New York State Department of Agriculture and Markets

Specialty Crop Block Grant Program – FY2010

AMS Agreement #12-25-B-1085

Final Performance Report

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Date Submitted:
February 9, 2014
REVISED April 15, 2014
REVISED May 5, 2014

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Project 1

Promoting New York State Specialty Crop Consumption through CSA Consumer Fairs

Project Summary

With increased media attention on obesity and corresponding need for people to lead a healthier lifestyle, more and more consumers are paying closer attention to what they eat. Community Supported Agriculture (CSA) provides consumers with an economical option to both increase their intake of fresh, specialty crop foods and support local agriculture.

For the past 20 years, the Northeast Organic Farming Association of New York (NOFA-NY) has championed the unique CSA farm-marketing model in New York State that is a particular benefit to direct-market, specialty-crop farmers. CSA consists of a community of individuals who pledge support to a farm operation by buying a "share" in a farm's annual production. Consumers purchase their share up front in the spring for a season's worth of specialty crops, which they receive weekly throughout the growing season. This marketing system allows growers and consumers to share the risks and benefits of food production. Through direct sales to community members, who have provided the farmer with working capital in advance, growers receive better prices for their crops, gain increased financial security, and are relieved of much of the burden of marketing. In return, consumers gain access to affordable, sustainably-grown specialty crops from June to November.

While the buy local movement is growing, most consumers are still not familiar with CSAs. Not only do CSA specialty-crop farmers need to sell the benefits of local food, but they also need to explain the CSA model. In 2007, NOFA-NY began a project to provide strategic support to CSA farms. NOFA-NY identified 134 CSA farms in New York and conducted a telephone survey with 75 of these farmers to obtain information about their size, scale, and marketing practices. Questions also explored production and marketing challenges. Farmers identified two areas where they need assistance: a) marketing innovations that connect consumers with local and regional producers and, b) beginning farmer support. This data was confirmed by a 2007 Cornell Small Farms Summit, which found that priorities for small farmers include: marketing innovations to connect consumers with local and regional producers and farmer support. NOFA-NY followed with a series of 5 regional meetings in the winter of 2008 to discuss marketing, consumer education, and technical assistance for CSA farmers. Participants included 120 farmers, extension agents, and CSA consumer members. The number one need that these sessions identified was more consumer education.

This project strove to coordinate, publicize, and host 18 CSA promotional fairs over three years—where farms staffed a table to explain their CSA and sell seasonal specialty crop shares to visiting consumers—in eight regions throughout NYS. The goals of the project were twofold: 1) to educate consumers about CSAs and, 2) connect consumers with their local specialty-crop CSA farms and increase the direct market sales of specialty crops in eight regions of NYS.

Project Approach

This proposal capitalized on the increased consumer interest in local, sustainable foods, an effective model of matching consumers with local food through CSA fairs, and supports CSA farmers in what they need the most help with—marketing and connecting consumers with CSA shares. Over the three years of the project, NOFA-NY increased consumers' awareness of CSAs, increased the number of

consumers who buy local specialty crops through participation in CSAs, improved specialty-crop farmers' marketing efforts to promote their farms' CSA shares, and increased sales of specialty-crop shares to local NYS farms.

To achieve this, NOFA-NY coordinated, publicized, and hosted 18 CSA fairs in eight regions throughout NYS (3 in year 1, 6 in year 2, and 9 in year 3). First, we reached out to contacts from Madison, WI and Ithaca, NY who had already successfully hosted CSA fairs for CSA fair resources and advice.

In each target area where we hoped to host a fair, we reached out to local farmers and CSA shareholders to identify the best venues and dates for the local areas, and then secured the fair venues and dates for the year's CSA Fairs. Each year we created and distributed promotional postcards and posters promoting the fairs, press releases, electronic promotion through the NOFA-NY e-news (9,000+ distribution), social media (Facebook and Twitter), and through our website. Connecting with regional and local media was the most successful. We also provided farms with photo examples of what a CSA Fair farm table could look like as well as resources to promote their CSA. We created farm evaluations, registration forms, and introductory CSA information for consumer education.

We achieved our goal of number of CSA Fairs held and exceeded our goals for participating specialty crop CSAs. We did not meet our consumer attendance goals, as fewer consumers attended events than we anticipated, but many more were exposed to the CSA concept and educated about local CSA options through our media coverage and public education tools.

In order to ensure that all SCBGP funds were used for solely specialty crop producers, we charged a registration fee for any CSAs that did not sell specialty crops (like meat or bread CSAs). CSAs that sold specialty crops but also any ineligible crops were charged a reduced registration fee, as their specialty crops were supported by the project. Program revenue was invested back into the project to cover additional personnel and project costs not covered by SCBGP.

Several project partners provided significant contributions to the project. Peacework Organic Farm, Quail Hill Farm, and Wyllie Fox Farm all played important roles at the beginning of the project by making sure that the initial year's CSA Fairs were established to best meet the needs of CSA Farmers. Peacework Organic Farm and Wyllie Fox Farm continued to participate in both the fairs and planning throughout the length of the project. Monika Roth, Tompkins County CCE, and Kiera Mulvey, Madison Area Community Supported Agriculture (MACSAC) provided technical support to this New York statewide initiative. Most of their support was utilized in the first and second years of the project. Both Roth and Mulvey contributed CSA fair resources to the project. In year two, many additional positive media relationships were built that contributed significantly to successful promotion and planning of fairs during that project year, some of these continued into project year three. Partnerships with farmers were built on seeking their input to accommodate positive change in future events. Relationships were also built with local media, some of whose coverage before the fairs was crucial to consumer attendance, and regional agriculture organizations who also helped promote the fairs to the local community.

Goals and Outcomes Achieved

Outcome (1): The first goal of the project was to increase the number of CSA specialty crop farmers participating in CSA promotional fairs in NYS from 12 (currently) to 32 in Year 1, 48 farms in Year 2, and

64 farms in Year 3. This was be measured by the number of specialty-crop CSA farms that participated in 18 CSA fairs over the three project years.

Outcome (2): The second goal of the project was to increase the number of consumers who learned about CSA through CSA fairs in NYS from the current 300 consumers to 10,400 consumers over the three project years. This outcome was measured by the number of consumers attending each CSA fair (recorded with registration sign-in).

Outcome (3): The third goal of the project was to increase the number of specialty-crop CSA shares, and therefore on-farm specialty-crop sales, sold through CSA fairs in NYS from the current approximate 1,200 shares ($600,000 sales) to 3,200 shares in year 1 ($1.6 million sales), 4.800 shares in year 2 ($2.4 million sales), and 6,400 shares in year 3 ($3.2 million in sales) measured by intake and outtake surveys from each participating farm that detail the number of shares available, the share price, and the number of shares sold after the fair.

Over three years, we successfully executed 18 CSA Fairs and exceeded our goal of 144 farms participating with 214 specialty crop farms who participated over the 3 years. In year 2 and 3, attending CSA farmers reported a satisfaction rate over 92%, demonstrating the value of CSA fairs for farmers.

Our consumer attendance goal was 10,400, which we found was difficult to meet with a new event. This number had been extrapolated from existing successful CSA fairs in Madison, WI and Ithaca, NY which had built up a large consumer following. In areas new to CSA and the concept of a CSA fair, it took longer to generate the same attendance; throughout the project we adjusted our attendance goals accordingly. Over the three years, we did achieve a combined attendance of over 3,000 consumers. Over 20,000 people were exposed to publicity of the CSA Fairs over the length of the project, which was positive because we found that people who did not attend a CSA fair still visited our website and called the NOFA-NY office to seek a local CSA as a result of the publicity around their local CSA fair. Each year, we added to the number of fairs we hosted, successively increasing geographical reach.

In the first two years, we were not able to capture the amount of shares sold as a direct result of the events, but by the third year, we determined a way to effectively collect this information that yielded a number of shares sold per CSA, from which we extrapolated an average number of specialty crop CSA shares sold by participating CSAs as a result of CSA fairs. This data was difficult to capture because we found that although many consumers attended the fairs, very few actually purchased a share at the fair. They instead used the fairs to learn more about the local CSA options, picked up information, and made their CSA decision after they left the fair. It was difficult for farmers to track if new CSA members joined as a result of attending the CSA fair because of the time lapse between the fair and consumers making a decision. Although not all participating CSAs responded to our survey, we were able to extrapolate some economic impact results in the third year and applied the average number of shares sold by those farmers who answered the survey to the total number of participating CSAs. Please see data in Table 1.

Table 1. CSA Fair Participation, Attendance, and Shares Sold Data from 2011-2013.

	Number of Fairs		Participating CSAs (specialty crop)		Consumer attendance		Shares sold	
	Grant Goal	Actual	Grant Goal	Actual	Grant Goal	Actual	Grant Goal	Actual
Year 1	4	3	32	48	1,600	1,000	3,200	Not available
Year 2	6	6	48	73	3,200	1,000+	4,800	Not available
Year 3	8	9	64	93	5,600 *1,800	1,200	6,400 *180	498
Total	18	18	144	214	10,400	3,200+	14,400	Not available

*Revised year 3 goals, after experience from year 1 and 2.

Consumer feedback was overwhelmingly positive. Some consumers, familiar with the CSA model, came to join the CSA that best fit their lifestyle. Others, new to CSA, came hoping to increase their consumption of local specialty crops and to learn more about CSAs. If customers did not sign up for a CSA on the spot, they took home informational brochures from farms. Cities that hosted fairs for 3 years showed the highest consumer exposure to CSAs. Data shows that new consumers came to the fairs each year; fair attendees did not typically attend the next year because they had found a CSA match the year before. This demonstrates that CSA fairs do a great job at introducing *new* consumers to local specialty crop farmers each year and past fair attendees continue to be consumers of CSA once they attend a CSA fair. Interest in future CSA fairs was evident in every region.

Beneficiaries

Specialty Crop CSA farms:

- The primary project beneficiaries were specialty crop CSA farms in New York State. Of the 214 CSA farms that directly benefitted from this project, we learned from anecdotal information and surveys that the participating CSA farms found the fairs helpful to their business success, helped fill their annual CSA shares, and identified the fairs as an effective marketing tool.
- In a post-CSA fair survey, 92% of farmer-participants said they were satisfied with the fairs. Farmers indicated that their goals for participating were to increase their understanding of local consumer market and desires, market their CSA, sell shares,

network with other CSA farmers, and increase general consumer awareness of the CSA model.

- One participating farmer said, "Meeting people and talking about the CSA program was helpful in getting new subscribers. We need more public awareness about CSA, how it works, and where to get info."
- Another CSA farmer reported, "The turnout was great-better than we anticipated. There was a diversity of attendees…We could have sold even more shares as a result of the CSA fair but were sold out before people connected."
- A beginning specialty crop farmer noted that she sold 27 shares (of the 50 available) through the 2013 CSA fairs, saying "the CSA fair plays an integral role in the advertising and marketing of our small, heirloom CSA farm."
- Another beginning farmer reported, "As a new farm to the Syracuse area in 2012, we met most of our original shareholders through the CSA fair. Many of these shareholders were new to the CSA concept, and the face-to-face interaction with a number of CSA farms really helped explain what a CSA is and how the various ones work. We don't know that we could have successfully started our CSA without the help of the fair!"

Economic Impact:

- According to the extrapolated average of shares sold, 42% of consumers who attended fairs purchased a CSA share. With the limited data we received back from farms regarding CSA shares sold as a result of the fair in the third year of the project, we estimate that at least 498 CSA shares were sold, and at an average price of $600/share. Therefore, we estimate that this project helped generate $300,000 dollars in revenue for specialty crop CSA farmers in New York State in the third year of the project.
- We can extrapolate that with 3,200 consumers attending the fairs over three years, 1,344 purchased a CSA share, which resulted in $806,400 income for specialty crop CSA farms in New York State. We anticipate that many more CSA shares were sold as a result of the fairs, but we were unable to track them. The likely economic impact of this project on CSA farms in New York State is greater that we are able to demonstrate from our recorded data.

Consumers:

- Over 3,200 consumers benefited from this project by gaining access to affordable, sustainably-grown specialty crops and learned about the availability and benefits of specialty crop consumption.
- In addition, although we did not meet our attendance goals, we discovered that the promotion for the fairs generated a lot of interest among consumers and resulted in frequent calls and website visits to accommodate those people who could not attend their local CSA fair, but were still interested in supporting local specialty crop farmers.

Lessons Learned

After gaining two years of experience in coordinating this project, we learned that there were two outcomes that we originally proposed that were too stringent: consumer outreach and shares sold

as a direct result of CSA Fairs. We adjusted these goals for year 3. We initially estimated that each fair would reach 400 consumers (1,600 total) in the first year, 600 (3,200 total) in its second year, and 900 (5,600 total), in its third year. On average each fair reached approximately 300 consumers in the first year and 150 consumers in the second year. It was unrealistic to think that attendance would increase at this rate. We altered this goal to 200 consumers per fair in year 3.

We estimated that as a result of CSA Fairs, shares sold would increase from 3,200 in the first year to 4,800 in the second, and 6,400 in the third. With approximately 1,000 consumers attending the fairs each year, it was unrealistic for more shares to be sold than consumers attending fairs. We set a new goal for 10% of consumers who attended CSA fairs to purchase CSA shares in year 3. We adjusted consumer attendance goals by anticipating that 200 consumers would attend each fair in year 3 and that 10% of attendees would purchase shares.

We did not meet our revised consumer attendance goals as an average of 133 consumers attended each fair in year 3. But we exceeded our revised CSA share sales goal.

We learned throughout this project, that in areas where CSA is a relatively new concept, it takes much longer to generate enough excitement to get people to attend a physical fair. However, we also learned that consumers in these areas were extremely interested in learning more about CSAs, and while they may not have attended their local fair, they paid attention to the publicity the fairs raised, visited the NOFA-NY website to find their local CSAs, and tried CSA.

Like any event planning, factors that resulted in a successful fair were often rooted in the logistics, location and timing. Throughout the project we remained flexible to change our timing and location if it did not gain the results we had anticipated.

We also remained flexible to support the needs of the different geographic factors of the state. For example, we had expected to host a CSA fair in Buffalo, NY in the first and second years, but all the CSAs serving the area already had waiting lists and were unsupportive of the idea of a fair, which would only build demand but not the supply. We worked with NYSDAM to allow us to host an educational workshop called a "CSA School" in the Buffalo/Western NY area to train more farmers about the CSA model, hoping to encourage CSAs to expand their shares and encourage other farmers to adopt the CSA model to meet the large demand for CSA in Buffalo. By the third year of the project we were able to hold a CSA fair in Buffalo with an eager and expanded group of CSA farms.

Finally, tracking CSA shares sold as a result of consumers attending a CSA fair proved to be difficult. By the third year of the project we found a method for surveying farms that generated better results and participation, but still failed to track all CSAs purchased as a result of the fairs. Farmers were reluctant to change or standardize the way they sell their CSA shares to comply with our reporting needs, and it was difficult to expect them to manage additional data tracking during their busy spring season. Many farms are continuing to sell CSA shares while they are beginning their spring planting, which is a busy time of year to track additional data. As a result, we were unable to demonstrate the actual impact of this project on specialty crop farms that market through CSA.

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Project 2
Adirondack Harvest "Small Farm Rising" PBS Education

Project Summary

Our project's goal was to increase the production and consumption of specialty crops in New York. To accomplish this we needed to not only educate consumers (to increase consumption) but also encourage and inspire farmers (to increase production). We chose a beautiful and visually compelling medium, a PBS documentary, to convey the messages.

Today's consumer has been urged to "buy local" for some time now, and while many have indeed flocked to the farmers' markets and local farm stands, there is still a call for accessing local foods more regularly and conveniently, while getting to know the farmer who is producing the food. Food safety concerns and what to do with all those vegetables have been a recent issue with consumers. Community Supported Agriculture (CSA) offers a farm model that meets all of these needs. The video was designed to show consumers that there are many philosophies and different models for farming, and can choose to support the model that they believe is best for them. It also demonstrates the how hard farming is, to help develop a sense of respect for farming and the farmer.

In the CSA model, the consumer pays ahead for a weekly "share" of the farm's bounty. The consumer is assured (barring agricultural disaster) of a constant seasonal supply of specialty crops, usually via on-farm pick-up, while getting to know the farming methods, thus alleviating food safety concerns. The farmer can also educate the consumer about how to use the items in the share.

The benefits to farmers switching to a CSA business model are numerous. Because CSA shares are purchased in the winter months, there is a gratifying influx of cash to the farm when capital is running low and supplies for the coming growing season are needed. The CSA members typically sign an agreement, sharing in the potential risks, such as crop failure, so that the farmer has a guaranteed income. In addition, the growing season can be spent actually growing the specialty crops instead of struggling to market them each week. Cornell University's Todd Schmit has found CSAs to be the most profitable model for direct market farms.

Finally, we wanted to entice more young and beginning farmers to the possibilities of rewarding careers in agriculture. This video, with its captivating cinematography and down-to-earth presentation of the profession, encourages youth to pursue farming as a career choice.

This project was particularly timely because of the recent intense interest in purchasing local foods and the encouragement by sources all the way up to the federal government to "know your farmer".

Project Approach

Director/photographer Ben Stechshulte filmed 200 hours of footage on three CSA farms in Essex County leading to the production of a 60 minute PBS documentary, "Small Farm Rising". Collaborators were Mountain Lake PBS (MLPBS), the Cornell Cooperative Extension Association of Essex County program Adirondack Harvest (AH), and Ben Stechshulte. The film premiered to a sold-out audience of 250 at the Golden Arrow Resort in Lake Placid, NY. Subsequently over 700 DVDs have been sold or distributed, there have been 24 public screenings, and 55 broadcasts on Public Television Stations for a total reach of approximately 450,700 households across the United States.

MLPBS created a website, www.smallfarmrising.org, to promote the documentary, describe the CSA farms shown in the film, provide educational materials and sell the DVD. This website has had over 7,500 visitors with over 115,000 views of the 8 educational video segments. The educational resources include 45 links to farming methods and lesson plans. In addition, the resource page directs young/new farmers to the Cornell Northeast Beginning Farmers Project website www.nebeginningfarmers.org, the premier resource in our region for people thinking about a career in small-scale agriculture. This link saw over 100 "click-throughs". To complete the social media outreach, Adirondack Harvest created a Facebook page for the film, www.facebook.com/SmallFarmRising, which currently has 132 followers. AH also created a state-wide e-mailing list of consumers interested in engagement on the program themes.

Adirondack Harvest conducted CSA surveys of the North Country region and determined a 29% increase in CSAs and an 80% increase in number of CSA shares purchased from 2010 to 2013. While actual share prices only increased by 3% during this time period, when combined with the increase in number of shares, the dollars spent on CSAs in the North Country increased by 86% from $650,400 spent in 2010 to $1,209,000 in 2013.

In a separate survey of CSA members, we determined that 11% of members who had viewed the documentary, signed up for their memberships as a direct result of the film. Extrapolating from NY PBS viewership numbers we can postulate that perhaps 26,400 memberships were generated statewide as a result of viewing "Small Farm Rising" on NY PBS stations.

Since only two of the three farms featured in the documentary produced specialty crops, we made sure that at least one third of the funding for this project came from sources outside the Specialty Crop Block Grant. A "Kickstarter.com" fundraiser proved very successful and a great deal of in-kind funding came from both Mountain Lake PBS and Cornell Cooperative Extension. In this manner we supported the project beyond the necessary one third to a nearly 45% match.

Goals and Outcomes Achieved

Activity:

- Filmed 200 hours of footage from three CSA farms in Essex County. (Ben Stechshulte)
- Created "Small Farm Rising", a 60 minute PBS documentary with Mountain Lake PBS (MLPBS), Adirondack Harvest (AH), and director/photographer Ben Stechshulte**.**

Our goal was to increase the production and consumption of specialty crops by:

"Increasing the number of farmers participating in the CSA farm model by 20% thereby offering more consumers the opportunity to procure, consume and gain knowledge of NY state specialty crops. USDA census data from 2012 will quantify any change in number of CSAs in New York State."

- Our CSA surveys showed an actual increase in the number of farmers participating in the CSA farm model of 29%.
- 2102 USDA census data is not available until 2014, therefore cannot show that NY State overall has had an increase in the number of CSAs, but…
- Extrapolating from our regional 29% increase and working with the original number of 364 NYS CSAs in 2007, it's possible that NYS CSAs now number about 470.

"Airing this documentary on PBS stations statewide. The subject of CSA farming has not been covered by PBS stations in the past. Mountain Lake PBS will be able to report the number of PBS stations carrying

the program and their respective market sizes. A limited number of large market PBS stations can provide Nielsen data on audience viewership."

- To date, 3 NY PBS stations have aired the documentary (Plattsburgh, Syracuse & Buffalo), with 2 more stations (Albany & Rochester) planning airings next year. New York's estimate viewing audience in the reporting period was 240,000 households.
- With national distribution to the 360 public broadcasting stations nationwide, the documentary was aired 55 separate times on 35 public television stations across the United States with an estimated viewing audience of 450,000 households.
- The film was shown at 24 documented public screenings with a total viewing audience of over 2,000 people.
- The DVD has been distributed to over 700 households for private viewing.

"Spreading information through social media outlets which is a very new marketing concept in agriculture. A customizable program web page will be made available to PBS member stations to supplement a program-related Facebook Social Media page. These will encourage site visitors to engage with farmers, seek out CSAs and specialty farms in their areas and will allow Adirondack Harvest to build a state-wide mailing list of consumers interested in continued engagement on the program themes. Detailed website analytics will track visitation, repeat visitors, spikes related to broadcasts or repeat broadcasts and even visitor demographic information (Facebook)."

- A website was created, www.smallfarmrising.org to promote the documentary, describe the CSA farms shown in the film, provide educational materials and sell the DVD.
    - To date, the website has had 7,531 unique visitors and over 27,000 page views.
    - The educational video segments have had over 115,000 views.
    - The video segments are complemented by lesson plans and resources on the website.
    - The largest spikes in page views were associated with the April 2012 broadcasts nationally (planned to coincide with Earth Day audiences)
    - MLPBS produced 8 short video "take-aways" for digital, new media and classroom use. These are accessible at www.smallfarmrising.org as well as on YouTube.
    - 38 links to further information about farming methods and lesson plans were added to the www.smalfarmrising.org "Learn" page.
    - 7 additional educational links were added to the "Resource" page.
    - In addition, Mountain Lake PBS did one screening for representatives from 15 school districts and provided them with information on the available lesson plans and educational clips.

- A Facebook page was created, www.facebook.com/SmallFarmRising, which promotes the film as well as receives posts about local farming activities.
    - This Facebook page currently has 132 followers.
    - 84 are women, 48 are men
    - The largest collective share (40%) is women ages 25 to 54.
    - The followers are mostly in the U.S. but some are in Canada, the UK and Norway

- A state-wide e-mailing list was created consisting of consumers interested in engagement on the program themes using emails gathered from correspondences with MLPBS, AH, an on-line sign-up list from the film premier and extra crowd funding efforts.

"Directing young or new farmers to Cornell University's Beginning Farmers resource web site www.nybeginningfarmers.org. These "new farmer" web users will "click-through" the program website to reach Cornell's site and will therefore appear as a separate measurable component of the program website analytics."

- There have been 786 unique visitors to the "Resource" page at www.smallfarmrising.org which includes the link to the Cornell Northeast Beginning Farmers Project.
- Cornell Northeast Beginning Farmers Project estimates 128 "click-throughs" from the film's website. This is an estimate because www.nebeginningfarmers.org experienced a website crash for several months in the middle of the reporting period.

"Increasing the number of consumers purchasing CSA shares by 20%. Benchmark data will be obtained by a phone survey to our Adirondack Harvest region CSA farmers in the winter of 2010-2011 and followed up by another phone survey during the 2013 growing season to determine growth or decline of CSA membership and dollars spent. Additionally we will ask the CSA farmers to poll their new members on the documentary's impact on their decision to join. We can then extrapolate this data to the rest of the state based upon viewership numbers reported from MLPBS."

- CSA surveys were conducted via phone and internet to determine the number and price of CSA shares and the influence of the documentary on CSA membership
- We determined 2010 quantitative baseline data documenting 28 CSA businesses in the North Country (approximately 10 counties in the Adirondack region) with a total of 1084 shares sold.
- We determined 2013 quantitative data documenting 36 CSAs in the North Country with a total of 1950 shares sold.
- This is a 29% increase in the number of CSAs, and an 80% increase in shares.
- We determined the average 2010 CSA share price in the North Country to be $600 and the average 2013 CSA share price to be $620.
- While the increase in share price is 3%, when the share price is combined with the number of shares we see:
    - $650,400 spent in 2010
    - $1,209,000 spent in 2013
    - An 86% increase in spending on CSA shares for North Country farmers
- 208 CSA members responded to our survey (a response rate of 11% assuming all 1950 current members were reached)
- Of those 208, 87 had seen the film and of those, 10 new memberships were generated as a result of seeing the film. This represents a possible 11% rate of conversion from viewer to CSA member.
- Extrapolating from NY PBS viewership numbers we can postulate that perhaps 26,400 memberships were generated statewide as a result of viewing "Small Farm Rising" on NY PBS stations.

Beneficiaries

Consumers:

- A 29% increase in the number of CSAs means better access to local fresh specialty crops under this business model with resultant connections to the farmer, increased addressing of food safety concerns and general agricultural education.
- Better access to specialty crops will mean more interest in the array of crops available and a greater likelihood that these crops will be incorporated into the consumer diet.
- Often families go to the pick-up and children learn where their food comes from. Plus the fresh food selected for flavor instead of transportation characteristics taste better so children learn to eat fruits and vegetables from a young age.
- The educational videos and links on the website benefit both farmers and consumers. Better education means a savvier consumer and a more competent farmer.
- The Facebook page generated interest in the film through the most popular social network on the internet. This internet exposure benefits both the farmers and consumers as a place to connect, discuss the film and participate in the enthusiasm about local food.

Beginning farmers:

- With 128 click-throughs to the Beginning Farmers project, it's possible that a large number of people have been linked with information to get them starting in farming. This benefits both them and the consumers who may have access to their products in the future.
- The 8 educational videos may inspire farmers to try some of the successful techniques these three farms use.
- We know of seven new farmers that have spun off from these CSA farms to start their own CSA enterprises. Shannon Eaton, Ashley Kleinhammer, Courtney Grimes-Sutton, Asa Thomas-Train, Racey Bingham, Nathan Henderson, and Chad Vogl.
- The broadcasting and screening of this documentary to over 450,000 households has educated consumers about this business model. They will be looking for local CSAs to take advantage of the membership opportunities.
- The screening held for 15 school districts that were provided with lesson plans and educational clips may serve to inspire a new generation of CSA specialty crop farmers.

Current CSA farmers:

- The increase in the number of CSAs also means that some farmers are transitioning into the CSA business model, which may be a more sustainable and profitable model for them. Ultimately, it may mean that more small farms stay in business, producing specialty crops.
- The wide broadcast and screening of the film will send some consumers searching for CSAs. Our survey numbers indicated a possible rate of 11% of viewers signing up for CSAs. Translating from the NYS viewership numbers, if 26,000 memberships were generated from viewing the film, at an average rate of $620/share, the result would be

over $16 million in CSA revenues in 2013. While some of these revenues might have been spent at other local food venues, such as farmers' markets, many were undoubtedly new consumers of local specialty crops.

CSAs portrayed in the film:

- The broadcast and screenings of the film resulted in tremendous exposure for the three farms featured in "Small Farm Rising". Not only did they enjoy a boost in membership, but also in interest from restaurants and other consumers of specialty crops.

Lessons Learned

- The number of farms portrayed in the film was limited to three, therefore some farms were unhappy about the publicity generated for the featured farms. Future projects will attempt to include other businesses.
- We believe that all the public television stations in New York would have shown the film if our original collaborator at MLPBS had relocated in the middle of this project.
- The documentary has been very well received despite its sometimes raw portrayal of farm life. We believe this medium was an excellent choice to grab the attention of consumers and farmers alike, setting it apart from the usual encouragements to "buy local" and "join a CSA".
- The subject matter generated much discussion amongst the farmers and consumers when they attended public screenings, thereby providing an excellent opportunity for further education and insight into the CSA business model.
- Nielsen data was much harder to obtain than anticipated.
- Because of the potential for video/audio material that may not represent the policies or viewpoints of NYSDAM or USDA, future NYSDAM SCBGP subcontracts for media projects such as these will require pre-approval along certain pre-identified stages of the project (e.g. approval of script) to be included in the contract. Although there are time constraints pertaining to filming, editing and other production processes and deadlines, this addition to the contract should be included to ensure that content does not contain information or activities that do not follow government regulations, policies or include any potentially offensive material, which is not supported by NYSDAM or USDA.

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Project 3
Maple Producers E-Business and Internet Marketing Project

Project Summary

In keeping with trends in consumer buying and online interaction, this project was intended to reach consumers through an Internet-based approach in marketing and business tools. These initiatives would expand the existing web presence of the New York State Maple Producers Association to become an interactive site, engaging consumers to understand, locate and purchase maple products. The efforts were intended to offer increased usability for both producers and the public, and to help promote the recent branding initiative "*Taste the Tradition*". Online tools were to be developed to collect email addresses of interested consumers, who wished to provide them, and to allow promotional information and coupons to be sent back. Consumers and producers were to be brought together better through interactive information about the location, products, hours of operation, public events and special promotions offered by maple producers who are near the consumer's location. Enhanced education was to be made available in "buyer's guide" format, through a variety of online media to increase the consumer's knowledge of what maple products are, how they are made and how to store them properly. Measures of success were designed to include increased website visits, a rising count of coupon redemptions, and increased count of consumers who interact with the instructional segments.

Therefore, the purpose of this project was to:

1) promote the recognition of the "*Taste the Tradition*" logo and brand, so that consumers will be more likely to purchase maple products bearing it wherever they may be found throughout the State of New York;
2) better educate consumers through more concise and organized information about maple products;
3) guide consumers more effectively in their search for local producers and local products;
4) enable the direct purchase of maple products online in a more consistent manner that has greater ease of use;
5) interact with consumers bi-directionally through social networking and coupon promotions.

Project Approach

The first phase of the project was for the web developer to develop an initial design of web page "look" – three concepts were proposed. A review committee of member volunteers was involved in the selection of the final design. Once the choice of appearance was made, the developer created an outline of web pages needed. The approach then was to develop the home page and shell, go live with those, and fill in details as they were developed. A professional photographer completed product photos as needed to create graphics for the pages.

Since a key feature of the website was to be the *Find a Producer Map*/zip code lookup, the webcoding for this was a major design component. The developer worked with us to set this up as a database extracted from the association's MS Access database, ensuring that there is only one source of data. We refined the data fields needed and made adjustments to the database as needed so that anyone in the association office will be able to update the website member data as needed in the

future. The map itself uses open source code and Google maps so it is compatible with most computer operating systems and browsers.

The next major design and implementation was an online store. A third party software – Shopify- was chosen to provide the store framework. We had to then set up all of the credit card processing, using Authorize.net. The product categories and descriptions were set up, and a member committee worked out product pricing. It was a challenge to develop an accurate shipping price calculation: an average maple order can be from 5-15 pounds, so it was important to get the shipping prices as real time as possible. Our members can be shipping using USPS, UPS, or FedEx from anywhere in New York State so there is variability in pricing. We developed a shipping price table based on postal zones, added a slight handling charge to each order, and tracked to ensure that the prices we charged are fair. There have only been 3 or 4 orders where an order has not had the actual shipping costs covered, and only when packages are extremely light weight has the charge been perhaps too high. We will continue to watch for improved methods of calculating real time shipping costs.

As these major components took shape and were tested and implemented, the information and support pages were slowly added and refined. The "about NYS Maple" started as two pages and has grown to include 11 pages of nutrition, storage, fun facts, etc. In similar fashion, the recipe section was continually added to. The *Family Fun* section contains the newly released Cornell Maple Program Coloring book, and we look to incorporate sections of the elementary school maple curriculum, which is currently under development for the Association.

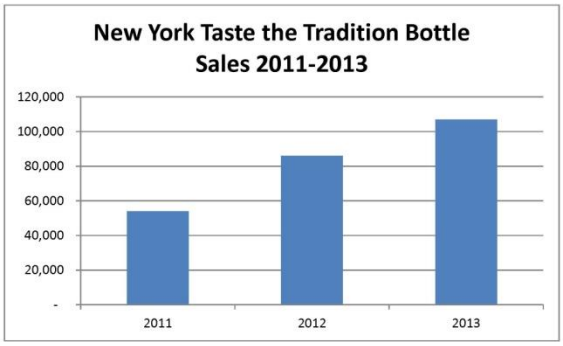
Of significant benefit to our membership is the *For Producers* section. This started as a place to download the member application and has been expanded to ten sections of information important to the maple producer.

At all times involved in the development, members were involved in the design. We solicited feedback from members at Association meetings and at the Annual Maple Schools. As mentioned elsewhere in this report, collecting accurate business information about our members and maintaining it as up-to-date as possible has been a key focus of the Association Executive Director, the regional officers, and the various volunteers and interns who have contributed to the project. We also receive an occasional email suggestion from customers and try to incorporate those ideas as well.

Goals and Outcomes Achieved

Goal 1 *-- To increase consumer awareness of the "Taste the Tradition" brand by consistent use of the logo throughout the website.*

We have been monitoring sales of the branded plastic syrup jug used in New York by the members that pack their syrup. This jug had just been released for sale at the start of this project. The projections for container use that we made were based on previous sales of paper stick-on labels. We hoped to see sales in the range of 40,000 units the first year, with an increase of 30,000 units the next year. Happily, those goals have been met and surpassed with the plastic branded jug alone. See the sales table below (Note: figures are courtesy of Hillside Plastics, Inc.) These do not reflect any counts of units sold by the producers who use the logo on their own private label jugs – since one of those producers supplies the Wegman's retail grocery chain, the total *Taste the Tradition* (TTT) units sold are probably 20% higher than the graph shows.



In addition, we have developed a shopping bag with the TTT logo that members can purchase for use in their retail location. Sales of those in 2012 were 16 cases of 500 bags; in 2013, 45 cases were sold.

Goal 2 -- *To provide a more accurate interactive map-based producer listing with accurate location information, driving directions, hours, offerings, and listings of any promotional events going on at that producer's location.*

The "*Find a Producer*" zip code lookup is the tool we created to accomplish this. We have a listing for each member's maple business giving the location, products, hours of operation, contact information, public events and special promotions offered by maple producers who are near the consumer's location. We included a generic search so that the consumer can look for any keyword they choose. We included a mapping using the absolute latitude and longitude of the producer location so the consumer can see the producer's correct location on the map.

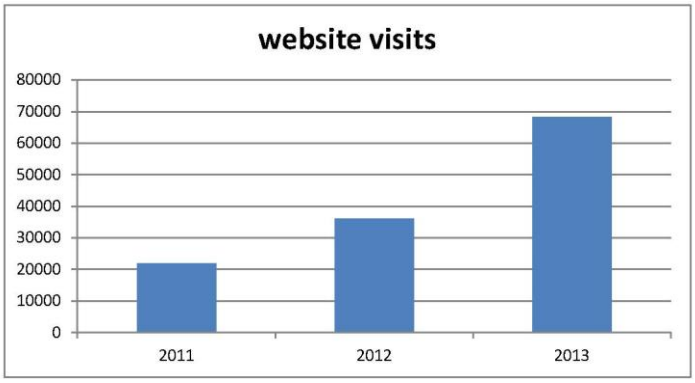
We know from feedback from our members that they have customers who tell them they "found them on the web". The state office has not received any requests from consumers asking for help locating a producer for over a year. The exact results of this effort are difficult to quantify with exact statistics. However, anecdotal reports from producers and discussions at our meetings recently has indicated that most producers testify that they have had direct benefit from this feature.

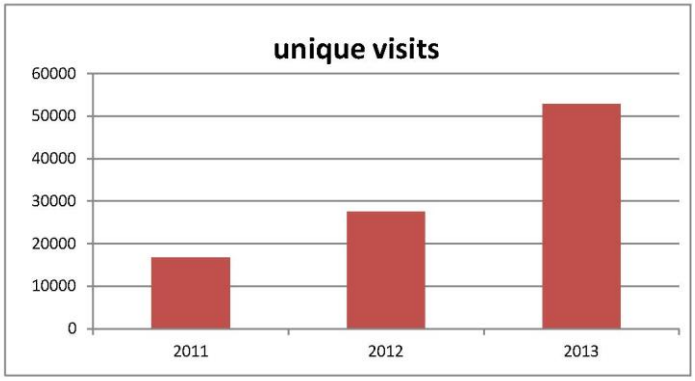
Goal 3 -- *To increase consumer contacts with the New York State Maple Producers Association through website search engine optimization (SEO).*

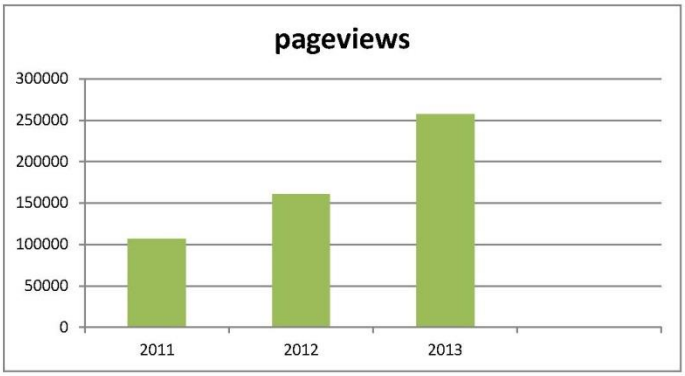
A Search Engine Optimization was accomplished, and now the New York State Maple Producers Association website comes up in the top first-page list in a Google search using various terms containing words associated with maple products and maple syrup. Some of the specific activities done included:

- Content added to the About NYS Maple Section
- All Page titles have been updated
- Cross linking from internal pages set-up where appropriate.
- Created XML Site Map and submitted to major search engines (Bing, Google, etc.)
- Modified all the page templates to include a menu structure in the footer of the page
- Created and uploaded a robots.txt file with instructions for Search Engine Robots to index specific pages and the site map.
- Added absolute links from Sub Pages to the home page where appropriate
- Started working on inbound links to specific content.
- Created Code for Producers to add to their sites with Maple Syrup as the Anchor Text.
- Started building Article Directory page about Maple Syrup to link to NYSMaple.com

Google Analytics have been used to analyze the statistics. Some of the major demographics are shown in the 3 figures below. We wanted to see an annual doubling of visitors the first year. This has been accomplished and has exceeded that amount in succeeding years.







<u>Goal 4</u> -- *To provide a New York State Products page that will explain and educate consumers about the benefits of locally produced food, and about the positive nutritional characteristics of maple products in particular.*

Enhanced education has been included in the section of the website called "*About Maple*" to increase the consumer's knowledge of what maple products are, nutrition information, how they are

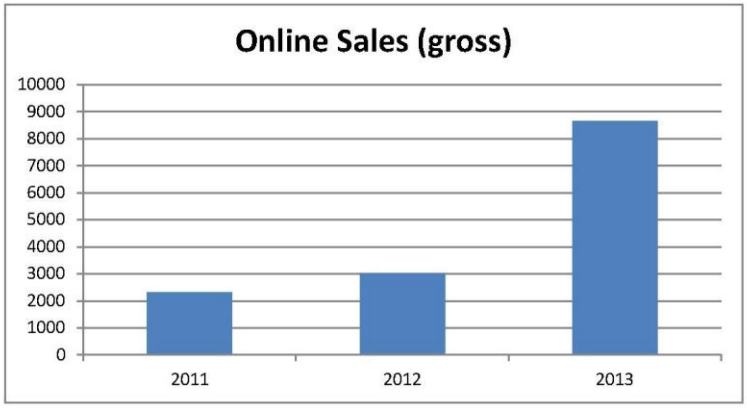
made and how to store them properly. The web developer was especially interested in this section as he drew on the questions he and his friends and family wanted answered. We were given free access to all of the materials available from the Cornell Maple Program to develop the content.

By 2012, at least 5,000 website visitors a year went to this section, with an average visit time of one minute, which indicates to us they are reading the FAQs.

Goal 5 -- *To create a more organized display of products available for purchase, offer a wider selection of pure maple and value added maple products, and make the process easier on the consumer to complete the purchase directly through a secured system.*

The website product store was enhanced to include a more organized display of products available for purchase, offer a wider selection of pure maple and value added maple products, and make the process easier on the consumer to complete the purchase directly through a secured system.

We wanted to see online sales increase and the graph below shows the growth. This growth is in addition to the increased traffic we have driven to our member producer stores directly.



Goal 6 -- *To provide news alerts and promotional coupons to consumers who register with the site, which will increase the likelihood that site visitors will return.*

Online tools were developed to collect email addresses of interested consumers, who wished to provide them, and to allow promotional information and coupons to be sent back. To date, more than 2,000 consumer email addresses have been collected for ongoing contact and future product promotion.

Goals 7+8 -- *Connect to a social networking site such as Twitter or Facebook for interactive content surrounding events such as Maple Weekend events, schools, festivals/fairs, cook-offs, Include a blog to encourage use of new recipes, to share stories, new innovations, promotion of the annual Maple Weekend public event, and other items.*

We now have a Facebook site, "NYSmaple", and it is linked to the www.nysmaple.com website in order to capitalize on social media marketing that can drive additional consumers to the website for more information and purchases. The need for a blog was eliminated by the increased features of Facebook as consumers and producers are communicating ideas, recipes, and maple season happenings directly on this website.

Additional Outcomes -- A producer section was created on the website, and has been a great help in sharing information with maple producers (although the section is open to all web viewers, not just Association members). We share documents and links to: information valuable to maple producers, marketing materials that can be downloaded and reproduced by the maple producer, links to other knowledge sources like NYS Ag & Markets, Cornell Maple, IMSI, etc. We also created an online calendar that producers can use to keep informed of upcoming workshops and meetings.

Beneficiaries

This project has significantly and positively impacted the 625 maple producing members of the New York State Maple Producers Association, representing a variety of small, medium and large maple producing businesses throughout the State of New York. In turn, the majority of these members have taken advantage of the increased visibility of their operation through the Association website, and through the enhanced visibility of the "*Taste the Tradition*" branding of their products to positively impact their consumers of maple products. We feel that the increased website visits, increased product sales, the collected central mailing list of consumers, increased revenues at the New York State Fair, and the ad-hoc reports of local sales increases from producers around the State, all indicate that this project to enhance market penetration for New York Maple has been successful for all parties involved.

As of the end of 2013, the number of unique maple producer businesses featured on the website has grown to 495, from 390 at the start of the project. Over the life of the project, we have seen membership in the state maple producer's association increase 30%. We estimate that at least 75% of those new members are existing producers who have seen or heard of the benefits to membership, such as the website exposure.

Member reports include:

- An Albany area maple producer who admits he is "computer illiterate". He has no computer himself. He has received so many customers from the web lookup that he called the Association office to talk over his web listing and make sure it said what he wanted.
- A Delaware county producer who gets walk-in visitors from the New York City area "all the time in summer now".
- An Allegany County producer who only has 25 taps, and claims to have the "smallest operating sugarhouse in NY". She has had to refer customers who telephone her to other producers because she doesn't make enough syrup to supply a lot of customers!

Lessons Learned

- In addition to working with large advertising and public relations firms, we learned that significant progress can also be gained through work with smaller firms and individuals who specialize in the expansion of information and brand recognition in many different ways. This provides us a more robust palette of potential services as we move forward, and can help us to reduce the costs involved in these types of activities. The web designer we are now using is a single person firm. His 25 years of experience in the radio and television advertising arena brings a wealth of knowledge about what today's consumer is attracted to. He is able to focus the message of the website accordingly.

- It is always challenging to interact with so many volunteers within an organization of this size – eliciting review and approval of online information and new centralized purchasing procedures from this diverse set of producers on a voluntary basis gave us some better insights about how to interact better with our membership. On the member side, most of our members are small businesses. Since the major emphasis of the website is *Find a Producer*, the data they provide us about their business is key to making the consumer look up experience a success. The design of the member detail intake form has been something we focused very heavily on. Wording the questions on the form to provide data as complete as possible has been a focus. The first year, over half of the intake forms came to the office with most of the information blank. In reply that year we sent the members a request to check their own page on the website. We got very little feedback from that. The remaining two years, we printed a version of what their data looked like and mailed it hard copy to the members asking them to proofread. Year 2 gave a lukewarm response: about 10% sent their forms back with corrections. Year 3, we sent the same printed information to them, but did so by including it with their annual renewed membership packet (which contains their member ID card) and also we included an envelope addressed to the Association office. The response in year 3 was about 50%, making the info the consumer sees more accurate and complete.
- Technology is changing as we developed these new resources, and we needed to be agile with regard to the approaches we used in order to keep up with the rapid developments in website and social media marketing technologies.
- Consumers demand instant gratification. It is one thing to create an opportunity for registering their demand, and now we must develop ways to scale up our responses to increasing demand for rapid and customized service. We have already set the standard that all online store orders must be filled and shipped within two business days of receiving the order, and that all customers receive package tracking information as soon as it ships.
- Standardizing information across a variety of producer business types is challenging, and it required us to develop a new approach to categorizing our products and services so that consumers would be better able to interact with this diverse population of producers. We reorganized the inventory by food type – maple syrup, maple granulated sugar, maple confections, coffee and tea, etc. The customer drills down to find the specific product size and flavor. This was more customer friendly than the original first level that immediately presented light, medium & dark syrup. Over the three years, we are finding many purchases on the store are for the specialty confections. Customers, especially those out of state, may be able to purchase maple syrup in their local area but cannot find the confections and specialty items locally. Having confections easily found has increased sales in that product category. We will be looking at ways to add additional value added maple products to the list in future. The most obvious is maple cotton – if we can develop a standardized shippable packaging for it, we expect that to be very popular.

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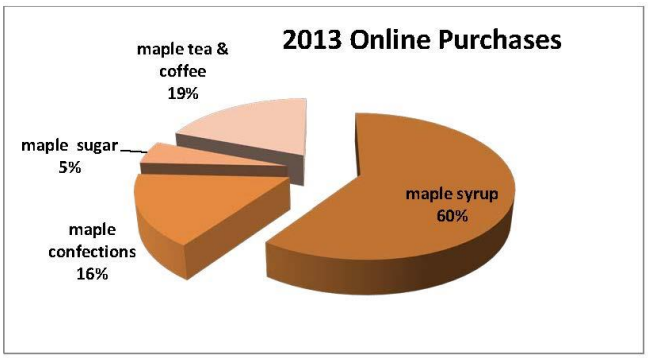

Project 4

Increasing New York City Access to NYS Specialty Crops by Strengthening the Wholesale Greenmarket

Project Summary

The target of this project was two very different underserved communities, one urban and one rural: residents of NYC food desert areas, and small and mid-size farmers who lack appropriate markets but who could provide these high-need urban neighborhoods with affordable fresh foods. Our project was to find innovative ways to market these products to retailers, restaurants and institutions while diversifying the market availability.

The fundamental goal of our work was to strengthen the Wholesale Greenmarket (WGM), New York City's only market for direct wholesaling of local specialty crops to retailers, restaurants, institutional food service, food processors, and community based organizations. This group of farmers is what remains from the Bronx Terminal Market, where dozens of growers set up weekly and sold directly to buyers of all stripes. Due to the construction of the new Yankee Stadium, they were forced to move and settled into the parking lot of the New Fulton Fish Market. The group that totaled only eighteen upon the initial move dwindled to a mere eleven when we began working with them in September 2009. This group historically served the bodegas, corner stores and other small retailers throughout New York City, however much of that business ended with their move to an out-of-the-way location with far less choice for buyers. Under-resourced communities already facing the challenges of limited access to healthy food were further disconnected to their sources and the rates of diet-related illness has sky-rocketed.

GrowNYC believes that these two groups' health and futures are intrinsically linked and have the capacity to sustain one another and thus set out to reconnect them.

Project Approach

To accomplish our goal of strengthening the Wholesale Farmers Market, we identified and pursued three main avenues of focus: recruit new buyers to the market; secure a viable long-term location to house a Wholesale Farmers Market; expand farmer participation.

Buyer Recruitment:

Project outreach was conducted in 4 of the 5 boroughs by visiting store owners in neighborhoods with poor access to local fresh fruits and vegetables. GrowNYC staff spent more than 400 hours of outreach during this grant period to identify opportunities to connect the farmers of the WGM and wholesale buyers in NYC dedicated not only to support regional agriculture and food systems, but also in need of access to these products.

GrowNYC staff continues to work closely with the WGM farmers to identify new opportunities that meet their needs and the needs of customers. At the same time, GrowNYC staff has represented the interests of WGM farmers in collectively working to further develop the vibrancy of the WGM. The staff has achieved this through print and electronic marketing as well as press releases and mailings to interested parties and patrons of the WGM on a regular basis during the market season. GrowNYC staff also conducted regular visits and tours of interested buyers, funders, press, and supporters to the WGM.

The WGM continues to be featured prominently on the GrowNYC website, providing information to various parties about the WGM farmers, products, related GrowNYC programs, and any new initiatives or developments in the work of GrowNYC staff and WGM.

During the growing season, weekly E-news letters were sent out to a WGM mailing list of over 250 individuals, including current and prospective buyers, chefs, institutional procurement managers, and other food industry professionals. In the off seasons, GrowNYC staff continued to send informational emails with monthly updates on the programmatic/operational changes taking place at the WGM.

Building off of our lessons learned about the kind of buyer demand that must be present to build a market and the number of vendors able to enjoy the market as a viable business opportunity, GrowNYC staff began surveying buyers as a part of buyer outreach. We identified key pieces of information around the buying practices of each potential buyer. From this GrowNYC staff has been able to direct outreach and continued customer relationship building toward client groups more likely to actually purchase from WGM farmers.

For each of the various programs and initiatives that have either supported or sourced from the WGM, GrowNYC staff has created marketing materials and campaigns to highlight the work and products of the WGM farmers. These materials have been in the form of posters, a-frames at events, point-of-sale materials, and recipes to name a few.

WGM staff has also created innovative partnerships to make the product of the WGM more accessible to new buyers. Over the course of the 2011 summer and fall season, WGM staff worked with fellow GrowNYC programming staff and Red Jacket Orchards (RJO) to create the "Fresh Bodega Initiative," a small distribution route in the community of Bedford-Stuyvesant. Here, the staff recruited interested buyers for delivery of both WGM produce and RJO fruits and juices to local bodegas. GrowNYC-lined refrigeration units, funded by the Strategic Alliance for Heath and which held RJO and WGM produce, further promoted WGM and the Fresh Bodega program. In partnering with RJO and the Strategic Alliance for Health, the produce of WGM farmers was able to be delivered for the first time, dramatically increased the number of potential buyers.

Through outreach to Yorkville Common Pantry and WGM staff coordinating the donation of produce from the WGM farmers, a connection was made that enabled both Greenmarket and WGM farmers to sell their produce to the pantry. J Glebocki farms in particular have, with the help of WGM staff, taken this opportunity in entirety and are currently selling truck loads of product to the pantry.

Just one season following the successful pilot delivery partnership with Red Jacket Orchards, the WGM program of GrowNYC has begun "Greenmarket Co," our own delivery of WGM produce to buyers city-wide. With a small staff coordinating logistics, procurement, and sales, WGM produce is now being sold to all types of clients from bodegas and corner groceries to gourmet restaurants and world renowned chefs. It has been the extensive buyer outreach coupled with farmer surveys to better meet their needs that have driven this new initiative. Not only has this made the WGM produce available to a far greater number of buyers, but it has also made the product more available to GrowNYC food access programming, thus further supporting the WGM.

Greenmarket Co. provided all of our retail buyers with marketing materials, ranging from in-store signage, price cards, recipe sheets and even branded refrigeration units. These materials were crucial incentives for many of the participating retailers to come on board, recognizing the customer support they receive when buying through our network of farmers. In fact, we have hosted cooking

demonstrations and other promotional programs at individual retailers to help promote GrowNYC-sourced products. We have not worked with "Pride of New York" to create these materials, but secured the pro bono assistance of Carbone Smolan Agency. They created brand design, assisted with tag line creation and provided all of the graphic design.

Another practice of WGM staff to recruit new buyers of WGM produce has been the development of Food Box programs, including 1 day spin offs for holidays. These programs are a CSA style distribution of a variety the freshest fruits and vegetables that WGM farmers are offering. WGM staff coordinates the outreach and community partnerships needed to attract buyers of the products. On the day of the events, community members come to buy a large bag or re-usable tote that includes a variety of WGM products. These events and Food Box programs are well accepted by consumers that enjoy a plentiful amount of local fruits and vegetables that are priced at or below what they would pay for a non local product in the local supermarket.

Currently GrowNYC supplies 10 food box sites with over 900 individuals served, and have expanded well beyond the estimated 15 additional delivery sites and actually distributed to over 30 clients weekly. This distribution route includes senior and assisted living centers, supermarkets and bodegas in underserved communities, and the diversity of restaurants throughout New York City. In 2012, these programs generated $235,000 in revenue for farmers. While this falls short of our target of $360,000, we are confident that our sales in 2013 will greatly exceed that number. Moreover, the $56,000 that we generated in income through those farmer sales exceeds our targets and will continue to expand over the next few years of operations. As previously mentioned, we aim to be self-sufficient in year 6. (The $56,000 in funds were placed back into the project and used solely to benefit and promote specialty crops).

Not only has WGM staff worked to create healthier food access options in communities that traditionally have poor access to quality fruits and vegetables, but through collaborative efforts with the Department of Education, WGM staff has also been working in NYC schools to source Healthy Fundraisers. These events are often initiated by PTA and enthusiastic teachers interested in promoting access for families to healthy, fresh, and local produce.

In all, WGM has expertly combined GrowNYC programming with buyer outreach to make the WGM farmer products available to communities in the city that would not otherwise have access. This effort has had a positive effect in return, opening a new market to the farmers providing them with new business opportunities and avenues to sell their goods. Included in the programs is Fresh Bodegas, a program that in many ways provided the essential lessons learned for the above mentioned programs that have successfully brought WGM products to all boroughs of Manhattan. The partnership between the Strategic Alliance for Health and Fresh Bodegas was also instrumental in defining how WGM can partner with community organizations to further increase the amount of outreach and recruitment for healthy food access initiatives.

Secure a viable, long-term market location:

To begin, being located in the New Fulton Fish market limited our ability to attract new growers to sell at the market. GrowNYC has consistently maintained that the most appropriate home for the Wholesale Farmers Market is to be co-located in the Hunts Points Produce Cooperative and throughout this grant period has advocated to the City and State for that to happen. Recognizing the challenges associated with such a move and the reality that any new construction would take years, which we didn't have the luxury of waiting, we immediately began in September 2009 to identify properties that would be suitable for a Wholesale Farmers Market.

We worked effortlessly to find a more viable location, working with the myriad of City Agencies, commercial real estate brokers, and other actors involved in real estate in the Hunts Point section of the Bronx to identify properties that could accommodate a Wholesale farmers market, including: The New York City Economic Development Corporation, NYS Empire State Development Corporation; NYC Department of Transportation, Bronx Overall Economic Development Corporation; Feinberg Realty; Metropolitan Transportation Authority; The New Fulton Fish Market. We looked at over 40 properties in 3 neighborhoods in the Bronx and Upper Manhattan to identify a location that would accommodate the current market, encourage future growth, and that was more strategically located to attract wholesale clients already conducting business in the Bronx. We identified three separate properties that could work for our project and submitted funding requests to build out infrastructure that could accommodate our needs; each of the locations needed some basic retrofitting and was beyond what this group of farmers could afford.

In the winter of 2011 we began conversations with a private developer, Steven Smith, about locating the farmers at his Oak Point Property while building a much larger food campus over the next several years that could house numerous food businesses, distributors, value added processors, and a wholesale farmers market.

In the winter of 2011 we also began conversations with City Harvest, the largest food rescue organization in New York City. Those discussions included partnering on certain programmatic initiatives, such as their Healthy Corner Store Initiative, and to make use of their warehouse to aggregate and store farms products for pickup and delivery. These conversations led to incredibly productive collaborations and Greenmarket Co is now operating out of their Long Island City facility and we are working together in several communities to connect farms directly to retailers, including supermarkets.

This entire process to find a new home took much longer than we hoped for, but to date, we have found a new space and will relocate to it in March 2013.

Expanded Farmer Participation:

To recruit these new farmers, we started by surveying dozens of area growers about their selling seasons, product diversity, desired buyer base, and desired methods of sales. It was important to generate this information in order to properly evaluate the potential business opportunity and relationship for each farmer with the WGM. The profile of the WGM farmer is a farmer that produces mainly staple or common variety crops in large wholesale quantities. Typically the farmer has a long history of direct wholesale business activity and balances equally wholesale and retail business opportunities.

Following our survey activities, we visited the farms that were most interested and that we felt best fit the marketplace needs. Through customer feedback and farmer input we knew that we needed to provide a fuller product line at the market rather than one dominated by flowers in the spring and vegetables in the summer and fall. Accordingly, we recruited fruit farmers to have the addition of non-competitive product to what was already being sold in the market.

As a result of our survey and recruitment, we had one meat and two fruit providers complete trials in the WGM. Unfortunately none earned the profitability needed to offset the cost of attending, despite our hosting buyer's tours on the days that they were present. As the New Fulton Fish Market proved to be an untenable market place for the new farmers we did successfully recruit to sell there and

whose tenure lasted less than one month each. We were therefore unable to increase market income through the generation of new rents. So, rather than collecting market fees from 35 farmers, for the past two seasons we collected fees from only 9 participating farmers. Due to the strength of the market itself, we charged participating farmers fees that strictly covered their market rent from the New Fulton Fish Market, and all other services were provided through other revenue streams.

However, as we continued to find a new home and continued our outreach to attract new farmers to participate in the marketplace we developed alternative means for them to do so. By creating Greenmarket Co, we were able to recruit 40 new farmers, greatly expanding our impact on regional agriculture as well as the diversity of products that we could offer to buyers. Rather than these farmers coming to the market and physically setting up, they sent trucks to our warehouse where we then distributed the products for them. In our new home we will recruit farmers to participate in both models, some actually utilizing the market to sell physically while delivering to the warehouse as well, thus maximizing their trip into the city and ensuring a full truckload of product.

As an example, a local vegetable farm, J. Glebocki Farms, tried to sell at the WGM but also was unable to earn the profit to offset costs of attending. Fortunately Glebocki was willing to make deliveries to buyers, a need required by over 60% of the potential buyers we surveyed, and we were able to connect Glebocki to the Yorkville Common Pantry (the largest provider of meals in NYC and who purchases over $160,000 of local products annually) and to other NYC based customers for direct drops of his product. Since then the farm has substantially grown its wholesale distribution efforts within the city and maintains a very strong organizational partnership with GrowNYC.

The Wholesale Greenmarket is New York City's only open-air wholesale farmers' market. If offers local and regional farm-fresh specialty crop products. Greenmarkets Co supports regional family farms and provides New Yorkers' with fresh, local foods beyond farmers' markets into local grocery stores, restaurants and institutions. The total amount of funds awarded for this project were used to solely promote fruits and vegetables at the Wholesale Greenmarket.

Through our work selling on behalf of the other 40 wholesale farmers through Greenmarket Co, in just our first 8 months we generated $56,000 of net income through sales. These funds were placed back into the project and used solely to benefit and promote specialty crops.

Goals and Outcomes Achieved

Expansion of farmer base, income and product line:

GrowNYC staff helped to not only to identify sales opportunities, but also build the capacity of smaller farmers to participate in wholesale business. In 2011, the WGM and Greenmarket farmers were devastated by Hurricane Irene. By working together, WGM farmers not only helped each other keep their farm stands and sales outlets satisfied, but also sold to a number of smaller farmers who had lost all of their crops. While this allowed the smaller farmers to at least finish the retail season, the larger impact has been on the relationships that were built. Just one year after the hurricane, the WGM has successfully helped a few of these small farmers to sell their 2012 season produce to the wholesale outlets that had been created a year before.

In the 2013 season 2 farmers who had left the market, one prior to our arrival and the other during the grant period, will return due to our securing a new home with all the necessary amenities of a vibrant direct wholesale market. Unfortunately, in 2012 we did lose one farmer who, due to this age, is

no longer actively a farmer but to his family, we were happy to see the Fichera Family Farm stay in the market in 2012 and have another successful season after we all mourned the unfortunate passing of Frank Fichera Sr., a founding WGM farmer.

In total, through the grant duration, GrowNYC programs and other connections bought $213,000 worth of WGM produce and donated over 2,000,000 lbs of produce to City Harvest.

Secure a viable, long-term market location:

WGM is now moving towards a secure and long-term market location, which will be co-located with Restaurant Depot and Jetro at Oak Point, the largest of their locations. WGM will be housed in an open lot with gated security, electricity for refrigeration, lighting, forklifts and other loading and unloading machinery, and bathrooms for the farmers and their customers. This is an ideal location for the WGM because it is nicely situated at the crossroads of the entrance to the Hunts Point Peninsula and is on the property of one of the highest traffic locations for food buyers in the city.

A few bridges away in Long Island City, Queens, the newly formed distribution arm of WGM is currently operating out of a shared cold storage facility with City Harvest. This facility allows WGM staff to legitimately offer services to buyers that are competitive with the leading food distributors of NYC all the while bringing more buyers to the products of WGM farmers.

Beneficiaries

New York and adjacent state farmers:

WGM staff has maintained strong relationships with the original farmers of the Bronx Terminal Growers and the Wholesale Greenmarket. For the duration of this project the total number of these farmers is fifteen. In 2011-12 farmers in the WGM program are those who are not only selling their produce through the Wholesale Greenmarket, but also those selling their wholesale product through alternative avenues provided by WGM Staff and GrowNYC Programming including Youthmarkets, Fresh Bodegas, and YUM Food Box. All of these farmers have received assistance from WGM staff in becoming eligible to participate in the numerous purchase-support coupon programs for their produce which in turn has opened to new doors for their business. Rottkamp Brothers Farm and Hoeffner Farms, in particular, have been leaders in working to supply GrowNYC programming with quality produce. Moreover, this group will relocate next season to a location that is co-located with other businesses supplying wholesale food buyers and will be closer in proximity to existing produce wholesale trucking routes and that will offer crucial amenities such as electricity, forklift operators and pallet jacks and bathrooms.

New farmers working with through Greenmarket Co:

In 2012, 16 new farmer relationships were created and nurtured to aid in supplying the Greenmarket Co operations. Many of these farmers are new to the WGM/Greenmarket/GrowNYC family and have brought new products, different grades and packaging standards, and new logistical opportunities and resources to the WGM and Farmer relationship. For the first time, the WGM also started working with farmer cooperatives, specifically Upstate Growers and Packers of Oneida Co. Working with a cooperative, WGM staff was able to access the products of over 15 farmers, thus

increasing efficiency and providing Greenmarket Co. clients with greater selection of quality wholesale products.

Farming community of New York and neighboring states:

Building on the relationships of farmers that have been cultivated by the implementation of this project, WGM/Greenmarket/GrowNYC is closer than ever to proving that aggregation, distribution, and direct wholesaling of exclusively local produce and foods can be viable for farmers. Demand for this product is higher than we can meet, but as testimonials to this success from our farmers increase, it will become known within the farming community that WGM represents a viable and genuine point of access to the wholesaling of local product and we will support this demand.

Communities with traditionally poor access to fresh, local, and healthy fruits and vegetables:

For the duration of this project the WGM farmers, and in 2012, the Greenmarket Co. farmers as well, have supplied GrowNYC food access programming in the following neighborhoods: Bedford-Stuyvescent, Brownsville, Rockaway, Ridgewood, Cypress Hills, Washington Heights, the South Bronx, and more. These programs include the Youthmarkets, Fresh Bodegas, Food Box, and farm-to-emergency food providers we work with including the Yorkville Pantry and City Harvest. Thanks to the support of our farmers, WGM and GrowNYC staff, and strong community partnerships and participation, residents of these neighborhoods now have access to more local food than ever before and all of the food is eligible to be purchased with EBT, WIC, and other food buying coupon programs.

East Harlem and La Marqueta Small Businesses:

By strategically locating one of our 5 Food Box locations in the La Marqueta shared business space in East Harlem, GrowNYC programming supplied by WGM farmers is helping to drive the La Marqueta business by bringing more people through the doors and building awareness of the location throughout the community as an affordable and accessible location for access to local and ethnic foods. Collectively over the course of the Food Box programs, we have learned that strong partnerships with respected community partners not only helps to provide healthier food access opportunities for residents but also helps to promote like-minded small businesses that are partnered or in support of the programming work and fixtures in the local community.

Washington Heights:

The YUM Food Box program at the Isabella Geriatric center has been a leading program of WGM and GrowNYC. In its third year, the program has grown to incorporate food box distribution throughout the Washington Heights neighborhood. What is special about this program is the direct link between consumers and farmers that it promotes. Residents at the Isabella center actively participate in the packing of the food boxes for distribution and learn about the seasonality of local produce and where their food comes from.

Processors Directly Connected to Farmers:

By acting as a public interest broker, WGM and Greenmarket Co. staff has connected farmers directly with processors and manufacturers in the City. A great example of this is the connection between small scale specialty pickler, Brooklyn Brine, and Hodgeson's Farm. Brooklyn Brine uses a specific size of fresh pickle and other various fresh vegetables. WGM and Greenmarket Co. staff searched out a farmer to meet these needs and found what they were looking for through the existing

WGM and Greenmarket farmer networks. Both parties finished the pickle season pleased with the relationship that was developed and look forward to picking it up again next season.

Lessons Learned

This project was incredibly successful with regard to the important lessons we learned in creating a viable wholesale market place, developing new markets for upstate growers, and ensuring that locally produced, healthy food is going to communities that traditionally have lacked access to it. The foundation that this grant provided has led to the creation of Greenmarket Co., a mission-driven distribution operation that, since April 2012, has been aggregating local farms products in City Harvest's Long Island City, Queens Warehouse and distributing them throughout the City.

Diversity of farmers:

- Infrastructure is the key to expanding wholesale opportunities for regional growers. The overwhelming majority of the hundreds of wholesale farmers in our region that we interviewed and recruited do not want to sell out of their trucks but through more efficient wholesale channels that can pay them a price that actually covers the cost of production and that requires cold storage, loading docks and trucks.
- We also found that there is great variety within regional wholesale farmers' production, packaging, and operations, in terms of scale, quality, and consistency. In most cases the variations in farmer wholesale practice is due to a cost benefit evaluation by which the farmer takes into consideration the input costs for the product that is demanded by the farmer's current outlets. For example, farmers that have pre-existing relationships with large scale chain stores will consistently have a graded, industry standard pack; while farmers typically selling their product to processors, packers, or open markets, will forgo the costs of grading and uniform packaging in order to sell at a lower price but still earn necessary profit.
- In relation to the variance in wholesale production is the variance in farm size and level of mechanization in production and volume of product output. Smaller farmers tend to produce greater variety of product and grow more specialty items using less mechanized and more labor intensive practices. We have found that the demand of specialty retailers and restaurants is an ideal match for these farmers. Larger farmers tend to produce a more limited variety of product but in a higher volume with more mechanized production practices. We have found that the demand of large scale buyers including institutions, supermarket, and commissary kitchens is the right match for these producers. Over the course of the project, we have developed an understanding of these differences and an ability to interface between these different profiles (in terms of volume and product demand) and the various regional producers. We have further implemented this through the development of Greenmarket Co., which has become a great resource to regional farmers.

Diversity of buyers:

- There is no "one model" of wholesale buyer. Restaurants, bodegas, supermarkets and processors all have different needs with regard to grading, packaging, consistency of delivery, need for delivery, willingness to be flexible, etc… The list is endless. Aspects of this were briefly touched on in the section above but it is important to also identify the 'back-end' logistics

required by different buyer types. Buyers serving different forms of clientele need their product at different times and in different forms. WGM and Greenmarket Co. staff work to construct the most efficient and valuable relationships with farmers to specifically meet these needs from the start by lining up the receiving times of farmers with the needed delivery times to clients and many other variables that are taken into consideration.

- Infrastructure and effective distribution is the crucial component to creating an efficient wholesale operation for local food in New York City. Over 60% of the nearly 900 potential buyers we surveyed require the food be brought to them, whether in our trucks or through their existing distributors. Moreover, if we can aggregate product in a manner that maintains cold-chain compliance, we will provide the mechanism for existing distributors to have a one-stop shop for the diversity of local product, thus driving down their costs and other barriers for buying local. We currently are experiencing this and our largest buyer that picks up from our facility is the New York City Meals on Wheels Program.
- Bodegas and corner stores, while prevalent in underserved communities, may not be the most effective means to increase consumption of healthy food or to generate business for regional growers. Even when we provided these stores with refrigeration units, they are limited in how much product can be purchased and stored weekly and distributors cannot be profitable making several $75-$150 orders in New York City. Rather, working with the larger grocers and even supermarkets in Bedford Stuyvesant, Brownsville and other food at-risk communities throughout the City provides thousands of dollars of weekly revenue for farmers and brings the equivalent tonnage of healthy foods into those neighborhoods. These are stores that have the existing expertise in produce handling and display and GrowNYC and Greenmarket can provide the in-store marketing materials that support sales and community education as to why these products are superior with regard to taste, freshness and nutrition. We hosted and partnered with others to perform in-store cooking demonstrations as well to make it simple for customers to understand these concepts and foods and which led to increased sales.
- The GrowNYC food box program is an excellent way to increase revenues for farmers and to provide the most affordable opportunities for New Yorkers to purchase regionally produced foods. Moreover, this model can be adjusted for all income backgrounds and buyers, including value added products, meats and dairy.

GrowNYC applied to the NYU Wagner School's Capstone Program, through which teams of graduate students work over the course of a year to meet an organizational need. We proposed that a Capstone team evaluate WGM programming, partnerships, management and impacts over the course of 2010-2011. It is a highly competitive program and GrowNYC was not accepted as an applicant. The Wholesale Manager collected the data information on the buyers, types and frequency and desired items.

The most important lesson we learned is that GrowNYC can build a viable, profitable distribution operation that pays farmers a fair price for their products and ensures that all New Yorkers have access to them. By expanding our own programs that target food access and affordability as well as securing infrastructure to aggregate products and redistribute them throughout New York City to buyers of all types and income levels, we are building a sustainable model that will generate millions of dollars of annual economic activity for upstate communities while contributing to the health and wellness of New York City communities, businesses and residents. And while we believe that infrastructure and distribution are the key to the future, we have secured a safe, viable home for the remaining farmers of the Bronx Terminal Market who have been the backbone of New York City's local wholesale food scene

for the past century and will continue to support their efforts to increase sales and acreage in production.

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Additional Information

Examples of promotional materials developed.

Greenmarket Co. Marketing Materials

Local, farm-fresh food at good prices delivered to your neighborhood.

S&SO Produce

Farmer Stanley Osczepinski of S&SO Produce is one of Greenmarket's founding farmers, working with the organization for over 35 years. He farms over 300 acres in Goshen, NY an area better

known as the "Black Dirt". The region is known for its premium quality onions, root crops, and lettuces.

Common Thread Farm

A small, organic vegetable farm in Madison, NY. We partner with mid-sized and family-owned farms committed to proper land care, pest management, and conservation.

The Rondout Valley Farmers Association

A non-profit community organization comprised of local farmers, residents and businesses committed to supporting the region's family farms and preserving open space for future generations.

Upstate New York Growers & Packers

A farmers cooperative that helps wholesale producers reach new markets. Partnering directly with growers, cooperatives, food hubs, and local agriculture distributors means we know we're getting high quality produce.

Use EBT and WIC to buy fresh produce.

Green Peppers

Locally grown in upstate New York

$

TIP If you want a sweeter pepper, look for one that is turning red

TASTE Slightly bitter or even spicy and very crunchy

BENEFITS Packed with Vitamin C to combat colds

Use EBT and WIC to buy fresh produce

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Project 5

Breeding for Genetic Control of Late Blight, Early Blight and Septoria Leaf Spot in Fresh Market Tomato Lines for NYS

Project Summary

This project targets all three of the important defoliating disease for NY tomato production of late blight (LB), early blight (EB) and Septoria leaf spot (SLS). Current tomato varieties lacking genetic resistant require multiple fungicide applications to prevent or to slow these diseases, particularly when weather conditions favor disease development.

Tomato is an important crop in NY; freshmarket tomato acreage in NY in 2009 was 2,700A with a value in excess of $32.7 million (USDA Statistics, 2009), with the majority of NYS freshmarket tomato grown by diversified fresh market vegetable producers

Disease control is a major concern for NY tomato production; many fungicide sprays are used to protect yields & quality. Vegetable IPM Priorities for tomato in NY and eight NE states gave high priority to "*Phytophthora"* and "other fungal diseases". Fungicide use is critical for current SLS, LB & EB control in conventional production. NE tomato growers average 6 sprays/season (Anon., 2002). Without disease resistant varieties, weekly applications of approved chemicals are also required in organic fields, but control is usually poor. Excessive spraying to control these three diseases results in increased production costs for growers, increased risks of compound release to the environment and rural community, and increased risks of residuals for consumers.

The Cornell breeding program had produced the first tomato lines combining LB resistance, SLS resistance and EB tolerance (referred to as LB/EB/SLS resistant lines). This provided the timely opportunity for this project.

To be useful these LB/EB/SLS resistant lines must combine these new resistances with horticultural type and quality needed by NYS growers and consumers. Our LB/EB/SLS resistant lines were derived from high quality parentage, providing good potential, and were sufficiently early generation that they are not yet fixed for important horticultural characters.

Our goal was to use the current LB/EB/SLS resistant lines and a related BC1F2 population to produce final breeding lines combining LB/EB/SLS resistance and the plant and fruit quality traits in tomato lines adapted to NYS growing conditions. The tomato line completed by this project was to reduce crop loss, such as that experienced in 2009, reduce fungicide sprays and expense for conventional & organic tomato growers in NYS, minimize risks to human health and the environment, and reduce risk of residuals in tomatoes for consumers.

Project Approach

For generation of self seed from a desired plant, fruit is collected when ripe, and deseeded using a standard acid extraction method followed by a sodium tribasic wash. This method is standard to insure high seed viability, and reduce risk of carrying externally seed borne pathogens

For generation of hybrid seed, plants of the female and male parents are grown under greenhouse conditions to flowering, female flowers are emasculated before opening, and manually pollinated using pollen collected from open flowers of the male parent, then the pollinated flower is tagged to confirm its identity as a cross pollinated fruit. Hybrid seed is collected from the ripe fruit in the same way as described above for selfed seed.

For field evaluation of plants (either line or hybrid) seed is sown in a greenhouse to grow transplants. See is sown 4 to 6 seed before intended date of transplantation. Transplants were grown conventionally unless intended for organic trials. Transplants for organic trials were grown for us by another project which only grows organic transplants.

All trials are grown using plastic beds. Starting in 2012 some plots had trickle irrigation. All plots used trickle irrigation in 2013. Some trials were field grown using trellising, others were ground bed grown, both using standard spacing and plot maintenance methods.

Evaluation for fruit size and yield in trials focused on those traits used ripe/ripening fruit harvests and fruit counts/weight data collection over 3 or 4 weeks, depending on the year of the trials, and the conditions prevailing that year.

Observation of disease presence identified disease visually, and determined degree of defoliation using a standard visual rating scale commonly used by plant pathologists.

Genotyping of plants for selection or to determine presence/absence of desired genes was performed by full panel SNP analysis performed as a service through SOLCAP, with a second paid run also performed by the same lab in Michigan.

Further analysis was performed in-lab at Cornell using PCR based CAP markers designed to match SNP panel markers in desired regions. Design of the PCR markers and their use was performed using standard molecular biology techniques.

In lab screens for SLS resistance/Susceptibility were performed using a 4-week old seed Mist Chamber screen developed in the Mutschler lab, which is a refinement of prior published SLS screens. Determination of resistance is most accurately determined by counting the Septoria pycnidia (a reproductive structure) present per lesion on the plants that had been inoculated with SLS pathogen and held in the mist chamber over 5 days (dry days/,misting nights).

In field SLS trials for disease spread were performed on field grown trellised plants, with each row of 10 to 12 experimental plants having a susceptible plant imbedded half way down the row. The susceptible plants in each row were inoculated with SLS pathogen, and field plots water as needed to maintain humidity/free moisture during inoculation period. In subsequent weeks, the degree of disease on each plant in each row was determined weekly, to chart the degree of disease spread.

Goals and Outcomes Achieved

The overall objective of the work is to use the F4 triple resistant lines and the BC1F2 selected in 2010 to create final freshmarket tomato lines adapted to NYS growing conditions that possess genetic control of EB/LB/SLS and are also fixed for high quality fruit and plant characteristics.

The specific objectives of stated for the work is given below in italic, and is followed by a summary of what was done and what was achieved:

1. *To advance selections from F4 lines already fixed for LB/EB/SLS resistance through to the F6 generation in replicated trials in years 1 and 2 with strong selection for necessary fruit and plant characteristics as well as uniformity of these fruit and plant characteristics to select optimal first generation lines*

    Around the time this project was started, a new set of SNP markers for tomato created by USDA funded SOLCAP project became available, and breeding programs could submit lines for analysis WITHOUT COST. This opportunity accelerated the progress possible in the objectives. This opportunity was therefore taken to characterize the then current LB/EB/SLS

lines in development for over 7,000 markers over the 12 tomato chromosomes. The SNP panel saturates the genome, provided over 2000 informative markers across the 12 tomato chromosomes. By using the data, we could see which chromosomes were still heterozygous (that is carried one copy of the desired alleles and one copy of the desired allele for a gene). The self-progeny of the plant would segregate for the alleles. The information allow us to PCR markers based upon the relevant SNPS, and to use these tools to select at the seedling stage among the progeny for those plants homozygous for only the desired alleles. By doing this, one can fully "fix" the final lines in one generation, bypassing the need for years of laborious in-field selections. This allowed us to very rapidly complete more and better second generation lines that are being released January 2014.

2. To select the subset of the 2010 BC1F2 selections which are fixed for SLS resistance. To advance these fully LB/EB/SLS resistant selections to the BC1F4 generation in replicated trials in years 1 and 2 with strong selection for necessary fruit and plant characteristics as well as uniformity of these fruit and plant characteristics, to create optimal second generation lines, and determine their advance over the first generation lines

The opportunity was also taken to improve the work on this goal using SNP analysis. Through this analysis we found which of the lines in development were already homozygous (fixed) for undesired regions from the DONOR parent, and so could not be improved through further selection. We also determined which plants carried in heterozygous form a detrimental allele which is only seen affecting the plant when the gene is homozygous for the detrimental allele. This allowed us to select those developing lines without the allele, or to progeny select a segregating population in the seedling stage for those plants that did not have the detrimental allele. This information and screening ability enabled us to focus effort on most promising lines, and to "fix" desired genes in far fewer generations.

The resulting lines were compared in a field observational trial at the Cornell Varna "conventional) farm summer of 2013. Selections were made both between and within lines for desired plant type. Additional marker analysis is underway from fall of 2013 to Feb of 2014. Some of the selected second generation lines in development were also used fall of 2013 to produce seed of new second generation hybrids that will be trials in 2014.

3. To generate F1 hybrid seed using the best of the F6 and BC1F4 lines to compare these experimental hybrids with current commercial hybrids for fruit and plant characteristics.

Trials seed was generated using the 3 best performing 1st generation EB/LB/SLS lines and 2 of the 2nd generation EB/LB/SLS lines. The first generation hybrids were grown in organic trials in Cornell Organic farm in Freeville NY in 2012 and 2013, at the Cornell Varna (conventional farm) in 2012 and 2013, and in a cooperative observational trial at a UW-Madison farm in 2013.

Results of observational trials of the 3 best performing 1st generation hybrids determined that the fruit size was smaller than large fruited hybrids, but matched well current commercial medium fruit hybrids. Harvested trials indicated that yields were also comparable to hybrids with similar fruit sizes.

The second generation hybrids could only be included in the 2013 trials. In these trials the second generation hybrids tested had somewhat larger fruit than the 1st generation lines, however the full extent of possible fruit sizes could not be determined, as only 2 second generation hybrids could be included in the 2013 trials. Considerable progress was made

over 2013 in refining and "fixing" the 2nd generation lines so that they would be fully homozygous. We now have the additional lines needed to create additional 2nd generation lines for testing in future years.

4. *Additional goal added to program: Mapping SLS resistance*

Since the original work proceeded more rapidly than anticipated, we were able to extend goals of project to mapping the location of SLS resistance. This work is near completion, and when finished spring of 2013 will be included in a publication to be submitted spring 2013, and will be shared with seed companies using the LB/EB/SLS lines released by this program. Mutschler's program had already created and provided to seed companies markers for the Ph2 and Ph3 late blight resistance genes The availability of the molecular markers for SLS resistance would allow selection for this resistance in tomato seedling stage, rather than labor intensive screens every generation, and will accelerate the release of additional tomato LB/EB/SLS hybrids, providing tomato growers additional choice in tomato hybrid varieties.

Beneficiaries

Seed companies:

- Seed companies producing and selling tomato hybrids were the first beneficiaries of this program. The work of the program completed development of LB/SB/SLS tomato lines as well as tests of hybrids made using these lines. These resources were released, under MTA, to seed companies which are using the lines both directly as parents of hybrids, and as germplasm for tomato line and hybrid development. First generation LB/SB/SLS tomato lines were released to seed companies. New second generation LB/SB/SLS tomato lines with the same resistances but refined fruit and vine characteristics are being released January 2014 to seed companies (as part of an official annual release that happens every January.) We have already received a number of advanced requests from the same seed companies.
- The first commercial hybrid resulting from the program is the hybrid "Iron Lady" which was first sold by High Mowing Organic Seed Company for the 2013 growing season. (See site: http://www.highmowingseeds.com/Organic-Iron-Lady-F1-Hybrid-Tomato-Seeds.html) A High Mowing official told Mutschler that demand was so great, that the seed supply they thought would be sufficient for selling over two years was so depleted that they started a second round of hybrid seed production nine months into the first year's seed sales!
- A different seed company is in the process of licensing another LB/SB/SLS line from Cornell to use as a parent for a second LB/SB/SLS hybrid to be sold for the 2015 season. Seed of LB/SB/SLS lines is also being used by more than 20 seed companies who are using the lines as germplasm for developing new LB/SB/SLS lines. No income has been generated from this project.
- Therefore the germplasm and information released by this program has had a profound impact on fresh market tomato breeding for the eastern US, and specifically the NE US.
- To date, the number of seed companies that have requested germplasm is 12. More requests are expected.

Tomato growers and consumers

- Organic growers, growers producing without sprays and home gardeners have benefited from the initial LB/SB/SLS hybrid sold (Iron Lady) and will benefit as additional LB/SB/SLS hybrids are released.
- Feedback from growers is starting to be gathered. One grower visited Mutschler at Cornell, telling her that their non-spray tomato production had suffered from Septoria in past years, and the Iron Lady was the only tomato without disease in 2013. He also indicated that as a result of posting an on-line article about Iron Lady next to the tomatoes in their sales stand, sales of the tomato were very brisk and repeat customers were indicating satisfaction with the fruit quality.

Quantitative data are not yet available. That the first hybrid is selling beyond company expectations is a rough estimate of demand for tomatoes with the multiple blight control trait. Use of hybrid would have to expand before growers could be surveyed to determine reduction in use of fungicidal controls or reduction in loss of production due to genetic disease control.

Lessons Learned

All goals of this project were achieved, indeed all of the additional goals added the project were also achieved.

This project demonstrated:

- *the need for tomato new fungal control hybrids:* The high demand for the LB/EB/SLS lines by seed companies and the unexpectedly high sales for the first commercial hybrid (Iron Lady) to tomato growers (particularly organic tomato growers) demonstrate the demand for control of fungal diseases without or with minimal sprays. Contacts by organic growers indicating that SLS might actually be the worst issue for them among the three diseases. That might explain why the demand for the first hybrid that has SLS resistance as well as LB resistance, was so high.
- *the power of genome-wide SNP analysis to accelerate completion of lines:* As discussed in section "Goals and Outcomes Achieved" section above, the ability to obtain genome wide genotypic data using a newly developed SNP panel provided an opportunity to improve selection and creation of the 2nd generation lines. By using the SNP data for over 2000 markers, we could easily determine which chromosomes were still heterozygous (that is carried one copy of the desired alleles and one copy of the desired allele for a gene). The self-progeny of the plant would segregate for the alleles. The information allow us to PCR markers based upon the relevant SNPS, and to use these tools to select at the seedling stage among the progeny for those plants homozygous for only the desired alleles. By doing this, one can fully "fix" the final line in one generation, bypassing years of laborious in-field selections. This allowed us to very rapidly complete more and better second generation lines than we could have without the SNPS.
- *the value of LB and SLS control, and that the remaining "weak link" in the triple resistance is genetic control of Early Blight.*
    - Regional use of LB/EB/SLS confirmed prior results that the Ph2/Ph3 gene combination fully controls Late Blight.

- Trials in 2012 and 2013 on the epidemiology of SLS (spread through a field over time) demonstrated the ability of SLS resistance to strongly curtail spread of SLS. A publication based on this work will be submitted Spring 2014.
- However the control of EB currently available is only tolerance. This tolerance controls lesion and lesion size on stems and peduncles but does not control EB on leaves, such that some supplemental sprays are needed. Future work to combine this form or EB tolerance with other tolerances to protect the leaves is needed to strengthen this "weak link" in the disease control chain.

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Additional Information

The results of this program, and introduction of the first LB/EB/SLS hybrid Iron Lady, has resulted in a number of report and web sites:

1. **Web sites with articles/reports about Iron Lady**
   Article "Ready to plant: 'Iron Lady' tomato punches out blights" on Cornell Chronicle**:**
   http://www.news.cornell.edu/stories/2013/03/ready-plant-iron-lady-tomato-punches-out-blights

   Article "New Tomato Fights Blight - High Mowing Organic Seeds Releases "Iron Lady".
   file:///C:/Documents%20and%20Settings/Martha/My%20Documents/Downloads/GreenStar%20Martha%20Iron%20Lady%20tomato%203-13.pdf

2. **Grower information web site**
   http://www.thegrower.com/news/New-tomato-hybrid-resists-three-fungal-diseases-199526261.html

3. **Organic information sites**
   http://eorganic.info/node/8841

4. **How to Control of disease web site: VegMD**
   Best of the best:
   http://vegetablemdonline.ppath.cornell.edu/NewsArticles/TomatoesBestoftheBest.pdf

   What tomato growers need to know:
   http://vegetablemdonline.ppath.cornell.edu/NewsArticles/tomato%20growers%20need%20to%20know%20Nov%202013.pdf

   Tomato disease management strategies for 2014:
   http://vegetablemdonline.ppath.cornell.edu/NewsArticles/Tomato_Strategies_Fungicide.pdf

5. **Single user blogs or reports**
   http://groweat.blogspot.com/2013/08/a-look-at-iron-lady-tomato.html#axzz2nSvwJkXR
   http://www.cantonrep.com/x1629898692/Green-Space-How-to-deal-with-peony-mildew-and-tomato-blight

6. **Educational use:** A YouTube presentation was created by students in Indonesia about why lines combining disease resistances are beneficial**:** Tale of Iron Lady web site
   http://www.youtube.com/watch?v=nEnW8psQ5MY

Project 6

Improving Fresh-Market Vegetable Production and Profitability with Bumble Bees

Project Summary

The European honey bee (*Apis mellifera*), an important pollinator of New York's most lucrative vegetable crops, continues to suffer population declines due to Colony Collapse Disorder. Consequently, fewer honey bee hives are available causing hive rental fees to increase from $30 to ≥$55 per hive, and forcing growers to either spend more on renting hives or gamble by not renting hives and hope wild bees will pollinate their crops. Based on our recent research, the common eastern bumble bee (*Bombus impatiens*) is a better pollinator of vegetable crops than the honey bee. This bumble bee is found naturally in New York and is also commercially available. The goal of this project is to increase yields, profitability and sustainability of fresh-market vegetable farms by maximizing use of the superior pollination services provided by bumble bees. This project is timely because growers may be investing in renting honey bee hives when this practice may not be necessary. A research-based, decision-making guide will be the main outcome. Growers can use this Guide to determine if they can rely exclusively on pollination by wild bumble bees or if they should pay for commercial bumble bees. This project will benefit conventional and organic fresh-market vegetable growers by increasing farm profits whenever free pollination services by wild bumble bees can reduce or eliminate rental costs for honey bees. No previous studies on this topic had been funded by the SCBGP.

Project Approach

This study was conducted in 23 pumpkin fields in 2011 and 19 fields in 2012 in the Finger Lakes region of New York State. The majority of fields were in commercial production. Field size ranged from 0.5 to 13 hectares. Pumpkin fields of similar size were grouped and then randomly assigned to one of three treatments: *B. impatiens* supplementation (2011: N = 6; 2012: N = 5), *A. mellifera* supplementation (2011: N = 10; 2012: N = 7), or a nonsupplemented control (2011: N = 7; 2012: N = 7). To compare fruit yield among these treatments, the same variety (*Cucurbita pepo* var. 'Gladiator' F1 hybrids) was transplanted into all fields. In each pumpkin field, greenhouse-grown plants that matched the size of field-sown plants were transplanted into three plots of 10 plants each (two adjacent rows of five plants; N = 30 transplants per field). In mid-July, when the plants were just beginning to bloom, *B. impatiens* and *A. mellifera* hives were stocked in pumpkin fields. Commercially reared *B. impatiens* hives were acquired from Koppert Biological Systems, Inc. Stocking density was approximately five *B. impatiens* hives per hectare of pumpkins; this stocking density was recommended by Koppert Biological Systems. *B. impatiens* QUADs (boxes of four hives) were placed within the field equidistant from each other. *A. mellifera* hives were supplied by local beekeepers with approximately equal hive strength. Stocking density was approximately one *A. mellifera* hive per hectare of pumpkins; this stocking density was the typical density used by local growers. Bee visits to pumpkin flowers were assessed visually in three transects throughout each field. Transects consisted of two rows of pumpkins, including the area of our small plots, and extended 40m beyond the plots for a total of 44m. The total number of bees visiting all pumpkin flowers in each transect was counted once a week for three consecutive weeks (rounds), which spanned the majority of the blooming period. Sampling was conducted between 0600-1100h (when flowers were open) on sunny to partly cloudy days with minimal wind (<15 km/h). Transects were surveyed for a total of 10 minutes each by slowly walking down the row. Observers scored the number of bee visits to flowers on each plant within the transect, bee species and total number of flowers in the transect. Fruit produced from the transplants in the small plots was harvested and weighed at the end of the growing season.

Significant results from our project indicated that supplementing pumpkin fields with either *A. mellifera* or *B. impatiens* hives did not increase their visitation to pumpkin flowers or fruit yield compared with those that were not supplemented. Next, the relationship between frequency of pumpkin flower visitation by the most prominent bee species (*B. impatiens and A. mellifera*) and fruit yield was determined across all pumpkin fields sampled (supplemented + non-supplemented). Fruit yield increased as the frequency of flower visits by *A. mellifera* and *B. impatiens* increased in 2011 and 2012, respectively, with the greatest yield resulting from a high flower visitation frequency by *B. impatiens*. These results suggest that supplementation with managed bees may not improve pumpkin production and that wild *B. impatiens* plays an important role in pumpkin pollination.

Koppert Biological Systems (Howell, MI) played a significant role as a partner for our project. This company donated bumble bees for our research and provided shipping costs to deliver them to Geneva during both years of the project. The estimated value of these bees for both years of the project was over $20,000. Without this donation, this project would not have been possible.

Goals and Outcomes Achieved

Measurable Outcome #1

Goal: This project will include a cost-benefit analysis for producing fresh-market pumpkins in fields supplemented with bumble bees, honey bees or no commercial bees. The information will be transferable to other vegetable crops that require bee pollination.

Benchmark: No such information exists.

Target: The cost-benefit analysis will be based on field research supported by this project. The information will be published in regional newsletters (e.g., Veg Edge, Muck & Mineral, etc.) and discussed over the course of the year at the Annual Fresh-Market Vegetable Winter Meeting in western NY, the Annual Winter Fruit and Vegetable Meeting in Albany, and the Empire State Fruit and Vegetable EXPO in Syracuse as well as other meetings. We anticipate this information will be delivered to at least 1,000 fresh-market vegetable farms (500 via written material and 500 at meetings).

Measurable Outcome: A cost-benefit analysis to determine approximately how much money will be saved by the reducing the acreage that does not benefit from supplementation by managed honey bees was conducted. We surveyed 16 growers in the Finger Lakes region with regards to how many acres of pumpkins they grow and whether or not they supplement fields with honey bees. Approximately 47% of the 380 acres of pumpkin grown in this region is supplemented with honey bees. Assuming this area is representative of the practices of growers in other parts of the state, we extrapolated this figure to New York State. Over the last five years, 3,161 acres of pumpkins grown in NYS were supplemented with pumpkins (47% x 6,725 acres). Based on the results from our research, we conservatively estimated that one-half of these fields likely do not benefit from supplementation (1,580 acres), which if growers were to adopt our recommendations would **save more than $50,500 annually** in pollination services costs (1580 acres x 1 hive per 2.5 acres = 623 hives x $80 per hive = $50,572).

Overall attendance at meetings in which research results from this project were presented was 678. Below is a breakdown in numbers of attendees and talks each year.

- 2011 – 2 talks given (attendances were 60 [New England Vegetable and Fruit Conference, Manchester, NH] and 120 [Empire State Fruit and Vegetable EXPO, Syracuse, NY])
- 2012 - 3 talks given (attendances were 12 [Empire State Fruit and Vegetable EXPO, Syracuse, NY], 60 [Northeast Organic Research Symposium, Saratoga Springs, NY], and 191 [Great Lakes Fruit and Vegetable EXPO, Grand Rapids, MI])
- 2013 – 3 talks given (attendances were 80 [Empire State Fruit and Vegetable EXPO, Syracuse, NY], and 50 + 80 [both talks at Great Lakes Fruit and Vegetable EXPO, Grand Rapids, MI])
- 2014 – 1 talk given (attendance was 25 [Empire State Producers EXPO, Syracuse, NY])

Measurable Outcome #2

Goal: This project will develop a Decision-Making Guide that vegetable growers can use to determine if their fields should be supplemented with commercial bees or if native populations of bumble bees are sufficient to pollinate the crop.

Benchmark: No such guide exists.

Target: The Decision-Making Guide will be published as a fact sheet, disseminated in regional newsletters (e.g., Veg Edge, Muck & Mineral, etc.), placed on the Cornell Vegetable website http://www.vegetables.cornell.edu/ and will be disseminated to at least 1,000 fresh-market vegetable farms via the modes of communication described above.

Performance Measure: The Decision-Making Guide was developed and can be viewed http://cvp.cce.cornell.edu/submission.php?id=127&crumb=crops|crops|pumpkins_/_gourds|crop*25). The fact sheet may be found at: http://ext.entomology.cornell.edu/cals/entomology/extension/wildpollinators/loader.cfm?csModule=security/getfile&PageID=1101025. Although we have received anecdotal reports that growers have used this information to reduce the numbers of honey bee hives they rent for pollinating their pumpkin fields, we do not yet have concrete figures on the amount of this reduction.

Beneficiaries

Vegetable growers, both conventional and organic, in New York State as well as those in nearby States should benefit from the completion of this project's accomplishments. At this time, the number of estimated beneficiaries from this project is 560**,** although it continues to rise. Below is how this figure was determined.

Based on interactions with stakeholders from the fresh-market vegetable production industry who grow vine crops, especially pumpkin, we estimate just under 750 contacts since 2010. These contacts were those in attendance at stakeholder meetings, one-on-one farm visits and those who have viewed our decision guide on the web. Of these 750 contacts, approximately 75% were growers and the others were from various other professions in the specialty crops industry (560 grower contacts). From these grower contacts, nearly all have benefited or will benefit from this project by learning about pollination of their crops in general, that native bees are very important for pollinating pumpkin, and that in most cases it is not economically justifiable to supplement pumpkin fields with honey bees or

bumble bees to increase yield because there are plenty of wild bees that are doing the job for them for free.

Because we did not observe increases in pumpkin yield in field supplemented with A. mellifera or B. impatiens, our results suggest that supplementing pumpkin fields with either *A. mellifera* or *B. impatiens* at the densities mentioned above may not be profitable to vegetable growers in most situations. Consequently, growers can save money on hive rentals (see estimates above).

Lessons Learned

We were very surprised that supplementing pumpkin fields with either honey bees or bumble bees did NOT significantly increase fruit yields. We also did not observe more bees visiting pumpkin flowers in the pumpkin fields that were supplemented with these bees. These results were not expected and stimulated interest into investigating where the bees are foraging.

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Additional Information

Publications in Refereed Journals

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2. Garibaldi, L.A., I. Steffan-Dewenter, R. Winfree, M.A. Aizen, R. Bommarco, S.A. Cunningham, C. Kremen, L.G. Carvalheiro, L.D. Harder, O. Afik, I. Bartomeus, F. Benjamin, V. Boreux, D. Cariveau, N.P. Chacoff, J.H. Dudenhöffer, B.M. Freitas, J. Ghazoul, S. Greenleaf, J. Hipólito, A. Holzschuh, B. Howlett, R. Isaacs, S.K. Javorek, C.M. Kennedy, K. Krewenka, S. Krishnan, Y. Mandelik, M.M. Mayfield, I. Motzke, T. Munyuli, B.A. Nault, M. Otieno, J.D. Petersen, G. Pisanty, S.G. Potts, R. Rader, T.H. Ricketts, M. Rundlöf, C.L. Seymour, C. Schüepp, H. Szentgyörgyi, H. Taki, T. Tscharntke, C.H. Vergara, B.F. Viana, T.C. Wanger, C. Westphal, N. Williams, A.M. Klein. 2013. Wild pollinators enhance fruit set of crops regardless of honey-bee abundance. *Science* 339: 1608-1611.
3. Petersen J.D., and B. A. Nault. Identifying landscape effects on bee-mediated crop yield. (submitted to the Journal of Applied Ecology).

Proceedings Articles

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3. Petersen, J. D. and B. A. Nault. 2012. Can pumpkin yield be increased by supplementing fields with honey bees or bumble bees?, pgs. 61-62. *In*: Proceedings of the Northeast Organic Research Symposium. January 19-20, 2012. Saratoga Springs, NY.
4. Nault, B. A., D. R. Artz and J. Petersen. 2011. Potential for bumble bees to improve production of pumpkins, pgs. 45-47. *In*: Proceedings of the 2011 New England Vegetable and Fruit Conference. December 13-14, 2011. Manchester, NH.
5. Nault, B. A., and D. R. Artz. 2011. The potential for bumble bees to improve production of cucurbit crops, 3 pp. *In*: Proceedings of the 2011 Empire State Fruit and Vegetable Expo. January 25-27, 2011. Syracuse, NY. Cornell Cooperative Extension and New York State Vegetable Growers Association.

Extension Publications

1. Petersen, J., and B. A. Nault. 2013. Is it worth supplementing pumpkin fields with bees? Cornell Cooperative Extension, Cornell Vegetable Program. Veg Edge 9(2): 6-7.
2. Petersen, J. and B. A. Nault. 2012. Can pumpkin yield be increased by supplementing fields with honey bees or bumble bees? Cornell Cooperative Extension, Cornell Vegetable Program. Veg Edge 8(2): 4-5.

Information on Web

1. Petersen J.D. and B. A. Nault. 2013. A decision-making guide for supplementing pumpkin fields (http://cvp.cce.cornell.edu/submission.php?id=127&crumb=crops|crops|pumpkins_/_gourds|crop*25)

Project 7

Towards Reducing Losses from Bacterial Diseases of Onions in New York State

Project Summary

Initially, the goals for this project were to emphasize studies of two particular bacterial diseases of onion, center rot and sour skin, caused by *Pantoea ananatis* and *Burkholderia cepacia*, respectively. These two diseases had appeared to cause substantial and increasing losses to onion growers and packers in the several years prior to the initiation of this project. Thus, our motivation was to develop and evaluate potential management strategies aimed at reducing losses from these diseases. However, during the course of our studies of *P. ananatis* and *B. cepacia* and their diseases, several other bacteria not known previously in New York were characterized as problematic to onions. Thus, the project goals were expanded to deal generally with bacterial diseases of onions and the pathogens that cause them in New York. To carry out the project goals, novel techniques for the identification of the bacteria affecting onions and techniques for assessing and characterizing their pathogenicity and the possible efficacy of control strategies were developed and subsequently shared with growers.

Project Approach

The original proposal covered a research period of one year, based on the funds available. Fortunately, additional funding from USDA Hatch Multi-State (W-1008 and W-2008), University and onion industry sources allowed research to occur additional years and to accomplish more than originally planned. As such, this project received onions from all the commercial onion growing regions of New York State, suspected to be infected with bacteria, over a three year period. Samples were collected during our visits to growers' fields and other samples were sent to us by Cornell Cooperative Extension (CCE) Specialists and onion industry representatives. These samples were used to determine the importance of numerous bacterial pathogens of onions and to identify the particular pathogens of importance. Based on our efforts with these samples, the following activities and accomplishments are listed below:

What are the bacteria that cause losses to onions in New York?

Based on the microbiological and molecular biological techniques we used to analyze unmarketable onions in storage, it soon became obvious that a plethora of bacteria are associated with the bulbs. The bacteria identified included *Pantoea ananatis*, *Pantoea agglomerans, Burkholderia cepacia*, *Enterobacter cloacae* and *Rahnella* spp. *Rahnella* strains were identified from approximately 40% of the strains isolated from cull onions. This bacterium had not been reported as a pathogen of onion in New York or elsewhere. Most of the strains tentatively identified as Rahnella sp. and a minority of the strains of *Pantoea agglomerans* caused symptoms when injected into healthy appearing mature onion bulbs or onion sets. Several other bacteria belonging to the genera *Pseudomonas* and some members of the Enterobacteriaceae family of Gram-negative bacteria were identified based on molecular-biological techniques. In preliminary pathogenicity tests, these did not cause symptoms in inoculated onion bulbs. These identification techniques were effective because the entire genome sequences of many organisms have been determined and are available for comparison with sequences that we, and other researchers, can determine with available techniques.

Why identify bacterial pathogens of onion?

Each bacterial pathogen likely behaves differently from others. Its source of inoculum is likely to be different, it likely initiates disease differently and the conditions favoring or not favoring disease

development and the symptoms caused are likely to differ for those for other bacterial pathogens. The key to control or management of plant disease is to interfere with the disease cycle, so details of the cycle should be known.

During the project term, it became apparent that two of the major bacterial pathogens of onion in New York, *Burkholderia cepacia* and *Enterobacter cloacae* are pathogens of special concern. These bacteria are of great importance because strains of the same named bacteria cause problems in humans and animals. Thus, based on NIH regulations, we applied for and have obtained a new Memorandum of Understanding (MUA) from the Cornell University Institutional Biosafety Committee (#16095). That MUA requires that our laboratory operate under BL2 and BL2-P Biosafety Regulations. These regulations prescribe specific means of maintaining personnel and environmental safety while conducting research with *Burkholderia species* and *Enterobacter cloacae.*

Identification of bacterial pathogens of onion

Two novel techniques were used to identify bacteria isolated from onions or onion-related samples. In the first, Polymerase Chain Reaction, (PCR), amplified a portion of *gyrB*, a housekeeping gene, from bacteria isolated from the suspect samples. The amplified gene fragment was further fragmented by reacting the DNA with a specific restriction endonuclease enzyme. This operation resulted in a number of DNA fragments of various sizes and thus mobilities in agarose gels. The patterns of the fragments were compared with previously generated patterns from a number of authentic strains of bacteria. Fragment patterns from newly isolated bacteria that closely matched that of an authentic strain thus were identified tentatively. Confirmation of the identification was based on comparing the total nucleotide sequence of a major portion of the *gyrB* gene with that of authentic strains.

In the second procedure that also relied on PCR, we identified highly specific primer pairs for amplification of regions of specific bacteria affecting onion, including *Pantoea ananatis*, *Enterobacter cloacae, Burkholderia* spp. *and Rahnella* spp. We utilized genomic data deposited in GenBank to identify genetic sequences common to multiple strains of the bacteria of interest and lacking from other bacteria that we and others had found were associated with onion.

The second technique was tested to ascertain the possible presence of the four bacteria in suspect onions or water. The sample is probed gently with a sterile applicator. The applicator tip then was swished in sterile water, which was diluted appropriately and then subjected to PCR with one or more of the highly specific primer pairs. The PCR results are considered valid based on the rigor of the testing done during the development of this technique.

Both new techniques developed and described above rely on PCR. Unfortunately, we found that PCR reactions are strongly inhibited by components of most of the tested samples including onion bulb and leaf tissue, onion extract, a component of the partially selective medium Onion Extract Medium (OEM) for growth of onion-associated bacteria, muck-soil or raw water collected from the vicinity of onion fields. Thus, considerable efforts were expended in attempts to overcome the inhibition of PCR by the plethora of components of the diverse samples we assessed. Use of different DNA polymerase sources and suppliers had little effect on inhibition and the use of multiple commercial kits for isolating DNA samples from feces, and soil was not effective. We did develop and use effectively two strategies for overcoming the PCR-inhibiting effects of the aforementioned sources of bacterial pathogens of onion: 1) diluting samples and, 2) enriching the template concentration by growth in OEM broth followed by dilution.

Determination of Pathogenic Capability of Bacterial Strains

To determine the relevance of isolated bacteria to decay, we initiated studies to determine whether the isolated strains could cause decay following inoculation into putatively healthy onion tissues. We used mature bulbs and onion sets in the laboratory and sprouted onion bulbs and young transplants growing in the lab, greenhouse and controlled environment chambers. Strains of *Pantoea ananatis, Pantoea agglomerans, Burkholderia cepacia* and *Enterobacter cloacae* consistently caused symptoms in inoculated whole onion bulbs or sets. Some strains of *P. agglomerans and Rahnella* spp. caused symptoms in inoculated bulbs.

Only strains of *Burkholderia cepacia* exhibited characteristic symptoms within a few days of inoculating slices of large bulbs incubated in Petri dishes. Strains of *P. ananatis* caused lesions consistently in inoculated leaf tissues, while only some strains of *P. agglomerans and P. vagans* caused lesions. Strains of *Enterobacter cloacae* did not cause leaf lesions in any of several tests. Similarly, strains of *Rahnella* sp. caused symptoms in bulbs, but no symptoms developed on leaves following inoculation with *Rahnella* sp. or *Enterobacter cloacae*.

Sources of Bacterial Pathogens of Onions

- **Planting material**
  During the first two years of this project, we assayed onion seed and transplant seedlings obtained from several New York growers and samples of muck soil in which onions had grown. Seed was free of pathogens; transplants were free of bacteria of consequence. Some transplant seedlings, grown in the Southwest, yielded strains of *Pantoea agglomerans*; only a small percentage of those tested caused lesions in inoculated onion leaves.

- **Muck soil collected from fields in which onions had grown**
  Most of the problematic bacterial pathogens of onion in New York were detected in samples of muck soil collected from the several regions where onions are grown in New York. In the third year, we assayed an additional ca. 100 samples of muck-land soils collected from fields in which onions were planted or had grown. Generally these samples also yielded evidence of the presence of all the bacterial pathogens of onion encountered in our analysis of suspect onions as assayed earlier. Thus, muck-land soil again was implicated as the source of over-wintering bacterial pathogens, and we had emphasized studies of muck soil as the reservoir of bacterial pathogens.

- **Water in the vicinity of muck-land onion fields**
  Muck-land soils routinely are drained by sub-surface tiles or tubes into ditches or creeks. Thus, as water percolates through the soil, bacterial pathogens present in the soil might be carried with the water and accumulate in the ditches or creeks, surrounding the fields of muck or in the water table under the fields. Some growers use these waters for irrigating onions and/or as carriers for pesticides including insecticides and fungicides sprayed on growing onions. Therefore, during the 2012 and 2013 growing seasons, we sampled ditch and creek water in a preliminary manner for content of bacterial pathogens of onions. Bacterial pathogens were detected in some samples of surface waters and in water from shallow wells beneath onion fields.

Evidence that Some Muck Soils Suppress Populations of Bacterial Pathogens

Some muck soils from onion fields, collected in spring before onion planting, seemed to reduce the populations of the bacteria that cause bulb rot. Known numbers of marked pathogenic bacteria were added to several soil samples in laboratory tests. The populations of the marked strains recovered

differed among the soils after intervals of incubation. Populations recovered from several of the soil samples were much reduced, while the populations from other samples were increased. However, if the suppressing soils were heat-treated prior to adding the marked bacteria, bacterial populations remained stable or increased. These results suggest that the unheated soil harbors a heat-labile microbe(s) that reduces bacterial populations under the conditions of our experiments. Further studies may lead to the characterization of the biotic component and the possible development of strategies to reduce populations of pathogenic bacteria in muck soils and consequent bacterial rot.

Strategies to reduce losses from bacterial disease of onions

The ultimate objective of this project is to reduce losses to onions caused by bacteria. During the second and third years of the project, we initiated laboratory, greenhouse and field studies to directly address this objective. These are listed here to give the reader an idea of the scope of studies that were aimed at accomplishing our ultimate objective. Some strategies were supported, in part, by SCBG funds, and in part by other funds.

1) Determine the effect of the amount of nitrogen fertilizer applied at onion planting on resulting bacterial decay.
2) Determine the effect of different plant spacing on resulting bacterial decay
3) Determine the effect of mustard meals applied to muck soil on resulting bacterial decay.
4) Assess the susceptibility of different onion cultivars to bacterial decay.
5) Assess the effect of sprays of resistance-inducing chemicals applied during the growing season on the extent of bacterial decay following harvest and storage.

For most of the operations listed above, effective techniques were needed to initiate disease so that the proposed disease reduction strategy could be applied and its efficacy evaluated in a statistically defensible manner. We emphasized studies with *Pantoea ananatis* because we found that this pathogen, and only this pathogen, causes foliar symptoms in response to artificial inoculation in a reliable and consistent manner. Foliar symptoms can be rated during their development in a non-destructive and progressive manner. We used methods for inoculating leaf tissues that we had developed in lab and controlled environment studies. For initiating center rot, we pierced leaves with toothpicks freshly dipped in suspensions of the bacteria. Alternatively, we dipped scissors in suspensions of *P. ananatis* and then snipped young or middle-aged leaves with the contaminated scissors. The “dip and snip” technique was simple, rapid and reproducible.

In the last project year, we organized extensive grower trials of sprays of a resistance-inducing chemical applied during the growing season on resulting bacterial decay. Ten trials were carried out in two of the important onion-growing areas of New York, Orange County and the Elba Muck-land (Orleans and Genesee Counties). These were arranged by Cornell Cooperative Extension Educators and carried out by cooperating growers using an EPA-registered chemical resistance inducer supplied by the manufacturer, Syngenta Inc. Four or five sprays were applied in each 2- to 5-acre field. In the “control” plots, no resistance inducer was applied, but all other aspects of crop management were similar. At harvest, three to five replicate samples of 100 bulbs each were hand-harvested and bagged. After typical storage for 6 to 12 weeks, each harvested bulb was examined and rated for the presence of bacterial decay; most were cut to reveal any evidence of bacterial decay. After the data were compiled and analyzed, there was no evidence that the sprays of the resistance inducer resulted in any significant differences in the percentage of bacterial decay in any of the 10 trials.

Outreach Activities Performed

Cornell University faculty members worked very closely with the CCE staff located in several key regions where onions are produced in New York State. This arrangement enabled more efficient applied

research to be carried out in order to address the crop management needs of onion growers. To further facilitate the relevancy of the research, University faculty members interacted regularly with the CCE staff and onion growers at several formal and informal meetings each year.

Presentations at State and National Meetings

- NYS Onion Industry Council – Winter meeting
- NYS Onion Industry Council – Summer meeting
- Orange County NY Onion School
- Oswego County Onion School
- Elba Muck-land Twilight Meeting
- NYS Fruit and Vegetable Exposition
- National Allium Conference
- Annual Technical Committee Meeting of W-2008

Publications and Manuscripts Currently in Review

- Bonasera, J. M., Asselin, J.-A. E. and **Beer, S. V.**, 2014. Identification of bacteria pathogenic to or associated with onion (*Allium cepa*) based on sequence differences in a portion of the conserved gyrase B gene. **J. Microbiological Methods** (Accepted for publication).
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- **Beer, S. V.**, Zaid, A. M., Bonasera, J. M., 2011. Studies of bacterial problems of onion In New York – 2010. Empire State Fruit & Vegetable Expo Proceedings 2011. http://www.hort.cornell.edu/expo/2011proceedings.php

Goals and Outcomes Achieved

Summary of Measurable Outcomes

Project Goal	Benchmark	Target	Performance Measure	Outcome
Determine the proportion of samples of onion planting stock used in NY that carries *Pantoea ananatis*, the **Center Rot** pathogen.	Collect 3 to 6 samples of seed and/or transplants before planting from onion growers in three onion-producing areas of NY	Assess all the collected samples quantitatively for the presence of the Center Rot pathogen	Based on the presence or absence of bacterial cells of the Center Rot pathogen, reach tentative conclusions as to whether planting stock provides inoculum for Center Rot.	In two seasons of testing, no pathogenic strains of bacteria were isolated from 8 and 13 lots of seed tested. Nonpathogenic strains of *Pantoea agglomerans* were isolated from all 11 lots of sampled transplant onions. Pathogenic strains of *Pantoea agglomerans* were isolated from two of the 11 lots of transplants. Based on this sample, seed and transplant seedlings seem not to be an important source of bacterial pathogens for New York onion growers.
Develop methods to induce **Center Rot** of in onions grown in the greenhouse and growth chamber	Onion plants will be grown in containers from sets (small bulbs) will be grown in the greenhouse. When plants are in the 6- to 8-leaf stage, they will be inoculated with a suspension of *Pantoea ananatis.*	We will aim to treat inoculate plants with four somewhat different techniques. Each will be applied to 10 to12 replicate plants to ensure that the experiment has statistical validity. Appropriate control treatments will be included.	We will evaluate the several treatments based on the degree of symptoms that develop. Resulting lesions will be measured at several intervals following inoculation of the plants. We will select the treatment, for further use, that results in symptoms most reminiscent of natural symptoms that have been observed in the field.	Following inoculation of onions in the greenhouse, leaf symptoms developed and several proceeded to the neck and bulb, thereby establishing that leaf symptoms can result in bulb symptoms. (Results published in Plant Disease 97:1524-1528 [2013]).

Develop methods to induce **Center Rot** of onions grown in the field.	Onion plants grown in a commercial field from sets (small bulbs). When plants are in the 6- to 8-leaf stage, they will be inoculated with a suspension of *Pantoea ananatis.*	We will aim to inoculate plants with four somewhat different techniques. Each will be applied to 10 to 12 replicate plants to ensure that the experiment has statistical validity. Appropriate control treatments will be included.	We will evaluate the several treatments based on the degree of symptoms that develop. Resulting lesions will be measured at several intervals following inoculation of the plants. We will select the treatment, for further use, that results in symptoms most reminiscent of natural symptoms that have been observed in the field.	Inoculation of onions in the field with toothpicks contaminated with *P. ananatis* resulted in leaf lesions that extended both distally and proximally from the point of inoculation. Snipping leaves with scissors previously dipped into a suspension of *P. ananatis* ("Dip & Snip") resulted in leaf lesions in the field and in onions growing in a controlled-environment chamber.
Develop methods to induce **Sour Skin** of onions grown in the field.	Onion plants grown in a commercial field from sets (small bulbs). When plants are in the 10- to 12-leaf stage, they will be inoculated with a suspension of *Burkholderia cepacia.*	We will aim to inoculate plants with four somewhat different techniques. Each will be applied to 10 to12 replicate plants to ensure that the experiment has statistical validity. Appropriate control treatments will be included.	We will evaluate the several treatments based on the degree of symptoms that develop. Resulting lesions will be rated at several intervals following inoculation of the plants. Inoculated but non-symptomatic plants will be grown to harvest, harvested and stored for several months to determine in Sour Skin develops in storage.	We discovered that the Sour Skin pathogen, *B. cepacia,* is a bacterium of clinical significance and research work with it is restricted by NIH regulations to BSL-2 approved facilities. Thus, work with cultures of *B. cepacia* in the field is not permitted. Therefore, we sought and were granted a special permit from the Cornell University Institutional Biosafety Committee (Permit MUA #16095) to undertake BSL-2 studies with *B. cepacia* in our laboratory. In preliminary studies in the laboratory, with onions grown from seed in a special controlled environment chamber, we found that muck soil contaminated with the sour skin pathogen, placed in leaf axils, induced symptoms in neck ad bulb tissue following incubation under warm and humid conditions.

Onions growing in the field will be treated with “resistance inducers” and then inoculated as indicated above with either *Burkholderia cepacia* (**Sour Skin**) or *Pantoea ananatis* (**Center Rot**).	Treated onions will be inoculated at two intervals following treatments with “resistance inducers”	The inoculation techniques found most appropriate in the above test will be used to determine if the treatment with “resistance inducers” affect the incidence or severity of bacterial disease development.	Treated and inoculated onion will be examined carefully to determine extent of losses due to infection by either *Burkholderia cepacia* or *Pantoea ananatis.*	In 2011, replicated field plots were sprayed periodically with the three materials on three different schedules and different plots were inoculated with *Pantoea ananatis* by stabbing leaves with a pathogen-contaminated toothpick, or nothing as a control. The inoculation technique was effective in inducing more leaf lesions. However, none of the resistance inducers reduced rot significantly in bulbs, although, some small differences were apparent. In 2012, a similar field trial of one resistance inducer (Actigard) was carried out that included inoculation with *P. ananatis* by Dip and Snip. Unfortunately, that field trial was affected by an unidentified root disease problem, which precluded development of the bulbs to maturity. Thus, we got no results from this trial. In 2013, we organized field trials of Actigard in 10 fields in Eastern New York and Western New York. Cooperating growers sprayed several acres with Actgard. Several others were treated the same, but without Actigard. Hundreds of onions were harvested from each trial and cut to reveal any rot. Actigard treatment did not result in significant differences in rot in any of the 10 trials. We consider that this extensive trial was rather definitive as to the lack of worthwhile effect of treating onions with Actigard against bacterial induced rot in New York.

Beneficiaries

The main beneficiaries of this project are the commercial onion growers of New York State, which number between 100 and 200. Other onion growers in the US also are likely to benefit because bacterial diseases cause losses wherever onions are grown. The economic benefits to the growers has not been measured to date; however, the results from this research are valuable and provides the basis for real and long-term benefits to the industry.

Lessons Learned

Bacterial bulb rots are indeed difficult problems. We certainly did not anticipate that the research team would spend more than three years attempting to isolate, characterize and identify bacteria associated with problematic onions. On the other hand, considering the attention that had been given to bacterial problems of onions worldwide, nationwide and statewide in the past, it is not that surprising. Bacterial disease problems of onion just had not been studied intensively. Nevertheless we feel that we have laid the groundwork for further productive studies.

We certainly learned that the relative dearth of basic plant pathological information concerning the epidemiological aspects of the several bacterial diseases is a real drawback to achieving a meaningful program of disease management. Nevertheless, we learned the following points that are likely to be useful in the future to those who conduct and deal with further research on the topic.

1. Loss of onions from bacterial decay is caused by several different pathogens in New York in addition to *Burkholderia cepacia*, which had been known previously.
2. Several bacterial pathogens heretofore not characterized in New York were found associated with losses in New York onions.
    a. *Pantoea ananatis*
    b. *Enterobacter cloacae*
    c. *Rahnella* spp.
3. Most bacterial pathogens of New York onion reside in the soil.
4. Some onion-pathogenic bacteria were detected in waters collected from the vicinity of onion fields
5. Surveys counter-indicated the importance of onion seed and seedling transplants as sources of pathogenic bacteria.
6. Several robust techniques for detecting and identifying bacterial pathogens of onion were developed and utilized with cull onions and onion samples provided to the laboratory for analysis of possible bacterial problems.
7. Techniques were devised to overcome the inhibition of PCR reactions used for detection and characterization of bacteria associated with samples from onion tissues, muck soil and raw water

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Project 8
Using Naturally Evolved Biological Systems to Control Plant Diseases

Project Summary

Powdery mildews affect several New York Specialty Crops. Their highly-evolved relationship with plants makes them remarkably effective pathogens, but it's also an "Achilles Heel" that can be exploited and used against them. The purpose of this project was to develop two parallel avenues of research to turn the pathogen's own biological systems against it. Powdery mildews have evolved to exploit a family of plant genes as "doorways" to bypass the normal defense reactions of plants. We evaluated plants in which the "doorway" genes have been silenced, thereby reactivating the natural defense mechanisms - a resistance strategy that has been durable in barley for 70 years. In the second avenue of research, we manipulated the light-sensitive systems that powdery mildews have evolved to control their reproduction, and thereby "switch off" spore production. We adapted low-cost, low-energy light-emitting diodes used in our previous work on rose powdery mildew for use against cucumber, grape, and strawberry powdery mildews. Practical application of either avenue of research would reduce dependence upon fungicides, and result in several spin-off projects involving other crops.

Problem to be solved, justification of approach, and objectives

Suppression of powdery mildews often requires use of fungicides because host resistance is either unavailable, unstable, unprofitable to utilize due to poor horticultural characteristics, or consumers demand qualities unavailable in resistant cultivars. Organic production is further hampered, as the powdery mildews are evolutionarily adapted to their hosts, and thrive under the best possible conditions for plant growth. For the same reason, trends toward crop production in high-tunnel systems have likewise enhanced the environment for powdery mildews, and increased dependence on fungicides. Continued reliance on fungicides has been plagued by resistance in the pathogen. Beginning with benzimidazoles in the 1980s, followed by demethylation inhibitors in the 1990s, and most recently the strobilurin compounds, broad classes of fungicides have been rendered ineffective following widespread use. For the first time in recent history, growers of a wide spectrum of crops face a period of unknown duration during which highly-effective fungicides may be unavailable, and management programs will revert to more intensive use of a battery of second tier materials with mediocre efficacy.

Fig. 1. Effects of *mlo*-based resistance on powdery mildew in strawberry. Upper leaf is the wild-type control, which became severely diseased one week after inoculation. Lower leaf was identically inoculated, but the gene for susceptibility has been silenced, thereby making the plant naturally resistant to powdery mildew (*mlo*-based resistance).

The purpose of our project was to enhance the sustainability of disease management by providing alternative methods of disease suppression that are economically and socially acceptable. The technologies that we investigated, while novel, are widely perceived as ecologically benign, and have proven

themselves in other systems. The research is timely for both of the aforementioned reasons: (i) present management options are limited by fungicide resistance, and (ii) there is increased pressure to move towards more efficient production systems, most of which increase the potential for loss due to powdery mildew. Therefore, the objectives of our proposed research were:

1. Evaluate resistance to powdery mildew in a newly-created strawberry clone in which *Mlo* has been silenced, thereby conferring resistance to strawberry powdery mildew (*Podosphaera aphanis*), as a model system for deployment of this strategy in other horticultural crops of relevance to New York stakeholders.

2. Exploit inexpensive, low-energy Light-Emitting Diodes (LEDs) to disrupt spore production in powdery mildew pathogens of horticultural crops important to New York stakeholders.

Dominant alleles in plants that allow infection are thought to be doorways by which powdery mildews gain access. The corresponding recessive alleles confer resistance, the best characterized of which is *mlo* in barley. Currently, over 50% of certified barley seed sold in Europe contains *mlo*-based resistance, and it remains durable.

Recessive *mlo* resistance genes occur in many plants (e.g., tomato, strawberry, grape, and barley). The availability of strawberry, grape, and other genome sequences has aided identification of additional *mlo* candidates in several specialty crops. Dr. Amit Dhingra at Washington State University has produced a strawberry clone with *mlo*-based resistance, which we will evaluate.

Different light wavelengths affect the ability of powdery mildews to produce spores. In collaboration with colleagues at the National Agricultural University of Norway, we pioneered development of LEDs that suppressed rose powdery mildew (Plant Disease 94: 339-344). We have identified an analogous requirement of light for sporulation in the grape powdery mildew (Phytopathology 100: *in press*). In this study, we extended this work to powdery mildews of specialty crops relevant to NY stakeholders.

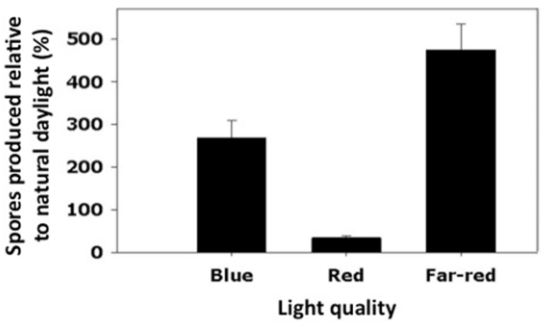

Fig. 2. Effects of light quality supplied by LEDs upon spore production by the rose powdery mildew. Blue (470 nm) and far-red (735 nm) light increased spore production compared to the natural daylight control, but spore production was greatly reduced in red (670 nm) light (from *Plant Disease* 94: 339-344).

Project Approach

Objective I

We obtained mlo-based resistant strawberry lines from our USDA collaborator at Washington State University. Strawberry plants with mlo based resistance to powdery mildew were established in greenhouses at the New York State Agricultural Experiment Station (NYSAES) and inoculated with powdery mildew to study the nature and degree of resistance compared to control plants.

DNA and RNA extraction from a broad collection of strawberry species was conducted in Dr. Cadle-Davidson's lab by Dr. Jan Davik, a strawberry geneticist working on the project. Analysis of this data will be completed by Jan 2014. To date over 500 million sequences have been obtained, and we were awarded time on some of the world's fastest supercomputers to analyze this massive amount of mlo-

related sequence data. These experiments will indicate additional *Mlo* resistance genes for development.

Objective 2

Powdery mildew sensitive pot rose cultivar 'Toril' and cucumber cultivar 'Confida' were grown in greenhouse with air temperature and relative humidity of 20°C and 70% RH. Supplemental lighting was provided by high-pressure sodium lamps to maintain minimum day length of 18 h and photosynthetic photon flux (PPF) (400-700 nm) of 200±20 µmol/m^2 s^{-1} at plant height (18 h white light). Single shoot roses with five leaves per shoot were inoculated with powdery mildew spore suspension by spraying with a hand held sprayer. Inoculated roses were exposed daily to either 18 h of white light or 18 h of white light with UV-B (1.2 W m^2) as night interruption for 2 to 5 min. Percentage of diseased leaf area was assessed nine days after inoculation.

Plant production, inoculum production, and inoculation

Seeds of the powdery mildew-susceptible cucumber cv. Confida were sown in 12 cm diameter plastic pots containing a 1:3 mixture of standard growth medium (VEKSTTORV, Ullensaker Almenning, Nordkisa, Norway) and perlite, and were grown in a greenhouse under supplemental lighting provided by high pressure sodium (HPS) lamps (Lucalox LU400/XO/T/40, GE lighting, Budapest, Hungary). HPS lamps augmented natural daylight to provide a daylength of 18 h with minimum photosynthetic photon flux (PPF) (400-700 nm) of 200 ± 20 µmol m^{-2} s^{-1} at plant height (Fig.1) as described previously. Temperature and relative humidity in the greenhouse were regulated with mean and range of 20 (15-32) °C and 84 (41-95) %, respectively. Plants were irrigated with complete nutrient solutions, as needed.

P. xanthii was isolated from diseased leaves of cucumbers obtained from a commercial greenhouse in Lier, Norway, and was sequentially transferred to disks cut from cucumber leaves (cv. Confida). Leaf disks were incubated in Petri dishes containing water agar at 20 °C under 14 h daily lighting supplied by mercury lamps as described previously. Once colonies on the disks sporulated at an age of approximately one week, conidial suspensions were prepared by placing the disks in distilled water containing 0.05% Tween 20, and shaking them gently to remove conidia. Suspensions were adjusted to contain a minimum of 8×10^4 conidia/ml and were sprayed onto healthy cucumber plants at the rate of 10 ml per plant as previously described. Inoculated plants were kept in isolated growth chambers, and pathogen inoculum was renewed weekly as described previously to maintain fresh inoculum throughout the experiments.

Optimum UV-B duration in pre- and post-inoculation exposure, and effects on plant growth and physiology.

Once plants had developed one true leaf (approximately 2 weeks after sowing), 72 plants were transferred to a separate greenhouse section and provided with a day length of 16 h. The day interval was 0700 h to 2300 h standard time (ST). Natural daylight was supplemented by HPS lamps which delivered 100 ± 10 µmol m^{-2} s^{-1} whenever solar irradiance fell below 914 µmol m^{-2} s^{-1} (200 W m^{-2}). The foregoing constituted the growth light (GL) control treatment (16 h GL). For the pre-inoculation experiment, 24 plants from above were subdivided into four groups of six plants, each of which was exposed to 16 h GL beginning 2 days before inoculation. During night, plants were either not exposed to UV-B (16 h GL control) or exposed to UV-B (1 W m^{-2}) for 5, 10, or 15 min (Fig. 2). UV-B radiation was supplied by UV-B fluorescent tubes (Model UVB-313EL, Q-PANEL Lab products, Cleveland, OH, USA). Once inoculated, similar treatments continued 9 days from the time of inoculation, after which treatment effects were assessed.

For the post-inoculation experiments, the same sample sizes and light treatments were used, but the UV-B treatments began during the first night interval following inoculation. UV-B treatments then continued for the duration of the experiment, until disease severity was recorded 9 days after inoculation. The

experiment was conducted twice as above, and twice more where UV-B exposure was delayed until three days after inoculation.

For those plants exposed to UV-B from 2 days before inoculation or beginning on the first night after inoculation, conidial germination and colony development were assessed 3 days after inoculation. Leaf disks of 1.8 cm diameter were cut from inoculated leaves (one leaf disk per plant, four leaf disks per treatment), soaked in 3:1 v/v ethanol plus glacial acetic acid for 3 h as described previously, stained with 5% acid fuchsin in aqueous lactic acid (50 % v/v), and examined under a light microscope at 400 × magnification. Fifty conidia per leaf disk were assessed. Conidia with germ tubes equal to or longer than the conidial width were counted as germinated. Successful stages of development were categorized as follows: (i) successful infection wherein a conidium developed more than one primary hyphae or one branched hypha; (ii) successful colony development wherein a conidium produced at least three primary hyphae, two of which had branched. The percentage of colonized leaf area was also visually assessed 9 d after inoculation.

For plants exposed to UV-B beginning 3 d after inoculation, four leaf disks of 1.8 cm diameter were cut from each replicate plant 9 d after inoculation. The leaf disks from each plant were placed in separate, 50 ml centrifuge tubes (four leaf disk per replicate plant per tube) with 10 ml of sterile distilled water containing 20 µl L^{-1} Tween 20 (Sigma-Aldrich Chemie GmbH, Steinheim, Germany) and shaken by hand 20 times. The leaf disks were removed, and number of conidia per ml was determined with a haemocytometer for two aliquots for each replicate (HYCOR, Hycor biomedical inc. Garden Grove, CA, USA). The experiment was conducted two times with six replicate plants per treatment in each experiment.

At the conclusion of the pre-inoculation experiment described above, 11 d after exposure to 16 h GL, or 16 h GL combined with 5, 10 or 15 min UV-B at 1 Wm^{-2} applied from 2 d before inoculation, relative flavonoids, maximal photosystem II efficiency (Variable fluorescence (F_v) / Maximum fluorescence (F_m)) (Fv/Fm) and leaf area was recorded. Relative flavonoids (anthocyanin and flavonol) were measured for plant canopy by a fluorescence excitation ratio method (8) using a hand held Multiplex 3 multi-excitation wavelength chlorophyll fluorometer (Force-A, Orsay, France). Three repeated measurements were carried out for each plant canopy. The measurements were standardized with the blue foil from the manufacturer. With this standardization, the amount of anthocyanin and flavonols was estimated as the green and UV-A light absorbance relative to the supplied blue standard. The experiment was conducted twice, with six replicate plants per treatment in each experiment.

Fv/Fm and leaf area were measured for the second true leaves of plants subjected to each lighting treatment. Fv/Fm was measured with a portable chlorophyll fluorometer (Plant Efficiency Analyzer, Hansatech instruments, Pentney, Norfolk, England), using excitation light of about 1500 µmol photons m^{-2} s^{-1} after 15 min dark adaptation of the second true leaves. For that, intact second true leaves were first adapted for 15 min in total darkness by using light-weight leaf clips with shutters supplied by the manufacturer. After dark adaptation, the sensor unit of the portable chlorophyll fluorometer was placed over the leaf clip, and the shutter was slid opened. Powerful illumination (1500 µmol photons m^{-2} s^{-1}) to the opened leaf was provided by light emitting diodes present in the sensor unit, and consequent fluorescence signals were detected. Area of the second true leaf was determined using an LI-3100 area meter (LI-COR inc. Lincoln, NE, USA).

Effects of inoculum concentration on efficacy of UV-B

Plants bearing the first true leaf were inoculated with conidial suspensions of the following concentrations: 5×10^3, 2.5×10^4, 7×10^4 and 1.6×10^5 per ml of water. Immediately after inoculation, four plants receiving each inoculum concentration were exposed to either 16 h GL or 16 h GL + UV-B radiation of 1 W m^{-2} for 10 min during the dark period, as described previously. The percentage of leaf area colonized by powdery mildew was assessed 3, 6, 9 and 12 d after inoculation. Four non-inoculated control plants were included for each light treatment (16 h GL or 16 h GL + UV-B). Assessments of the inoculated plants ceased

before visible symptoms were observed in the non-inoculated plants. The experiment was conducted two times.

Effects of background light quality on suppression of powdery mildew by UV-B

Cucumber plants bearing one unfolded leaf were inoculated with 10 ml of a conidial suspension as described above. Immediately after inoculation, plants were exposed to one of the following treatments (eight plants per treatment): (i) 16 h GL, (ii) 16 h GL followed by 10 min of UV-B at 1 W m^{-2} beginning at the start of the night interval, (iii) 16 h GL followed by 2 h of light supplied by high pressure mercury lamps (70 ± 10 µmol $m^{-2}s^{-1}$), and (iv) 16 h GL followed by UV-B at 1 W m^{-2} plus 2 h of light supplied by high pressure mercury lamps (70 ± 10 µmol m^{-2} s^{-1}) beginning at the start of the night interval. The percentage leaf area diseased was assessed 12 d after inoculation. The experiment was conducted twice with inoculum concentration of 5 × 10^4 and 7 × 10^4 conidia per ml.

Cucumber plants bearing one unfolded leaf were also inoculated with 10 ml of a conidial suspension containing 8.4 × 10^4 conidia per ml. Immediately after inoculation, eight plants were exposed to each of the following treatments: (i) 16 h GL; (ii) 16 h GL followed by 10 min of UV-B at 1 W m^{-2} beginning at the start of the night interval; (iii) 16 h GL plus 2 h of UV-A (2.2 W m^{-2}) at the start of the night interval; (iv) 16 h GL followed by 10 min of UV-B at 1 W m^{-2} plus 2 h of UV-A (2.2 W m^{-2}) beginning at the start of the night interval; (v) 16 h GL followed by 2 h of blue light (39 µmol m^{-2} s^{-1}) beginning at the start of the night interval; (vi) 16 h GL followed by 2 h blue light (39 µmol m^{-2} s^{-1}) and 10 min UV-B at 1 W m^{-2} beginning at the start of the night interval; (vii) 16 h GL followed by 2 h red light (42 µmol m^{-2} s^{-1} beginning at the start of the night interval; (viii) 16 h GL followed by 2 h red light (42 µmol m^{-2} s^{-1}) and 10 min UV-B at 1 W m^{-2} beginning at the start of the night interval (Fig. 3). UV-A radiation was supplied by 120 cm UV-A tubes Model UVA-340 (Q-PANEL Lab products, Cleveland, OH, USA). Blue light (Fig.1) was supplied by GreenPower light-emitting diode (LED) module HF (Philips, Boschdijk, Eindhoven, The Netherlands). Red light (Fig. 1) was supplied by 162 W high-power LED growth lights (Sola-co, Grimstad, Norway). The experiment was repeated using a suspension of inoculum with a concentration of 4.3 × 10^4 conidia per ml.

Three days after inoculation, 1.8 cm diameter leaf disks were collected from leaves exposed to each treatment and assessed for conidial germination, infection, and colonization as described above. The percentage of leaf area diseased was also assessed at 3 d intervals from the time of inoculation until 12 d after inoculation, and the area under the disease progress curve (AUDPC) was calculated as described by Campbell and Madden using the following formula:

$$\text{AUDPC} = \sum_{i=1}^{n} \frac{(x_i + x_{i-1})}{2} (t_i - t_{i-1})$$

Where n is the number of evaluation times, x_i is the disease severity (%) at the evaluation time and ($t_i - t_{i-1}$) is the duration between each assessment.

Viability of conidia

Sixteen plants bearing a single unfolded true leaf were inoculated using a suspension containing 8.4 × 10^4 conidia per ml and were incubated in the greenhouse under similar temperature and RH conditions and 16 h GL as above for five days to allow sporulation to occur. Plants were then exposed to the eight treatments used in the background light experiments (Fig. 3) (two plants per treatment) over the subsequent 4 days. The inoculated leaf was removed from each plant and shaken in 50 ml of distilled water to harvest the conidia and 1 ml of the resultant suspension was added to 1 µl of 0.5 % (W/V) of the fluorescent vital stain Fluorescein Diacetate (FDA) on a glass microscope slide. After 3 min, 100 conidia per slide were examined under a fluorescence microscope (325 – 500 nm excitation filter and transmission filter > 530 nm) and the number of conidia exhibiting bright green fluorescence (indicative of viability) was recorded. The experiment was conducted twice.

Recording of environmental conditions

Light intensity supplied by mercury, HPS, red and blue LED lamps at plant height was recorded with a digital Lambda LI-185B photometer (LI – COR Inc., Lincoln, NE, USA) containing a quantum sensor LI-190. Spectral qualities of all lamps used in the present study were confirmed using an Optronic model 756 spectroradiometer (Optronic Laboratories, Orlando, FL, USA). Intensity of UV-B irradiance was measured using a SKYE SKU430 sensor (Skye instruments Ltd., Wells, UK) calibrated for the UV-B sources by an Optronic model 756 spectroradiometer (Optronic Laboratories, Orlando, FL, USA). The intensity of UV-A was measured by a SKYE SKU426 / SS2 38582 sensor (Skye instruments Ltd., Wells, UK). Air temperatures and RH was recorded at 5 min intervals using a Priva greenhouse computer (Priva, Zijlweg, The Netherlands) with dry and wet bulb thermo sensors deployed at plant canopy level.

Data analysis

Analysis of variance was performed using the General Linear Model (GLM) procedure (Minitab version 16.0, Minitab Corp., State College, PA, USA) containing light treatment, experimental repeat, replicate, time of exposure to treatment (2 d pre inoculation, from day of inoculation and 3 d post inoculation), treatment × experimental repeat, and treatment × time of exposure. Data were checked for homogeneity of variance and normality, and transformed as necessary before analysis; and then back-transformed for presention. Treatment means were compared using Tukey's pair wise comparison tests at P = 0.05. Regression analyses were performed by SigmaPlot 10 (Systat Software, Inc. Chicago, IL, USA).

Significant Results

Pre- and post inoculation exposure of plants to UV-B

- Germination, infection and colony development were significantly reduced by all treatments that included UV-B radiation when compared with 16 h GL (P = 0.001). Mean germination of conidia under 16 h GL was 67%, and the percentage reduction in conidial germination relative to the 16 h GL treatment was significant at all UV-B treatments (P = 0.001). The germination reduction was within the range of 23% to 27% (Table 1). The percentage reduction of successful infections under UV-B treatments of 5, 10 and 15 min were 43.3, 70.0 and 76.8, respectively, compared to the 16 h GL control (Table 1). The percentage of successfully-established colonies declined from 53 % under 16 h GL to less than 2 % in all UV-B treatments (P < 0.0001). The magnitude of the UV-B treatment effect increased significantly (P < 0.0001) at each sequentially later stage of pathogen development (i.e., germination, infection, colony development) (Table 1).
- Disease severity exceeded 90 % on plants exposed only to 16 h GL (Fig. 4). When UV-B was applied from 2 d before or from the time of inoculation, disease severity declined significantly as UV-B duration increased from 5 to 10 min (Fig. 4), but not as duration increased from 10 to 15 min (Fig. 4). However, exposures of plants to UV-B from two days before inoculation had no additional effect in suppressing disease than plants exposed to the same duration of UV-B from time of inoculation (Fig. 4). When UV-B exposure had not begun until 3 days after inoculation, there were sequential decreases in disease severity at each increase in duration of exposure to UV-B (Fig. 4). Irrespective of the duration of the exposure to UV-B, exposure of plants to UV-B from 2 d prior to or from the time of inoculation was significantly more effective in suppressing disease severity than exposure of plants to UV-B three days after inoculation (Fig. 4). Sporulation of colonies on plants exposed to UV-B at 1 W m^{-2} three days after inoculation decreased exponentially with increasing duration of UV-B exposure (Fig. 5) (P < 0.0001, R^2 = 0.77).

Plant growth performance

- Leaf area decreased slightly but not significantly when exposed to 5 min UV-B at 1 Wm^{-2} compared to the 16 h GL control, but more substantially and significantly after 10 or 15 min exposure to UV-B (Fig. 6). A quadratic model fit to the data yielded the equation: $Y = 537.8 + 1.8 X – 1.1 X^2$, where Y = leaf area of the second true leaf in cm^2, and X = the duration of exposure to UV-B at an intensity of 1 W m^{-2}, $R^2 = 0.70$ (Fig. 6). Relative flavonoids were reduced under all UV-B treatments compared with 16 h GL. Photosystem II efficiency was significantly reduced at 15 min of UV-B treatments compared to other treatments (Table. 2).

Effect of inoculum concentration

- Disease severity increased exponentially as inoculum dose was increased on plants exposed only to 16 h GL, yielding a quadratic model: Y = 23.7 + 75.1(1-e (-0.06 X), $R^2 = 0.67$ (Fig. 7). In contrast, disease increased only slightly from 0.6 to 7.5% across the range of inoculum dose (5×10^3 to 1.6×10^5 per ml) when plants were exposed to 16 h GL followed by 10 min of 1 Wm^{-2} of UV-B during the dark interval (Fig. 7). Although the increase of disease with increasing inoculum dose was reduced by the inclusion of UV-B treatment, there was a significant linear trend, and a model fit to the data yielded the following equation: $Y = 0.22 + 0.05 X$, $R^2 = 0.75$ (Fig. 7).

Effects of background light quality on suppression of powdery mildew by UV-B

- Disease severity was significantly reduced by a factor of 172X when inoculated cucumber plants were exposed to 16 h GL followed by UV-B, compared to plants only exposed to 16 h GL ($P < 0.0001$). Disease severity (compared to the 16 h GL control) was significantly reduced by a factor of 4.4X when UV-B exposure occurred during a 2 h period of lighting supplied by high pressure mercury lamps ($P < 0.0001$). The reduction was 1.3X in plants exposed to 16 h GL followed by 2 h of light supplied by high pressure mercury lamps compared to the 16 h GL control ($P < 0.001$) (Fig. 8).
- Germination of conidia on inoculated cucumber plants exposed to UV-B supplemented with red light during the dark interval was reduced 1.8 times compared to 16 h GL control ($P = 0.00001$) (Fig. 9A). Exposure to only UV-B during the dark period reduced conidial germination 1.4 times compared to 16 h GL ($P = 0.0024$) (Fig. 9A). Although not significantly different, conidial germination increased if exposed to UV-A in the night phase. The reduction in conidial germination in the other treatments ranged from 1.1 to 1.3X compared to 16 h GL, but were not significantly different from the control.
- UV-B and UV-B + red light in the night phase reduced number of successful infections by 1.9 and 3.2X, respectively, compared to 16 h GL ($P = 0.0002$, and 0.00001, respectively) (Fig. 9B). The other treatments were not significantly different from the control, although all treatments including UV-B slightly reduced number of successful infections.
- Similar effects of background light quality on the suppressive effects of UV-B were observed with respect to establishment of the pathogen, measured as colony formation (Fig. 9C) and area under the disease progress curve (Fig. 10). UV-B or UV-B + red light in the night phase strongly suppressed colony expansion, and none of the conidia developed successful colonies within three days under these treatment conditions. Compared to 16 h GL, development of successful colonies was reduced by a factor of 15.3X in plants exposed to UV-B with UV-A. The reduction was 8.8 times in plants exposed to UV-B together with blue light. If only red light was provided during night, development of successful colonies was reduced by a factor of 2.6X (Fig. 9C). AUDPC for UV-B or UV-B + red light treatments were reduced to 5.6 or 1.3 %, respectively, of the control treatment (Fig. 10). AUDPC was reduced to 25.2 or 34.0 % of the control, respectively if UV-A or blue light was provided together with UV-B. Only blue light or UV-A in the night phase slightly but not significantly reduced or

increased, respectively, number of successful colonies and AUDPC (Fig. 9C and 10). Viability of the conidia produced under different UV/light treatments was not affected by any of the treatments (data not shown).

Table 1. Effect of different UV-B doses applied daily during night time on conidial germination and successive colony development of *P. xanthii* on cucumber cv. Confida.

Treatment	Pathogen developmental stage (%)		
	Germination[1, 2]	**Infection[1, 3]**	**Successive colony[1, 4]**
16 h GL[5]	67.0 ± 2.86 **a**	59.1 ± 3.25 **ab**	53.00 ± 3.19 **b**
1 W m^{-2} × 5 min.	49.0 ± 4.44 **b**	33.5 ± 3.06 **c**	01.63 ± 0.84 **ef**
1 W m^{-2} × 10 min.	48.8 ± 4.83 **b**	17.8 ± 2.55 **d**	00.00 ± 0.00 **f**
1 W m^{-2} × 15 min.	51.6 ± 3.95 **b**	13.8 ± 3.53 **df**	00.00 ± 0.00 **f**

[1]Leaf disks of 1.8 cm diameter were made three days after inoculation; pooled data from plants exposed to the various treatments from two days before inoculation (four leaf disks per treatment) or at the time of inoculation (four leaf disks per treatment). Leaf disks were treated with ethanol:glacial acetic acid (3:1 v/v) solution for 3 h and then stained with lactofuchsin. Fifty conidia were counted in each leaf disk. Values are mean and standard error of two independent experiments with eight replicated leaf disks per treatment in each experiment. Different letters indicate significant differences at P = 0.05.
[2]Conidia with germ tubes equal to or longer than the conidial width were counted as germinated. [3]More than one primary hyphae or one branched hypha per conidium were considered as a successful infection.
[4]Conidium having three primary hyphae with at least two of them branched was considered as a colony.
[5] All treatments received 16 h growth light (GL), and only exposure to 16 h GL served as a non-treated control; treatments were as explained in Fig. 2.

Table 2. Relative content of flavonoids (flavonol and anthocyanin) and the chlorophyll fluorescence parameter (Fv/Fm) in inoculated cucumber cv. Confida after exposure to different doses of UV-B.

Treatment	Flavonol[1]	Anthocyanin[2]	Fv/Fm[3]
16 h GL[4]	1.536 ± 0.038 **a**[5]	0.928 ± 0.0027 **a**	0.792 ± 0.0025 **a**
1 W m^{-2} × 5 min.	1.409 ± 0.037 **b**	0.920 ± 0.0027 **b**	0.791 ± 0.0022 **a**
1 W m^{-2} × 10 min.	1.341 ± 0.028 **b**	0.917 ± 0.0020 **b**	0.786 ± 0.0026 **ab**
1 W m^{-2} × 15 min.	1.188 ± 0.019 **c**	0.920 ± 0.0028 **b**	0.773 ± 0.0061 **b**

[1,2]Measurements were performed 11 days after start of exposure to UV-B, using a Multiplex 3 multi-excitation wavelength chlorophyll fluorometer with the fluorescence excitation ratio method (8). Three repeated measurements were carried out for each plant canopy. Values are relative to the blue standard provided by the manufacturer.
[3]Recorded with a portable chlorophyll fluorometer, using excitation light of 1500 µmol m^{-2} s^{-1} after 15 min dark adaptation. Two measurements were done for the second true leaves of each plant.
[4]All treatments received 16 h growth light (GL), and only exposure to 16 h GL served as a non-treated control; treatments were as explained in Fig. 2.
[5]Values are mean and standard error of two independent experiments with six replicate plants per treatment in each experiment.

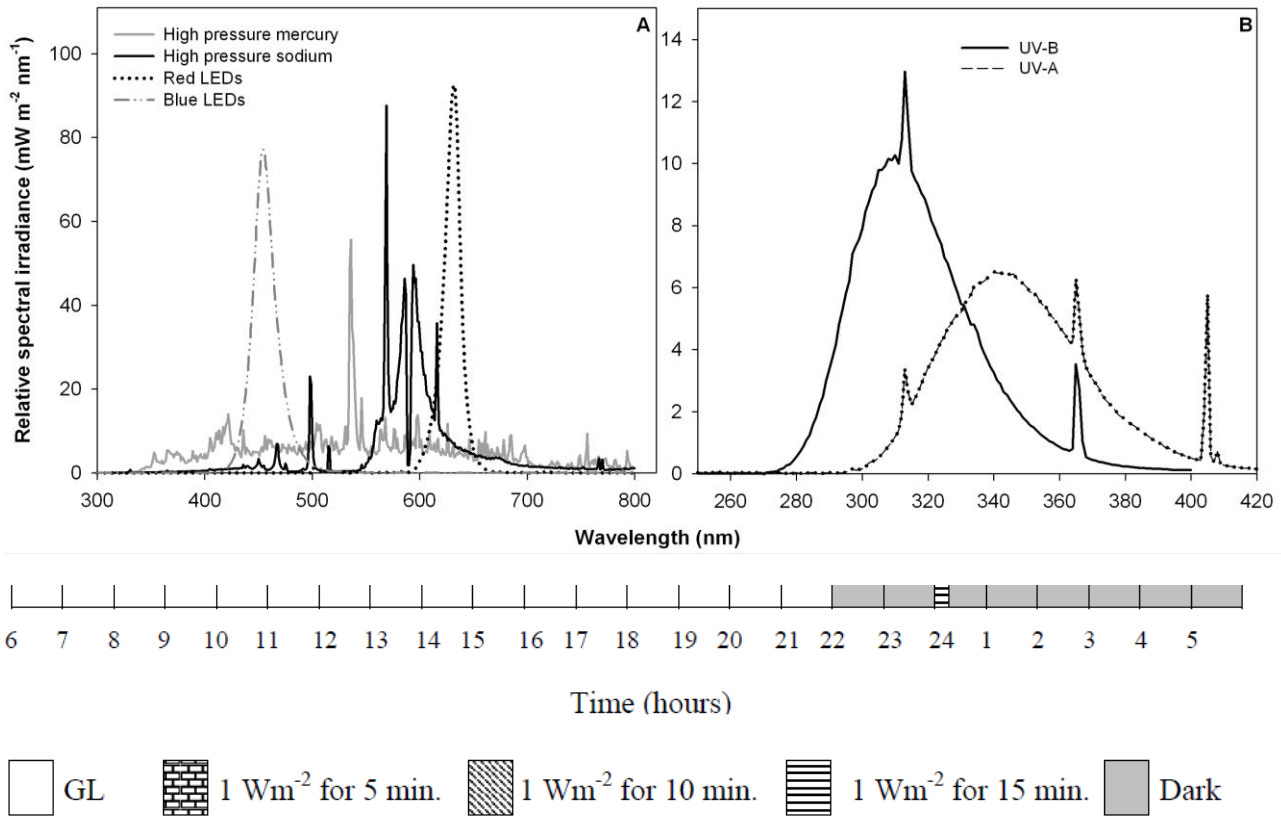

Fig. 2. Schematic illustration for different treatments of UV-B duration and its application time in daily light cycles during pre and post inoculation exposure experiments conducted with cucumber cv. Confida. Daily light cycles were 16 h of solar irradiance supplemented with HPS lamps followed by dark (16 h GL), or 16 h GL with the night interval interrupted by either 5, 10 or 15 min UV-B at 1± 0.1 Wm^{-2}.

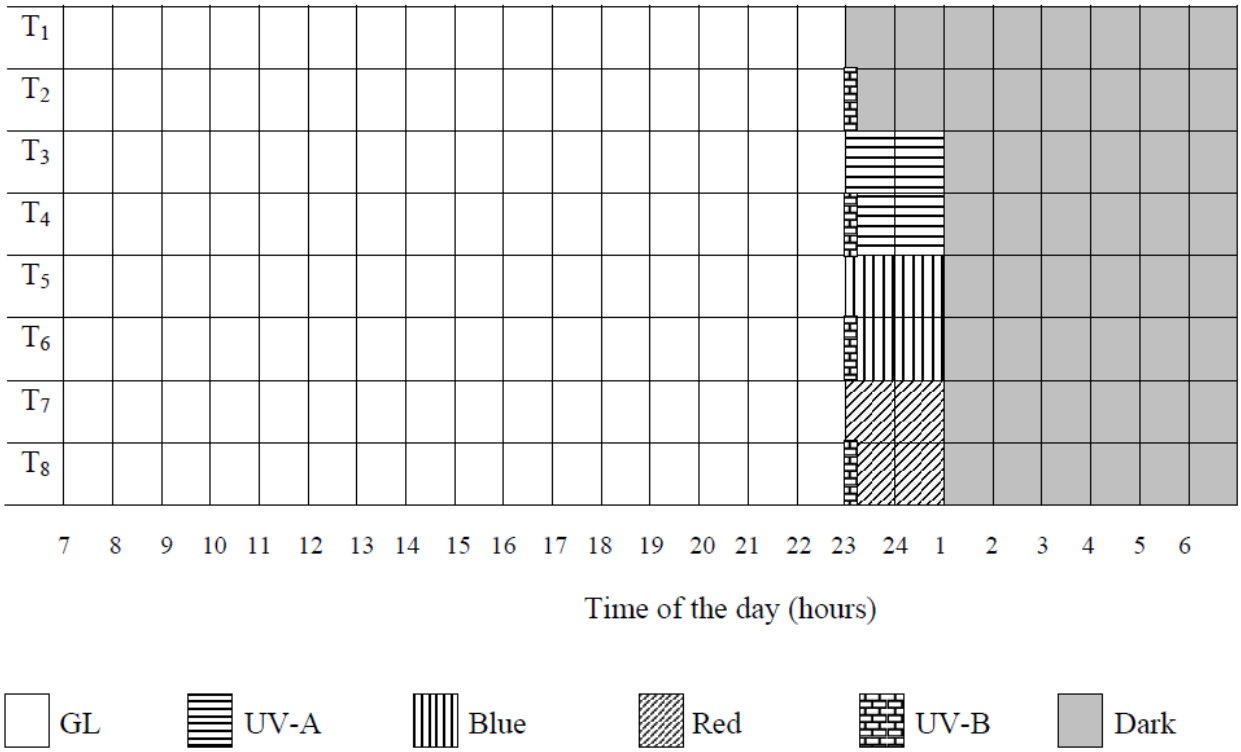

Fig. 3. Schematic illustration of the time of UV-B application and background light qualities in daily light cycles during the experiment on the effect of background light quality on suppression of cucumber powdery mildew by UV-B. Solar radiation of 16 h supplemented with HPS lamps followed by either darkness (16 h GL) (T_1), 10 min of UV-B with 1 ± 0.1 W m^{-2} followed by dark (T_2), 2 h of UV-A (2.2 ± 0.1 W m^{-2}) followed by dark (T_3), 2 h of blue light (39 ± 8 µmol m^{-2} s^{-1}) followed by dark (T_5), 2 h of red light (42 ± 6 µmol m^{-2} s^{-1}) followed by dark (T_7), 10 min of UV-B (1 ± 0.1 W m^{-2}) together with 2 h of either UV-A (T_4), blue light (T_6), or red light (T_8) followed by dark.

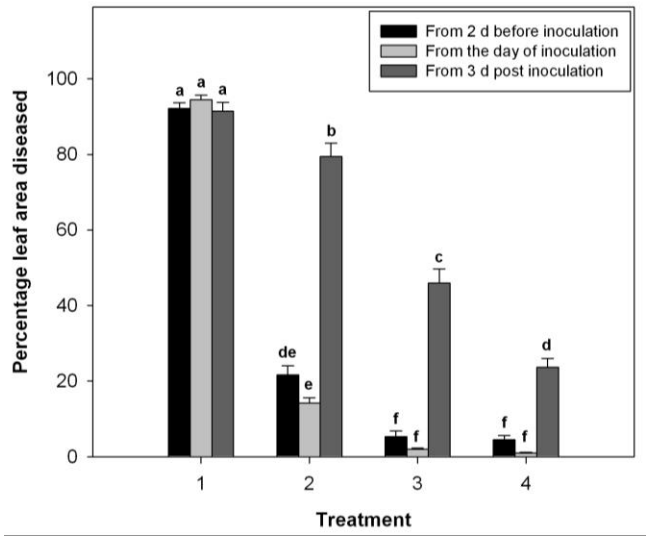

Fig. 4. Disease severity of *Podosphaera xanthii* on cucumber cv. Confida exposed to either 16 h GL (1), 16 h GL + 5 min of 1 W m^{-2} UV-B (2), 16 h GL + 10 min of 1 W m^{-2} UV-B (3) and 16 h GL + 15 min of 1 W m^{-2} UV-B (4). Plants were exposed to treatments either from two days before inoculation, from the day of inoculation, or from three days post inoculation. Percentage of leaf area covered by powdery mildew was assessed 9 days after inoculation. Bars represent one standard error of the mean of two repeated experiments. Different letters indicate significant differences among treatments and time of exposure to treatments (P = 0.05).

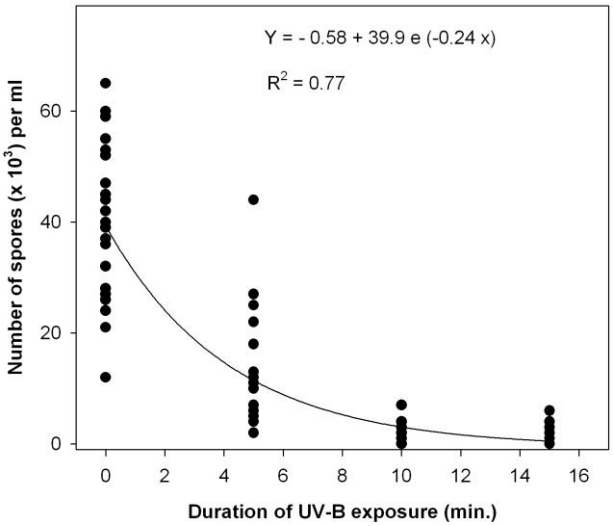

Fig. 5. Relationship between increasing duration of UV-B exposure at 1 W m^{-2} and spore production of *Podosphaera xanthii* in cucumber cv. Confida. Inoculated plants were maintained at 16 h GL for the first three days and then exposed to either 16 h GL (0 min UV-B), 16 h GL + 5 min UV-B, 16 h GL + 10 min UV-B, or 16 h GL + 15 min UV-B treatments as explained in Fig. 2 for six days. Two measurements were done for each replicate and the experiment was conducted two times.

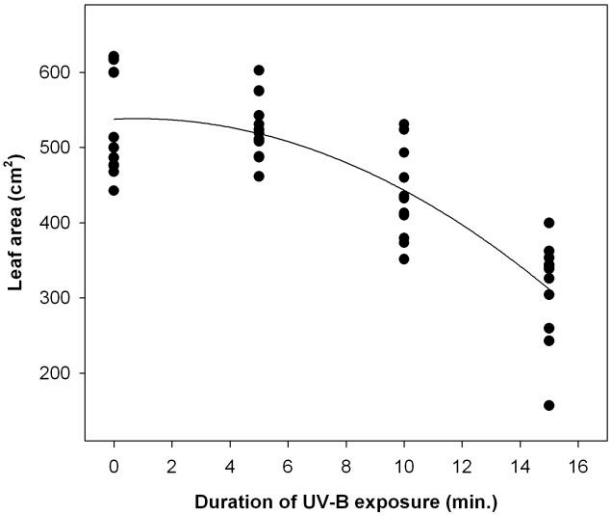

Fig. 6. Relationship between increasing duration of UV-B treatment and its effect on leaf area of the second true leaves of cucumber cv. Confida 11 days after exposure to treatments. Plants at one unfolded true leaves stage were exposed to either 16 h GL (0 min UV-B), 16 h GL + 5 min UV-B, 16 h GL + 10 min UV-B, or 16 h GL + 15 min UV-B as explained in Fig. 2. The experiment was conducted two times.

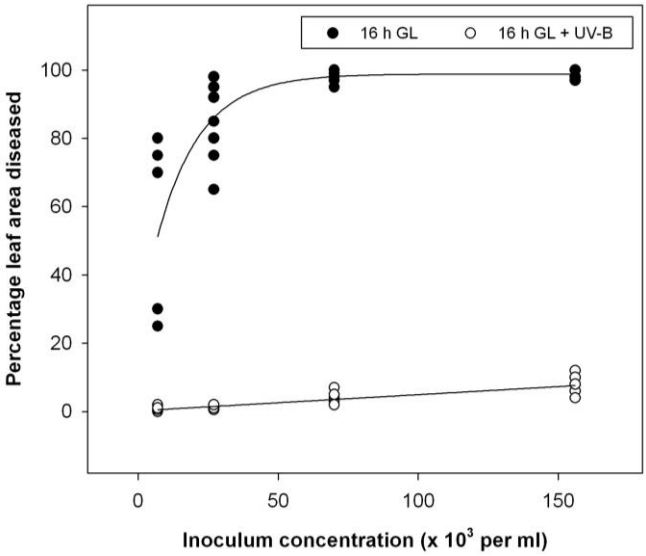

Fig. 7. Relationship between increasing inoculum concentrations and disease severity of powdery mildew in cucumber caused by *Podosphaera xanthii* 12 days after inoculation. Plants were inoculated by spraying 10 ml of spore suspension with four different inoculum concentrations (ranged from 5×10^3 to 1.6×10^5 conidia per ml) and were exposed to treatments of either 16 h GL or 16 h GL + 10 min of 1 W m^{-2} UV-B. The experiment was conducted twice.

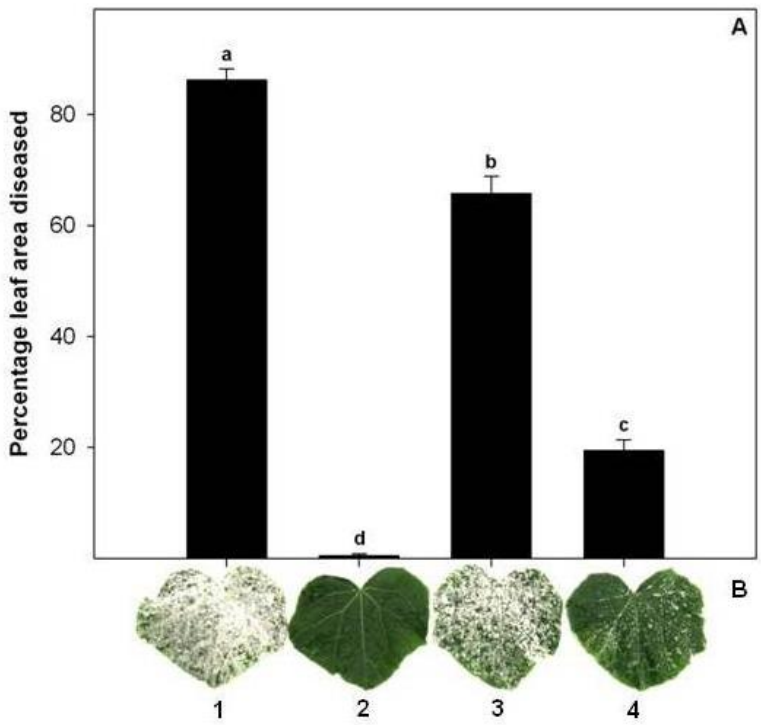

Fig. 8. Effect of UV-B with background or end of day light supplied by high pressure mercury lamps on severity of powdery mildew 12 days after inoculation (A) and representative diseased leaves of cucumber cv. Confida (B). Plants were inoculated by spraying 10 ml of spore suspension onto the first unfolded true leaves and exposed immediately to treatments of 16 h growth light (GL) (1), 16 h GL + UV-B (2), 16 h GL + 2 h light supplied by high pressure mercury lamps (3), 16 h GL + UV-B + 2 h light supplied by high pressure mercury lamps (4). Values are the mean of two repeated experiments with standard error. Different letters indicate significant differences at P = 0.05.

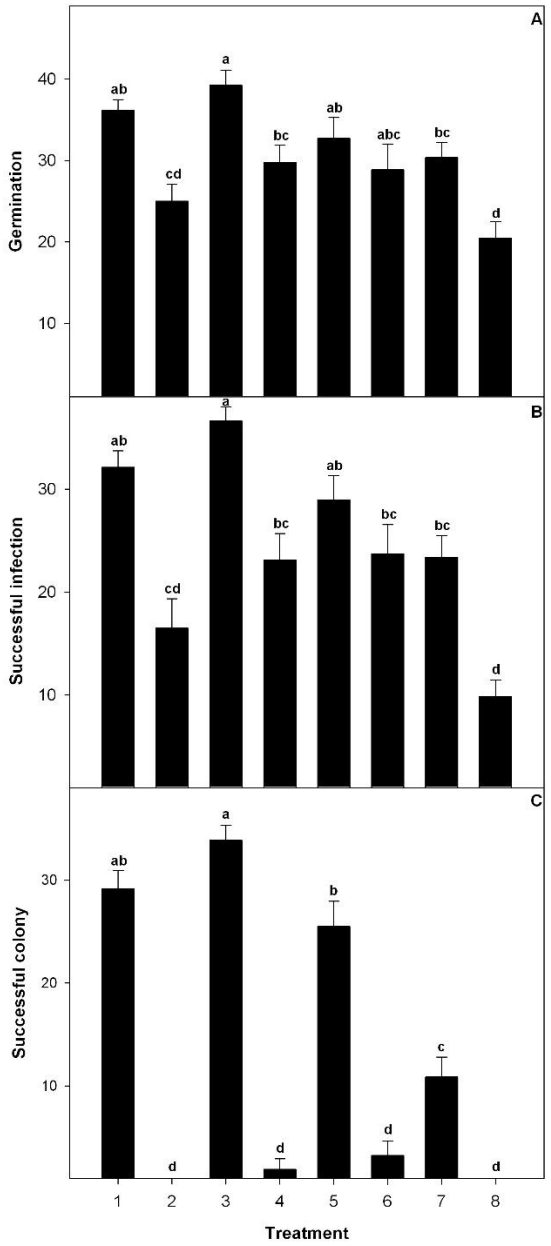

Fig. 9. Effect of background radiation on the efficiency of UV-B on germination (A), successful infection (B), and development of successful colonies (C) of *Podosphaera xanthii* in cucumber cv. Confida. Inoculated plants were immediately exposed to treatments of either 16 h growth light (GL) (1), 16 h GL + UV-B (2), 16 h GL + UV-A (3), 16 h GL + UV-B + UV-A (4), 16 h GL + blue (5), 16 h GL + UV-B + blue (6), 16 h GL + red (7), or 16 h GL + UV-B + red (8) as explained in Fig. 3. Leaf disks of 1.8 cm diameter were made three days after exposure to the treatments; treated with ethanol:glacial acetic acid (3:1) for 3 h; and stained with lactofuchsin. Fifty conidia were assessed for germination, infection and development of successful colonies. Values are means of two repeated experiments, and bars represent one standard error of the mean. Different letters indicates significant differences (P = 0.05).

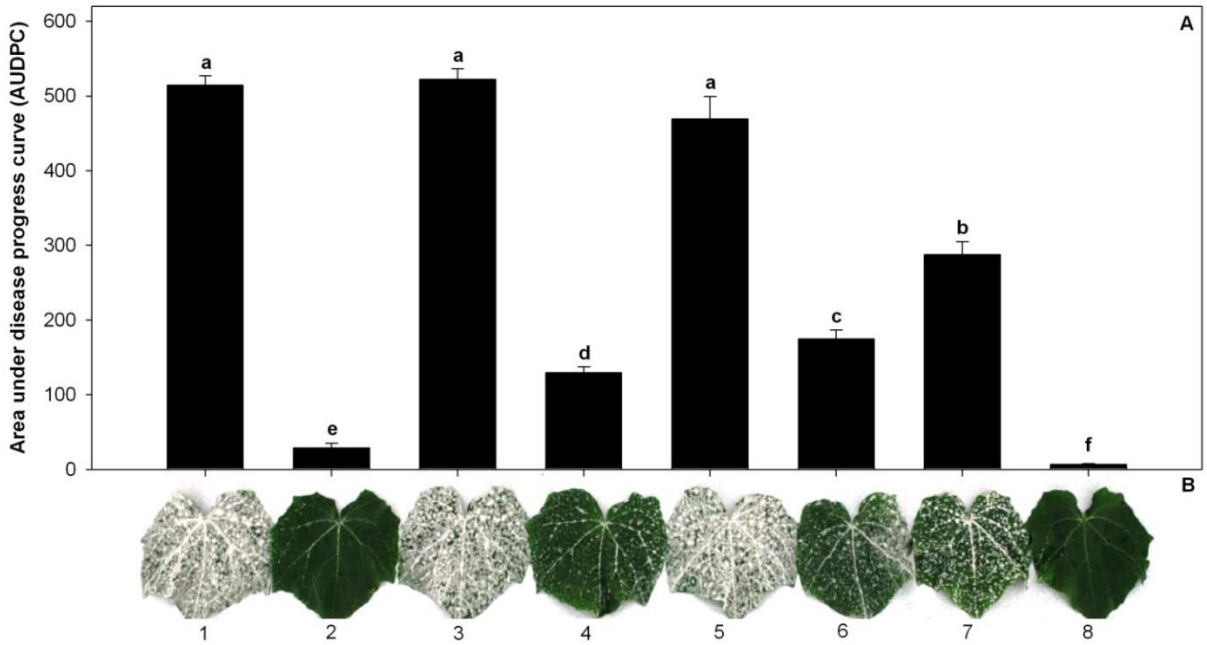

Fig. 10. Effect of UV-B with different background or end of day light qualities on area under the disease progress curve (AUDPC) (A) and disease severity on representative leaves 12 d after inoculation (B) with *Podosphaera xanthii* in cucumber cv. Confida. Plants were inoculated by applying 10 ml of a spore suspension to the first unfolded true leaves and exposed immediately to treatments of either 16 h growth light (GL) (1), 16 h GL + UV-B (2), 16 h GL + UV-A (3), 16 h GL + UV-B + UV-A (4), 16 h GL + blue (5), 16 h GL + UV-B + blue (6), 16 h GL + red (7), or 16 h GL + UV-B + red (8) as explained in Fig. 3. Percentage diseased leaf area was assessed at three day intervals from time of inoculation to twelve days after inoculation. Values are the mean of two repeated experiment with one standard error. Different letters indicate significant differences at P = 0.05. Data were square root transformed prior to analysis to induce homogeneity of variances, and back transformed data is presented here.

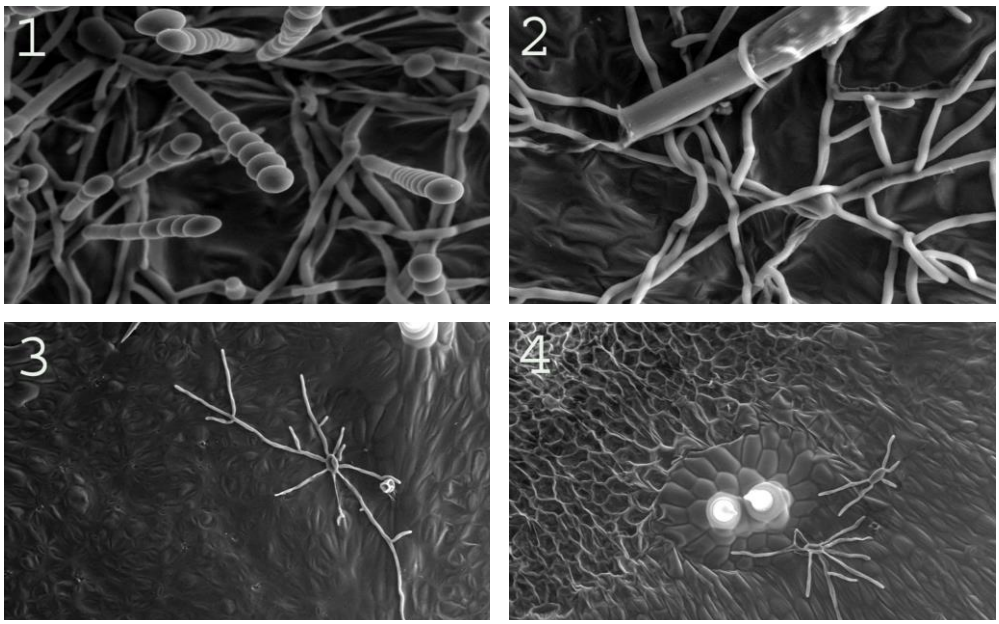

Fig. 11. Scanning electron micrograph of the effect of different levels of UV-B treatments on development of *Podosphaera xanthii*, the causal agent of powdery mildew in cucumber, six days after inoculation. Inoculated plants were exposed to either 16 h growth light (GL) (1), 16 h GL + 5 min 1 W m^{-2} UV-B (2), 16 h GL + 10 min 1 W m^{-2} UV-B (3), or 16 h GL + 15 min 1 W m^{-2} UV-B (4) as explained in Fig. 2.

Outreach Activities (Please note that none of the international travel was supported by SCBG funds):

- August 12, 2013. Presented research results to extension small fruit pathologists and horticulturists at the annual meeting of the American Phytopathological Society in Austin, Texas in a talk entitled: Inoculum density of *Podosphaera aphanis*, infection efficiency and apparent susceptibility of the upper and lower surfaces of strawberry leaves. Approximately 125 stakeholders in attendance.
- August 13, 2013. Presented research results to extension small fruit pathologists and horticulturists at the annual meeting of the American Phytopathological Society in Austin, Texas in a talk entitled: Geographic and climatic discontinuity in production of cleistothecia in *Podosphaera aphanis.* Approximately 100 stakeholders in attendance.
- 22 January 2013. Presented research results at the Empire State Producers Expo in Syracuse NY in a talk entitled Strawberry Powdery Mildew: an update. Approximately 200 stakeholders in attendance.
- 12 November 2013. Presented research results at NJF International Strawberry Conference in Copenhagen, Denmark in a talk entitled Increased Knowledge of Pathogen Biology and Epidemiology for Integrated Disease Management: the Case of Strawberry Powdery Mildew. Approximately 100 stakeholders in attendance.
- 12 November 2013. Presented research results at NJF International Strawberry Conference in Copenhagen, Denmark in a talk entitled. UV-B as a means to control powdery mildew in strawberry. Approximately 100 stakeholders in attendance.
- 13 November 2013. Presented research results at NJF International Strawberry Conference in Copenhagen, Denmark in a talk entitled Strawberry powdery mildew: the where and why of inoculum sources. Approximately 50 stakeholders in attendance.

- 19 November 2012. Presented seminar to extension and research faculty, students, and technical staff at Cornell University entitled Recent Advances in Pathogen Ecology and Epidemiology of Strawberry Powdery Mildew (*Podosphaera aphanis*). Approximately 50 in attendance.
- 5 August 2012. Presented research results to small fruit pathologists at the annual meeting of the American Phytopathological Society in Providence, RI in a talk entitled Suppression of cucumber powdery mildew by UV-B is affected by background light quality. Approximately 100 in attendance.
- 10 February 2011. Presented research results to extension personnel, crop advisors and primary stakeholders at North American Strawberry Growers Conference entitled New Developments in the Management of Strawberry Powdery Mildew. Approximately 250 in attendance.
- 31 March 2011. Presented research results at National Council on Undergraduate Research at Ithaca College entitled Effects of acute low temperature events on establishment of *Erysiphe necator* colonies and susceptibility of *Vitis* species. Approximately 550 students attending.

Goals and Outcomes Achieved

1) An improved understanding of the role of mlo in resistance to powdery mildew in strawberry
2) A method by which powdery mildews of diverse crops can be suppressed using UV-B
3) An apparatus by which effective doses of UV-B can be applied to greenhouse crops
4) Discovery of improved efficacy of UV-B applied during night hours
5) Discovery that DNA repair in powdery mildews is down-regulated during darkness, which increases sensitivity to UV-B.

Beneficiaries

The beneficiaries of our research are anyone who grows crops susceptible to powdery mildews in New York, crop advisors, and extension personnel. Researchers interested in the development of parallel research project to explore the suppression of powdery mildews in other crops represent another class of beneficiaries.

Economic benefits of our research would are gained from two principal avenues: reduced fungicide use (perhaps as much as a 50% reduction is feasible based upon our preliminary data), and reduced crop loss. Given the likely erosion of fungicide performance over time, savings of one or more fungicide sprays coupled with greatly improved control are conservatively estimated direct benefits of this work. Furthermore, both values would be inflated by a switch to high-tunnel production systems, where yields, disease potential, and fungicide inputs are higher than in open field production, and where powdery mildews are certain to be more severe.

Lessons Learned

- Exploitation of mlo-based resistance against powdery mildews will not be as straightforward as we initially envisioned due to the quantity of basic research that will be required before practical levels of disease resistance can be transferred to commercially relevant plants.
- Partnership with commercial enterprises will likely speed the development of low-cost apparatus to allow widespread adoption of UV-B to suppress powdery mildews.

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Additional Information

Publications from the research

Suthaparan, A., Stensvand, A., Solhaug, K.A., Torre, S., Telfer, K.H., Ruud, A.K., Mortensen, L.M., **Gadoury, D.M.,** Seem, R.C., and Giselrød, H.R. 2013. Suppression of cucumber powdery mildew (*Podosphaera xanthii*) by supplemental UV-B radiation in greenhouses can be augmented or reduced by background radiation quality. Plant Dis. 97:0000-0000 (in press).

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Project 9
New York State Hops

Project Summary

As of 2009 there were only three commercial growers and 16 acres of hops in New York State. Recognizing the potential for New York to be part of the burgeoning craft beer industry, New York State brewers were seeking New York grown hops to differentiate their products from that of west coast. In fact, at the time of the original SCBG application, there was immediate buyer demand to purchase 500,000 pounds of New York State hops from local growers. This would require over 500 production acres, and at a premium price, and would represent approximately $6.5 million in annual hop sales.

There was tremendous interest from the State's farmers and landowners to take capture this opportunity and produce hops, yet the northeast lacked the expertise to comprehensively assist potential growers. Therefore, Cornell Cooperative Extension of Madison County, in conjunction with the Northeast Hops Alliance (NeHA), trained an extension educator to work with current and potential future hop growers throughout New York.

The educator developed a targeted, multi-faceted approach to educate growers and provide on-going technical assistance. This approach included direct contacts through email and phone, on farm visits, development of fact sheets, newsletters and other resources that were posted on the Northeast Hop Alliance website (nehopalliance.org), as well as hosting numerous field days, grower meetings and industry conferences.

Project Approach

Hops production in New York State is very different from the established farms in the primary production area of the Pacific Northwest, where the average farm is several hundred acres and they have generations of experience. Growers here are generally beginning with ½ to 5 acres, with the largest being 10 acres. In order to help this industry become established it was determined that education of the grower base was the most effective way to achieve the goals of increased hops production.

One of the primary parts of the work plan was to identify and provide training for an extension educator to work with the hop industry in New York. After going through a national search, an extension educator in New York was hired to carry out the project. He had considerable experience working with the commercial horticulture and vegetable industry in New York, including some knowledge in hops. It was determined that the project would be better served by having him work a greater amount of time than originally expected. He was able to gain more experience with hop production by communicating with growers and researchers in the Pacific Northwest. This additional time made it possible for the project leader to spend more time in the field with growers in New York and with staff at the University of Vermont (UVM) who had begun some research in hops production.

A targeted, multi-faceted approach was utilized to transfer knowledge to the grower audience. This included direct contacts through email, phone and on farm visits. During the course of the project, the project leader had over 3,100 un-solicited direct contacts with growers and prospective growers. These growers were looking for information on a variety of subjects including: cost of establishment, site selection, variety selection, processing and marketing, etc.

A second tactic was to utilize Internet opportunities for mass education. The project leader used the Northeast Hop Alliance website (nehopalliance.org) to post events, newsletters and other resources for growers to read when they had the opportunity. During any of the 3,100 contacts mentioned above, these people were notified that more information was available on this website. As events or pertinent

information came up, a mass email was sent to approximately 350 people to alert them of new information posted on the website.

A third approach was to provide a number of field day opportunities to growers so that they could see first -hand how hops are grown, identify pests, and to network with growers and brewers. Established growers have been inundated with requests from potential growers to visit their yards, so much so that it has had a negative impact on their ability to complete their daily workload on the farm.

In the two years of the project, 8 opportunities like this were offered, with over 900 participants. Participants indicated that these on site opportunities were very valuable.

Finally, two annual conferences were held in the fall of 2011 and 2012. The Hops Advisory Committee provided guidance to the project leader to determine what subjects would be offered at the conferences, as well as the field events. These were opportunities for growers to hear from researchers and other experts from the major hop growing areas of the Pacific Northwest as well as from the Northeast. Over 585 growers and prospective growers attended these conferences. The agendas for the two conferences are provided in the Appendix. In addition, the events were professionally filmed so that the presentations could be utilized as additional resources for both growers who attended, and also for those who could not attend the conference.

One of the tasks in the work plan was to develop a "How To Manual" for growing and processing hops. The project leader has been developing information and publishing articles along with staff from Cornell and UVM. In addition, all of the presentations from the speakers at the two conferences were filmed and these talks are all available on dvds. At the time of this report, the "How to Manual" was in the final review and will be available in electronic and hard copy as a Cornell Guidelines for Growing Hops.

Partners in this project include the board of directors and members of the Northeast Hop Alliance, the New York State Brewers Association, a number of growers, brewery owners, and faculty and staff of several institutions, including Cornell University and the University of Vermont.

These individuals and institutions have provided advice on priorities as well as research and outreach contributions for the advancement of the hops and brewing industries. At each of the field events the advisory committee convened and discussed issues that were of importance to the development and success of the industry. In addition, a research meeting was held the day before each of the conferences. This gave grower representatives and opportunity to meet with researchers from the Northeast. A similar event is held each year for the hop industry in the Pacific Northwest. During the first year of the project, the project leader attended one of those, which lead to the creation of the events held in New York.

Goals and Outcomes Achieved

One of the goals of the project was to provide an Extension resource to hop growers in New York. This included developing the knowledge base of the growers as well as the project leader since very little information was available to either before the project began. Formal education opportunities that were offered to the growers over the two years included 8 field days and 2 major conferences. In addition, the project leader provided information to Cooperative Extension staff and other professionals (Soil and Water Conservation Staff, crop consultants, etc.) around the state, through direct contacts, consultation, production of resource materials and formal education experiences. This created an effective multiplier to reach many more potential growers with information.

There were two measurable outcomes in the project. The first was to increase the number of commercial hop growers in the state. The second was to increase the number of breweries utilizing NYS grown hops. Outcomes were measured using several methods.

First, regarding planted acreage, the Northeast Hop Alliance conducted two bulk orders of hop rhizomes for their members during the project. In addition, Cornell Cooperative Extension provided "clean" plants propagated from stock from the National Clean Plant Network. These numbers provided an indication of the minimum amount of new acreage planted. To further substantiate acreage data, growers were also asked to provide acreage numbers at all of the field days and conferences. For example, at the Fall 2012 Conference, participants were surveyed of their plans and intentions for 2013. 52% said they increased their acreage in 2012. 89% said they planned to increase acreage in 2013 by 46 acres and 65 acres in 2014. During the 2013 growing season growers reported actually planting an additional 65 acres.

So to summarize, at the beginning of the project there were only 3 commercial hop growers within a total of 16 acres. By the end of this project, there were 95 growers (60 with more than an acre) with a total of approximately 78 acres in the State (62 new acres).

The second measurable outcome was more difficult to obtain definitive data. By the end of the project there were over 100 craft breweries in the state and every brewery was producing at capacity. Although we do not have the revenue figures, we do know that at least 47 breweries in New York are now using locally grown hops. In addition, several major breweries in the state have begun evaluating their potential to purchase local hops. The project leader has also received inquiries from brewers in several other states for sources of New York grown hops.

At the 2012 Fall Hops Conference 16 growers indicated that they had sold their crops to breweries in New York. In addition, 96% of the surveyed growers expected their sales to brewers would increase in 2013. Growers also indicated that they have had no difficulties in selling their hops to a number of breweries in the State, and that the brewers were impressed with the quality of the crop.

By these metrics, both of the project measureable outcomes have been attained. Indications are that in 2013, 2014, and 2015, the hop industry and sales to brewers will continue to increase significantly. Although not part of this project, it is important to point out that in 2012 the State of New York passed a new law creating the opportunity for brewers to obtain a Farm Brewery License, which went into effect January 2013. It requires that these new Farm Breweries utilize at least 20% of the hops and 20% of the other ingredients by weight, which are grown in NY. The requirement increases to 60% in 2018 and 90% by 2023.

Beneficiaries

There are several groups who have benefited from the activities and information developed during this project.

Growers

- The primary beneficiaries are the hop growers in New York and the northeast. Many growers from out of state have attended the field days, conferences (over 400 at the conferences alone), and workshops that were offered in New York. In addition a great deal of information has been developed and been made available through the website, printed material, and DVD's of the 2 conferences that were held during the project. These growers have also contributed to each other's base of knowledge through multiple interactions.
- In New York alone, by the end of the project, there are now 95 growers, 60 with more than an acre, who have planted approximately 75 new acres of hops. Hops do not produce a mature crop until the third year, but early signs indicate that growers are yielding about 500-800 pounds of dried hops/acre with a value of $12/pound. The estimated crop value to these growers the second year of the project was $540,000. This should double in 2013 based on normal increases in yield, as a planting matures.

Breweries

- The number of breweries in New York has increased from 62 to over 140 over the course of this project and they are running at full capacity. At the beginning of the project there were not enough hops grown in the State to supply brewers at a minimum level. That has changed dramatically in the last two years.

Ancillary businesses

- A third group that has benefited from the project are ancillary businesses. At an average cost of $15,000/acre (trellises, plants, irrigation, labor), the 75 acres planted in 2011 and 2012 totals $1,125,000. This amount includes the cost of establishment of the acreage, but not buildings, tractors, sprayers, trailers, drying, harvesting, processing, or storage equipment. In some cases the hop farmers are established in other crops and may, for example, already have a tractor, etc. However, at least half of the new hop farmers may only have land resources, but very little in the way of equipment or buildings. Also, equipment for harvesting, drying, and processing hops is very specialized so this has required most growers to purchase new. These expenditures all have a significant impact on the local economy.
- Several companies have also begun investing in the manufacture of equipment for harvesting, drying, pelleting and packaging of hops. We expect to see significant investments in these areas during 2013, 2014 and beyond.
- In addition, at least two greenhouses in New York have begun propagating hops plants for stocking these hopyards. During 2012 these companies sold approximately $15,000 worth of hop plants to growers in NY. They expect to sell about $60,000 in 2013.

Lessons Learned

The most important long term benefit from this project is the information developed that will aid growers in their investments in growing hops for decades. The development of research and relationships with other State's hop industries will help the industry to strengthen in the long term. In early 2014 Cornell will release a *Guidelines for Growing Hops*. This publication is the direct result of the work carried out in this project. It will contain information on site selection, varieties, production, and pest management. Information on processing has been presented at the conferences and is available on the Northeast Hop Alliance website.

The greatest challenge in the project has been the shear enthusiasm and numbers of the audience. Even after finding out that the initial investment of time and money is high, few people are deterred from planting hops. This is also positive, however it resulted in an extremely heavy investment of time on the part of the project leader and everyone else involved. The craft beer industry is riding a wave of expansion and consumer demand, and thus has encouraged those interested in planting hops.

This rapid expansion in growing hops has also driven a demand for information. To put this in perspective, the 30,000 acres of hop production in the Pacific Northwest is comprised of about 65 farm families, with comparatively large acreage farms and many decades of collective knowledge and on farm investment. The project leader on the other hand, has been working with several hundred, highly motivated people who lack much of the basic knowledge related to growing hops.

The new industry in the East requires the rapid development of knowledge, capital investment, and infrastructure investment. Growers are also breaking into a marketplace that is well established and supplied from outside the state. The challenge is to obtain or develop specific knowledge that is appropriate to the scale of the industry as well as the climate and soils in the Northeast.

As the project progressed, it was very important to develop professional relationships with researchers and other industry professionals in the Northeast and the Pacific Northwest. The project leader participates in regular conference calls with staff at Cornell, the Geneva Experiment Station, University of Vermont, Connecticut, Michigan, Wisconsin, Ontario, and Quebec. In addition he has participated in Hops Research Meetings in Oregon and Washington, as well as held similar meetings here prior to each of the hops conferences. These have proven a valuable opportunity for all involved.

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Additional Information

See the Appendix for resources developed as a result of this project:

- data from the 2012 Fall Hop Grower survey
- FAQ sheet entitled "*FAQS for Starting a Hop Farm in New York*" (addresses basic questions for initial inquiries)
- "*Stocking Your Hop Farm*" (information on the site selection, materials, varieties and trellises.)
- "*Growing Hops In the Home Garden*". (Some people who request information do not intend to grow hops commercially, and this publication helps Cooperative Extension staff to provide them with a quick, but thorough resource. This bulletin was originally written in Oregon, but was adapted to New York conditions by the project leader.)
- www.nehopalliance.org -- The Northeast Hop Alliance website was used as an outlet for newsletters, events, publications, slides from presentations and a number of other project resources.

Project 10
Improved Control of Fire Blight Shoot Infection of Apple Trees

Project Summary

Fire blight is a threat to New York apple growers, because almost all varieties, especially the newer, high value varieties, are very susceptible to infection. Because of changing climate, weather conditions are becoming more favorable to the disease, so that every year there are danger periods. The disease affects the flowers and fruits, the shoots and branches, and the rootstock. Antibiotics control infection of flowers quite effectively when timed correctly, and fire blight resistant rootstocks are becoming available. However materials for controlling infection of vegetative shoots are very limited, and mainly comprise use of prohexadioneCa (Apogee), which stunts shoot growth. Effective materials with less side effects are urgently needed to reduce shoot blight, which can result in loss of large branches and even whole trees in severe cases. An assay using inoculation of vigorously growing shoots, preceded and followed by application of the candidate material, has been developed, and will be used to test novel materials, including biological controls, in existing experimental apple blocks. Because of annual variation in weather conditions, the assays will be repeated in three growing seasons. Results will be analyzed and an integrated set of recommendations for reducing shoot infection will be publicized to growers.

The main issue is the widespread occurrence of shoot infection of apple trees by fire blight, and the lack of effective recommendations to control it. These infections affect almost all popular, high value varieties and annually cause damage to hundreds of thousands of valuable trees in New York. The shoot infections also allow the bacteria causing fire blight to overwinter in the trees, to return the following year and cause further damage.

The project is urgent and timely because growers currently have very limited options for controlling shoot blight and are annually suffering serious losses because of it. It is important also to provide the growers with an effective, benign, control so that they are not forced to use streptomycin for this purpose and so encourage development of resistance to streptomycin by the causal bacteria.

The objectives of the project were:

1) To identify effective control materials that can be used without undesirable side effects, and which will not contribute to development of resistance to streptomycin, the best control for infection of flowers.
2) To prepare an integrated set of recommendations for reducing shoot infection and publicize them to extension field staff and to New York apple growers.

Project Approach

A protocol has been developed in which 20 shoots on each of 6 trees of Idared (very susceptible to fire blight) and 6 of Empire (moderately susceptible) are inoculated with *Erwinia amylovora*, the bacteria causing fire blight. Actively growing shoots are inoculated by cutting their two youngest leaves with scissors dipped into a bacterial preparation. The test materials are sprayed on the shoots 24 hr. before the inoculation and 24 hr. after. The shoots are observed at frequent intervals after the inoculation for the development of symptoms of infection. These are light brown, becoming dark-brown, lesions formed along the cut line and then extending down the veins into the leaf. In severe cases the lesions extend into the shoot and down it. The length of the lesion back from the cutline is used to determine the severity of infection. Preliminary experiments have shown that in this assay, the well-known control, streptomycin antibiotic, reduces the severity of infection. (Streptomycin cannot be recommended for control of shoot blight because of the danger of causing the bacteria to become resistant to it, and thereby making it

unavailable for control of flower infection.) This assay will be done twice, in June and July, in 2011 and 2012, to obtain sufficient results for a confident determination of effectiveness of new materials.

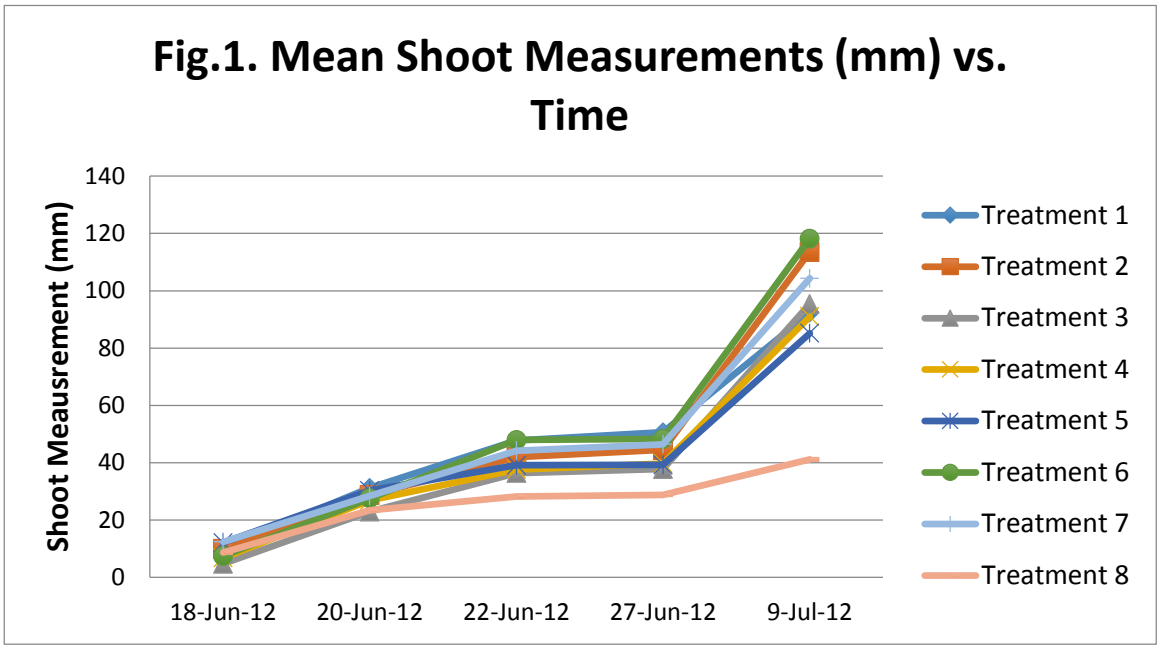
2012 Inoculated Shoot Blight Trial

An inoculated shoot blight trial was conducted in spring/summer 2012. Twenty shoots on each of 6 trees for each of 9 treatments were inoculated by bisecting them with scissors dipped in *E. amylovora* inoculum. The length of infections on the inoculated shoots was determined at intervals after inoculation and the area under the disease progress curve determined. The treatments for the inoculated trial were as shown in Table 1.

Table 1. Treatments in 2012 Inoculated Shoot Blight Trial.

Treatment #	Treatment	Rate	Sprays		Inoc
			June 8	June 15 a.m.	June 15 p.m.
1	Non-treated inoculated				X
2	Blossom Protect + Buffer Protect x 4	1.25 lb/Acre		X	X
3	Firewall (strep)	24 oz/acre		X	X
4	Kasumin	64 floz/acre		X	X
5	Serenade Max	3lb/acre		X	X
6	Fireline (Oxytet) full rate	16 oz/100gal		X	X
7	Actigard 3.2	3.2 oz/acre	X		X
8	Agogee	6 oz/100gal	X		X
9	Non-treated Non-inoculated				

Results of 2012 Inoculated Shoot Blight Trial



In the 2012 trial, Apogee was by far the most effective treatment resulting in more than 50% reduction in the length of shoot blight cankers. Kasumin, Firewall (streptomycin), and Serenade Max (a preparation from the culture filtrate of the bacterium, *Bacillus subtilis*) resulted in lesser reductions in canker length. Blossom Protect (a preparation of the yeast Aureobasidium pullulans) and Fireline (oxytetracycline) produced no reduction in canker length.

2013 Inoculated Shoot Blight Trial

This trial was conducted on 5-yr-old 'Idared' apple trees on B.9 rootstocks. Shoots for the shoot blight treatments were inoculated on 13 June by bisecting the two youngest leaves with a pair of scissors dipped *in Erwinia amylovora* inoculum. Shoot blight symptoms were assessed on inoculated shoots on 28 June. Shoot blight was assessed as the length of canker extending from the site of wounding with 10 shoots assessed for 5 replicate trees. Disease intensity data were subjected to analysis of variance (ANOVA) for a randomized block design using accepted statistical procedures and software (i.e. Mixed Models (MIXED)) procedure of SAS (version 9.3; SAS Institute Inc., Cary, NC). All percentage data were subjected to arcsine square root transformation prior to analysis.

Results of 2013 Inoculated Shoot Blight Trial

Trt #	Material/Rate	Timing of Sprays	Shoot Blight Canker Length (mm)	LSMEANS
1	Non-treated inoculated		121.4	ab
2	MasterCop 1.5 pt	1,2,3	125.8	a
3	Serenade Optimum 1.5lb/A + Regulaid 3 pt Ag Streptomycin 24 oz + Regulaid 3 pt	1,3 2	109.8	bc
4	Actigard WG 2.0 oz Actigard WG 2.0 oz + Firewall 17WP 24 oz + Regulaid 3 pt	1,3 2	107.6	abc
5	Ag Streptomycin 24 oz + Badge SC 16 fl oz Badge SC 16 fl oz	2 3	103.1	cd
6	Actigard WG 0.5 oz/A, 1 oz/A	2,3	99.2	cde
7	Ag Streptomycin 24 oz + Regulaid 3 pt Serenade Optimum 1.5lb/A + Regulaid 3 pt	1,3 2	92.3	f
~~8~~	Bloomtime Biological 5.28 oz/A	2,3	91.5	d
9	Firewall 17WP 24 oz + Regulaid 3 pt Apogee 18 oz	2 3	71.9	e
10	Ag Streptomycin 24 oz + Regulaid 3 pt	1,2,3	29.7	f
11	Kasumin 64 fl oz/A	2,3	25.2	f

Treatment timings were: 1 = 50% bloom (9 May); 2 = 80% bloom (14 May); 3 = during terminal shoot growth (12 Jun). Rates are in amount per acre or the amount for drench treatments (see text above).

**All values represent the means of 20 shoots for 5 replicate trees. Values within columns followed by the same letter are not significantly different ($P \leq 0.05$) according to the LSMEANS procedure in SAS 9.3 with an adjustment for Tukey's HSD to control for family-wise error.

All treatments including a streptomycin product (Ag Streptomycin or Firewall), except for treatments #3 and 4, gave a significant reduction in canker length. Greatest reductions (almost 80%) were caused by 2 sprays of Kasumin and 3 sprays of Ag Streptomyin plus Regulaid. Two sprays of Firewall (streptomycin) plus one spray of Apogee gave 40% reduction in canker length. Lesser, but still statistically significant, reductions (27%), were caused by Bloomtime Biological and Ag Streptomycin plus Serenade (a preparation from the culture filtrate of the bacterium, *Bacillus subtilis*). Actigard caused only a small reduction (21%) in canker length. Badge SC did not appear to enhance the effectiveness of streptomycin. MasterCop had no effect on canker length but, unlike all other treatments, caused some russeting of fruit.

Due to weather problems in Year 1 (2011) the field experiment on control of shoot blight yielded no useful results. The field experiment in 2012 was successful. It was decided to do another field experiment in 2013 to make up for the missing results for 2011. The results of the 2012 and 2013 experiments are reported in the final report; however, because the analysis of the results was delayed from the original plan for the grant, they could not be reported to the growers as planned. We now plan to report to growers in publications and at meetings next winter.

Goals and Outcomes Achieved

The most effective treatments to reduce shoot blight severity in the different trials were the growth regulator, Apogee, and the two antibiotics, streptomycin Ag Streptomycin and Firewall) and kasugamycin (Kasumin). Each of these compounds have drawbacks for use in reducing the severity of infection of shoots by fire blight. Apogee must be applied when shoots are only 1-2 in long (in late bloom), and results in significant reduction of shoot growth, which may be a detrimental effect in young trees.

Use of the antibiotics in plantings where fire blight infections have already taken place runs the risk of selecting for antibiotic-resistant strains *of Erwinia amylovora*, the bacterium causing fire blight. Use of antibiotics to control shoot blight is only recommended before or immediately after hailstorms. Although it only resulted in a modest reduction in canker length, Bloomtime Biological, which is a preparation of the bacterium, *Pantoea agglomerans*, may be useful in managing shoot blight.

Revised recommendations for control of shoot blight will be prepared in 2014, and hopefully will be used in email-distributed control alerts sent to growers in the 2014 growing season, and also in publications for growers including Scaffolds, NY Fruit Quarterly, and County Extension Newsletters, and on the Fruit and Berry Website. The new recommendations will be presented to growers in talks at the NY Fruit Expo and Fruit Schools in winter 2014/15. Records will be kept of number of growers attending these meetings.

Beneficiaries

Several hundred New York growers with orchards of fire blight susceptible apple varieties will benefit from the results of the project. The recommendations coming out of the project should help reduce their tree damage due to shoot blight infections.

Loss of young bearing trees through killing of major branches is especially costly to growers. They have already made the considerable investment in the nursery trees, trellis, land preparation, and maintenance. They lose not only the trees, but also the production for the next several years before replacement trees can be established. The loss per acre can amount to several thousand dollars.

Loss of branches from older trees is also costly as bearing surface for the current and future seasons is lost. Losses on dwarf trees can amount to many hundreds of dollars per acre. Better recommendations to reduce shoot blight infections would prevent a large proportion of these losses.

The total annual economic impact to NY growers of better recommendations for controlling shoot blight could be more than $1 million in years when fire blight conditions are severe.

Lessons Learned

Since this research depends on working with young shoots on apple trees, there is essentially only a brief window each year for conducting the projected trials. Due to the vagaries of the weather, trials may not yield useful data every year. This was the case with the first year of this project. Therefore to obtain the results projected in the proposal, the trials were extended into the 3rd year, when useful results were obtained.

Although the project confirmed our assumptions on the effectiveness of certain products (Apogee and streptomycin), novel data on effectiveness were obtained for newer products (kasugamycin and Bloomtime Biological). Just as important is the finding that some products were ineffective (Fireline [oxytetracycline], Blossom Protect, Badge SC and MasterCop) in the trials.

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Additional Information

The results of these trials will be published in scientific and grower-oriented media.

Project 11

Delivering Tools for Quantifying Sulfur Spray Residues to the Wine & Grape Industries

Project Summary

Winegrape growers in New York State and elsewhere in the US routinely control the common grapevine disease powdery mildew (PM) using elemental sulfur (S) as a fungicide due to its low cost, low risk of fungicide resistance development, and acceptance in sustainable and organic practices. As an example of its associated cost savings, the cost of elemental S sprays is <$5/acre, compared to $15-$40/acre for other chemical fungicides, a typical NY State winegrape grower with 25 acres of winegrapes could realize savings of $4,500 by replacing half of their powdery mildew control sprays with S containing products.

However, elemental S-residues remaining on grape berries at harvest can be converted into hydrogen sulfide (H_2S) during wine fermentations, resulting in undesirable rotten egg aromas in the finished wine. Studies to determine how long S-residues persist after spraying have been limited by a lack of analytical methods to measure S-residues. Consequentially, growers have avoided late season S sprays as a point of caution and instead have relied on more expensive and/or environmentally damaging sprays, even when unnecessary.

The objectives of this project were:

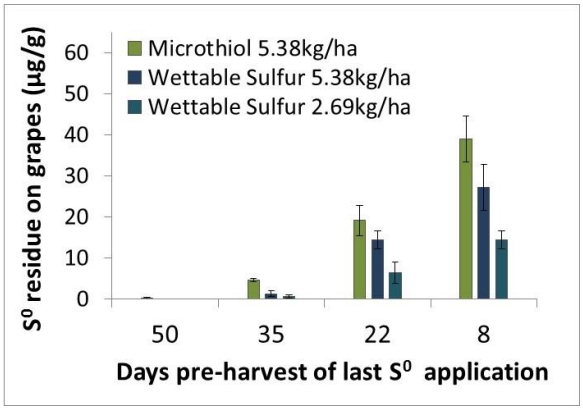
1. to quantify S-residue persistence following spraying in vineyards and during initial stages of wine production to provide guidelines to growers regarding when to cease S applications during the growing season;
2. to develop online materials to train industry members in the use of a new S measurement methodology.

The expected impact of this work was to increase the responsible use of elemental S in vineyards, which should increase the economic and environmental sustainability of the grape and wine industries in New York State and elsewhere in the US.

Project Approach

To meet Objective 1, "*Quantifying S-residue persistence in vineyards and during winemaking*", grapevines were sprayed with different elemental S treatments (composition and application rate), and S-sprays ceased at varying intervals prior to harvest. Control vines that were not exposed to S were also included. Grape samples were collected from all vines in 2010 and 2011 from mid-season until harvest at roughly 10-day intervals. S residues were quantified in all samples to characterize the effects of spray treatment and spray cessation date on S persistence. Grape samples from each treatment were then vinified, and S-residues quantified at multiple time points to determine the effects of winemaking practices on S-residue extraction. Data from the multiple years of study was then used to prepare recommendations for industry members.

An example of data from one of the time course studies is shown below.



Above: Example of data from vineyard spray studies, showing persistence of sulfur (S^0) sprays in a Chardonnay vineyard in 2010 with three different spray treatments. S^0 residues over 1 μg/g have been linked to off-aroma formation during fermentation.

Our observations were that grapes sprayed >6 weeks before harvest generally had S-residues below 10 mg/kg, less than concentrations known to cause off-aromas. Increasing the concentration of the S-spray resulted in proportional increases in spray residues, and the product type had only a minor effect. Because there was some variability in persistence across years, direct measurement of S-residues by wineries will be the best approach. Winemaking choices had a large effect, as proper must clarification during white winemaking resulted in a >98% reduction in S-residues. Therefore, with white grapes, it is possible to use S-sprays up until harvest without negative effects so long as appropriate winemaking practices are employed. These recommendations were then presented at regional wine industry workshops, and published in industry journals and extension publications.

To meet Objective 2, *"Develop online materials to train industry members*", we developed a video version of the protocol available through YouTube; and also prepared a written version of the protocol through the national Extension website. The latter protocol includes not only step by step instructions, but also suggested retailers for the necessary supplies. These protocols have been promoted through the Cornell extension website.

As part of these objectives, we distributed elemental S kits to over 30 industry members or extension agents, including those at Channing Daughters (Christopher Tracy and Larry Perrine), Sheldrake Point (Dave Breeden), and Andrew Rockwell (Premium Wine Group). We received results and feedback from several of these winemakers, including:

- "After some work we were able to get some useful data to guide our spray program", Jim and Carol Doolittle, Frontenac Point Winery, Trumansburg NY
- The video helped clarify the process and we were able to get consistent results after following those instruction.", Mario Mazza, Mazza Vineyards, North East, PA
- "Thanks, the kit helped us assess whether some fruit coming in was sulfur tainted or not.", Pindar Vineyards, Peconic NY

We also performed analyses for some wineries who suspected that they had grapes with excessive S-residues, including Canandaigua Wine Co. and Millbrook Winery.

Goals and Outcomes Achieved

Overall, we were successful in reaching our goals of determining factors that affect sulfur (S) residue persistence and in developing and distributing our S-residue protocols for winemakers. We are still in the

process of changing industry behaviors so that they can realize the financial benefits from our work. A summary of the proposed activities and outcomes is provided below.

Proposed Task/Project Activity	**Outcomes during SCBG reporting period**
For Objective 1 Determine S residue persistence on grapes in vineyards following S spraying	Grape samples were collected in 2010 and 2011. Sulfur residues on grape samples were analyzed during the reporting period using a newly developed assay. The results indicated that for red grapes, spraying should be ceased no earlier than ~6 weeks before harvest in most years. Some variation in S-persistence was observed as a result of weather, type of S formulation used, and other factors, and in many cases this recommendation may be too conservative. We are recommending that growers and winemakers learn to measure S residues at their sites to account for this variability. For white wine grapes, in which skin fermentation is less common, we determined that S-residues can be removed by proper clarification of the must prior to fermentation, even when the fruit was sprayed as little as 1 week before harvest. Therefore, S-residues are unlikely to present a problem for white winemaking. White winegrape growers should consider substituting S-sprays for more expensive sprays for powdery mildew control. Results were presented at 15 events attended by the NY State and other regional wine and grape industries. Approximate attendances are included below. 1. Jan 2011: Long Island Agricultural Forum; (Riverhead, NY). 40 growers 2. Feb 2011: Finger Lakes Grapegrower Conference (Waterloo, NY); 150 growers 3. Feb 2011: Maryland Grape Growers Assoc., Annual Meeting: (Rocklin, MD). 125 growers 4. May 2011: Finger Lakes Regional Grape Program, Spring IPM Meeting: (Dundee, NY). 125 growers 5. May 2011: Long Island Enology Research & Extension Planning Meeting (Riverhead, NY); 20 winemakers 6. July 2011: American Society for Enology and Viticulture – Eastern Section (Baltimore, MD). 80 researchers, extension specialists, and growers 7. April 2011: NYS Wine Industry Workshop (Geneva, NY); 100 winemakers 8. Mar 2012: NYS Wine Industry Workshop (Geneva, NY); 100 winemakers 9. Mar 2012: Finger Lakes Grape Growers Convention (Waterloo, NY). 300 growers 10. May 2012: Long Island Agricultural Forum (Riverhead, NY). 40 growers

Disseminate this information to the New York wine and grape industries, including presentations at the joint NYS Wine Industry Workshop/Finger Lakes Grape Growers Meeting as well as regional grower meetings.	11. July 2012: American Society for Enology and Viticulture – Eastern Section (Traverse City, MI). 100 researchers, extension specialists, and growers 12. Jan 2013: Long Island Agricultural Forum (Riverhead, NY). 45 growers 13. Feb 2013: Ontario Fruit & Vegetable Conference (Niagara Falls, ON). 150 growers and winemakers 14. Feb 2013: Viticulture 2013 (Rochester, NY). 150 growers and winemakers 15. May 2013: Finger Lakes Regional Grape Program, Spring IPM Meeting (Branchport, NY). 130 growers We are disseminating this work through 2 peer-reviewed publications and 4 extension publications 1. Kwasniewski MT, Sacks GL, Wilcox WF. Persistence of Elemental Sulfur Spray Residue on Grapes during Ripening and Vinification. *Am J En Vit,* ***submitted Jan 2014*** 2. Kwasniewski MT, Allison RB, Wilcox WF, Sacks GL. Convenient, inexpensive quantification of elemental sulfur by simultaneous in situ reduction and colorimetric detection. *Analytica Chimica Acta.* **2011**; 703:52-7. 3. Gerling CJ and Sacks GL. Measuring Field-applied Sulfur Residues in Juice and Wine. **2010**. *Veraison to Harvest* (vol 7). Ithaca, NY: Cornell University. (extension publication) 4. Wilcox WF "Grape Disease Control, 2011" **April 2011**. (Extension publication, distributed throughout NY State) 5. Wilcox WF "Grape Disease Control, 2012" **April 2012**. (Extension publication, distributed throughout NY State) 6. Wilcox WF "Grape Disease Control, 2013" **April 2013**. (Extension publication, distributed throughout NY State)
For Objective 2 Develop web-based materials on performing the sulfur (S) residue measurement, so that commercial growers and winemakers can detect residues in the vineyard or winery. develop a step-by-step protocol, including a supply check list. Make protocol available via the Cornell Enology & Viticulture website by the end of 2010 and will be publicized through	We released both video and written protocols for S-residue analyses in language understandable by a vineyard operator or winemaker. Sources for supplies are included along with step-by-step directions. The protocols are posted here: http://www.extension.org/pages/69748/analyzing-elemental-sulfur-residues-on-grapes#.UpZS2-KyObE (written protocol) http://www.youtube.com/watch?v=yH83vDX8ORQ (video protocol) We have publicized these protocols through the Cornell enology extension website and newsletter

Cornell enology and viticulture extension newsletters	http://cals.cornell.edu/cals/grapesandwine/veraison-to-harvest/loader.cfm?csModule=security/getfile&PageID=1022668 http://www.fruit.cornell.edu/shared/pdfs/SulfurResidue.pdf
Aim to have at least 100 industry members download the protocol. Participant's names will be recorded by requiring registration prior to downloading, and follow-up emails can determine if they utilized the protocol successfully	We had 70 views of the video protocol. We also were directly contacted by ~35 winemakers, to whom we distributed measurement kits. In total, we believe that we approached our target of reaching 100 winemakers. However, because of difficulties with the eXtension website, we were not able to track the number of downloads of the written protocol, and thus could not evaluate the exact number of protocol downloads.

Beneficiaries

The major beneficiaries of this project are approximately 500 winegrape growers and 350 wine producers in NY State and elsewhere in the US. While anecdotal evidence that S-sprays on red winegrape cultivars should cease at ~6 weeks pre harvest, this is not the case for white wine grapes. Our data indicate that that inexpensive S-residue sprays can be used late into the growing season for controlling powdery mildew on white grapes. Although S-residues are still present on the grapes, they will be not be extracted into the juice prior to fermentation assuming standard white wine protocols are followed, e.g. the must is properly clarified.

As an example: a typical New York State vineyard planted with European winegrapes (*V. vinifera*) is sprayed 12 times during the growing season, with most sprays including a fungicide for control of powdery mildew. The cost of elemental S sprays is <$5/acre, compared to $15-$40/acre for other chemical fungicides. Assuming that the number of sprays with more expensive fungicides could be reduced 50% by more frequent use of elemental S and that the price difference between sprays was $30/acre, a typical grower with 20 acres of white winegrapes could realize savings of $3,600 through expanded use of elemental S. Considering that the total plantings of white winegrapes in New York State cover ~3000 acres, this project could result in economic savings for approximately 300 commercial winegrape growers of $540,000 per year by reducing the costs of inputs.

Lessons Learned

Our observation that having S-residues on white wine grapes should be of negligible concern to growers assuming standard white winemaking practices was unexpected. In principle, this should mean that growers can utilize elemental S until the end of the growing season. However, several growers and winemakers have been skeptical of this idea, even though there are clear financial benefits, possibly because they are worried about catastrophic effects on their wine quality if our results prove to be error. We will continue to reinforce our recommendations through workshops in future years.

We have also confirmed that growers should be wary of spraying elemental S on red wine grapes within 6 weeks of harvest. While this is not unexpected, it is also is helpful to have firm data to share with curious growers and winemakers.

We had challenges quantifying the number of individuals who had downloaded our protocol because the website we used (eXtension) was not set up to require registration for downloading individual materials. We have discussed adding this feature with the current site managers.

One very positive and unexpected outcome not previously discussed was that our elemental S assay can be adapted to measure sulfites. Sulfites are widely used in NY State and elsewhere in the world as a wine preservative. Due to federal regulations they are routinely measured in the winery, but many winemakers perform measurements at irregular intervals because of the tediousness of analyses. Our new method greatly simplifies analyses, and should be of particular use to small and mid-sized wineries with limited analytical capabilities. This was in no way a planned goal of the project, but was discovered serendipitously.

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Project 12
Integrated Management Strategies of Leafroll Disease in Vineyards

Project Summary

Previous surveys showed that viruses associated with grapevine leafroll disease such as *Grapevine leafroll-associated virus 1* (GLRaV-1) and *Grapevine leafroll-associated virus 3* (GLRaV-3) are prevalent in Finger Lakes vineyards. So, is *Pseudococcus maritimus* - the grapevine mealybug - although vector population densities are low for the most part. Leafroll viruses lower vine vigor, reduce fruit yield, delay fruit ripening, reduce soluble solids, and increase titratable acidity in juices. No grapevine is known to be resistant to these viruses or to their mealybug vectors and no cure is available in infected vineyards. Management of leafroll disease relies primarily on preventive measures based on the use of planting material derived from clean, virus-tested stocks.

At the start of this project, limited information was available on the economic impact of leafroll disease in Finger Lakes vineyards and on best management options. The objectives of our proposal were to:

- Determine the efficacy of insecticides at reducing populations of mealybugs
- Evaluate the efficiency of insecticides at slowing the natural spread of viruses by reducing the rate of virus acquisition and transmission by mealybug vectors
- Develop crop budgets to assess costs of leafroll disease management
- Reach out to the local grape and wine industries to raise awareness on disease impact, promote integrated pest and disease management strategies based on a predictive model for virus spread and profitability estimates.

Leafroll was recognized as an important virus disease complex in the Finger Lakes region of New York in the mid-2000. Extended interactions with the industry clearly indicated little awareness of the disease, its distribution and impact among stakeholders. Little was also known on management options. Consequently, these gaps in knowledge needed to be filled. These efforts were timely in complementing parallel efforts to reinstate a grapevine certification program in New York that would help supply cleaner planting material.

Project Approach

<u>To determine the efficacy of insecticides at reducing populations of mealybugs</u>, we selected two commercial Chardonnay vineyards in the Finger Lakes region. These vineyards were selected for their relatively moderate populations of mealybugs and moderate incidence of either GLRaV-1 and GLRaV-3 or GLRaV-1, as shown by previous surveys. In the first Chardonnay vineyard, we engaged the owner in our research and applied dormant oil, Assail and Movento®. Early results showed that dormant oil and Assail have limited effect at reducing the spread of GLRaV-1 and GLRaV-3 spread in the vineyard. However, the performance of Movento® was encouraging. Therefore, we selected a second Chardonnay vineyard (infected only by GLRaV-1) and engaged the owner in our research. We applied the insecticide Movento® to manage overwintered crawlers at budswell and first generation crawlers in the spring of 2011, 2012 and 2013. The experimental design consisted of six replicates of 48 vines per plot with a plot size of 12 vines in four contiguous rows. Mealybug populations were evaluated mid-May by counting the number of immatures on loose or cracked bark of two-year old canes. Mealybugs were also counted early August by inspecting for mealybugs under loose bark on the trunk and older canes.

Fig. 1. Symptomatic leafroll-affected Chardonnay (left) and a healthy asymptomatic Chardonnay (right).

Results of a comparative time census of *P. maritimus* populations in treated and untreated vines showed a 70% decrease in the abundance of immature mealybugs 30 days post-application of Movento® in 2011 while no mealybugs were found in 2012 and very low numbers in 2013 (Figure 2). Differences in mealybug population between treated and untreated vines were significant ($P<0.001$). *These results showed that the systemic insecticide Movento® efficiently reduces P. maritimus populations in a commercial vineyard.* Based on these findings, it was hypothesized that the spread of GLRaVs can eventually be reduced through the use Movento®.

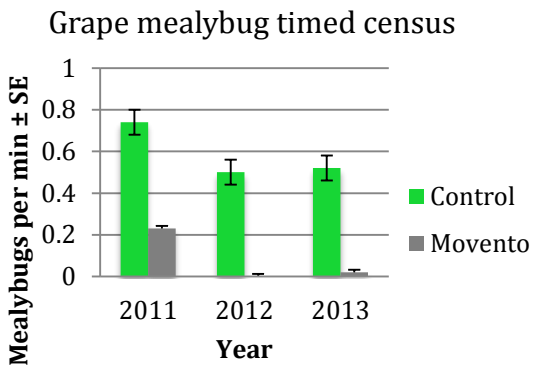

Fig. 2. Timed census of *P. maritimus* on Movento®-treated and untreated vines in a Chardonnay vineyard over three consecutive years.

To test the potential of Movento® at reducing the natural spread of GLRaV-1 by interfering with the rate of virus acquisition and transmission by *P. maritimus* vectors, we determined and compared virus incidence in the Chardonnay vineyard from 2011 to 2013. The presence of GlRaV-1 was determined in every vine on September 24, 2012 by double antibody sandwich enzyme-linked immunosorbent assay. Virus occurrence was also confirmed in a few selected vines by reverse transcription polymerase chain reaction using appropriate primers.

Leaf samples from every vine were collected on September 26, 2011 and indexed for GLRaV-1 by ELISA. Test results indicated a 30% infection rate (30%, 216 out of 722 vines). This information was used as a baseline infection rate against which virus incidence was measured over time. In September 2012, 250 of the 722 vines tested (35%) were infected with GLRaV-1. This represented an overall 5% increase of infected vines in the Chardonnay vineyard surveyed. In September 2013, 296 of the 722 vines tested (41%) were infected with GLRaV-1, representing a 6% increase in infected vines. Interestingly, the increase of virus incidence was lower in Movento®-treated compared to untreated vines (Figure 3). The differential incidence of GLRaV-1 in treated versus untreated vines was significant ($P<0.02$). *These results suggest that Movento not only drastically reduces the population of P. maritimus mealybugs but can also reduce the spread of GLRaV-1.*

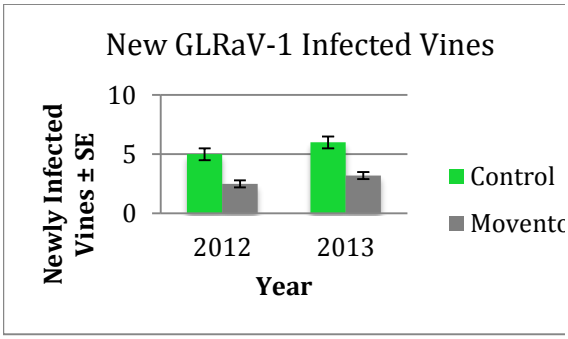

Fig. 3. Incidence of GLRaV-1 in newly infected Movento®-treated or untreated vines in a

In parallel, we collected *P. maritimus* mealybugs and initiated reverse transcription (RT) polymerase chain reaction (PCR) assays using specific primers to determine their viruliferous status over time. The work was done in the first Chardonnay vineyard in which the co-presence of GLRaV-1 and GRLaV-3 was previously documented. We collected mealybugs from mid-April to mid-November (Figure 4). Results indicated that genetic material from GLRaV-1 and/or GLRaV-3 was found in majority of grape mealybugs (77%, 128 of 175) throughout the testing period, even in mealybugs collected as early as mid-

April at budswell (77%, 20 of 26) (Table 1). Interestingly, transmission of GLRaV-1 was documented in healthy vines following exposure of mealybugs collected mid-April in the selected Chardonnay vineyard. Also, a preferred virus uptake was noticeable from budswell (April) to bloom (April to June) and at pre-veraison (July-August). *These results indicated that overwintered P. maritimus mealybugs have the potential to uptake and transmit viruses if they are exposed to infected vines, even if their population density is low, in particular early spring in a commercial vineyard.* These findings are consistent with the fact that insecticides should be applied to target overwintering crawlers and crawlers hatching from overwintering eggs to prevent them from feeding and acquiring GLRaVs early spring. In contrast, very few, if any, mealybugs from the late collections (September-November) had viral genetic material, suggesting that almost no viruliferous mealybugs is overwintering. *These results indicated that few crawlers become viruliferous in fall.* In addition, testing 213 eggs, 51 crawlers on egg masses in the vineyard and 33 crawlers that hatched from eggs in the lab by RT-PCR showed no transovary transmission of GLRaV-1 and GLRaV-3. These findings confirmed a semi-persistent transmission mode of these viruses.

Table 1. Occurrence of GLRaV-1 and GLRaV-3 in grape mealybugs over time in a Chardonnay vineyard in New York in 2010-2011.

Month	Stage	N	No virus	LR1	LR3	LR1+LR3	Positive/Tested	(%)
April	C	26	6	19	0	1	20/26	77
May	C	26	1	0	14	11	25/26	96

Fig. 4. Grape mealybug under the bark of a Chardonnay vine at budswell in April (left) and bloom in June (right).

To assess costs of leafroll disease impact, vineyard managers at 10 vertically integrated wineries, e.g. wineries that source their grapes partially or completely from their own vineyards, in the Finger Lakes region were surveyed to gain a better understanding of their winery operations, such as acreage, cultural practices, typical pest and disease pressures. Surveys were also done to get a better understanding of leafroll disease awareness and management response. The survey responses were employed to specify the parameter ranges to be used in constructing the analysis scenarios, including disease prevalence (1, 5 and 40%), spread dynamics based on a model developed in New Zealand, methods of disease control (roguing of infected vines, vineyard replacement or no response) and yield penalty (0 or 10%) for poor fruit quality (low sugar content and higher acidity).

Survey outputs were integrated and used to estimate the financial impact of leafroll disease and construct economically sound control scenarios (no control, roguing, vineyard replacement) based on initial infection rates (0-60%), yield reduction (30% and 50%) and penalty for poor fruit quality (0 or 10%). A net present value (NPV) was calculated for different leafroll control scenario based on the interviews of vineyard managers. Six leafroll disease control scenario were identified: Scenario 1, the baseline scenario; Scenario 2, no disease control; Scenario 3, disease prevention through the use of planting material derived from certified, virus-tested, clean stocks; Scenario 4, roguing, i.e. elimination of diseased vines; Scenario 5, entire vineyard replacement; and Scenario 6, late vector-mediated infection. Disease impacts were computed in NPV terms over the economic lifetime of vineyards (25 years) and for each scenario. Disease impacts are calculated as the difference between the baseline NPV (i.e. no infection) and the NPV of the particular scenario considered. Optimal control measures were identified as those with the highest NPV.

Results indicated an economic impact of leafroll over the vineyard lifetime ranging from $10,282 per acre (for a 30% yield reduction and no quality penalty) to $16,600 per acre (for a 50% yield reduction and a 10% penalty for poor fruit quality) if no control measures are implemented. Paying a price premium of 25% for certified, clean planting material was predicted to reduce losses to $740 per acre. This loss is substantially smaller than those following roguing ($1,298-$22,677 per acre) and vineyard replacement ($9,977 per acre).

Based on these findings, a decision matrix was developed for optimal disease management. This matrix indicates that removal of the entire vineyard is economically attractive if leafroll incidence is >25% while roguing is recommended if leafroll incidence is <25%. To further optimize roguing in vineyards for which the presence of mealybug vectors is documented, a bioeconomic study was carried out to test other profit-maximizing control strategies. This study took into account the latency period of symptom development following exposure to viruliferous mealybugs, virus detectability in infected vines, the spatial dynamic of virus spread by mealybugs and vine age. A disease diffusion model was developed based on distinct infection states (healthy, infected and asymptomatic, moderately infected and symptomatic, and highly infected and symptomatic), the stochastic neighborhood-dependent transition state from healthy to highly infected and symptomatic, and the spatial relationship of infected vines with neighbor vines. Bioeconomic outcomes were measured based on vineyard expected half-life, e.g. time to 50% disease prevalence, and expected net present value (ENPV). Different scenarios were compared to baseline of 'no control' and ENPV improvement relative to baseline of 'no control'. *Results showed the value of removing each neighbor vine that is adjacent to the rogued, infected vine within a row, regardless of their infectious status, in terms of enhanced disease management.* These findings are important for eradication of leafroll disease.

To reach out to the grape and wine industries and extend research outputs, an extension article titled "Economic impact of grapevine leafroll disease on *Vitis vinifera* cv. Cabernet franc in Finger Lakes Vineyards of New York" by Atallah, S., Gomez, M., Fuchs, M. and Martinson, T. was published in Appellation Cornell in 2012 (http://cals.cornell.edu/cals/grapesandwine/appellation-cornell/). This article summarized some of our research and accomplishments to extension specialists, researchers, agriculture service providers, and growers alike.

A presentation titled "Molecular strategies for the control of leafroll disease" was delivered by Fuchs at a symposium on 'Grapevine leafroll and vitivirus diseases: A continued and increasing problem for vineyards' during the Annual Conference of the American Society for Enology and Viticulture on June 20-24, 2011 in Monterey, CA (100 participants, including 80 growers). Another presentation titled "Seasonal pattern and dynamics of virus acquisition by the grape mealybug in a leafroll-diseased vineyard" was made by Fuchs and Loeb at the 17th conference of the International Council for the Study of Viruses and Virus-like Diseases of the Grapevine in Davis, CA on Oct. 7-11, 2012 (200 participants, including 40 growers). A third presentation titled "An Agent-Based Model of Plant Disease Diffusion and Control: Grapevine Leafroll Disease" by Atallah, S., Gomez, M, Conrad, J.M. and Nyrop, J.P. was delivered at the 2012 Meeting of the Agricultural and Applied Economics Association, August 12-14 in Seattle, Washington (http://ageconsearch.umn.edu/handle/124936) (250 participants, including 25 growers).

An article titled "Economic Impact of Grapevine Leafroll Disease on *Vitis vinifera* cv. Cabernet franc in Finger Lakes Vineyards of New York" by Atallah, S.A., Gómez, M.I., Fuchs, M.F. and Martinson, T. E. was published in the American Journal of Enology and Viticulture (2012, 63:73-79). Two other articles titled "Genomic analysis of *Grapevine leafroll-associated virus-5* and related viruses" by Thompson, J.R., Fuchs, M. and Perry, K. (Virus Research, 2012, 163:19-27) and "*Grapevine leafroll-associated virus 1* occurs as genetically diverse populations" by Alabi, O.J., Al Rwahnih, M., Gandhi, K., Poojari, S., Fuchs, M., Rowhani, A. and Rayapati A. N. (Phytopathology, 2011, 101:1446-1456) were also published. Another article titled "A Plant-level, spatial, bioeconomic model of plant disease diffusion and control: Grapevine leafroll disease" by Atallah, S., Gomez, M, Conrad, J.M. and Nyrop, J.P. is in press in American Journal of Agricultural Economics.

We are also in regular contact with Finger Lakes growers who adopted our management recommendations. We assist them in optimizing roguing for better control of leafroll disease. Our continued engagement with the grape and wine industry help raise awareness on disease impact, promote integrated pest and disease management strategies based on a predictive model for virus spread and profitability estimates.

Two grape growers (owners of the two Chardonnay vineyards selected for this study) and vineyard managers at 10 wineries in the Finger Lakes region of New York contributed to the success of the project. The two growers provided access to their Chardonnay vineyards for evaluating the efficacy of insecticides at reducing virus spread and determining the viruliferous potential of mealybugs over time. The vineyard managers at 10 wineries contributed to the surveys on the economic impact of leafroll disease. The direct involvement and contribution of grape growers and vineyard managers put us in an ideal position to address all the objectives of the project.

Goals and Outcomes Achieved

To determine the efficacy of insecticides at reducing populations of mealybugs, Movento® was applied at budswell (April) and bloom (June) from 2011 to 2013, and a follow-up census of mealybugs were done on treated and untreated vines. To valuate the efficiency of insecticides at slowing the natural spread of viruses by reducing the rate of virus acquisition and transmission by mealybug vectors, the incidence of GLRaV-1 was tested in every vine from 2011 to 2013 and trends over time were analyzed. To develop crop budgets to assess costs of leafroll disease management, vineyard managers were surveyed and net present values were used to determine the most attractive management options from a biological and economical perspective. To reach out to the grape and wine industries in order to raise awareness on disease impact, promote integrated pest and disease management strategies based on a predictive model for virus spread and profitability estimates, oral presentations were given and extension articles were written and published.

Progress has been made towards achieving all set goals. Some growers have even adopted some of our disease management recommendations. A comparative analysis of accomplishments and set goals indicates completion of all activities and tasks. We achieved all the objectives of the project.

Movento® was shown to effectively reduce populations of *P. maritimus* mealybugs and to slow the spread of GLRaV-1. Estimates of the economic impact of leafroll disease ranged from $10,282 to $16,600 per acre with roguing ($1,298-$22,677 per acre) and vineyard replacement ($9,977 per acre) being recommended as disease management if virus incidence was <25% or >25%, respectively. Reaching out to the local grape and wine industries helped raise awareness on disease impact, promote integrated pest and disease management strategies.

Beneficiaries

Several grape growers in the Finger Lakes have adopted our recommendations in terms of disease management. Some have replaced entire leafroll-diseased vineyards. It is estimated that at least 10 acres of leafroll-affected vineyards were removed in 2012 as a direct consequence of our research and outreach efforts. Other growers and vineyard managers are practicing roguing; they replace diseased vines with healthy vines if disease incidence is less than 25%.

A dozen grape growers and vineyard managers in the Finger Lakes region of New York have adopted our disease management recommendations, i.e. roguing or vineyard removal. As a direct consequence of our outreach efforts, they recognized the impact of leafroll on fruit quality and decided to implement our economically attractive management options that were tailored to their vineyards and business models.

Lessons Learned

The project relied on a multidisciplinary approach. It was based on the contributions of entomologists, economists, virologists and extension educators. This complementary interdisciplinary approach was paramount to the success of the project. In particular, the contribution of economists was key in raising awareness and convincing the grape and wine industry of the negative impact of the disease. The involvement of economists was also essential for the adoption of optimal management options by the grape and wine industry in New York.

Based on our success, we are currently expanding our project to California and assessing the economic impact of leafroll in the major grape-growing region in the United States, with funding in part by USDA-APHIS.

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Project 13
Education & Promotion of the Nutritional Benefits of New York's Specialty Crops

Project Summary

As interest and participation in "buy local" has grown dramatically, interest from schools is also growing and presenting many new opportunities for New York farmers. In response to this interest, the New York State Department of Agriculture & Markets (NYSDAM) has led the creation of and continues to staff the New York State Farm to School Coordinating Committee, comprised of food service directors, growers, health professionals, distributors, parents and other advocates of featuring locally-grown, healthy foods in school meals. Together, they are collaborating to advance sound policies, programs and resources to expand capacity for successful farm to school efforts throughout the State.

As a result, Farm to School efforts are now common throughout the State with most schools organizing events for New York Harvest for New York Kids Week. New York Harvest for New York Kids, or "Farm to You Fest!" is a weeklong celebration of local food and agriculture where a diverse variety of activities occur throughout the State. During this celebration, school cafeterias feature New York farm products, classes do food-tastings, schools visit farms and farmers markets, students harvest their school gardens, and much more.

The purpose of this project was to provide a new resource that food service directors, parents, teachers, school administrators and others can use during *New York Harvest for New York Kids Week* and throughout the year to help schools and communities learn about New York agriculture, enjoy locally-grown foods, and inspire healthy food choices.

This project built upon funding provided by FY06 SCBG that supported printing of the first set of produce trading cards featuring new specialty crops. This project enhanced and expanded these previous efforts, as the trading cards were very popular and in high demand after first being introduced.

NYSDAM match covered all costs associated with non-specialty crop portion of the *Fascinating Food & Farm Facts brochure* (27% of the brochure). The *Fascinating Food & Farm Facts* brochure constituted 6.75% of the total requested SCBG funds for this project.

Project Approach

In review, all of the following work plan tasks were successfully executed between 2010-2012: 1) Developed content for nine *Produce Trading Cards*; 2) Translated the *Fascinating Farm & Food Facts* from English into Spanish; 3) Worked with graphic artist to configure typeset and layout of *Fascinating Farm & Food Facts* brochure, Spanish version; 4) Printed the *Fascinating Farm & Food Facts* brochure, Spanish version; 5) Worked with graphic artist to illustrate, work on layout and typeset of trading cards and then utilized Lane Press to print two-sided, perforated 8 ½ x 11 silk cover sheet allowing separation of individual 2 ½ x 3 ½ cards; 6) Translated *Produce Trading Cards* into Spanish; 7) Worked with graphic designer to configure typeset and layout of *Produce Trading Cards*, Spanish version and then printed brochures; 8) Successfully distributed the *Produce Trading Cards* and *Fascinating Farm & Food Facts* brochures to farmers' markets, schools, and many other outlets; and 9) tracked distribution of materials to gather both qualitative and quantitative outcome data.

In the first year, 10,000 copies of the Spanish *Fascinating Farm & Food Facts* brochure and 40,000 English *Produce Trading Cards* were printed, all of which were successfully distributed to multiple educational outlets. Due to its popularity, an additional 20,500 English trading cards were printed in 2013. In 2011, a process for schools and community organizations to place order for the promotional materials was created. This included outreach about the availability of the new materials an order form and database, which was populated as materials were distributed. Utilization of this process was done throughout the remainder of the grant period. Further, a survey for NYS School Food Service Directors (FSDs) was drafted

and distributed in 2012 via Survey Monkey to not only gauge interest and barriers to farm to school participation, but also interest in and knowledge of the promotional materials. Survey findings yielded that many FSDs were unaware of the promotional materials, and so additional email blasts and outreach to institutions were subsequently executed. This included correspondence with the New York State School Nutrition Association (SNA), exhibiting at food system conferences, and holding meetings to discuss best practices with the NYS Farm to School Coordinating Committee.

Thousands of children have been positively impacted as a result of this project. There was on-going participation in *Farm to You Fest!* from institutions spanning across NYS. During each weeklong event, the Department received a multitude of orders and mailed the requested materials in a timely manner. Even after *Farm to You Fest!* ended each year, the public's interest in ordering materials was still prevalent. In addition to mailing the requested promotional materials, the Department shared through additional outlets, such as distributing at farmers' markets, conferences, farm to school and nutrition events, and more. The cards were also shared with partner organization *The Rock on Café*, which manages 13 school districts in the Broome-Tioga region of New York State and offers healthier versions of food that children like while still being affordable, convenient and locally sourced.

Goals and Outcomes Achieved

Several avenues were taken to achieve/measure the desired outcome. First, a connection with a graphic artist/designer was developed to foster creative concept for the promotional materials. Second, a method for ordering the materials from the Department website and conducting outreach was developed. Third, a yearly spreadsheet was established to maintain orders for promotional materials, capture the activities featuring the promotional materials, and evaluate the number of children impacted. Fourth, continuous attendance at conferences, meetings, schools, and various farm to school events assured that public knowledge of the materials was preserved.

The expected measureable outcome set in the original approved project proposal was for the materials to reach about 80,000 school aged children. According to multiple data sheets, the project was successful in achieving a number close to this target, an average of 61,166 children over the course of three years and with steady participation. Additional support for the popularity of the promotional items include continuous requests for the materials. One hundred percent (100%) of the 10,000 copies of the *Spanish Fascinating Farm & Food Facts* brochure and 40,000 English *Produce Trading Cards* have been expended. Of the second order in 2013, about 6,000 of the 20,500 English Produce Trading Cards currently remain.

Beneficiaries

A multitude of diverse organizations and individuals have been affected by this project. Data illustrating yearly participation in *Farm to You Fest!* includes the following:

- In 2011, more than 60,000 children and families from 40 counties and more than 30 school districts across NYS received promotional materials
- In 2012, more than 55,000 children and families from more than 25 counties across NYS received promotional materials
- In 2013, more than 68,000 children and families from 32 counties across NYS received promotional materials

As captured by the project data sheets, participating organizations include, but are not limited to pre-schools, day care centers, elementary, middle, and high-schools, Senior Centers, WIC, Child Day Care Programs, Cornell Cooperative Extension offices, and Youth Gardening Programs. The Block Institute in Brooklyn has been a participant for over four years, consistently offering events such as petting zoos; apple

themed activities; farmers' market showcases; harvest from school garden development and nutritional lessons.

Many schools showcased farmers' market produce stands in the cafeteria; some established school gardens; while others went on field trips to local farms for children to pick produce and then prepare lunch with the school chefs. NYS WIC programs provided parents and caregivers with instructions on how to prepare fresh apple sauce from local apples; and, in 2011, the NY Fresh Connect Ag POD (Agriculture Promotion, Outreach and Demonstration mobile kitchen) celebrated Farm to You Fest! in Endicott where students and community members were encouraged to "build their own tacos" using fresh, local ingredients.

Additional *Farm to You Fest!* events featuring the promotional materials include, but are not limited to: 1) Erie County schools providing prizes and giveaways to the students who try the fresh fruits and vegetables in their breakfast and lunch programs; 2) Rockland County hosting a *Rockland County Farm Tour!* which included workshops, kids' activities, cooking demonstrations, and farm tours; 3) Ulster County distributing produce trading cards at farmers' markets; and 4) Suffolk County featuring locally-grown potatoes and apples in their school.

Lessons Learned

Lessons learned from this project are quite positive. It was apparent that the target audience had a strong desire for educational materials promoting nutrition and local agriculture to be used in a variety of settings. There was an overabundance of positive feedback regarding the materials which continuously drove requests. An unexpected outcome of this project was the overwhelming desire for the *Produce Trading Cards,* which have since then been asked about by other, and even out-of-state organizations regarding how to replicate and produce.

However, as an avenue to ensure fidelity of future projects, a data collection sheet should be utilized by all project partners if promotional materials are being utilized. Unfortunately, not all events where the promotional materials were featured recorded the number of materials shared with the public. There were, however, unexpected outcomes and delays. In November 2011, the project manager left the Department and there was a long transition period during the next several months. Due to this transition, the project experienced a long delay in ultimate completion; therefore, the remainder of project money was expended in early 2013 on the last order of English *Produce Trading Cards.* There were likely requests that came in during the transition period that were never reported.

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Additional Information

- Fascinating Farm Facts Brochure PDF:
  http://www.agriculture.ny.gov/f2s/documents/FF_FF_Brochure_2010.pdf
- Farm to School Resource Page:
  http://www.agriculture.ny.gov/f2s/resources.html
- Order form for Promotional Materials:
  http://www.agriculture.ny.gov/f2s/documents/2013_FTUFest_OrderForm.docx

- Farm to You Fest! 2011 Participation List: http://www.agriculture.ny.gov/f2s/documents/FarmtoYouFest_Events2011.pdf
- Map of Counties Impacted by Farm to You Fest! 2011: http://www.agriculture.ny.gov/f2s/documents/FTUFest_2011Map.pdf
- Farm to You Fest! 2012 Participation List: http://www.agriculture.ny.gov/f2s/documents/2012FarmtoYouFestEvents.pdf
- Farm to You Fest! 2013 Participation List: http://www.agriculture.ny.gov/f2s/documents/2013FarmtoYouFestEvents.pdf
- 2012 Food Service Director Survey Highlights: http://www.agriculture.ny.gov/f2s/documents/2012_FSD_Results.pdf

- **Produce Trading Cards**

Tomatoes

Taste Tomatoes diced, sliced, stewed, pickled or fried; they are the base for many sauces and salsas

Did you know…?

- Botanically, tomatoes are ***actually a fruit!*** Vegetables are edible stems, leaves, and roots; fruits are the parts that contain seeds. The Supreme Court ruled to classify them as a vegetable in 1893
- Producing approximately ***35 million pounds annually,*** New York is the 9th ranked tomato producer in the nation
- Tomatoes contain powerful ***antioxidants,*** proven to lower the risk of many cancers
- Tomatoes are known as '***the apple of love***' in some cultures

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Potatoes

Dig into Potatoes baked, roasted, mashed, in soups, or served hot or cold in salads

Did you know…?

- Potato '***eyes' are sprouts*** that start the growth of a new plant
- Potatoes provide one of the most concentrated sources of potassium, which is important to ***build stronger bones***
- About ***20,000 acres*** of potatoes are grown for seed, fresh and processing in New York
- The average person eats ***126 pounds of potatoes a year,*** which are healthiest when eaten with the skins on
- ***Adirondack Blue*** potatoes were developed at Cornell University; they are unique in that they are blue-colored inside and out

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Asparagus

Spear Asparagus that is steamed, stir fried, or roasted; add to pasta, or soups

Did you know…?

- Asparagus plants can grow up to ***5 feet tall*** and produce for 15 years without being replanted
- Asparagus is one of the ***most nutritionally well-balanced vegetables.*** It is an excellent source of vitamins K, C, A and folic acid that produces healthy blood cells
- Asparagus was first cultivated about ***2,500 years*** ago in Greece; its name means stalk in Greek
- Asparagus is a spring vegetable and is a ***cousin of onions and garlic***

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Cherries

Chow down on Cherries, sweet or tart; consume them fresh, dried, frozen, in pies, juice and jams

Did you know…?

- On average, a sweet cherry tree will produce 800 cherries a year; a tart cherry tree can produce 7,000 cherries a year! It takes about ***250 cherries to make a pie***
- ***New York ranks 4th*** in the U.S. in tart cherry production, growing approximately 10 million pounds annually
- With their distinct bright color, cherries contain ***disease-fighting antioxidants***
- Cherries are believed to help ***prevent memory loss*** and delay the aging process

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Broccoli

Rock with Broccoli in salads or bake on top of pizza, steam lightly or stir-fry

Did you know…?

- Like most vegetables, broccoli ***loses valuable nutrients,*** flavor and its vibrant color if ***overcooked***
- Broccoli is a hearty plant and ***grows best in cool weather***
- A broccoli head is actually a compact cluster of ***unopened flower buds***
- Broccoli contains a ***powerhouse of vitamins*** including A, C, and K; it has the unique ability to detoxify your body
- The name broccoli is from Latin and means branch or arm to reflect its ***tree-like shape***

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Peas

Pile on Peas shelled or in the pod, cooked or raw, they are supercharged legumes

Did you know…?

- If you feel sluggish, ***eat peas!*** Peas have very good amounts of 8 vitamins, 7 minerals, fiber and protein that support ***energy producing cells*** in your body
- There are ***three common types of peas***: garden, snow and snap
- Snow peas are flat; snap peas are plump; both have ***edible pods***
- New York grows over ***38,000 tons*** of peas annually on more than 17,000 acres; most are frozen or canned

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Peppers

Polish off Peppers in salads, sandwiches, relishes, sautéed, roasted or stuffed; their bright colors perk up a veggie platter!

Did you know…?

- Bell peppers come in ***green, red, purple, orange, brown or yellow*** and have various levels of sweetness; red are the sweetest
- Peppers are excellent sources of vitamins C and A, which help ***ward off diseases*** such as cancer, arthritis, and cataracts
- Like tomatoes, ***bell peppers*** are botanically ***fruits,*** but considered as vegetables
- Peppers grow best in ***hot weather and moist soil;*** they do not like cold and need to be protected on frosty nights

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Beets

Feast on Beets grated in salads, roasted, or pickled; you can also eat the leaves just like spinach

Did you know…?

- When cooked, beets have a ***sugary, buttery, and earthy flavor***
- Beet roots are loaded with vitamins A, B1, B2, B6 and C; the ***leaves*** contain the ***finest quality of iron*** that is highly effective in treating many ailments
- The deep red color of beets comes from betalain — a pigment often used as a ***natural food dye***
- Beets are in the plant order Caryophyllales that also includes ***cacti, carnations, spinach and venus fly traps***

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Design & Illustration by Alice Bernat • www.alicebernat.com TC#17/2011

Pears

Pick Pears to eat fresh, bake or grill, add to salad or serve with cheese; they are delicious in jams and chutneys

Did you know…?

- Pears are a unique fruit that ***ripen best off the tree;*** and ripen from the inside out
- Pears are a ***good source of vitamin C*** that aids in fighting infections and viruses
- There are over ***3,000 pear varieties*** grown around the world; popular varieties grown in New York are Bartlett and Bosc
- New York ranks 4th in the U.S. in pear production, with over ***11,000 tons*** produced annually

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Project 14

Pride of New York "Buy Local" Wholesale/Retail Promotion Program

Project Summary

The purpose of this project was to address growing consumer demand for specialty crop products at the retail and wholesale levels throughout the State. Based on previous conversations with retail produce managers, they communicated sometimes having difficulty knowing where to look for local produce and/or lacked the resources to source locally. At the same time, some farmers, particularly small operators, said they were overwhelmed with making sales connections to retailers.

Recognizing a need to help both sides of the equation, the intent of this project was to provide promotional and marketing assistance to retail grocery chains so they can develop or expand consumer-focused, customized, "buy local" fresh produce promotions as well as increasing opportunities to highlight thousands of other processed specialty crop products, which are available to the State's consumers throughout the entire year.

In addition, in order to build synergies between growers, distributors and retailers in buy local sales, NYSDAM helped specialty crop wholesalers to differentiate New York Grown products by designing and producing "Grown in New York" box stickers. The stickers featured the Pride of New York logo so growers, distributors and wholesalers could feature New York grown produce and make them readily identifiable "on the dock". NYSDAM had received input from buyers of various scales, both retailers and wholesalers, that this would help move New York produce more efficiently to shelves and increase sales volumes.

Because of limited response and challenges that retailers faced to participate in a program, as well as staffing changes at NYSDAM, this project was implemented on limited basis and scope was amended to address different wholesale opportunities (see Project 17). None the less, as a result of this project, two large retail chains participated and reported increased specialty crop sales as a result. Also, 11,000 "Grown in New York" box stickers were produced and distributed to the State's wholesale distributors and due to their success, NYSDAM has received numerous requests for more stickers.

Project Approach

In March 2011, NYSDAM announced the Pride of New York "Buy Local" Wholesale/Retail Promotion Program by issuing a press release (http://www.agriculture.ny.gov/AD/release.asp?ReleaseID=1949),regarding the availability of funding for promotional and marketing assistance to retail grocery chains so they could develop and/or expand consumer-focused, customized "Buy Local" fresh produce promotions. NYSDAM submitted the release to industry newsletters and met with retailers to provide information and answer questions about the program.

Program guidelines and participation requirements that were developed were as follows:

- The "Buy Local" Retail Promotion Grant Program was open to individual food stores, as well as grocery store chains in New York State. Each applicant is eligible for up to $3,500 to highlight fresh produce, and $1,500 to promote processed and value-added products made in New York, including, but not limited to those involving specialty crops, such frozen produce, jams and jellies, maple syrup and honey.

- Grants were awarded on a first come, first served basis. Awarded funding had to be matched by the retailer and no more than $350 per individual store will be awarded. The funding could have been used to supplement existing consumer-focused programs or to initiate new "buy local" retail efforts.

- For all eligible applicants, NYSDAM also provided promotional and marketing assistance in developing or expanding "buy local" promotions that can be customized and consumer-oriented and that range from point-of-sale materials and promotional items to advertising.
- Any projects that include non-specialty crops must use their match to cover the non-specialty portion of the project so that grant funds were limited solely to specialty crops.
- Each retailer that expressed interest in the program was contacted to discuss implementation, development, and placement of their retail promotional materials.

Goals and Outcomes Achieved

Retail Promotion Program

- Of the three retailers that participated, specialty crop items were promoted by via large display signs, portable banners and print media. Their placements helped promote sustainability and increase consumer awareness and brand recognition amongst thousands of consumers daily.
    - One retailer used signage and a portable display at a buy local awareness day held at a local college festival to raise Pride of New York awareness within the student population. One section of the display featured "Why Buy New York?" while at the store, stickers were placed on eligible specialty crop items so the students and other consumers could identify locally produced items.
    - Another major retailer's project consisted of a 4-page ad insert, in-store signage, and a "Close to Home" brochure distributed to approximately 12,400,000 consumers. Items featured in the 5/8/11 flyers resulted in a 47% lift in the week following the ad. Items featured in the 8/14/11 flyer resulted in a 35% lift in the week following the ad. Items featured in the 10/2/11 flyer resulted in a 27% lift in the week following the ad. Sales of brochure items increased by 3.2% in the two months following the release of the publication.
    - The third retailer focused their promotion on local maple syrup by creating a banner that was seen by approximately 15,000 motorists per day.
- Overall, based on phone interviews, sales were estimated to have increased 6% as a result of the promotions.

Wholesale Promotion Program

- 11,000 "Grown in New York" box stickers were produced and distributed to the State's wholesale distributors, in partnership with the New York growers that they source from, to feature New York grown produce. This project was well received by the wholesale distributors, growers and co-op organizations that participated and the NYSDAM received numerous requests for more stickers.

Beneficiaries

Of the six large retailers that applied, two qualified and/or decided to proceed with their project and receive funding. Although retail participation was limited, literally thousands of consumers were exposed to the "buy local" information and specialty crop producers received increased exposure as a result.

Lessons Learned

Although there was an interest in the "Buy Local" Retail Promotion portion of the program, as the program requirements were discussed in detail with each applicant, several of the larger retailers regrettably decided to withdraw their applications for reasons such as:

- the requirement of having to exclusively promote specialty crops and concerns about tracking data accordingly
- the limited amount of funding that was being offered did not warrant them redesigning their promotional materials

Therefore, making adjustments to the activities and requirements to make it more flexible, as well as providing sufficient funding, is critical to a program such as this succeeding. Understandably, a grocery store's own promotional program takes precedence over a statewide branding initiative/marketing campaign. Symbiotic approaches to such initiatives must be developed in a manner that does not create any burden on the retailer and is easy for them to incorporate into their own identify (and not appear too similar to their competitors).

For the smaller scale retailers, strained economic conditions at the time of this project being offered resulted in them cutting back their advertising budgets. This coupled with of the required paperwork to participate resulted in them withdrawing their applications. Increasing the amount of funding available would likely create a more realistic incentive for their participation.

One aspect of this project that was not implemented, which still holds significant potential, is to work with retailers to highlight the thousands of processed specialty crop products (e.g. frozen vegetables, salsa, pickles, etc.) that are produced in the State but are not currently promoted to the extent that fresh produce is. Because of seasonal limitations in the northeast and consumers' growing interest in "buy local", this represents a tremendous opportunity to increase sales on a year-round basis.

In addition, staffing changes at NYSDAM, in combination with the need to make program adjustments, impacted our ability to give the program the full attention it needed. At the time the project was being developed, a staff person with significant retail experience, who had developed relationships with retail produce staff over a period of years, decided to retire. This left an immediate gap in expertise and program delivery. Providing ongoing individual assistance and follow-up with retailers is key to a program such as this being successful.

Contact Person

Dtrae Carter
Marketing and Promotion Specialist
NYS Department of Agriculture & Markets
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Albany, NY 12235
(518) 457-2774
Dtraecelle.carter@agriculture.ny.gov

Additional Information

See application template on next page

Pride of New York "Buy Local"

Retail Promotion Grant Program

APPLICATION

Name of retail business _____

Name of contact: _____

Street address: _____

City:_____ State:_____ Zip:_____

Telephone: _____ Cell: _____ Fax: _____

E-Mail: _____ Website: _____

1) Grant funds applying for: ☐ Fresh Produce

☐ Value-Added/Processed

2) Please submit the number of stores you have in New York State and their locations to: phillip.bibbo@agmkt.state.ny.us

3) Please describe how you intend to use these "Buy Local" grant funds to promote New York producers/processors. (Attach additional sheets as necessary)

_____

_____

_____

_____

_____

_____

_____

_____

4) Please list the New York State producers and/or processors you will be purchasing from. (Attaching a list or emailing to phillip.bibbo@agmkt.state.ny.us is also acceptable.)

Producers

Name/City	Products

Processors

_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____

5) Please provide your proposed project budget in the table below. Other state or federal grant funds cannot be used for this program.

Description of Deliverable (e.g. POS producer signage)	Grant Funds	Applicant Match		Total
		Amount	Source	
	$	$		$
	$	$		$
	$	$		$
	$	$		$
			Total	$

I certify that the information contained in this application is accurate and complete.

Signature _____ Date _____

Questions: *Contact Phil Bibbo, Retail Promotion Specialist, Pride of New York Program (518) 457-6773 or phillip.bibbo@agmkt.state.ny.us*

NYSDAM USE ONLY Date recv'd _____ By: _____ VIA: ___ email _____ fax ____regular mail

Project 15
Organic and Sustainable Fruit & Vegetable Storage Guide

Project Summary

Fruit and vegetable producers, especially those growing a diversity of crops, need up-to-date, easy to access storage techniques for their farm products. Sustainable and organic produce storage recommendations are needed by the countless small and larger farmers who are either transitioning to organic production or are currently producing organically, who must comply with the USDA National Organic Program.

Storage techniques are critical not only for storage vegetables, but also for all fresh produce. Anecdotal information (newspapers) indicates that farmers are not only increasing their use of short-term storage facilities, but also constructing new longer term storage, to increase their sales days and market opportunities. It is very likely that the new USDA NASS census data will reveal just how much additional storage is being built by producers.

For storage vegetables and fruits, storage success begins with the timing of harvest and the specific care given the harvested crop at that time. Not only is it important to keep the specific fruit or vegetable from acquiring storage diseases, but the crop's actual sugar to starch ratios change over time and storage techniques can be used to keep crops at the stage desired by the market.

Producers can gain days of marketability for perishable vegetables and fruits depending on harvest techniques associated with short-term, optimum storage conditions. Perishable crops can be extremely high value and even one additional day of shelf life can mean more grower market flexibility and customer satisfaction.

This project created and distributed a *Production Guide for Storage of Organic Fruits and Vegetables* – a comprehensive, user-friendly, farmer oriented resource that is available for download for free on the New York State Integrated Pest Management (NYS IPM) website.

Project Approach

Staff of the NYS IPM program coordinated the knowledge base of faculty and staff at Cornell University and wrote a manual that provides state-of-the-art storage techniques for organic vegetables and fruits grown in NYS, herein referred to as the "storage guide". Much of the expertise in crop post-harvest care is as specialized as crop production. Consequently, the expertise of Cornell faculty, closely associated with the NYS IPM program staff, can be tapped by the project contractor.

Cornell's method for writing the storage guide was to locate either University or other national expertise on the topic and ask the expert contributor to provide the substance. Then one individual wrote the entire guide, pulling together advice from each contributor. In this case, Dr. Chris Watkins, a national expert at Cornell University on fruit storage, pulled together the content for the guide.

The project work plan specified that farmers be involved in review of the draft manual. The draft manual was distributed to at least 6 farmers with different specialty crop storage needs, as well as the NYSDAM coordinator. Their input was incorporated into the storage guide.

The manual was not completed when originally planned, due to staff changes at the NYS IPM program; however, the storage guide was made available to the public in the spring of 2012.

Outreach for promotion of the guide was accomplished via NYS IPM program press release. (See: http://www.nysipm.cornell.edu/press_rel/stored_products.asp) The guide itself can be downloaded at: http://www.nysipm.cornell.edu/organic_guide/fruit_org_guide.asp.

Beneficiaries

New York State's 850+ certified organic producers and sustainable producers who use organic practices but do not seek certification, are the most direct beneficiaries of the storage guide. However, there are many more diversified fruit and vegetable producers in New York who can benefit from the information contained in the storage guide.

The number of tracked downloads for 2013 was 381 unique users. There were technical issues in tracking the number of downloads over a 7-month period (from June-December 2012), including when the manual was first released. Unfortunately, this is likely when the volume of traffic to the website and corresponding downloads was the highest, but we do not have data to support this. On a positive note, because this was a Land Grant University publication, the breadth of outreach was magnified and available for effective distribution by other States.

In addition, since the pdf-format of the manual allows anyone to print the document, it is also important to note that the major organic organization in the state, NOFA-NY, has downloaded the storage guide and made it available to their members and all those who visit their site.

Lessons Learned

The most important lesson that we learned on this project is that the information regarding best post-harvest and storage techniques is changing, based on new research. For example, researchers have only recently focused on lesser known food properties, such as phytochemicals that are not, in and of themselves, vitamins or minerals. Research into harvest and storage impacts on these components of food will likely dictate storage recommendations that will best preserve these newer and now clearly valuable food components.

In addition, organic specialty crop storage, like crop production, does require pest and disease control. Controls can include pesticides. Consequently, as new pesticides are introduced and become available to organic producers, they need to be incorporated into the storage manual.

Contact Persons

- Christopher B Watkins, Associate Director for Agriculture and Food Systems
  Cornell Cooperative Extension
  College of Agriculture & Life Sciences
- Herman M. Cohn, Professor
  Postharvest Science
  Department of Horticulture
  356 Roberts Hall
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  607-255-8546
  cbw3@cornell.edu
- Sarah Johnston, coordinator
  NYS Department of Agriculture & Markets
  (518) 457-4531
  sarah.johnston@agriculture.ny.gov

Project 16
Good Agricultural Practices Education and Certification Assistance Program

Project Summary

Fresh and minimally processed, ready-to-eat fruit and vegetable production is a multi-billion dollar industry in the United States. In recent years, food safety has become a major concern in the production of fresh produce in the United States and globally. Many major international and domestic retailers, wholesale buyers, foodservice companies, restaurants and schools now require their suppliers to provide certification from a third-party to verify adherence to Good Agricultural Practices (GAP); and/or Good Handling Practices (GHP). In order to assist New York's specialty crop producers and handlers of fresh produce address these growing demands and remain competitive in the marketplace, the New York State Department of Agriculture & Markets (NYSDAM), using funds from the 2010 Specialty Crop Block Grant Program-Farm Bill (SCBGP-FB), implemented a multi-faceted food safety program to educate growers about GAP/GHP requirements as well as to assist growers, producers and handlers in paying the costs associated with first time audits, informational assessments and costs of water testing to comply with GAP/GHP.

Project Approach

The *Good Agricultural Practices Certification Assistance Program* was established so growers and handlers could receive financial assistance in paying up to $750 of costs associated with third party GAP/GHP audits. This reimbursement approach was taken in order to provide a significant incentive for producers who were not familiar with the GAP/GHP certification process and may therefore be hesitant to have an audit performed or may not otherwise be able to afford it. The audits were performed by NYSDAM and funds distributed on a first-come, first-served basis. An informational brochure and associated program applications/forms were developed and made accessible both in hard copy and on NYSDAM's website.

In order to effectively and efficiently target producers/growers/handlers, outreach and education was conducted at venues throughout the State including farm/trade shows, county fairs, food safety conferences, etc. In addition, Cornell Cooperative Extension conducted nine GAP workshops throughout the State in partnership with Cornell University staff and NYSDAM.

Furthermore, in order to meet the increased need and demand for certifications, funds were used for training auditors and to maintain necessary certification of USDA auditor qualifications.

Goals and Outcomes Achieved

Total grower/packers/handlers participation in GAP/GHP audits in New York State nearly doubled by the completion of this project, compared to previous years. In the previous SCBG cycle (2008-2010), NYSDAM conducted 267 audits in total, with 161 of them being first time audits. At the conclusion of this SCBG grant cycle (2011- 2013), NYSDAM conducted 532 audits in total, with 121 of them being first-time audits eligible for reimbursement (see table below). This growth in participation indicates that growers/handlers who have audits for the first time, as a result of this program, are continuing to have audits conducted in future years, thereby leading to increased food safety and long term benefits to both producers and consumers.

Year	# of first-time GAP/GHP audits performed by NYSDAM
2011	36
2012	29
2013	56
TOTAL	121

NYSDAM provided and/or participated in over 34 outreach and educational regional venues over the course of the project, directly reaching more than 2,000 growers/packers/handlers. This included 14 venues in 2011 reaching more than 1,060 individuals, 11 venues in 2012 reaching more than 475 individuals, and 9 venues in 2013 reaching more than 550 individuals.

All growers who attended the multi-day GAPs training course initiated development of their individual farm food safety plan. In addition to developing their own food safety plans, many of these growers have attended a mock audit conducted by NYSDAM auditors. These mock audits are conducted on a farm whose owner has volunteered to share their farm food safety plan with other attendees so that growers can learn about audit expectations and processes. This multi-day GAPs training course is a collaborative effort between NYSDAM, Cornell University, Cornell Cooperative Extension, and the National GAPs Program to provide education and outreach to growers to support development and implementation of produce safety practices. Interviews are currently underway with growers to learn more about the status of individual farm food safety plans, progress towards completing third party audits, and the economic costs and benefits of implementation.

In 2011, 17 NYS auditors attended 3 day live meeting training for Harmonized audit, a new audit checklist developed by produce industry and USDA. One auditor attended new auditor training in Fredericksburg, VA in 2013. Currently, New York State has 17 USDA licensed GAP auditors and one auditor is currently being trained on the job.

Beneficiaries

The primary beneficiaries were the numerous New York State growers and handlers that participated in the various workshops and educational outreach sessions, and/or had a GAP/GHP audit performed for their operation.

A secondary group of beneficiaries were the various levels of major international and domestic retailers, wholesale buyers, foodservice companies, restaurants and schools that participated in educational outreach venues and/or had their produce suppliers participate in this program and became more aware of the benefits of GAP/GHP.

A third group of beneficiaries are the millions of consumers of locally produced fresh fruits and vegetables who benefitted from improved food safety practices on farms and at handling facilities.

Lessons Learned

This project demonstrated that providing financial assistance to growers/handlers for first-time third party GAP/GHP certification is an effective way to encourage participation in implementing and documenting effective food safety practices. Coupling that assistance with broad-based educational outreach and comprehensive technical assistance throughout the certification process significantly extended the impact of the grant funds and resulted in grower/handler implementation and satisfaction.

Many producers who participated in this program realized that they were already implementing many of the recommended food safety practices, but just weren't documenting it within the context of a food safety plan. As a result, the perceived costs associated with potential changes to improve food safety practices were not as significant as some growers/handlers feared. At the same time, this project demonstrated that as producers/growers/handlers become more aware of food safety issues and incorporate changes in their practices into a farm food safety plan, the benefits of GAP/GHP certification become increasingly recognized throughout the industry.

Another lesson learned is that the diversity of the fresh and minimally processed produce industry needs to be considered on many levels throughout the development of a food safety education and implementation program. New York State's specialty crop industry is particularly diverse and complex, consisting of farms with a wide range of commodities, sizes and shapes. As a result, developing a program, educating the industry and implementing GAP/GHP procedures on individual farms is challenging and requires cooperation and working partnerships among various segments of the industry, including farmers, buyers, commodity organizations, educators, and government agencies.

Contact Person

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Project 17

Pride of New York Pavilion at 2013 Produce Marketing Association Trade Show

Project Summary

The New York State Department of Agriculture & Markets has historically supported domestic and international marketing by sponsoring an exhibitor pavilion at the Produce Marketing Association's (PMA) Fresh Summit. The Produce Marketing Association's (PMA) Fresh Summit Produce Expo provides a unique opportunity for the New York State Department of Agriculture and Markets to assist with the marketing and promotion of the NYS Specialty Crop growers who exhibit at the New York State pavilion.

We received feedback from industry that grouping producers under one New York State Pavilion provides much greater visibility and increased impact upon potential buyers. When Expo attendees walk down the aisles and see individual grower exhibits, which are spread out in many different locations, there are two common results. One, buyers often do not realize how many producers are from New York, or that New York produces the variety of specialty crops that it does. Secondly, not all New York producers receive the same traffic or attention as others, due to their individual booth locations, which detracts from the overall industry presence and strength.

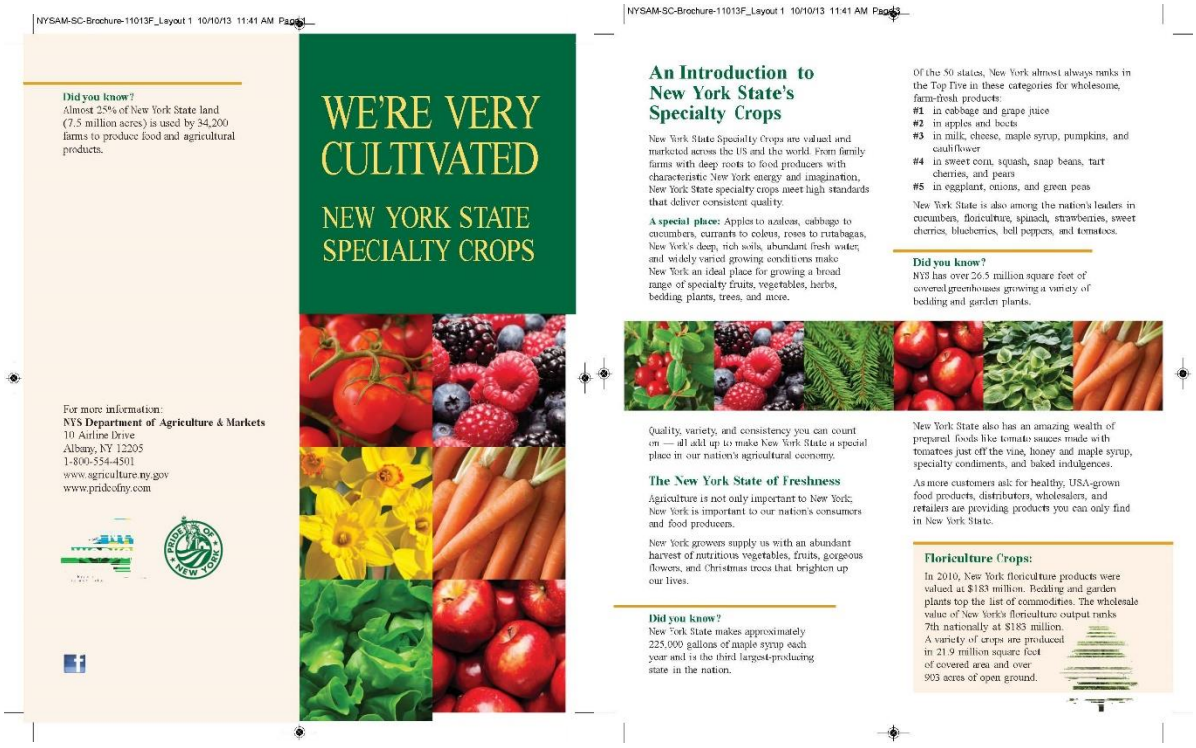
For the 2013 PMA Expo, the Department provided assistance by implementing a marketing and promotional plan that included assisting and supporting the companies and associations that exhibited at the Fresh Summit. The project was developed to create greater awareness among the Expo attendees that New York is a supplier of a wide array of fruits and vegetable and to encourage broader industry participation in the Expo.

Project Approach

Prior to the expo, the Department contacted the eleven (11) / seven (7) New York companies that had registered to exhibit in the NY Pavilion as well as those that exhibited at other locations within the venue. They were advised that there were unencumbered funds available from a 2010 USDA Specialty Crop project and that the funds had been re-allocated for the marketing and promotion of this event. They were asked to provide their comments and/or suggestions on how the funds should be spent to meet the expected measureable outcomes. This was an important fact to communicate as the timeframe that was available limited the activities to be performed and it was important that they were made aware of the activities that were to be implemented. These efforts included:

- A Department generic tradeshow booth that was located in the New York pavilion highlighting the diverse Specialty Crops available in NYS.

- A brochure was produced and made available at the Department booth.



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Did you know?
Almost 25% of New York State land (7.5 million acres) is used by 34,200 farms to produce food and agricultural products.

For more information:
NYS Department of Agriculture & Markets
10 Airline Drive
Albany, NY 12205
1-800-554-4501
www.agriculture.ny.gov
www.prideofny.com

WE'RE VERY CULTIVATED

NEW YORK STATE SPECIALTY CROPS

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An Introduction to New York State's Specialty Crops

New York State Specialty Crops are valued and marketed across the US and the world. From family farms with deep roots to food producers with characteristic New York energy and imagination, New York State specialty crops meet high standards that deliver consistent quality.

A special place: Apples to azaleas, cabbage to cucumbers, currants to coleus, roses to rutabagas, New York's deep, rich soils, abundant fresh water, and widely varied growing conditions make New York an ideal place for growing a broad range of specialty fruits, vegetables, herbs, bedding plants, trees, and more.

Of the 50 states, New York almost always ranks in the Top Five in these categories for wholesome, farm-fresh products:

- #1 in cabbage and grape juice
- #2 in apples and beets
- #3 in milk, cheese, maple syrup, pumpkins, and cauliflower
- #4 in sweet corn, squash, snap beans, tart cherries, and pears
- #5 in eggplant, onions, and green peas

New York State is also among the nation's leaders in cucumbers, floriculture, spinach, strawberries, sweet cherries, blueberries, bell peppers, and tomatoes.

Did you know?
NYS has over 26.5 million square feet of covered greenhouses growing a variety of bedding and garden plants.

Quality, variety, and consistency you can count on — all add up to make New York State a special place in our nation's agricultural economy.

The New York State of Freshness

Agriculture is not only important to New York; New York is important to our nation's consumers and food producers.

New York growers supply us with an abundant harvest of nutritious vegetables, fruits, gorgeous flowers, and Christmas trees that brighten up our lives.

Did you know?
New York State makes approximately 225,000 gallons of maple syrup each year and is the third largest-producing state in the nation.

New York State also has an amazing wealth of prepared foods like tomato sauces made with tomatoes just off the vine, honey and maple syrup, specialty condiments, and baked indulgences.

As more customers ask for healthy, USA-grown food products, distributors, wholesalers, and retailers are providing products you can only find in New York State.

Floriculture Crops:

In 2010, New York floriculture products were valued at $183 million. Bedding and garden plants top the list of commodities. The wholesale value of New York's floriculture output ranks 7th nationally at $183 million.
A variety of crops are produced in 21.9 million square feet of covered area and over 903 acres of open ground.

- A rack card that listed the companies located within the pavilion as well as those located at other locations at the expo. This card listed the company name and contact information. The participating companies had these cards at their individual booths to support the overall marketing efforts of promoting NY Specialty Crops as well as increase attendee interaction.

- A promotional giveaway of pens shaped as fruits and vegetables were produced and made available at each company booth.

- The development of a face book page to educate and promote NYS Specialty Crops and the companies that were participating at the expo. Each company received e-mails to encourage them to Like and Share the page as well as obtain information they would like to promote.
- A Facebook Sweepstakes Contest with an Apple iPad mini as the prize. This contest was housed on the NYS Specialty Crop Facebook page where customers were prompted to scan a QR code which would take them to the entry page. The entries were then captured into a database.
- E-mail blast promotions were conducted to registered attendees of the expo in advance of the show to promote the New York companies and the iPad sweepstakes promotion to encourage them to visit the pavilion as well as those companies located at other locations.
- Badge scanners were provided for each company within the pavilion for them to capture the contact information for follow-up. This information was sent to the Department e-mail address and those contacts that visited each individual company were sent to them.
- During the event, pictures taken by Department staff were posted on the Facebook page.

Goals and Outcomes Achieved

After the event each company (those located within the pavilion as those outside of the pavilion) were surveyed to indicate the outcome of the marketing and promotion project. The response from companies was lower than expected but the feedback we did receive was informative. Below are a sampling of comments received from a survey distributed after the Summit regarding sales and/or buyer contacts as a result of the Department's specialty crop pavilion and presence at the Expo.

QUESTION: Was there an increase in buyer contacts and/or sales as a result of this project?

- *"Yes"*
- *"We found an increase in buyer contact due to the presence of the NY booth, not particularly because of the scanners but with NYS having a Department booth and good signage which made it easier, according to our customers, to locate us."*
- *Facebook page - neutral impact*

Facebook contest - positive impact
Rack card - positive impact
Pens - positive impact
Scanners - positive impact

- *"We did have visitors to our booth that were directed to us from the NY booth and the literature identifying all NYS booths was useful."*

A summary of the responses from all companies showed that the Department exhibit was informative and was helpful in directing visitors to their booth. The presence of the booth assisted in driving visitors to their booths because of the generic signage. The Facebook page had a neutral impact and those companies located in the NY Pavilion. The scanners were helpful but several responded that they preferred to exchange business cards. The sweepstakes contest had a positive impact as well as the promotional pens.

Perhaps one of the most important questions asked was if there was funding available in the future for marketing and promotion of the New York Pavilion what would their suggestions be for its use. Overwhelming the response was for funding to promote there was a pavilion, and cost –sharing of the booth fee and having a directory of the growers, wholesalers and shippers made available either in print or electronically.

The Department was able to have a staff member attend the expo and was able to provide feedback on the project. The feedback received was that the booth and signage was very much appreciated by the vendors as it drew attention to the New York pavilion which hadn't been available in past years. In addition to being able to coordinate the distribution of the marketing and materials and scanners, the staff member was able to discuss the overall specialty crops the New York grows and produces.

Beneficiaries

The beneficiaries of this project were the New York companies that were provided with marketing and promotional support which they have not had in past years. New York State received overall exposure as a result of the Department booth and information that was distributed.

Lessons Learned

The majority of the companies considered the presence of having in the future a Department exhibit as well as funding available for marketing and promotion opportunities to be beneficial to inviting visitors to their exhibits. The feedback from the companies was lower than we expected even though we contacted them by e-mail as well as telephone. In the future we should consider having them commit in writing that they complete the post-survey since they were specifically included on the marketing and promotional materials that were funded. Those that did respond said the project had a positive and any future funding opportunities would undoubtedly benefit the exhibitors. With the limited amount of funding and timeframe that was available for this project, there is a great potential for an expanded program in the future.

Contact Person

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Appendix

2011 Fall Hops Conference

Brown's Brewing Troy, N.Y., Nov 5th

7:30 Registration

8:30 **Welcome** Steve Miller, Cornell Coop. Ext. Ag. Eco. Devel. Prog Madison Co.

8:40 **Soils and Fertility for Eastern Grown Hops** Dr. Heather Darby, Univ. of Vermont
Soils, fertility, land preparation and cover crops

9:25 **Trellises and Getting Started** Steve Miller, Cornell
Various systems and cost of getting started

9:45 **Factors in Growing Quality Hops** Dr. Shaun Townsend, OSU Corvallis
Growing quality hops and keeping them that way post harvest

10:45 Break

11:00 **Managing Diseases and Pests in the Hopyard** Dr. David Gent, USDA ARS OSU Corvallis Identifying and Managing downy and powdery mildews, aphids and spider mites

12:00 Lunch

12:45 **Northeast Hop Alliance Annual Meeting** Larry Fisher, President NeHA
Farm Brewery Legislation Presentation Becca Jablonski Cornell PHD candidate

1:30 **Small Scale Hops Processing** Kate Fisher, Foothill Hops Munnsville, NY
Equipment and regulations for the small scale processor

2:00 **Managing Weeds in the Hopyard** Tim Weigle, Cornell LERGP
Strategies for managing weeds in hops

2:30 **Grazing Sheep in the Hopyard** Tom Barse, Stillpoint Farm Mt. Airy, Maryland
Using sheep to manage weeds and do your pruning for you

3:00 Break

3:15 **New Hop Harvesters for Eastern Growers** Chris Callahan, Callahan Engineering Vermont and Larry Fisher Foothill Hops New York description and video of new, small scale hop harvesters

4:00 **Grower/Brewer/Researcher Panel** varieties and other issues in growing hops for brewers

5:00 Wrap Up and AdjournHave a safe trip home!

Sponsored by: Northeast Hop Alliance, Cornell Cooperative Extension, USDA/NYS Ag & Mkts Specialty Crops Block Grant, and a Northeast SARE Speaker Grant

Cornell/NeHA Fall Hops Conference, Dec 1, 2012 Morrisville State College

7:00 Trade show set up

7:30 Registration opens

8:30 **Welcome** Steve Miller Cornell Cooperative Extension Madison County

Dr. Dave Rogers Provost and Chief Operating Officer Morrisville State College

8:45 ***The Latest in Hops Research in Vermont*** Dr. Heather Darby Agronomy and Nutrient Specialist UVM and Chris Callahan Extension Specialist UVM

9:40 ***Stocking Your Hopyard*** Steve Miller Cornell Hops Program CCE of Madison County

10:10 Break , visit trade show

Getting Started in Hops Option

105,107 Crawford Hall

10:30 ***Basic Hops Production, Site Selection, Fertility, Trellis Design and Varieties***

Rosalie Madden Crops and Soils Technician UVM Extension

11:***00*** ***Hops IPM, An Overview of Pests*** Tim Weigle Grape IPM Specialist Cornell Lake Erie Research and Extension Lab Portland, NY

11:30 **Lunch at Seneca Dining Hall** Visit Wolf harvester on campus on your own and return to trade show at Student Activity Center, NeHA Annual meeting begins at 1:30

Farm Brewery Option

10:30 ***From Farm to Foam, Lessons Learned in Starting a Farm Brewery*** Randy Lacey, owner

Hopshire Farm Brewery, Dryden, NY

11:10 ***Obtaining and Operating with a Farm Brewery License In NY*** *January 2013*

Thomas Donohue, Special Counsel NYS Liquor Authority Albany

Bob Somers NYS Dept of Agriculture and Markets Albany

11:45 ***What's New from the Industry*** Trade Show representatives

12:**20** **Lunch , visit trade show**, or visit Wolf harvester on campus turn In Hop Grower Surveys!

1:30 ***How Oregon Hop Growers Produce for the Craft Beer Industry*** Tony Weathers Willamette Mission Farms Gervais, Oregon

Tony Weathers, is a 4th generation hop farmer from the state of Oregon. He has been on the board of directors of the Hop Growers of American, The Oregon hop commission, and is currently on the Oregon Hop growers Association. He is co-owner of Kerr Supply. He and his brother farm 500 acres of 12 different kinds of hops. They also raise wheat, grass seed, and Hazelnuts.

2:25 ***Northeast Hop Alliance Annual Meeting*** Larry Fisher, Pres. FootHill Hops Munnsville, NY

2:45 ***Break visit trade show***

3:00 ***Hops IPM , from Roots to the Top Wire*** *weed management, snout and Japanese beetle research* Tim Weigle, IPM Specialist , Cornell Lake Erie Lab Portland , NY

3:35 ***Grower Brewer* Panel** growers and brewers will address the direction the industry is taking and your questions

4:30 Adjourn Have a safe trip home or to the Happy Hour at the Colgate Inn, Hamilton NY

FAQs for starting up a hop farm in New York by Steve Miller

Thank you for your interest in growing hops. The following is some information that I have put together for people interested in getting started in hops. This information is a general primer to answer commonly asked questions. This is an exciting time for the industry with excellent potential for marketing to over 140 microbreweries around the state, with more appls. pending. The NY Farm Brewery legislation will create new opportunities for on the farm brewing and sales. This legislation went into effect in January 2013, so contact Sam Filler at the Empire State Development Corp to get info on obtaining a Farm Brewery License 518 292 5366 or sfiller@esd.ny.gov There are 12 new farm breweries in NY as of September 1st. 2013.

History

Yes, we had a very important hop industry here a hundred years ago. In 1880 New York produced 21 million pounds of dried hops, the majority of the US crop which sold upwards of $1.00/pound. What happened and why can we grow them now? New York State produced a large portion of the hops in the US at one time. Disease pressure from downy mildew and powdery mildew, as well as aphids and spider mites made production much more difficult and risky. The industry started moving to the mid-west and then the Pacific Northwest fleeing disease pressure. Along came prohibition, the price went from a high of $1/ pound to 5 cents overnight, and most of the hops in NY were pulled out of the ground.

There are several reasons why we can grow hops commercially again in New York. The industry in the PNW has funded strong plant breeding and IPM research for many decades and a good deal of effort has gone into developing new varieties with disease resistance. These varieties are doing well in NY and offer the best potential. Secondly, pest management options, both chemical and cultural have come a long way in the last hundred years. These advances make commercial hop production viable in New York.

Finances and Costs

What's the minimum acreage for a farm to make enough money on hops to have a livable income?

It looks like if you are doing a good job of it, 10-15 acres should provide a good income. It doesn't sound like a lot but it is a lot of work and about $12-$15,000/A (see below) investment to get started. Currently there is no one in New York with more than 10 acres of producing hops.

What returns can be expected and how many years does it take to get a return?

There is great potential now for growers in NY. Local prices are all over, anywhere from $10-$14/pound for dried, pelleted, hops with about 800-1200 #s/A yield if you are doing an excellent job. Brewers currently pay from $4-10/pound for hops grown on the west coast or from Europe, varying greatly on the amount they purchase and the variety. It is important to keep market prices in mind when developing a business plan, as brewers are conscious of their contracted prices for hops and although most are willing to pay some premium, prices need to be realistic. Also quality is more important than where they were grown, so "local" will not make up for poor quality hops. The first year you may have some hops, a partial crop the second and a full crop the third. Expenses are

variable but most growers believe they need to have gross sales of more than $6-8,000/A to break even because of initial investment, equipment, harvesting and processing costs.

What are the fixed costs to start up and what are the variable costs for ongoing production?
It costs about $12-15,000 /A to get started including labor, plants, trellises, irrigation, and then add on the equipment you buy. Growers are looking at sharing some things, such as harvesters, kilns (oasts) and pelletizing and packaging machines.

What are the costs, such as harvesting machines, etc.? Harvesting is one of the main costs in producing hops. Hand picking is not feasible for anything more than an acre or so. A stationary Wolf harvester will cost in the range of $35,000 but not easy to find in the US so shipping is involved from Europe. NEHA has one located at Morrisville College that is available for members to use. There are 3 more of these privately owned around the state. Keep in mind that the harvester you use needs to be within an hour of your farm because of transportation time and costs. Growers are developing small scale machines and several types may be available soon. Larry Fisher of Foothill Hops has built his own and will be sharing the plans. There are plans from UVM in Burlington, VT for a harvester they designed and built with funds from SARE, as well as for a small scale kiln and baler.

What other equipment is needed to grow hops?
Small tractor, trailer, weed sprayer, crop sprayer like what is used in vineyard or orchard, truck, drying equipment, possible pelleter, a cooler, and a building for storage and drying.

Marketing your hops

What is the demand for hops in New York State to local brewers and in the future?
Hops are easy to ship once dried, however the demand right now is from micro-brewers and local is "in". The growth was slow at first because the brewers want to be sure that they can get a consistent product, both in quantity, availability and quality. As the number of acres increases the demand will also increase. Brewers like the quality that they are getting from local producers! The demographics of the consumers of these products are in their 20s and 30s and it seems unlikely that they will go back to more generic beers. This is a good indicator that there is plenty of room for longevity and growth in the craft beer industry. We estimate there is a need for 400-500 acres of hops in New York to satisfy the domestic demand for local hops.

Is it possible to be classified as an organic producer? Yes there are some growers going organic. It is more work and risky I'd say and time will tell if brewers will be willing to pay a premium for organic hops. Eastern hops are already higher in price than west coast hops. That said, there is interest on the part of growers and brewers. As of January 2013 organic beer requires the use of organic hops.

Is there a profitable online sales market?
I would say yes but with a caveat. New York hops are going to be more expensive to produce so many home brewers are looking to the PNW still because they are less expensive. You would have to build interest in "local" or uniqueness on the part of home brewers.

Land preparation

It is very important that you select the area where you will be growing and begin the get the land prepared. It should be well drained, have access to water for irrigation, be flat or have a gentle slope, and have good air circulation as well as full sun. Those are the key ingredients to site selection. I

would start by going to your Cornell Cooperative Extension office in your county and obtain copies of the soil maps of your farm. The USDA NRCS or the County Soil and Water District staff can tell you about the particular qualities of each of the soil types.

I would also obtain a soil test box there for Dairy-one/Agro-one and send it in with the "F" form filled out for hops establishment. This will tell us if you need lime or other minerals to be added before you plant. I also would suggest that you ask the Ext staff about establishing a cover crop this year to cut down on the weeds. Buckwheat followed by clover is a good choice. Will you be organic? What is growing in the field now? Grass, weeds, corn? Atrazine carryover can be harmful. You may want to kill off what is there with either tillage and cover crops or with glyphosate (Round-up) as perennial weeds and grasses will be a problem, and you want as little of those as possible before the hops go in.

Here are a few typical questions about growing hops commercially:

What is the system of growing plants that will produce the highest yield?
The highest yields are still with full size plants on high trellises 16-20 ft. About 900 plants /acre are required about 3ft apart and rows 12 ft apart. There are a few different high trellis systems being tried out in the Northeast. Low trellis systems (10 ft with plastic deer netting) are being used out west, but require specialized ($350,000) over the row harvesters unless you plan to hand pick in the field. It may also be more difficult to manage diseases in low trellis hops so I do not see this as a viable option. Also there are very few varieties that lend themselves to dwarf production, which also means less diversity to offer a brewer.

What about irrigation?
Hops need at least an inch of water a week, more as the season progresses. Most growers are using drip with the emitters set at 18-24 inches apart. You need to know how many acres you want to put in and determine if you have an adequate water source. You usually can water one block at a time for several hours and then shift to another. An acre can use 5-6,000 gals/day.

How are the plants harvested?
The plants grow up twine (coconut coir) and it is cut at top and bottom and brought to a barn to be hand-picked or trucked to someone with a harvester to machine picked. Baling twine will stretch and not last. Hand picking is not cost effective, about 1 man hour per mature plant. We have 3 Wolf harvesters in New York and a couple smaller pickers in the state now. As acreage grows we may see more of these purchased or built. Mobile harvesters are being built in 2013 that can travel from farm to farm.

What is the process to dry and possibly pelletize the crop?
After harvest, the crop needs to be dried right away. Use plenty of warm air, no more than 100-120F, too hot will destroy flavors. The hops can now be stored in air-tight bags in a cooler. Before pelleting, they may need to be ground in a hammer mill and then pelleted, vacuum sealed and again, stored cold.

What is the shelf life of product?
This depends on quality but almost a year if processed right and vacuum packed in Mylar bags, gas flushed and kept in a cooler or freezer. Many growers don't pelletize until they have orders ready to ship. Well processed hops, cold stored, can last a year or more with minimal loss of potency.

What varieties are in demand?
For the most part brewers are looking for the more aromatic varieties as they can get the bittering varieties more easily from PNW. Cascade, Willamette, Mt Hood, Fuggle, Liberty, and Perle are aroma varieties, and Brewers Gold, Chinook, Centennial, Nugget and Newport are a few bittering varieties that are being grown in the Northeast and are in demand. We also must consider disease resistance. Mt Hood, Centennial, and Columbus (CTZ) for example, are not resistant to downy mildew. Saaz and most of the German varieties have not done well in the East so far but growers are experimenting with these.

Finding more information

As for hop information I would start by going to the NEHA site www.nehopalliance.org and reading some of the literature that is listed on the resource page. Copies of our newsletter are listed there as well as articles from U of Vermont. Also, consider joining the Northeast Hop Alliance. The Alliance supports research and development of the industry and is a small investment for your farm. The NEHA growers will likely be putting in a group order for coir and plants each fall. This can save on start up costs because of quantity purchases.

Cornell Univ. and Cooperative Extension will be offering a Cornell Guidelines for Hop Production in the Fall of 2013. There is also a new hop research yard being planted at the NYS Experiment Station in Geneva. Variety and pest management trials will be carried out there.

In 2011 and 2012 we held a hops conference in Troy and Morrisville, NY . A 2 DVD set(approx.7 hours) is available from each conference for $60 ea. including shipping. All 4 DVDs can be purchased for $100 from Cooperative Ext of Madison County.

P.S. If interested in brewing, contact : **NYS Brewers Association** PO Box 656 Cazenovia , NY 13035 315 256 7608 www.thinknydrinkny.com

Karl Siebert at the NYS Ag Expt Stat. in Geneva offers an excellent brewing short-course for commercial and home brewers. They sell out so get on the list for the next one.
Or for the brew school in Vermont. Contact: **American Brewers Guild** 1001 Maple Street Salisbury, **VT** 05769 http://www.abgbrew.com/admissions.htm

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Stocking Your Hop Yard by Steve Miller Cornell Cooperative Extension

Out west newly plant hop yards are called "babies" and growers make that distinction because they are not producing a crop yet. Starting with clean plants of known variety is very important to the success of a commercial yard.

Hops are usually propagated by rhizome cuttings. These are 4-6 inches and should have several buds but no roots. They need to be kept moist but not soaking, and cold but not freezing, until ready to use. Thicker rhizomes generally get off to a better start. In the Pacific Northwest, growers commonly place two to as many as six rhizomes per hill. This provides good assurance that there will be at least one growing plant and in many cases enough crop to harvest the first year, and a larger crop the second-year. This is a practice that Eastern growers should consider, even though it does increase the cost of establishment.

Another practice that is gaining popularity is potting up the rhizomes and starting them in a greenhouse. This yields a plant with roots, and a foot or more of top growth with several shoots. Depending on the size of the rhizome, 4 ½ inch pots can usually be used. Some growers have also used market pack peat flats that are used for bedding plants. Follow the directions under the "potting up plants" section for potting mixes.

Propagation by rhizomes does carry some risk. Rhizomes can harbor diseases such as verticillium wilt, powdery mildew, downy mildew, nematodes, and a number of virus and viroid diseases.

Hops have been found to carry Hop Latent Virus ,HpLv, American Hop Latent Virus ,AHLV, Hop Mosaic Virus, HpMV, and Apple Mosaic Virus ,ApMV. The first 3 have not caused significant crop losses and are transmitted by aphids. However, ApMV mosaic virus can reduce yields by up to 30% is transmitted by sap, most often with mechanical practices.

HLVd, hop latent viroid is commonly found in hopyards around the world and can reduce yields in and alpha acids by as much as 10%. Hop Stunt Viroid, HSVd, was found in Pacific Northwest about five years ago. This disease is spread mechanically, especially during propagation. it reduces plant height by up to 40%, cone yield by 50-75% and alpha acids in those cones by as much as 50%.

This disease is a threat to Western hop yards and has great potential to cause reduced yields in new hop yards being planted in the East. Washington State University operates the Hop Clean Plant Network. Under Dr. Ken Eastwell, virus indexed cuttings and stock plants are produced of many commercial varieties so that propagators can produce virus free plants for growers. These are usually available in July. This virus free stock is what we use to produce hop plants in the hop clean plant program.

Hops may also be propagated by softwood cuttings. Hops take root very easily. They will send out adventitious roots all along the stems of softwood cuttings. Rooting percentage is enhanced by either

dipping in a rooting hormone solution or by using propagation blocks that are hormone impregnated. It is not unusual to obtain a 90% success rate with hop cuttings. However, plants will not form rhizomes and be able to overwinter unless there are roots that arise from the leaf nodes. Make sure that at least one node is below the soil line when sticking cuttings in the soil.

Once rooted, plants can be grown in 6 or 8 inch pots as stock plants. Cuttings taken from stock plants that have had a cold treatment are more vigorous. Stock plants can be grown until late November in a greenhouse and then should be vernalized in a cold room (34 to 40°F) similar to conditions used for storing nursery stock or forcing bulbs. The roots should not be allowed to dry out, so it is necessary to check soil conditions weekly and water as needed.

Hops only require 8 weeks of cold dormancy. They can be brought back into the greenhouse in February and begin growth. Once a strong flush of growth has occurred, you can start taking cuttings.

Softwood cuttings should be 2.5 -4 inches long with at least one leaf node. Use shoots that are somewhat firm, growing tips are too fragile for rooting. Cuttings will root under mist with bottom heat in less than two weeks, longer with only ambient heat.
Rooting cubes can now be cut and plants potted in 4-5 inch pots. In two more weeks they will have enough growth to go outside, but not until they are gradually exposed to the elements for a week or two of hardening off. These plants cannot stay outside until after the last frost.

You can continue to take cuttings from the stock plants with at least three flushes of growth. A stock plan can produce roughly 20 cuttings with each flush. Some varieties are more vigorous than others Liberty and Fuggle in particular are slow to root and slow to grow.

Care and Feeding of Your Baby Hop Plants

There are 3 good options for going forward with planting your hop plants. Each has its own advantages.

1) They can be repotted into larger pots for the summer and planted in the ground this Fall

2) They can be planted now into a nursery bed and dug up and divided next Spring

3) They can be planted directly into the field now.

1) Potting them up Why? If you are not ready to plant directly in the field this could be a good option. Hops will be in the field a long time and it is important to have the soil worked up and weeds under control.

How? Use 1 or 2 gal. pots. The larger the pot the less often they will need watering. The soil should be a soilless mix that you can purchase and add some course sand to, or a good home made mix would be 1 bushel of peat moss (you could use some well- rotted compost) 1 bushel of perlite, add 2 pounds of sharp sand , ½ pound of lime and 1 pound of 5-10-5 or slow release osmocote. If the sand has a pH of over 7, than no lime would be necessary. Mix thoroughly, wetting it down as you go. Carefully remove the hop plant from the pot, keeping the soil and roots together. Water in, and stake up with bamboo stakes. These plants may have to be watered more than once a day on very hot sunny days. They grow fast and may become tangled if too close. Plant by late summer or early fall, as they will not overwinter well in the pots in our climate.

2) Plant in a nursery. Why? Again, because you are not ready to put them into the field, and this can be done in a smaller area. Secondly, you could dig them up early in the Spring and divide them, yielding more plants than you started with. They should grow well enough to produce 4 or 5 good rhizomes to divide, this brings the price/plant down to the cost of purchasing dug rhizomes from out west, but having the advantage of not risking disease transporting. **How?** In this case you will be planting your hops in a bed that is thoroughly prepared. This area should be like a good vegetable garden. The pH should be between 6 and 7. A good level of organic matter will help the roots get established and hold water when needed. Only use well -rotted compost as wood chips and sawdust will compete for nitrogen. Manures, horse manure can contain a lot of weed seed so they too should be well composted. Plants can be placed 18-24 inches apart in the row with rows about 30-36 inches, wide enough so you can weed or cultivate. Keep different varieties in separate rows where possible. **Trellises-** These plants should be trellised, but no need for 18 ft. Out West they let the babies grow without a trellis on the ground, or with bamboo stakes, but their weed pressure is much less than what we have in the East.

An 8 ft fence or trellis wire with drop coir strings could be used in the nursery. Precut coir comes about 20 ft so one string can double for two plants. Do not prune, let it all grow so as to build up a good root system. **Scouting-** One of the advantages of growing your crop this way is to gain some knowledge. Regular scouting to check for insects and diseases is a great way to learn. Japanese beetles can be a problem so watch for these in particular. If you get some hops they can be hand -picked without damaging the plants. These plants will need plenty of water so set up a drip system or seep hose. It is best not to get the leaves wet when irrigating. Let the plant die back in the Fall. They can be dug in early Spring and moved to the field, or divide them up, each plant should yield 4 or 5 rhizomes. Keep in mind that if the crowns are divided, you will reduce the yield that an undivided plant would have produced.

3) Plant in the Field Why? You have the field prepared and are ready to go! **How?** You can follow much of the instructions as in a "nursery bed" except in this case plants should be 36-40 inches apart in the row with rows 12' apart. When planting, carefully remove the pot and plant immediately so not to let the roots dry out. Hop shoots are very brittle so be careful handling them in the planting and training process. Be sure not to break the growing tip. Make sure the top of the soilless mix is covered with field soil since soiless mixes will dry very rapidly if exposed. This is especially true if peat pots are used. These can go right into the soil but the upper edges of peat pots should be covered or removed. **Field Prep** Baby hops will need some fertilizer the first year. The amount should be based on soil test results. Hops need some nitrogen at the rate of about 50-75 #s/A the first year. Half of this should go on before planting and the other half in by late June, either as a side dress or through the drip irrigation system. Some of this N can come from plant materials that have been incorporated into the ground before planting (ie. clover or grasses). Phosphorus is of lesser importance but hops will need at least 20 pounds of P/A. Potassium is also needed at similar rates as

nitrogen. You should plant a cover crop in the row middles. Use a grass mix that is not aggressive such as tall fescue or rye grass. Clovers are good to plant around the perimeter of the field to attract beneficial insects. Trellises should be 18' out of the ground with poles 4 ' in the ground. In most cases it is easier to put these up before the plants go in the ground. Even if you are using a "V" trellis, it is usually only necessary to have one string up per hill for the first 2 growing seasons. This means that if you do not cut the plants the first year, that coir string will last for the second season.

Drip irrigation is a must. Emitters should be 18-24 inches apart so that you water on either side of the plant. Some growers have experimented with laying black plastic as you would for tomato plants. This has worked well to control weeds and get the hops off to a good start. In this case you would have to use drip tape under the plastic at the time you lay it down or use spaghetti tubes pierced through the plastic. . Plant through the plastic, cutting small holes as you go. Some commercial transplanters have attachments that cut the holes as well as water in the plants. These are difficult to use if the poles are already in and hand planting gives better results. Coir twine needs to be in place by the time the hops have reached 3 ft. Train them clockwise on to the coir. Scout at least once a week for insects and diseases. Keep weeds from going to seed, they will be even worse next year if you don't. Hand pick any hops the first year and don't cut the plants, to help build the root system.

For more information on soils, irrigation, and plastics check out **Cornell's Integrated Crop and Pest Management Guidelines for Commercial Vegetable Production**, under the chapters on "General Culture" and "Soil Management". In the Fall of 2013 we expect to have a Cornell Guidelines for Hops. More information on growing hops can be found on the Northeast Hop Alliance website www.nehopalliance.org. We also have DVDs of our hop conferences available. You may email me at sgm6@cornell.edu . Good luck with your hop enterprise.

Growing Hops - In the Home Garden

Susan M. Hiller, Gale A. Gingrich and Alfred Haunold[1]

*This version of their fact sheet has additions and edits by Steve Miller for New York conditions.

The Plant

The hop plant *Humulus lupulus* L. is an herbaceous perennial, producing annual vines from an overwintering rootstock. In the spring and early summer, vines grow rapidly, winding around their support in a clockwise direction and clinging with strong, hooked hairs. They reach their ultimate height of 15-25 feet by the end of June when, in response to shortening day length, vines stop growing vertically and produce side arms which bear the flowers. The hop is dioecious, having separate male and female plants. Only the females produce the cone-shaped "hops" used in brewing. The male plant serves only as a pollinator, but is not essential for the female plants to produce hop cones. Hops are heterogeneous and new plants coming from seed could be either male or female. The rootstock is an underground structure consisting of both rhizomes (with buds) and true roots (without buds) which may penetrate the soil to a depth of 15 feet or more. During the first year little growth and few flowers are produced because the plant is establishing its root system. A normal crop of hops should be expected the second year.

Climate

The hop plant produces best under specific climatic and soil conditions. A minimum of 120 frost free days are needed for flowering. Direct sunlight and long day length (15 hours or more) is also needed. As a consequence of day length and season length, hop production is limited to latitudes between 35 and 55 degrees. The hop plant requires ample moisture in the spring followed by warm summer weather. In dry climates the hop plant will produce best if supplemental irrigation is provided.

Soil and Plant Nutrition

A deep well drained, sandy loam soil is best. A soil with a pH of 6 to 7.0 is ideal for hop production. Poorly drained, strongly alkaline or saline soils should be avoided. Fertilizers rich in potassium, phosphate, and nitrogen should be applied each spring. Nitrogen is required at a rate of approximately 150 lbs per acre (3 lbs N/1000 ft2) for mature plants, half that the first year or two. The nitrogen may be applied in split applications 2 or 3 times between March and mid-July. If manure or compost is applied around the hop plant, fertilizer applications may be reduced accordingly.

Planting

The soil should be tilled to create a weed free area. A strong support system is needed for the plant to climb on. Look for space along fences, garage, or property lines. Plant in early spring once the threat of frost is gone and can be planted into June in NY. Rhizomes can go in a little earlier because they are underground. The soil should be worked into a fine, mellow condition prior to planting. In cold climates you can plant rhizomes in pots and transplant in June. If planting is delayed, keep rhizomes refrigerated in a plastic bag to prevent them from drying. Plant two rhizomes per hill with the buds pointed up and cover with 1 inch of loose soil. Hills should be spaced at least 3 feet apart if the hills are of the same variety and 5 feet apart if they are different. The first year the hop plant requires frequent light watering. Mature plants will benefit from a seep hose and regular watering if rainfall is sparse. Hops need plenty of water but should not be water logged.

Pruning

When the young bines are about 1 foot long, two to six vigorous bines are selected for each hill and the rest are removed. One to three bines are trained clockwise on a string which has been staked to the hill. Be very careful not to damage the growing point of the bine as this will affect the production of the hop flowers. Hops mainly grow vertically, but lateral sidearms extend from the main bine and produce flowers. The main concern is to support the bines and prevent the sidearms from tangling. Most cones are produced on the upper part of the plant.

In early July, the lowest four feet of foliage and lateral branches can be removed on mature plants to aid in air circulation and reduce disease development. The removal of lower leaves (stripping) must be done carefully to avoid breaking or kinking the main stem. In August allow additional bottom growth to remain to promote hardiness of the crown and plant vigor for next year.

At the end of the season you can bury healthy bottom vines for propagating new plants the next spring. Simply bury the vines in a shallow trench and mark their location. In spring dig them up and cut them into pieces about 4 inches long. Make sure each new cutting has an eye or bud.

Diseases

Downy Mildew

This disease is caused by the fungus *Pseudoperonospora humuli*. The fungus infects only the hop plant and will not affect other garden plants. The disease first appears in the spring as infected shoots (spikes) emerge from the overwintering rootstock. The number of infected shoots may vary from none to all in any given hill. Infected shoots are stunted, brittle, and lighter in color than healthy shoots. The leaves are often deformed and curled. Infected shoots are unable to climb. Gray or black masses of fungal spores are often present on the underside of infected leaves. Spores are dispersed by wind and rain. The disease is favored by warm (65-70°F) wet weather and the fungus requires free water on leaf and shoot surfaces for infection. Spiked shoots should be removed promptly and buried.

Flowers often become infected when blooming occurs during wet weather. Young cones that are infected stop growing and turn brown. When older cones are attacked, part or all of the petals turn brown and cones fail to develop properly.

Verticillium Wilt

This disease is uncommon in the Pacific Northwest but may occur in the East. Symptoms include yellow veining of the leaves and wilting of leaves and vines. Early symptoms may include wilting on only one side of a leaf. A brown discoloration inside the vine may be observed by cutting diagonally into the vine. Depending on the hop variety and the strain of the fungus, disease can vary from year to year. A plant showing symptoms this year may seem entirely healthy the next year. There are no effective control measures. The fungus can persist in the soil for several years. If this disease recurs regularly, remove the infected plant and replace with a new one in a different location

Abiotic Wilt

Hop plants are extremely sensitive to soil residues of the pesticides heptachlor and chlordane. Chlordane was widely used in home gardens in the l960's but both were banned in 1972. Symptoms of heptachlor and chlordane poisoning may be similar to those of Verticillium wilt but there are some important differences. The

lower part of the affected vine will have a rough, scaly appearance with deep cracks which may ooze sap. Vines are brittle and may easily snap when bent. In cross-section, the central sap of the vine may have a darkened, water-soaked appearance instead of a light color. Plants will likely exhibit a slow decline over a period of 2-3 years. There is no known cure. The hop varieties Cluster and Chinook seem to be somewhat more tolerant than other varieties.

Viral Disease

Symptoms of virus infection vary with environmental conditions. The virus may cause leaf and vine tip distortions, tip die back, yellow spotting of the leaves, stunted growth, failure to climb on the trellis and flower blasting. There is no cure and severely affected plants should be removed and destroyed. Over the years many of the most severe viruses have been eradicated from commercial production. Rootstock purchased from a reliable propagator is unlikely to have severe virus problems.

Insects

Hop aphids and spider mites are the most common hop pests. Other less serious insect pests include wire-worms, leaf rollers, armyworms, hop looper, root weevils, omnivorous leaftiers, western spotted cucumber beetles, corn earworms, and several species of cutworm. These usually are not present in damaging numbers.

Hop aphid, *Phorodon humuli*

The hop aphid is a small (2mm) soft bodied, pale green pest. The hop aphid overwinters on Prunus species (ie. ornamental plum trees) and in the spring return to the hop plant. Hop aphid infestations develop more rapidly during cool weather. The hop aphid does damage by sucking plant juices. Aphids should be controlled before or during flowering to keep them from entering the young cones. Once the aphids have entered the cones, they will secrete a honeydew and cause a sooty mold in the cones.

Spider Mites, *Tetranychus urticae.*

The adults are very small, have eight legs. They are pale green, yellowish to reddish in color, often with a dark spot on each side of their body. A hand lens is needed to see the pearly white spherical shaped eggs. The spider mite feeds by puncturing the lower leaf surfaces and withdrawing plant sap. Each puncture produces a small light colored spot. Eventually the leaves become bronzed, shrivel and die. White webs may also appear if infestation is severe. The spider mite will also feed on the petals of the cones causing them to turn brown, a condition growers call "red hops". Spider mites are a problem during prolonged periods of warm, dry weather. Mite predators include the western predator mite and the small black lady beetle. Regular washing of the plant's leaves with your garden hose may prevent an outbreak.

Cutworms

Cutworms over-winter as larvae or pupae in the soil. The adult moths emerge in late spring and lay eggs. The larvae that emerge from the eggs feed on plant stems at night. Cutworms can generally be found just beneath the soil surface during the day.

Eastern comma, Japanese beetles, black vine weevil and potato leaf hopper are all potential insect pests on hops in New York.

Weeds

On a small scale hops can be mulched and hand weeded to keep down weed growth. Hops are sensitive to herbicides like glyphosate and 2, 4 D so be careful not to let these drift onto the hop leaves or stems.

Harvesting

Hop harvest in the Pacific Northwest and in New York usually runs from mid August to mid September, depending upon the variety. If you want to use your hops for ornamental purposes, pick your hops early. Otherwise hand pick hop cones and dry them in a food dehydrator.

To determine ripeness pick a cone and touch and smell. If the cone is too green it feels slightly damp to the touch and has a softness to its scales. If you squeeze the cone it will stay compressed in your hand. A dry cone will feel papery and light. It will feel drier than a green cone, some varieties take a lighter tone as they mature. If your hands quickly take up the smell and are slightly sticky due to the yellow powdery lupulin, your hops are ready for harvest.

To harvest, the cones can be hand- picked in the field. This process takes about 45 minutes to an hour /mature plant. Picking in the field will preserve the full amount of nutrition in the plant for over wintering. If you have many plants you may want to cut the vine at the bottom leaving 3-4 feet of the vine to lay on the ground and cut the string at the top. Lay the vine on the ground and pick off the cones. This can be done in the shade, just as they did in the old days. The harvested vine can be mulched, chipped up, or woven into a wreath. When handling fresh hop plants wear long sleeves and gloves because the hooked hairs of the plant may cause a slight rash. Hops are high in natural estrogen and some precaution may be necessary for pregnant women such as wearing gloves.

If you choose to construct a dryer, good airflow is essential, and the temperature must not exceed 140°F. Drying hops at a lower temperature takes longer, but a better quality hop is obtained. For drying the low-tech way, you can use a window screen. Spread the hops evenly across the clean screen. Place the screen off the ground and in an enclosed area to keep wind and bugs from creating problems. A healthy vine will produce 1-2.5 pounds of dried cones per plant.

The dried hops are ready for storage when springy to the touch and the yellow lupulin powder easily falls out. Another indicator is when the central stem breaks rather than bends. The stem takes much longer to dry than the petals. The enemies of hop quality are moisture, sunlight, oxygen and heat. So keep them cold, dry, in compressed bags and in the dark. Cones are best stored in plastic bags that can be sealed. It is important to make sure the cones are sufficiently dry. If cones are not properly dried, they become moldy, wilted, or even rancid and cannot be used for brewing. Fill the bag until the cones are well compressed. Once the bags have been sealed and properly labeled store them in a freezer. Thawing and refreezing stored hops reduces quality and freshness.

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2012 Fall Hops Conference Survey Results

1. GROWER PROFILE

State:

	% of Respondents	Number of Respondents
NY	88.30%	83
Canada	2.13%	2
MD	1.06%	1
PA	3.19%	3
MA	1.06%	1
MO	1.06%	1
VT	3.19%	3
Number of respondents		94
Number of respondents who skipped this question		1

1. Are you currently growing hops?

	% of Respondents	Number of Respondents
Yes	62.11%	59
No	37.89%	36
Number of respondents		95
Number of respondents who skipped this question		0

2. How many years have you been growing on a commercial scale (more than 100 plants)?

Number of Respondents	56
Zero:	19
One:	4
Two:	7
Three:	3
Four-Six:	2
Seven-Nine:	0
10 or more:	1
Number of respondents who skipped this question	39

3. How many plants do you have currently?

Plants	52
0:	1
<100:	19
100-200:	12
201-800:	13
800-1500:	7
Acres	11
0:	1
1:	5
1.5:	2
2:	1
7:	1
10:	1
Number of Respondents	59
Number of respondents who skipped this question	36

4. Did you increase your planting in 2012?

	% of Respondents	Number of Respondents
Yes	51.67%	31
No	48.33%	29
Number of respondents		60
Number of respondents who skipped this question		35

5. Are you considering expanding your hopyard?

	% of Respondents	Number of Respondents
Yes	88.89%	56
No	7.94%	5
Maybe	3.17%	2
Number of respondents		63
Number of respondents who skipped this question		32

6. If yes, how may hills/plants or acres are you considering expanding in these years...

	2013	2014	(Number of Respondents)
Hills			
<200	19	6	
200-500	17	9	
Acres			
1	20	2	
2	4	5	
3	2	4	
4		1	
5	3	1	
10		2	
Total Increase in Acres including Hills at 800/acre	46	65	
Number of Respondents			68
Number of respondents who skipped this question			27

7. What factors are your primary concern to overcome so that you may expand your hop farm?

Number of Respondents 62

Number of respondents who skipped this question 33

Time.Knowledge,
Yield
Pest / Disease, Trellis Design,
Harvesting,
Marketing. Weed Control, Labor
Cost, Zoning
Location
Nutritional Needs. Disease
Irrigation, Marketing, Harvesting
Developing a strong market, becoming more knowledgable in all aspects of growing hops
Processing
Profit/yield, acreage

Equipment
Market price of hops, herbicide program, nutrition management
Trellis structure and irrigation
Irrigation, harvesting, fertilizer, pests
Profitability
Funding, Pests. Harvesting
Market, Price stability
Harvester, hop dryer
Irrigation, timber harvest, nutrients
In process of buying farmland now, commerical start - up
Cash, processing equipment, land
Quality rootstock, harvesting, marketing
Ability to irrigate. Pest management without chemicals
Harvesting, buyers, cost
Irrigation, harvest, weeds crop cover
Irrigation, cost
Equipment, Irrigation, Time
Yield, Pests
Yield, Revenue or sale of hops
Irrigation, pest and money
Pest & Weed Management, Harvesting, selling
Pole installation, Irrigation
Power for irrigation pump, Varieties to grow, Sustainability of locust grove
Soil Quality, zoning, markets - I have some urban issues
Soil Quality, Irrigation, Pests
Building trellising, Irrigation, Pest Control
Fracking
Harvester, Buyers, Trellis
Cost, Equipment, Quality
Hop picker, drier, pelletizer

Experience
Harvesting, Processing, Packaging
Irrigation
Mechanical Picking, Pelletizing
Land Prep, Trellis Poles, Irrigation
Cost of production, Harvesting, Packaging
Irrigation
Financial, Trellis systems, market directions, forecast
Profitability
Soil and set-up
PM, Downy Mildew, Processing, Price Volatility
Harvesting and distribution
Water, Pests, Mildew
Productivity, Quality, Profits
Pest, disease
If I want to grow at all - Cost, Labor, Harvesting & Drying
Land acquisition, Cash Flow, Rhizomes (disease free)
Cost, labor
Soil prep, amount of sun, pests/mold
Time & materials
Time, Labor, Weed Management, Yield

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8. What is the spacing between your rows?

<10:	6
10:	7
11:	2
12:	22
13:	1
14:	3
15:	4
16:	3
Number of Respondents	48
Number of respondents who skipped this question	47

9. Which trellis system do you use?

	% of Respondents	Number of Respondents
Vertical Row	61.54%	40
"V" trellis	27.69%	18
Other	10.77%	7
Number of respondents		62
Number of respondents who skipped this question		33

10. What varieties have worked well for you so far?

	% of Respondents	Number of Respondents
Bertwell	0.70%	1
Brewers Gold	5.59%	8
Cascade	26.57%	38
Centennial	9.09%	13
Chinook	11.19%	16
Columbus	0.70%	1
Cluster	0.70%	1
Galena	0.00%	0
Glacier	0.70%	1
Golding	0.70%	1
Hallertau/Saaz/	0.00%	0
High Alphas	0.70%	1
Kent Golding	0.00%	0
Liberty	1.40%	2
Low Alphas	0.00%	0
Magnum	1.40%	2
Mt. Hood	4.20%	6
Newport	6.29%	9
Northern Brewer	0.00%	0
Nugget	8.39%	12
Perle	2.10%	3
Wild / Feral Hops	1.40%	2
Willamette	14.69%	21
Zeus (CTZ)	2.10%	3
Other (Specify)	1.40%	2
Number of respondents		56
Number of respondents who skipped this question		39

11. What varieties have not performed well so far?	% of Respondents	Number of Respondents
Bertwell	0.00%	0
Brewers Gold	3.70%	2
Cascade	18.52%	10
Centennial	1.85%	1
Chinook	5.56%	3
Columbus	0.00%	0
Cluster	0.00%	0
Galena	1.85%	1
Glacier	3.70%	2
Golding	0.00%	0
Hallertau/Saaz/	12.96%	7
High Alphas	0.00%	0
Kent Golding	3.70%	2
Liberty	1.85%	1
Low Alphas	1.85%	1
Magnum	3.70%	2
Mt. Hood	3.70%	2
Newport	0.00%	0
Northern Brewer	3.70%	2
Nugget	5.56%	3
Perle	7.41%	4
Wild / Feral Hops	0.00%	0
Willamette	7.41%	4
Zeus (CTZ)	3.70%	2
Other (Specify)	9.26%	5
Number of respondents		32
Number of respondents who skipped this question		63

12. What is your average yield per acre (assume 1000 mature plants/acre) in pounds?

Wet	5
Dry	9
Number of Respondents	13
Number of respondents who skipped this question	82

2. SALES TO BREWERS

13. I have been selling hops to brewers since 20___

	% of Respondents	Number of Respondents
01	0.00%	0
02	0.00%	0
03	0.00%	0
04	0.00%	0
05	0.00%	0
06	0.00%	0
07	0.00%	0
08	1.12%	1
09	0.00%	0
10	1.12%	1
11	1.12%	1
12	12.36%	11
Not Yet	84.27%	75
Number of respondents		89
Number of respondents who skipped this question		6

14. I sell primarily to…

	% of Respondents	Number of Respondents
Breweries	55.00%	11
Home Brewers	20.00%	4
Both	25.00%	5
Number of respondents		20
Number of respondents who skipped this question		75

15. How many individual breweries do you sell to over the course of a year?

1:	6
2:	4
3:	1
4:	2
6:	2
10:	1
Number of Respondents	16
Number of respondents who skipped this question	79

16. In 2012, how many pounds of hops were sold as...

Wet	9
8, 10, 25, 25, 30, 30, 50, 250, 600	
Dried Whole Leaf	5
1, 15, 25, 50, 50	
Dried and Pelleted	2
14, 80	
Number of Respondents	13
Number of respondents who skipped this question	82

17. Was this amount more or less than in previous years?

	% of Respondents	Number of Respondents
More	91.67%	11
Less	8.33%	1
Number of respondents		12
Number of respondents who skipped this question		83

18. I expect my sales in 2013 to ...

	% of Respondents	Number of Respondents
Increase	96.67%	29
Decrease	0.00%	0
Stay the same	3.33%	1
Number of respondents		30
Number of respondents who skipped this question		65

3. PRIORITIES FOR YOUR HOP FARM

19. What are your greatest needs in terms of information for your hop farm?

Number of Respondents	76
Number of respondents who skipped this question	19

Weed management Pest management Fertility Harvesting/Drying Equipment
Spray programs, Organic production, Drying, Sheep use in weed management
Source of poles
Pest Control, Trellis (Low vs. High)
Drying, Pelletizing
Nutrition, Pelletizing
Establish a network between growers and brewers
Process and pelletizing
Cultural, Pest Control, Harvesting and marketing
Cost
Grants, basic financial info on starting a commercial hop yard
Meeting other hop growers
Info about, small scale harvesting equipment
Timing harvest, available herbicides, nutrition management
Plant source, pest control
Profitability
Organic production, weed control, pathogen ID, irrigation workshops
Co-op to reduce costs, Grants for harvester, Pest control and weed management
Soil testing, identify proper varieties, co-oping opportunities
Start up support, financial & legal, supply & material resources, Equipment (Harvest/Processing)
Market to sell hops, variety preferences, trellis engineering data
Disease management, hop breeding
Source for clean healthy rhizomes
Buyers/Brewery connections, organic pest control/fertitizer info
Soil nutrient, pest, weed control
Irrigation, trellis
Marketing to breweries

Pests, Companion Plants, IPM definitive job
Disease, pests
Disease control, harvest mechanization
Pest management, Irrigation, Mechanization
Harvest, Sales, Organization, IPM
Crop Quality
Pelletizing, Organic Fertilizer, varieties - demand
Best Variety, How to make the sale, customer acceptance
Processing Equipment, Marketing
Irrigation, Pest Control
Organic, Pest control, Organic Fertilizer
Pest Management, Trellis Design
Expanding, Organic Cert., Organic Fert.
Ability to recognize pests instantly and correct problems
Disease and pests
Pests, Trellis Construction
Disease, Organic Req., Pests
Pricing, Low-cost harvesting & processing, Organic fertilization
Organic control
What is the market going to be for NY grown hops? Best method for starting plants? IPM?
Pesticides, Fertilization, Harvesting
Varieties, pest management, fertility and cultural practices
Organics, Pest Control
Set-up, Organic disease management, marketing
Pest management, weed control
Trellising info
Pest control and plant sources
Varieties and pests
New to business want to learn as much as we can
How to information
Chemicals, crop management tools, local non-organic info on cultivars, materials, etc
Hardiness to temp, organic information, networking, sales farmers markets
How to start out
Resistant varieties, pest management, processing
Rhizomes, IPM, Fertalizer
Pest/disease management, marketing products, mechanics co-op
Verities best for area/soil - growing information - disease/Insects cost
IPM, Grant & loan progress, Equipment Supplies, High yielding varieties & disease and mildew resistance
Design
Start to finish
Trellis/Yard design, Plants vs. rhizomes, pest control, irrigation design
Trellis systems, Organic practices
harvesting, drying, IPM
Not growing but have interest in possibilities - profitability, markets, production
Start up materials
Hop varieties suitable for short growing season
Starting & setting up
Weed Management, Pesticide Application

20. Are you currently using pesticides in your hop operation?

	% of Respondents	Number of Respondents
Yes	23.19%	16
No	76.81%	53
Number of respondents		69
Number of respondents who skipped this question		26

21. Do you intend for your hop farm to be organic?

	% of Respondents	Number of Respondents
Yes	58.11%	43
No	41.89%	31
Number of respondents		74
Number of respondents who skipped this question		21

22. How would you rate the success of your pest management efforts?

	% of Respondents	Number of Respondents
Poor	4.92%	3
Fair	32.79%	20
Good	54.10%	33
Excellent	8.20%	5
Number of respondents		61
Number of respondents who skipped this question		34

23. If less than excellent, is this success rate due to the lack of (select as many as appropriate)...	% of Respondents	Number of Respondents
Knowledge	43.48%	40
Chemicals	10.87%	10
Equipment	9.78%	9
Time	31.52%	29
Other	4.35%	4
Number of respondents		50
Number of respondents who skipped this question		45

24. Would you like to attend a course to obtain pesticide certification in New York?	% of Respondents	Number of Respondents
Yes	59.74%	46
No	40.26%	31
Number of respondents		77
Number of respondents who skipped this question		18

25. What are the issues that concern you the most in terms of the success of your hop farm?

Number of Respondents	72
Number of respondents who skipped this question	23

Pest identification, Yield, Fertility
Yield
Labor. Funds, Insect and Disease Control, Water,
Sales. Disease, Labor
Pest Control , Post Harvest Processing
Market
Production / breaking even
Consistency. Irrigation, Weed Control
Mildew
Marketing, Harvesting, Equipment
Processing, pest, costs
Quality of yield, profitability, keeping organic
Money, Laws, State fee taxes, climate change
Quality Processing, Equipment/Data
Return on investment

Pest control, irrigation
Harvesting, irrigation, pest management, soil prep/weed control
Diseases, pests, R.O.I.
Pests, Harvesting
Stable & sustainable prices
Harvesting Mechanically vs. by hand, propagating & cloning
Market access, yields for area
R.O.I. and self sustainable growth and profitability
Pests, water/irrigation, market w/ fair $, oversupply causing low prices
Marketing, Labor Harvesting
Ability to irrigate & manage pests without chemicals
Cost, equipment - harvesting/drying and support
Irrigation, Soil nutrient, pest control, weed control, crop cover
Irrigation, my knowledge
Market Saturation, Craft beer "bubble", Multinational agribusiness involvement
Pests
Pest, Disease
Disease control, harvest mechanization, brewers gold replacement rhizomes and weed management
Pest Disease, Money
IPM, Buyers, use for brewing
Harvesting
Variety demand, processing, storage
Zoning, Marketings, Picking the hops to grow
Marketing, Processing
Irrigation and pest control
Yield , Equipment
A buyer, Too many people getting involved
Irrigation, Nutrution, Staying Chemcial Free, Becoming organic certified
Creating healthy yummy high quailty saleable hops
Harvesting, Processing, Packaging
Return on investment
Marketing, Financing
Financing Expansion
Low-Cost Harvesting & Processing, Effective pricing & building customer base
Time/money return on investment when we expand
Profitability, Financial startup, Product marketability
Harvesting, Selling wet hops
Poor quality rhizomes, irrigation, disease
Harvesting, Pest Control
Weeds, Pest, Trellising
Costs, Diseases, weeds
Marketing and quality
Disease, Harvest logistics and establishment
Obtaining clean hops of varieties we want and having or sharing harvestor, processing
Equipment - how possible is this, the logistic difficulties of sharing equipment and profitability
Soil type, clearing land, topography, patterns
Disease, who to sell to
Yield, Investment
Growth, IPM, Sales, Labor costs
Labor, Market
Cost, Viability, Labor, Equipment
Labor, Cash Flow, Mildrew & Insects, Space (Barns & Oasts)

Harvesting, Pests, Water
Yields, Pest Management, Irrigation, Harvesting/Marketing
Pests, Labor needs
Is there money to be made? Can we pay the taxes on the farm?
Propety tax breaks (my partners want to see tax savings), irrigation, varieties brewers want
Cost of Production, Quality. Yields, Labor

4. HARVESTING PROFILE

25x. How are you currently harvesting?

	% of Respondents	Number of Respondents
Hand picking	84.75%	50
Have my own harvester	8.47%	5
Bring my bines to someone with a harvester	6.78%	4
Number of respondents		59
Number of respondents who skipped this question		36

26. Please estimate how many total man-hours it took to harvest this past season...

Number of Respondents	38
TOTAL HOURS Reported for Harvesting: 910	
Number of respondents who skipped this question	57

27. Are you considering purchasing a harvester?

	% of Respondents	Number of Respondents
Yes	42.42%	28
No	57.58%	38
Number of respondents		66
Number of respondents who skipped this question		29

28. Would you consider a shared harvester?

	% of Respondents	Number of Respondents
Yes	86.15%	56
No	13.85%	9
Number of respondents		65
Number of respondents who skipped this question		30

29. What is the maximum you would be willing to spend to purchase a harvester?

	% of Respondents	Number of Respondents
$10-15,000	56.60%	30
$15-20,000	30.19%	16
$20-25,000	9.43%	5
$25-35,000	3.77%	2
Number of respondents		53
Number of respondents who skipped this question		42

30. Please rate the following characteristics of a small-scale hop harvester... (1-5)
(1 being NOT IMPORTANT and 5 being VERY IMPORTANT)

Mobile farm to farm	Ave: 3.9	75
Mobile within field	Ave: 3.4	74
Processing speed (60+ Bine/hour)	Ave: 3.4	70
Clean sorting	Ave: 4.5	71
Electrically Powered	Ave: 2.3	68
Tractor (PTO) Powered	Ave: 4.0	74
Number of Respondents		77
Number of respondents who skipped this question		18

Mobile farm to farm	Mobile within field	Processing speed (60+ Bine/hour)	Clean sorting	Electrically Powered	Tractor (PTO) Powered
1	5	5	5	1	5
4	1	4	5	5	5
5	5	5	5	1	5
5	4	3	3	1	5

3	4	3	4	2	4
2	3	4	5	2	2
4	1	4	5		
5	3	4	5	1	5
4	2	4	4	2	4
3	3	4	5	2	5
5	5	3	5		5
1	1	1	5	1	1
5	5	3	5	1	5
5	5	5	4	1	5
1	5	5	5	1	5
4	3	5	5	1	5
5	2	1	2	1	4
5	1	4	4	1	4
3	3	2	5	1	5
5	2	5	4	2	4
5	5	3	4	2	4
5	5	3	3	3	5
5	4	4	5	3	5
1	5	5	5	1	5
4	2	3	5	3	3
3	4	2	5	3	3
3	5	2	4	2	4
5	3	5	5	5	3
5	3	3	5	4	4
5	2	2	4	1	4
3	5	2	5	3	3
3	5	2	5	3	3
2	1	4	5	1	1
	5				
5	3	3	4	3	3
5	5	3	4	1	4
2	3	3	5	3	5
5	5	3	5	2	4
5	3	3	5	2	3
5	3	3	5	1	5
4	4	4	4	1	4
5	2	3	4	2	2
5	5	4	5	1	4
2	4	5	5	2	4
5					5
1	3	4	4	3	3
5	3	2	5	5	3
4	2	2	4	3	3
5	4				5
3	5	1	5		5
5	2		5	3	5
1	3	4	5	3	3
5	1	3	4	1	5

4	5	3	4	2	3
1	4	3	4	1	4
3	3	5	4	4	5
3	3	3	5	1	4
5					5
5	2				
5	3	3	4	1	5
5	5	4	4	2	5
4	4	5	5	5	3
4	4	4	4		5
5	2	3	4	2	2
5	3	3	4	1	4
4	4	3	3	2	4
5	5	4	5	3	3
5	4	2	3	3	4
5	2	5	4	2	5
5	3	4	4	3	4
5	3	5	5	5	4
3	3	2	4	5	3
5	4	2	5	3	3
3	4	3	4	2	4
5	3	2	4	4	3
1	1	5	5	4	4