New York State Department of Agriculture and Markets

Specialty Crop Block Grant Program – FY2011

AMS Agreement #12-25-B-1245

Final Performance Report

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Date Submitted:
March 11, 2015

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Project 1

Improving Management & Profitability of Sweet Corn through Enhanced Insect Control

Project Summary

Project purpose and background:

New York State sweet corn producers face a new complex of insect pests in the 21st century. *Helicoverpa zea*, the corn earworm (CEW), was a late season migratory pest of less importance throughout the 1900's. In contrast, *Ostrinia nubilalis*, the European corn borer (ECB), was the primary insect pest during the same period of time. As of 2014, the relative importance of these caterpillars has flip-flopped where CEW is a primary concern because corn borer populations have drastically declined. The spread of Brown Marmorated Stink Bug (BMSB), an invasive polyphagous piercing-sucking insect, into New York State combined with the new CEW concerns leave stakeholders with unanswered questions about the suitability of existing management guidelines that were implemented in the early 1990's.

There is a consensus among Cornell Cooperative Extension Educators, sweet corn growers and agricultural consultants from western New York, the Capital District, the Hudson Valley and Long Island regions of New York that shifts in the caterpillar pest complex of sweet corn, in addition to new concerns about BMSB, that producers are left with the sense that there is a lack of reliable data-driven management options. Poor control of CEW in the context of existing management guidelines and a lack of knowledge about options and efficacy of BMSB in sweet corn production systems across New York were the two primary factors driving the research that was funded by this grant project.

Project importance and timeliness:

The New York State Integrated Pest Management Program, based in Geneva, NY, at the Cornell University Agricultural Experiment Station, has monitored populations of ECB and CEW since 1993. This dataset shows that ECB populations have declined so much that they are no longer a primary pest of concern. In contrast, CEW populations are now detected nearly 8 weeks earlier than in the mid-1990's (Figure 1) and the predictability of pest pressure from year to year is less more difficult (Figure 2). While CEW is a migratory pest from the southern US, factors that drive its first arrival and annual population cycle have changed.

A third concern surrounding CEW has also arisen. Populations that cause economic loss in New York are evolutionary dead-ends. Because CEW populations don't overwinter in this region, traits that are carried by adult moths from the southern US are not passed successfully to a new generation. For this reason, and also because CEW arrived so late in the season during the 20th century, insecticide resistance was not a concern among growers or researchers. However, the advance of first detection by 8 weeks and the failure of traditional pyrethroid applications to control CEW, as demonstrated in 2010 field trials (Figure 3), prompted new concern about the possibility of insecticide resistance in NY sweet corn growing areas. From that 2010 study, we found that sweet corn sprayed 8 times with a pyrethroid yielded only 18% marketable ears and an average of 1.8 CEW larvae per ear. Further laboratory testing of F1 and F2 individuals collected from this population indicated some level of resistance, compounding concerns and providing support for the need to quickly address these unanswered questions.

Some research suggests that different regions (western NY, Capital, Hudson, Long Island) could be infested by different populations having different points of origin. Since it appears that there are several migration routes of CEW into the major sweet corn growing regions of New York (western NY, the Capital District and the Hudson Valley and Long Island regions), it is now important to monitor pyrethroid resistance in CEW populations from each of these areas.

Pyrethroid applications are inexpensive and have historically been effective against ECB. Until 2010, growers and researchers hadn't considered whether their efficacy was holding up to historical standards for CEW. Other registered insecticides are also used for CEW control, and needed to be tested. Both conventional and Bt sweet corn growers are at greater risk of infestation by CEW than ever before and growers need reliable information on options for control.

Very little is known about BMSB impacts on sweet corn production in New York. In other states, the insect has proven to be troublesome, with significant yield reduction and economic losses in sweet corn production systems. BMSB nymphs and adults pierce corn kernels to extract nutrients and the outcome results in an unmarketable ear for either fresh market or processing purposes.

We don't how BMSB will impact sweet corn crops within specific growing regions of New York. For this reason, a comprehensive review of currently registered insecticides labeled for BMSB control in sweet corn was needed, as well as corresponding evaluations of their efficacy. Without any other knowledge of developmental factors, landscape interactions, or mechanisms of biological control within the specific context of New York sweet corn systems, it is critical that growers and researchers understand what the best chemical control options are for BMSB.

Project Approach

***Goal #1* -- (a) establish baseline measurements of pyrethroid resistance among field-caught male populations of CEW from three sweet corn growing regions in New York State and (b) evaluate the efficacy of alternative registered insecticides in the event that pyrethroids are found to be ineffective.**

Goal 1(a). In 2012 and 2013, CEW pheromone traps were placed at the New York State Agricultural Experiment Station (NYSAES), Geneva NY (lat/lon 42.877096,-77.032356), New Paltz, NY (lat/lon 41.738496,-74.111238), and Riverhead, NY (lat/lon 40.922852,-72.672501). In 2012, 61 moths were collected in Geneva, NY and 134 adult male moths were collected from Riverhead, NY. CEW populations in New Paltz, NY failed to produce catches. In 2013, CEW populations were absent throughout the northeast US and failed to produce catches in both Geneva and New Paltz but insects were collected in Riverhead. To quantify the prevalence of pyrethroid resistance in CEW populations, glass vials were treated with a discriminating dose of the pyrethroid insecticide cypermethrin (5.0 μg pure compound per vial). Healthy trap-caught male moths were placed in vials for 24h and evaluated for mortality. Treated vials resulted in significantly lower rates of control compared to a positive control among insects in Geneva and Riverhead during the 2011 (59.1%, n=21 and 89.2%, n=119 respectively) and 2012 (73.3%, n=15 and 38.1%, n=34, respectively) field seasons (Table 1). Our results show that pyrethroid resistance genes are present in New York CEW populations, though not at levels that explain control failures observed in 2010 sweet corn field trials.

Goal 1(b). Methomyl, the active ingredient in Lannate LV (DuPont) was used as a positive control in the experiments described in Goal 1(a). Lannate (methomyl) is also a common standard treatment for caterpillar control in sweet corn throughout NY which is why we included it as a positive

control. Our results show methomyl was effective against insects sampled from Geneva (100% at 12.5 ug and 25.0 ug) and Riverhead (100% at 12.5 ug and 90.1% at 25ug). These results suggest that methomyl is still a reliable control if questions about pyrethroid efficacy arise.

Partner involvement:

Abby Seaman (NYSIPM program), Sandy Menasha, and Dan Gilrein (Cornell University Cooperative Extension of Suffolk County) worked closely with us to collect data and provide historical trap catch data. Without their significant contributions, data collection would not have been possible. Abby Seaman also coordinated/moderated presentations which we participated in and shared or discussed our findings to regional and statewide stakeholders.

The New York State Vegetable Growers Association provided an important annual venue for sharing the progress and outcome of our pyrethroid resistance research. We gained valuable feedback and perspective on our work from this group.

Goal #2 -- Evaluate the effectiveness of candidate insecticide products, either registered or unregistered, against BMSB to establish baseline efficacy data for east coast sweet corn management.

Goal #2. Insecticide efficacy trials against BMSB were conducted in 2012 and 2013 (Table 2). In 2012, three insecticides caused significant BMSB mortality when applied to corn plants at R1 green silk stage of development. Lannate® LV (94.9% ± 3.2), Baythroid® XL (72.8% ± 1.7), and Warrior® (48.6% ± 0.4) significantly suppressed insect population compared to the untreated check (2.0% ± 2.0). Entrust® (5.7% ± 1.6), Radiant® SC (5.7% ± 2.0), DiPel® DF (3.8% ± 1.3), Belt® SC (0.9% ± 0.9), and Coragen® (0.9% ± 0.9) did not cause significant mortality.

The only insecticide to cause significant BMSB mortality in 2012 when applied to corn plants at R2 blister stage of development was Lannate® LV (85.5% ± 1.3), when compared to the untreated check (8.2% ± 4.1). Baythroid® XL (37.4% ± 4.1), Warrior® (25.6% ± 4.1), Entrust® (31.1% ± 3.0), Radiant® SC (25.6% ± 5.2), DiPel® DF (16.2% ± 2.1), Belt® SC (1.3% ± 4.1), and Coragen® (21.3% ± 1.3) did not cause significant BMSB mortality at this stage of plant development.

In 2013, BMSB mortality was evaluated in R2 stage corn only, due to limited quantities of colony-reared insects. Two insecticides caused significant BMSB mortality when applied to corn plants at R2 blister stage of development. Lannate® LV (94.2 ± 2.3%) and Baythroid® XL (43.6 ± 7.1%) significantly suppressed insect population compared to the untreated check (10.2 ± 3.1%). Entrust® (39.4 ± 4.6%), Radiant® SC (35.3 ± 8.2%), Belt® SC (7.5 ± 2.2%), and Coragen® (13.9 ± 1.9%) did not cause significant mortality.

Fast-acting insecticides such as Lannate® LV (carbamate) are the most effective option for control of BMSB. Baythroid® XL (pyrethroid), and Warrior® (pyrethroid) also provide some control but vary depending on plant reproductive phase. BMSB are mobile and quickly move around either by walking or flying. As a result, they may have received limited exposure to treatments in these studies.

Morphological differences between R1 green silk and R2 blister stage ears of corn may also account for differences in efficacy among treatments. Ears at the green silk stage are relatively small and insecticide coverage may be more thorough than on R2 blister stage ears. Extended silks and growing husk leaves on R2 stage ears obstructed coverage and provided refuge to BMSB in contrast to R1 green silk ears.

Goals and Outcomes Achieved

	Goal #1(a)	Goal #1(b)	Goal #2
Proposed goals and measureable outcomes	Establish baseline measurements of pyrethroid resistance among field-caught male populations of CEW from three sweet corn growing regions in New York State	Evaluate the efficacy of alternate registered insecticides in the event that pyrethroids are found to be ineffective	Evaluate the effectiveness of candidate insecticide products, either registered or unregistered, against BMSB to establish baseline efficacy data for east coast sweet corn management
Actual Accomplishments	Datasets were obtained and evaluated for 2011 and 2012. 2013 field conditions did not produce trap catches at any location, but this was observed throughout the northeast US. We successful established baseline pyrethroid resistance information for western NY and Suffolk County, NY which are two important sweet corn production regions.	Methomyl, the active ingredient of Lannate LV, was evaluated in tandem with a standard pyrethroid as a positive control. In all cases, methomyl caused nearly complete mortality among moths tested. This result confirms that Lannate LV, another industry standard for caterpillar control in sweet corn, is a suitable alternative to pyrethroid insecticides if there are concerns about the effectiveness of the latter.	A suite of standard insecticides was successfully evaluated for control of BMSB nymphs and adults feeding on select reproductive phases of sweet corn in New York State.
Activities completed	• Three pheromone trap sites were established for collection of adult male moths in 2012 and 2013. • Weekly monitoring and collections took place during peak moth flights to collect specimens for evaluation. • Laboratory assays	• Three pheromone trap sites were established for collection of adult male moths in 2012 and 2013. • Weekly monitoring and collections took place during peak moth flights to collect specimens for evaluation.	• BMSB colonies were established and maintained for 2 years to obtain large quantities for controlled field trials. • Field plots of sweet corn were established and maintained in 2012 and 2013 to serve as hosts for BMSB. • Insecticides were identified and applied

	were prepared using standard methods to evaluate live insects for pyrethroid resistance. • Statistical analysis was performed to evaluate results for significant resistance effects.	• Laboratory assays were prepared using standard methods to evaluate live insects for pyrethroid resistance. • Statistical analysis was performed to evaluate results for significant resistance effects.	against select sweet corn reproductive stages as curative controls • Statistical analysis was performed to evaluate results for significant control effects.

Beneficiaries

All results were shared with stakeholders, growers, and researchers at numerous events and functions in 2011, 2012, 2013 and 2014. In each of these years, results were presented to the New York State Sweet Corn Advisory Council, audiences at the New York State Fruit and Vegetable Expo, Cornell University Cooperative Extension Agricultural In-services, university departmental seminars and discussion groups. Total direct audience reach from these interactions are estimated to be >350 stakeholders, researchers and growers.

The 1,425 sweet corn growers in New York, both fresh market and processors, have and will continue to directly benefit from this project. A summary of our experiment is posted on the Shelton Lab website for public view http://shelton.entomology.cornell.edu . Supplemental information, including recent insecticide efficacy data published by our lab in Arthropod Management Tests (AMT) for control of CEW in sweet corn and is useful in situations where effective insecticidal control of CEW with pyrethroid insecticides are questionable (http://shelton.entomology.cornell.edu/?p=1042). Data on BMSB insecticide efficacy is available via Arthropod Management Tests, (DOI: http://dx.doi.org/10.4182/amt.2013.E61). This will reduce unnecessary sprays of ineffective insecticides and reduce costs as well as negative environmental impacts.

As an economic example, downstate where CEW pressure is more intense, a pyrethroid is normally applied at least 6 times to almost all sweet corn acreage. Assuming even 1 of those sprays (at $10/acre) was ineffective on the 10,000 acres in the region, which means $100,000 was wasted for insect control (this amount is less than the cost of the grant). If one ineffective spray was eliminated over the 40,500 acres grown statewide, that would translate to $405,000 in wasted spray cost, not to mention insect damage incurred.

Knowledge of CEW susceptibility to pyrethroids, which is the inexpensive choice of sweet corn growers, is essential to any insect management program. In addition to CEW control, sweet corn growers could sustain large losses due to BMSB unless they have information on what insecticides can be effective against it. A baseline dataset of chemical efficacy now exists for this new agricultural pest as a direct result of this NYSDAM grant-funded project.

Lessons Learned

1. Corn earworm adults are arriving earlier into our region and management practices must adapt to this change. We detected low levels of pyrethroid resistance but alternative insecticides are still effective.
2. Populations of European corn borers are declining. The reasons for this decline may be the adoption of Bt field and sweet corn and changing weather patterns.
3. Brown marmorated stink bugs are effectively controlled with contact insecticides such as Lannate, Baythroid and Warrior. Insecticides that were not effective included Bts, diamides and spinosads.

Table 1. Mortality of field collected adult male *Helicoverpa zea* moths exposed to different discriminating insecticidal doses using an adult vial test method in 2011 and 2012.

Location	Year	Treatment	Dose/vial	n	% control[a]
Geneva, NY	2011	cypermethrin	5.0 µg	21	59.1
	2012	cypermethrin	5.0 µg	15	73.3
		methomyl	12.5 µg	15	100.0
			25.0 µg	15	100.0
Riverhead, NY	2011	cypermethrin	5.0 µg	119	89.2
	2012	cypermethrin	5.0 µg	34	38.1
		methomyl	12.5 µg	34	100.0
			25.0 µg	34	90.1

[a] Abbott's adjusted mortality rate.

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Project 2

Diagnostic Services for Monitoring & Managing Recent Outbreak of Bloat Nematode on Garlic in New York State

Project Summary

The overall objective of the project was to offer assistance on the diagnosis and management of the bloat nematode (*Ditylenchus dipsaci*) on garlic by providing subsidized and timely nematode analysis services to growers, buyers and/or sellers. An outbreak of the bloat nematode was first observed occurring on garlic in a field in western New York in June 2010 and later was documented to be widespread and causing significant yield and quality losses throughout the production areas in the state. The bloat nematode moves only to limited distances on its own in the soil, but it spreads mainly in infected planting materials (garlic cloves/bulbs) and in infested soil transported by irrigation water or surface run-off or on contaminated equipment.

Unfortunately, only severely infected bulbs and at late stages of infection exhibit visual symptoms that include discoloration, shrinking, light weight, cracks near the basal plate and eventually decay due to the involvement of saprophytic soil organisms (See Appendix 1 in Additional Information). Thus, the use of bloat nematode-free garlic seeds and planting into nematode-free soil is the critical first step in controlling this problem in both organic and conventional garlic production systems. Accordingly, a bloat nematode diagnostic service and an outreach educational program on the management of this nematode targeted primarily to New York's garlic producers and industry personnel were urgently needed and were provided over the duration of this project. The specific objectives of the project were the following:

1. Process and analyze garlic bulb and soil samples submitted by producers in New York State for the presence and density of the bloat nematodes and other parasitic nematodes.
2. Provide the appropriate interpretation of results and discuss their utility in the management of the bloat nematode and other parasitic nematodes, if found.
3. Assist garlic growers in the selection of appropriate and cost-effective management practices and provide the needed information on garlic and soil sampling to assess the efficacy of implemented control practices, satisfying garlic certification requirements, and other needed information.

Project Approach

1. Garlic samples received and processed for the bloat nematode diagnostic services:

In fall 2011 and early 2012, project leaders provided detailed information to garlic growers and industry personnel on the objectives of this project and guidelines for collecting and submitting garlic and soil samples for assessing their infestation by the garlic bloat nematode, if any. A sample submission form was developed (Appendix 2 in Additional Information) and widely made available through Cornell Cooperative Extension Vegetable Newsletters (Capital District and Western NY Region Teams), the International Garlic Foundation Newsletter and the recently established Garlic Grower's List Serve. Abawi made a presentation and lead a discussion at the Cornell Cooperative Extension In-Service Training on November 16, 2011 held in Ithaca, NY and also gave a seminar to the Department of Plant Pathology at Cornell University on October 27,

2011 titled "2010 outbreak of the garlic bloat nematode on garlic in New York". Over 300 garlic samples were processed in our laboratory during 2010 and 2011 and about 30% of these samples tested positive for the garlic bloat nematode, as juveniles and adults of this nematode were recovered from the processed tissues or soil. Results of the bloat nematode testing, their interpretations, their utility and any resulting questions were communicated to the sample submitters and the appropriate extension educators through e-mails, hard copy, and/or telephone conversations.

A. *Diagnostic samples analyzed in 2012:* A total of 119 garlic samples were submitted and analyzed for the garlic bloat nematode. The bloat nematode was recovered from 17.7% of the samples and at a population ranging from 16.3 – 5,033.0 nematodes/g tissues processed by the Pie-Pan Extraction Protocol, a modification of the Bearmann Method. This method of nematode extraction recovers only live and active nematodes over a 3-days incubation period in water and under room temperature. Interestingly, only 9.8% of the garlic samples submitted after July 1, 2012 (81 samples) were found infested with the garlic bloat nematode. The latter suggests the impact of the project activities and the progress made by garlic growers and others in the detection and effective management practices employed to reduce the spread and damage of this nematode.

B. *Diagnostic samples analyzed in 2013*: A total of 108 garlic samples were received and processed during this year of the project. The garlic bloat nematode was recovered from 13 samples, thus representing an infestation level of 12.04%. Average infestations of the latter garlic samples ranged from 6.4 to 1,376.8 nematodes/1 gram of garlic tissues processed.

C. *Diagnostic samples analyzed in 2014:* A total of 118 garlic samples were received and analyzed for the bloat nematode during the final year of the project. Fifteen of these samples tested positive for the bloat nematode (12.7% recovery) at densities from 0.34 – 937.5 nematodes/g tissues processed.

2. **Outreach project activities provided during the project***:*

Training workshops, field visits, publications and presentations at formal and informal meetings were provided to growers and industry personnel during the duration of the project.

A. *Training workshops:* The project leaders presented 7 workshops to garlic producers and industry personnel dealing with the biology, detection, damage and management of the bloat nematode as well as other production constraints, harvesting, curing and storage of garlic (Appendix 3). In 2012, three workshops were held in Albany, NY on March 26; Geneva, NY on March 27; and Ithaca, NY on March 28. 113 growers, extension educators and other industry personnel attended the 3 workshops. In 2013, similar workshops were held in Geneva, NY on March 21 and in Albany, NY on April 10 and were attended by 26 and 40 growers and other personnel, respectively. Similarly, two workshops were conducted in 2014, one in Geneva, NY on March 28 and the other in Albany, NY on April 9th. There were 51 and 55 in attendance at the Geneva and Albany area workshops, respectively.

B. *Presentations:* In 2012**,** an illustrated poster on the current status of the garlic Bloat Nematode in NY was prepared by the project leaders and presented at the annual meeting of the Society of Nematologists held in Savannah, Georgia during August 12 – 15, 2012. Abawi also made a

presentation at the Agriculture & Food Systems In-Service, Cornell Cooperative Extension on November 13, 2012.

In 2013, Abawi presented an invited talk at the onion session on January 30, 2013 during the Mid-Atlantic Fruit and Vegetable Convention in Hershey, PA titled "Bloat Nematode: A re-emerging and damaging pest of garlic and other hosts". Crystal Stewart collaborated on organizing an "Allium School: Garlic, leek & Shallots" at the Empire State Producers Expo in Syracuse, NY on January 24, 2013 and gave two presentations, one dealing with seed selection and pest management of garlic and the other on harvest and post-harvest considerations for garlic and leeks.

In 2014, Abawi made a presentation titled "Updating the status of the re-emerging and damaging bloat nematode on garlic" at the NE Division meeting of the American Phytopathological Society that was held in Portsmouth, NH during October 29-31, 2014 and with about 70 in attendance.

C. *Field visits, other communications and contacts:* In 2012, Abawi and Stewart visited with several garlic growers in Eastern, NY on June 28, 2012 and discussed various appropriate practices to manage the garlic bloat nematode as well as other diseases and pests (Appendix 3). Similarly, Abawi and Hadad visited with several garlic growers in Western NY on July 25, 2012. Furthermore, detailed information on the detection and management of the bloat nematode were provided to garlic growers through responses to their e-mail messages, phone calls, during farm visits and/or via reports send on the results of their submitted samples and possible management solutions to consider. Currently there are about 450 growers receiving information on garlic issues through the weekly newsletters of the Cornell Cooperative Extension Programs in the western region of NY and the Albany area. The project co-leaders attended and conducted outreach activities at the Saugerties and the Milford Garlic Festivals (Appendix 3). Crystal Stewart outreach efforts with garlic growers and industry personnel to-date included direct contacts with 235 stakeholders (workshops, farm visits, garlic festivals, and talks at growers meetings) and indirectly to additional 470 growers through telephone calls, e-mail messaging, and updates in the newsletters of the capital district extension office. Similarly, Robert Hadad had 124 contacts with garlic growers through farm visits and garlic schools.

In 2014, Project leaders attended and participated in a twilight field meeting held at a garlic grower's farm in Livonia, NY on June 17, 2014 with 25 producers in attendance. The leaders also visited several garlic plantings and growers in eastern NY on June 23, 2014. In addition, the project leaders attended and distributed the survey that was prepared for the evaluation of the project to all garlic growers exhibiting at the *Hudson Valley Garlic Festival* held during September 27 & 28, 2014 in Saugerties, NY. About 70 garlic growers/farms were in attendance and >40,000 people visited the 2-days festival.

Finally, Crystal Stewart and Robert Hadad wrote newsletter articles on garlic production, harvesting, curing and storage that also included information on the garlic bloat nematode. Over the 3 years duration of the project, the project leaders communicated with large numbers of growers throughout the state on various issues dealing with the diagnosis and management of the garlic bloat nematode as well as numerous garlic production constraints including other pests, harvesting, curing and storage concerns.

Goals and Outcomes Achieved

1. A total of 345 samples submitted by garlic growers were analyzed for the Garlic Bloat Nematode during the project duration (2012-2014). In 2007, the number of garlic producers in New York was documented to be at 330. There are likely more garlic growers at present (possibly 400), but it is hard to accurately assess the number at this time. We believe that about 60% of garlic growers in New York State had submitted one or more samples for diagnosing the presence or absence of the bloat nematode in their garlic seeds or soils. Approximately 85 growers attended field days or were visited during the project. We are very pleased with the satisfaction and use of the testing results and the information provided by all those who participated in the program.

2. Diverse and numerous educational programs were offered in the form of 7 training workshops, several presentations at formal and informal meetings (meetings of the Society of Nematologists, The American Phytopathological Society, Empire Fruit and Vegetable Expo, Mid-Atlantic Fruit and Vegetable Conference, etc.), many farm visits and interactions at annual garlic festivals (Hudson Valley garlic Festival, Cantine Field, Saugerties, NY; and Fox Run Winery Garlic Festival, Geneva, NY), frequent contacts by establishing the garlic e-mail list (>450 contacts), newsletter articles and others. We have reached most, if not all the garlic growers and interested personnel in the state and a great numbers of them have participated in the diagnostic services and educational programs provided by the project leaders.

3. As a result of the diagnostic services and the formal and informal educational programs provided by the project, garlic growers have made several changes in their production, handling and marketing practices. Growers have learned how to effectively scout their fields and remove all plants with symptoms of infection by the bloat nematode or other diseases and pests. They are also employing an improved production practices for harvesting, curing and storing of garlic. In addition, growers are harvesting, curing and storing garlic for use as seeds the next season separately from the garlic to be sold for food. Furthermore, they are testing their seed stocks on hand or those to be purchased to assure they are nematode-free planting materials. Also, many growers have changed or lengthened their crop rotations, experimenting with the use of bio-fumigant cover crops (mustards, sudan-grass hybrids, oilseed radishes, etc.), improved fertility, better timing of harvest, proper curing, and appropriate storage conditions. The latter were confirmed by discussions with garlic growers and from responses to surveys conducted during the training workshops and from the final survey (Appendix 4A) prepared to assess the impact of the project. For example, of the 27 responses to the survey distributed after the 2014 Training Workshop held in Geneva, NY; 16 out of the 27 (59%) that completed the survey indicated that they have changed one or more of their production practices and all but one will recommend others to use the nematode testing service.

4. The final survey conducted to assess the impact of the project was distributed to garlic exhibitors at the "*Hudson Valley Garlic Festival*" and 29 completed surveys were returned. Eighteen of the exhibiting growers (62%) indicated that they have used the Bloat nematode diagnostic service provided by the project. In addition, 17 of those responding indicated that of the testing results confirmed that their own seeds and those they purchased were nematode-free, thus assisting them in their management decisions. Another 11 indicated that the testing results made it possible for them to assure their customers that the garlic they are buying is nematode-free. Finally, 21/29 respondents indicated that the garlic testing results have contributed to implementing one or more new practices in their production practices including crop rotation, use of cover crops, seed treatment, planting site, harvesting and/or changing seed

sources. In addition, 4 growers indicated that the testing made it possible for them to select a confirmed nematode-free site for their next planting.

Beneficiaries

We believe that 100% of garlic growers and industry personnel in New York State have directly and/or indirectly benefited from the diagnostic services and the outreach activities provided by the project. Records indicate that 279 growers and extension educators attended the 7 training workshops presented. Furthermore, Co-PIs Crystal Stewart and Robert Hadad had direct contact with 235 and 124 growers, respectively. One garlic producer commented, "Cornell's response to our problems with garlic bloat nematode saved my business and my livelihood... Because of their continued involvement of identifying pests and hold garlic schools we, the garlic growers, are growing better crops than we ever thought possible".

The project had a significant impact on improving the profitability of garlic production in New York and elsewhere. Assessment of actual benefits is difficult to assess due to the extreme variability in the size of production (<1/4 acre to >10 acres) and the reported losses (from negligible to 100%). However, even 5 - 10% annual losses in garlic production is highly significant when one considers the garlic yield of about 8,000 lbs. /A and the sale price of $10 – $16 per pound of garlic.

Lessons Learned

1. Project leaders were pleased with the great interest, needs and satisfaction that garlic growers and other industry personnel showed in learning about the bloat nematode and its management as well as the numerous outreach activities that dealt with other garlic production constraints.
2. It was surprising to learn from the samples submitted for the bloat nematode diagnostic testing and the many outreach activities provided the existence of several other major diseases and pests as well as serious production constraints impacting garlic production. The latter included diseases caused by several fungal pathogens (*Fusarium*, *Penicillium*, *Botrytis*, *Aspergillus*, others), and uncharacterized bacterial and viral diseases. In addition, there is a great need for optimizing fertilizer applications, weed management, timing of harvest, curing and storing of garlic. The Co-PI's of this project and others are already collaborating with several growers on investigating these issues and with additional funds from NE-SARE program and other sources.
3. Progress is been made on characterizing the genetic diversity among the recovered populations of the bloat nematode from the samples submitted to our laboratory in Geneva, NY. Since our laboratory started receiving garlic samples from growers in other states and without prior notice, we applied and received a permit from APHIS/USDA for the interstate movement of live plant pests (Permit # P526P-13-01838). To-date, the molecular characterization of 25 out of a total of 45 populations of the bloat nematode recovered from samples received from New York and other states have been completed. The characterized populations have exhibited little polymorphism, thus suggesting that the same or very close strains of the bloat nematode are been distributed via the exchange or purchase of infected garlic seeds. However, additional characterizations and confirmations are warranted.
4. Discussion and information provided in the surveys after the training workshops indicated that garlic growers are interested in the establishment of a certification program for garlic seed

production in New York. However, interested growers are not willing to pay the high cost needed at the present time to cover the total cost of implementing such a certification program.

5. In greenhouse tests, we confirmed information available in the literature that the bloat nematode survives for longer period under dry than wet conditions. Two tests were conducted by placing infected garlic seeds in soil that was maintained dry, wet and fluctuating between wet and dry conditions. Results obtained (Appendix 5 A) clearly show that the bloat nematode survives for considerably longer periods under the dry and wet-dry soil conditions, as compared to its survival under continuously wet conditions.
6. It was also learned that garlic growth was stimulated with the soil application of the nematicide Vydate L (Oxamyl) applied at the rate of 2 gallons/A in the presence or absence of the bloat nematode (Appendix 5 B).

Additional Information

Publications:

Abawi, George S. and Kundan Moktan. 2011. Bloat nematode problem on garlic: Symptoms, distributions and management guidelines. 4 pages summary, Proceedings of the Empire State Fruits & Vegetable Expo, Cornell Cooperative Extension.

Abawi, G. S., K. Moktan, C. Stewart, R. Hadad, and C. Hoepting. 2012. Current status of the bloat nematode on garlic in New York. Poster presented at the Society of Nematologists meeting held in Savannah, Georgia during August 12-15, 2012. Page 30 of the Meeting Proceedings (Abstr.).

Abawi, G. S., and K. Moktan. 2013. Bloat Nematode: a re-emerging and damaging pest of garlic and other crops. Pages 168 – 170, Proceedings of the Mid-Atlantic Fruit and Vegetable Conference, Hershey, PA (Jan. 28-31, 2013).

Abawi, George S., K. Moktan, C. Stewart, R. Hadad, L. A. Jones, and C. D. Smart. 2014. Updating the status of the re-emerging and damaging bloat nematode on garlic. Proceeding of the NED-APS (American Phytopathological Society) meeting held in Portsmouth, NH during October 29-31, 2014.

Attached Appendixes:

Appendix 1 A-F: The garlic Bloat Nematode (A, *Ditylenchus dipsaci*), symptoms of infection on plants in the field (B, C), mature bulbs (D, E) and a pile of infected and unmarketable garlic (F).

Appendix 2: Sample submission form requested with each garlic sample submitted for testing.

Appendix 3 A-D**:** Photos of participants at one of the Training Workshops offered (A), a visit to a commercial garlic field (B), and garlic festivals (C, D).

Appendix 4 A-B): Results on the survival of the bloat nematode under dry, wet and dry-wet soil conditions (A) and the stimulatory effect of soil application of Vydate on garlic growth (B).

Appendix 5: Survey questions for assessing the impact of the bloat nematode diagnostic services and the project in general (A), and photos on garlic harvesting (B), curing (C), and storage (D).

Appendix 1. The bloat nematode (Ditylenchus dipsaci), symptoms of infection and damage to garlic.

Appendix 2. Sample submission form request with each garlic sample submitted for testing.

Bloat Nematode Diagnostics Lab
Sample Submission Form

Cornell University
Cooperative Extension

Please mail sample and payment to: Cornell University, NYSAES, Barton Lab, Room 111,
630 West North Street Geneva, NY 14456

Location where the sample was taken

Home Owner ☐ Commercial Grower ☐ Others ☐

Business name: _____

Person to contact: _____

Address: _____

_____

Phone: _____

Fax: _____

Email: _____

County: _____

Collection Date: _____

Referring Agent: (i.e. CCE educator)

Name: _____

Email: _____

Guidelines:

Samples can be collected anytime, but best close to harvest and before planting. Send 10 representative bulbs/ variety/ garlic sample or one pint or more of a composite soil sample (> 10 subsamples)/ field or bed. Pack garlic and soil sample separately and, avoid exposure to direct sun light and high temperature. Send only during the week and by overnight delivery, if possible.

Describe the nature and extent of the problem

_____

_____

_____

_____

_____

Production History:

☐ Organic ☐ Conventional

Previous Crops: 2011) _____ 2010) _____ 2009) _____ 2008) _____

Objective of Testing:

☐ Sale for Seed ☐ Sale for Food ☐ Sale for Seed and Food

☐ Seed for Replanting ☐ Poor Growth/ Quality ☐ Soil Infestation

Size of Planting:

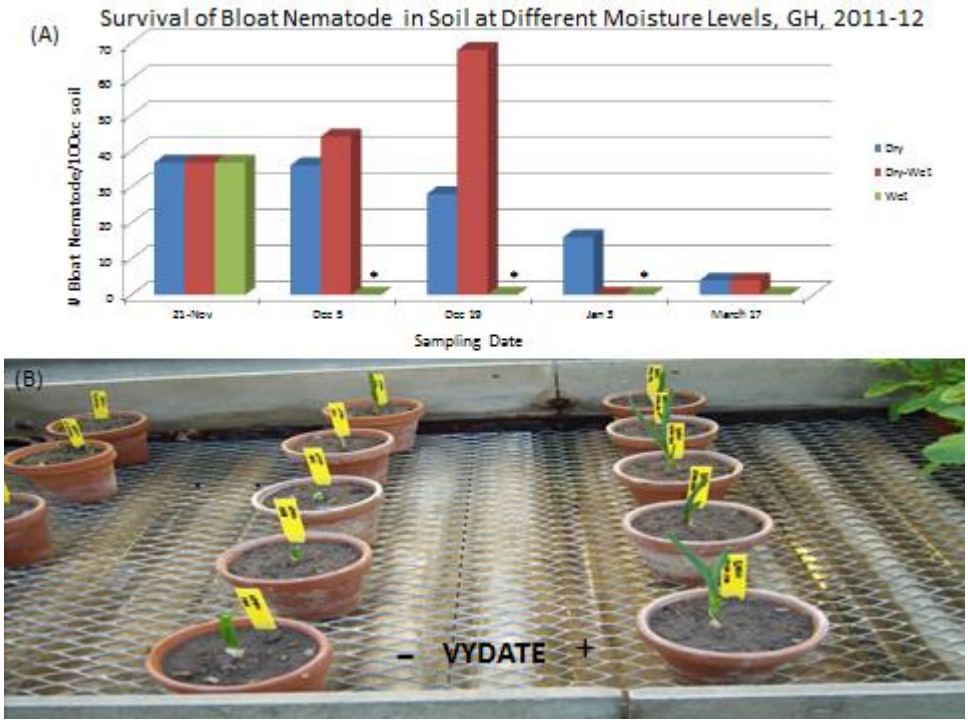
☐ < ¼ Acre ☐ 1/4 – 1/2 Acre ☐ 1/2 -1 Acre

☐ 1-2 Acres ☐ > 2 Acres ☐ Area Affected: _____

Charges and Payment: $20/ sample (Garlic or Soil) for NY growers and Industry; $40 for all others.
Please Make Check Payable to **Cornell University** and write **Garlic Project** in the memo section of the check.

Appendix 3. Photos of participants at one of the training workshop offered (A), a visit to a commercial garlic field (B), and garlic festivals (C, D).

Appendix 4. Results on the survival of the bloat nematode under dry, wet and dry-wet soil condition (A) and the stimulatory effect of soil application of Vydate on garlic growth (B).



Appendix 5. Survey question for assessing the impact of the bloat nematode diagnostic services and the project in general (A), and photos on garlic harvesting (B), curing (C), and storage (D).

(

Hudson Valley Garlic Festival 2014 Grower Survey

Please fill out this brief survey to help us document our project impact, improve the services provided, and address other needs. Your responses are very important!

I have used Garlic Bloat Nematode Testing Services in the following capacity.

☐ Garlic bulb testing ☐ soil testing ☐ garlic and soil

As a result of the nematode analysis report (please check all that apply):

- ☐ I have confirmed that my garlic seed is clean
- ☐ I confirmed that the seed source I purchase from was clean
- ☐ I was able to assure my customers that my garlic seeds are clean
- ☐ I was able to select a clean site for my next planting
- ☐ I learned that my garlic seed was infested with garlic bloat nematode
- ☐ Other (please explain)

As a result of testing for and education about garlic bloat nematode, I experienced the following results (check all that apply)

☐ Reduced losses due to the bloat nematode

Changed my production practices (check all that apply): ☐ rotation ☐ seed treatment ☐ planting site ☐ harvesting ☐ changed seed source

☐ Increased net profit

☐ Other_____

How do you rate the information you received on the bloat nematode via training workshops, field visits, presentations at meetings, phone calls and/or e-mails on a scale of **1=not helpful to 10=extremely helpful**

Ranking number: _____

Are there any problems you are facing with your garlic that you need help addressing? Please write them down below. If you want us to contact you about them, leave us your contact information.

PLEASE FILL OUT THE OTHER SIDE, RELATED TO SARE RESEARCH PROJECTS!!

Contact Persons

George S. Abawi (PI), Professor, Dept. of Plant Pathology and Plant-Microbe Biology, Cornell University, NYSAES, Geneva, NY 14456, 315-787-2374, gsa1@cornell.edu.

Crystal Stewart (C0-PI), Regional Agricultural Specialist, CCE – Capital District, 141 Fonclair Terrace, Johnstown, NY 12095, 518-775-0018, cls263@cornell.edu.

Robert Hadad (Co-PI), Fresh Market Specialist, CCE, 4487 Lake Ave., Lockport, NY 14094, rgh26@cornell.edu.

Project 3

Managing Japanese Beetle in Eastern Vineyards by Reducing Grub Populations in Sod Row Middles with Persistent Entomopathogenic Nematodes

Project Summary

This project investigate the use of persistent entomopathogenic (insect-attacking) nematodes (EPNs) to manage foliar feeding damage by adult Japanese beetle (JB) in commercial vineyards. Grapes are the second largest fruit crop in New York. Current practices dictate the use of insecticide applications for management of JB adults. This project evaluated an approach that could substantially reduce insecticide use in vineyards, thereby enhancing profitability and sustainability for the industry.

Foliar feeding by adult JB is of major concern for grape growers in New York, and other grape growing states in the region resulting in multiple applications of often broad-spectrum insecticides. In addition to the cost, chemical control of adult beetles has been associated with increased problems with secondary pests such as spider mites. Nearly all vineyards in New York maintain permanent sod in the row middles, providing a reliable food source for Japanese beetle larvae in close proximity to grape vines. Upon emergence, adult beetles consume large amounts of grape foliage resulting in reduced vine growth, reduced cluster number and weight, reduced fruit quality and decreased overwinter bud hardiness. We proposed to test the feasibility of EPNs that kill larvae in row middles for reducing adult populations and foliar damage.

A one-time release of the correct species complex of entomopathogenic nematodes has successfully controlled pest beetles in perennial crop systems. New York native cold-adapted strains of the nematode species *Steinernema carpocapsae* ("NY001"), *S. feltiae* ("NY004"), and *Heterorhabditis bacteriophora* ("Oswego") were isolated in the early 1990s by one of the PIs (ES) and used extensively during the past 20 years in field research under New York conditions. These strains have been shown to kill mature larvae (third instar) of Japanese beetle. All three native strains have been documented to persist in field sites for many years after inoculation and are currently being effectively used on a large scale as a biological control agent against alfalfa snout beetle, *Otiorhynchus ligustici*, a severe invasive pest of alfalfa in nine counties of New York. Farmers within the infested area are being trained to rear their own nematodes, and inoculate their own fields for long-term alfalfa snout beetle control.

The principal goal of this project was to enhance the profitability of growing grapes in New York through the development of a sustainable, cost-effective approach to managing Japanese beetles in New York vineyards. Grapes are one of the most economically important fruit crops grown in New York with 34,000 acres in production worth approximately 50 M in farm gate receipts. Moreover, a recent economic analysis revealed that the grape industry in New York generates $3.75 billion dollars of benefits annually for the state economy. Persistent entomopathogenic nematodes targeting Japanese beetle larvae in sod row middles have the potential to eliminate the need to apply insecticides against adult beetles resulting in significant economic and environmental benefits.

We proposed to address the following objectives: 1) Determine the establishment potential and persistence of three native New York entomopathogenic nematodes in sod row middles, 2) Measure the efficacy of the entomopathogenic nematode treatments against JB larvae in sod row middles relative to insecticide, 3) Evaluate the potential of reducing adult JB feeding damage on grape foliage by reducing larval populations within sod row middles.

Project Approach

Identification and Establishment of plots:

In the fall of 2011, four vineyard sites were identified, pre-sampled for indigenous entomopathogenic nematodes, and subsequently inoculated with a mixture of laboratory-reared entomopathogenic nematodes (*Steinernema carpocapsae* ["NY001"] and *S. feltiae* ["NY04"]. Two additional sites were inoculated in the fall of 2012.

Fall 2011 inoculations included two vineyards in the Finger Lakes region (Red Tail Ridge and Silver Thread Wineries), in which vineyard blocks were divided into zones designated for release of entomopathogenic nematodes, or control zones without release. A similar procedure was followed at a Lake Erie region vineyard site (Sam Ark Vineyard). At the Lake Erie site, half of the block was treated with a soil insecticide toxic to larval Japanese beetle, while the other half was not treated.

Fall 2012 inoculations included one additional site in the Finger Lakes (King Ferry Vineyards) and one additional site in the Lake Erie region (Joy Vineyard). Again, sites were divided into zones designated for nematode release, or control zones.

Plot sizes varied at each site but were generally 3-5 acres in size. Lab reared nematodes were applied using a boom sprayer with the nozzles removed at an approximate rate of 500 million infective juveniles per acre. In addition to the row middles we also released nematodes in grassy areas at the periphery of vineyard blocks assigned to receive nematodes. These grassy areas are common at many vineyard sites in New York and are likely to be important sources of adult Japanese beetles.

Sampling for entomopathogenic nematodes and Japanese beetle:

During the growing seasons from 2012 thru 2014, established sites were sampled for Japanese beetle, other Scarabaeidae beetle larvae and entomopathogenic nematodes from each zone of experimental treatment and control.

For beetle grub assessments, we collected multiple soil cores about 20 cm in depth and 10.8 cm in diameter using a golf cup cutter and inspected cores in the field for different grub species. Adult beetle assessments of density and feeding damage were completed annually at each site.

For entomopathogenic nematode assessments, smaller diameter soil cores (3.8 cm) were collected. Soil cores were divided into upper and lower zones and returned to Cornell University for evaluation. Wax moth larvae were used to test for the presence of entomopathogenic nematodes.

Significant results and conclusions:

Across study sites we have observed a consistent or increasing proportion of soil samples with evidence of entomopathogenic nematodes as measured by capacity to kill sentinel wax moth larvae. Of the two species being monitored, *S. feltiae* (Sf) has established particularly well, averaging around 25% infectivity of soil samples in 2014 (Figure 1). Abundance of *Steinernema carpocapsae* (Sc) has remained low but consistent.

Scarabaeidae larvae were fairly rare at all sites throughout the duration of this investigation. Moreover, due to the considerable labor required to collect soil cores relative to the small actual amount of area sampled, our capacity to detect grubs was limited. Adult feeding damage was monitored annually for each site, concluding with a survey in 2014 in which all four of the remaining sites with valid control and treatment blocks were assessed. Overall, we recorded higher percentage

defoliation in control zones than in nematode treated zones in 2014 (Figure 2). Results were more mixed in 2013 (Figure 2). Focusing on the results from 2014, damage varied from site to site, with three of the sites having relatively low amounts and one site with relatively high amounts. However, at each site in 2014, a greater proportion of damage was recorded from control sites compared to nematode release sites (mean proportion decrease in release sites was 46%). Survey data from 2013 and 2014 for adult Japanese beetle was generally consistent with trends in feeding damage (Figure 3).

Results from this investigation show an encouraging association of lower levels of leaf feeding damage and the presence of the introduced entomopathogenic nematodes. A limiting factor to this conclusion is the relatively low incidence of Japanese beetle that occurred over the period of time that this investigation was conducted. While tolerance varies from grower to grower and by variety for feeding damage, it is thought that defoliation levels of 15-20 percent or less, do not affect grape productivity, fruit quality and yield. This investigation included one site with control levels that approached this threshold in 2014.

Persistence of the entomopathogenic nematodes in the commercial vineyard environments was also encouraging. It was unclear going into this investigation if the intensive agricultural practices that go into the management of commercial vineyards would adversely affect the nematodes. Data from this investigation indicate that these nematode species are self-sustaining once established and that growers will not need to spend time and energy maintaining them.

One challenge experienced during this investigation was the loss of one of the sites (Red Tail Ridge) at which a vineyard management decision was made by the owner cooperator that adversely affected the control zone of the experiment for that site. While nematode persistence data was still recorded, there was not a valid control zone for comparison of Japanese beetle infestation and damage data. This challenge was addressed with the addition of two addition sites to the investigation in 2012.

A considerable amount of time and effort went into measuring the occurrence of Japanese beetle grubs within the treated sod zones each year, and at each site. Despite these efforts, the frequency of their detection was so low it is difficult to draw any meaningful conclusions from this data. Fortunately, measurements of adult presence and activity have provided a measure of the most pertinent effect of the pest.

A particularly sad development was the death of one of our owner cooperators as a result of a farm accident. His surviving family was supportive of our project and we were able to complete the investigation at their vineyard.

Dissemination of research to stakeholders:

The project team prepared newsletter articles, conference proceedings, and gave presentations at winter grower meetings during the course of this project to communicate research results to stakeholders. These activities are summarized below.

<u>Publications related to project:</u>

2012 Loeb, G. Grape Insect and Mite Pests-2012 Field Season. 2012. Vineyard Notes (Finger Lakes Grape Program newsletter) 18 May 2012, #4: 2-18.

2012 Loeb, G. Grape Insect & Mite Pests-2012 Field Season. 2012. Vineyard Notes (Lake Erie Regional Grape Program newsletter) #2: 2-17.

2012 Loeb, G. Underground battles – Japanese beetle and phylloxera. Proceedings of the 2012 Lake Erie Regional Grape Growers' Conference held in Portland, NY on 8 March 2012, pages

18-19.

2013 Loeb, G. Managing phylloxera on own-rooted vinifera and use of entomopathogenic nematodes for management of Japanese beetles. Proceedings of Viticulture 2012 Conference and Trade Show held February 6-8, 2013. Pp 108-109.

2014 Loeb, G., T. Weigle, and E. Shields. Below ground insect threats to grapevines: Grape rootworm and Japanese beetle. Proceedings to the Lake Erie Regional Grape Program 2014 Wnter Grape Growing Conference, pp 15-16.

2014 Loeb, G. Grape Insect & Mite Pests-2014 Field Season. Lake Eire Regional Grape Vineyard Notes, May 2014: 2-24.

Presentations related to project:

Portland, NY. 8 March 2012. Underground battles – Japanese beetle and phyloxera. 30 min talk at the 2012 Lake Erie Regional Grape Growers' Conference. Audience approximately 100 growers, industry reps, and extension educators.

Rochester, NY. 8 February 2013. Managing phylloxera on own-rooted vinifera and use of entomopathogenic nematodes for management of Japanese beetle. 0.33 hour talk to growers, industry representatives and extension educators as part of NY State viticulture and enology meeting held every three years. Approximately 100 people in the audience for talk.

Portland, NY. 25 July 2013. 0.2 hour talk at CLEREL summer meeting and open house to discuss ongoing grape entomology research. Approximately 30 growers and industry representative present as part of tour of the research farm at CLEREL.

Fredonia, NY. 20 March 2014. Grape rootworm/Japanese beetle project. 30 minute talk at the Lake Erie Regional Grape Program Winter Grape Grower Conference held in Fredonia, NY on 20 March 2014. There were approximately 75 growers and industry representatives in attendance.

Grower Survey results:

Survey on interest in using entomopathogenic nematodes for managing Japanese beetle in NY grape vineyard systems conducted in March 2014 at the winter meeting of the Lake Erie Grape Grower Conference.

1. Concern of Japanese Beetle damage in vineyard (52)
Very (2)
Somewhat (38)
Not Concerned (12)

2. Getting more information on entomopathogenic nematodes (49)
Yes (32)
No (17)

3. Willing to rear and release your own nematodes (50)
Yes (17)
No (33)

Project partner contributions and roles:

All members of the project made significant contributions to project activities in the first year. These are summarized below.

- PI Greg Loeb and Research Support Specialist Steve Hesler: In addition to overall coordination of the project, they led sampling efforts for Japanese beetle in the Finger Lakes and assisted with sampling in Lake Erie. Prepared quarterly and annual progress reports. Presented updates to grower groups through extension meetings and newsletter articles.
- Co-PI Elson Shields and Research Support Specialist Tony Testa: Had primary responsibility for the rearing, release and evaluations of entomopathogenic nematodes at all sites. Provided written reports of progress to PI for progress reports.
- Co-PI Tim Weigle: Actively involved in activities in Lake Erie area. Took the lead for assessing nematodes and Japanese beetle in the Lake Erie area, and coordinated presentations and reports to stakeholder groups. Provided data to PI for preparation of progress reports.

Goals and Outcomes Achieved

Measurable Outcome #1

This project was designed to quantify the establishment potential and optimal species mix of entomopathogenic nematodes in sod row middles of New York vineyards, its impact on feeding damage by adult Japanese beetle, and associated costs.

Annual survey data for the presence of entomopathogenic nematodes indicated a consistent or increasing proportion of soil samples with evidence of nematodes across all sites (Figure 1). Of the two species being monitored, *S. feltiae* ('NY04') has established particularly well. Abundance of *S. carpocapsae* ('NY001') has remained low but was consistently detected at all sites.

Survey data for the presence of adult Japanese beetles and the resulting feeding damage to grape foliage, for the year 2014, indicates lower levels of feeding damage (Figure 2) and presence of adult Japanese beetle (Figure 3) in areas that were treated with entomopathogenic nematodes.

Most vineyard sites in New York include considerable amounts of grassy areas surrounding rows of grapes, in addition to grass row middles. It is likely that these surrounding areas are important food sources for grubs and therefore likely sources of adult Japanese beetles that can easily move into vineyards. Hence, we believe the successful use of entomopathogenic nematodes to manage adult feeding damage in vineyards will be enhanced by treating surrounding grassy areas.

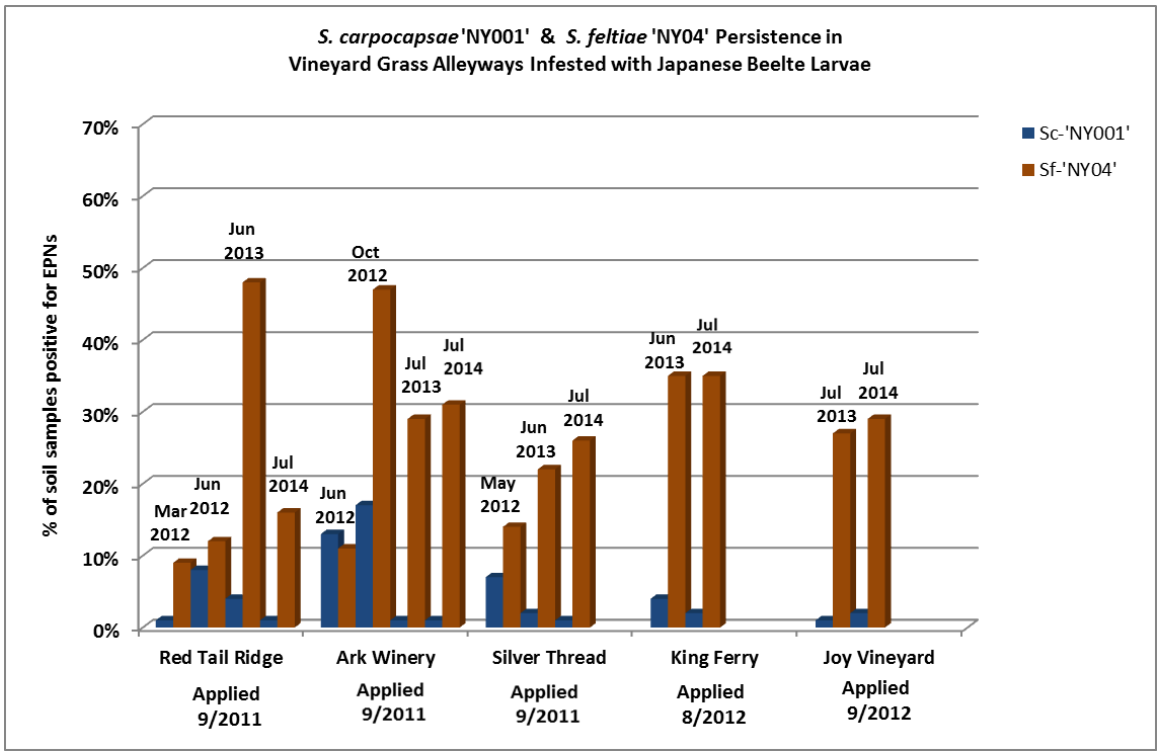
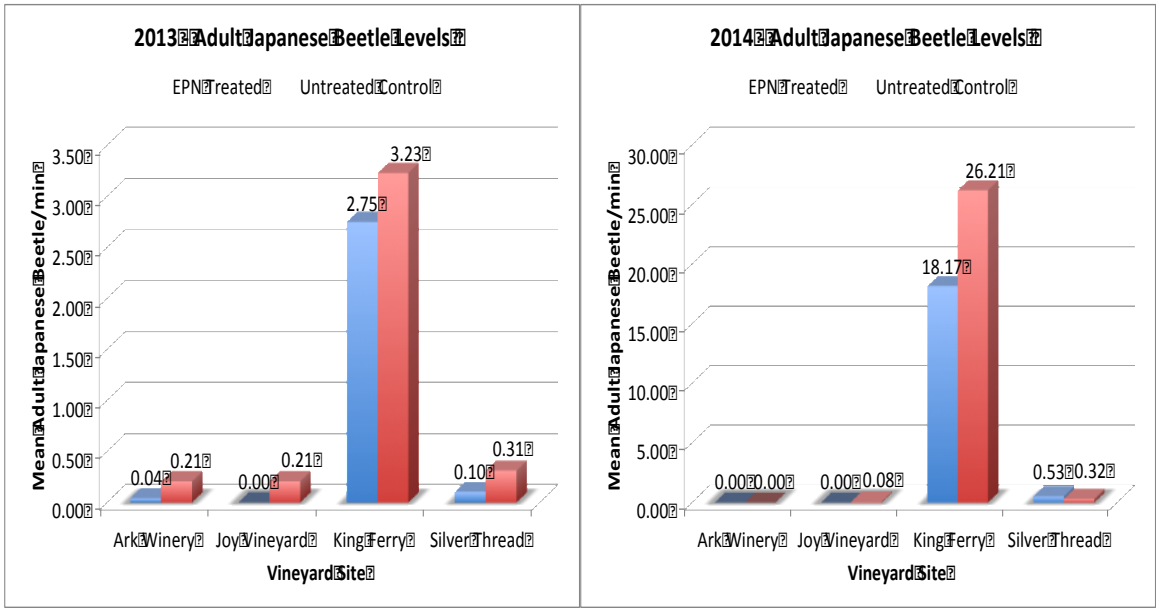


Figure 1. Multi-year persistence of two species of entomopathogenic nematodes, *S. carpocapsae* 'NY001' and *S. feltiae* 'NY04' at five vineyard sites in NYS. Red Tail Ridge, Ark Winery, and Silver Thread were treated with nematodes Sept-2011. King Ferry and Joy vineyards were treated with nematodes Sept-2012.



Measurable Outcome #2

The overall objective of the project will result in the production of a grower-oriented guide on how NY grape growers can rear and establish persistent entomopathogenic nematodes in row middles of vineyards for effective management of adult Japanese beetle feeding damage to foliage. An update of this project was presented at the annual Lake Erie Regional Grape Program winter meeting in spring 2014, which included a summary proceedings report. At the end of the meeting we conducted a survey of growers asking questions about the study and their interest in learning more about the potential of using entomopathogenic nematodes to manage feeding damage by adult Japanese beetle in vineyards. 80% of responders indicated they were somewhat or very concerned about Japanese beetle (40 out of 52), 65% indicated they would like to learn more (32/49), and 33% indicated they would be interested in

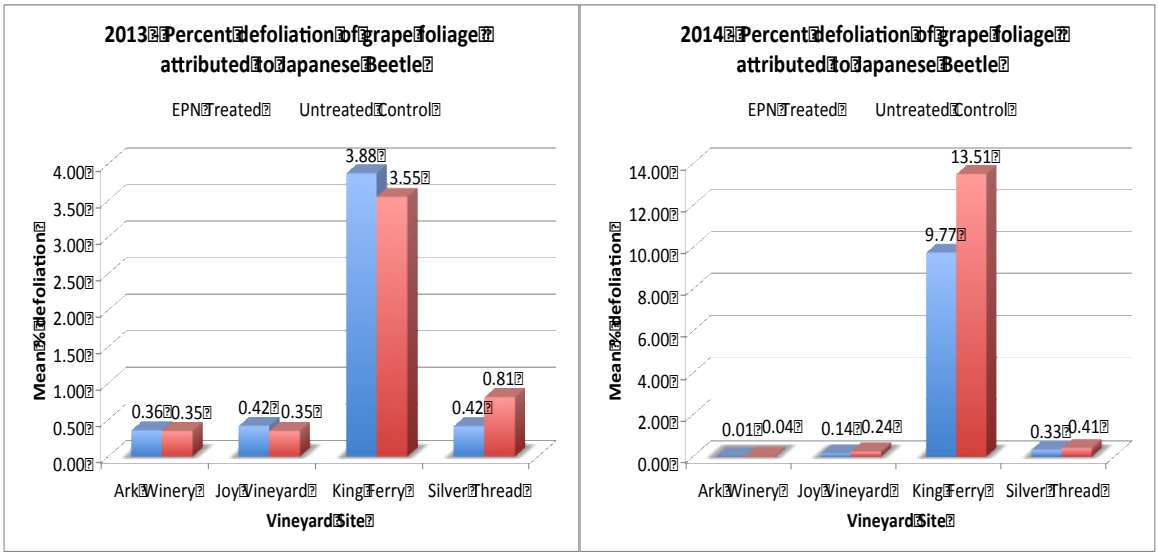


Figure 2. Percent defoliation attributed to Japanese beetle at four grape vineyard sites in NYS that had an area of 3-5 acres treated with a mixture of entomopathogenic nematodes (EPN) and a similar area left untreated as a control. Grape shoots were randomly selected from within the treatment zones and a percentage of leaf tissue removed due to Japanese beetle feeding was recorded.

rearing nematodes themselves and releasing in their vineyards (17/50). At this time we have not completed a guide for rearing and establishing entomopathogenic nematodes for grape growers. The main reason is that we have yet to observe sufficient evidence that the release of nematodes results in a large enough decrease in adult Japanese beetle feeding damage to justify the time and money involved in carrying out large scale use of this method. Therefore, we are not ready to produce a guide promoting this technique.

During the time period of this project we presented research results at several different meetings, with a total audience of approximately 300 growers and industry representatives. At the 2014 Lake Erie Grape Growers Annual Winter Meeting we summarized the final results of the project with an estimated audience of 75 growers and industry representatives.

Beneficiaries

The primary beneficiaries of this project are the grape growers of New York and surrounding grape growing regions, especially those growers operating at sites prone to high abundance of Japanese beetles. The majority of the 33,000 acres of grapes in production in New York use grass row middles. In addition, most vineyard sites also include considerable amounts of mowed grassy areas around the periphery of vineyard blocks. The sites with grass row middles and significant turf and hay fields present in the surrounding landscape are the most likely to benefit from the results of this project. We estimate that in any given year, approximately 10% of grape acreage in New York is treated for Japanese beetle at a cost of approximately $66,000/yr ($20/acre X 3,300 acres). As noted above, 33% of growers attending one of our extension talks reported an interest in rearing and releasing entomopathogenic nematodes to help manage Japanese beetle and 75% of respondents indicated they were either very or somewhat concerned with damage by Japanese beetle. Hence, we estimate that 75% of New York grape growers (1,000 growers) could potentially benefit from the results of this study. Of these concerned growers, we estimate that 33% (about 330 growers) potentially would be willing to rear and release entomopathogenic nematodes for use on their farms assuming such releases would provide long-term benefit, something our project has yet to determine. The costs associated with the rearing and one time release of nematodes is relatively low. At the rate of EPNs that we used, the farm-reared cost would be $90/acre. However, we upped the rates to get quicker action. In subsequent research, we have found there is little rate effect at application so for the grape growers, a rate similar to alfalfa would be sufficient. That rate is 100 million per acre at a cost of $30/ acre if on farm reared or $60/acre if purchased from Cornell. Given a one-time cost of $30/acre, and assuming the entomopathogenic nematodes successfully eliminated the need to apply insecticides, would result in a net savings of $170 per acre over 10 years ($20/acre X 10 years-$30 establishment costs).

Lessons Learned

Key insights from completing this project include the following:

1. Abundance of Japanese beetles varies considerably from year to year and site to site in the Finger Lakes and Lake Erie regions of NY. This variability contributed to the challenge of detecting statistically significant differences in damage between release and non-release sites. Nevertheless, the trend toward reduced damage at release sites is encouraging.

2. The time and labor involved in applying entomopathogenic nematodes to relatively large vineyard areas was modest (less than a day). Given the level of persistence of both species of nematodes released, we believe in many situations, it will only require a one-time release to permanently establish these beneficial nematodes thereby making this a potentially cost effective approach to managing Japanese beetles in vineyards.

3. Sampling for larvae of Japanese beetles in vineyard environments is labor intensive and inefficient. In the future, we will need to find a better way to assess larvae.

4. One concern with this study was that since adult Japanese beetle is very mobile, they would simply move into treated areas from untreated areas thereby reducing or masking larval mortality caused by the entomopathogenic nematodes. This may have happened to some extent, however, the data on damage and abundance of adults suggest it was not sufficient to mask the benefits of nematode releases in terms of reduced foliar feeding. The use of large plot sizes, including treating surrounding grassy areas, likely helped mitigate the problem of movement.

Additional Information

Loeb, G., T. Weigle, and E. Shields. 2014. Below ground insect threats to grapevines: Grape rootworm and Japanese beetle. Proceedings to the Lake Erie Regional Grape Program 2014 Winter Grape Growing Conference, pp 15-16.

Loeb, G. Grape Insect & Mite Pests-2014 Field Season. 2014. Lake Eire Regional Grape Vineyard Notes, May 2014: 2-24.

Loeb, G. 2014. Managing phylloxera on own-rooted vinifera and use of entomopathogenic nematodes for management of Japanese beetles. Proceedings of Viticulture 2012 Conference and Trade Show held February 6-8, 2013. Pp 108-109.

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Project 4
Biological Control of Plum Curculio in Organic Apple Production Systems

Project Summary

Plum curculio (PC) is a key pest in eastern US apple orchards, and is considered to be one of the primary pests limiting organic apple production in this region. Unsprayed orchards can sustain more than 60% fruit damage and even in conventionally managed orchards, damage at harvest can average up to 3%. Until about 2002, organic apple orchards could experience almost total fruit loss from PC in New York and other areas in the region where the species is endemic. Investigators feel that organic apple plantings tend to have greater PC infestations because of fewer effective management options. The cost of PC control and its marginal effectiveness is a major obstruction to profitable organic apple production in New York State. PC treatment costs in the organic program can range between $150 - $457/acre/year with fruit damage remaining above 5-20%. Adopting a control measure of Surround (kaolin clay) as a physical barrier to the insect's attack was the first approach in organic apple orchards. However, the economics of control prove difficult, as the product is not only expensive ($25-$50/A per application), but must be repeated weekly (4-5 applications) to maintain suitable coverage for protection during the rain-prone spring period of the pest's activity. Further control measures needed to be researched to reduce impact of PC on organic apple production while also reducing costs for the apple producer, which led researchers to try biological control.

Research in other states has indicated that the use of entomopathogenic nematodes in a biological control program has potential against PC in apples. Field studies have reported that biocontrol nematodes have reduced adult emergence by 77-97%. Prior to the project start date, no biological control programs for plum curculio existed in New York. The purpose of this research project was to evaluate the potential of a biological control program for plum curculio using native cold-adapted entomopathogenic (insect-attacking) nematodes (EPNs) in apple orchards using organic production practices. New York native entomopathogenic nematodes are being effectively used in a large-scale biological control program in northern New York against a related species and should also be effective against plum curculio in New York to reduce the impact of PC on organic apple production. The utilization of persistent nematodes in an inoculative approach requires only a single application of nematodes to the soil surface area, and the inoculation of an acre of orchard costs approximately $75. In comparison, the current organic foliar spray program annual reoccurring cost is 2-6 times that amount. The goals were to establish an effective plum curculio biological control program that would result in 50-80% reduction in pressure while increasing the number of marketable fruit for the producer, yielding a higher profit margin and a higher level of total profit. Successful biological control of PC will result in a lower cost of insect control, reduced pesticide use, and a lower level of fruit damage.

Project Approach

Establishing Long Term Persistent Nematode Populations

Laboratory Study-Shields

A laboratory study was conducted during the first 12-months of the project to determine the potential of the three nematode species *S. carpocapsae* (strain NY 001'), *S. feltiae* (strain NY 04'), and *H. bacteriophora* (strain 'Oswego'), as PC biocontrol agents. In the lab, petri plates were filled with autoclaved soil and inoculated with water solutions at concentrations of 250-1250

nematode IJs per ml, and PC larvae and adults were confined in the plates to determine the ability of different nematode strains to kill these two life stages. Adults used in the dishes died of starvation as the source of apples rotted before observations could be recorded. The highest mortality of mature PC larvae was obtained using a combination of *S. feltiae* and *S. carpocapsae* (up to 75%) and the mortality of PC larvae was observed within 14 days (Fig. 1). There was no effect of increasing the IJ concentration above 250/ml. The study was duplicated between January-March 2013 to confirm the combination choice of *S. feltiae* and *S. carpocapsae* used in the field sites after the initial field establishment in the field was lower than expected. Results from 2013 laboratory efficacy trials were similar to the 2012 results, indicating the multi-species approach to be the best course to use as a biocontrol against PC larvae (Fig.2) and adults (Fig. 3). Lower than expected populations levels of EPNs were determined to be a result of dry soil conditions at the time of field inoculation, coupled with the lack of natural hosts (other insect larvae) in the two field sites.

Fig.1

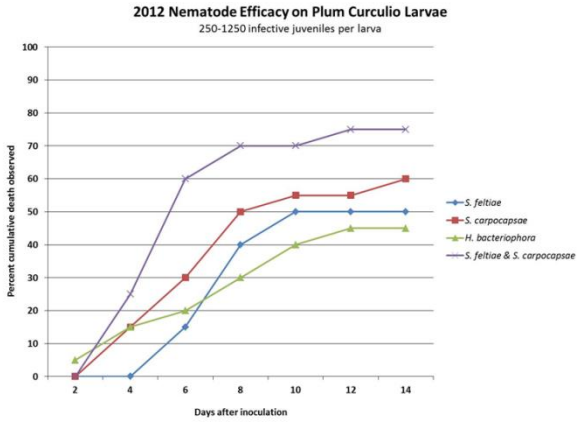


Fig.2

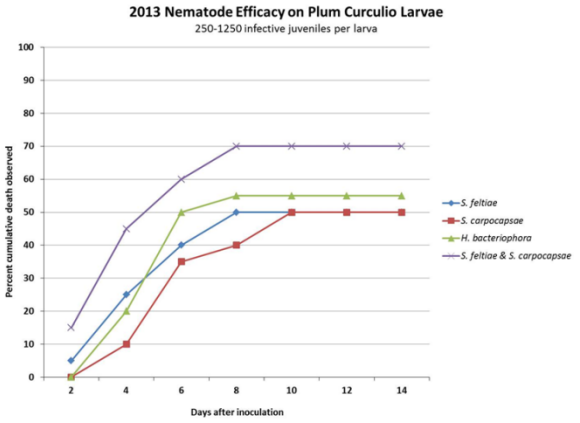
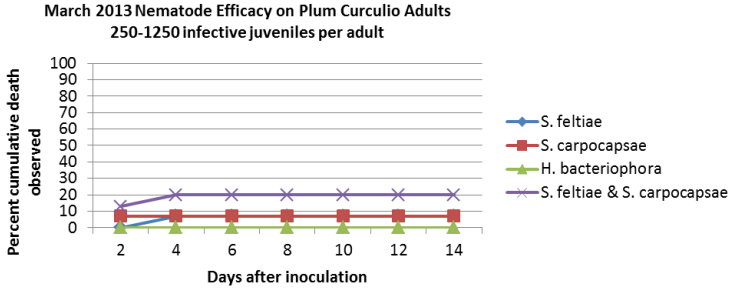


Fig.3



Laboratory Study-Agnello

Plum Curculio Larvae to Adult Survival Rates

A laboratory study at the Geneva Experiment Station was initiated to assess typical survival of plum curculio larvae to adult stage in the colony under growth chamber conditions (25°C, 16:8 hour L:D). Three replicates of 100-156 larvae each were tracked in individual rearing arenas until all adults emerged (35-40 d). Results of the trial gave researchers a clearer understanding of survival rates for rearing plum curculio under laboratory conditions allowing for future considerations when planning laboratory and field trials (Table 1).

Table 1. Percentage of Surviving PC Larvae to Adult Stage in the Laboratory

Plum Curculio Larvae	Days to Adult Emergence	% Survival
Group 1	35-40	62.2
Group 2	35-40	71.0
Group 3	35-40	59.0
	% Mean Survival	64.1

Evaluating Soil Characteristics: Impact on EPN Establishment and Survival

Beginning in May 2014 and ending in July 2014, tests were conducted on various soil characteristics in research orchards to investigate their potential impact on nematode establishment and survival. The field sites being tested are the Davies Farm (Red Jacket Orchards, south of Geneva) and three NYSAES sites in Geneva, at the Loomis Farm (an organic apple block), and Research-North Farm (an Empire block and an Idared block). The management practices of all these apple orchards vary from site to site.

Once evaluation of the characteristics was completed, 180 intact cylindrical soil cores (10 cm diameter, 13 cm tall) were collected in July 2014, to assess EPN persistence: 45 cores from each site (Red Jacket Orchards' Davies Farm, NYSAES Loomis, Ida Red, and Empire orchards), and 15 cores per treatment (EPN, EPN/PC, PC) per site. For each treatment, 15 cores per site were collected (60 total), brought into the lab and kept at 25°C in plastic containers on shelves in the growth chamber. These cores were allowed to equilibrate for at least two weeks (with regular watering to maintain 60% water holding capacity) before any bioassays were conducted. *S. carpocapsae* (NY01) and *S.feltiae* (NY04) inoculations were made at a concentration of approximately 5,000 of each species of nematode per core. After a minimum of 30 days, the persistence of nematodes in this treatment was assessed using two different methods.

- *Method 1 - Sample Persistence Assessment Method:* A small sample was taken from each core (size 12 Cork Borer: ~1 cm diameter, 5 cm deep). The soil from these samples was then broken up into smaller aggregates and placed into a cup with 5 *Galleria mellonella* larvae. After 7 days, percent mortality was assessed, and data was recorded.
- *Method 2 - In-Core Persistence Assessment Method:* In the hole left from the sampling for the first persistence assessment, a fiberglass screen sleeve cage was inserted containing two *Galleria mellonella* larvae. The opening of these sleeve cages was sealed and the larvae were left for 7 days, after which mortality was assessed and data recorded.

Field Site Designation-Shields

Although the initial grant proposal called for two different locations over the project duration, eight field sites were established. Field sites were located at the Davies Farm (RJO, south of Geneva) and three NYSAES sites in Geneva, the Loomis Farm (an organic apple block), at Research-North Farm (an Empire block and an Idared block), and the four Hudson Valley orchards (Westwind Orchards, Prospect Farm, and Fishkill Farm, all inoculated in 2013 and HVRL Eco Block, inoculated in 2014).

Prior to inoculating NY native entomopathogenic nematode populations (EPNs) at each field site, designated field sites were bioassayed for presence of native EPNs. GPS waypoints were recorded within each sample row. Samples were returned to Cornell University and bioassayed for EPNs.

Past research had indicated little to no existing populations of EPNs were to be found. However, the Hudson Valley sites had higher natural populations than the sites near Geneva, NY.

Both nematode species, *S. carpocapsae* (NY01) and *S.feltiae* (NY04) were reared at Cornell University prior to field inoculation. Soil inoculations were made in the evening using an ATV equipped with a 25 gallon tank with 0008 fertilizer stream nozzles. Nematodes were washed and strained through mesh screens to remove debris from rearing cups prior to being added to the ATV tank. EPN IJs were then applied to the grassy alleys between the rows and at the base of the trees. EPNs were applied at the equivalent of 450 million IJs per acre. At Westwind Orchard and Fishkill Farm, a truck equipped with a spray rig applied nematodes to areas surrounding established trees outside row blocks at the same rate using similar application techniques and equipment.

Reducing the Population of PC in Organic Apple Orchards

In untreated organic orchards, fruit loss ranges from 5-20%, depending on the magnitude of the PC population and the intensity of the management efforts. Each treated and untreated block was evaluated to give an accurate estimate of the insect population levels. These population estimates and resultant fruit damage will allow for a direct estimation of effectiveness for each of the experimental treatments.

Fruitlet Data-Agnello; NYS Agricultural Experiment Station, Geneva, NY

In early June of each year of the project, fruitlet samples were taken from each of the (2012-inoculated) research orchards, as well as from the (2013-inoculated) commercial Red Jacket orchard – in each row of each plot, we sampled 100 fruits from each of 5 trees and assessed them for PC oviposition damage (scars).

Table 2. Plum Curculio Oviposition Damage Results

Idared (Small-Plot) Block	**% Damage**		
	2012	**2013**	**2014**
Untreated Rows	7.2	2.7	3.0
Treated Rows	3.8	1.7	0.0
Empire (Large-Plot) Block	**% Damage**		
	2012	**2013**	**2014**
Untreated Rows	35.9	8.6	26.1
Treated Rows	33.7	14.1	21.3
Red Jacket (Davies Farm) Block	**% Damage**		
	2014		
Untreated Rows	15.1		
Treated Rows	5.7		

Damage levels in the Idared block were reduced further (essentially to zero) from 2013, but the results cannot be directly attributed to the nematode treatment, as all the rows mistakenly received an insecticide application at petal fall. In the Empire block, damage was uniformly higher than in 2013, but rows receiving the nematode treatment had approximately

19% less damage than the untreated rows. At the Red Jacket orchard, treated rows were also less damaged (approximately one-third the amount) than untreated rows.

PC Exclusion Employing Insecticide Treated Netting-Jentsch; Fishkill Farms, NY

At the Fishkill Farm site (Fig.4) in the Hudson Valley, a 7'H, 600' L woven netting barrier, hung 10' from Paula Red apple, was sprayed at a 5d interval between May 10, 2013 and June 3, 2013 with Warrior II at 2.6 oz./A. An evaluation of 3 rows of tree fruit, sampling 50 fruit / section (I-VI) in the Western most edge was conducted. Sections I-III were behind the netting, IV-VI were outside or East of the netting.

Fig. 4 Fishkill Farms Treated Netting

Results showed in the netted portion of the block highest levels of PC injury occurred along the Western edge (9.3% from the W edge), while 1.3% and 2.8% occurred along the center and Eastern portions of the netting. Injury again increased on fruit rated east of the netting from 5.3%, 10.7%, and 9.8% along the Western edge.

Table 3. Percentage of PC Injury When Treated Netting Employed

PC Injured Fruit Netted		PC Injured Fruit UN-Netted	
Column I	9.5%	Column IV	5.3%
Column II	1.3%	Column V	10.7%
Column III	2.8%	Column VI	9.8%

Reductions of PC fruit injury were achieved within the constraints of the netted barrier.

In 2014 we again conducted the netted barrier trial. In response to growers' concerns using broad spectrum insecticides and possible impact on pollinators, we conducted the study using applications on May 28, 2014 and June 7, 2014 with the reduced risk neonicotinoid insecticide Calypso (thiacloprid) at 8.0 oz./A. and subsequent assessment on 1 July of the effectiveness of the barrier netting during PC migration. Fruit evaluations showed no significant difference between netted and un-netted portions of the apple block. The contact activity of Calypso on a 14-day schedule may be ineffective at reducing adult migratory populations compared to the pyrethroid group.

Micro-Arena Data-Agnello & Jentsch

Field micro-plot arenas at all Geneva sites (2012 sites: Research-North Idared and Empire plantings, 2013 sites: Loomis organic apple research planting, Red Jacket Davies Farm apple block) and three Hudson Valley sites (2013 sites: Westwind and Fishkill Farms, 2014 site: HVRL Eco Block) were established in each of the project years to conduct a larval exposure trial. Within rows, micro-arenas (4.5" diameter x 5" deep), demarcated with an acrylic tube sleeve were dug in a single row and pushed 2-3 cm into the soil. Field plots consisted of 10 replicates in one of each of the following rows at each site:

- field-inoculated (May 2012, June 2013, July 2014) row
- untreated row (negative check)
- untreated row with arenas individually hand-inoculated with lab-mixed EPN solutions (positive check). Each arena received 4,000-4,500 infective juveniles of each of the two EPN strains.

Between June and August of each project year, arenas were supplied with test PC larvae reared in the lab. Delays occurred as the plum curculio colony in Geneva experienced a lag period in the production of larvae each year, which resulted in a staggered establishment for field assays. Once production stabilized, ten plum curculio larvae were introduced into each arena; larvae used were taken from the plum curculio colony as they became available. Arenas were topped with an emergence trap top. Sites with arenas were inoculated whenever the Shields Lab were able to provide nematodes.

Goals and Outcomes Achieved

Establishing Long Term Persistent Nematode Populations

EPN Persistence across Field Sites-Shields

Field sites were sampled for persisting EPN populations at the Davies Farm (RJO, south of Geneva) and three NYSAES sites in Geneva, the Loomis Farm (an organic apple block), at Research-North Farm (an Empire block and an Idared block), and the four Hudson Valley sites (2013 sites: Westwind, Prospect, and Fishkill Farms, 2014 site: HVRL Eco Block). Sites were bioassayed at various days post inoculation throughout the project, and samples returned to Cornell University for evaluation.

Table 4. Percentage of positive samples in EPN establishment

Idared Block		**34-Days Post Inoc**		**345-Days Post Inoc**		**482-Days Post Inoc**		**748-Days Post Inoc**	
		% Positive Samples		**% Positive Samples**		**% Positive Samples**		**% Positive Samples**	
		Sc	Sf	Sc	Sf	Sc	Sf	Sc	Sf
Block 1-Row 8		0	40	16	36	4	32	8	56
Block 1-Row 7		0	32	28	20	4	20	0	36
Block 1-Row 4		0	2	12	24	0	24	4	40
Block 1-Row 3		0	0	24	32	4	24	0	56
Block 2-Row 4		0	12	8	40	4	16	0	20
Block 2-Row 3		0	16	8	8	0	28	0	36
Block 4-Row 4		0	28	20	36	8	16	0	32
Block 4-Row 3		4	8	8	40	4	4	0	28

Empire Block		**34-Days Post Inoc**		**345-Days Post Inoc**		**482-Days Post Inoc**		**748-Days Post Inoc**	
		% Positive Samples		**% Positive Samples**		**% Positive Samples**		**% Positive Samples**	
		Sc	Sf	Sc	Sf	Sc	Sf	Sc	Sf
Border-Row 1		0	0	20	24	20	5	5	35
Alley Row 1&2		4	8	8	20	10	15	5	30
Alley Row 2&3		12	4	12	16	5	20	5	30

	Loomis (Organic) Block	**343-Days Post Inoc**			**Red Jacket (Davies Farm) Block**	**343-Days Post Inoc**	
		% Positive Samples				**% Positive Samples**	
		Sc	Sf			Sc	Sf

	Rep I	2	38		Rep I	1	28
	Rep II	2	44		Rep II	6	38
	Rep III	0	36		Rep III	2	32
					Rep IV	0	24

Westwind Orchards		**41-Days Post Inoc**	**386-Days Post Inoc**		**Fishkill Farm**	**35-Days Post Inoc**		**373-Days Post Inoc**	
		% Positive Samples	% Positive Samples			% Positive Samples		% Positive Samples	
Zone 1		20	21		Zone 1	2	21	3	27
Zone 2		25	26		Zone 2	13	20	5	7
Zone 3		26	34		Zone 3	4	27	1	18

Prospect Farm		**42-Days Post Inoc**	**387-Days Post Inoc**		**Hudson Valley Eco Block**	**37-Days Post Inoc**	**37-Days Post Inoc**
		% Positive Samples	% Positive Samples			% Positive Samples - Sc	% Positive Samples - Sf
30 Treated Rows		28	22		Odd Treated Rows	1	23

These data indicate that native NY nematodes became established at all sites from a single application/inoculation. The establishment of *S. carpocapsae* was much lower than expected and reflects that insect hosts are not occurring in the top 2 inches of the soil when this nematode species dominates and remains. In contrast, *S. feltiae* has become well established at all sites. When the levels are above the 20-25% range, the nematodes are actively recycling through available insect hosts. The higher the level, the more intense the nematode attacks on available insect hosts. This also indicates a higher level on soil insects along with PC in the soil within these orchards. Nematode levels between 15-20% are the long-term persistent levels when insect hosts are scarce and the nematodes will remain at these levels for several growing seasons waiting for an insect invasion.

Evaluating Soil Characteristics-Agnello: Impact on EPN Establishment and Survival

- *EPN/Plum Curculio Treatment*: The cores that are to be used for this treatment have been collected and inoculated with EPNs as above, and it is planned that mature Plum Curculio larvae will be added to them in the coming months, after which percent emergence of Plum Curculio adults will be assessed. Nematode establishment tests (using the same method as the persistence tests from EPN treatment) are currently under way.
- *Plum Curculio Persistence Treatment*: The cores that are to be used for the Plum Curculio persistence treatment have already been collected and in the coming months Plum Curculio larvae will be added to these cores, and percent emergence will be assessed to obtain a base survival level in the absence of EPNs.

Reducing the Population of PC in Organic Apple Orchards

Micro-Arena Data-Agnello & Jentsch

Observations on PC adult emergence began 30-days after larval introduction for a period of 30-days and were conducted each project year. Researchers recorded the average % emergence of PC adults at each location.

Table 5. Plum Curculio Nematode Field Plot Emergence

NYSAES Idared				**NYSAES Empires**		
	Average % Emergence				Average % Emergence	
	2012	20	20		2013	2014
Hand Inoculated Arenas	31.0	22	39	Hand Inoculated Arenas	26.3	14.0
Field Inoculated Arenas	70.0	13	55	Field Inoculated Arenas	18.8	44.0
Untreated Rows	41.0	15	41	Untreated Rows	30.0	32.0

Fishkill Farm			**Prospect Farm**		
	Average % Emergence			Average % Emergence	
	2013	2014		2013	
Hand Inoculated Arenas	3.0	2.0	Hand Inoculated Arenas	11.0	
Field Inoculated Arenas	0.0	2.25	Field Inoculated Arenas	0	
Untreated Rows	4.0	1.17	Untreated Rows	8.0	

NYSAES Loomis		**RJO Davies**		**Westwind Orchards**	
	Average % Emergence		Average % Emergence		Average % Emergence
	2014		2014		2014
Hand Inoculated Arenas	19.0	Hand Inoculated Arenas	14.0	Hand Inoculated Arenas	1.75
Field Inoculated Arenas	27.8	Field Inoculated Arenas	26.0	Field Inoculated Arenas	1.63
Untreated Rows	36.0	Untreated Rows	34.0	Untreated Rows	2.50

Hudson Valley Research Lab Eco Block	
	Average % Emergence
	2014
Hand Inoculated Arenas	2.75
Field Inoculated Arenas	2.00
Untreated Rows	4.38

In evaluating the progress made in nematode establishment as evidenced by the results of the micro-arena assays, it can be stated that initial results the first year after nematode treatment showed slow progress in population establishment; however, by the third year, results in several of the orchard sites are approaching the levels of PC mortality seen in those plots that were directly treated by hand, which is and encouraging sign that the nematode populations will ultimately contribute significantly to the reduction of plum curculio numbers and damage in these test sites.

Sharing Results within the Apple Producing Community (Organic and Conventional)

2013

ESA Meetings

- A presentation at the Entomological Society of America Eastern Branch Meeting in Lancaster, PA on March 19, 2013 was given by Arthur Agnello. The title of the presentation was, “Preliminary Assessments of native Strains of Entomopathogenic Nematodes for Plum Curculio Management” Audience: 40 (20 min).
- An updated version of the same presentation was given at the ESA Annual Meeting in Austin, TX on November 12, 2013; Audience: 30 (12 min).

Extension Presentations – Arthur Agnello

- Cornell Fruit Field Day, Geneva (August; audience: 200, 20 min)
- New England/NY/Canada Fruit IPM Workshop, Burlington, VT (October; audience: 45, 15 min)
- Cumberland-Shenandoah Fruit Workers Meeting, Winchester, VA (December; audience: 40, 15 min)

2014

Extension Presentations – Arthur Agnello

- CCE Regional Fruit School(s) – e.g., Lake Ontario Fruit Schools, Niagara (audience: 140 (20 min) & Wayne Counties (audience:120 (20 min); NE-NY/Upper Hudson/Champlain Fruit School, Lake George (audience: 80 (20 min); Hudson Valley Commercial Fruit Growers School, Kingston (audience: 190 (20min)

NOFA NY Conferences

- NOFA-NY Conference, Peter Jentsch, Saratoga, NY, January 25, 2014; Audience: 75 (30 min)
- NOFA-NY Field Workshop, Art Agnello & Elson Shields, Redbyrd Orchards, Trumansburg, NY, August 12, 2014; Audience: 15 (2 hours)

Research Presentation – Arthur Agnello

- IOBC-WPRS Working Group "Integrated Plant Protection in Fruit Crops", Subgroups "Pome Fruit Arthropods" and "Stone Fruits", Vienna, Austria. October 2014. Assessments of native strains of entomopathogenic nematodes for biological control of plum curculio (*Conotrachelus nenuphar*) in apples. Audience: 40 (20 min).

Beneficiaries

The cost of plum curculio control and its marginal effectiveness is a major obstruction to profitable organic apple production in New York State. Currently, the organic apple industry in New York is only a small part of the state's apple production, with an estimated 36 growers and 465 acres (USDA 2007), compared with 694 conventional commercial apple producers growing 42,000 acres of apples (USDA 2013).

The development of an effective biological control for this serious native pest of fruit will not only benefit the current organic apple producers but will encourage the organic apple industry to grow

in size. Preliminary results from our research strongly suggest that the persistent nematode-biocontrol strategy can reduce plum curculio damage from 70-90% in organic orchard settings.

While this project was focused on the organic apple industry, the entire apple industry could also benefit. Even with the use of conventional insecticides applied 2-3 times per season, conventional orchards suffer fruit losses of 0.5-3% from this insect.

Successful biological control of plum curculio will result in both a lower cost of insect control, reduced pesticide use, and a lower level of fruit damage. Since these strains of nematodes are persistent under NYS conditions, the impact of biological control on PC will be cumulative over several years until the insect and its biological control agents establish a lower population equilibrium than currently exists. As a result, the organic apple producer will have a larger marketable crop, a higher profit margin and a higher level of total profit.

Lessons Learned

Plum curculio (PC) is recognized by NOFA-NY as the single greatest insect pest management challenge for organic apple production. Unsprayed orchards can sustain more than 60% fruit damage, and even in conventionally managed orchards, damage at harvest can average up to 3%. In the NE Tree Fruit IPM Working Group's annual ranking of research and extension priorities, plum curculio routinely ranks second only to internal worms in the category of direct apple insect pests; additionally, it ranks second or third in priority ranking polls administered yearly to grower audiences at regional winter fruit schools, including Lockport, Sodus, Lake George, and Kingston.

Our attempts to initiate a biocontrol program for PC using cold-adapted entomopathogenic nematodes in Geneva and the Hudson Valley has made some progress in both research and commercial plantings, establishment of the nematodes at economically effective levels has been slow. However, our preliminary results are encouraging and suggest that nematodes have the potential to reduce PC damage in organic orchards by 70-90%.

Additional research will continue to focus on specific orchard soil and ground cover factors that could promote nematode population establishment, persistence and spread, to optimize their effectiveness in reducing the impact of PC on organic apple production, to reduce cost of apple production, provide a higher degree of marketable fruit, and a higher profit for the organic apple producer.

The economic benefit of this approach will be realized by organic producers who have previously tried using inundative releases of commercially reared nematode strains, which do not persist at effective population levels under New York conditions, and must be continuously reapplied.

Additional Information

Publications

Agnello, A., P. Jentsch, E. Shields, T. Testa, and M. Keller. 2014. Evaluation of Persistent Entomopathogenic Nematodes for Biological Control of Plum Curculio. NY Fruit Quarterly. 22(4): 21-24.

Press Releases

- Morning Ag Clips. (2014). Control for alfalfa pest helps apple growers [press release]. Retrieved from https://www.morningagclips.com/control-for-alfalfa-pest-helps-apple-growers/
- American Agriculturist. (2014). Alfalfa Pest Biocontrol May Help with Apple and Stone Fruits [press release]. Retrieved from http://farmprogress.com/story-alfalfa-pest-biocontrol-may-help-apple-stone-fruits-0-119393
- International HortiDaily. (2014). NNY-developed biocontrol for alfalfa pest may be useful to NY apple growers [press release]. Retrieved from http://www.hortidaily.com/article/12167/NNY-developed-biocontrol-for-alfalfa-pest-may-be-useful-to-NY-apple-growers

Figures and Photographs

Fig. 5 Persisting EPNs at Orchards near Geneva, NY

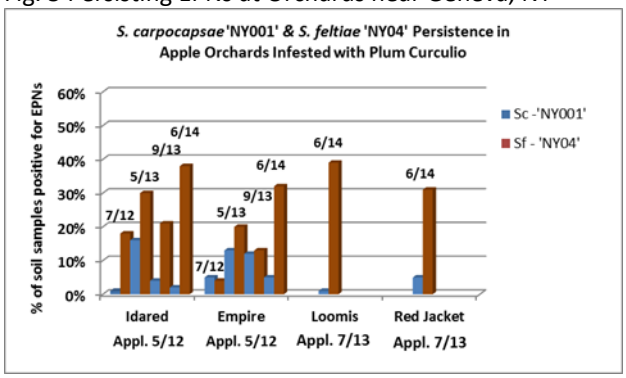


Fig. 6 Persisting EPNs at Orchards in Hudson Valley, NY

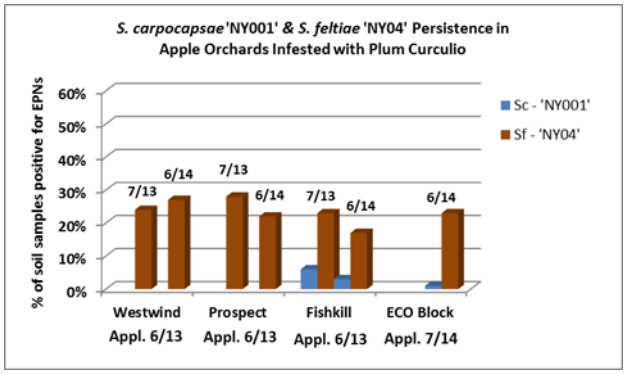


Fig. 7 NYSAES Geneva, NY (Ontario Co.)

Fig. 8 Red Jacket Orchards Davies Farm (Ontario Co.)

Fig.9 NYSAES Loomis Farm (Ontario Co.)

Fig.10 Westwind Orchards (Ulster Co.)

Fig.11 Prospect Farm (Ulster Co.)

Fig.12 Fishkill Farm (Dutchess Co.)

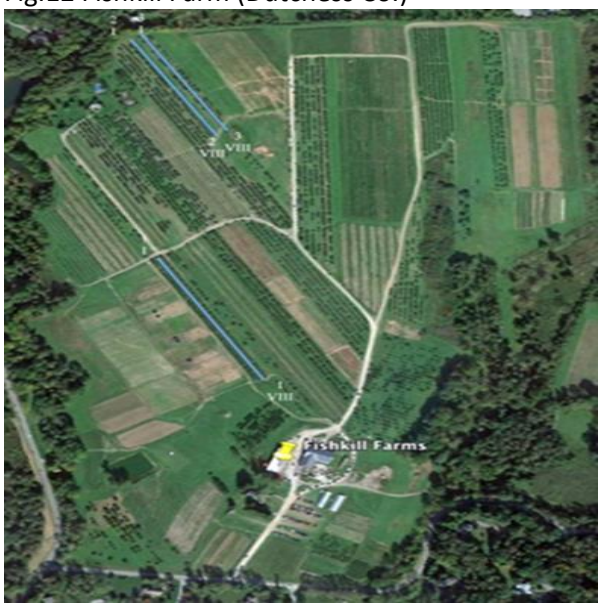


Fig.13 HVRL (Ulster Co.)

Fig.14 HVRL Eco Block (Ulster Co.)

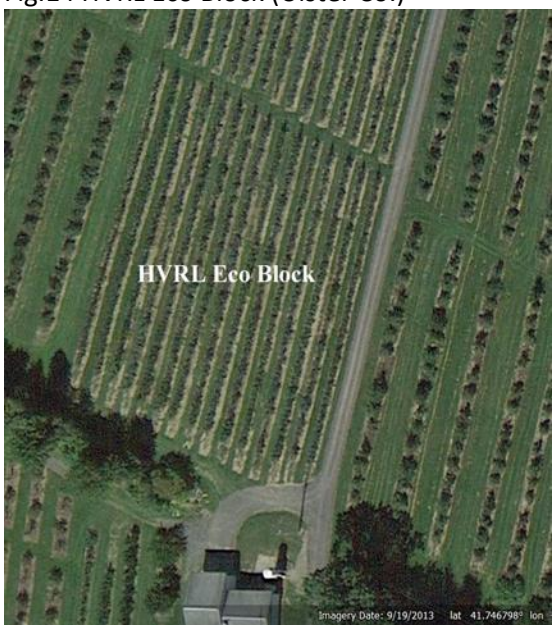


Fig.15 Acrylic Tube Sleeve

Fig. 16 Establishing Micro-Arena

Fig.17 Micro-Arena

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Project 5

Developing a Monitoring, Scouting & Damage Assessment Tool to Assess the Spread and Impact of the Invasive Brown Marmorated Stink Bug

Project Summary

The newly invasive Brown Marmorated Stink Bug (BMSB), *Halyomorpha halys* (Stål) has become a problematic urban and agricultural pest in New York State. It has a broad host range that includes plants of economic importance such as peas, soybeans, apples, peaches, cherries, and various other fruit and ornamental trees. Feeding from BMSB to crops removes fluids from the stems, leaves and fruit, resulting in cell death, surface depression, skin darkening and corking beneath the skin, making the crop unmarketable (Image 1). Since 2007 when BMSB was first documented in New York (Hoebeke and Carter, 2003)[1], the insect has spread across most of the south and central parts of New York State with only a few casual observations in the Thousand Islands and Lake Champlain regions. Increasing population density has been observed within the entire Hudson Valley south of Albany and suburban Syracuse area. The BMSB is also now present in Buffalo urban environs and western tree fruit and grape growing regions and the grape and vegetable production areas of the Finger Lakes. The insect has been documented to cause damage to homes of concentrated aggregations in plumbing and electrical fixtures, with its greatest impact to diverse agricultural crops from intensive feeding of late summer crops throughout the mid-Atlantic and southeastern New York.

In 2010 the insect was responsible for pome fruit injury estimated to exceed $26 million in the mid-Atlantic, with over 20% injury documented to apple occurring in three counties of New York's Hudson Valley. The development of a citizen science project in 2010 has documented urban BMSB populations in the lower Hudson Valley through insect submissions to the Hudson Valley Research Laboratory for identification. The data shows increasing populations in the upper, central and western areas of New York State. Beginning in 2011, subsequent monitoring and trapping efforts carried out by CALS faculty and Cornell Cooperative Extension staff have provided county-based presence data for statewide rural mapping of BMSB distributions along wooded borders of agricultural crops. Two invasive species mapping sites now provide a visual timeline-assessment of BMSB population in New York.

Damage to tree fruit and economic injury to vegetable crops observed in 2014 are displayed, using on-demand user generated maps of insect presence, which now include action thresholds for management. Employment of pheromone based trapping tools provide data of local BMSB population presence and levels of threat were made available to agricultural producers as summary action thresholds. This information was sent via e-mail pest alerts, generated from the entomology department at the Hudson Valley Research Laboratory (HVRL), and recommendations for effective management were included. Weekly updates on BMSB pest threshold of the agricultural presence of BMSB in New York State is made available on-demand beginning in 2014 through the use of the EDDMapS site.

Project Approach

The project had three monitoring elements to provide data summaries for mapping the invasive insect across New York State. They include development of an urban-based citizen science project, agricultural field scouting assessments and agricultural monitoring using black light and pheromone based trapping.

New York BMSB Working Group Development

Beginning in September 2010, the HVRL Dept. of Entomology initiated a BMSB Working Group (WG) consisting of strategies to bring together regional research and extension staff working in commercial agricultural commodities and ornamental plants to acquire information on a newly emerging insect pests now present in growing population throughout the Hudson Valley of New York State, to collectively develop priorities for the 2011 growing season that will include strategies to monitor, predict and assess commercial loss caused by the BMSB and define effective ways for the implementation of these objectives. Participants include Charles Bornt, CCE-Rensselaer, Troy, NY, Laura Mc Dermott**,** CCE Washington County, Hudson Falls, NY, Crystal Stewart, CCE Albany County, Johnstown, NY 12095, Maire Ullrich, CCE Orange County, Middletown, NY, Dan Gilrein and Faruque Zamen**,** CCE of Suffolk County, L.I. Horticultural Research and Extension Ctr, Riverhead, NY., Teresa Rusinek, CCE Ulster County, Kingston, NY, Jody L. Gangloff-Kaufmann, Community IPM Ext. Area Educator, Farmingdale, NY, Mike Fargione, Jim O'Connell, Dan Donahue**,** Fruit Extension Educators, Hudson Valley Regional Fruit Program, Highland, NY, Art Agnello, professor of entomology at the New York State Agricultural Experiment Station in Geneva, N.Y. Deborah Breth, Integrated Pest Management, Lake Ontario Fruit Team (LOFT) Team Leader, CCE Orleans County 12690 Rt. 31 Albion, NY., Amy Ivy, Clinton County Agricultural Team Leader/Executive Director, CCE of St. Lawrence County, Canton, NY., Anna Wallis, Extension Fruit Specialist, CCE Clinton County, Plattsburgh, NY., Judson Reid, Extension Vegetable Specialist, CCE Yates County, Penn Yan, NY. Individual WG members participate in BMSB monitoring and trapping, present to farmers on the topic and develop master gardener (MG) training to utilize the connection MG groups have with to homeowners and agriculturally interested groups for BMSB identification and specimen location. The working group has been instrumental in developing and sustaining the agricultural monitoring program of BMSB over the past 4 years.

Urban-based Citizen Science Project

The rise in urban BMSB populations and the insect's predisposition to overwinter in homes has escalated its importance as an urban nuisance pest. The yearly emigrations of BMSB to the urban environment begins in the early fall, after the insect has fed intensively on fruit and seeds from mid-August through late November, entering homes to find dry shelter for the long winter. During the overwintering phase the insect is less active, often going un-noticed during periods of cold temperatures, and becoming more active as temperatures increase. It relies solely on stored reserves to survive the long winter. The BMSB migrate out of the home and back to the natural environment during the following spring, as they actively seek their way out of overwintering sites and back to host plants. The onset of these yearly cycles incite homeowners to find urban pest management solutions, often leading them through Internet search engines to then find and participate in Cornell's Citizen Science BMSB Project and contribute BMSB specimens to this study.

The first BMSB identified by the HVRL was collected from Milton, NY by a homeowner sample on December 1, 2008. Beginning in September 2010, the HVRL Dept. of Entomology initiated an Urban-based Citizen Science Project requesting homeowners submit 'live' specimens to the HVRL for identification and mapping. Newspaper articles in print and digital media were distributed throughout New York State between October 2011 and September 2014, describing the pest and providing the Internet link to submission of BMSB urban-based populations. The first of 17-featured articles in LoHud Patch provided video and a poll for Westchester County residents, to which 90% of 757 participants stated seeing the insect in their homes (Image 2). Citizen Scientists were able to participate by submitting either a 'live' insect specimen in 2010-2011, or, beginning in 2012, either live or digital images via GPS enabled smart phones. We recorded over 460 specimens of 232 submissions from 87 distinct zip code locations in 33 NYS counties coming into our lab by the beginning of 2012. Updated

submission including EDDMapS specimens expanded to 541 submissions in 41 counties of 2 states. Outreach to the NYS populous was made through video (Poughkeepsie Journal, News Channel 9 WSYR-TV), radio interviews (WAMC), Social media (CCE Facebook page), Cornell University Webinar Education and News (Cornell Focus, Chronicle), newspaper (Middletown Record, Kingston Freeman, Press & Sun-Bulletin) magazines (Hudson Valley Magazine, Vegetarian Times, Good Fruit Grower, NY Fruit Quarterly) Highest concentrations of Citizen Science submissions were observed in the mid to lower Hudson Valley (Image 3). Central New York submissions had a significantly higher rate of non-BMSB urban complex pests, comprised predominately of box elder bug *Boisea trivittatus* and western conifer seed bug *Leptoglossus occidentalis*. When Citizen Science participants were queried in the spring of 2012, 57% of NY respondents perceived increases in the adult BMSB overwintering populations moving into their home compared to 2010-11 fall migrations (Image 4). Hudson Valley participants perceived a 71% increase over the previous year (N=62). To date, the Citizen Science Study data has collected over 800 specimens, verifying 540 BMSB specimens from 41 NY counties (Image 5). A summary of the data representing a timeline of confirmed BMSB submission locations can be found on the iMapinvasives website for on-demand viewing (Image 6). Individual samples can be observed by accessing the link for each specific submission on a magnified portion of the EDDMapS map (Image 7).

Continuing Community Education, Urban Survey and Mapping of Overwintering BMSB Adults

A continuing Citizen Science Study (CSS) on the presence of BMSB in the urban environment continues to show increasing populations of the invasive insect in man-made structures environments throughout New York State. The EDDMapS now displays historical population distributions including both urban and agricultural data sets into a single map.

Agricultural monitoring

Two methods of agricultural surveys for BMSB were conducted using either visual observations or traps. BMSB adults were first found in 2008 in New Jersey with black light traps used to capture noctuid moths in sweet corn, while pheromone traps were first used to trap for BMSB.

2011 Visual Observations. During the growing season we scouted for all life stages of BMSB in individual tree specimen foliage and seed pods of American Ash, Sugar Maple, Tree of Heaven, and Black Locust. We conducted baseline sampling of all shrubs and trees plants along the wooded edge of 3 pome and stone fruit orchards, 1 vineyard home and 1 home vegetable garden and 1 commercial organic vegetable farm in 3 fields. The first confirmed observation of a single BMSB egg mass was located in Seyval grape on 6 June in Marlboro, NY. BMSB were later found along the edge of an Orange County orchard on Tree of Heaven, *Ailanthus altissima*, numbering 3 third, 3 fourth and 5 fifth instar nymphs with 45 adults observed in seed pod clusters. Nymphs and adults numbering 40 BMSB and 1 green stink bug, *Chinavia halaris* (Say), were also found in *A. altissima.* A total of 11 BMSB (nymphs in third, fourth and fifth instar and adults) were observed on organic green pepper on 30 September just after heavy nor'easter winds in late August, which appeared to blow down the insects from nearby *Ailanthus altissima* trees. Overall the Tree of Heaven ranked highest in finds of BMSB, serving as a season long host for the insect.

2011 Trapping using methyl (E,E,Z)-2,4,6-decatrienoate (MDT) and black light traps: Black light traps (BLT) have been used for 30 years in the U.S. to trap corn pests. The first catch of BMSB in BLT's occurred in NJ in 2002. We employed BLTs in two orchards in 2011 with no seasonal captures of nymphs or adults. However, we constructed two BLTs using diode lighting stationed on the top of the Tedders traps with and without MDT. We did see low levels of BMSB nymphs and adults in 'blue light only traps' the organic green pepper field (mentioned above) on 30 September where visual observations were made.

Field trapping began in 2011 using a novel but low level attractant MDT 'kairomone' in 2011. This lure was derived from the male-produced pheromone of another pentatomid, the brown-winged green bug, *Plautia stali* Scott, common in eastern Asia. Using the MDT kairomone we established 72 Tedder's trap sites throughout the tree fruit, grape and vegetable growing regions of NY (Image 8). Yet, only a single site capturing BMSB in September of that season, in a field of green pepper in Marlboro, NY.

2012 Pheromone Trapping using methyl (E,E,Z)-2,4,6-decatrienoate (MDT) and black light traps: During the 2012 growing season, field observations employed Tedder's traps and lures, pheromone baited insecticide treated netting and traditional black light trapping have been used along the agricultural edge bordering woodlands. Trapping in 8 of 15 counties demonstrated the presence of BMSB populations along the wooded agricultural commodity interface from early May to harvest of late varieties using combination of the Ag-bio MDT (methyl- decatrienoate) and USDA #10 lure combinations the newly developed USDA #10 lures finding their effectiveness to be significantly more attractive than either lure alone (Image 9). We also evaluated a commercial series of lures by Alpha Scent in a late season study to demonstrate the effectiveness of the #20A lure capturing 3X the number of BMSB over the USDA #10 + MDT combination (Image 10). The use of pheromone baited insecticide treated netting with high intensity lighting captured over 14,000 BMSB nymphs and adults from the September 9 to October 3, 2013, demonstrating the potential of this strategy as a viable mechanism of BMSB population reduction. Although the use of black light traps is expensive, the data gathered from using these traps to monitor BMSB provides adult migration data not often observed in pheromone-based traps (Image 11). Late season trapping for the insect using all of these techniques are ongoing for use in determining BMSB adult thresholds at each farm site for county alerts.

Agricultural Mapping

Economic injury was reported to have occurred in peaches, apple and vegetable crops in Columbia, Dutchess, Orange and Ulster Counties last season, with damage beginning in late July 2014. Injury to apple was first reported in Columbia County in 2014 beginning on July 29. Tree fruit growers with significant injury in 2012 employed strategies developed through studies funded by the New York State Department of Agriculture & Markets through Cornell University's Hudson Valley Laboratory to manage the insect and reduce fruit injury during the 2013 growing season. Through partnership with The Nature Conservancy, NY Natural Heritage Program, NatureServe and universities interested in monitoring the spread of invasive insect species, the EDDMapS site was used to provide GIS maps revealing the density of BMSB relative to its predominant deciduous host plant, the invasive Tree of Heaven, *Ailanthus altissima* (Image 12). We have begun to develop NYS maps using the EDDMapS site for growers to access specific county data including tree fruit specific commodity information of BMSB numbers, thresholds, presence and damage levels updated as of October 2014 (Image 13). National presence of BMSB on a county basis can be found at the EDDMaps site (Image 14). The web site provides access to GIS statistical data of trap locations for each farm site in each county for growers using this data to determine if trapping thresholds are relative to their farm regarding distance, woodland host ecology and historical BMSB populations (Image 15).

Goals and Outcomes Achieved

The primary goal of the project was to develop a tool for tree fruit producers to use that would express the statewide presence of BMSB in urban and agricultural settings. This outcome would provide historical documentation of the emergence of this invasive insect in New York State, while also providing current threshold data on the potential for crop injury to commodity host plants focused on tree fruit, vegetable and sweet corn. As a result of this project, 57 articles received over 4,000 visits made to

Jentsch Lab blog site to access information on invasive insect pests, mapping, biology, and guidelines for management (http://blogs.cornell.edu/jentsch/)

Development of Strategies for BMSB Management

During the growing season of 2014 weekly communications were sent to over 275 regional fruit growers, CCE extension staff, researchers and stakeholders using email with embedded links to web based documents and blog web based information including map updates of BMSB state-wide presence, pest alerts, trapping and monitoring updates, updates on management, Section 18 materials, and the use of trapping thresholds for management and current PowerPoint presentations on developing topics video webinar educational materials on the topic. This information will be updated over the years to provided agricultural producers with information pertaining to BMSB biology, identification keys and recommended IPM insect pest management strategies.

Management protocols were originally developed using research and grower experience from mid-Atlantic with updated research on attract and kill control measures developed at the Hudson Valley Research Laboratory in Highland, NY. The protocols for directing commercial control measures began by first employing pheromone traps along woodland edges and hedgerows of tree fruit perimeters. Upon sustained captures of BMSB, scouting along orchard edge that bordered wooded edges and hedgerows of orchards would begin. Upon the sighting of one nymph or adult within 100' of linear tree fruit row inside of three perimeter rows, applications would begin, directed only along the first 30' of orchard perimeter. Thereafter, perimeter applications would only be made after confirmed BMSB sightings. Effective materials could be limited to border rows to minimize negative impact of late season insecticide applications.

Recommended insect pest management tools were based on New York State labeled insecticides with known laboratory and field efficacy, provided to producers as a PDF file with pertinent re-entry, pre-harvest and application interval data for decision-making. Strategies will continue to be modified as we develop refined protocols.

Beneficiaries

The mapping resources were made available free of charge via on-line access to all New York State residents as well as to fruit producers in New York and throughout the world who are concerned with BMSB population distribution. For producers, such as the Amish and Mennonite communities along the southern tier in New York State, we provided written materials at winter fruit schools in Penn Yan and *Seneca* Falls *Finger Lakes Produce* Auction Houses of BMSB life stage imagery and damage.

Weekly communications of advancing BMSB populations throughout the growing season were sent to over 275 regional fruit growers, Cornell College of Agriculture and Life Science faculty and Cornell Cooperative Extension staff for further distribution in newsletters throughout the state as the need for management arose.

Presentations to growers at regional winter fruit schools on BMSB presence utilizing these tools were made to over 1,500 participants over 3 years across 7 states, at the SCRI Working Group meetings in Winchester, Virginia and at the national ESA meeting in Portland, Oregon in 2014. Mapping of the insect presence was also utilized by NEIPM for inclusion into the Stop BMSB Project, accessible by a 52-member SCRI working group team for map use in applying management recommendations based on monitoring thresholds.

Lessons Learned

This insect continues to be very unpredictable. It has been observed in the field and along the perimeter of agricultural commodities, yet, being an arborial insect, it prefers the woodland host plants until the populations build, moving from a reduced host plant food source into agricultural commodities during migration and preparation for its overwintering phase. Knowing when and where to begin management studies is not a science based forecast, yet we have made observations in population density obtained by pheromone trapping and weather as it relates to rainfall and hours above 90% relative humidity to aid in predicting the insects' movement in commodities in 2014. We are presently working on development of a model using these perimeters combined with passive (without attractants) and active trapping thresholds (using pheromones, lights and host plants) for use in the field this season.

Additional Information

Publications

Jentsch P. J. 2014. Impact From 17-Year Cicada In Tree Fruit. Scaffolds Fruit Journal 23(2). On-line. http://www.scaffolds.entomology.cornell.edu/2014/index.html

Jentsch P. J. 2014. Hudson Valley Pest Management Updates. Plan For Early Scale Management. Scaffolds Fruit Journal 23(2). On-line. http://www.scaffolds.entomology.cornell.edu/2014/index.html

Jentsch P. J. 2013. Assessing the Invasiveness of the Asian Brown Marmorated Stink Bug in NY. Fruit Quarterly, Volume 21 No. 3. On-line: http://www.nyshs.org/pdf/2008-Volume-16/Vol-16-No-3/Hudson-Valley-Stink-Bug-Management.pdf

Jentsch P. J. 2013. Hudson Valley Pest Management Updates. BMSB Update. Scaffolds Fruit Journal 22(21). On-line. http://www.scaffolds.entomology.cornell.edu/2013/index.html

Brown marmorated stink bug in the Hudson Valley: Appellation Cornell Newsletter Issue 12 November 2012 http://grapesandwine.cals.cornell.edu/cals/grapesandwine/appellation-cornell/

Jentsch P. J. 2012. Stink Bug Management in the Hudson Valley. Scaffolds Fruit Journal 21(17). On-line. http://www.scaffolds.entomology.cornell.edu/2012/index.html

Jentsch P. J. 2012. The Unpredictable Brown Marmorated Stink Bug in New York State. Fruit Quarterly, 20 (4). On-line: http://www.nyshs.org

P.J. Jentsch 2014. Preliminary Results of Insecticide and Acaricide Studies in Eastern New York. Cornell University's Hudson Valley Laboratory Pub. # HV2014. On-line.

P.J. Jentsch 2013. Preliminary Results of Insecticide and Acaricide Studies in Eastern New York. Cornell University's Hudson Valley Laboratory Pub. # HV2013. On-line.

P.J. Jentsch 2012. Preliminary Results of Insecticide and Acaricide Studies in Eastern New York. Cornell University's Hudson Valley Laboratory Pub. # HV2012. On-Line.

Blog Site Communication: Over 57 articles receiving 4,000 visits made to *Jentsch Lab* blog site to access information on invasive insect pests, mapping, biology, and guidelines for management (http://blogs.cornell.edu/jentsch/)

Out-of-State presentations at meetings of tree fruit professionals: (2012-2014)

- Management of the Brown Marmorated Stink Bug. December 18th, 2013; *New England Vegetable and Fruit Conference in Manchester, NH, (30 min.; 110 attendees primarily growers).*
- *Monitoring and Management of the BMSB in Urban and Agricultural Environments in New York State. October 23, 2013. New England, New York, Canadian Fruit Pest Management Workshop. Burlington Vt. (65 University faculty, fruit extension educators, and private consultants)*
- *Monitoring the BMSB in Urban and Agricultural Environments in New York State.* Northeast IPM Brown Marmorated Stink Bug Working Group meeting, November 29, 2012, *88th Annual Cumberland-Shenandoah Fruit Workers Conference, Winchester, VA. (55 University faculty, fruit extension educators, and private consultants).*
- Tree Host Survey, Monitoring and Management Strategies for the Invasive Brown Marmorated Stink Bug, Halyomorpha halys (Stal): (Pentatomidae), Along Borders of NY Tree Fruit. . Northeast IPM Brown Marmorated Stink Bug Working Group meeting, November 27, 2012, Alson H. Smith Research and Extension Center, Virginia Agriculture Experiment Station, Winchester, VA *(20 min.; 75 attendees; fruit growers, extension agents, researchers and graduate students, total contact hours = 25).*
- Development of a Citizen Science Project to Monitor the Spread of the Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål), in NYS.
- *October 23-24, 2012 New England, New York, Canadian Fruit Pest Management Workshop. Burlington Vt. (55 University faculty, fruit extension educators, and private consultants)*
- Threat of the Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål) to New England on Tree Fruit, Small Fruit, Vegetable and Sweet Corn. New England Annual Grower and Advisory Meeting, South Deerfield, MA 01373 March 21, 2012*, (35 min.; 65 attendees; fruit growers, extension agents, researchers and graduate students, total contact hours = 38).*
- Monitoring the Spread of Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål) in NY. Measuring the Value of Urban Citizen Science. Northeast IPM Brown Marmorated Stink Bug Working Group meeting,, Fruit Research & Extension Center , Penn State University , Biglerville, PA 17307 June 12-13, 2012*, (20 min.; 80 attendees; fruit growers, extension agents, researchers and graduate students, total contact hours = 27).*

In-State Presentations at fruit grower meetings and other meetings: (2012-2014)

- Entomology Update on Invasive Species Management. February 10th, 2015; Hudson Valley Commercial Fruit Growers School, Garden Plaza Hotel, Kingston, NY (30 *min. :209 conventional and* organic tree fruit growers, extension educators; *total contact hours = 104*)
- Migration and Population Increase of the BMSB in NYS. Agrassistance Mtg; March 7, 2014, Studebakers Restaurant, Lyons, NY (60 *min. :120* conventional tree fruit growers, extension educators; *total contact hours = 120*)
- Overview of Three Years of ARDP Funded Research in Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål) Management in NY Tree Fruit. Apple Research & Development Program NYSAES, Jordan Hall, Geneva, NY November 12, 2013; *(15 min.; 20 attendees; researchers & ARDP Board Members; total contact hours = 5).*

- Migration and Population Increase of the BMSB in NYS. Agrassistance Mtg; March 7, 2014, Studebakers Restaurant, Lyons, NY (60 *min. :120* conventional tree fruit growers, extension educators; *total contact hours = 120*)
- Management of the Stink Bug Complex in Commercial Tree Fruit. February 12th, 2014; Hudson Valley Commercial Fruit Growers School, Garden Plaza Hotel, Kingston, NY (30 *min. :209 conventional and* organic tree fruit growers, extension educators; *total contact hours = 104*)
- Review of the 2014 Pest Management Season in ENY. Cornell Cooperative Extension Eastern NY Commercial Horticulture Program, Upper Hudson / Champlain Commercial Tree Fruit School, February 10, 2014, Fort William Henry Hotel and Conference Center, Lake George, NY (30 *min. :65 conventional and* organic tree fruit growers, extension educators; *total contact hours = 32*)
- Brown Marmorated Stink Bug Management Update. January 10th, 2014; Seneca Produce Auction Growers Meeting, 2295 Yerkes Road, Romulus, NY (45 *min. :30 conventional and* organic vegetable growers, extension educators; *total contact hours = 5*)
- Brown Marmorated Stink Bug Management Update. January 9th, 2014; Finger Lakes Produce Auction Growers Meeting, 3691 State Route 14A, Penn Yan, NY (45 *min. :30 conventional and* organic vegetable growers, extension educators; *total contact hours = 5*)
- Monitoring *the BMSB in Urban and Agricultural Environments in New York State.* Agricultural Invasive Species session. November 13, 2012. Annual CCE Agriculture and Food System In-service, Ithaca, NY, *(30 min.; 20 CCE Vegetable Extension educators, total contact hours = 10*
- *Panel Discussion on Invasive Insect Presence between the Urban and Agricultural Environmental Interface in New York State.* Agricultural Invasive Species session. November 14, 2012. Annual CCE Agriculture and Food System In-service, Ithaca, NY, *(30 min.; 20 CCE Vegetable Extension educators, total contact hours = 10*
- Insect Pest IPM of Hudson Valley Pome Fruit: Early Season Management. *May 21th, 2013 Hudson, NY* (40 Orchardists, fruit extension educators)
- Insect Pest IPM of Hudson Valley Pome Fruit: Early Season Management. *May 21th, 2013 Milton, NY* (40 Orchardists, fruit extension educators)
- Insect Pest IPM of Hudson Valley Pome Fruit: Early Season Management. *May 24th, 2013 Lake George, NY* (40 Orchardists, fruit extension educators)
- Insect Pest IPM of Hudson Valley Pome Fruit: Early Season Management. *May 24th, 2013 Lake Champlain, NY* (40 Orchardists, fruit extension educators)
- Results from 2012-2013 Hudson Valley Insecticide Trials. *February 14, 2013 Hudson Valley Fruit School, Kingston, NY (30 min.; 55 tree fruit growers, fruit extension educators, and private consultants*; *total contact hours = 28)*
- Creature Features: Predictions and Management of BMSB and 17-Year Cicada in the Hudson Valley for 2013. *February 13, 2013 Hudson Valley Fruit School, Kingston, NY (45 min.; 85 tree fruit growers, fruit extension educators, and private consultants*; *total contact hours = 64)*
- Tree Fruit Insect Round-Up. Managing the Hudson Valley Pome Fruit Insect Complex. *February 12, 2013 Hudson Valley Fruit School, Kingston, NY (45 min.; 85 tree fruit growers, fruit extension educators, and private consultants*; *total contact hours = 64) (40 min.; 200 Fruit growers, fruit extension educators, and private consultants*; *total contact hours = 133)*

- Updates on the Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål) in NY State. February 11, 2013, *Upper Hudson & Lake Champlain School, Lake George, NY (30 min.; 85 tree fruit growers, fruit extension educators, and private consultants*; *total contact hours = 43)*
- Updates on the Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål) and Spotted Wing Drosophila, *Drosophila suzukii* in NY State: January 22, 2013, 2013 Fruit & Vegetable Expo, Oncenter, Syracuse NY (3*0 min.; 85* fruit & vegetable producers, landscape professionals, fruit extension educators; *total contact hours = 43*)
- *Managing Insecticide Use: January 10, 2013, Aroma Thyme Restaurant, Ellenville, NY* (*90 min.;* 21 fruit growers, fruit extension educators; *total contact hours = 31.5*)
- 2012 Insect Pest Management of Tree Fruit Updates: *January 10, 2013, Long Island Agricultural Forum, Riverhead, NY* (*20 min.;* 45 fruit growers, fruit extension educators, and private consultants; *total contact hours = 23*)
- *Monitoring the BMSB in Urban and Agricultural Environments in New York State.* Apple Research and Development Board. November 26, 2012. Annual Report, Geneva, NY, *(15 min.; 20 CCE Fruit Extension educators, University Researchers, Fruit Producers, total contact hours = 5*
- *Monitoring the BMSB in Urban and Agricultural Environments in New York State.* Agricultural Invasive Species session. November 13, 2012. Annual CCE Agriculture and Food System In-service, Ithaca, NY, *(30 min.; 20 CCE Vegetable Extension educators, total contact hours = 10*
- *Invasive Pest Update –Spotted-Winged: August 21, 2012 Cornell Cooperative Education Center, Troy, NY (40 min.; 2 Small Fruit growers, fruit extension educators*; *total contact hours = 1)*
- *The Brown Marmorated Stink Bug, Halyomorpha halys (Stål) in NY Ornamental and Landscape Environments: Biology and Management. Cornell Cooperative Extension.* February 27, 2012, Webinar: Hudson Valley Laboratory, Highland, NY (6*0 min.;* 15 CCE Sites; 150 landscape professionals, 30 fruit extension educators; *total contact hours = 180*)
- Invasive Pest Update – Biology and Management of Brown Marmorated Stink Bug and Spotted-Winged Drosophila on Grape. *March 8th , 2012 WNY Grape School, CLEREL Laboratory, Portland, NY (45 min.; 110 grape growers, fruit extension educators, and private consultants*; *total contact hours = 83)*
- Invasive Pest Update – Biology and Management of Brown Marmorated Stink Bug and Spotted-Winged Drosophila on Grape. *February 17, 2012 Hudson Valley Grape School Kingston, NY (45 min.; 30 grape growers, fruit extension educators, and private consultants*; *total contact hours = 23)*
- Invasive Pest Updates – Biology and Management of Brown Marmorated Stink Bug on Tree Fruit. *February 13, 2012. Upper Hudson & Lake Champlain School, Lake George, NY (45 min.; 85 tree fruit growers, fruit extension educators, and private consultants*; *total contact hours = 64)*
- Tree Fruit Insect Round-Up. Managing the Hudson Valley Pome Fruit Insect Complex. *February 14, 2012 Hudson Valley Fruit School, Kingston, NY (40 min.; 200 Fruit growers, fruit extension educators, and private consultants*; *total contact hours = 133)*
- Invasive Pest Update: Management of BMSB and SWD on Tree Fruit in NY State. *February 15, 2012 Hudson Valley Fruit School, Kingston, NY (40 min.; 200 Fruit growers, fruit extension educators, and private consultants*; *total contact hours = 133)*

- Tree Fruit Insect Pest Management. Novel Insecticides & Newly Invasive Pests. *February 6-7, 2012 Western NY Fruit Schools, Niagara County CCE Training Center, Lockport, NY (40 min.; 200 Fruit growers, fruit extension educators, and private consultants*; *total contact hours = 133)*
- Tree Fruit Insect Pest Management. Novel Insecticides & Newly Invasive Pests. *February 6-7, 2012 Lake Ontario Fruit Schools, Wallington Fire Hall, Sodus, NY (40 min.; 200 Fruit growers, fruit extension educators, and private consultants*; *total contact hours = 133)*
- Surveying the Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål) in NY State. January 25, 2012, 2012 Fruit & Vegetable Expo, Oncenter, Syracuse NY (3*0 min.; 85* fruit & vegetable producers, landscape professionals, fruit extension educators; *total contact hours = 43*)
- Insect Pest Management 101: Future Fruit Growers of NY; Cornell University. February 3, 2012, Hudson Valley Laboratory, Highland, NY (*180 min.;* 40 fruit growers, fruit extension educators; *total contact hours = 120*)
- 2011 Insect Pest Management of Tree Fruit & Web Based Pest Management Resources. *January 13, 2012, Long Island Agricultural Forum, Riverhead, NY* (*30 min.;* 45 fruit growers, fruit extension educators, and private consultants; *total contact hours = 23*)

Cited References

1. Rick Hoebecke, Cornell University, first confirmed Halyomorpha halys in 2001 from specimens collected in 1998 from Allentown PA, and later from specimens collected in NYC in 2007. Hoebeke ER, Carter ME, 2003. Halyomorpha halys (Stal) (Heteroptera: Pentatomidae): a polyphagous plant pest from Asia newly detected in North America. Proceedings of the Entomological Society of Washington, 105(1):225-237

Images & Maps

Image 1. BMSB feeding injury expressed after 10-21 days on pome fruit.

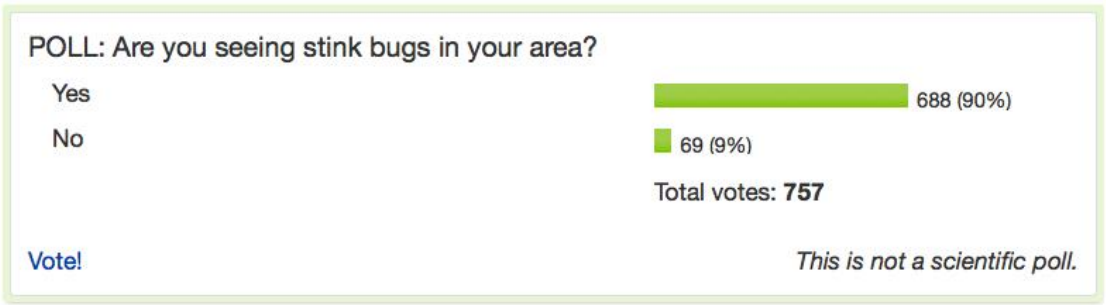

Image 2. Digital News LoHud Patch poll of Citizen Scientist participant observations of BMSB in the Lower Hudson Valley, October 2011.

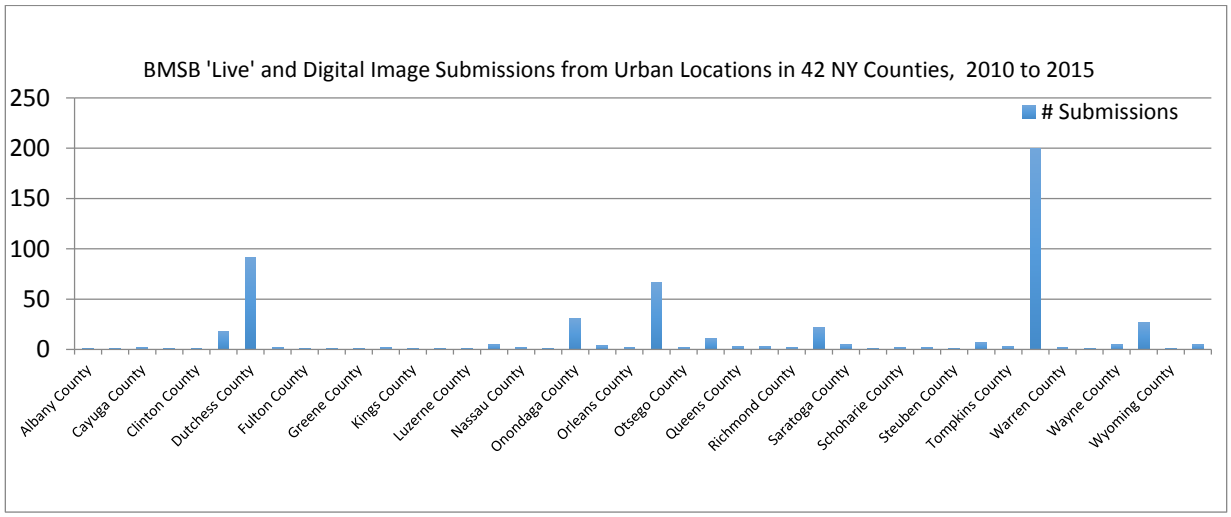

Image 3. Citizen Science based submissions of BMSB populations in counties across NYS.

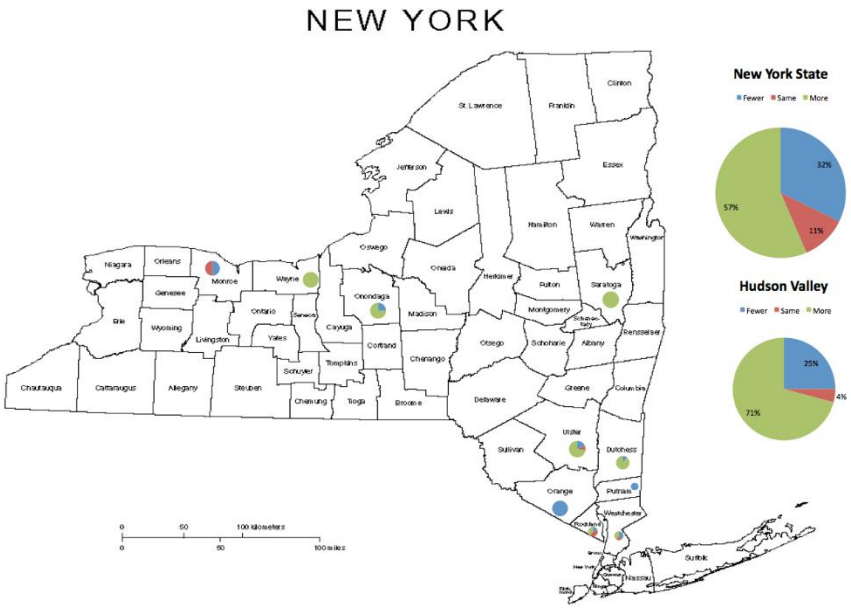

Image 4 E-mail poll of NYS resident observations of urban BMSB populations over a two year period. Majority of residents are seeing increasing numbers of BMSB in their homes from 2010 to 2012.

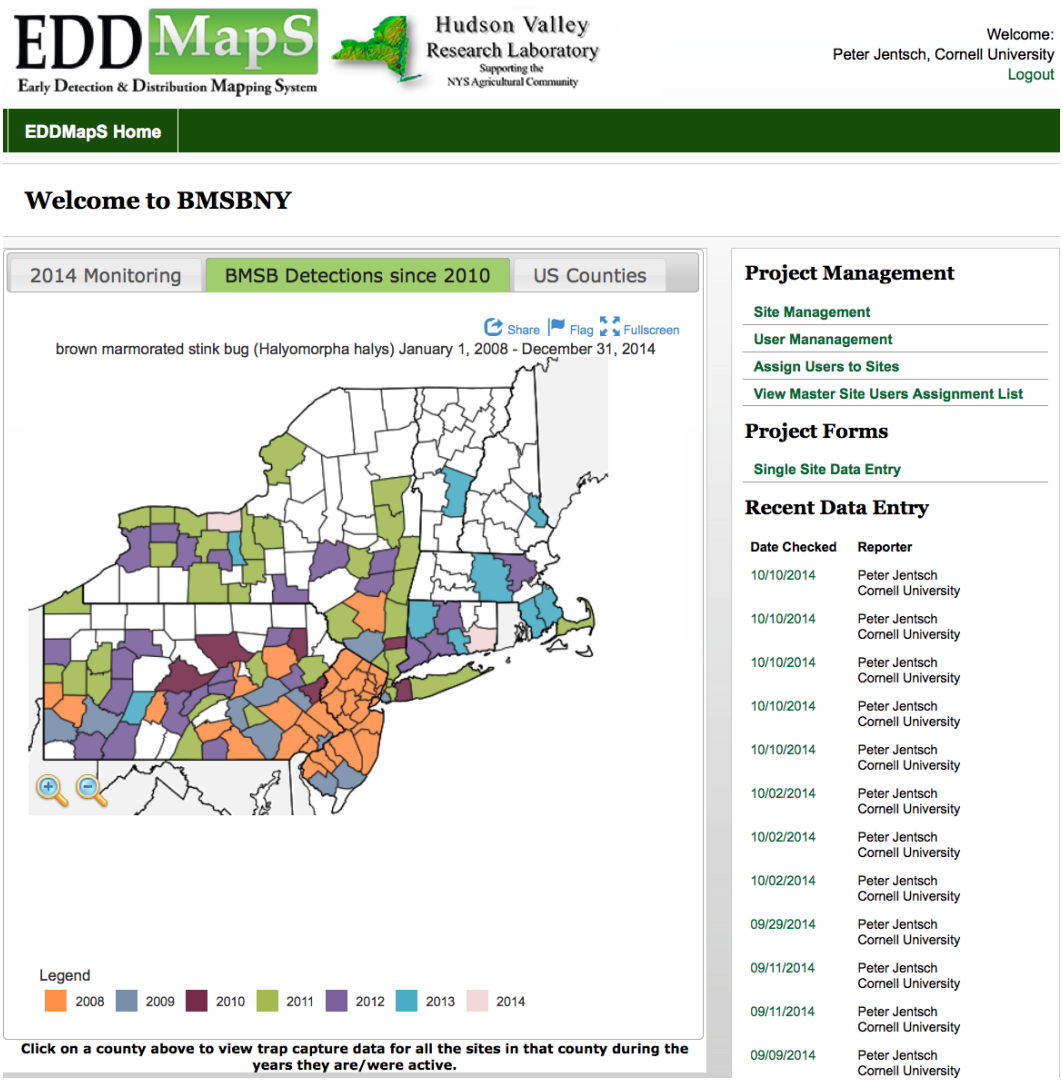

Image 5. EDDSMapS displaying historical population distribution (2010 Tab) of urban and agricultural data sets into a single map.

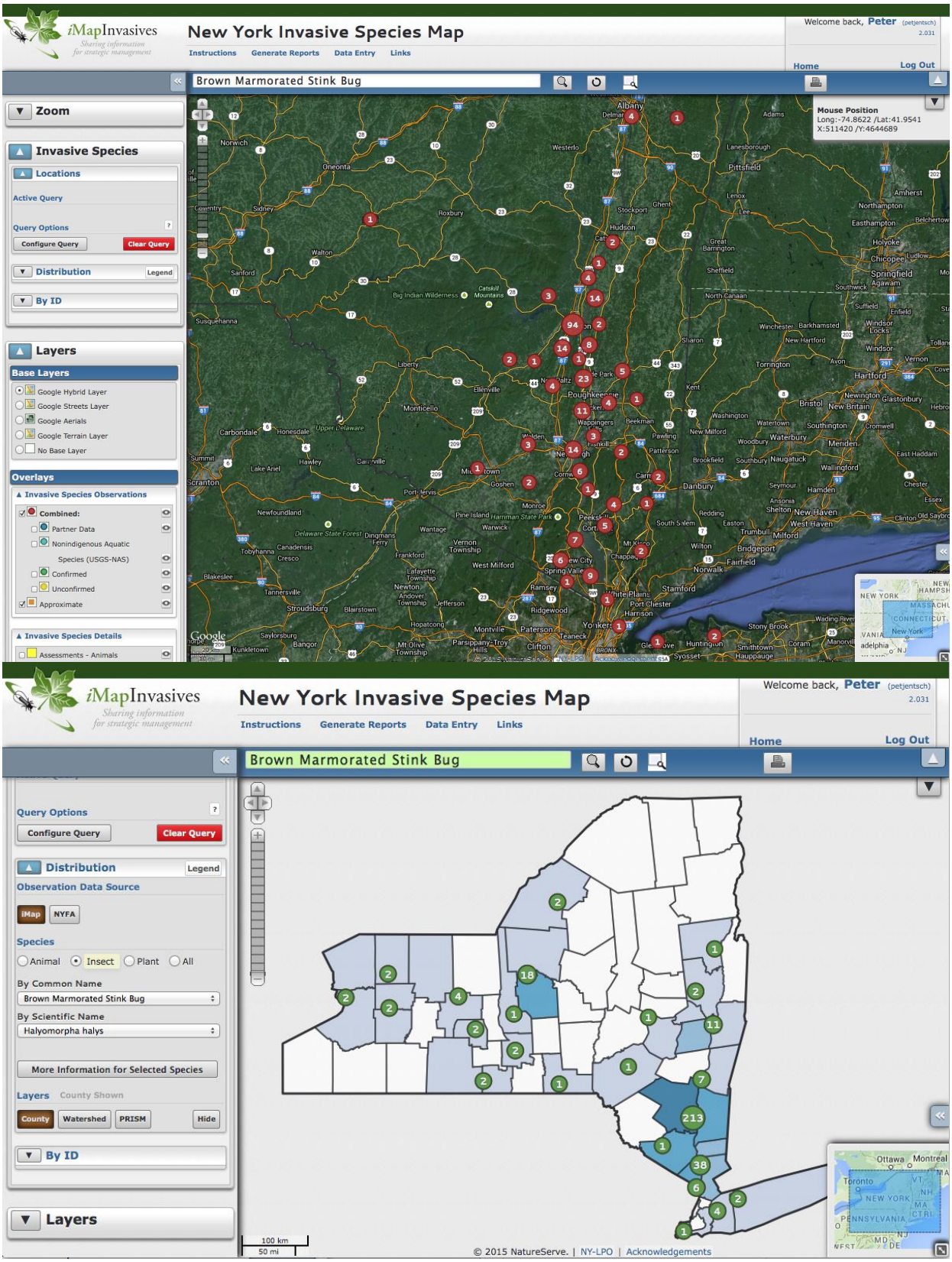

Image 6. Developing iMapInvasives map of Urban BMSB populations in NYS. Public users can access invasive species data by selecting species (insect button) and common name (BMSB).

brown marmorated stink bug
Halyomorpha halys (Stal)

Record ID	4100975
Location	Westchester County, New York
Source	David Soderberg
Project	StopBMSB
Comments	Yorktown heights
Identification	Verified
Credibility	
Observation Date	October 3, 2014
Date Entered	October 3, 2014
Validator	George Hamilton
Validation Date	October 4, 2014
Verification Method	Photographs
Source Type	Web Report

Record ID	4099801
Location	Westchester County, New York
Source	Corinne Rea
Project	StopBMSB
Locality	Can you possibly confirm what this is and also how do we rid our home of these bugs? any information would be greatly appreciated !
Comments	Outside of home on windows and occasionally seen in side of home.(Lower Westchester county-Bronxville new york
Coordinates	40.99916, -73.81599
Identification	Verified
Credibility	
Observation Date	September 28, 2014

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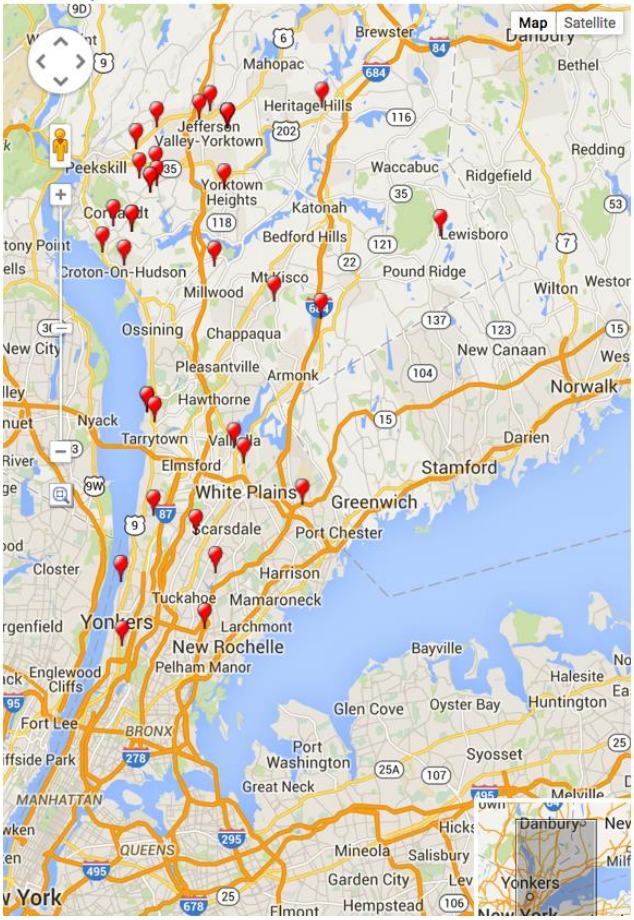

Image 7. Each EDDMapS mapped entry. Select a pin on the map for Record ID with Location, Source, Observation Date with Coordinates of the locations if GPS smartphones are employed.

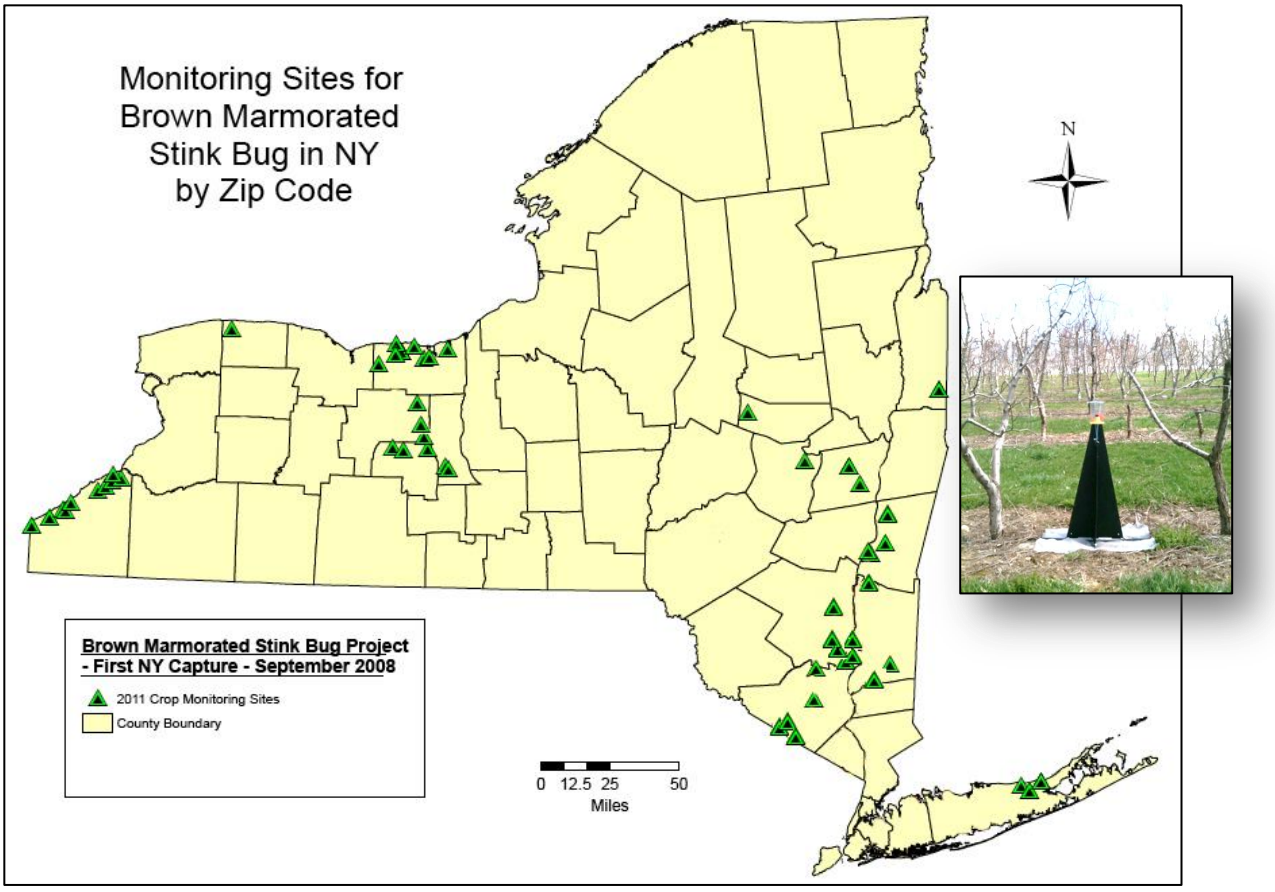

Image 8. Agricultural monitoring of BMSB in NYS.

BMSB Trap Site	Lat	Long.	County	Crop
Bellona-Orchard	42.74786	-77.01583	Yates	Apple
Campbell Hall - Orchard	41.42821	-74.23972	Orange	Apple
Chazy-Orchard	44.90238	-73.43094	Clinton	Apple
Columbia-Orchard	42.19387	-73.82546	Columbia	Apple
Cutchogue-Peach Orchard	41.01231	-72.48331	Suffolk	Peach
Fishkill - Orchard	41.51773	-73.82363	Dutchess	Apple
Greenwich-Vegetable	43.0724	-73.5571	Washington	Corn
Hudson Valley Lab - Highland	41.74551	-73.96775	Ulster	Apple
K M Davies Co	43.23571	-77.18898	Wayne	Apple
Kinderhook-Orchard	42.39906	-73.70259	Columbia	Apple
Milton East - Vegetable	41.63812	-73.96396	Ulster	Organic Pepper
Milton West - Orchard	41.65032	-73.9931	Ulster	Apple
Montgomery-Veg	43.00424	-74.32636	Fulton	Bean
Motts	43.23399	-77.17352	Wayne	Apple
Orleans-Orchard	43.2575	-78.23857	Orleans	Apple
Red Jacket-Orchard	42.86137	-77.0256	Ontario	Apple
Rexford-Orchard	42.81575	-73.83824	Saratoga	Apple
Schoharie-Veg	42.75273	-74.45422	Schoharie	Apple
Tivoli - Orchard	42.04537	-73.85442	Dutchess	Apple
Warwick - Orchard	41.23259	-74.3873	Orange	Apple

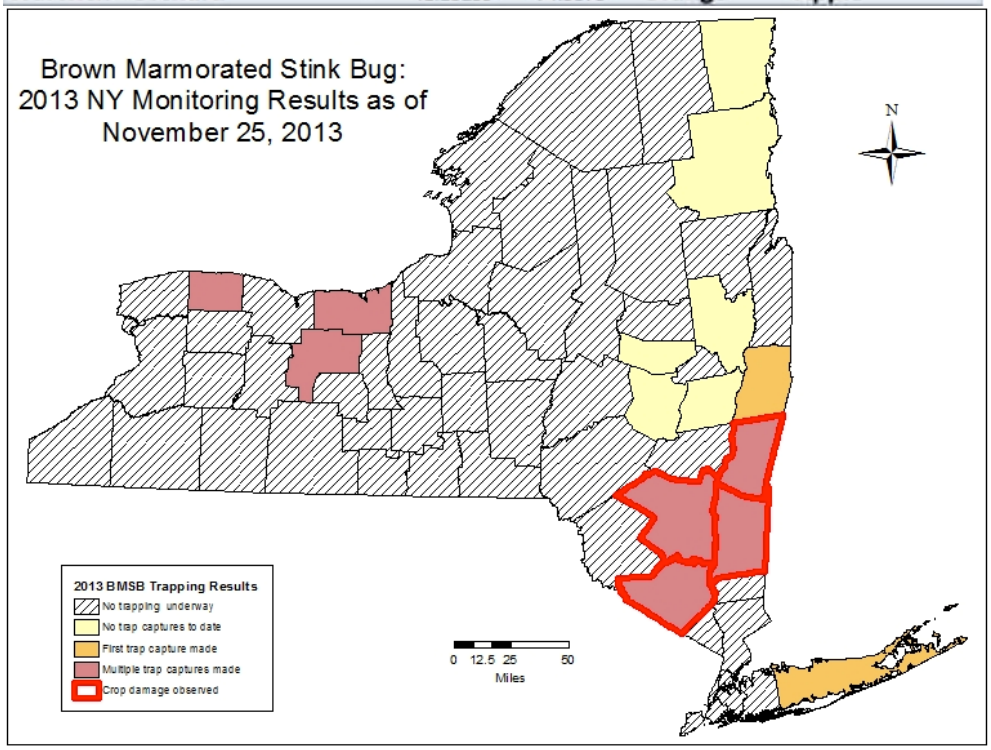

Image 9. Locations and commodities of trap sites using #10 lure +MDT lures in 15 NY counties employing a static mapping system for Internet based on-demand stakeholder communication.

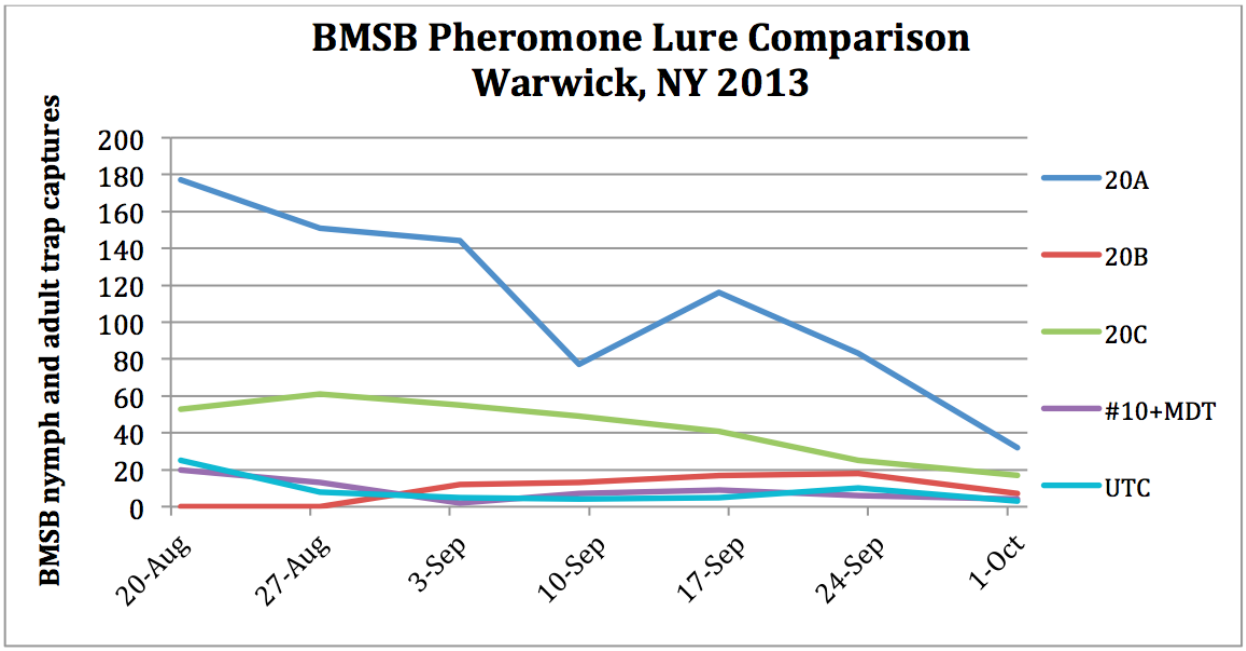

Image 10. Trap captures of BMSB employing 4 pheromone blends in comparison to an untreated control (UTC) indicating the presence of BMSB along the orchard edge.

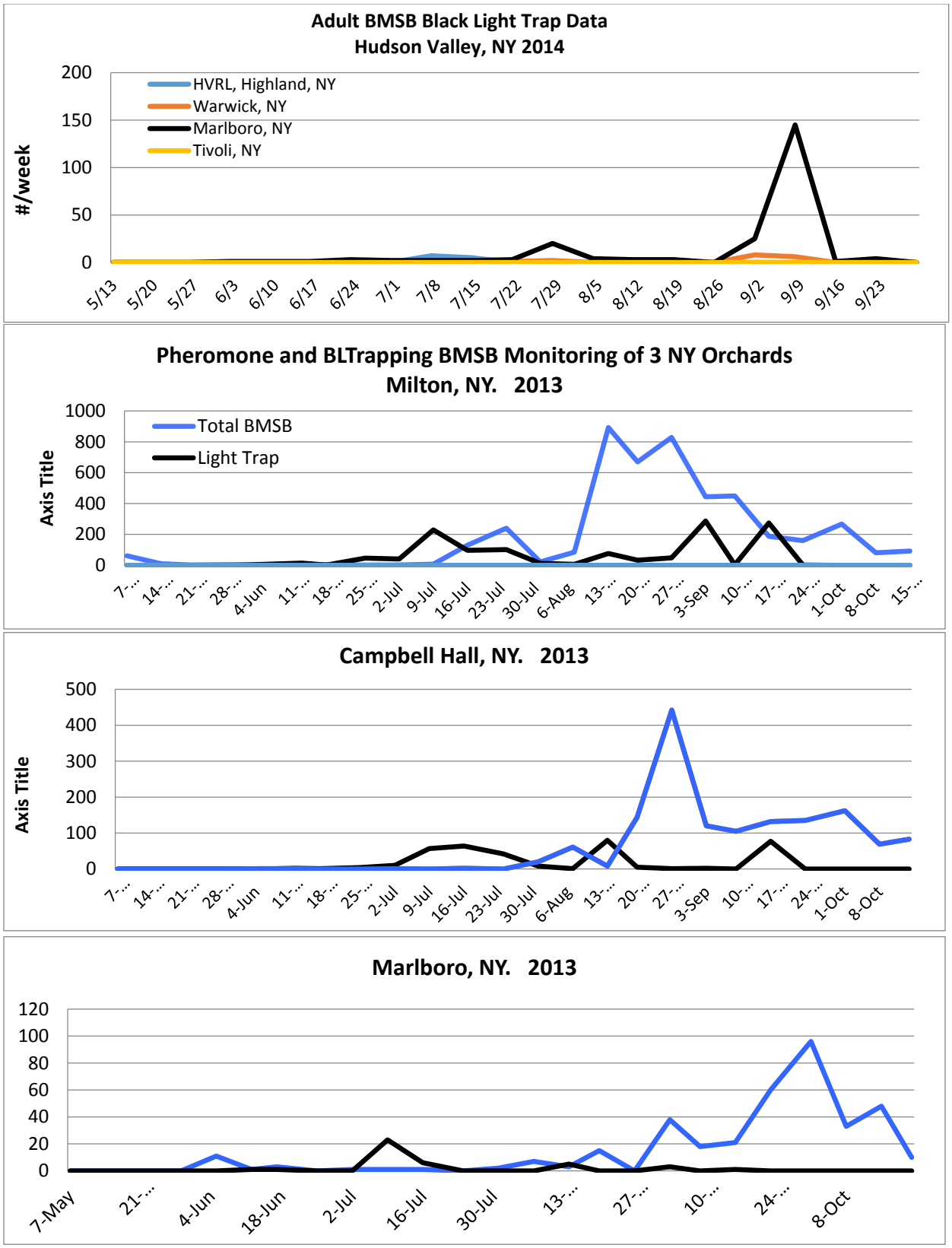

Image 11. Mid-Hudson valley monitoring sites using black light to capture BMSB adults between 2013 and 2014.

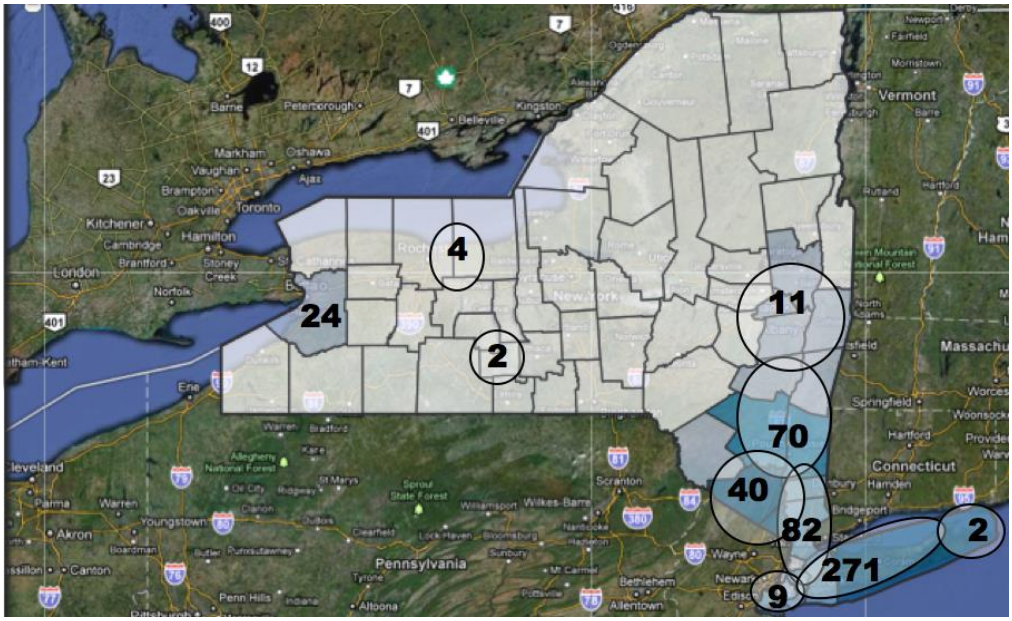

Image 12. iMapInvasives map of the BMSB host, Tree of Heaven, *Ailanthus altissima*.

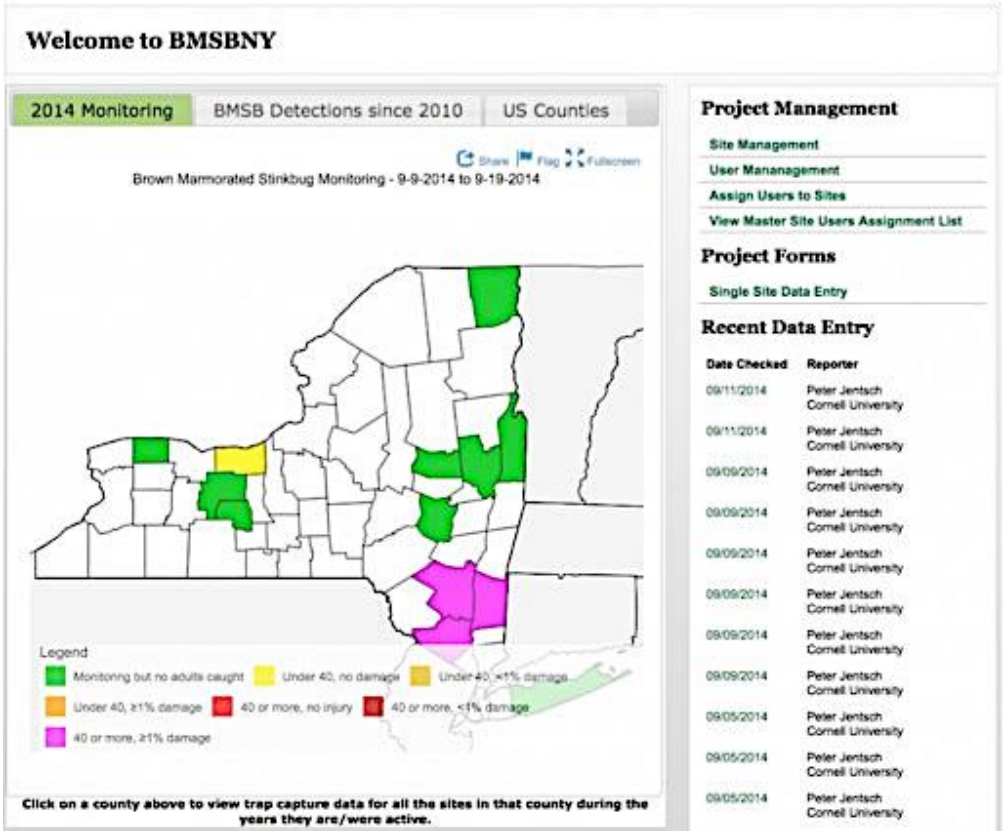

Image 13 EDDMapS showing late season BMSB population increase above threshold with ≥ 1% damage observed to fruit in Ulster, Orange and Dutchess Counties. Remaining counties are either below threshold or have not been observed.

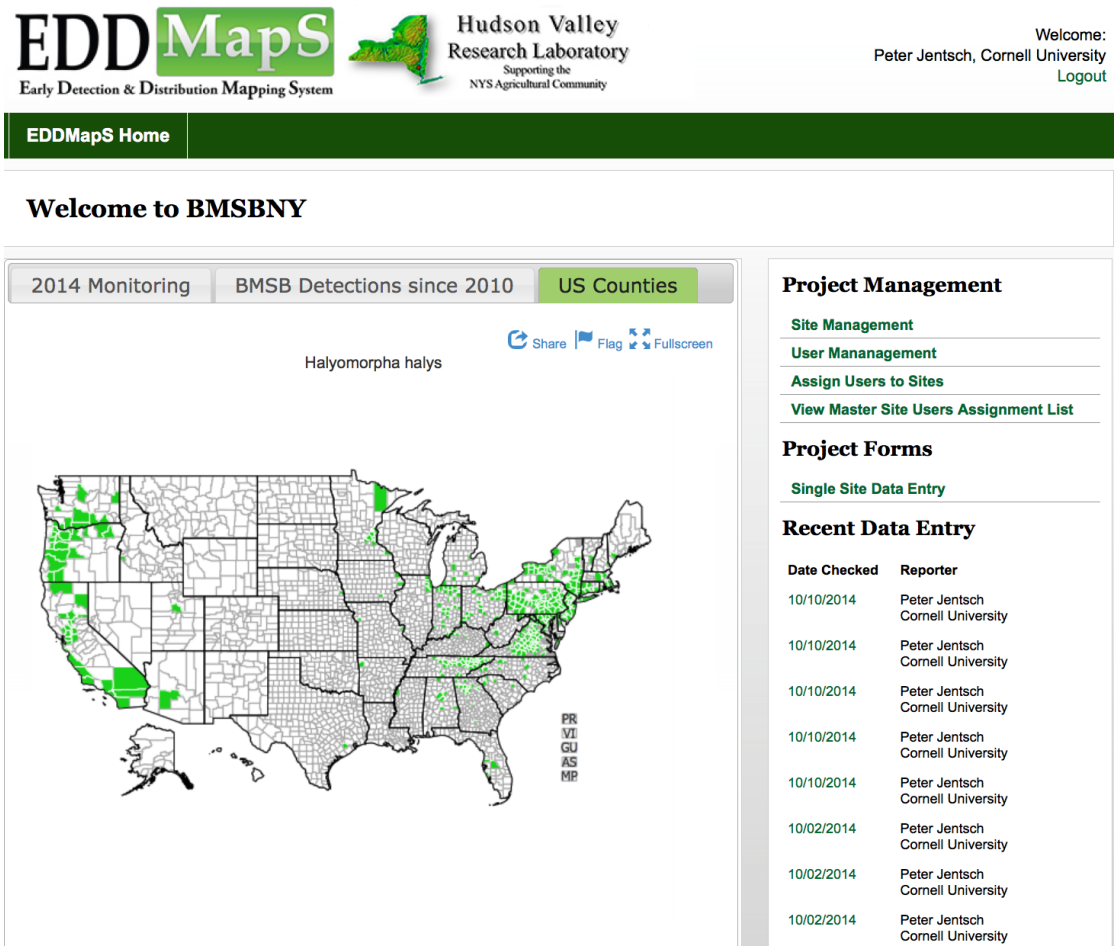

Image 14 2014 County based on-demand communication to agricultural producers using EDDMapS

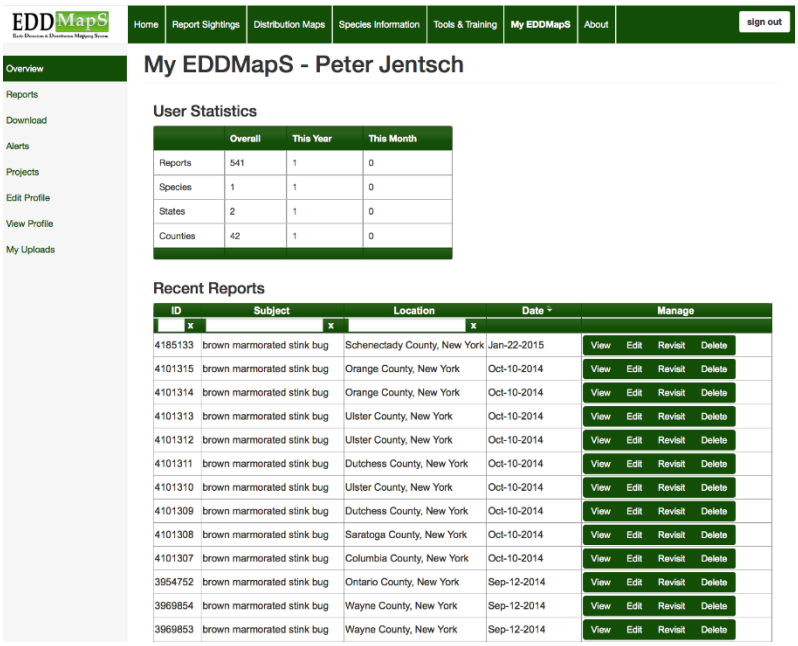

Image 15 User statistics for urban mapping of BMSB updated to show 541 reports from 42 NY counties since project inception.

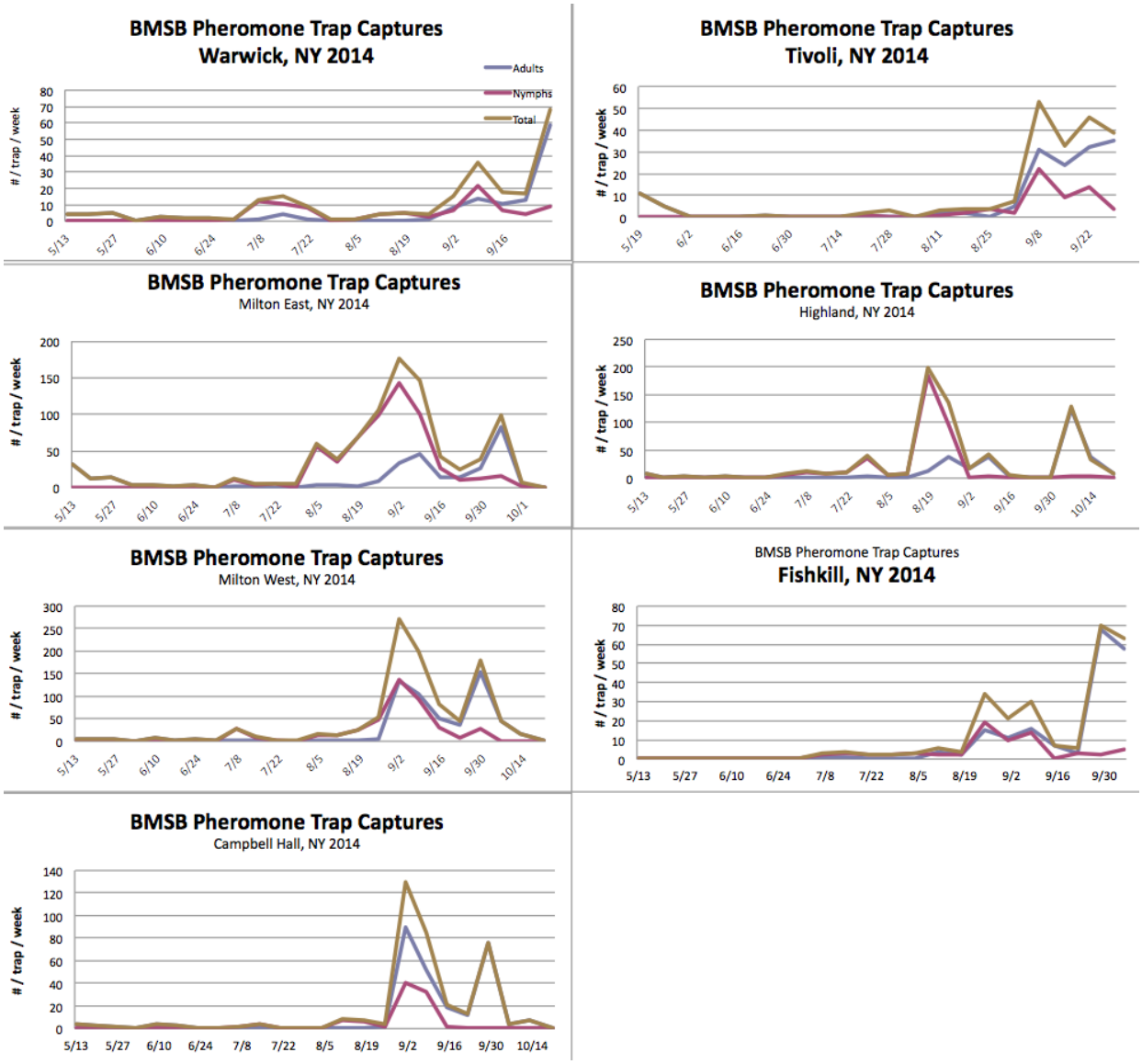

Image 15. Pheromone trap captures of BMSB on seven Hudson Valley farms indicating the degrees of difference in BMSB populations along the orchard or field edge of each site.

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Project 6
Predicting Chemical Thinning of Apples to Maximize Crop Value of Apple Orchards

Project Summary

Crop load management is the single most important, yet difficult, management strategy that determines the annual profitability of apple orchards. The number of fruit that a tree carries directly affects yield, fruit size and the quality of fruit that are harvested, which largely determine crop value. Calculations of crop value at various crop load levels using fruit size and yield as the main variables have shown in a number of experiments to that the relationship of crop value to crop load is curvilinear. At very high crop loads (unthinned trees) fruit size is often very small but yield is very high.

Crop value in this situation is almost zero since the value of the fruit is often exceeded by the packing and storage costs. When crop load is reduced to more moderate levels through thinning, then crop value rises dramatically even though yield is lower due to larger fruit size, which has greater value. At some point crop value peaks and then with further reductions in crop load crop value declines due to lower and lower yield. Although fruit size continues to increase it does not compensate for the loss in yield. Thus, management of crop load is a balancing act between reducing crop load (yield) sufficiently to achieve optimum fruit size and adequate return bloom without reducing yield excessively. It is striking how narrow the crop value peak is in many situations.

Identifying and then achieving this optimum crop value is often very difficult for apple growers. It is difficult for fruit growers to know the economic impact of not achieving the optimum crop load. In addition if fruit thinning is inadequate return bloom the following year will be reduced. The difference between the optimum crop load and under thinning or over thinning can sometimes be a difference of thousands of dollars per acre. Thus growers often fail to capture the full crop value possible without knowing how much "money they left on the table". More precisely managing crop load will help growers achieve the optimum crop load and maximize crop value.

Fruit growers attempt to manage crop load by spraying chemical thinning compounds in the springtime. Chemical thinners reduce crop load by causing the abscission of a portion of the young fruitlets shortly after bloom, which results in larger fruit size of the remaining fruits, and better return bloom the following year.

Despite 40 years of experience with chemical thinning, it remains an unpredictable part of apple production with large variations from year to year and within years due to weather. One of the most critical crop production problems in apples is to predictably reduce crop load each year by chemical thinning to achieve the optimum crop load and fruit size, which will maximize crop value.

Through this project we have developed and extended a method to predict thinner response and also to use this information to make thinner application decisions that will result in consistent thinning. Our method uses a carbohydrate supply/demand model developed at Cornell University, which utilizes weather data to predict the trees carbohydrate status and thus susceptibility to chemical thinner action. We have developed a web-based version of the model as a practical thinning prediction tool for use by apple growers statewide.

We have also developed a network of grower cooperators to give real-time feedback on thinning which allows fast dissemination of predictive and thinning assessment data to be delivered through Cornell Extension, private crop consultants and through the Internet.

Project Approach

The goal of the project was to develop a predictive tool, which apple growers could use with their consultants, extension agent or over the web to predict chemical thinner efficacy before and after application to achieve the optimum crop load and maximum crop value. Specific objectives were:

1. Predict thinning efficacy of chemical thinners at various geographic locations in NY State using a carbohydrate supply/demand prediction model to estimate tree sensitivity and correlate the results with field trials.
2. Develop improved temperature and sunlight forecasts to give improved precision to the predictions of the carbohydrate supply/demand model.
3. Improve and simplify the existing carbohydrate thinning prediction model, and develop a practical user friendly prediction tool based on the carbohydrate model which growers can use to predict chemical thinning efficacy.

Previous research of ours had shown there are large variations in chemical thinning efficacy in New York State from year to year and within years due to weather. Beginning in 2000, we began to study this variability by conducted annual spray timing trials in New York State, which showed extreme variation in timing of response and thinning efficacy between years over the 3 week period after bloom when chemical thinners are applied (Robinson and Lakso, 2004; Lakso et al. 2006). There are two major sources of this variability: spray chemical uptake and environmental effects on tree physiology. Variability in spray uptake includes the chemical thinner concentration, the environment at the time of application (temperature and humidity), application method and coverage, drying conditions, and leaf epicuticular wax. However, generally temperature and humidity largely compensate for one another in affecting drying time and uptake.

A second and more important source of variation is the sensitivity of the tree itself, which is related to the level of bloom, how many fruits are present at the time of application, leaf area, temperatures, sunlight, and tree vigor. Many of these factors are directly related to the balance of carbohydrate supply from tree photosynthesis in relation to the demand for carbohydrates from all of the competing organs of the tree (crop, shoots, roots, and woody structure). Immediately after flowering, demand for carbohydrates by developing fruit is only moderate during the initial lag phase of an expolinear growth pattern. However, when fruit reach 8-10 mm in diameter (about 1-2 weeks after petal fall), rapid fruit growth results in an ever-increasingly large carbohydrate demand which may not be met by current photosynthesis.

At that time in spring considerable variation in temperature and light gives large variations in carbohydrate balance. Temperature, number of shoots, and number of fruit are important factors that control the demand for carbohydrates. With cool sunny days with a light initial crop, the balance of supply and demand carbohydrates is positive due to the high photosynthesis while the cool temperatures limit demand for carbohydrates by shoots and fruits. On the other hand, hot cloudy days with a heavy initial crop load have a negative balance of carbohydrates due to a reduced supply but the high temperatures drives up demand by stimulating growth rates of shoots and fruits.

Chemical thinners are reputed to work by providing a transient stress on the tree during the rapid growth stage of shoots and fruits and when fruits are most susceptible to a carbohydrate deficit. Chemical thinners appear to have the capability to create a carbohydrate stress by reducing photosynthesis, increasing respiration or impeding carbohydrate movement to the fruit. Many have observed that the greatest fruit abscission caused by thinners is associated with periods of 3-5 days of reduced carbohydrate availability immediately following thinner application. These weather conditions are generally a combination of warm temperatures and low light. Unfortunately, these are empirical observations that have not been quantified to aid in prediction of thinner response or used to make thinner recommendations.

Alan Lakso at Cornell University developed a simplified mathematical model that mechanistically estimates apple tree photosynthesis, respiration and growth of fruits, leaves, roots and woody structure (Lakso et al., 2006, 2007). The model uses daily maximum and minimum temperatures and sunlight to calculate the production of carbohydrates each day and allocates the available carbohydrates to the organs of the tree. From these data the model calculates the daily balance of carbohydrates for a virtual tree based on an Empire/M.9 tree grown in Geneva, NY.

The value of the model in predicting chemical thinner efficacy has been observed in our thinning experiments over the last 10 years (Lakso et al., 20078; Robinson and Lakso, 2011). For example, in 2004 a very warm, cloudy period occurred shortly after bloom resulted in a net carbohydrate deficit during the first 10-14 days after petal fall followed by a sunny cool period of particularly good carbohydrate balance. The poor carbohydrate balance period correlated well with the strongest thinning response while the least thinning response later during the good carbohydrate balance. In 2006, however, the carbohydrate balance was good initially after bloom corresponding to light-moderate thinning. The hot period beginning at about 21 days after bloom led to a poor carbohydrate balance that correlated with the strongest thinning effect. Other years showed similar correlations that explained many of the year-to-year variations shown earlier (Fig. 2). We have used the estimated supply-demand balance of the tree to predict or explain thinning response as follows: carbohydrate surplus will support fruit growth giving less thinning while carbohydrate deficits will limit fruit growth giving more thinning We have used results from field and greenhouse experiments at Geneva to develop simple decision rules based on carbohydrate balance for the day of thinning and the next 3 days.

The carbohydrate model has potential to predict thinner responses prior to the application of thinners thus allowing growers to adjust thinner treatment and timing to achieve an optimal amount of thinning. However, it imprecisely assesses the real effect of the chemical thinner after application. A more precise assessment tool after application would be of value to growers in deciding whether to apply a second application of chemical thinner.

Work on this project began in Feb. 2012 when we hired a postdoctoral scientist (Jim Myers) to develop a web adaptable version of the carbohydrate model under the direction of Alan Lakso. By the end of June 2012 he has developed a simplified spreadsheet version of the carbohydrate-thinning model using Microsoft Excel. He has also begun work on translating the model from “Stella” software to “Python” software, which could be mounted on a server and used over the Internet. This latter effort was completed by Dec. 2012.

At the same time Art DeGaetano began developing improve solar radiation forecasts for use in the carbohydrate-thinning model. He developed new algorithms for forecasting radiation using airport weather data. Keith Eggleston who works with Art DeGaetano linked these improved solar radiation forecasts with the web version of the carbohydrate model. This work was completed by April 2013. The completed Cornell Apple Thinning model with forecasting capabilities is housed at the Cornell NEWA website: http://newa.cornell.edu and was operational May 1, 2013.

We began to introduce the use of the new model at a 2-day in-depth statewide fruit school held at Geneva, NY in March 2013 on Precision Orchard Management. This In-depth School attracted 200 participants from throughout New York State as well as Michigan, Pennsylvania, Virginia, North Carolina, and New England. At the school we introduced apple growers to the concepts of precision orchard management, which could improve profitability. We produced a 130-page spiral bound manual of precision orchard management. The objectives of the school were: 1. Help apple growers understand the potential income from each orchard block and how to use precision orchard management to capture that potential. 2. Help apple growers plan future orchards to take advantage of precision orchard management strategies to increase profitability. There were several orchard management practices that were discussed, including crop load management with the carbohydrate model and the fruit growth model. We introduced the use of these models under a new term we named Precision Crop Load Management. We taught growers how to manage

crop load more precisely and the significant impact this could have on orchard profitability. Through this school, we helped growers consider the question “How much money are we leaving on the table and can precision orchard management help capture that money?" Information from In-Depth School was further disseminated via 3 articles in the NY Fruit Quarterly magazine in 2013 and via regional extension newsletter articles written by faculty and extension educators. We also conducted follow up extension workshops and field activities during the 2013 season. They included a field workshop on precision crop load management (150 persons), a chemical thinning workshop (300 persons), a hand-thinning field workshop and the Geneva Fruit Field day on Aug. 1, 2013 (300 persons).

In late April we organized a group effort to implement and test the carbohydrate model and the fruit growth rate model to achieve precision thinning. We convened a training meeting in early May of interested growers and consultants across the state where we taught them how to use the models and how to make decisions based on the results (50 persons). The project involved each participant measuring fruit growth in their own orchard and emailing the results to the project leader. The project leader then analyzed the data and returned to the grower the results and a recommendation for thinning within 24 hours. This project of testing and validating the model was done in the Lake Ontario Region, the Hudson Valley, the Champlain Valley and the Finger Lakes Region. There were 24 grower participants. As the season progressed this group effort resulted in extremely useful real-time data which allowed growers to make the best possible decisions concerning thinning. The information we gathered each day was communicated to other growers via the fruit fax system of extension. Extension educators including Mario Miranda, Steve Hoying, Craig Kahlke and Mike Fargione were key partners in this effort.

Work to disseminate the results of the carbohydrate model was continued in the fall with a meeting of project leaders, extension cooperators, private consultants and select fruit growers (50 persons). This meeting led to the planning of 3 presentations in winter by Terence Robinson and Steve Hoying at fruit grower schools (4 schools with combined attendance of 550 persons). The presentations at the winter fruit grower’s schools presented a summary of the project’s first year’s results with plans for 2014. We also made a presentation to an international audience of fruit growers at the International Fruit Tree Association Meeting in Boston MA in late Feb. 2013 (400 persons).

In 2014 we repeated and expanded the program from 2013. In late April we organized a group effort to implement and test the carbohydrate model and the fruit growth rate model to achieve precision thinning. In 2014 Mario Miranda, Steve Hoying and Craig Kahlke were key participants in this effort. We convened a training meeting in early May of interested growers and consultants across the state where we taught them how to use the models and how to make decisions based on the results (60 persons spread over 4 locations in NY State). The 2014 group-thinning project involved 50 participants measuring fruit growth in their own orchards and emailing the results to the project leader. This project of testing and validating the model was done in the Lake Ontario Region, the Hudson Valley, the Champlain Valley and the Finger Lakes Region. The information we gathered each day was communicated to other growers via the fruit fax system of extension.

We have published numerous articles and given many presentations about this project, which are listed in the additional information section. We have also incorporated the concepts from this project into the Cornell Guidelines for Commercial Tree Fruit Production.

Goals and Outcomes Achieved

We achieved the primary goal of the project, which was to develop a predictive tool, which apple growers could use with their consultants, extension agent or over the web to predict chemical thinner efficacy before and after application of chemical thinners. We did this by developing an online tool based on the carbohydrate model, which has specific recommendations for growers based on the weather prediction over the next 7 days to achieve the optimum crop load and maximum crop value. The online model uses

sophisticated prediction algorithms developed through this project by Alan Lakso, Art DeGaetano and Keith Eggleston to provide the best prediction of thinner response.

We vigorously worked to implement the concept of precision crop load management with all commercial apple growers and did this via meetings, articles and a group participatory thinning project. At the end of the project, the two primary outcomes are:

1) A precision thinning program was introduced and implemented for 2 seasons with New York apple growers that has helped many commercial apple growers more successfully thin their trees to achieve the optimum yield and fruit size and maximize crop value. Using the carbohydrate thinning model and the fruit growth rate model together in the precision thinning program resulted in greater precision of crop load management and in greater profitability for apple growers. We believe the success of the precision thinning program improved the value of the New York State apple by tens of millions of dollars in both years. This was especially true in 2013, which was a difficult year to achieve proper thinning. This project gave growers confidence to thin aggressively which resulted in good fruit size. If they had not thinned aggressively the 2013 crop would have had a lot of small fruit, which is worth very little. Thus, this project was very critical to the success of the New York apple industry in 2013.

2) The project successfully involving growers directly in using the models, measuring fruit diameters and then making informed thinning decisions based on sound data through the group-thinning project. In addition to the growers who participated in the group-thinning project, many other growers simply used the thinning prediction model via the Internet to guide their thinning decisions.

We informally surveyed growers at the 2014 fruit school (four schools with a combined attendance of 550 persons) where we made presentations of precision thinning. We estimated that 150 of the 550 growers had utilized or their consultant had utilized precision thinning the year before. We estimated that 500 of the 550 had benefited from the project by following the results of the group precision thinning project through the extension newsletters. We also conducted discussions with the seven most important apple crop consultants in New York State on their use of precision thinning. Five of the seven had used it when making recommendations to their clients, one did not and one indicated he did not believe in this approach to crop load management.

Beneficiaries

This project benefited the commercial apple growers in New York State. The project helped them consistently achieve the optimum crop load in 2013 and 2014, which can mean a large difference in crop value compared to excessively heavy or excessively light cropped trees. We estimate that if fruit size is very small due to excessive crop load (<2.5" diameter) crop value can be as low as $4,000 per acre, which is below the cost of production. If fruit size is near the fresh market optimum of 3" then crop value can be as high as $10,000-15,000 per acre depending on variety.

The difference between the juice price and the optimum fresh market crop value can be $6,000-11,000 per acre. If hand thinning is necessary to compensate for a poor chemical thinning result then the difference if crop values would be less but when considering the cost of hand thinning ($1,000-2,000/acre), an excellent job of chemical thinning result could still result in an increased crop value of $4,000-7,000 per acre compared to a poor result of chemical thinning coupled with expensive hand thinning. Our informal survey of crop consultants and extension educators indicates that our thinning prediction models were used on about one third of the apple acreage in New York State in 2013 and about 40% in 2014.

We conservatively estimate that this resulted in a 20% increase in the crop value of apples from those acres. This estimate is based on the data from Geneva, NY trials in both years where we compared

typical thinning strategies to the precision thinning program. We estimate that increased value of the New York State crop was between $30 and $36 million. This project has improved the profitability of the State's apple growers and will help keep apple production in the New York competitive with other producing areas. This will also benefit the rural economy of the State and provide significant social benefits to fruit producing counties.

Lessons Learned

This project was and will be very critical to the success of the New York apple industry in 2014 and beyond. One of the best growers observed in the spring of 2014 that following the frost-reduced crop of 2012, New York State apple farms were "set up" to have a bumper crop in 2013 but with small fruit size and thus to enter a biennial bearing cycle in 2014. However through the efforts of this project and the extension educators and consultants who cooperated in this effort, the thinning job of the 2013 job was done well resulting in good fruit size in 2013 and a high crop value. Just as important is that in 2014 the trees had a good bloom and a large 2014 crop also with good fruit size.

Additional Information

We have published several scientific and popular articles, bulletins and extension newsletter articles about predicting chemical thinning during the course of this project. Tables and charts with data from these publications or the entire publication can be supplied on request.

2012

Lakso, A.N. and T.L. Robinson. 2012. Integrating physiological models in applied fruit crop research. 10th International Symposium on Orchard Systems: Program and Abstracts p. 38.

Robinson, T.L. and A.N. Lakso. 2012. Precision thinning and precision irrigation. Proceedings Great Lakes Fruit Workers Annual Meeting 2012:40 (Abstr.)

Robinson, T.L., Lakso, A.N. and Hoying, S.A. 2012. Advances in predicting chemical thinner response of apple using a Malusim carbon balance model. Acta Hort. 932:223-229.

2013

Greene, D.W., A.N. Lakso, T.L. Robinson and P. Schwallier. 2013. Development of a Fruitlet Growth Model to Predict Thinner Response on Apples. HortScience 48:584-587.

Greene, D.W., A. Lakso, T. Robinson, and P. Schwallier. 2013. Fruitlet model for assessing thinner response. Compact Fruit Tree 46(3):6-8.

Hoying, S.A. and T.L. Robinson. 2013. Pruning for Precision Crop Load Management. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.21-24.

Hoying, S.A. and T.L. Robinson. 2013. Hand thinning for precision crop load management. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.32-33.

Miranda Sazo, M. and T.L. Robinson. 2013. Working efficiently in the orchard. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.81-89.

Miranda Sazo, M. and T.L. Robinson. 2013. Frost protection methods. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.104-109.

Robinson, T.L. 2013. Precision orchard management. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.5-7.

Robinson, T.L. 2013. Precision crop load management. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.20-21.

Robinson, T.L. 2013. Managing the risk of hail and sunburn. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.100-103.

Robinson, T.L. 2013. Precision harvest management. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.137-143.

Robinson, T.L., A. Lakso, D. Greene and S. Hoying 2013. Precision chemical thinning. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.25-31.

Robinson, T.L., A. Lakso and L. Dominguez. 2013. Precision irrigation management. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.57-62.

Robinson, T.L., S. Hoying, M. Miranda Sazo, A. DeMarree and L. Dominguez. 2013. Apple orchard systems of the future. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.71-81.

Robinson, T.L., M. Miranda Sazo, P. Wafler. 2013. Harvest mechanization: Challenges and outlook. In Robinson, T.L. (ed.) 2013 Eastern Apple Summit on Precision Orchard Management. pp.90-95.

Robinson, TL. and M. Miranda Sazo. 2013. Precision Thinning Group Effort in Western NY in 2013. Lake Ontario Fruit Newsletter 2013(10):3-4.

Robinson, TL., 2013. Update on Precision Chemical Thinning. Lake Ontario Fruit Newsletter 2013(11):1.

Robinson, TL. and M. Miranda Sazo 2013. Precision Chemical Thinning – An Update on Fruit Measurement Studies. Lake Ontario Fruit Newsletter 2013(13):1-2.

Hoying, S.A. and T.L. Robinson. 2013. Hand Thinning for Precision Crop Load Management. Lake Ontario Fruit Newsletter 2013(15):4-5.

Robinson, T.L. (ed). 2013. Eastern Apple Precision Orchard Management Summit Proceedings. New York State Agricultural Experiment Station, Cornell University, 146 pages.

Robinson, T., A. Lakso, D. Greene and S. Hoying. 2013. Precision crop load management. NY Fruit Quarterly 21(2):3-9.

2014

Agnello, A.M., A. Landers, D.A. Rosenberger, T.L. Robinson, J.E. Carroll, L. Cheng, P.D. Curtis, D.I. Breth, and S.A Hoying. 2014. Pest management guidelines for commercial tree-fruit production 2014. Cornell University, Ithaca NY 252 pp.

Hoying, S., T. Robinson, and M. Miranda Sazo. 2014. Precision Hand Thinning. Lake Ontario Fruit Newsletter 2014(16):6-7.

Miranda Sazo, M., T. Robinson, C. Kahlke and L. Tee. 2014. Preliminary Results of Precision Thinning Group Effort in Western NY in 2014. Lake Ontario Fruit Newsletter 2014(15):2-4.

Robinson, T., S. Hoying, M. Miranda Sazo and A. Rufato. 2014. Precision crop load management: Part 2. NY Fruit Quarterly 22(1):9-13.

Robinson, T.L., A.N. Lakso and D. Greene. 2014. Precision crop load management: The practical implementation of physiological models. International Symposium on Physiological Principles and Their Application to Fruit Production: Program and Abstracts. p.37.

Robinson, T.L. and M. Miranda Sazo. 2014. Thinning Without Carbaryl in 2014. Lake Ontario Fruit Newsletter 2014(11):3-4.

Robinson, T. and M. Miranda Sazo. 2014. Precision Chemical Thinning in 2014 for Gala and Honeycrisp. Lake Ontario Fruit Newsletter 2014(12):5-6.

Robinson, T.L., M. Miranda Sazo, C. Kahlke and L. Tee. 2014. Last Call to Join the Precision Thinning Group Effort in Western NY in 2014. Lake Ontario Fruit Newsletter 2014(13):1-2.

Rufato, A., L. Rufato, and T. Robinson. 2014. Precision thinning of 'Royal Gala' apples trees using the fruit growth model. International Symposium on Physiological Principles and Their Application to Fruit Production: Program and Abstracts. p.75-76.

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Project 7
Testing Budwood for Latent Fire Blight Bacteria Threatening Nursery Trees and New Plantings

Project Summary

New apple plantings in New York suffer up to 80% tree loss from fire blight. This catastrophic loss is sometimes due to lack of streptomycin sprays on late blooming newly planted trees. However, tree loss in young plantings often results from what appear to be infections from the previous season in the bark of nursery stock developing into shoot blight infections in these fast growing trees. Transfer of fire blight on nursery trees was evidenced by presence of streptomycin resistant bacteria on trees from Michigan planted in New York in 2002. If fire blight is spread through nursery stock, the original source of bacteria may be budwood collected from infected source trees, as reported in Washington State. Budwood for new cultivars and those with few sources available is commonly collected from orchards where fire blight is established. In high such value varieties, growers usually remove active infections, and nurserymen subsequently collecting budwood are typically unaware of the trees to avoid during the collection. This project will investigate the phenomenon of bud-transmitted fire blight, and then establish protocols for preventing it. The purpose of this project is to investigate whether fire blight can be transmitted to new nursery trees by infected buds taken from trees in fire blight affected orchards.

Currently, nurserymen cannot avoid collecting budwood from commercial orchards and rare cultivar source blocks with fire blight infections. While individual trees appear to be free of infection, the possibility exist that budwood may indeed harbor asymptomatic fire blight bacteria. Moreover, commercial growers are propagating their own nursery trees from budwood collected on site to establish cost-effective high-density plantings. In this production climate it is imperative that the potential for asymptomatic fire blight infections be thoroughly investigated and the risks of transmission assessed.

This project was not based on a previously funded SCBGP or SCBGP-FB project.

Project Approach

The activities and tasks of the project are summarized below by the objectives of the grant. For each task/activity, we list the progress below.

Objective 1: Evaluate the potential for budwood sourced from fire blight affected orchards to carry cryptic fire blight bacteria within the buds.

Task/Project activities and progress/accomplishments for each task are listed below.

1. *Examine budwood collected from commercial source blocks for the presence of fire blight bacteria (Erwinia amylovora).*

    a. For three years, we have collected budwood from commercial Gala and Topaz plantings used as source blocks to assay for asymptomatic fire blight infections. In each year, cultivar we examined 5 shoots from 10 trees for each cultivar with each of the following conditions: buds from a scaffold with fire blight, buds from a shoot on the opposite of the tree with a fire blight, and buds from a shoot on a apparently clean tree.

    In each of three years on Topaz apples, we found: differences in the frequency of fire blight recovery from bud surfaces or internal contents between all types of asymptomatic shoots were not statistically significant ($P > 0.05$), but the most fire blight was recovered from buds near shoots with fire blight. In some cases there was 100% fire blight recovery from all asymptomatic tissues

In each of three years on Gala apples, we found that the frequency of fire blight recovery from the internal contents was significantly higher ($P < 0.05$) for shoots < 1 m from an strike compared to buds from shoot on same tree >1 m from a strike

In both cultivars, we found that the fire blight is truly inside the bud tissues. We dissected the 'Topaz' and 'Gala' meristem of 10 buds from asymptomatic tree >20 m from nearest tree with a strike. We recovered *Erwinia amylovora* colonies on selective media, which were virulent as demonstrated by necrosis on green pear halves (see section 7).

2. *Characterize presence of fire blight in asymptomatic budwood and determine the genetic identity of the Ea strains isolated by sequencing standard marker genes*

    a. In each of the three years of the experiment, we characterized the 96 fire blight strains isolated from buds in 2012, 2013, and 2014. We found that the both virulent and avirulent *Erwinia* species in addition to other epiphytic bacteria. In all cases, the presence of *Erwinia* inside and outside of bud tissues was highest for buds collected near a shoot with fire blight.

3. *Inoculate several trees with a marked strain of Erwinia amylovora during the bloom period in 2012 and assess the potential for asymptomatic infection.*
    a. In the spring of 2012, we created two marked strains of *Erwinia amylovora* and inoculated Gala and Idared apples during full bloom with 10^7 CFU/mL. We then collected and assayed 100 buds from those trees in August. We found that 3% of the Gala and Idared buds had the marked strain of *Erwinia amylovora*

Objective 2: Evaluate the potential for these bacteria to become active in nurseries and new plantings.

Task/Project activities and progress on each activity are listed below.

1. *Collect budwood from the orchards in objective 1 and the orchard inoculated with marked strain from Objective 1 and establish a grafted planting on susceptible M.9 rootstocks at the NYSAES.*

    a. In 2012, we identified a commercial planting in Western NY with naturally occurring fire blight in Topaz and Gala apples from which to collect budwood. We also collected budwood from trees inoculated with the marked strain of *Erwinia amylovora*. In 2013, we obtained M.9 rootstock plants, we planted them in the spring of 2013, and grafted them with the collected buds during late august of 2013. For each cultivar and treatment condition from the commercial budwood collection, we made 10 grafted trees. This yielded a total of 400 trees grafted with potentially infected budwood.

2. *Monitoring and planting of nursery trees.*

    a. As mentioned in the above task, the budded "nursery trees" were planting in the summer of the 2013 season and were monitored until winter. During this time there was more than 90% grafting success. There were forty necrotic failed grafts that were analyzed for the presence of fire blight. Colonies of *Erwinia amylovora* were only recovered from 3 of the failed grafts. Other common *Erwinia* epiphytes were recovered from the other 37 failed grafts.

    b. In 2014, grafted trees were planted into a high density planting and further monitored for the trees for fire blight infections. During the 2014 season, none of the 360 trees developed fire blight.

Objective 3: Establish protocols to avoid bud transmission of fire blight.

Task/Project activities and progress on each activity are listed below.

1. *Writing of protocols for avoiding collecting bud wood from infected trees.*

    a. We drafted protocols for avoiding asymptomatic fire blight which were presented to our CCE extension outlets in 2013-14 (see below). Additional information from these protocols was incorporated in the Cornell Pest Management Guidelines for Commercial Tree Fruit Production

2. *Presentation of recommendations at Expo and fruit schools.*

    a. We have given numerous talks at the Expo and fruit schools in which we presented fire blight management recommendations protocols. These included information on avoiding cryptic infections of nursery bud wood (See below). All of the talks listed below included presentation of the research outcomes from this project.
    Empire State Fruit and Vegetable Expo. January 22-24, 2013. Developed and provided a 1.0 hour long education programs on fruit diseases management and emerging issues to fruit production stakeholder and agriculture industry representatives. The program was delivered to approximately 101 stakeholders in Syracuse, NY for a total of 101 contact hours.

    2013 Eastern Apple Summit on Precision Orchard Management. March 15, 2013. Delivered precision disease management recommendations to apple stakeholders including information on this project. Approximately 0.5 hours were spent with the 77 stakeholders for a total of 38.5 contact hours.

    2013 Hudson Valley Commercial Fruit Growers' School. Feb. 12, 2013. Delivered disease management research and extension programming on diseases of apple to apple stakeholders. One of the topics was this project. Approximately 1.3 hours were spent with the 66 stakeholders for a total of 85.8 contact hours.

    2013 Upper Hudson / Champlain Commercial Tree-Fruit School. Feb. 11, 2013. Delivered disease management research and extension programming on diseases of apple to apple stakeholders. One of the topics was this project. Approximately 1.0 hours were spent with the 71 stakeholders for a total of 71 contact hours.

    Lake Ontario Fruit Team Petal Fall/Thinning Meeting. May 22-23, 2013. Worked with the Lake Ontario Fruit Team to provide a field tour for NY tree fruit producers. Provided season specific apple and stone fruit disease management training and recommendations to growers and stakeholders. The content included the outcomes of this project. Meetings occurred in both Orleans and Wayne counties to different stakeholder groups. Approximately 1.0 hour was spent with 60 stakeholders on average for each location for a total of 120 contact hours.

    2013 Lake Ontario Winter Fruit School. February 4 & 5, 2013. Worked with the Lake Ontario fruit program to provide a workshop for NY apple producers. A 0.5 hour instructional talk on management of stone and pome fruit diseases and pesticide resistance was delivered to 109 commodity stakeholders in Lockport, NY. The content included the outcomes of this project. The instructional talk was also repeated to 113 commodity stakeholders in Sodus, NY for a total of 111 contact hours.

    Geneva Fruit Field Day. September 4, 2013. In cooperation with entomology, co-hosted an applied research field day for tree fruit industry stakeholders in Geneva, NY. A presentation entitled, "Managing apple scab, powdery mildews, and fire blight with new fungicide products" was delivered to stakeholders. The content included the outcomes of this project. Education was provided to 51 stakeholders for 1.0 hours for a total of 51 contact hours.

Cornell Fruit Field Day 2013. August 1, 2013. Worked with members of the fruit PWT to organize (head of the executive planning committee member) the triennial field day for NY tree fruit, grape, and berry producers at the NYSAES in Geneva, NY. The content included the outcomes of this project. Headed the organization/planning and delivered applied research field presentations to tree fruit and berry stakeholders in two sessions. Approximately 1.0 hours were spent with 200+ fruit stakeholders over the two sessions for a total of 200+ contact hours.

Significant contributions and role of project partners

- Kerik Cox was responsible for project oversight and coordinating the analysis of results and preparation of reports, the writing of management protocols, presentation of recommendations at stakeholder meetings and schools. Cox was also responsible for securing the planting site and coordinating the planting of budded nursery trees at the NYSAES. Cox was responsible for the presentation of recommendations at the stakeholder meetings and fruit schools, coordination and presentation at the in depth school, and assisting with the preparation of the management recommendations.
- Deborah Breth was responsible for identification of budwood source sites with fire blight, collection and selection of budwood from fire blight infected mother trees. Debbie was also responsible for coordinating the budding effort for activities involving nursery budwood. She also assisted with the presentation of recommendations at the stakeholder meetings and fruit schools, coordinated and presented at the in depth school, and assisted with the preparation of the management recommendations.

Goals and Outcomes Achieved

As described in the original grant application, the first goal of the project was to determine the potential for the spread of fire blight bacterial from infected to buds to nursery trees and to young trees planted in orchards. The second goal was to publicize our findings to New York growers via the Expo and the fruit school to alert them of the consequences of using buds from contaminated mother trees.

Goal #1: Determine the potential for the spread of fire blight bacterial from infected to buds to nursery trees and to young trees planted in orchards

Activities accomplished to achieve this goal:

1. We examined budwood collected from commercial nursery source blocks for the presence of *Erwinia amylovora* (fire blight).
2. We then characterized presence of fire blight in asymptomatic budwood and determined the genetic identity of the Ea strains isolated by sequencing standard marker genes
3. We then inoculated trees with a marked strain of *Erwinia amylovora* during the bloom to assess the potential for asymptomatic infection.
4. We used budwood from the naturally infected orchards and the orchard inoculated with marked strain to establish a grafted planting on susceptible M.9 rootstocks at NYSAES.

Goal #2: Publicize our findings to NY growers via the Expo and the fruit school to alert them of the consequences of using buds from contaminated mother trees.

Activities accomplished to achieve this goal:

1. We have written of protocols for avoiding collecting bud wood from infected trees.
2. We have presentation recommendations for avoiding asymptomatic, but infected budwood, at the Expo and numerous fruit schools and extension venues (see Section 3 for specific presentations).

Conveying completion of goals via baseline data and set targets:

In the original proposal, our **benchmark** was to exceed the anecdotal evidence for asymptomatic fire blight and provide **baseline data** on the potential gravity of the asymptomatic fire blight. Our baseline data resulting from the activities indicates that fire blight bacteria are nearly ubiquitous on the surface of buds. However, fire blight bacteria is more prevalent in the in the internal contents of buds taken from shoots that have fire blight strikes. While, those baseline data sound worrisome, the point must be made that only 3% of buds taken under these "high risk" conditions lead to fire blight infections in established orchards as determined by our activities. Our **performance target** was to provide information on the outcomes of our work to 100 to 150 growers at the Expo and regional fruit schools. Indeed, using our **performance measure** of attendance (see Section 3 for specific presentations) we can determine that nearly half of the 855 contact hours mentioned above included the content of this award.

The information about bud transmission of fire blight and preventive protocols was presented to 84 growers at Empire State Fruit and Vegetable Expo. January 22, 2014. In addition a protocol, *2014 Guidelines for Fire Blight Management in New York*, was developed and delivered to fruit growers. This protocol included manangment practices developed from the scientific information generated by the products of the protocol. Similarly, the information was presented to 58 growers at the Hudson Valley Commercial Fruit Growers' School on Feb. 10, 2014, and to 66 growers at the Upper Hudson / Champlain Commercial Tree-Fruit School. Feb. 11, 2014. Additional recommendations for managing fire blight in regard to preventing transmission in latent bud wood were delivered to 125 growers with protocol handouts describing final outcomes of the project at the Lake Ontario Fruit Team Petal Fall/Thinning Meeting on May 29, 2014 and Summer Tour on July 24, 2014. The outcomes of the research were presented on July 4, 2013 at the 13th ISHS international Fire Blight Workshop, presented at the 2013 American Phytopathological society, presented on December 5, 2013 at the 89th Annual Cumberland Shenandoah Fruit Workers Conference, Winchester VA. Information on the project was published in Acta Horticulture vol. 590, Phytopathology vol 103, Acta Horticulture 590, and in the New York Fruit Quarterly Vol 2. Finally, project outcomes were incorporated in the management guidelines presented in the 2012, 2013, and 2014 Cornell Pest Management Guidelines for Commercial Tree Fruit Production.

Beneficiaries

The group who benefits the most from this project is New York apple growers. Nearly all growers are putting in new plantings of high density (>1000 trees/A) apple varieties all of which are sensitive to fire blight and are created from budwood in plantings were fire blight is often present. This information resulting from this project also stands to further benefit growers with home nurseries and commercial nursery operations who produce trees from bud wood sources in New York from varieties that are susceptible to fire blight.

Loss of newly planted trees to fire blight infection that develops from asymptomatic infection is especially costly to growers. New trees for planting typically cost $5-10 USD/tree, which can result in astronomical monetary as growers plant tens to hundreds of acres of apples at densities often exceeding 1000 tree/A. For example, at $7/tree and 1250 tree/A, losing a single acre due to contaminated budwood

would cost nearly $8,750 in trees alone. Such losses are not uncommon as epidemics in MI and WA have resulted in 100s of acres lost to fire blight.

In addition to trees, growers make considerable investment in land preparation, (trellising), and orchard maintenance. They lose not only the trees, but also the possibility for production for the several years until replacement trees can be established.

When all of these economic factors are considered, the monetary loss per acre can amount to nearly tens of thousands of dollars. Since all successful growers are continually planting and replanting portions of their operation, the outcomes of this work would allow nurserymen to avoid budwood material that would lead to these costly losses. Specifically, losses could be mitigated by having nurserymen avoid taking budwood from block with active fire blight strikes.

Lessons Learned

From the completed activities of the proposal we have learned several lessons. These are as follows:

1. Fire blight bacteria are present on the surface of buds even in plantings that appear to be free from infection.
2. Fire blight bacteria are often more numerous inside buds near fire blight strikes. However, certain cultivars and blocks can be completely infested.
3. Because of the possibility of complete infestation, blocks used for budwood should probably be "certified" using the same testing protocol implemented in this award.
4. While there may be in high level of fire blight infestation, the potential losses due to asymptomatic may be minimal except in warm wet years and during initial establishment of nursery plantings and young orchards.

Additional Information

Below is selected data from the protocol, presentations, and grower information packets on this project.

Topaz:

- Differences in the frequency of *E. amylovora* recovery **from bud surfaces or internal contents** between all types of asymptomatic shoot proximities to fire blight strikes were **not statistically significant** (P> 0.05).
- However in all cases, recovery of *E. amylovora* was highest near strikes.

Gala:

- Differences in the frequency of *E. amylovora* recovery **from bud surfaces** between all types of asymptomatic shoots were **not statistically significant** (P> 0.05) (Fig. 2A).
- Interestingly, the frequency of *E. amylovora* recovery **from the internal contents was significantly higher** (P = 0.034) for shoots < 1 m from an strike compared to buds from shoot on an asymptomatic tree > 20m from a tree w/strike (Fig. 2B). In all cases, recovery of *E. amylovora* was highest near strikes.

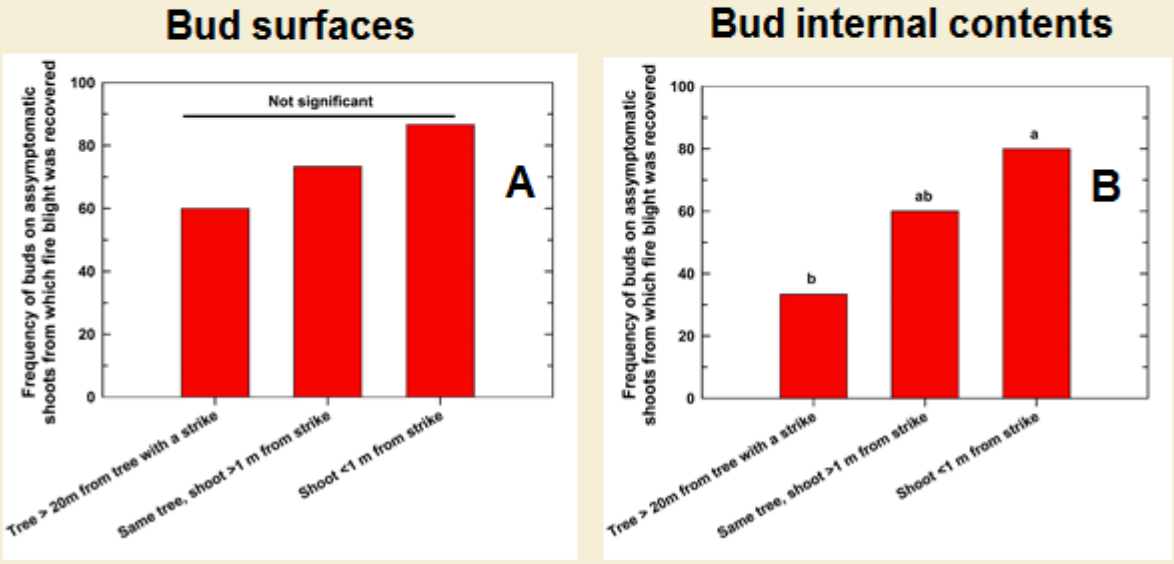

Figure 2. Frequency of *E. amylovora* recovery from the surfaces **(A)** and from the internal contents **(B)** of 'Gala' buds collected from shoot of differing proximities to fire blight strikes.

***E. amylovora* in the meristem:**

- 20 buds from asymptomatic shoots on a tree >20 m from nearest tree with a fire blight strike were dissected to the meristem, surface sterilized 5 minutes in NaOCl, the internal contents were subjected to isolation and green pear virulence testing.
- Virulent colonies of *E. amylovora* were routinely recovered from the meristems (approx. 55% of the bud meristems) (Fig. 3).

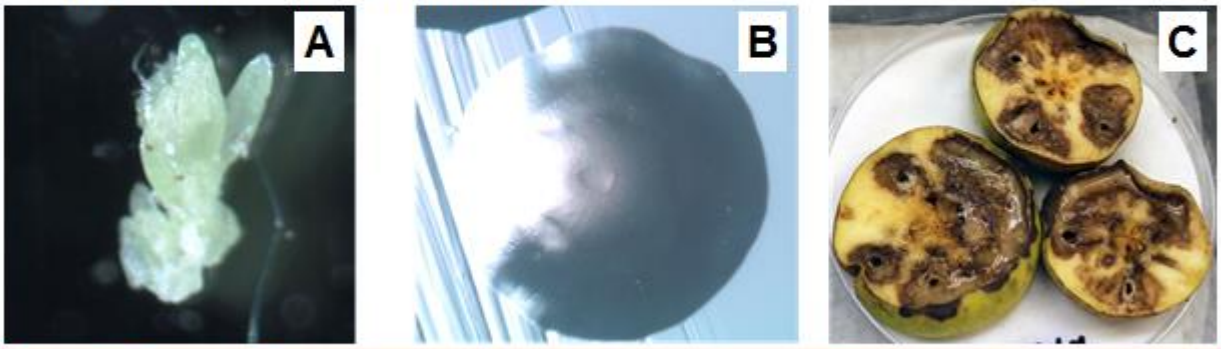

Figure 3. Recovery of *E. amylovora* colonies isolated from surface sterilized dissected meristematic tissues **(A)** of 'Topaz' or 'Gala' on selective CG medium **(B)**, and *E. amylovora* reactions during a green pear virulence test **(C)**.

Figure 5. Planting of rootstocks (nursery trees) in the late summer of 2013 being budded by program members and professionals. Rootstocks were budded in with the three levels of asymptomatic infected commercial budwood treatments from two cultivars. The treatments were replicated in four blocks for each treatment by cultivar combination. Infections would be observed following transplanting in the summer of 2014.

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Project 8
Expanding Consumer Awareness and Institutional Purchasing Capacity of New York Food and Farms

Project Summary

The interest in buying local New York specialty crop products has increased dramatically in recent years. Retailers, wholesalers, distributors, restaurants, schools, institutions and the public are seeking a wide range of farm products in varying quantities and geographic locations. The Pride of New York website has become an important tool to highlight the many specialty crops produced in New York. It helps the public find New York a wider range of specialty crop products as well as providing other valuable information on the State's specialty crops.

At the same time, the New York State Department of Agriculture & Markets (NYSDAM) received industry feedback that a customized portal to direct commercial trade and bulk purchases of specialty crop products would be extremely valuable for timely sales opportunities for a wide array of specialty crop producers.

To assist consumers and small-scale interested buyers in easily searching for and locating sources of specialty crops, food and agricultural products, NYSDAM, supported in part with FY2009 SCBGP-FB funds, created a comprehensive on-line directory/database to support a *New York Food and Farms* website (Note: the website has since been renamed/incorporated into the Pride of New York website (http://www.prideofny.com/PONY/consumer/viewHome.do) . Although the database/website is proving to be a valuable resource in connecting consumers and interested small-scale commercial buyers with local producers, NYSDAM, in consultation with the New York SCBGP Advisory Committee identified several needs and opportunities to expand the scope and functionality of the *Pride of New York* website.

The primary proposed purpose of this project was to promote and publicize the website/database as a resource for discovering local specialty crops. Plans were also for the project to develop a new mobile application to maximize the impact and usability of the database/website as well as to develop a commercial/ trade portal to address the specific and varied needs of institutional and bulk purchasers.

Project Approach

While the website has search and advance search function, NYSDAM received feedback from the industry during the early stages of this project that it was difficult to search the website for specific products and businesses. Therefore, prior to promoting the site as originally proposed, it was determined that the functionality of the site needed to be revised to better enable consumers and businesses to more easily find local businesses.

In order to accomplish this, the project manager developed a plan in coordination with an IT contractor to redesign the website in a manner that would provide a consistent and efficient method to maintain and update business/community contact information. This approach was necessary so NYSDAM could continue its outreach to the agricultural community and build the impact of the website to the highest number of specialty crop businesses as a possible. As part of this effort there was an ongoing process of application development, refinement, testing and retesting. A website designer was brought in and offered several versions of a design for staff to choose from. Once a design was chosen, the landing and secondary pages were created.

In addition, the Department developed a plan to migrate all current contact information into one database. This includes all information currently in the Pride of New York database as well as in separately maintained spreadsheets. Unfortunately, due to the comprehensive nature and complexity of the website

there were delays in completing the necessary technical revisions that prevented the project from implementing the marketing and promotion activities, which was the bulk of the project. This is a custom built web application based on Java scripting thus requiring significant effort to accommodate the desired changes.

The website is currently in its final design and approval stages. Once it goes live, consumers will be able to more easily find local specialty crops with a much more user-friendly search function. Current frontend capabilities that were developed include: product search by county, wholesale information, ability to print wholesaler and agricultural organizations information, mapping of search results, Pride of New York electronic application, Pride of New York Pledge electronic application for restaurants, link to sign up for The Insider – the Department's monthly newsletter. Also new producer program participants can now be highlighted on the main page. Additionally, the website has the following administrative tools and functions: create new establishments, update contact/business/product information, generate lists to use for outreach, change search areas, edit the text for search pages, and update main search areas on the home page to address seasonal changes.

When the new website is launched, the Department will execute a strong push to make the audience aware of this new feature. The Department will also move forward with incorporating the necessary marketing and promotion aspects of the project including developing a new app so more people can find local specialty crops produced in New York.

Goals and Outcomes Achieved

The website receives about 3,300 visits a month. Most of these visits are from consumers looking for locally grown specialty crop products. Below is a summary of the original goals of the project and actual outcomes.

Goal	Performance Measure	Actual Outcome
Increased awareness of 50 commercial buyers regarding New York specialty crops	Track number of commercial/trade system users that become registered users	A new wholesale/business page was created and an application was designed specifically for commercial/trade buyers; however, because the website was not completed we were not able to measure this outcome at the time of submitting this report.
Increase consumer awareness of one million people regarding availability and purchasing locations of New York specialty crops through paid advertisements, media exposure, and new mobile ap	Number of downloads, website hits, media reports	Because the website was not completed we were not able to measure this outcome at the time of submitting this report.

250 specialty crop producers/processors will directly benefit from a 5% increase in commercial sales	On-Line survey	Because the website was not completed we were not able to measure this outcome at the time of submitting this report.

Beneficiaries

All New Yorkers will benefit from this project. Those who produce agricultural products will have a place to highlight their products while consumers can use the website to find local products. All specialty crop and businesses will benefit from increased exposure and sales.

The number of specialty crop producers/processors represented on the website at this time are as follows: Produce – 581, Fruit Juices – 104, Wine – 190, Honey – 301, Jams/Jellies/Salsa – 186, Maple Products – 397, and Nursery/Plants – 298. (Note: Some producers may appear in multiple categories)

Lessons Learned

There were numerous challenges with this project. One of the biggest was the change in technology from the time the website was initially built to what is now available. While there were several options we would have liked to pursue, we were limited in what we could do because of the amount of data located in various places. This situation complicated the overall function, performance and usability of the website and required a major time consuming effort to migrate data from multiple sources into one central location. Staff turnover also presented a key obstacle as the program manager left NYSDAM for another position.

We also had to keep our customers in mind and make sure that certain information was readily available. We had to look at all the information on the site and determine what we wanted on the home page – what was the most important information for people to see – and move this information and links to the front. By looking at it from the customer's point of view, we have been able to create a more user friendly website.

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Project 9
Enhancing the Marketing & Promotion of Regional "Buy Local" Campaigns

Project Summary

In recent years, consumer awareness of -- and interest in -- food and agricultural products that are locally grown has sharply increased. This increased demand provides a tremendous marketing opportunity for many farmers, processors, wholesalers, retailers, restaurants and other businesses throughout the State's farm to table network.

As consumers have become more educated and interested in the various benefits of buying local, many are seeking products that are produced as nearby as possible. As a result, regional "buy local" campaigns have been created throughout the State in the last several years. These campaigns are raising the profile of local products within their respective regions and the State. They offer an additional platform to expand the "buy local" movement by providing a range of services and/or activities to help local producers market their products and to assist consumers in identifying local products.

However, in order to ensure the collective effectiveness of regional "buy local" campaigns and to minimize potential consumer confusion, the Department, using FY2008 SCBGP funds, had initiated a program to functionally integrate regions in a statewide manner under the Pride of New York umbrella program. The FY 2008 project was delayed due to NYSDAM staffing changes, adding new partners, and a redesign of the program to ensure a more cohesive statewide approach.

The purpose of this project was to provide critical resources to these regional "buy local" not-for-profit organizations to build capacity for increased sales and to meet the demands of consumers who are becoming more informed and savvy regarding local food sources. NYSDAM's Regional "Buy Local" Campaign development project distributed SCBG funds to market and promote organizations in each of New York State's tourism regions (as defines by I LOVE NY) to develop and promote regional brands.

Project Approach

In February of 2011, the Department requested and received an extension to implement this program in order to more fully develop quality regional campaigns in 9 of the State's 11 tourism regions. A new RFP was issued offering a total of $18,550 available per region. Of those funds, $2,800 was set aside for creating each region's brand and $2,750 per region to be used for the development of a marketing/media plan. The remaining $13,000 was to be used for the implementation of the marketing/media plan. (Those regions that already had a brand developed and/or marketing/media plans deemed acceptable by the Department were credited such funds for the implementation of their approved marketing/media plan).

There were six (6) regions (Adirondack, Long Island, Catskill, Hudson Valley, Finger Lakes and New York City) that had an existing regional branding program in place. There were two (2) regions that developed new regional programs (Central New York and Thousand Island-Seaway) and two (2) regions (Chautauqua-Alleghany and Greater Niagara) that joined together to form one (1) program.

The six (6) regional groups that had a campaign in place were able to hire a professional independent marketing firm evaluate their current marketing strategy and provide constructive comments and suggestions on methods to increase consumer awareness of the specialty crops grown/produced within their region and to drive traffic to local farm and markets, which would result in increased sales of local specialty crop.

The three (3) regional groups which developed a "buy local" campaign for their regions were able to contract with a marketing firm to provide them with a business/marketing plan on how their regional

program could be structured and how to promote and support networking connections between local agricultural producers and the consumer. The outcomes that were achieved was the creation of a regional logo to be utilized in the branding campaign, the creation of their marketing plan, and the buy-in of the regional producers and other community stakeholders into the project.

There were a range of creative and innovative marketing activities that were used to implement the regional projects, including: web development, public relations activities, print advertisements, brochures, signage, etc. All of the materials were required to receive prior program approval to ensure they focused on specialty crops only.

The marketing and media plan activities outlined in the original plan were not fully executed. This project was designed as a component to be featured on the previously submitted proposal *Expanding Consumer Awareness and Institutional Purchasing Capacity of New York Food and Farms/NY Farm and Food* website, which was delayed once it was determined that the functionality of the site needed to be revised to better enable consumers and businesses to more easily find local businesses. As such, new designs had to be integrated with new search functions along with other technical updates and the site has not yet gone live. However, once the website is live, we will be including a link to direct consumers to the regional "Buy Local" programs.

Goals and Outcomes Achieved

The overall objective of this project was to foster increased consumer awareness and recognition of locally produced foods and agricultural products thereby leading to increased sales and economic development within each region.

There were very creative and innovative marketing activities that were used to implement the various projects such as: web development, public relations activities, print advertisements, radio and television spots, a farmer's market token program, brochures, tote bags, signage, social media management, etc. In each case Specialty Crops were the focus of the marketing activities.

Those with existing programs were all in agreement that the project enhanced their current brand and expanded their marketing efforts of the availability of specialty crops in their regions. Existing marketing efforts were analyzed and refreshed and they were able to produce new marketing materials, media placements, etc. The projects were able to build additional recognition among stakeholders (farmers, producers and other food sellers).

Examples of specific goals and outcomes of the regional "buy local" programs were:

"*It was estimated that consumer awareness increased by 10% and farm stands sales increased as well.*"

"*Our goal was to recruit 47 new specialty crop farmers. We enlisted 32 specialty crop producers that reported they increased their sales by 16%.*"

"*Our goal was to increase the number of specialty crop farmer members by 10% during the time frame encompassed by this grant. Our specialty crop producer membership grew from 62 to 78 members, an increase of 26%*"

"*While some of the goals and outcomes remain difficult to quantify, we can confidently say that we enhanced the current brand of `Grown on Long Island 'and expanded it to our Growing Target Markets on Long Island and New York City. We were able to refresh existing farmstands, CSA, farmer market, etc. We were able to build additional recognition among stakeholders (farmers, producers and other food sellers to create a coalition for future campaigns.*"

"*The greatest accomplishments of this campaign were the creation of new promotional language and the enhancement of social media content. The new promotional language is targeted to specialty crops*

that grow in the Catskills region. This content will be available on the Pure Catskill webpage for future years."

Once the updated website is live, we will be track the number of visits to the regional "Buy Local" programs via our link.

Beneficiaries

Beneficiaries of the project included an estimated 500,000 consumers throughout the State who saw advertisements and/or promotional materials that highlighted the regional campaigns and who gained access to nutritional, local produce.

It was estimated that the economic opportunities to producers and communities alike spread throughout the State was significant. The entire specialty crop industry benefited from the generic promotional aspects and consumer education/awareness activities related to "buy local" that the project offered.

Indirectly the project benefitted commodities and farm/food businesses other than specialty crops by increased traffic through food stores, restaurants, stands and farms.

Other beneficiaries included specialty crop farmers who were not a part of the regional group.

Examples included:

- *"This project benefitted 164 New York City based food processors who now have a dynamic place-based marketing tool to directly tap into growing consumer demand for locally-made food. The project also benefited the specialty crop producers to be able to form new business linkages through the procurement assistance feature on the website."*
- Regarding the Thousand Island-Seaway Marketing Workshop at the intensive hops conference in Morrisville, NY on December 1, 2012: *"22 percent (of survey respondents) said they would begin to grow hops as a result of the survey, and 44 percent said they would increase their hops production… 22 percent said their incomes would increase by three or more percent as a result of conference attendance."*
- *"This project benefitted approximately 500 Long Island specialty crop farm operations."*
- *"Specialty crop producers, farms and farm markets were identified by the agricultural industry representatives throughout their region. Contact information, operations, products and website links were added to the website."*
- *"Specialty crop farms that are now included in lists on their website, chefs, restaurants and consumers who are interested in sourcing and purchasing local foods."*
- *"This project confirmed that there is a desire in the local food sector to increase the amount of locally foods produced and served in our region. There is a desire to engage the local consumer in the education of their food choices, not only in relation to locality of production but also in terms of food safety."*
- *"It is difficult to get our members to use the Adirondack Harvest logo to further brand recognition and boost sales of specialty crops. It was a tremendous help to be able to offer the members items with the logo already on it to hand out."*
- *"While we were promoting specialty crops in particular, we believe that consumers ultimately purchased more of all types of locally produced food which should be the goal to increase economic sustainability in any region."*

Lessons Learned

The majority, if not all of the regional groups, do not have paid staff dedicated to their campaigns and rely solely on volunteers to maintain their programs. Therefore, the opportunity for the existing regional groups to have funding available to have their current programs evaluated and to receive important feedback from professionals was certainly appreciated.

Although the funding made available to those regional groups that developed a new campaign allowed them to create a brand mark, produce minimal promotional products and implement a small marketing initiative to begin to build awareness with consumers, they also learned that in order to be able to sustain a program, there will need to be collaboration of groups working together.

In addition, due to the timing of the campaigns, there were challenges for the groups to coordinate with the growing seasons. In some instances by the time campaign materials were ready and approved, the relevant season had passed.

Several examples of specific lessons learned from regional groups were:

- *"The best way to engage farmers was through direct contact via email, phone or in-person conversations. To engage the consumers, social media and access to general content about farm products was very effective."*
- *"Challenges were related to engaging producers in promotional work. The campaign was created to augment the promotional work farmers are able to perform themselves. They tried to make promotional giveaways very simple for the producers by providing all necessary materials and promoting the opportunity but were challenged by getting the producers themselves to promote the opportunity."*
- *"Focus groups are a far more effective way of gleaning marketing and promotional needs from local food processors than traditional surveys. Focus groups provided a dynamic environment for multiple companies to share their challenges and opportunities and gave a broad picture of the industry's needs."*
- ***"**Professional advice focused on improving their image, messaging and outreach to increase awareness of the regions food and farm establishments. This was extremely helpful in future marketing efforts and will improve the overall impact of our program."*
- *"We were able to develop new improved tools for marketing for long term (marketing plan and website). This resulted in maximum impact of the funds that were allocated and avoided unrealistic expenditure on television or other media that is much more costly with less long term impact."*
- *"Specialty crop growers who have a wholesale focus were in general, not interested in participating. It was difficult to get members to participate in the survey with the biggest objective directed at the question related to their sales."*
- *"This project allowed us to take a closer look at the marketing efforts of our buy local campaign. Working with marketing and public relations professionals allowed us to evaluate our work with outside support."*

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Project 10
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. This project built upon the previous SCBG-FB project by conducting additional GAP workshops and mock GAP audits for growers as well as the ability for GAP auditors to participate in training sessions. This project also allowed an additional 14 growers/handlers to get a GAP audit done for the first time. Most auditees (75%), who were reimbursed by this project, give the reimbursement a high value in making their decision to implement GAP at their operation facility. Most (81%) auditees also anticipate a boost to their business due to participating in the program.

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 three GAP workshops throughout the State and three mock audits 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

As of the conclusion of this SCBG grant period, the Department of Agriculture & Markets had conducted 150 audits in total, with 19 of them being first-time audits.

NYSDAM provided and /or participated in 10 outreach and educational venues during this period, directly reaching more than 800 growers/packers/handlers. During this period 18 NY State auditors also

attended USDA and State trainings/refreshers in order to meet continued education requirement for auditor license.

Outreach and education was conducted at the following venues:

Date	Event-Location	No. of Attendees
1/21 – 1/23/14	Empire State F&V Expo, Syracuse	150
2/27 – 2/28/14	Cornell GAP Workshop, Bath	25
3/6 – 3/7/14	Cornell GAP Workshop, Geneva	29
3/10/14	Wegmans GAP Workshop, Rochester	50
4/30 – 5/1/14	Cornell GAP Workshop, Voorheesville	12
8/4 – 8/7/14	Empire Farm Day, Seneca Falls	200
8/6/14	Wayne County Fruit Tour, Wolcott &Williamson	400
8/12/14	Rutzke Farms Mock Audit, Ithaca	6
8/15/14	Clover Road Farm Mock Audit, Cohocton	7
8/28/14	OCFS Industry School Mock Audit, Rush	15

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. Approximately 800 growers/packer/handlers directly benefited by participating in outreach activities. Fourteen auditees completed their first time GAP audits through this project and received reimbursement for the expense associated with the audit.

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.

A four-question survey was also conducted from first-time auditees, the questions asked and their results are presented below:

Q.1 What was the value of reimbursement for you in making your decision to have a GAP audit?
Responses: Most auditees think that reimbursement has high value, few think it has moderate value, few think it has low value and few think it has no value in their decision for GAP audit.

Q.2 Do you see a benefit in having GAP audit at your facility?
Responses: All auditees see benefit in having GAP audit at their facility, responding YES to this question.

Q.3 How much benefit do you anticipate GAP audit will give you in boosting your business?
Responses: Most auditees anticipate high benefit, few anticipate moderate benefit while few anticipate low benefit of GAP audit in boosting their business.

Q.4 Since Reimbursement incentive is only for first time, would you participate in this program (GAP & GHP) in future with no reimbursement incentive?
Responses: All auditees responded YES to this question and intend to stay in the program in future.

These responses indicate that the program's overall mission for long-term grower participation in GAP will continue in future years.

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