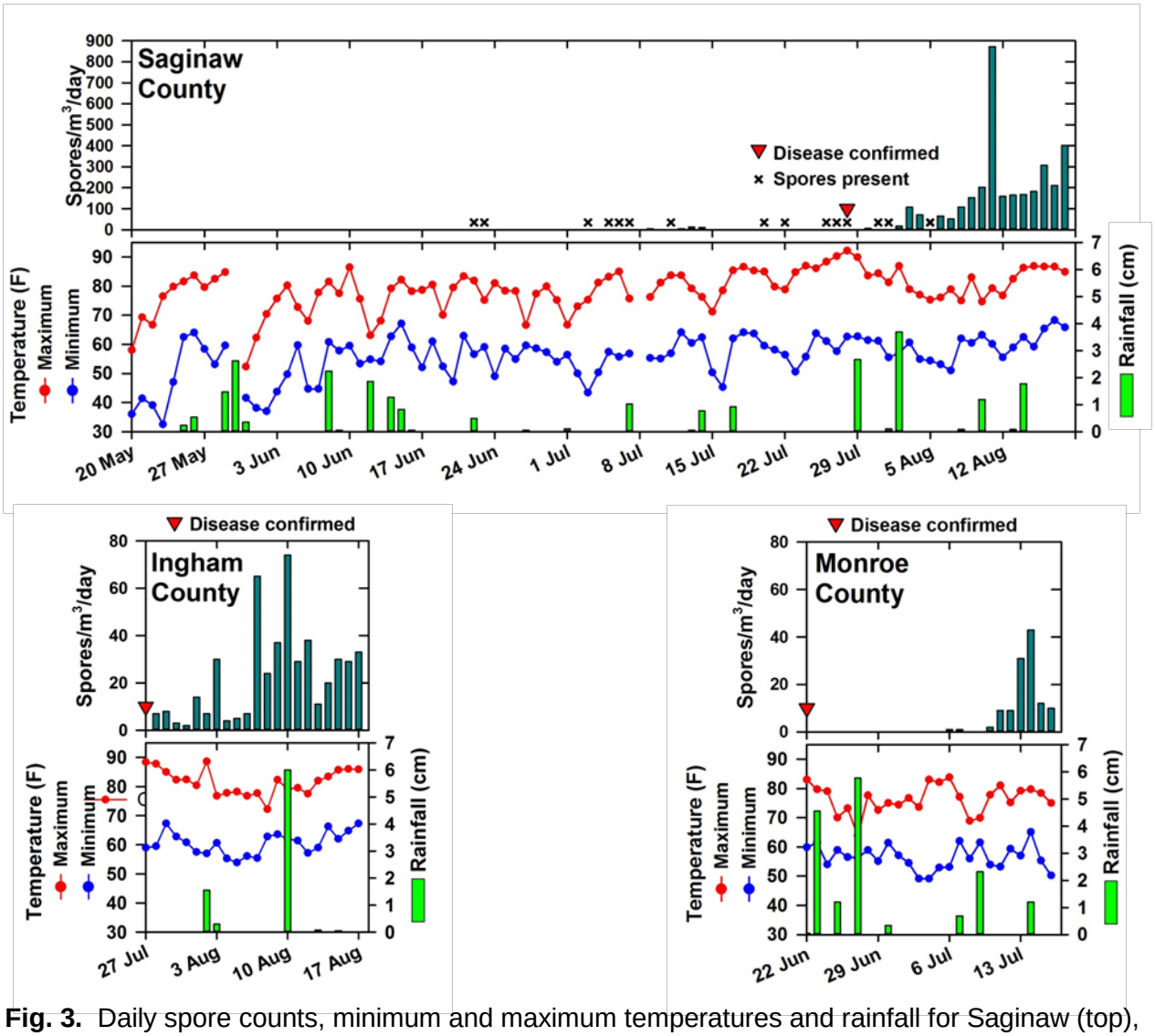


Fig. 3. Daily spore counts, minimum and maximum temperatures and rainfall for Saginaw (top), Ingham (bottom left), and Monroe (bottom right) Counties during the 2015 growing season.

Spores and disease. Seven spore traps (Fig. 4) were operated from May to August 2015 in fields in cucurbit-producing areas in the lower peninsula of Michigan: east-central counties (Arenac, Bay, Monroe, Saginaw); central counties (Gratiot, Ingham); and western counties (Allegan, Berrien, Muskegon). Spore trap reels were changed each week and nearby fields scouted. The reels were brought back to the lab and tapes prepared for microscopic examination and quantification of DM spores. Spore counts were continually uploaded to Dr. Hausbeck's website. Confirmation by county of cucurbits infected with DM were uploaded to a Michigan map at Dr. Hausbeck's website. Detection of the first DM spore via spore trap occurred on 27 May-22 June, 11 June, and 29 May-21 June in the east-central, central and west areas, respectively (Table 1). Spore numbers peaked on 8-11 August, 3 August, and 3-14 August in the east-central, central and west areas, respectively. Peak spore numbers ranged from 24-19,072; 1,695; and 16-4,168 in the east-central, central and west areas, respectively. Two other traps were placed in Ingham (central) and Monroe (east-central) Counties later in the season (Fig. 1, Table 1). Weekly spore totals for Ingham County were 71 (28 Jul-3 Aug), 215 (4-10 Aug) and 190 (11-17 Aug).

Table 1. Spore trapping dates and numbers and confirmed DM dates by county in 2015.

Area	East-central				Central		West		
County	Arenac	Bay	Monroe	Saginaw	Gratiot	Ingham	Allegan	Berrien	Muskegon
Trapping start date	5/20	5/20	6/26	5/20	5/20	7/28	5/19	5/21	5/19
First spore date	5/27	6/3	7/6	6/22	6/11	7/28	6/21	6/17	5/29
DM confirmed date	7/25	7/23	6/22	7/28	7/3	7/27	7/7	7/21	7/30
Peak spore date	8/8	8/8	7/14	8/11	8/3	8/7	8/14	8/3	8/9
Peak spore number	24	19,087	43	872	1,695	65	4,168	152	16
Trapping end date	8/18	8/18	7/16	8/18	8/18	8/17	8/17	8/19	8/10

Sentinel plots were planted on 9 June in Benton Harbor (Berrien County), on 11 June in Lansing (Ingham County), and on 15 June in Frankenmuth (Saginaw County), MI. Six cucurbit crops were planted included six cucurbits ('Hales Best Jumbo' melon, 'Waltham' butternut squash, 'Straight Eight' slicing cucumber, 'Mickey Lee' watermelon, and 'Table Queen' acorn squash). The plot in Frankenmuth failed due to extreme weather. 'Straight Eight' cucumber and 'Hales Best Jumbo' melon were observed to be infected with DM on 21 July in Benton Harbor. 'Straight Eight' cucumber was infected on 27 July in Ingham County.

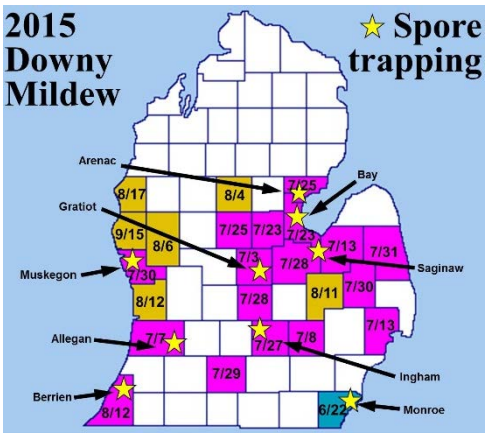


Fig. 4. Map showing spore trap sites (stars) and counties with confirmed DM.

Disseminate new management recommendations to growers

Dr. Hausbeck's 'For Growers' webpage was continually updated with cucurbit DM news, including daily spore counts (http://veggies.msu.edu/Research/2015DMSporetraptotals.pdf). Over the course of the growing season, 24 Michigan counties had confirmed cases of DM (http://veggies.msu.edu/Research/2015DMmap.pdf). Three counties reported DM on multiple cucurbit crops: DM was found on cucumber and melon in Monroe; cucumber, melon, pumpkin and yellow summer squash in Berrien; and butternut squash, zucchini and pumpkin in Oceana County. All other counties reported DM on cucumber.

Dr. Hausbeck published three articles on DM in Michigan during the 2015 growing season, two for commercial growers, (http://msue.anr.msu.edu/news/downy_mildew_on_cucumbers_detected_in_key_areas_of_michigan, http://msue.anr.msu.edu/news/cucumber_downy_mildew_makes_an_early_appearance_in_michigan), and one for home gardeners (http://msue.anr.msu.edu/news/cucumber_downy_mildew_management_practices_for_home_gardeners).

Website statistics from 1 Jan through 30 Sep 2015 for Dr. Hausbeck's website (www.veggies.msu.edu): The website was accessed by people in 95 countries. The most popular page was the 'For Growers' page with a total of 4,509 out of 9,523 pageviews or almost half of the pageviews of the entire website (the next most popular had 640 pageviews). Pageviews of the 'For Growers' page peaked at 189 on 7 Jul. The 'For Growers' page was the landing page in 2,681 out of 4,011 sessions, showing that many people have bookmarked this page.

BENEFICIARIES

This research benefits growers of cucurbit crops and allied industries, such as processors, commodity groups, and fungicide registrants. Michigan ranks #1 in the US for production of pickling cucumber and fresh market/processing squash, #4 for fresh market cucumber, and #5 for fresh market/processing pumpkin, crops grown on 42,900 acres and worth $78.4 million in 2014. Before 2005, pickles could be produced in Michigan without fungicide input. After the re-emergence of the new isolate of DM, Michigan pickle growers must apply fungicides at three- to five-day intervals to preserve their crops when DM is present. It has been particularly difficult to keep effective fungicide programs in place as the DM organism continues to adapt and become resistant to fungicide sprays that at one time were particularly effective.

LESSONS LEARNED

Michigan had a less than optimal growing season in 2015. Extended extreme weather in June destroyed the sentinel plot in Frankenmuth. Record-setting severe rainstorms with over 1-inch-per-hour rainfall caused substantial flooding in the Lansing area on 10 August (Fig. 5). The fields where the fungicide trials were established at the MSU Plant Pathology Farm received 2.36 inches of rain causing flooding of the fields. Yields of the research plots may have been compromised due to flooding.

Fig. 5. Left, water overflowing a drain in a research field as a result of torrential rain. Above, workers dig ditches to drain a research field before soil becomes overly saturated. Ditches for other fields were dug with a tractor.

CONTACT PERSON

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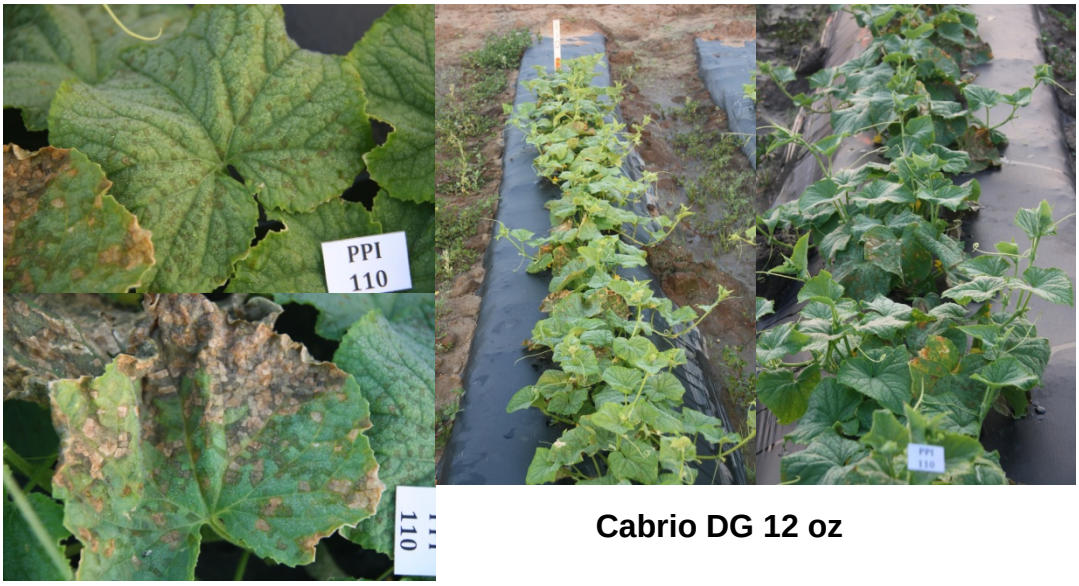
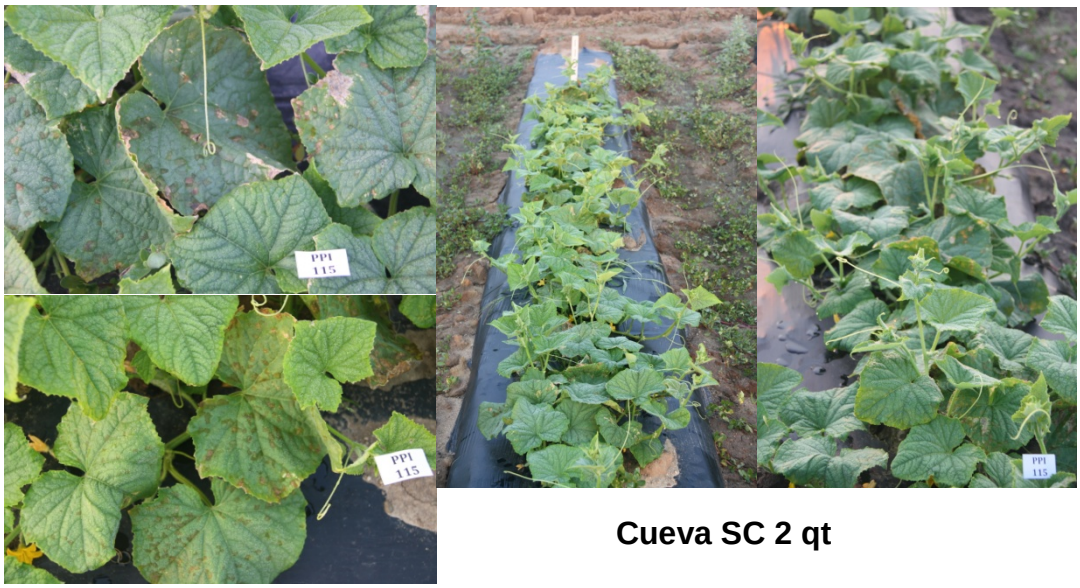
ADDITIONAL INFORMATION

MSU Trial #1: photographs.

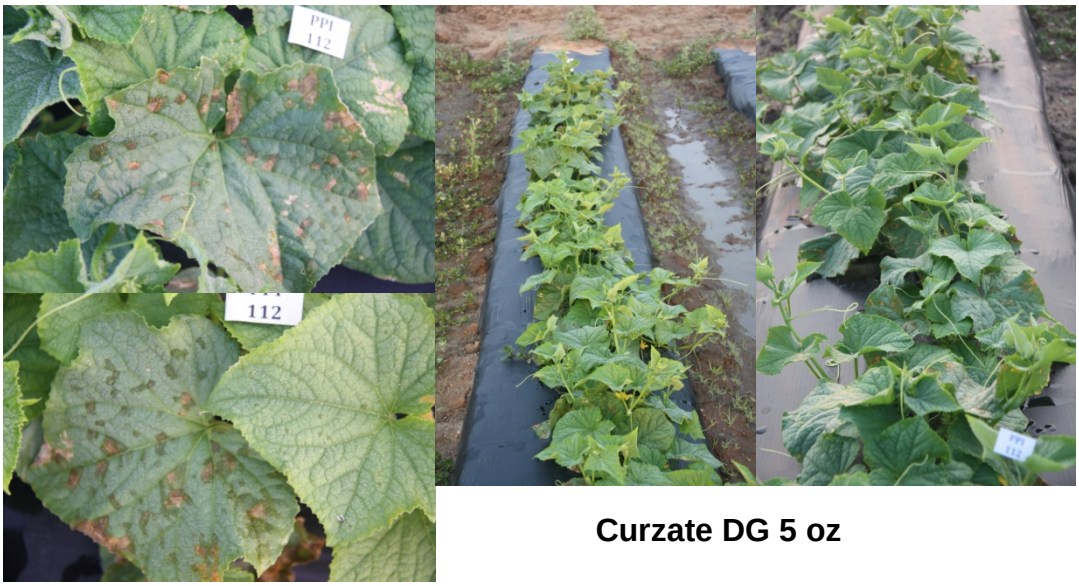
Bravo WeatherStik SC 2 pt



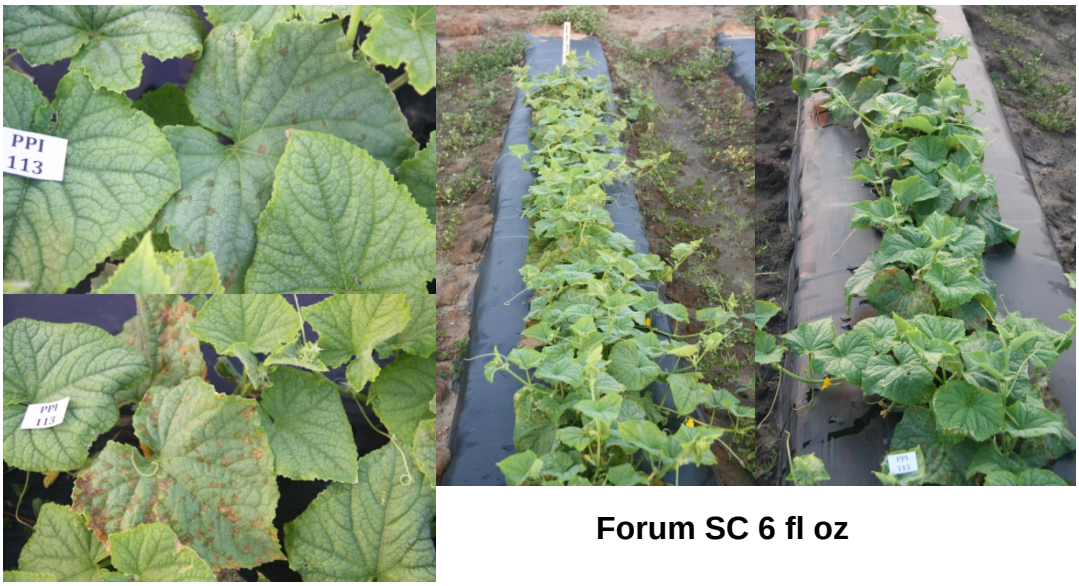
Cabrio DG 12 oz



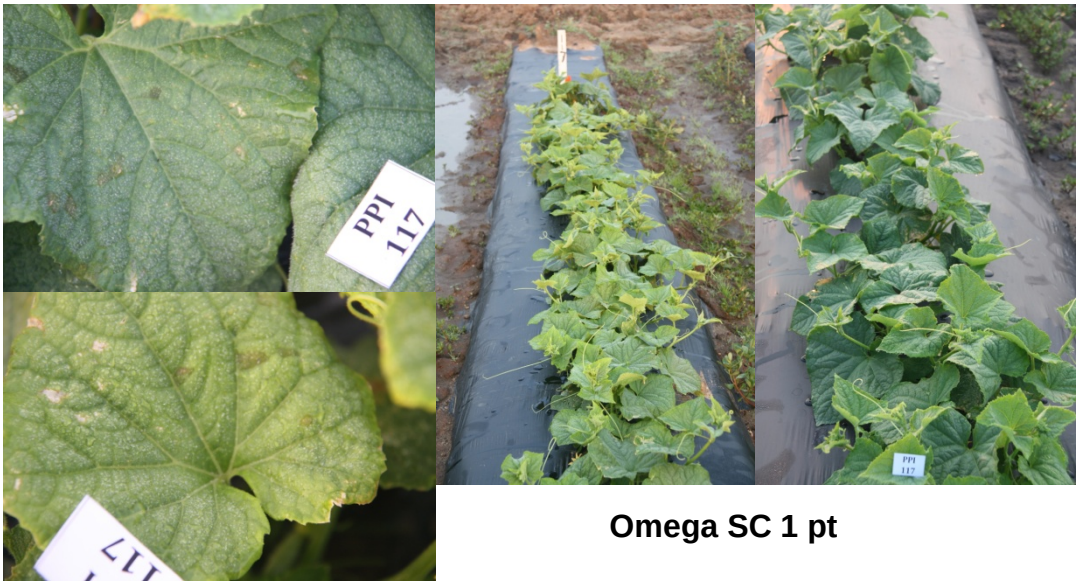
Cueva SC 2 qt



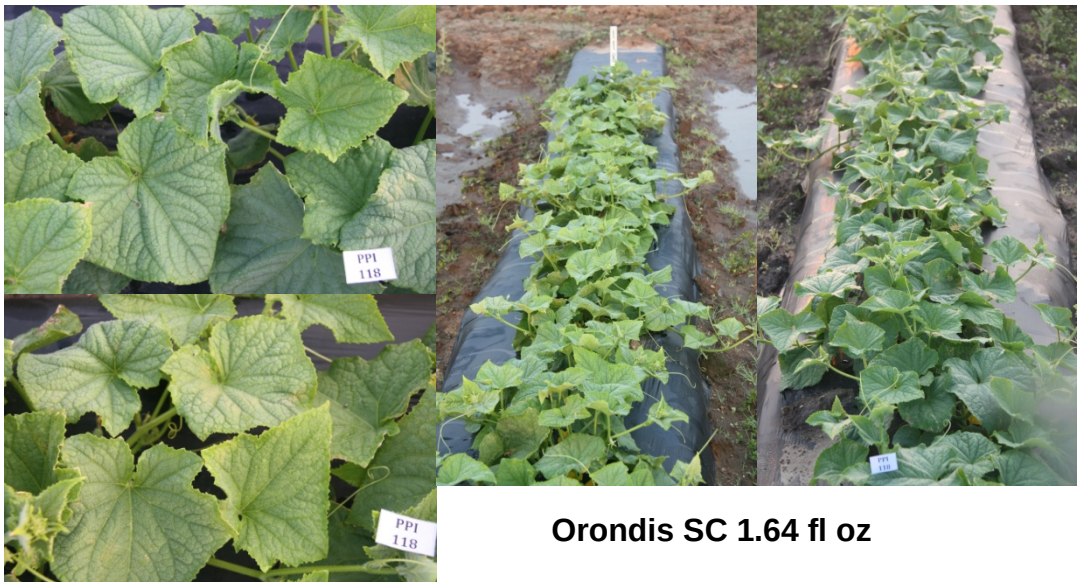
Curzate DG 5 oz



Forum SC 6 fl oz



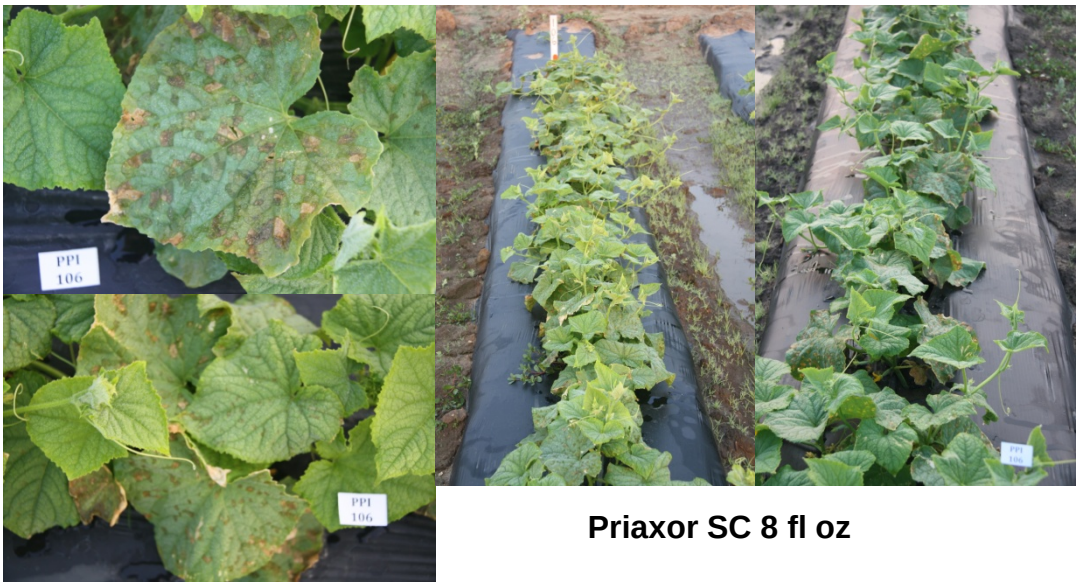
Omega SC 1 pt



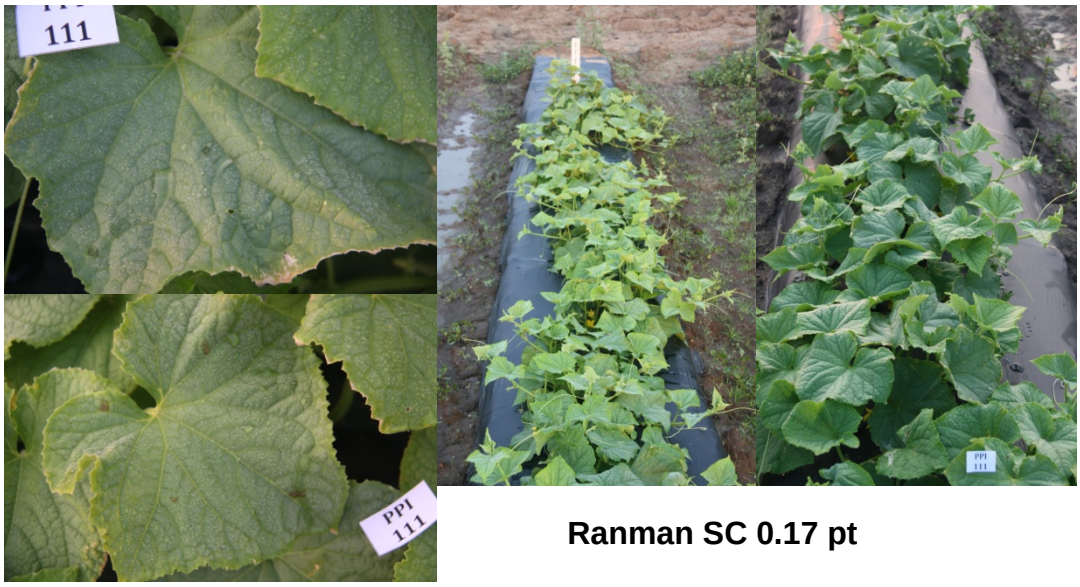
Orondis SC 1.64 fl oz

Presidio SC 0.25 pt

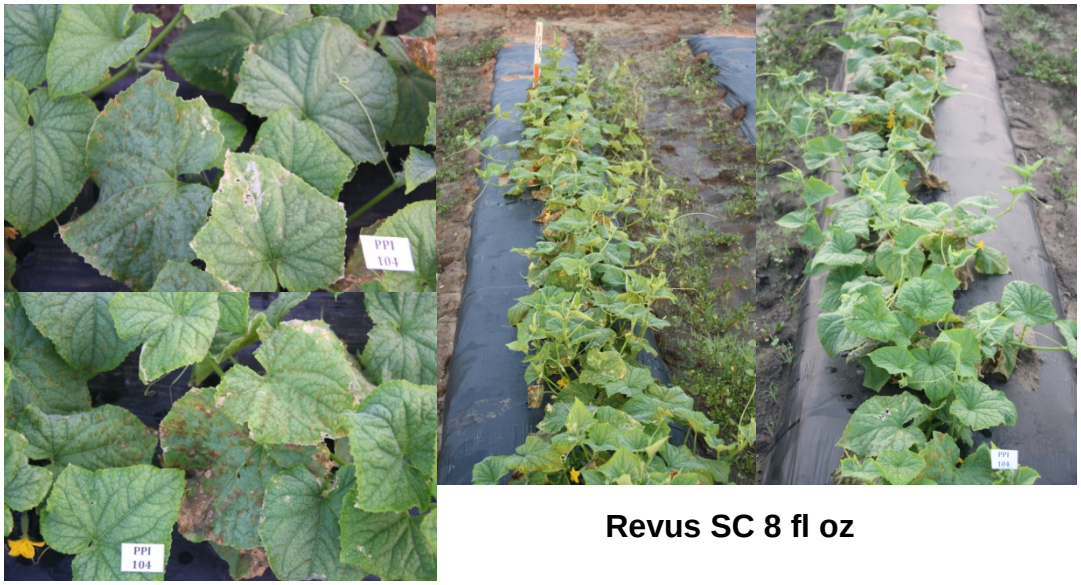
Previcur Flex SL 1.2 pt



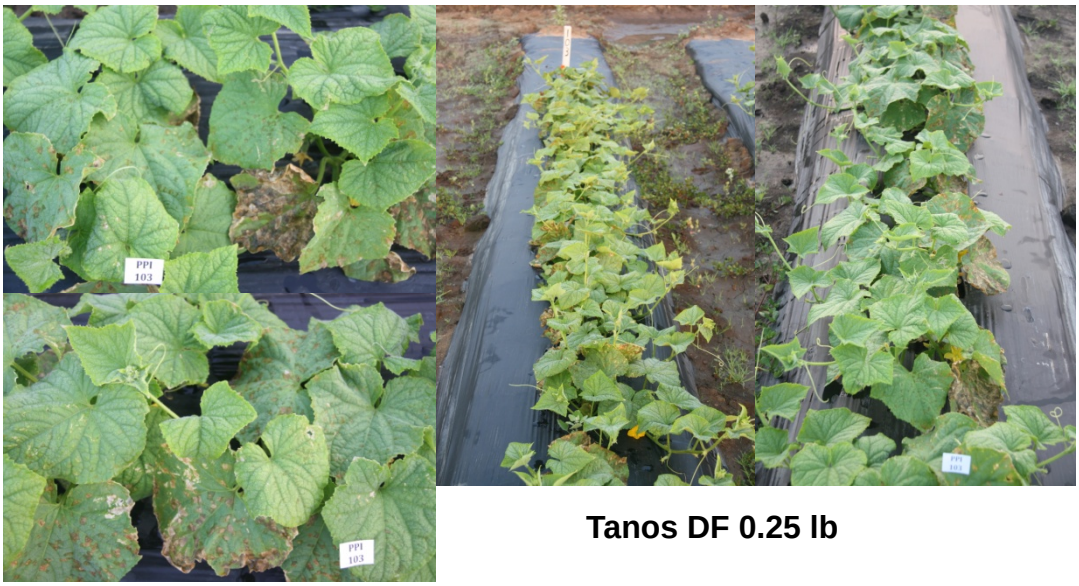
Priaxor SC 8 fl oz



Ranman SC 0.17 pt



Revus SC 8 fl oz



Tanos DF 0.25 lb

V-10208 SC 8 fl oz

Zampro SC 0.88 pt

Untreated control

PROJECT TITLE - Michigan Onion Committee – Identifying the Cause of Postharvest Storage Rot in Michigan Onions - **FINAL**

PROJECT SUMMARY

In Michigan, the production acres of onions have been decreased as a result of reduced yields and poor bulb quality in storage. In contrast, the cost of production has increased. Solutions have been requested by growers who experienced yield losses during the growing season and in postharvest storage. Bacterial leaf blight caused by *Pantoea agglomerans* was first identified in

onions from fields in Allegan and Ottawa Counties and it has been a major limiting factor to the onion industry since 2012. Onion fields were monitored for diseases and pests from 2012 to 2014, and bacterial leaf blight was observed in all 10 fields with nearly 100% of plants showing visible symptoms. Onion growers have been concerned that the *P. agglomerans* causing the bacterial leaf blight in the field might also initiate bulb rot as a result of the bacteria being washed down the neck into the bulb region, allowing the secondary infections to develop and rapidly rot bulbs during storage. Prior to this work being conducted, it had not been known if the newly identified bacterial leaf pathogens are responsible for and/or contributing to bulb rot in storage. Alternatively, the onion bulb infection may be initiated by other bacterial pathogens. To prevent future loss and develop meaningful management strategies, activities in this project focused on identifying the cause of postharvest storage rot in Michigan onions.

This project builds upon, but does not duplicate the objectives of previous SCBG-funded projects which focused on characterizing and managing the pathogens causing pink root and anthracnose, and identification/characterization of bacteria and managing bacterial leaf blight (caused by *Pantoea agglomerans*). We determined susceptibility of 30 onion cultivars to pink root (caused by *Setophoma terrestris*) and 16 cultivars to leaf and neck anthracnose (caused by *Colletotrichum coccodes*), and studied the epidemiology of infection of the anthracnose pathogen. In addition, we evaluated the fungicides in limiting infection of both diseases. We found that Fontelis provided the largest plant growth to the onions infected by the pink root pathogen, and Quadris, Cabrio, Priaxor, and Inspire limited the number of infected plants caused by *C. coccodes*. Bacterial leaf blight (*P. agglomerans*) and bacterial center rot (*P. ananatis*) were identified as the major bacterial diseases infecting onion in Michigan. Kocide and Kasugamycin were significantly better than other treatments at reducing bacterial leaf blight severity. The results from these studies have been implemented into recommendations for growers.

PROJECT APPROACH

Research was carried out by Dr. Mary Hausbeck, Michigan State University. Onion bulbs (at least 12) were sampled from three storage sites from January through May, photographed and sampled. Isolates suspected to be *P. agglomerans* were identified using Biolog. All isolates were tested for their pathogenicity; pathogenic isolates were sequenced with 16S primer for identifying the species. There were 1,350 onion bulbs showing bacterial symptoms; 880 bacterial isolates were obtained and 166 isolates caused water-soaked or sunken lesions on onion slices 2 to 4 days post inoculation. Species involved in postharvest rot of onion bulbs included *Bacillus pumulis, B. subtilis, Burkholderia caryophylli, Burk. cepacia, Burk. gladioli, Curtobacterium flaccumfaciens, Ewingella americana, Klebsiella* sp.*, Leifsinia soli, Luteibacter* sp., *Paenibacillus* sp.*, Pantoea agglomerans, P. ananatis, Pseudmonas* sp.*, Rahnella aquatilis*, and unidentified isolates. Pathogenic and nonpathogenic *P. agglomerans* isolates were tested; eight isolates were pathogenic, producing water-soaked lesions on onion slices in vitro. The rot caused by *P. agglomerans* is relatively superficial and limited to the outer scales nearest to the bulb's neck. In contrast, the other bacterial pathogens identified appeared to be responsible for infections affecting the core of the bulb resulting in the most significant rot symptoms.

GOALS AND OUTCOMES ACHIEVED

1.) Collect onion bulbs in Michigan storage units, and test and use a diagnostic molecular marker to quickly and effectively identify affecting Michigan onions postharvest.

Onion bulb collection. Onion bulbs were collected monthly from January through May from three storage facilities (Table 1).

Table 1. Number of onions collected from each storing facility, bulbs cut, and total bacterial isolates obtained by month.

Location/ Storage site	Collecting month					Total/ site	Total
	Jan	Feb	Mar	Apr	May		
Number of bulbs collected							
Grant/Site 1[y]	240	300	300	300	300	1440	
Grant/Site 2	120	300	n/d[*]	n/d	n/d	420	3,150
Stockbridge/Site 3	120	270	300	300	300	1290	
Number of bulbs with symptoms and isolated							
Grant/Site 1	208	209	99	43	37	596	
Grant/Site 2	66	112	n/d	n/d	n/d	178	1,376
Stockbridge/Site 3	69	241	140	73	79	602	
Number of bacteria isolated							
Grant/Site 1	55	112	76	46	27	316	
Grant/Site 2	20	27	n/d	n/d	n/d	47	880
Stockbridge/Site 3	47	171	115	92	92	517	

[*]n/d = not determined; onions from this storing facility were sold after the second sampling was performed.

Bacterial isolation. Onion bulbs were cut in half lengthwise. Each half with symptoms including necrotic tissue, discoloration, or rotten tissue was photographed. Subsequently, each half was cut into quarters using a sterile knife. A 1x1 cm^2 piece of onion tissue was excised, briefly surface sterilized with 95% ethanol, rinsed with sterile distilled water twice, air dried for 1 to 2 minutes, put in a 1.7-ml tube containing 100 µl of sterile distilled water, and crushed with a sterile plastic pestle. The bacterial suspension was streaked on nutrient yeast extract (NBY) agar amended with cyclohexamide using a sterile bacterial loop, and incubated at 30°C for 48 to 72 hours. A bacterial colony was transferred to a new fresh NBY agar and incubated under the same conditions, and this step was repeated twice to contain a pure culture. All isolates were placed on NBY agar in 60 mm x 15 mm Petri dishes at 4°C for short-term storage.

Pathogenicity test. Bacterial pathogenicity was assayed in vitro. An onion slice was cut into 1.5 x 1.0 inches, surface sterilized with 95% ethanol for 10 seconds, rinsed with sterile distilled water, allowed to dry in the hood for 15 minutes, and placed in a Petri dish containing a moist cotton ball to maintain a high relative humidity. The onion slice was inoculated using a sterile toothpick dipped into bacteria and incubated at room temperature. The slices were observed every two days until six days post inoculation for bacterial symptoms showing translucent or sunken lesions (Figure 1).

Bacterial identification. Bacterial isolates suspected to be *P. agglomerans* were identified using the BIOLOG application. Bacterial isolates that produced translucent or sunken lesions on the onion slices were identified with sequencing. Each isolate was transferred to NBY agar, incubated at 30°C for 24 hours and submitted to Diagnostic Services at Michigan State University using BIOLOG. To confirm *P. agglomerans* and pathogenic isolates, 16S primer set was used in polymerase chain reaction (PCR) amplification. Total nucleic acids were extracted from bacterial cultures grown on NYB agar at 30°C for 24 hours. The DNA was isolated from each bacterium using the Wizard Genomic DNA Purification kit (Promega Corp., Leiden, The Netherlands) by following the gram-negative bacteria protocol. DNA quality was determined on 1% agarose gel and DNA quantity was measured using Nanodrop1000 spectrophotometer (Thermo Scientific Wilmington, DE). 16S rDNA was amplified with 16S primer set (forward primer: 5′-AGTTTGATCCTGGCTCAG-3′ and reverse primer: 5′-TACCTTGTTACGACTTCGTCCCA-3′). The reaction mixture contained 1x PCR reaction buffer, 0.2 mM dNTPs, 0.2 µM of each primer, and 0.625 U/µl of Taq Polymerase (Promega Corp., WI) in a total volume of 25 µl. The PCR reactions were conducted in a Mastercycler Pro thermocycler (Eppendorf, Hauppauge, NY) with

an initial denaturation at 94°C for 5 minutes, following by 3 cycles of denaturation at 94°C for 45 seconds, annealing at 50°C for 2 minutes, and extension at 72°C for 1 minute, and 30 cycles of denaturation at 94°C for 20 seconds, annealing at 50°C for 1 minute, and extension at 72°C for 1 minute, and the final extension step at 72°C for 7 minutes. DNA amplicons were separated on 1% agarose gel, dissolved in 1x Tris-borate-EDTA (TBE) buffer. The amplified PCR products were sequenced with a single primer by submitting to Macrogen Corp. (Macrogen USA, Rockville, MD). The nuclei sequences were compared to the nucleotide collection in NCBI using a BLASTn search (http//:blast.ncbi.nlm.nih.gov/Blast) analysis.

A total of 3,150 onions were collected from three storage sites. There were 1,376 bulbs showing rot symptoms and 880 bacterial isolates obtained (Table 1); 166 isolates were determined to be pathogenic, causing translucent or sunken lesion on the onion slices within 2 to 6 days post inoculation, and 714 isolates were nonpathogenic. However, only 58 isolates were identified; 29 isolates could not be identified using either the Biolog system or 16S primers sequencing. Seventy-nine isolates were not recovered after storage at 4°C for at least two months. Most pathogenic bacterial isolates caused different sizes of lesions on the onion slices 2 to 4 days post inoculation (Figure 1d and 1e). Eight out of 37 isolates of *P. agglomerans* (Table 3) produced a small water-soaked lesion on the onion slices mostly 4 days post inoculation or after (Figure 1f). Most pathogenic bacteria and *P. agglomerans* isolates were from bulbs that exhibited bacterial symptoms on small areas adjacent to the neck (Figure 2a to 2q). Most nonpathogenic bacterial isolates were recovered from the onion bulbs with a rotten semiliquid center (Figure 2r to 2t), and these isolates appeared to be the secondary invaders of tissue damaged in some other way. *Pseudomonas* sp. was the predominant species among bacterial species recovered from stored onions, following by *P. agglomerans, Rahnella aquatilis,* and *P. ananatis*. The frequency of isolation of each bacterial species is shown in Table 2.

Table 2. Number of pathogenic bacterial isolates from each storing facility

Bacterial species	Number of isolates			Total
	Grant (site 1)	Grant (site 2)	Stockbridge (site 3)	
Bacillus pumulis	1	0	2	3
B. subtilis	0	0	1	1
Burkholderia caryphylli	0	0	1	1
Burk. cepacia	0	0	2	2
Burk. gladioli	0	0	1	1
Curtobacterium flaccumfaciens	0	0	2	2
Ewingella americana	0	0	1	1
Klebsiella sp.	0	0	3	3
Leifsonia soli	0	0	1	1
Luteibacter sp.	0	0	2	2
Paenibacillus sp.	0	0	4	4
Pae. terrae	0	0	1	1
Pantoea agglomerans	6	0	2	8
P. ananatis	1	0	5	6
Pseudomonas poae	2	0	1	3
Pseudomonas spp.	4	0	7	11
Rahnell aquatilis	3	0	4	7
Uncultured bacterium	1	0	0	1
Unidentified cultures	21	1	7	29
Total				87

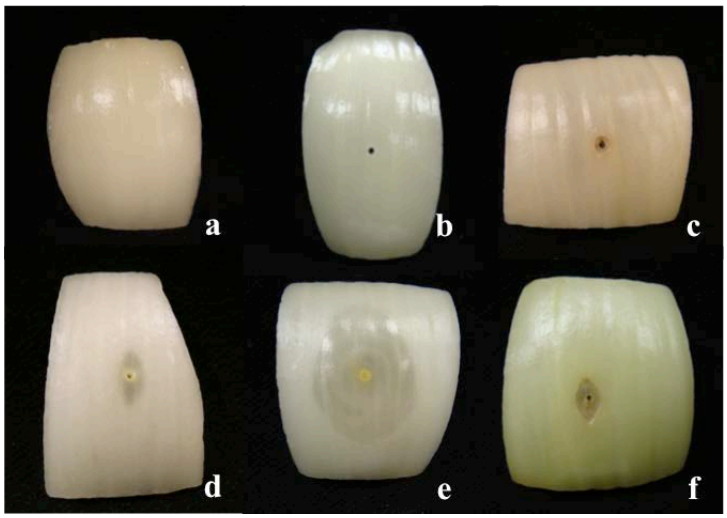


Figure 1. Pathogenicity testing (a) unwounded; (b) inoculated with distilled water; (c) caused by nonpathogenic and; (d-e) pathogenic bacterial isolates; (f) and *P. agglomerans*.

Figure 2. Internal disorder of bulb onions caused by a) *Bacillus pumulis*, b) *B. subtilis*, c) *Burkholderia caryophylli*, d) *Burk. cepacia*, e) *Burk. gladioli*, f) *Curtobacterium flaccumfaciens*, g) *Ewingella americana*, h) *Klebsiella* sp., i) *Leifsonia soli*, j) *Luteibacter* sp., k) *Paenibacillus* sp., l) pathogenic *Pantoea agglomerans*, m) *P. ananatis*, n) *Pseudomonas* sp., o) *Pseu. poae*, p) *Pseu. rhodesiae*, q) *Rahnella aquatilis*, r) uncultured bacterium, s) nonpathogenic *P. agglomerans*, and symptoms associated with (t) nonpathogenic bacteria.

Table 3. Number of *P. agglomerans* isolates.

Location/ Storage site	Collecting month					Total/ site	Total
	Jan	Feb	Mar	Apr	May		
Number of pathogenic *P. agglomerans* isolates							
Grant/Site 1	2	1	1	0	0	4	
Grant/Site 2	0	0	n/d*	n/d	n/d	0	6
Stockbridge/Site 3	0	0	1	1	0	2	
Number of nonpathogenic *P. agglomerans* isolates							
Grant/Site 1	12	0	4	0	0	16	
Grant/Site 2	4	0	n/d	n/d	n/d	4	21
Stockbridge/Site 3	1	0	0	0	0	1	

*n/d = not determined; onions from this storing facility were sold after the second sampling was performed.

2.) Disseminate new management recommendations to grower.
The results were presented to 25 people including growers, educators, and company staff at the onion twilight meeting held in Grant, MI on August 26, organized by MSU Extension, Grant Office. In addition, the results will be presented at the Great Lakes Fruit, Vegetable and Farm Market Expo on December 9 at the Onion Session and published in the Great Lakes Expo proceedings online (http://glexpo.com/education-program/session-summaries) and distributed in hard copy during the program. The Great Lakes Expo was attended by over 4,200 people from 42 states and 5 Canadian provinces in 2014. Results will also be published in the trade magazine Onion World in January 2016.

BENEFICIARIES

This research benefits growers of onion crops and allied industries, including processors, commodity groups, and fungicide registrants. Michigan ranks 7th in the U.S. for production of summer storage onions, a crop grown on 2,500 acres in 2014 with a value of $11.1 million.

LESSONS LEARNED

Isolating, culturing, and identifying bacteria from onion was difficult and time consuming. Some bacterial species produced high amount of polysaccharide on the agar medium used in short-term storage, so we were not be able to recover them for use in other studies. Some of the bacterial isolates could not be identified because the sequences were not clearly generated; this could be the result of technical problems, e.g., the original culture was not a pure culture.

CONTACT PERSON

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ADDITIONAL INFORMATION

A newly formatted website will soon be available for MSU vegetable pathology that will include the onion rot photos and the identified bacterium.

PROJECT TITLE - Michigan Grape and Wine Industry Council – Trade and Media Relations Project - **FINAL**

PROJECT SUMMARY

Activities will address a significant barrier to growth of the Michigan wine industry, which is lack of awareness outside the state of the quality of Michigan wines.

The purpose of this project is to conduct specific promotional activities to:
- increase attendance by media and the wine trade to the Michigan Wine Showcase events in Detroit and Chicago in Spring 2015 and - gain increased media coverage for the industry around Michigan Wine Month (April) in Detroit, Chicago, and key national trade publications.

Michigan's wine industry is growing at a rapid rate, with the number of wineries growing by 10% per year and sales increases contributing to increased market share for Michigan wines in Michigan. There are opportunities for the Council to explore and test activities to enhance current promotional efforts, increasing awareness of the quality of wine made from Michigan grapes and other fruit and the economic impact of the industry to the state's economy.

The promotional activities covered in this project will increase awareness and interest and contribute to increased sales of wines made from Michigan grapes and other fruit, to expand the economic impact of the industry.

PROJECT APPROACH

- New promotional activities will increase awareness, interest and sales of wines made from Michigan grapes and other fruit, to expand the economic impact of the industry. Michigan ranks in the top ten states for Michigan wine grape production. It is important and necessary that the Council's communications activities evolve with the industry as it grows, to reach out to trade and media in important markets and the national wine trade publications to inform these important target audiences about the growing reputation and impact of Michigan wine production.
- The Michigan wine industry has grown rapidly over the last 10 years, but the perception of the quality and variety of Michigan wines has lagged behind the growth. The Council must actively seek ways to communicate and demonstrate the world-class quality of Michigan wines.
- This project builds on a previously funded Specialty Crop Block Grant, "Developing New Markets for Michigan Wine Grapes" in which preliminary research was conducted to plan promotional activities in Chicago for Michigan wines. Much of this project was conceived as a direct result of that project, in which we found a large gap in awareness among consumers, trade and media, and recognized an opportunity for education about the quality and diversity of Michigan wines to this important wine market.

GOALS AND OUTCOMES ACHIEVED

- Media outreach surrounding the Michigan Wines Showcase in Detroit (April 20, 2015)
- Media outreach surrounding the Michigan Wines Showcase in Chicago (June 1, 2015)
- Paid advertising for Detroit market: WineBuzz (Ohio), Michigan Festivals and Events Association
- Paid advertising for Chicago market: Edible Chicago (print), KitchenChat (radio), WLS 890 AM "Big John Howell Show" (radio), Make It Better (web), Chicago Magazine Dish (web)
- Hired media/trade consultants in Detroit and Chicago markets
- Submitted articles for trade publications:
    - Michigan Chefs
    - Flavor 574

        - Midwest Wine Press
        - Michigan Restaurant Association
        - Plum Market
        - Windy City Chefs Newsletter
        - ACF Windy City Professional Culinarians
        - Wine Business Monthly
- Conducted aggressive Twitter campaigns surrounding both the Detroit and Chicago Showcase events, focusing on media targets in particular
    - #MIWinesShowcaseDetroit: 27 tweets, 38 retweets
    - #MIWinesShowcaseChicago: 24 tweets, 49 retweets
- Conducted Facebook campaigns surrounding both the Detroit and Chicago Showcase events, focusing on consumer interaction
    - Detroit: 50 likes; 2,443 people reached
    - Chicago: 71 likes; 5,731 people reached
- Distributed media release promoting April as Michigan Wine Month, highlighting key events including the Detroit Michigan Wines Showcase

- Media outreach surrounding the Michigan Wines Showcase in Detroit (April 20, 2015) resulted in a marked increase in media attention surrounding the event.
- Paid advertising in key consumer publications plus the additional media attention contributed to an increase in attendance compared to 2014: trade and media attendance increased from 92 in 2014 to 120 in 2015 (target was 110); and consumer attendance increased from 180 in 2014 to 300 in 2015 (target was 110+).

WINE TRADE & MEDIA RELATIONS USDA GRANT RESULTS | 2015

PROJECT GOAL #1

Increase attendance at MI Wine Showcase events by trade and media personnel, leading to increased sales of MI wines over the long term.

MEASURABLE RESULTS

Increase attendees to Detroit showcase to at least 110 from the trade/media (plus 110+ consumers)

Michigan Wines SHOWCASE DETROIT

ATTENDANCE

120 trade/media
300 consumers
28 wineries

30% INCREASE IN 2015

2014 Attendance:
92 trade/media
180 consumers
28 wineries

Be a part of the conversation:
#MIWinesShowcaseDetroit

27 tweets
38 retweets

50 likes
2,443 people reached

Printed/Online Stories

Detroit News | "Michigan Wines Showcase coming up Monday April 20 at the Rattlesnake"

Michigan Chefs- April 2015 | "Marvelous Michigan Wines"

Flavor 574 | "Sampling MI Wines and Ciders at Detroit Showcase"

HOUR Detroit | "Wineries Converge in Detroit for Annual Showcase"

Detroit News | "Wines Showcase shines light on Michigan Varieties"

Gang of Pour | "BLOG: Snapshots from the Michigan Wines Showcase Detroit"

EIN Presswire | "Gov. Rick Snyder Declares April Michigan Wine Month"

Midwest Wine Press | "New Michigan Wine Video"

Pure Michigan blog | "Eight Answers to Your Michigan Wine FAQs"

Michigan.org | "Pure Michigan Hotspot"

Flavor 574 Blog | "Seven Michigan Wines Take Center Stage"

Kzoo Connect | "April is Michigan Wine Month – Get Out & Get Sipping"

Michigan By The Bottle | Giveaway to Event

TV Spots

Click on Detroit "Live in the D" | Michigan Wine Showcase

Detroit Public TV Discover the 'D' episode 1148

WDIV TV Rattlesnake Club Wine Segment Clip

Fox 2 Detroit Recipe Segment with Mark Johnson of Chateau Chantal

Online Ads

Drink Michigan

Mfea.org

Michigan by the Bottle

Mccachef.org

The Wine Buzz

WAAMTalk 1600.com (free spots)

Video

You Tube Video on Pure Michigan Website

Calendar Events Listings

Local Wine Events.com | Detroit Michigan Wines Showcase

Woodberry Wine.com | Detroit Michigan Wines Showcase

Crain's Detroit, WXYZ, WWJ, WJBK, WKBD, MLive, Eventful, WEMU, WFUM, WUOM, WCBN, WAAM, WRCJ

Bacchus Club

DrinkMichigan.org

WAAMTalk1600 Calendar

Detroit Metro CVB Partner Portal Event Calendar

whofish.com

Newsletters

Rattlesnake enews (x3)

AFPD enews (x2)

Midwest Wine Press

MI Wines enews (x2)

DMCVB enews

MI Chefs news

MRA eblast to membership

Plum Market eblast

Radio

WAAMTalk1600 Radio Spots

WRCJ 90.9 FM

WJR Travel Michigan Radio Show April 11 featuring Claudia (aired on WKMI, WJIM, WBCH)

WWJ featuring Claudia

Social

Detroit Metro CVB Connection | Save the Date Facebook event share, Reach: 422 likes, 376 followers

Wineries of WOMP | Twitter Posts 4/11/15 & 4/12/15 Reach: 1,971 followers

Media outreach surrounding the Michigan Wines Showcase in Chicago (June 1, 2015) – resulted in a minor increase in media attention surrounding the event; however, we did not experience an increase in attendance for either trade/media or consumers.

- We discovered that wine tastings are prevalent in Chicago, making it more difficult to get on trade and consumer calendars. In fact, there was a wine tasting event at the same location two days after the Michigan Wines Showcase. For future events, we will attempt to choose dates that do not coincide so closely with other wine tasting events.

WINE TRADE & MEDIA RELATIONS USDA GRANT RESULTS | 2015

PROJECT GOAL #1 *Increase attendance at MI Wine Showcase events by trade and media personnel, leading to increased sales of MI wines over the long term.*

MEASURABLE RESULTS *Increase attendees to Chicago showcase to at least 110 from the trade/media (plus 110+ consumers)*

Michigan Wines SHOWCASE CHICAGO

ATTENDANCE

85 trade/media
100 consumers
22 wineries

0 % INCREASE IN 2015

2014 Attendance:
86 trade/media
100 consumers
21 wineries

Be a part of the conversation:
#MIWinesShowcaseChicago

24 tweets
49 retweets

71 likes
5,731 people reached

Printed/Online Stories

Make it Better – Make it a Wine Monday
Midwest Wine Press – City Winery Michigan Wines Showcase Photos
Edible Chicago – Mon., June 1: Michigan Wineries Showcase at City Winery
Windy City Chefs Newsletter

Print Ads

Edible Chicago

Online Ads

Make It Better Make It Wine Monday
Dish E Newsletter

Online Events Listings

Cheap Wine Finder
MetroMix
WTTW; Check, Please!
City Winery
Chateau Chantal
Le Pan Magazine
Heyevent
Slow Food Chicago
Make It Better
SevenFifty Members-Only Calendar

Newsletters

MI Wines enews (x5)

Radio

Kitchen Chat: Mawby-Michigan's Sparkling Wine
Kitchen Chat: Michigan Wines Featuring Karma Vista Vineyards
WLSAM 890 AM interview "BIG" John Howell Show

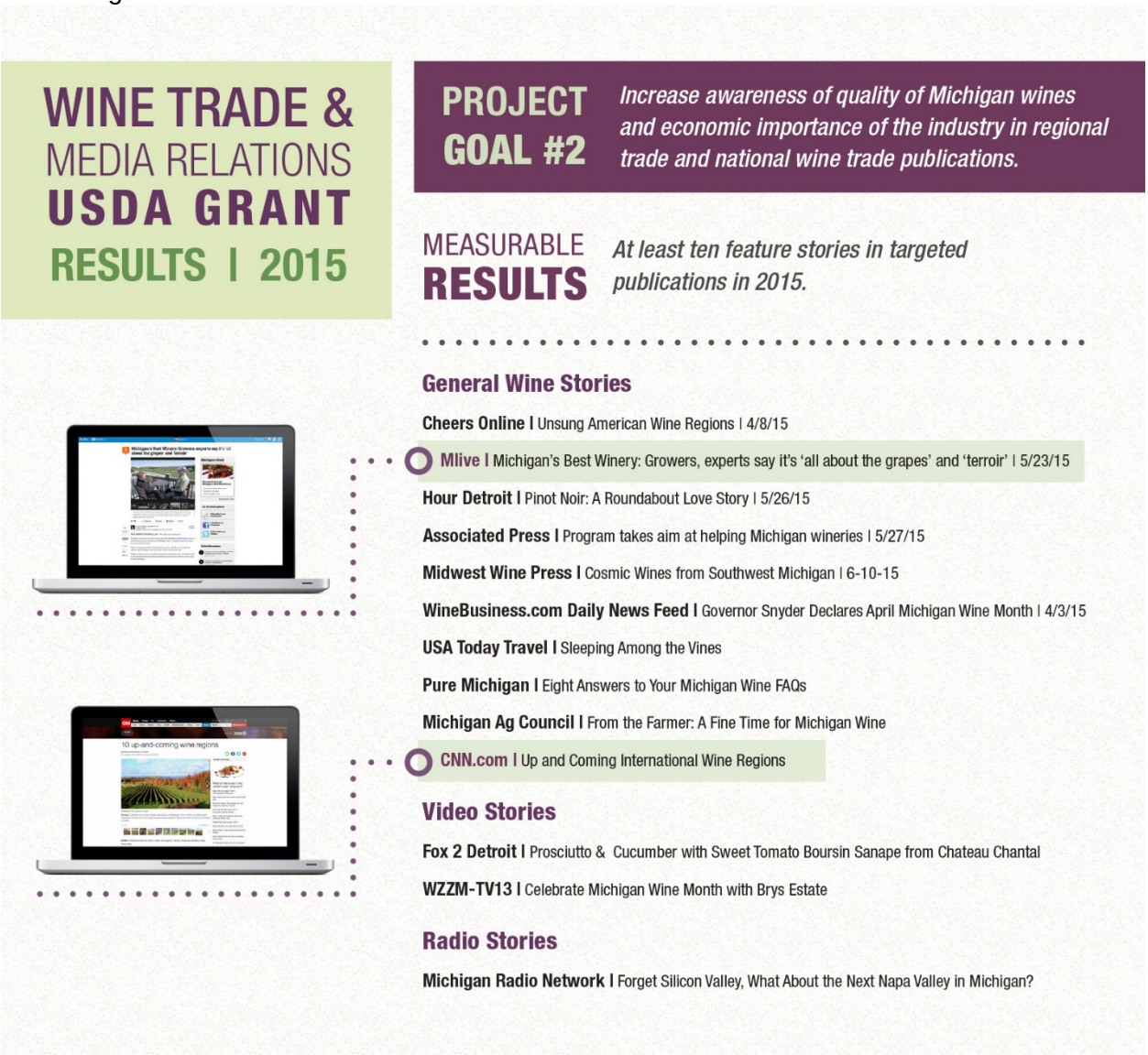
Social

ACF Windy City Professional Culinarians
Facebook share, Reach: 333 page likes

-

In addition, articles were submitted to wine trade journals promoting April as Michigan Wine Month, and a media release was distributed to more than 600 media contacts. As a result, we met our target for Project Goal #2, which was to get 10 feature stories on the subject of positive impacts and quality of Michigan wine. Notable stories featured through these media outlets:

- USA Today Travel
- WineBusiness.com Daily News Feed
- Cheers Online
- Mlive
- HOUR Detroit
- Associated Press
- Midwest Wine Press
- Fox 2 Detroit
- WZZM-TV 13
- Michigan Radio Network



BENEFICIARIES

- The 28 Michigan wineries that participated in the Detroit Showcase directly benefited from this project; 92% of survey respondents made new trade contacts as a result of their participation
- The 22 Michigan wineries that participated in the Chicago Showcase directly benefited from this project; 40% of survey respondents made new trade contacts as a result of their participation
- Michigan's other wineries and vineyards also benefit from this project. Michigan's wine industry has experienced significant growth in the last ten years, and the potential exists for continued growth, especially in the key wine markets of Detroit and Chicago. The additional trade and media attention garnered by the targeted approach in these two markets resulted in an increase in awareness of the quality of Michigan wines.

LESSONS LEARNED

- We were surprised and disappointed in the lack of increase in trade and consumer attendance at the Chicago Showcase. We discovered that wine tastings are prevalent in Chicago, making it more difficult to get on trade and consumer calendars. In fact, there was a wine tasting event at the same location two days after the Michigan Wines Showcase. For future events, we will attempt to choose dates that do not coincide so closely with other wine tasting events.

We have not administered this type of project before, so weren't sure how much of the media outreach could be conducted by our creative agency (LKF) vs. independent media consultants. LKF was able to conduct most of the media outreach in-house, instead of subcontracting. As a result, expenses budgeted for the Detroit media consultant and additional consultant were used to cover LKF staff time. Travel expenses were also lower than budgeted, because there was less need to convene a larger group, so we also used the leftover travel budget to pay for LKF staff time.

CONTACT PERSON

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ADDITIONAL INFORMATION

PROJECT TITLE – FINAL - Michigan Floriculture Growers Council – Creating More Visually Compelling Retail Garden Center Display Signs

PROJECT SUMMARY

Our goal was to better understand how people who buy plants use information on signs to make their purchase decisions. This would help plant retailers (and growers and wholesalers) to sell more plants, increasing revenue and profits. After obtaining human subjects research approval, researchers developed and tested 16 images to better understand how consumers make a plant choice in a retail garden center. We studied how the type of plant, sign location (center or left or

right in the display), price (low, medium, or high for the container size), and product information (nothing, product feature, product benefit) affected product choice. We conducted an online study with 795 participants and an in-person study with 50 volunteers who participated in the survey with an eye-tracking portion to the study. Results showed that purchase decisions are based primarily on the plant type (50%), followed by price (15%), then by sign information (12%) and location of sign in display (10.6%) and location of price on sign (11%). Furthermore, we found that adding plant benefit information to the information sign slightly increased the plant's likeliness to be purchased compared to having only a product feature described. Visits to nine retail garden center locations to collect information about the percentage of signs with benefit information and sales of plants from those displays showed similar results.

PROJECT APPROACH

Signs are prevalent in our world from stop signs we see while driving to sales signs we are exposed to in retail outlets. The information on those signs can be a critical influence as to whether a plant is purchased or not. Our objective was to investigate the type and order of information presented on a single sign such as would be displayed in a retail garden center to help consumers make product selections. One primary concern is price as this product feature is often how a substantial portion of consumers make a decision. We were also interested in what the relationship was between purchase and the type of information. Features are characteristics of products and quite often some of the more descriptive information provided on many signs. However, features are often meaningless to consumers if they are not translated into benefits. For example, a fragrant (feature) plant may attract pollinators (benefit). Thus, consumers will often find more value in benefits compared to features. Our hypothesis was that signs with product benefits would have a greater likelihood to have consumers make a purchase from it compared to signs with product features. Since price is a key product feature, we wanted to understand how the relative position of price in relationship to other sign information affected choice. Our hypothesis was that if price was conveyed at the top of the sign that it would reduce the likelihood of a consumer wanting to make a purchase from that display. However, we further hypothesized that positioning the price near the bottom of the sign would essentially reduce its prominence and increase the likelihood of purchase.

GOALS AND OUTCOMES ACHIEVED

- We developed an online (and identical for in person) survey instrument and eye-tracking protocol to be in compliance with the federal laws regulating research involving human subjects. The instruments and protocols were both approved by the University Committee on Research Involving Human Subjects prior to data collection.
- We adapted survey instruments from prior research involving signs.
- We developed 17 images to use in the study by visiting a retail collaborator in Kalamazoo and taking photographs of plants on a black bench with a black fabric background a blank sign. We subsequently added the information (which included price, plant feature or benefit, and plant name/identification). The 16 images were generated using SPSS software to devise an incomplete factorial conjoint design. A complete 3 x 3 x 3 x 3 x 3 or 3^5 factorial design would have resulted in study subjects needing to evaluate 243 images, which would have taken considerable time and effort, tiring even the most enthusiastic subject. Thus, the incomplete factorial design permits researchers to generate the full set of information from having study subjects view only a small, but deliberately crafted, set of combinations.
- We recruited 1400 subjects for the online study through Global Marketing Insight, and achieved 795 completed responses (56.7% response rate). We also recruited 50 subjects from Craig's List to generate the sample for the eye-tracking study. Online participants were paid "points" while in-person survey participants were paid $30 for their participation

- We also visited nine garden center collaborators in three regions of Michigan to identify signs which depicted product benefits (rather than features) and gather anecdotal evidence that portraying plant benefits does help increase plant sales.
- We analyzed the online survey data and are still in the process of analyzing the in-person eye-tracking data.

- GOAL: Expected outcomes included greater knowledge about garden center signs and consumer's use of signage, information acquisition, and importance of information to different age cohorts and plant shoppers from different outlets. We achieved this goal by generating more knowledge about signage use overall. We found that sign location (left, center, or right of the display) contributed to 10.6% of the purchase decision and that signs in the center of the display contributed more positively to the purchase decision while signs to the right of center contributed the least positively to the purchase decision. We found that when the price was centrally located on the sign it contributed most positively to the purchase of the plant but when price was located at the top of the sign it detracted most from the purchase decision. We found that signs that depicted product benefits were more favorable to the purchase decision compared to signs with product features.

We achieved the collection of a substantial amount of data, both in-person and online.
The online results showed that our sample of 795 subjects was approximately 20.8% Gen Y (persons ages 18-29), 37.4% Gen X (persons ages 30-49) and 41.7% Boomers (persons aged 50 and higher). We found that, overall, purchase decisions are based primarily on the plant type (50%), followed by price (15%), then by sign information (12%) and location of sign in display (10.6%) and location of price on sign (11%). However, we found that the younger age cohorts (Gen X and Gen Y) were less concerned with the plant species and more influenced by the price location and information presented on the sign. This means that situating the price in the middle helped to increase the likelihood of a plant purchase, especially for younger aged consumers. Also placing the signs centrally increased the likelihood of purchase for all subjects, but even more so for the younger aged consumers.

We had planned to recruit 10 MI plant retailers in March, 2015, and collect data on the percentage of signs that provide benefits in smaller type font compared to price. We were only able to visit nine retailers and estimate the percentage of signs that had benefits depicted and anecdotal evidence that those signs did help facilitate purchases.

The exceptionally short timeline (eight weeks) in which to complete the project permitted survey approval and data collection, but did not permit researchers to complete data analyses. In addition, nearly all of the travel budgeted in the project was not able to be used due (again) the exceptionally short time period for the study. Also, the PI's mother was diagnosed with a terminal brain tumor, and she succumbed to it shortly after the diagnosis. The PI's main responsibility was with her family, thus the data was not analyzed as quickly as hoped. Researchers are still working on data analyses.

BENEFICIARIES

The economic impact of the results of this study can be quite substantial. An investment of the funds can be returned to the industry approximately five times that investment. Hodges, Hall, and Palma (2011) estimated that there were 45,855 general merchandise firms selling specialty crops, or approximately 9000 per state. We used this as the basis for the number of stores/outlets who directly benefitted from this research. We accomplished approximately a 5x ROI by helping retailers create more eye-catching point-of-purchase materials and/or selling more plants with an average retail price of $8 per plant used with 10% profit, and once distributed to the industry, should help to sell approximately 1 million more plants. Even spread across 50

states, represents an increase in sales of approximately 100,000 plants per state or 10 plants per retail establishment.

LESSONS LEARNED

The goals were achieved, but the short time frame we had to collect and analyze the data was insufficient. We also were not able to travel to any meetings to present results because the time for the work was restricted to 2.5 months. Since no-cost extensions are not permitted, in the future, researchers should be certain that the work and dissemination can be conducted within the time restrictions given.

CONTACT PERSON

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ADDITIONAL INFORMATION

None.

PROJECT TITLE - Michigan Apple Committee - Educational Videos for Michigan Apples **FINAL**

PROJECT SUMMARY

The ultimate purpose of this project was to educate consumers about Michigan Apples in an effort to help them understand what goes into producing them and also to give them a positive association with growers and the industry. The idea is to instill a connection with Michigan growers and inspire support of the industry they know more about.

Through our consumer panels, conducted in 2008 – 2013 in Michigan, as well as the greater Chicago area, we have learned that consumers are extremely interested in buying Michigan apples; but they often have difficulty in determining the source of the apples they purchase in the store. Often consumers thought they were buying Michigan apples when, in fact, they were buying products from other places. Educational videos provide the opportunity to educate consumers about what to look for in the store, and possibly increase demand for the Michigan-grown product, based on positive associations with the industry fostered by the video.

In addition, many retailers request video from us that can be played in-store. It would be an opportunity to show video about growers, the industry and apple production right in the store where the apples can be purchased.

This project could benefit our local efforts as well as beyond Michigan. It could even be a part of future export efforts.

The Michigan Apple Industry is still recovering, particularly from a marketing perspective, from the crop loss of 2012. Regaining any momentum we had previously with consumers and retailers will take a significant amount of time and effort.

This project has not been previously funded or built onto a previously funded project.

PROJECT APPROACH

One of the main goals of the Michigan Apple Committee is to provide education to consumers and retailers about the Michigan Apple Industry.

During the grant period, MAC staff worked with a videographer to visit various orchards in Michigan during different times of the growing season. The videographer and MAC staff interviewed growers and researchers about what happens in the orchard during the different seasons, the considerations made by the growers, how they cope with pests and disease, and other challenges within the orchard. Of course, apple harvest was also covered in the videos. Four videos were created during the grant period. MAC did not publish videos until June due to uncooperative weather. When it came time to film the winter orchard video, the orchards did not have any snow.

Once the videos were finalized, they were posted on the Michigan Apples YouTube channel. In June, MAC hoped to tally 100 views, and totaled 756. The August goal was 150 views, and MAC achieved 843 views. In September, MAC began work with Google Ad Words and used the new videos for part of the online advertising. By September 30, MAC's new videos had tallied 10,226 views.

GOALS AND OUTCOMES ACHIEVED

Activities completed to achieve the goals and outcomes for the project included development of outlines, working with a videographer, planning and recording of videos, posting videos online, and tracking YouTube Analytics.

The performance measures established for the grant period were to achieve 50 views in March, 100 views in June, and 150 views in August. We exceeded the measures by tallying 756 views in June and 843 views in August. The goal we set was to increase consumer engagement. Prior to this project, MAC had 27 subscribers to our YouTube channel. At the end of this project, we have 56. We feel this indicates an increase in consumer interest and engagement.

Prior to the creation of these videos, MAC's benchmark for views was an average of 12 views for month. Since the videos were posted, we now average 85 views per month.

BENEFICIARIES

Michigan Apple growers, shippers and other industry members benefit from these videos, as they continue to increase the consumer interest in Michigan Apples.

With thousands of views and twice as many YouTube channel subscribers, we feel that the videos have engaged consumers and built some brand loyalty that could result in increased sales of Michigan Apples. With these types of projects, however, these results take years to build and measure.

LESSONS LEARNED

Through this project, our belief that consumers respond to online videos was confirmed. In addition, we had to be flexible with our planning of the videos, especially since getting footage of a snow-covered orchard did not work out. We were still able to convey the message about what happens in the orchard during each season of the year.

The creation of the new videos inspired us to pursue online advertising through Google Ad Words, and use the videos for some of the ads. This has proven to be a beneficial program for us, on top of simply promoting the videos through social media.

CONTACT PERSON

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ADDITIONAL INFORMATION

YouTube video links:

https://youtu.be/Ee0XsADkQb8

https://youtu.be/GLEU1B3b7K8

https://youtu.be/4BumoDT-wFQ

https://youtu.be/8GtKMMVsOrA

PROJECT TITLE – MI Department of Agriculture & Rural Development – Food and Dairy Division – Increasing Awareness and Sales of Healthy Michigan Specialty Crops and their Nutrition Value through Education Tools - FINAL

PROJECT SUMMARY

In Michigan, intake of fruit and vegetables is lower than recommended for both adults and adolescents**.** Michigan produces a wide variety of specialty crops and leads the nation in production of many fruit and vegetable specialty crops. Specialty crops provide nutrient dense, low calorie foods important for health. Eating a diet high in fruits and vegetables is associated with a decreased risk of some chronic diseases and is associated with weight management.

Michigan will see both economic and health benefits from increasing consumption of Michigan specialty crops through promotional and educational tools. Specialty crop information/recipe cards were created to help educate Michigan consumers on healthy produce products. The cards contain recipes to encourage consumption of specialty crops which in turn, can increase the economic value to the farmers through purchases.

Michigan is working to decrease its obesity rates; and in SCBG 12-25-B-1235, 17 individual specialty crops educational cards were created. This project allowed for the addition of four more specialty crops to be marketed as educational tools. Each card contained helpful hints on the individual crop such as, seasonal availability, nutrition information, recipes, food safety tips, and a USDA nutrition message. Four hundred additional cards of the original 17 Michigan specialty crops cards were printed. 1,000 of each of the new nutrition cards were printed, along with an additional 1,500 Michigan produce seasonal availability charts. The educational and promotional materials were provided at events such as, Michigan Farmers Markets, conferences, and events like the Detroit River Days. The cards increased awareness of Michigan specialty crops by providing information to work toward healthier eating behaviors by increasing purchases and consumption of Michigan specialty crops produce. Sample cards are provided as reference.

PROJECT APPROACH

Consumers were educated using the wheel game purchased in our original grants on specialty crops grown in Michigan. Educational messages to consumers contained nutrition-health benefits, seasonal availability, production, storage, food safety, and economic benefits to Michigan. The main goal of this grant was to increase the quantity of nutritional cards to enhance education on Michigan specialty crops and their value to the consumer and State of Michigan. Along with the additional printing of the original nutrition cards, four new specialty crops were created and printed. They included beans, apples, potatoes, and grapes. All cards provided messages on food safety, nutrient content, a recipe, a nutrition message and information on the crop in regards to production and season availability. The nutrition cards were utilized at events and conferences. They are also available to businesses through a PDF of each card found on the Pure Michigan FIT webpage, http://michigan.gov/puremichiganfit .

GOALS AND OUTCOMES ACHIEVED

The four additional specialty crop cards created promoted specialty crops grown in Michigan. Potatoes, dried beans, grapes and apples are some of Michigan's largest specialty crops produced in Michigan. The cards encouraged safe food consumption of local foods. There were benefits to the consumer toward healthy eating and to the farmers, economically. PDF copies of all the specialty crop nutrition cards were created to allow them to be used by businesses or as part of a tool kit. The http://michigan.gov/puremichiganfit website was printed on each card to allow additional PDF copies to be printed. This allows consumers to visit the website where they found the cards, seasonal availability charts, along with other nutrition and physical activity information. This additional educational information helped to meet our objective of reducing obesity in Michigan.

(Goal): Increase awareness and health benefits of Michigan specialty crops business **(target)** by having at least one new business **(performance measure)** sign on to utilize the specialty crop cards or PDF file. There is currently no **benchmark** for businesses utilizing these specialty crop produce crops.

(Goal): Increase consumer understanding of Michigan's specialty crops through education at events. **(Target)** consumers that visit the booth will be able to answer 2 of 4 (50%) questions regarding Michigan specialty produce crops **(performance measure). Benchmark** will be the pretest of the same four questions prior to becoming educated.

Nutrition cards were provided at 25 events, meetings and conferences. More than 3000 cards have been distributed along with specialty crop, food safety and nutrition information. Outcome number 2 was met through farmers markets at the capitol where consumers were provided with education on agriculture and specialty crops of Michigan. A review of Michigan agriculture facts was provided to visitors. The information included at least four areas of education including, listing Michigan specialty crops, diversity in Michigan crops, area crops are grown, economic benefits to farmers, season availability, how to prepare them and nutrition information. The visitors would then utilize the recipe cards for further information or try the wheel with agriculture facts to answer the information discussed. 25% of the visitors stayed at the booth for follow up questions. 100%were able to provide information back on specialty crops and Michigan agriculture from what they had learned or by utilizing the recipe cards as a resource for information when unable to answer the questions asked.

Outcome number 1 was met through two new venues where the recipe cards were utilized - Wise Woman Conference held May 13, 2015. Here the cards were available as resources for health, and at four trainings through the Michigan Farmers Market Association (MIFFA) to local farmer's market managers in September and October 2015. MIFMA utilized seven of the

different nutrition cards, including the new card created for pears. The trainings provided recipe demonstrations, specialty crop information and food safety techniques to be used at local markets. Trainings were provided in four different areas of the State of Michigan and a total of 2000 cards were distributed. Managers were then educated on printing additional cards through the use the PDF copy from the Pure Michigan FIT website to use at their local market and food demonstrations when hard copies ran out.

BENEFICIARIES

Michigan consumers were educated on the diverse crops grown throughout Michigan. This education would prompt consumers to try recipes using these specialty crops, thereby increasing consumption of Michigan fruits and vegetables. Specialty crops farmers would benefit by the increase in purchases, and consumers would experience health benefits by eating more fruits and vegetables.

Michigan Farmers Market Association trainings allowed for market managers to learn how to demonstrate a recipe, using several of the specialty crop cards. They were also educated on how to demonstrate food safety and safe food sampling with the recipes at their markets around Michigan. This increased the likeliness of more consumers purchasing and consuming specialty crops.

LESSONS LEARNED

Consumers are very interested in the diversity of Michigan specialty crops. Providing a receipe and information would encourage even more intake by the consumer.

We should consider other organizations or department partners in the development of a grant.

CONTACT PERSON

Lori Yelton, Michigan Department of Agriculture & Rural Development
517-420-3249

ADDITIONAL INFORMATION

We will continue to share the specialty crop cards at grocery stores and at other events.

A future goal is to include a budget for translation of the specialty cards for Spanish and Arabic populations that are in Michigan.

To sustain the use of the specialty crop cards, a PDF file was created for businesses, such as, grocery stores or farmers markets available on line at the Pure Michigan FIT website, http://michigan.gov/puremichiganfit .

PROJECT TITLE – Commercial Maple Syrup Producers of Michigan – 2015 Maple Syrup Fall Awareness Campaign (FY15) - FINAL

PROJECT SUMMARY

Currently, consumption of maple syrup is less than two ounces per average household in Michigan, according to a feasibility study conducted by the MSU Product Development Center in 2011. Funds are needed to increase awareness and consumption of Michigan maple syrup in our state. It should be noted that much of the maple syrup sold in Michigan is a product of Canada and other states.

The 2015 Maple Syrup Fall Awareness Campaign consisted of a series of TV commercials throughout the greater Grand Rapids area. Commercials aired on the following cable stations – HGTV, The History Channel, Food Network, and The Weather Channel. A total of 3,670 commercials were aired during September 2015. Social media was also utilized by targeting the entire state through Facebook's mobile and news feeds.

Results of the campaign have been posted to our website and shared with various media outlets and maple syrup equipment suppliers. We have also been active on MapleTrader and Sugarbush.Info, which are interactive maple forums. Results will also be shared with our members in our quarterly newsletter.

PROJECT APPROACH

The Outreach Coordinator spoke with several maple syrup producers to determine which area would benefit the most from targeted advertising. It was determined that the Southeastern side of the state was out of our price range given the amount we had to work with. We also determined that those who are aware of maple syrup production in Michigan generally think of upper Michigan as the place where syrup is made. Thus, the committee determined the Southeastern side of the state would make a good target.

While it is impossible to gage if our campaign contributed to the economic growth or investment of Michigan at this point, we are hopeful that our members will report an increase in sales during this fall season and beyond as a result of these awareness efforts. Surveys have been sent out to random syrup producers in Michigan to determine if their sales increased and if they gained new customers. Surveys are still coming in so we are unable to determine at this point how much, if any, sales may have increased. We are confident that whether or not sales increased, consumers gained an awareness of Michigan Maple Syrup and its many health benefits which was the basis of our campaign.

GOALS AND OUTCOMES ACHIEVED

Our Facebook ads resulted in over 27,000 views of the video. Those who clicked on the advertisement were taken directly to our Facebook page. This resulted in 50 new likes to our Facebook page and several inquiries of where to purchase Michigan maple syrup. The engagement was even larger. With the ad placement on Facebook, we were able to draw over 800 people to our website. This allowed consumers to locate a sugarbush in their area. Although it is tough to quantify the results from our TV commercial, we do feel that we were successful in achieving our goals, as we did see an increase in our website traffic during the month of September, which is when the commercials were aired.

It is a proven fact, that once people consume maple syrup, they find it hard to go back to imitation products. People in Michigan want to know where their food comes from, and they want

to support Michigan farmers. We have provided, and will continue to provide, consumers with the information they need to make informed choices about the syrup they buy. As long as we can continue to educate our consumers, we can continue to grow our consumer base. Utilizing Facebook proved to be a good way to achieve awareness. It was more easily measured and less expensive than TV. It was hard to determine how successful the TV advertisements were. For example, it was hard to determine who viewed the commercial and whether or not it would influence a future purchase whereby, when someone viewed our Facebook post, we could easily determine if they were male or female, their approximate age and where they lived. We could also tell if there was an interest in maple syrup if they visited our website.

BENEFICIARIES

We reached out to the Michigan Maple Syrup Association and syrup equipment suppliers throughout Michigan for their support and assistance through this campaign. Posters were provided to them to display at their facilities to make producers aware of our campaign and help to get the word out. We will continue to work with the Michigan Maple Syrup Association, as well as syrup equipment suppliers to strengthen ties and build awareness by including those organizations in our future endeavors as our goals align well together.

LESSONS LEARNED

As stated previously, it is hard to determine the benefit of the TV commercials but we are pleased that we now have a video that can be used at various promotional/educational venues throughout the state. We have also compiled numerous statistics on the healthy benefits of maple syrup. These statistics will be shared on Facebook posts as well as posted on our website on a continual basis.

It is doubtful that any jobs were created as a result of this grant, mainly because of the timeframe. However, the fact that we were able to create an awareness of maple syrup in Michigan, leads us to believe that we will see more sales, which will in turn create jobs in the future.

CONTACT PERSON

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ADDITIONAL INFORMATION

Website: http://www.cmspm.org/ Commercial Maple Syrup Producers of Michigan
Facebook: Commercial Maple Syrup Producers of Michigan
2015 Fall Campaign Video – https://youtu.be/U0uPz347ERM ;
Fall Advertising Campaign Results - http://www.cmspm.org/2015/12/08/fall-advertising-campaign-results/

Fall Campaign Press Release – Next page.

Contact: Craig Waldron
Tel. 231-492-4031
Email: cmspmich@gmail.com
Date: 08/05/15

FOR IMMEDIATE RELEASE

COMMERCIAL MAPLE SYRUP PRODUCERS OF MICHIGAN RECEIVES 2015 SPECIALTY BLOCK GRANT FOR AWARENESS CAMPAIGN

Burt Lake, Mich. – The Commercial Maple Syrup Producers of Michigan (CMSPM) is pleased to announce it has received a $9100 grant to be used for a Fall 2015 Maple Syrup Awareness Campaign. "This grant aligns well with the CMSPM's goals of increasing awareness and consumption of Michigan maple syrup" stated Chairman, Craig Waldron. "Current consumption of maple syrup is less than 2 ounces per average household in Michigan. We hope that by educating the consumer about the many nutritional benefits that maple syrup has to offer, that producers will see more activity around their sugarhouse and as a result, they will see an increase in their sales."

The CMSPM is a non-profit organization serving maple producers of all sizes with an interest in being a part of the growing maple industry. Through the support of its members, CMSPM has been able to address some of the maple industry's most pressing needs, including increasing public awareness and consumption of maple syrup as well as increasing tap count.
The Michigan Department of Agricultural and Rural Development (MDARD) awards grants through a competitive application and review process. The purpose of the Specialty Crop Block Grant Program (SCBGP) is to solely enhance the competitiveness of Michigan's specialty crops.

About Commercial Maple Syrup Producers of Michigan (CMSPM) – A recently formed association of commercial maple syrup producers formed to promote, encourage, and support the sustained growth of all aspects of the Michigan Maple Syrup industry. For more information, visit www.cmspm.org.

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September 2015 CMSPM Newsletter –