Project No. and Title: NCERA224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes

Period Covered: 01/01/2023 to 12/31/2023

Date of Report: 08/20/2024

Annual Meeting Dates: 12/10/2023 to 12/12/2023, Santa Barbara, CA, Veterans Building

Participants:
In attendance: in-person 7; thru zoom 1; time conflicts 3; total=11
For the meeting, 11 state reports were provided.

For the meeting, 3 members had time conflicts and submitted state reports. Steve Franks (North Carolina State University), Karla Addesso (Tenessee State University) and Enrico Bonello (Ohio State University) had time conflicts for the meeting.

For the meeting, 8 State reports, power points and discussion were provided by members on their research and outreach programs. in-person 7; thru zoom 1; Vera Krischik, UMinnesota (chair); Ada Szczepanie, Colorado State University; Gary Chastagner, Washington State University; JC Chong, Clemson University; Jana Beckman, Purdue University; Kyle Broderick, University Nebraska; David Smitley, Michigan State University; Brian Kunkel, Univ of Delaware (zoom).

Brief Summary of Minutes of Annual Meeting:
On Monday, Dec 12 2023, NCERA 224 met at Santa Barbara, CA, Veterans Building to discuss 11 state reports. Administrator Dr. Christina Hamilton, and Advisor, Dr. Shibu Jose spoke by zoom.

On Tuesday, December 13 2023, the members visited the Santa Barbara Botanical Garden and Channel Islands Plant Restoration Research Station. Pritzlaff Conservation Center (PCC) Keith Nevison, Nevison knevison@sbbotanicgarden.org**,** Director of Horticulture & Operations, 1212 Mission Canyon Rd. Santa Barbara, CA 93105, SBBotanicGarden.org

Member states (12): Delaware, North Carolina, South Carolina, Indiana, Ohio, Kentucky, Tennessee, Michigan, Minnesota, Nebraska. Colorado, Washington.
State reports included below.

Accomplishments:
Brief summary:
The NCERA annual meeting permits us time to freely speak of our research and outreach programs and provides peer discussions. It is a very important venue to permit us to openly discuss research and outreach programs. All members can seek collaborations and engage in multistate projects. **See individual stat reports.**

Impacts:
All research and outreach programs were concerned with using IPM principles to reduce pesticide use, better time pesticide use, use cultural management, better identify pests, protect pollinators, protect beneficial insects, and improve worker safety.

Please list outputs and outcomes:
https://www.nifa.usda.gov/logic-model-planning-process
Please see each state report.
We don't have any collaborative projects at the present time, but are discussing some for next year. Members currently are not using Extension's guidelines for establishing changes in outcomes, knowledge, behavior, or condition at this time. We will discuss and mandate using these criteria for the 2025 report.
Outputs. Products, services and events that are intended to lead to the program's outcomes.
Outcomes. Planned results or changes for individuals, groups, communities, organizations or systems.
Change in pesticide use. Research and outreach in each state is to understand and promote biorational management and pesticides that conserve pollinators and beneficial insects.
Change in knowledge. Occurs when there is a change in knowledge or the participants actually learn.
Change in behavior. Occurs when there is a change in behavior or the participants act upon what they have learned.
Change in condition. Occurs when a societal condition is improved.
Change in pollinator conservation.
Change in management that reduces crop loss and or economic loss.

Publications: In state reports

Members: 2024 NCERA 224
Administrators
Christina Hamilton <christina.hamilton@wisc.edu , NCRA Assistant Director and NIMSS System Admin
Jose, Shibu <joses@missouri.edu> Administrator, University of Missouri
Samuel-Foo, Michelle - REE-NIFA <Michelle.Samuel-Foo@usda.gov>
Byamukama, Emmanuel - REE-NIFA <Emmanuel.Byamukama@usda.gov>

On NIMMS site as approved members(A) status, 15 members
*Karla Addesso <kaddesso@tnstate.edu>
*Janna LBeckerman<jbeckerm@purdue.edu>
*Enrico Bonello <bonello.2@osu.edu>
*Kyle Broderick <kbroderick2@unl.edu>
*Gary Chastagner<chastag@wsu.edu>
*JC Chong JC.chong@sepro.com
*LauraJesse<ljesse@iastate.edu>

*William Kilingemn<wklingem@utk.edu>
*Vera Krischik krisc001@umn.ed
*Brian Kunkel <bakunkel@udel.edu>
*Jill Pollok <jillp@udel.edu>
*Ada Szczepaniec<A.Szczepaniec@colostate.edu>

New members not yet posted at NIMSS
Zee Ahmed mahmed2@clemson.edu
Chelsea Harbach, charbach@iastate.edu
Midhula Gireesh mgireesh@tennessee.edu

Other members, please contact Christina Hamilton <christina.hamilton@wisc.edu , NCRA Assistant Director and NIMSS System Admin to become an approved member
David Held <dwh0004@auburn.edu>
Rodriguez-Salamanca, Lina linar@vt.edu
Steven D. Frank <sdfrank@ncsu.edu>
E. Vanessa Campoverde<evcampoverde@ufl.edu>
Carmen Medina-Mora <mls.lab.forestpathmsu@gmail.com>
Adam GDale <agdale@ufl.edu>
Raymond Cloyd <rcloyd@ksu.edu>

State reports:
Delaware, *Brian Kunkel <bakunkel@udel.edu>
No state report, power point

Tennessee, *Karla Addesso <kaddesso@tnstate.edu>
State report, could not attend, no power point
Project No. and Title:
NCERA 224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes

Year: 2023

1. Monitor and characterize new and emerging arthropod pests and host plant pathogens (including invasive species and climate change induced range expansion). Investigate and develop detection methods, biology, and management.

In 2023, we had our first report of major flea beetle management problems in a middle Tennessee nursery. There have been sporadic reports of flea beetles in the last few years, but no known established farm populations. This population was causing heavy damage to *Itea*, despite contact sprays being applied to control the adult population. We conducted a sweep net survey of the infested containers and blocks of host and non-host areas adjacent to the *Itea*. Sweep samples of the *Itea* collected 73 beetles on average. *Fothergilla*, a plant which was adjacent to the *Itea* and had minor evidence of feeding, had 8 beetles when directly adjacent to the *Itea* and 7 beetles in a plot located directly across a gravel driveway to the left of the *Itea*. One beetle was recovered from the boxwood block directly adjacent to the *Itea* with no visible feeding damage. A sweep was also made of the woodline located across a gravel drive on the right of the *Itea*. One beetle, on average, was collected in those sweeps. Media/root cores were taken from the containers to see if eggs or larvae were present. Core samples were taken from 10 pots in each of the previously described plot locations. The plants were being grown in felt bags, so root balls could not be removed to look for larvae, as is commonly done with plastic containers. The cores were held for a week and observed for eggs or larval hatch. No definitive sign of flea beetle larvae or eggs were present in the media samples. The grower was provided with management suggestions for controlling both larvae and adults in containers in spring and to scout incoming plant material.

It was clear that the beetles were actively dispersing from plots of preferred hosts, through other less preferred hosts, but they did not congregate in those areas. However, these areas could provide refuge for adults if left untreated. It is also unclear if they were laying eggs in the media of non-preferred hosts since the soil sampling method used here was not effective. There is a need to better define how far outside the infested plot should be treated and whether treating adjacent, less preferred hosts is necessary for adequate control. If this location or others becomes a perpetual hotspot, more work on this pest may be initiated.

2. Pesticide alternatives: Develop management strategies for key pests based on classical biological control (i.e., predators and parasitoids), host plant resistance, and cultural control.

We have initiated a survey of parasitoids attacking Japanese maple scale in nursery and landscape settings. Two collections made in early July 2023 from heavily infested euonymus and privet had 7.8 and 7.0% parasitized scales, respectively. Three species of parasitoids were reared from collections. One is the exotic parasitoid, *Marlattiela prima* Howard. The other two are a species of *Aphytis* [possibly *Aphytis hispanicus* (Mercet)] and *Encarsia*. Species level identifications are being confirmed by Dr. Jim Woolley, an Aphelinid expert at Texas A&M. More funding is being sought to expand this survey.

Kentucky, *William Kilingemn<wklingem@utk.edu> <bakunkel@udel.edu> ,
No state report, could not attend, no power point

North Carolina, Steven D. Frank <sdfrank@ncsu.edu>
State report, could not attend, no power point

Project No. and Title:
NCERA 224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes
Year: 2023

NAME OF REPRESENTATIVE: Steve Frank

AES (STATE): North Carolina

LABORATORY NAME OR LOCATION: Department of Entomology & Plant Pathology

North Carolina State University

2303 Gardner Hall

PHONE: 919-515-8880

E-MAIL: sdfrank@ncsu.edu

OTHER PARTICIPANTS: None

ACCOMPLISHMENTS: We conducted research and extension related to IPM and biological control in greenhouses, nurseries, and urban landscapes. 1) Research is ongoing to understand conservation biological control in urban landscapes and specifically the role of urban trees in supporting natural enemy populations. 2) We conducted research on augmentation biological control and microbial control of mealybugs, scales, and other pests in greenhouses and how to integrate biological control with insecticides. 3) Research was conducted to understand the biology and management of European pepper moth. We now have knowledge of the life cycle, feeding preferences, effective insecticides, and we are beginning work with nematodes and other biological control measures. Our extension activities have been increasing since COVID. We gave several presentations and produced other extension resources this year.

UTILITY OF FINDINGS: Our results in greenhouses, nurseries, and landscapes are valuable to improve pest management and to encourage adoption of biological control due to increased efficacy and integration with other methods. Creating more resilient landscapes with conservation biological control reduces insecticide use and associated risks in these places where people live, work and play. It also enhances the conservation value of urban areas.

WORK PLANNED FOR NEXT YEAR (2023)

We will continue work in all three systems. Biological control research will continue to provide solutions for growers and managers of urban spaces.

PUBLICATIONS:

Frank, S.D., Backe, K. (2022) Effects of urban heat islands on temperate forest trees and arthropods. Current Forestry Reports. doi.org/10.1007/s40725-022-00178-7.

Wilson, C.J., Frank, S.D. (2022) Scale insects support natural enemies in both landscape trees and shrubs below them. Environmental Entomology. https://doi.org/10.1093/ee/nvac081.

Dale, A. G., & Frank, S.D. (2022). Water availability determines tree growth and physiological response to biotic and abiotic stress in a temperate North American urban forest. Forests, 13(7), 1012.

IMPACT STATEMENT:

The impact of our research is to reduce insecticide use in the production and management of ornamental plants. This will impact human health and improve environmental quality. Our management methods should also have a positive impact on grower profits as we increase the efficacy and simplicity of IPM.

South Carolina, *JC Chong JC.chong@sepro.com
State report and power point
Project No. and Title:
NCERA 224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes

Year: 2023

Name: Juang Horng Chong

State: South Carolina

University and complete mailing address: Clemson University, Pee Dee Research and Education Center, 2200 Pocket Road, Florence, SC 29506

Phone number: 843-662-3526

Email: juanghc@clemson.edu

Period Covered: 01/01/2023 to 12/31/2023

Date of Report: Email to krisc001@umn.edu by 11/31/2023, BEFORE THE MEETING

Annual Meeting Dates: 12/11/2023 to 12/13/2023

In attendance: In person

Suggestions for NCERA 224 cooperative research or outreach program: A coordinated development of an outreach product will be well received by stakeholders and help attract new members to the working group.

Suggestion for location of 2024 meeting: Somewhere in the Southern Region, even if the region is outside of the realm of North-Central Region. Having the meeting in the Southern Region, where there are several newly hired research and Extension faculty, will help attract new members to the working group or to the meeting.

Brief summary:
Objective 1: New and emerging pests: Investigate detection methods, biology, and management of new and emerging pests

Crapemyrtle bark scale (*Acanthococcus lagerstroemiae*) is an invasive felt scale species that was introduced to South Carolina in 2019. Infestation continues to expand in South Carolina, where currently more than ten counties are known by this researcher to be infested. The distribution and impact of this invasive species throughout SC and the southeastern US is likely to expand in the coming years. This researcher had provided management recommendations for this invasive scale insect species in five (mainly southern) states

Experiments were conducted to develop more effective and efficient monitoring methods for flatheaded borers in nursery productions. In a long-term study established at a nursery in NC and a field site in SC, we have demonstrated that purple pole traps (i.e., a purple sticky trap folded in a triangular pole and placed vertically) are most effective in capturing flatheaded borers than purple panel trap. Additionally, the pairing of purple sticky traps (both pole and panel) with ethanol, belzaydehyde and green-leaf volatile did not increase the capture of flatheaded borers. This result suggests that volatile lures may not be an important component of trap design for flatheaded borers.

A series of experiments were conducted to improve the monitoring of ambrosia beetles using bolt traps. The first experiment was conducted to identify the minimum concentration of ethanol needed to be used in bolt traps to achieve the greatest attractiveness to the ambrosia beetles. Ethanol concentrations tested were 3%, 5%, 15%, 30%, 60% and 90%, and the data were compared to the bolts filled only with water (0% ethanol). As expected, the numbers of ambrosia beetles attracted to bolts increased with the ethanol concentration. The greatest numbers of beetles were attracted to bolts filled with 60% and 90%, but these two treatments were not significantly different from 30%. Results indicated that attractiveness of bolts is highest when filled with ethanol at 60%, but ethanol at 30% can also be used with significant reduction in cost. In the second experiment, the team attempted to identify the best alternatives to commonly used tree species (e.g., redbuds, dogwoods and tulip poplar) for constructing bolt traps. Contradicting results from 2022, where horsesugar, mimosa and smooth-barked sweetgum were identified as the most attractive tree species for constructing bolt traps, results from 2023 identified water oak, tulip poplar and horsesugar as the most attractive species.

Objective 2: Pesticide technology development: Evaluate effectiveness of reduced–risk pesticides, biopesticides, new and novel chemistries, and application technologies for control of key disease and arthropod pests of landscapes, nurseries, and Christmas trees

Research team at Clemson University had conducted 28 trials in 2022-2023 to evaluate the efficacy of reduced-risk insecticides and miticides, biopesticides, and novel chemistries and adjuvants against aphids, sweetpotato whitefly, western flower thrips, mealybugs, redheaded flea beetle, omnivorous leafroller, and twospotted spider mite.

A series of experiments also evaluated the efficacy of various insecticides, concentrations, application methods, and residual ages in preventing attacks of ambrosia beetles on nursery trees. This team evaluated nine products or product combinations in 2023 and determined that Onyx Pro (bifenthrin) applied at 32 fl oz/100 gal, either by itself or in combination with Botanigard ES, was the most effective treatment. The application of Botanigard ES (*Beauveria bassiana*), MBI-306, Mainspring (cyantraniliprole), Sarisa (cyclaniliprole), Provaunt (indoxacarb) and Hachi-Hachi (tolfenpyrad), although prevented some attacked, did not achieve significant reduction of beetle attacks when compared to the untreated control. This team again failed to identify an effective replacement for bifenthrin and other pyrethroids.

There appeared to be significant difference in the efficacy among pyrethroids. This team evaluated the efficacy of Barricor (deltamethrin) in preventing ambrosia beetle attacks when applied at varying application rates and compared the efficacy of Barricor to Onyx. Barricor applied at 10.9, 21.8 and 43.6 fl oz/100 gal did not achieve significant reduction of beetle attacks when compared to the untreated control and significantly lower (470% lower) efficacy than Onyx at 32 fl oz/100 gal. Results from this experiment suggested that growers need to choose the insecticides they use carefully because even different active ingredients within a chemical class (such as pyrethroids) can provide different levels of protection against ambrosia beetle attacks.

The residual efficacy of bifenthrin (Onyx) was evaluated. Bolts were sprayed with water (untreated control) or Onyx at 32 fl oz/100 gal. The treated bolts were deployed in the field when the residue was fresh or had been aged for 7, 14, 21 and 28 days. The greatest prevention of attacks was achieved on bolts containing fresh and 14-day residue; however, there was not significant difference in the efficacy of all residue ages (all residue ages achieved significantly lower attacks than untreated control). Additional experiments will be needed to further identify the effective residual age of bifenthrin.

Seven different commercially available surfactants were evaluated for their ability to extend the longevity of bifenthrin (Onyx at 32 fl oz/100 gal). Results suggested that all Onyx-treated bolts suffered fewer attacks than the untreated control, whether the spray solution contained surfactant or not. This experiment suggested that the addition of surfactant is not necessary to extend the longevity of bifenthrin.

Impacts:

Myriad of arthropod pests attack ornamental plants and turfgrass grown in nurseries and landscapes, among which scale insects, whiteflies, thrips, aphids and spider mites are the most commonly encountered and damaging. The team at Clemson University evaluated and developed management approaches and tools (e.g., novel insecticide and compatibility between chemical and biological control) against various arthropod pests in the greenhouses, nurseries and landscapes. Novel insecticide and miticide active ingredients and biopesticides evaluated by this program provided a greater range of options for managing important arthropod pests and formed the basis for developing an IPM program that truly integrates reduced-risk insecticides, biopesticides and biological control. The information generated by this project is provided to the stakeholders via publications (both peer-reviewed and layman), presentations and training programs. This team collaborated with researchers and Extension personnel at other states, including CO, DE, GA, MI, NC, OH, TN and VA, on various research and outreach activities to achieve the goal of reducing pest management cost and crop losses of growers and landscape care professionals.

Please list outputs and outcomes.
https://www.nifa.usda.gov/logic-model-planning-process

Outputs:

Team at Clemson University had provided 12 extension presentations and webinars to audience throughout the country. In addition, 25 e-newsletters and 9 extension bulletins or factsheets had been published. The team provided 112 species identification and management recommendations.

Publications Outreach and research:
Outreach section

Chong, J. H. 2022. Phytophagous mites and their Management on ornamental plants. Land-Grant Press, LGP 1154. https://lgpress.clemson.edu/publication/phytophagous-mites-and-their-management-on-ornamental-plants/

Crout, K., D. R. Coyle, M. Bean, L. Smith, and J. H. Chong. 2023. Asian longhorned beetle biology and management in South Carolina. Land-Grant Press, LGP 1158. https://lgpress.clemson.edu/publication/asian-longhorned-beetle-biology-and-management-in-south-carolina/

Research section

Arshad, R., J. H. Chong, A. Del Pozo-Valdivia, and S. V. Joseph. 2023. Growing media is the major source of damaging population of *Systena frotalis* (Coleoptera: Chrysomelidae) in ornamental plant nurseries. Journal of Economic Entomology 116: 1760-1766.

Pandey, S., A. L. B. Ribeiro da Silva, B. Dutta, J. H. Chong, M. A. Mutschler, and J. M. Schmidt. 2023. Acylsugar tomato lines suppress whiteflies and *Amblyseius swirskii* establishment. Entomologia Experimentalis et Applicata 171: 745-753.

Brown, M. S., and J. H. Chong. 2023. Efficacy of pre-plant dip and foliar application against twospotted spider mites on marigold seedlings, 2021. Arthropod Management Tests 48: tsad050.

Ren, L. and J. H. Chong. 2023. Repellency and toxicity of eight plant extract against western flower thrips, *Frankliniella occidentalis*. Applied Science 13: 1608.

Coyle, D. R., J. Afams, E. Bullas-Appleton, J. Llewellyn, A. Rimmer, M. J. Skvarla, S. M. Smith, J. H. Chong. 2022. Identification and management of *Cydalima perspectalis* (Lepidoptera: Crambidae) in North America. Journal of Integrated Pest Management 13: 24.

Janna L Beckerman, <jbeckerm@purdue.edu>
State report and power point
Project No. and Title:
NCERA 224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes
Year: 2023

Year: 2023

Name: Janna Beckerman

State: IN

University and complete mailing address: Purdue University 915 West State Street, West Lafayette, IN 47907

Phone number:765-494-4628

Email: janna@purdue.edu

Period Covered: 01/01/2023 to 12/31/2023

Date of Report: Email to krisc001@umn.edu by 11/31/2023, BEFORE THE MEETING

Annual Meeting Dates: 12/11/2023 to 12/13/2023

In attendance:
In person or by zoom

Suggestions for NCERA 224 cooperative research or outreach program:

Suggestion for location of 2024 meeting:

Brief summary:
In recent years, nurseries in multiple states (TN, IN, NC, VA, FL) have reported moderate to severe dieback, chlorosis and stunting of redbud, including vascular streaking, associated with the fungus *Ceratobasidium theobromae*. In October 2023, we've identified the 24th genus associated with this fungus on debilitated plants. We are currently conducting Koch's postulates on redbud. In September 2023, we planted 60 infected trees, in a randomized design, in the field. 48 trees were positive for VSD; 12 healthy (no symptoms or detection of VSD) were planted as controls. Trees were subjected to deep planting, shallow planting, late season fertilization and excessive fertilization. Trees will be scored for symptoms and survivorship in spring of 2024. Remaining trees will be used for inoculum for field trials on fungicide efficacy, assuming survivorship in 2024.

The **Purdue Plant Doctor** website (**www.purdueplantdoctor.com**) was released in August 2022 to help users diagnose and manage the thousands of plant health problems (insect, disease, and other biotic or abiotic conditions) on over 250 species of the most common Midwest landscape plants. Just like the apps, the Purdue Plant Doctor website has thousands of color photos, and current recommendations to help homeowners, arborist or plant health care professional diagnose and manage the most common plant problems in the Midwest and Northeast US. New features include the ability to compare lookalike diagnoses as well as links to short YouTube videos on keypests in English and Spanish. Photos of host plants are also included to help users confirm proper host diagnosis. This web page provides our clientele the ability to access the thousands of accurately identified and curated, high-resolution photos to help educate yourself or your clients regarding important plant health management decisions. This site received a significant boost when it appeared in the New York Times:

Impacts:
Delivered 6 talks on VSD to growers across the country and via webinar and discussed long-term plans with HRI to deliver information to improve VSD management.

The Purdue Plant Doctor website has over 160K visits in its first year, with 25% downloading information. Short descriptive videos associated with key pest groups have been downloaded over 10K times. The reach of the site was expanded by two articles written by New York Times reporter and garden writer Margaret Roach:

Diagnosing plant troubles, with the Purdue plant doctor
https://awaytogarden.com/diagnosing-plant-troubles-with-the-purdue-plant-doctor/
So Your Plant Is Sick? Here's How to Get a Diagnosis.
https://www.nytimes.com/2023/06/21/realestate/sick-dying-plant-treatment.html

This article was on the 'cover' of the New York Times digital edition June 21, 2023.

Please list outputs and outcomes.

Outputs: In collaboration with the PPDL and Tennessee State University (Dr. Fulya Baysal-Gurel), we are improving the diagnostic capacity to identify VSD on multiple hosts; identifying which cultural practices predispose plants to infection, are training graduate students (starting 1/2024) and extending this information to growers via Extension and the Horticultural Research Institute (HRI).

Maintaining updating and improving the Purdue Plant Doctor Website and Videos.

In response to the recent expansion of the range of emerald ash borer, a review of urban pest control practices was published in the Journal of IPM in August, entitled Emerald Ash Borer: Urban Myths and an Operational Synthesis.

Outcomes: The key outcome will be healthy redbud (and other trees). Proof of concept at this stage is redbud, with later expansion to red maple and dogwood. We are completing the validation of primer sets for VSD detection. We are currently working on what conditions predispose woody plants to infection by *C. theobromae* and will continue to update our information via the Purdue Landscape Report and the HRI website.

The EAB Urban Myths JIPM article was downloaded over 1200 times since August.

Publications Outreach and research:

Beckerman et al., 2023. Fifty years of fungicide development, deployment, and future use. Phytopathology: 113:4, 694-706
Beckerman, J., Creswell, T., Bonkowski, J. and Baysal-Gurel, F. 2022. Vascular Streak Dieback of Redbud: What Plant Pathologists Know So Far. Available at: https://www.hriresearch.org/vascular-streak-dieback-update
Beckerman, J. and Janicki, J. 2022. Comparison of fungicides for control of peony measles, 2022. PDMR: submitted
Newsome, E. and Beckerman, J. 2022. Evaluation of block applications with A22613 for the control of powdery mildew on bee balm, 2022, PDMR: submitted
Beckerman, J. 2023. Comparison of fungicides for control of Septoria leaf blight on dogwood, 2023. PDMR: submitted
Beckerman, J. 2023. Evaluation of fungicide rate and treatment for Phytophthora control in petunia, 2023. PDMR: submitted
Beckerman, J. 2023. Foliar fungicides for the control of bee balm powdery mildew, 2023. PDMR: submitted
Beckerman, J. 2023. Evaluation of foliar applications for the control of powdery on bee balm, 2023. PDMR: submitted.
Beckerman, J. 2023. 'Ornamentals'. In Agrios' Plant Pathology. Revised and edited by R. Oliver. Palmer, C. and Beckerman, J. 202X. Fungicides. In 'Diseases of Woody Ornamentals and Trees in Nurseries, second edition'. Jay Pscheidt, ed. APS Press. In preparation.
Beckerman, J. 202X. Crabapple. In 'Diseases of Woody Ornamentals and Trees in Nurseries, second edition'. Jay Pscheidt, ed. APS Press. In preparation.

Field Code Changed

Beckerman, J. 202X. Flowering Pear. In 'Diseases of Woody Ornamentals and Trees in Nurseries, second edition'. Jay Pscheidt, ed. APS Press. In preparation.
Dawadi, S., C. S. Sadof 2023. Response of the soft scale insect Parthenoclecnium corni and its natural enemies on honeylocust trees to urban conditions. Biological Contol. 179: 105178 https://doi.org/10.1016/j.biocontrol.2023.105178
Sadof, C. S., D. G. McCullough, and M.D. Ginzel. 2023. Urban ash management and emerald ash borer (Coleoptera: Buprestidae)): facts, myths, and an operational synthesis. Journal of Integrated Pest Management. 14:1-14 https://doi.org/10.1093/jipm/pmad012

Ohio, Enrico Bonello <bonello.2@osu.edu>
State report and power point
Project No. and Title:
NCERA 224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes
Year: 2023

Pierluigi (Enrico) Bonello
Department of Plant Pathology
The Ohio State University

1. Impact Nugget

- Ohio State University mapped the environmental risk for beech leaf disease (BLD) across northeast Ohio, western Pennsylvania and western New York.
- Ohio State University showed the deleterious effects of climate change on the physiology of tree responses to *Diplodia pinea* that make the host much more susceptible to disease.
- Ohio State University clarified the temporal expression of the various BLD symptoms.
- Ohio State University formalized methodological pipelines on the use of metabarcoding for the diagnosis on novel tree diseases.

2. New Facilities and Equipment. Include production areas, sensors, instruments, and control systems purchased/installed.

3. Accomplishment Summaries.

- We conducted an analysis of BLD risk across Northern Ohio, Western Pennsylvania, and Western New York, USA. Since the absence of BLD in the absence of symptoms cannot be certain, due to its fast spread and the lag in observed symptoms after infection, we employed two widely used presence-only species distribution models (SDMs). The Maxent model provided a quantification of variable contribution for different environmental factors, indicating that meteorological (isothermality and temperature seasonality) and land cover type (closed broadleaved deciduous forest) factors are likely key contributors to BLD distribution. In addition to offering the ability to predict where the disease may spread next, our work contributes to the epidemiological characterization of BLD, providing new lines of investigation to improve ecological or silvicultural management. Furthermore, this study shows strong potential for extension of environmental risk mapping over the full American beech distribution range, so that proactive management measures can be put in place. Similar approaches can be designed for other significant or emerging forest pest problems, contributing to overall management efficiency and efficacy.

- We conditioned 3-year-old Austrian pine saplings to a simulated climate change (CC) environment (combined drought and elevated temperatures), followed by pathogenic inoculation with two sister fungal species characterized by contrasting aggressiveness, *Diplodia pinea* (aggressive) and *D. scrobiculata* (less aggressive). As expected, CC conditions enhanced host susceptibility to the less aggressive pathogen, *D. scrobiculata*, to a level that was not statistically different from the more aggressive *D. sapinea*. Under controlled climate conditions, *D. pinea* induced suppression of critical pathways associated with host nitrogen and carbon metabolism, while enhancing its own carbon assimilation. This was accompanied by suppression of host defense-associated pathways. In contrast, *D. scrobiculata* infection induced host nitrogen and fatty acid metabolism as well as host defense response. The CC treatment, on the other hand, was associated with suppression of critical host carbon and nitrogen metabolic pathways, alongside defense associated pathways, in response to either pathogen. We propose a new working model integrating concurrent host and pathogen responses, connecting the weakened host phenotype under CC treatment with specific metabolic compartments. Our results contribute to a richer understanding of the mechanisms underlying the oft-observed increased susceptibility to fungal infection in trees under conditions of low water availability and open new areas of investigation to further integrate our knowledge in this critical aspect of tree physiology and ecology.

- Understanding the phenological relationship of the host tree and its pathogens is essential for identifying optimal management strategies to help prevent future spread of the disease. Since beech leaf disease (BLD) is a recently discovered disease, information about the general epidemiology and symptom phenology is largely unavailable. This study sought to answer questions related to symptom progression by conducting two observational studies on ten trees from Cleveland Metroparks during the 2019 and 2020 growing seasons. BLD symptoms are characterized by two distinct leaf symptom types: dark green interveinal banding pattern or completely dark green and thickened leaf. Since there is evidence that the exotic nematode *Litylenchus crenatae* ssp. *mccannii* is associated with symptom development after direct inoculation into the buds, we hypothesized that symptoms would be apparent on the leaves at bud break. In our study, we visually confirmed the presence of both BLD leaf symptom types at bud break in naturally infected trees. Along with visual confirmation, a generalized linear mixed model (GLMM) showed that symptoms do not change throughout the growing season as time was not a significant variable when comparing symptoms across a growing season. Using both a Fisher's Exact Test and GLMM, we also determined that BLD leaf symptoms from a single leaf-bud pair do not progress in a specific or predictable pattern through subsequent growing seasons. These results formally validate the timing of BLD symptom expression and patterns of severity between years which will assist in furthering our understanding of the BLD pathosystem.
- Metabarcoding, which uses phylogenetically informative reference genes to

taxonomically classify short DNA sequences amplified from environmental samples. Using metabarcoding, we are able to compare the microbiota of symptomatic and asymptomatic (including presumably naïve) samples and identify microbe(s) that are only present in symptomatic samples and could therefore be responsible for the undiagnosed disease. Metabarcoding involves two main steps: library preparation and bioinformatic processing. For library preparation, the appropriate reference gene for the organism of interest (i.e. bacteria, phytoplasma, fungi, or other eukaryotes, such as nematodes) is amplified from the DNA extracted from the environmental samples using PCR and prepared for sequencing. The bioinformatic processing includes four major steps: (1) quality check and cleanup on raw reads; (2) classification of the sequences into taxonomically informative groups (ASVs or OTUs); (3) taxonomy assignments based on the reference database; and (4) differential abundance and diversity analyses to identify microbes that are significantly associated with just symptomatic samples and that point towards the putative causal agent of the disease.

4. Impact Statements.

Objective 1, New and emerging pests (including invasive species and climate change-induced range expansion): Investigate detection methods, biology, and management of new and emerging pests.

- Ohio State University has continued important work to characterize beech leaf disease, a new disease of unknown etiology that, after being detected first in 2012 in NE Ohio, is now affecting forest areas across the northeastern US and Canada.

Objective 2, Pesticide technology development: Evaluate effectiveness of reduced-risk pesticides, biopesticides, new and novel chemistries, and application technologies for control of key disease and arthropod pests of landscapes, nurseries, and Christmas trees.

Objective 3, Pesticide alternatives: Develop management strategies for key pests based on classical biological control (i.e., predators and parasitoids), host plant resistance, and cultural control.

Objective 4, Technology transfer: Develop and deliver science-based educational materials focused on management of key pests through outlets such as mass media, publications and fact sheets, eXtension.org and social media.

- Ohio State University delivered several talks on the beech leaf disease problem and our approach to diagnosing it.

5. Published Written Works.

1. Fearer CJ, Malacrinò A, Rosa C, **Bonello P** (2022) Phytobiome Metabarcoding: A Tool to Help Identify Prokaryotic and Eukaryotic Causal Agents of Undiagnosed Tree

Diseases. In: Luchi N (ed) Plant Pathology: Method and Protocols. Springer US, New York, NY, pp 347-366. doi:10.1007/978-1-0716-2517-0_19
2. Fearer CJ, Conrad AO, Marra RE, Georskey C, Villari C, Slot J, **Bonello P** (2022) A combined approach for early in-field detection of beech leaf disease using near-infrared spectroscopy and machine learning. Frontiers in Forests and Global Change 5. doi:10.3389/ffgc.2022.934545
3. Ghosh SK, Slot JC, Visser EA, Naidoo S, Sovic MG, Conrad AO, Kyre B, Vijayakumar V, **Bonello P** (2022) Mechanisms of Pine Disease Susceptibility Under Experimental Climate Change. Frontiers in Forests and Global Change 5. doi:10.3389/ffgc.2022.872584
4. **Bonello P**, Carnegie AJ, Ormsby M (2022) Editorial: Forest Biosecurity Systems and Processes: A Global Perspective. Frontiers in Forests and Global Change 5. doi:10.3389/ffgc.2022.867860
5. Fearer CJ, Volk D, Hausman CE, **Bonello P** (2022) Monitoring foliar symptom expression in beech leaf disease through time. Forest Pathology n/a (n/a):e12725. doi:https://doi.org/10.1111/efp.12725

6. Scientific and Outreach Oral and Poster Presentations.

1. Lee-Rodriguez J, Ranger C, Michel A, **Bonello P**, and Canas L. 2022. Sweet potato whitefly (*Bemisia argentifolii*) detection integrating plant volatiles, near infrared spectroscopy and environmental DNA in tomato plants for integrated pest management automation. Annual Meeting of the Entomological Society of America. Vancouver, BC, Nov. 13-16.
2. **Bonello P.** 2022. Sentinel trees - A fully reciprocal international sentinel planting collaboration as a case study. Society of American Foresters National Convention. Baltimore, MD, Sept. 20-24. (Invited presentation.)
3. Ghosh SK, Slot JC, Visser EA, Naidoo S, Sovic MG, … **Bonello, P.** 2022. Mechanisms of pine disease susceptibility under experimental climate change. 7th IUFRO International Workshop on the Genetics of Tree-Parasite Interactions in Forestry. Pontevedra, Spain, Sept. 12-16.
4. Ghosh SK, Ishangulyyeva G, Erbilgin N, **Bonello, P.** 2022. Is there a role of terpenoids in systemic induced resistance in Austrian pine? 7th IUFRO International Workshop on the Genetics of Tree-Parasite Interactions in Forestry. Pontevedra, Spain, Sept. 12-16.
5. **Bonello P**, Conrad AO. 2022. Infrared spectroscopy and machine learning for rapid host resistance screening. 7th IUFRO International Workshop on the Genetics of Tree-Parasite Interactions in Forestry. Pontevedra, Spain, Sept. 12-16.
6. Eisenring M, Perret-Gentil A, Britt E, Ladd T, Dedes J, Roe A, **Bonello P**, Queloz V, Gossner MM. 2022. European ash genotypes with increased resistance against the ash dieback disease may also be more resistant against the emerald ash borer. IUFRO Conference Division 7 – Forest Health Pathology and Entomology. Lisbon, Portugal, Sept. 6-9.
7. Fearer CJ, Conrad AO, Marra RE, Georskey C, Villari C, Slot J, **Bonello P**. 2022. Early *in situ* detection of beech leaf disease using near infrared spectroscopy and machine learning. IUFRO Conference Division 7 – Forest Health Pathology and Entomology. Lisbon, Portugal, Sept. 6-9.

8. Kime CG, Cleary MM, Digirolomo M, Migliorini D, Munck I, Santini A, Sun H, Sherwood P, Shetlar D, Bonello P. 2022. Lessons learned from an international reciprocal sentinel planting project. IUFRO Conference Division 7 – Forest Health Pathology and Entomology. Lisbon, Portugal, Sept. 6-9.
9. Ghosh SK, Slot JC, Visser EA, Naidoo S, Sovic MG, … **Bonello, P.** 2022. Mechanisms of pine disease susceptibility under experimental climate change. IUFRO Conference Division 7 – Forest Health Pathology and Entomology. Lisbon, Portugal, Sept. 6-9.
10. Ghosh SK, Ishangulyyeva G, Erbilgin N, **Bonello, P.** 2022. Is there a role of terpenoids in systemic induced resistance in Austrian pine? IUFRO Conference Division 7 – Forest Health Pathology and Entomology. Lisbon, Portugal, Sept. 6-9.
11. Kime CG, Cleary MM, Digirolomo M, Migliorini D, Munck I, Santini A, Sun H, Sherwood P, Shetlar D, **Bonello P.** 2022. A reciprocal sentinel planting approach for assessment of risk from invasive alien tree pests. Annual Meeting of the American Phytopathological Society. Pittsburgh, PA, Aug. 6-10.
12. Peart A, Ralston Z, Fearer C, **Bonello P**, Lopez-Nicora H. 2022. Early detection of soybean cyst nematode (SCN)-infected soybean plants using near-infrared (NIR) spectroscopy and machine learning techniques. Annual Meeting of the American Phytopathological Society. Pittsburgh, PA, Aug. 6-10.
13. Ghosh SK, Slot JC, Visser EA, Naidoo S, Sovic MG, … **Bonello, P.** 2022. Mechanisms of pine disease susceptibility under experimental climate change. Annual Meeting of the American Phytopathological Society. Pittsburgh, PA, Aug. 6-10.
14. Ghosh SK, Ishangulyyeva G, Erbilgin N, **Bonello, P.** 2022. Is there a role of terpenoids in systemic induced resistance in Austrian pine? Annual Meeting of the American Phytopathological Society. Pittsburgh, PA, Aug. 6-10.
15. Fearer CJ, Conrad AO, Marra RE, Georskey C, Villari C, Slot J, Bonello P. 2022. Early *in situ* detection of beech leaf disease using near infrared spectroscopy and machine learning. Annual Meeting of the American Phytopathological Society. Pittsburgh, PA, Aug. 6-10.
16. Ghosh SK, Ishangulyyeva G, Erbilgin N, **Bonello, P.** 2022. Is there a role of terpenoids in systemic induced resistance in Austrian pine? International IUFRO Meeting on *Foliar, Shoot, Stem and Rust Diseases of Trees*. Durham, NH, June 26-July 1.
17. Fearer CJ, Conrad AO, Marra RE, Georskey C, Villari C, Slot J, **Bonello P**. 2022. Early *in situ* detection of beech leaf disease using near infrared spectroscopy and machine learning. International IUFRO Meeting on *Foliar, Shoot, Stem and Rust Diseases of Trees*. Durham, NH, June 26-July 1.
18. Ghosh SK, Slot JC, Visser EA, Naidoo S, Sovic MG, … **Bonello, P.** 2022. Mechanisms of pine disease susceptibility under experimental climate change. International IUFRO Meeting on *Foliar, Shoot, Stem and Rust Diseases of Trees*. Durham, NH, June 26-July 1.
19. Kime CG, Cleary MM, Digirolomo M, Migliorini D, Munck I, Santini A, Sun H, Sherwood P, Shetlar D, **Bonello P.** 2022. A reciprocal sentinel planting approach for assessment of risk from invasive alien tree pests. International IUFRO Meeting on *Foliar, Shoot, Stem and Rust Diseases of Trees*. Durham, NH, June 26-July 1.
20. **Bonello P.** 2022. Mechanisms of pine disease susceptibility under experimental climate change. Western International Forest Disease Work Conference: *Climate, Climate Change and Tree Diseases*. Virtual, April 13.

Michigan, *Dave Smitley <smitley@msu.edu>
State report and power point
Project No. and Title:
NCERA 224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes
Year: 2023 NCERA 224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes

Michigan Report for 2023
David Smitley

Department of Entomology, Michigan State University, Natural Science Building, 288 Farm Lane Room 243, East Lansing MI 48824

517-977-4093

smitley@msu.edu

01/01/2023 to 12/31/2023

Date of Report:	Sent to committee chair on December 12, 2023
Annual Meeting Dates:	12/11/2023 to 12/13/2023
In attendance:	In person
Suggestions for NCERA 224:	Continue JB biocontrol cooperative work, begin new cooperative project on 'smart street tree selections to counter increased damage to street trees from drought and flood caused by climate change'

Suggestion for location of 2024 mtg: San Antonio, Texas

Brief summary:
In 2023 I worked cooperatively with two other committee members, Ada Szczepaniec (Colorado) and Vera Krischik (Minnesota), to analyze data and report results from the last three years on our project to introduce a microsporidian pathogen of Japanese beetle, *Ovavesicula popilliae*, to Colorado, Minnesota and four other North Central states. We are doing this because of documented declines in Japanese beetle populations following introductions of the pathogen to Michigan sites (Smitley et al. 2022). Progress was made in three important areas: host range, establishment following introductions, and determining need for introductions in six North Central states. Examination of over 4,000 individual beetles from a total of 35 species of beetles trapped at sites where Japanese beetles were heavily infected, indicate that only Japanese beetles were infected

heavily enough to have any impact on the population. Using qPCR analysis, low levels of *Ovavesicula* were detected in three species other than Japanese beetle: northern masked chafer, Oriental beetle, and Asiatic garden beetle. Less than 5% of the beetles of any of these three species were infected heavily enough to cause disease, suggesting that they have a healthy immune response to the pathogen. For Japanese beetles trapped at these sites, 20 – 50% were heavily infected. In Colorado, where *Ovavesicula* was not found prior to the first introductions, the pathogen has established and infection rates have increased rapidly at 11/12 sites where it was introduced before 2021. Introductions were made by spraying *Ovavesicula* spore solutions over turfgrass. Spore solutions were made in Michigan from thousands of beetles collected at a pathogen-active site. Filtered solutions were kept frozen until shipped with dry ice to Colorado. Finally, new sampling work in 2023 revealed the pathogen is absent from 90% of 85 tree fruit, small fruit and park sites sampled in Michigan, Minnesota, Iowa, Nebraska, and Missouri. The pathogen spreads slowly and must be introduced to avoid a 20-year or longer delay in establishment. The survey work, completed with support from USDA APHIS, NCIPM and Project GREEEN has identified at least one site in each state (with the exception of Nebraska, all negative) where infected beetles can be trapped for introductions at new sites.

Impacts:
Japanese beetle has a serious economic impact on nursery crops, small fruit production, tree fruits, hops and golf courses. In a recent survey by the Oregon Department of Agriculture used to justify a Japanese beetle eradication and prevention program, they estimated losses of over $25 million per year to their nursery and tree fruit industries. If Japanese beetle populations decline in the western region of Michigan where apples, cherries, blueberries and grapes are grown, at the rate they did in southern Michigan, we expect damage to those crops to decrease by 75%.

Please list outputs and outcomes.
https://www.nifa.usda.gov/logic-model-planning-process

In southern Michigan where the pathogen is well established, golf courses no longer need to treat all of their fairways, tees and greens with a neonicotinoid insecticide for control of Japanese beetle grubs. Similar results are expected for small fruit, tree fruit and hop farms where *Ovavesicula* is introduced.

Tree fruit, blueberry, grape and hops growers in Michigan were actively involved in supporting a survey of farms to determine where the pathogen needs to be introduced. They are now requesting assistance and offering support for introductions in 2024 and 2025.

Publications:

D Smitley, E Hotchkiss, K Buckley, M Piombiono, P Lewis, J Studyvin. 2022. Gradual Decline of Japanese Beetle (Coleoptera: Scarabaeidae) Populations in Michigan Follows

Establishment of *Ovavesicula popilliae* (Microsporidia), *J. Econ. Entomol.* 115; 1432–1441, https://doi.org/10.1093/jee/toac085

Hulbert, D., D. Smitley, E. Hotchkiss, Y. Wu, P. Lewis, and J.J Smith. 2020. DNA extraction and qPCR detection of *Ovavesicula popilliae* Andreadis and Hanula, a microsporidian pathogen of the Japanese beetle (*Popillia japonica* Newman). Journal of Invertebrate Pathology: Volume 175, September 2020, 107455.

Piombino, M. and D. Smitley. 2020. Survival of Japanese beetle, *Popillia japonica* Newman, larvae in field plots when infected with a microsporidian pathogen, *Ovavesicula popilliae.* Journal of Invertebrate Pathology: Volume 174, July 2020, 107434

Iowa, *LauraJesse<ljesse@iastate.edu>
No state report, could not attend meeting, no power point

Project No. and Title:
NCERA 224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes
Year: 2023
Name: Vera Krischik
State: MN
University and complete mailing address: 1980 Folwell Ave#219, Saint Paul, MN 55108
Phone number: 612.625.7044
Email: krisc001@umn.edu
Period Covered: 01/01/2023 to 12/31/2023
Date of Report: Email to krisc001@umn.edu by EC 19 2023
Annual Meeting Dates: 12/11/2023 to 12/13/2023
In attendance: yes
In person or by zoom: Yes
Suggestions for NCERA 224 cooperative research or outreach program:
2004 NCERA 224 IPM manual revisions
Online course

Suggestion for location of 2024 meeting: At bi-annual ornamental NC State, Steve Franks.
Late afternoon, early evening meeting, 1 day

Brief summary:
2021-2024 LCCMR: Biocontrol of Bee Lawns in Parks and Landscapes
Progress report July 15, 2023
Outcomes:
Establish biocontrol of a JB to reduce populations with a native soil inhabiting pathogen.
Develop and distribute IPM management that protects pollinators in established bee lawns and restorations.

Research in collaboration with MSU:
Distribution of pathogen: Survey 30 sites for 2 yrs to understand distribution of Ova (microsporidian Ovavesicula) in MN. Use qPCR techniques to identify pathogen and verify by counting spores in JB.

Establish pathogen: At 30 MN nursery sites add the pathogen to JB grub infested areas.

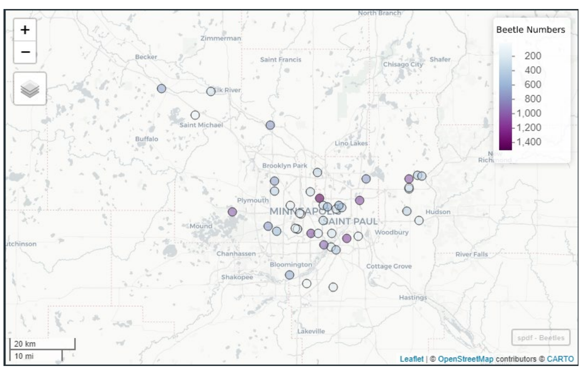
IPM: LC50 studies on advertised insecticides and efficacy and non-target effects.

Distribution tools: Research of JB traps are better at distributing the pathogen than pouring spores on the ground.

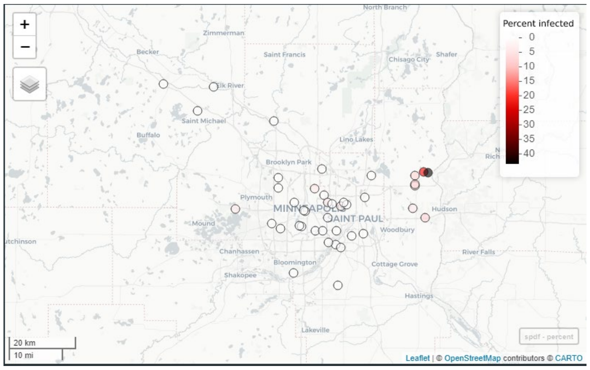
Map 1(blue) shows the distribution of JB adults at the 44 sites. In total, we collected 77,326 JBs from 44 sites, sampling each site 4 times from July 5 through Sept (Map 1, blue). The fewest JB recovered at one time were 1 and the most were 3,951. The Northwestern side of the Metro has the fewest JB as seen by white circles in Map 1.

Map 2 (red) shows the percent of JB infected with Ovavesicula. We have spent the winter dissecting adult JB, counting pathogen spores inside the gut, and extracting DNA and using qPCR to identify the pathogen The Stillwater area has 8/44 sites that had pathogen spores inside adult JB.

Research from 2022 to 2023, so far:



Map 1: The number of adult JB in 44 sites in MN. Circles represent a site and the darker the blue the more JB. JB abundance at each site was averaged over the course of the season.



Map 2: The percent of adult JB infected with *Ovavesicula* pathogen spores in 44 sites in MN. Circles represent a site and the darker the red the more JB adults contain pathogen spores. The
Stillwater area had 8/44 sites that had pathogen spores inside adult JB.

LC50 bioassays:
A standard method to compare toxicity of different chemicals or different doses to determine relative toxicity. It is done for mammals, birds, fish, and insects by the EPA. It is used to understand how toxic an insecticide is to the environment or to kill a pest. Nontarget effects of JB insecticies: Dead painted lady butterfly(PLB) larvae after an application of a biorational insecticide that kills JB. Bioassays using insects and leaves to test the effects of insecticides.

Biorational	Insect/Product	LC50 (CI)
Bacillus thuringiensis galleriae	**JB/BeetleGone**	**1.37 mg/ml kills JB**
Bacillus thuringiensis galleriae	**PLB/BeetleGone**	**1.87 mg/ml kills PLB**
Beauveria bassiana	**JB/Mycotrol**	**3.79 mg/ml kills JB**
Beauveria bassiana	**PLB/Mycotrol**	**3.77 mg/ml kills PLB**
8 other insecticides tested on JB and PLB in progress summer 2023.		

Table 1. MN has less pathogen spores compared to Eastern states with lower JB populaitons. Spores per beetle consistently increase with years after introduction until JB population collapses. Data are estimated from samples of 96 beetles per site and a

standardized scale based on an established relationship between PCR Ct values and spores per ml counted with a microscope. (Hulbert et al. 2020).

Field insecticide residues, acute and chronic bioassays with monarch and painted lady butterflies, bumblebees, and honeybees

Vera Krischik, Matt Lagus, Temo Balaxashvili, Nicholas Partington, Department of Entomology, University of Minnesota, Saint Paul, MN 55116

Abstract

The USFWS assessment plans indicate that pesticides may contribute to the decline of the rusty patched bumblebee and monarch butterfly. Although a vast literature documents insecticide toxicity to bees, few papers study the toxicity of insecticides to butterflies, such as the migratory monarch (*Danaus plexippus*) and painted lady butterfly (*Vanessa cardui*). Comparing host-specific monarchs and generalist-feeding painted ladies, may provide insight into whether there is a general response of butterflies. Both species of butterflies had higher LC50s to the neonicotinoid insecticides clothianidin and imidacloprid than honeybees and bumblebees, but lower LC50s for chlorantraniliprole compared to bees. Often it is thought that smaller instar larvae may be more susceptible to insecticides, but fifth- and third-instar painted lady larvae had similar response to the four insecticides. For *D. plexippus* larvae, the acute clothianidin LC50 was 3.7 µg/mL solution which was 237 times higher than the acute LC50 of 15.6 ng/mL that is usually referenced (Pecenka and Lundgren 2015). Chronic studies were performed for 44 days at 0.146 µg/g leaf (0.04 µg/mL) clothianidin for monarchs, which was 91 times lower than monarch larval LC50 of 13.3 µg/g leaf (3.7 µg/mL solution), and at 0.035 µg/g leaf (0.04 µg/mL solution) clothianidin for painted ladies, which was 2,400 times lower than the painted lady LC50 of 84.6 µg/g leaf (96.2 µg/mL solution). Chronic clothianidin exposure reduced monarch larval survival by 38% and painted lady larval by 25%. Clearly, chronic exposure reduces survival at lower concentrations than the LC50 acute values in many studies and should be compared to field residues.

Figure 1. Acute LC50 bioassays (4 days) for painted lady adults, *Vanessa cardui* and sublethal behavior of wing opening. The bars are the percent of butterflies that opened their wings when dropped from a height of 90 cm. CHL, chlorantraniliprole

(n=100); BIF, bifenthrin (n=240); CLO, clothianidin (n=169); IMI, imidacloprid (n=102); *p < 0.05; **p < 0.001.

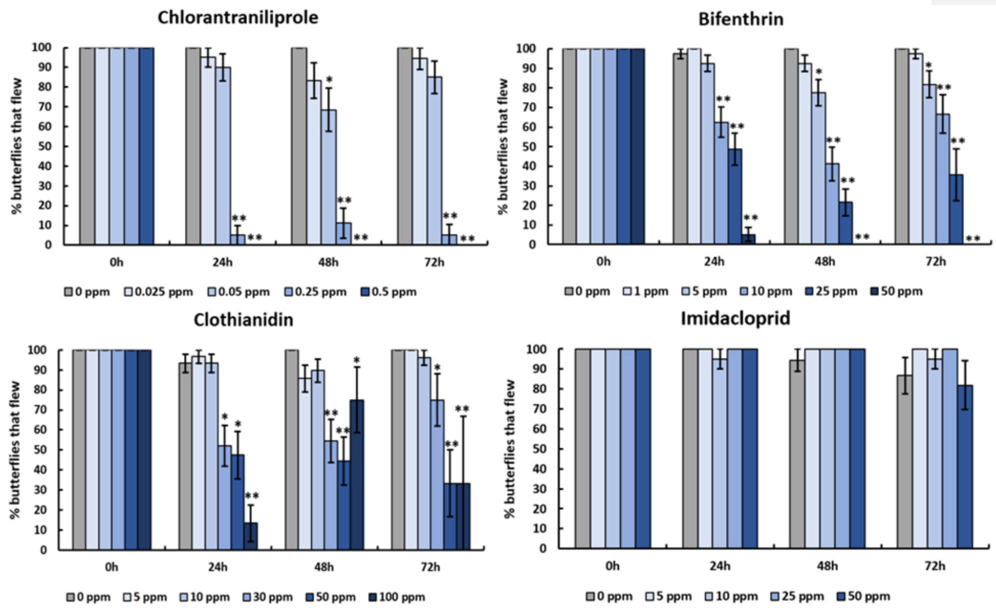


Figure 2A. Chronic bioassays (44 days) for monarch butterfly, *Danaus plexippus*, exposed to sublethal doses of 0, 0.01, 0.02, and 0.04 ppm clothianidin from third-instar larvae until pupation. Mean (±SE) monarch butterfly larval weight ($F(3,20) = 2.10$, $p = 0.13$), larval survival ($X^2(3) = 1.84$, $p = 0.61$)**,** days to pupation ($X^2(3) = 15.03$, $p = 0.002$), pupal weight ($X^2(3) = 4.92$, $p = 0.18$), egg lay per female ($X^2(3) = 2.38$, $p = 0.50$), number of larvae that pupate ($X^2(3) = 18.45$, $p = 0.0004$), number of pupae that eclose ($X^2(3) = 8.88$, $p = 0.03$), and cumulative survival ($X^2(3) = 3.24$, $p = 0.36$). Replicate 1 was started August 21st, 2019; Replicate 2 was started August 26th, 2019. *$p < 0.05$; **$p < 0.001$; n = 60 larvae/treatment.

2B. Chronic bioassays (44 days) for painted lady butterfly, *Vanessa cardui*, exposed to sublethal doses of 0 and 0.04 ppm clothianidin from third-instar larvae until pupation. Mean (±SE) painted lady butterfly larval weight ($F(1,6) = 2.52$, $p = 0.16$), larval survival ($X^2(1) = 4.34$, $p = 0.037$), days to pupation ($X^2(1) = 1.29$, $p = 0.26$), pupal weight ($F(1,22) = 0.07$, $p = 0.80$), days to eclosion ($X^2(1) = 1.20$, $p = 0.27$), number of larvae that pupate ($X^2(1) = 4.99$, $p = 0.026$), number of pupae that eclose ($X^2(1) = 2.15$, $p = 0.14$), and cumulative survival ($X^2(1) = 0.52$, $p = 0.47$). November 4th, 2019. *p <

0.05; **p < 0.001; n = 40 larvae/treatment.

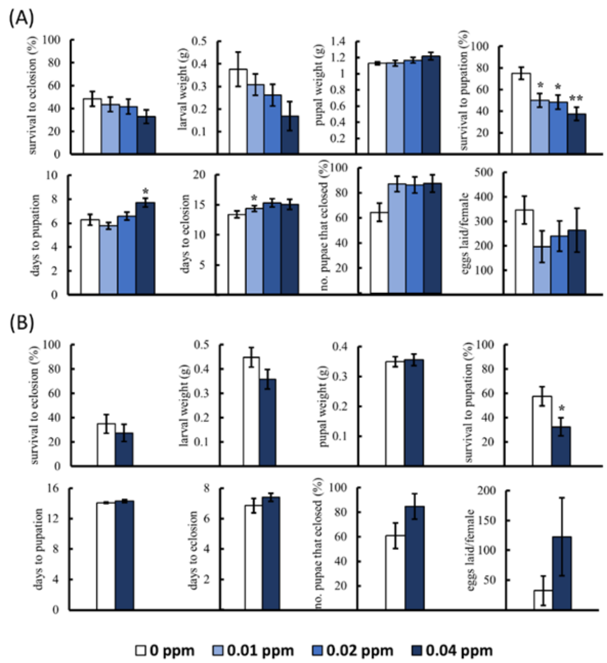


Table 6. Acute LC50 96h bioassay for adult painted lady butterfly. CHL; chlorantraniliprole; BIF, bifenthrin; CLO, clothianidin; IMI, imidacloprid. [a]total number of insects used, [b]Lethal concentration (µg/mL solution), [c]fiducial limits, [d]probit slope ± standard error, [e]Chi-square value (Pearson goodness of fit), [f]*P* value (Pearson goodness of fit).

Insecticide	**n[a]**	**LC_{10} [b]**	**95% FL[c]**	**LC50 [b]**	**95% FL[c]**	**LC_{90} [b]**	**95% FL[c]**	**Slope ±SE[d]**	**X^2 [e]**	***P*[f]**
CHL	100	0.024	(0.01, 0.03)	0.05	(0.04, 0.08)	0.12	(0.08, 0.4)	1.6 ± 0.4	0.6	0.8
BIF	240	3.0	(1.9, 4.5)	6.9	(5.6, 8.2)	16.0	(12.7, 23.0)	1.5±0.2	0.2	0.98
CLO	150	5.8	(3.9, 7.5)	14.0	(11.3, 17.3)	33.7	(25.9, 50.4)	1.5 ±0.2	2.1	0.4
IMI	100	7.2	(2.5, 11.5)	32.9	(22.7, 62.1)	149.7	(74.0, 947.0)	0.8±0.2	4.8	0.1

Table 9. Field residue and acute LC50 96h bioassay for monarch fifth-instar larvae and painted lady fifth-instar and third-instar larvae.
mon5, monarch fifth-instar larvae; pl5, painted lady fifth- instar larvae; and pl3, painted lady third-instar. CHL; chlorantraniliprole; BIF, bifenthrin; CLO, clothianidin; IMI,

imidacloprid. Values in parentheses are 95% confidence intervals or fiducial limits. References: a, Halsch et al. 2020; b, Runquist 2014; c, Pecenka and Lundgren 2015; d, Olaya Arenas and Kaplan 2019; e, Basley and Goulson 2018; f, Peterson et al. 2018; g, Mogren and Lundgren 2016; h, Botías et al. 2015.

Insecticide	**Acute larval LC50 (ng/g leaf) (ppb) (95% fiducial limits)**			**Field residue (ng/g leaf)**	**Is field residue toxic to butterflies?**		
	mon5	**pl5**	**pl3**		**mon5**	**pl5**	**pl3**
CHL	770.1 (467.2, 1182.5)	25.5 (17.6, 38.7)	10.1 (7.0, 15.8)	1-66[a]	no	no	yes
BIF	1810.2 (1259.1, 2656.9)	7460.6 (4047.0, 11438.1)	172.4 (92.4, 263.9)	9-71[b]	no	no	no
CLO	13328.5 (6897.8, 21985.4)	84614.3 (43881.6, 126919.7)	77166.0 (54419.9, 106338.8)	0.01-351[a] 1-4[c] 0.71-56[d] 0.02-6.3[e] 3.6-4[f] 1-13[g] 2.27[h]	no	no	no
	146 (chronic) 73 (chronic) 36.5 (chronic)	35 (chronic)	NA		no	no	NA
IMI	4197.1 (2704.4, 6565.7)	224711.9 (167012.1, 306370.8)	202045.0 (145170.2, 265190.4)	1-3[a] 1.8-2.1[f] 0.01-4[d] 0.56[h]	no	no	no

Table 10. Comparison of field residues, acute LC50, and chronic studies for honeybees, bumblebees, and painted lady adults. BIF, bifenthrin; CHL, chlorantraniliprole; CLO, clothianidin; IMI, imidacloprid; CPS, chlorpyrifos; TMX, thiamethoxam. Values in parentheses are 95% confidence intervals or fiducial limits. References: a, Reid et al. (2020); b, Wade et al. (2019); c, Williams et al. (2020); d, Smagghe et al. (2013); e, Liu et al. (2017); f, Dai et al. (2010); g, Pettis et al. (2013); h, Sánchez-Bayo and Goka (2014); i, Besard et al. (2010); j, Heard et al. (2017); k, Laurino et al. (2011); l, Laurino et al. (2013); m, Tison et al. (2020); n, Kim et al. (2020); o, Dai et al. (2018); p, Meikele et al. (2021); q, Schneider et al. (2012); r, Wood et al. (2020); s, Scholer and Krischik (2014); t, Godfray et al. (2014); u, Nauen et al. (2001); v, Suchail et al. (2001); w, Marletto et al. (2003); x, Boily et al. (2013); y, Saleem et al. (2020); z, Mommaerts et al. (2010); aa, Feltham et al. (2014); bb, Gill and Raine (2014); cc, Leza et al. (2018); dd, Muth and Leonard (2019); ee, Potts et al. (2018); ff, Switzer and Combes (2016); gg, Whitehorn et al. (2012), hh, Mundy-Heisz et al. (2020); ii, Henry et al. (20120; jj, Thompson et al. (2019); kk, Tosi and Nieh (2017); ll, Baron et al. (2017).

Insecticide	Honeybee LC50, ppm	Bumblebee LC50, ppm	PLB adult LC50 ppm	Field residue pollen µg/g, ppm	Field residue Author	HB Yes or no	BB Yes or no	PLB adult Yes or no
CHL acute LC50	1041 µg/g bee[a] 7.06 µg/g bee (2.75, 29.5)[b] 150 µg/mL[c]	13 µg/mL (11, 16)[d]	0.05 µg/mL (0.04, 0.08) Present study 1 µg/mL[e]	0.068 0.0096 0.002-0.066 (leaves)	Chan 2019 Tsvetkov 2017 Halsch 2020	no	no	yes
CHL chronic	LC50: NA	LC50: 7 µg/mL (6-9)[d]	NA	0.068 0.0096 0.002-0.066 (leaves)	Chan 2019 Tsvetkov 2017 Halsch 2020	NA	no	NA

BIF acute LC50	16.7 µg/mL (12.4, 22.6)[f] 0.11 µg/mL[g]	3.4 µg/g bee[h]	6.9 µg/mL (5.6, 8.2) Present study	0.0066-0.053 0.0022-0.013	Pettis 2013 Sánchez-Bayo and Goka 2014	no	no	no
BIF chronic	LC50: NA	LC50: 0.36 µg/mL[i]	NA	0.0066-0.053 0.0022-0.013	Pettis 2013 Sánchez-Bayo and Goka 2014	NA	no	NA
CLO acute LC50	0.06 µg/mL[j] 0.075 µg/mL (0.06, 0.09)[k] 0.03 µg/g[l] 0.04 µg/g bee[h] 0.037 µg/g bee[m]	0.03 µg/mL[j] 0.05 µg/g bee (0.04, 0.05)[n]	14.0 µg/mL (11.3, 17.3) Present study	0.0001-0.015 0.0005-0.011 0.001-0.009 0.001-0.088 0.171 0.001-0.009 0.004 0.01	Botias 2016 David 2016 Krupke 2012 Krupke 2015 Larson 2013 Long 2016 Tsvetkov 2017 Sánchez-Bayo and Goka 2014	yes	yes	no
CLO chronic	LC50: 2 µg/mL[o] 0.02 µg/mL[j] Sublethal: 0.005 µg/mL[p] 0.005 µg/g bee[q] 0.004 ug/g[r]	LC50: 0.02 µg/mL[j] 0.02 µg/mL[s] Sublethal: 0.009 µg/mL[m]	0.04 µg/mL Present study	0.0001-0.015 0.0005-0.011 0.001-0.009 0.001-0.088 0.171 0.001-0.009 0.004 0.01	Botias 2016 David 2016 Krupke 2012 Krupke 2015 Larson 2013 Long 2016 Tsvetkov 2017 Sánchez-Bayo and Goka 2014	yes	yes	yes
IMI acute LC50	0.04 µg/g bee[t] 0.7 µg/g bee[l] 0.04 µg/g bee[u] 0.04 µg/g bee[a] 0.13 µg/g bee[h] 0.4 µg/g bee[v]	0.2 µg/g bee[w] 0.4 µg/g bee[a] 0.3 µg/g bee[h]	32.9 µg/mL (22.7, 62.1)) Present study	0.0002-0.026 0.004 0.0004-0.004 0.0009-0.0011 0.003-0.037 0.025	Botias 2015 Chan 2019 David 2016 Long 2016 Pettis 2013 Sanchez-Bayo and Goka 2014	no	no	no
IMI chronic	LC50: 0.002 µg/g bee[x] Sublethal: 0.4 µg/mL[y] 0.015 µg/g bee[q]	LC50: 0.02 µg/mL[z] (0.019-0.021) 0.020 µg/mL[s] Sublethal: 0.006 µg/g pollen[aa] 0.01 µg/mL[bb] 0.01 µg/mL[cc] 0.011 µg/g bee[dd] 0.006 µg/mL[ee] 0.005 µg/g bee[ff] 0.006 µg/g pollen[gg]	NA	0.0002-0.026 0.004 0.0004-0.004 0.0009-0.0011 0.003-0.037 0.025	Botias 2015 Chan 2019 David 2016 Long 2016 Pettis 2013 Sanchez-Bayo and Goka 2014	yes	yes	NA
CPS acute LC50	0.86 µg/mL[g] 2.4 µg/g bee[a] 2.4 µg/g bee[h]	5.7 µg/g bee[a] 2.3 µg/g bee[h]	NA	0.003-0.016 0.05	Pettis 2013 Sanchez-Bayo and Goka 2014	no	no	NA
CPS chronic	LC50: NA	LC50: NA	NA	0.003-0.016 0.05	Pettis 2013 Sanchez-Bayo and Goka 2014	NA	NA	NA

TMX acute LC50	0.05 µg/g bee[t] 0.12 µg/mL[k] 0.04 ug/g bee[l] 0.05 µg/g bee[h]	0.18 µg/g bee[n] (0.15, 0.21) 0.012 µg/g bee[hh]	NA	0.0001-0.086 0.0001-0.021 0.001-0.003 0.007 0.0001-0.002 0.06 0.004	Botias 2015 David 2016 Krupke 2012 Krupke 2015 Long 2016 Sanchez-Bayo and Goka 2014 Tsvetkov 2017	yes	yes	NA
TMX chronic	LC50: NA	LC50: 0.12 µg/mL (0.04-0.38)[z]	NA	0.0001-0.086 0.0001-0.021 0.001-0.003 0.007 0.0001-0.002 0.06 0.004	Botias 2015 David 2016 Krupke 2012 Krupke 2015 Long 2016 Sanchez-Bayo and Goka 2014 Tsvetkov 2017	yes	yes	NA

Impacts:
All research and outreach programs were concerned with using IPM principles to reduce pesticide use, better time pesticide use, use cultural management, better identify pests, and protect pollinators and improve worker safety.
Please list outputs and outcomes.
https://www.nifa.usda.gov/logic-model-planning-process
Outputs: Products, services and events that are intended to lead to the program's outcomes.
Outcomes: Planned results or changes for individuals, groups, communities, organizations or systems.
Types of outcomes include:
Change in knowledge - Occurs when there is a change in knowledge or the participants actually learn.
Change in behavior - Occurs when there is a change in behavior or the participants act upon what they have learned.
Change in condition -Occurs when a societal condition is improved.
Change in pesticide use.
Change in pollinator conservation.
Change in management that reduces crop loss and or economic loss.

Publications Outreach and research:
Outreach section
Research section

Nebraska, Kyle Broderick <kbroderick2@unl.edu>
No state report, power point
Project No. and Title:
NCERA 224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes
Year: 2023

No state report submitted, power point at meeting

Colorado, Ada Szczepaniec<A.Szczepaniec@colostate.edu>
State report and power point
Project No. and Title:
NCERA 224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes
Year: 2023

Colorado State Report (CSU) for 2023
Ada Szczepaniec

Department of Agricultural Biology, Colorado State University, Fort Collins, CO 80523

a.szczepaniec@colostate.edu

01/01/2023 to 12/31/2023

Date of Report: Sent to committee chair on January 12, 2024

Annual Meeting Dates: 12/11/2023 to 12/13/2023

In attendance: In person

Suggestions for NCERA 224: Expand work on use of biological control of Japanese beetles; create updated regional factsheet on Japanese beetle, emerald ash borer; explore collaborative efforts to coordinate planting and monitoring of trees adapted to changing climate conditions and biotic pressure common to each region.

Suggestion for location of 2024 mtg: Denver, CO

Brief summary:

The key activities in 2023 focused on surveys of a microsporidian pathogen of Japanese beetle, *Ovavesicula popilliae* in Colorado, establishing and coordinating connections between CSU and local Forestry Divisions to mitigate the increasing impact of emerald ash borer on urban forests, and assisting Colorado Department of Agriculture (CDA) staff in identifying future invasions of key pests of urban landscapes and streamline public reporting mechanisms for invasive pests. Several training opportunities were also provided for Master Gardeners and Arboriculturist Society members from Colorado and Wyoming. Significant improvements and updates have been completed to the educational resources focused in sustainable pest management on the Colorado Center for Sustainable Pest Management website (https://agsci.colostate.edu/agbio/ipm/tree-and-shrub-pests/). Most of the resources were updated based on the latest primary literature on each pest, and all the resources now meet accessibility standards. The website also provides monitoring data, which will be expanded to Japanese beetles in 2024.

Impacts:

Japanese beetles, emerald ash borer, and engraver beetles remain the main threat to trees and shrubs in Colorado. Climate-related decreases in precipitation and increases in temperature are likely to add scale insects and mites to the list of key pests. The updates and expansion of online educational resources for professionals and public are going to improve our ability to respond and address increasing impacts of these pests. Live and up-to-date monitoring for pests such as Japanese beetles will allow for prompt response and, where appropriate, taking steps to mitigate their impact. Lastly, close coordination between CSU, CDA, and local government that has been started in 2023 will allow for streamlined responses to pest threats, and establishing long-term solutions to consequences of invasive species on urban landscape composition.

Outputs and outcomes:

Presentations and training:

- **Szczepaniec, A.** International Arboriculturist Society – 60 min presentation on major pests of trees: "Key pests and threats to urban forests" (200 participants). June 2023
- **Szczepaniec, A.** Pest Management in the Intermountain West – 25 min talk "Key pests and pests management updates". December 2023

Educational and Extension resources and activities:

- Extensive improvements to the website for the Colorado Center for Sustainable Pest Management and content within, particularly related to insect and mite pests. All content is accessible and is continually updated with new pages and peer- reviewed information. I oversaw the following improvements in 2023:
  - 30 new webpages were created and posted. All meet accessibility standards and are easily viewed on mobile devices.
  - Additional resources for highly destructive invasive pests have been created (emerald ash borer, spotted lanternfly).
- CSU interacted with CDA staff to address and mitigate the impact of new invasive pests. This included assisting with updated potential pests lists and response plans in case of detection.
- CSU also engaged with City of Fort Collins Forestry Division to address and mitigate the impact of invasive beetle (emerald ash borer) and explore climate-forward and pest resilient urban tree species.

Washington, Gary Chastagner, chastag@wsu.edu
State report and power point
Project No. and Title:
NCERA 224: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes
Year: 2023

Name: Gary Chastagner

State: Washington

University and complete mailing address:
Washington State University

Research and Extension Center
2606 West Pioneer
Puyallup, WA 98371

Phone number: 253-445-4528 (O); 253882-6856 (C)

Email: chastag@wsu.edu

Period Covered: 01/01/2023 to 12/31/2023

Date of Report: December 10, 2023

Annual Meeting Dates: 12/11/2023 to 12/13/2023

In attendance: In person

Suggestions for NCERA 224 cooperative research or outreach program: Help facilitate the collection of samples to determine the distribution and host range of sooty bark disease. This will also provide a geographically diverse set of *Cryptostroma coritcale* isolates to obtain a better understanding of the population structure of this pathogen. See WSU Sooty Bark Disease Diagnostic Guide for what to look for: https://pubs.extension.wsu.edu/sooty-bark-disease-diagnostic-guide.

Suggestion for location of 2024 meeting: Not sure it would ever be approved, but holding the meeting in Hawaii might be an effective way of increasing participation in the meeting. It might be possible to meet at the Hawaii Department of Agriculture in Honolulu to obtain an overview of the regulatory process to reduce the introduction and spread on non-native plants and organisms, and visit a local nursery or research center.

Brief summary:
The WSU Ornamental Plant Pathology program conducts research relating to the etiology, epidemiology, and management of diseases on cut flowers, Christmas trees, landscape/forest trees, and nursery stock. Major areas of activity relate to diseases caused by *Phytophthora* and *Botrytis* species, as well as the emergence of sooty back disease on urban trees. Studies are also underway to examine climate-related shifts in disease and postharvest factors affecting the postharvest quality of Christmas trees and cut flowers. The overall goal of this program is to deliver outcomes for mitigating the abiotic and biotic stressors of cut flowers, Christmas trees, urban trees, and nursery stock through collaboration, community and stakeholder engagement, and applied research.

Impacts:
Leaf blight caused by *Botrytis* is the most common fungal disease on tulips and lilies. Growers typically make multiple applications of fungicide during the growing season to control this disease. Compared to a calendar-based application schedule, switching to a crop phenology-based schedule to manage Botrytis diseases has reduces the number of fungicide sprays on these crops by up to 40 to 60%

Sooty bark disease (SBD), caused by *Cryptostroma coritcale,* is an emerging disease associated with mortality in landscape trees in Western Washington. For some people, inhalation of aerially dispersed spore of this pathogen is known to cause a respiratory condition known as maple bark disease. Following the detection of this disease in Seattle parks in 2019, more than 300 suspected SBD samples from a broad range of hosts and locations have been submitted to the WSU Ornamental lab. Results indicated that SBD has a much broader host range and is much more widely prevalent than previously known. Heat and moisture stress are known to favor the development of SBD and the increased frequency of high temperature and drought during the growing season has likely contributed to the increased morality of trees in Western Washington.

Phytophthora root rot (PRR) can limit where noble and Fraser fir Christmas trees which are in high demand by consumers can be grown. Research at WSU Puyallup has shown that Eurasian species of true firs, such as Nordmann and Turkish fir have the potential to make high quality Christmas trees and are much less susceptible to PRR than noble and Fraser fir. Because saturated soils are necessary for Phytophthoras to infect conifer roots, screening populations of trees for resistance to PRR under field conditions is typically very difficult because of the variability in soil moisture levels. To alleviate this problem a ‘rice paddy” system, where seedlings are planted in basins that are then flooded for various lengths of time, has been developed to provide very uniform saturated soil conditions needed to screen trees under field conditions.

Botrytis decay is a major problem that limits the ability of peony growers to extend the storage of flowers in cold storage. To maintain the moisture levels in stems, growers have attempted to store stems in chambers, but the resulting high relative humidity exasperates Botrytis development. Trials have shown that storage of stems in chambers with modified atmosphere (low oxygen/high carbon dioxide) is not effective in reducing *Botrytis* development. However, postharvest studies have shown that a single application of a fungicide, such as Medalion or Broadform to the flower buds prior to harvest or as a 5 second postharvest dip prior to storage is very effective in reducing Botrytis decay, make it possible for growers to store flower stems for up to eight.

Multiple applications of fungicides are typically used to control Botrytis gray mold during the production of conifer seedlings. Although most biological based fungicides are not very effective in limiting disease development, several newer, highly effective fungicides have been identified. Studies have also looked at the levels of fungicide resistance within populations of *Botrytis* in conifer nurseries and found that high levels of resistance are present to some high-risk fungicides. Based on our research, the largest conifer nursey in WA indicated they were changing their fungicide use pattern to reduce the risk of fungicide resistance and improve their management of Botrytis gray mold.

Outputs:
The WSU Ornamental Plant Pathology program delivered outcomes for mitigating the abiotic and biotic stressors of cut flowers, Christmas trees, urban trees, and nursery stock through collaboration, stakeholder engagement, and applied research as indicated below. Accomplishments include identifying more potential host species for the sooty bark disease pathogen and new geographic locations, confirming *Cryptostroma coritcale* is more widely distributed than previously thought. The diagnostics and research resulted in the publication of an extension fact sheet and a manuscript in the Journal of Forest Pathology. The program also continued to monitor an Oregon Ash common garden planting to monitor for pests and pathogens and study the phenotypic variations and genetic diversity in this host. Additional analyses were conducted to further identify fungal communities associated with pacific madrone leaf blight. Root disease surveys also were conducted in Christmas tree plantings impacted by climate change.

A collaborative review was also published to demonstrate the opportunities for community engagement in Phytophthora research. An access agreement was finalized, and a site was selected with the Port of Tacoma to establish a sentinel plant garden to monitor for the early detection of pests and pathogens. Stakeholders were engaged in state-of-the-science information during many virtual and in-person events. Overall, the program developed and delivered pertinent information for keeping trees healthy across the state during the reporting period. Planned results or changes for individuals, groups, communities, organizations, or systems.

Presentations:

Chastagner, G.A. and Elliott, M. Unprecedented mortality of Christmas trees. PSCTGA Annual Meeting, Kent, WA. January 28, 2023

Chastagner, G. A., Hulbert, J. M., Elliott, M., and Marshall, C. 2023. Sooty bark disease (*Cryptostroma corticale*) has a broader potential host range and distribution in North America than previously known. APS Pacific Division, Tucson, AZ. March 13-14, 2023

Chastagner, G.A. Overview of ongoing Christmas tree research at WSU Puyallup. WSDA CT Advisory Meeting, Olympia, WA. April 26, 2023

Chastagner, G.A. Screening for resistance to Phytophthora root rot resistance. Pierce County Master Gardner Tour. Puyallup, WA. May 12, 2023

Chastagner, G.A. Managing diseases on tulips and peonies. WSU Cut Flower Grower Field Day. Puyallup, WA. May 19, 2023

Chastagner, G.A. Management of Douglas-fir twig weevil and tree mortality survey results. PNWGTA Summer Tour and Meeting. Oregon City, OR. June 17, 2023

Chastagner, G.A. Keys to managing *Botrytis* while ramping up conifer nursery production. Joint Meeting of the Western Forest and Conservation Nursery Association and the Forest Nursery Association of British Columbia. Portland, OR. Sept. 19-20, 2023 (Invited Presentation)

Chastagner, G.A. Summary of Christmas tree research activities at WSU Puyallup. WSDA CT Advisory Meeting, Olympia, WA. October 4, 2023.

Chastagner, G.A. Overview of ornamental disease research at Washington State University. Syngenta Vero Beach Research Center. Vero Beach, FL. October 31, 2023 (Invited Seminar).

Chastagner, G.A. Overview of ozone and storage trials on peonies. Alaska Farm Bureau Annual Conference, Anchorage, AK. Nov. 10, 2023

Chastagner, G.A. Peony diseases and recent *Botrytis* research. Norwest Peony Society Annual Meeting, Puyallup, WA. Nov. 18, 2023

Chastagner G.A. Overview of sooty bark disease, Christmas tree, and peony research. NCERA-224 Annual Meeting, Santa Barbara, CA. December 11, 2023

Elliott, M. and Yadrick, M. 2023. Health and Resilience of Pacific Madrone, an Iconic Shoreline Tree. Workshop and field trip. Sound Waters University, Camano Island, WA. Feb.3-4 2023.

Elliott, M. 2023. Preventing *Phytophthora* Infestations in Native Plant Nurseries and Restoration Sites. Columbia Gorge Invasive Species and Exotic Pests Workshop. Stevenson, WA. 2/23/23

Elliott, M. and Yadrick, M. 2023. Preserving the Pacific madrone: exploring ecology, cultivation, and conservation of a favorite Northwest tree. Skagit Co. Master Gardeners 9/12/23.

Elliott, M. Tree disease diagnosis. Advanced Plant Pathology Series, Master Gardener Diagnosticians, Snohomish Co. 9/28/23.

Elliott, M., Chastagner, G., and Sniezko, R. 2023. Foliar fungal communities of Pacific madrone (*Arbutus menziesii*) in Washington and Oregon. 68th Western International Forest Disease Work Conference, Rohnert Park CA. June 5-9, 2023.

Elliott, M., Hulbert, J.M., Murray, T., and Chastagner G. 2023. Detecting biological invasions with sentinel plantings at ports and urban points of dispersal in Washington State. 68th Western International Forest Disease Work Conference, Rohnert Park CA. June 5-9, 2023.
Elliott, M., Hulbert, J.M., Marshall, C., and Chastagner, G. 2023. Identification of the sooty bark pathogen (*Cryptostroma corticale*) from hosts in multiple states. 68th Western International Forest Disease Work Conference, Rohnert Park CA. June 5-9, 2023.
Hulbert JM. 2023. Community engagement for healthy forests, Western International Forest Disease Work Conference, Sonoma, California.
Hulbert JM, 2023. Community engagement can enhance biosurveillance, Western Forest Insect Work Conference, Seattle, Washington.
Hulbert JM. 2023. Washington State University Extension Western Washington Family Field Day, *Emerging Diseases in the Pacific Northwest*.
Hulbert JM. 2023. Port of Tacoma, Invasive Species Workshop, *Sentinel Plantings in Tacoma: a tool for detecting new arrivals of invasive species*, Tacoma, Washington.
Hulbert JM. 2023. South Sound Mushroom Club, *Fungi and tree health in the Pacific Northwest*, Olympia, Washington.
Hulbert JM. 2023. Northwest Natural Resources Group, Fireside Chat, *Monitoring tree health: community mapping to study western redcedar dieback*.
Hulbert JM, Elliott M. 2023. Sooty Bark Disease Tour, Annual Training Conference, Pacific Northwest Chapter of International Society of Arboriculture.

Workshops, Field Days and Tours:
CAHNRS Dean's visit to PREC, Puyallup, WA. Oct. 31, 2022
Pierce County Master Gardener Tour. Puyallup, WA. May 12, 2023
WSU Cut Flower Grower Field Day. Puyallup, WA. May 19, 2023
Washington State University Extension Western Washington Forest Field Day. Pack Forest, Eatonville, WA. June 10, 2023
Port of Tacoma, Invasive Species Workshop. Tacoma, WA
Sooty Bark Disease Tour, Annual Training Conference, Pacific Northwest Chapter of International Society of Arboriculture. Tacoma, WA. October 4, 2023
Northwest Peony Society grower tour, Puyallup, WA. Nov. 18, 2023

News Releases and Media Stories to Disseminate Information to Stakeholders and The Public
April 24, 2023. Seth Truscott. WSU sentinel plantings to guard against invasive pests, diseases at Washington ports. https://news.cahnrs.wsu.edu/article/wsu-sentinel-plantings-to-guard-against-invasive-pests-diseases-at-washington-ports/
December 6, 2023. Seth Truscott. Christmas tree scientists work to identify, manage grinchy fungal foes. https://news.cahnrs.wsu.edu/article/christmas-tree-scientists-work-to-identify-manage-grinchy-fungal-foes/
November 19, 2023. Holly Menino, KOMO TV. Washington's 'Dr. Christmas Tree' works to improve tree health, longevity amidst climate change. https://komonews.com/news/local/christmas-trees-washington-state-university-research-program-climate-change-environment-tree-health-longevity-forest-forests-land-festive-holiday-fir-tree-industry
December 1, 2023. Julia Jacobo, ABC News (New York) Real versus fake Christmas trees: Which is more environmentally friendly? https://abcnews.go.com/US/real-versus-fake-christmas-trees-environmentally-friendly/story?id=105179766
December 4, 2023. ABC's Good Morning America. Real versus fake Christmas trees: Which is more environmentally friendly? https://www.goodmorningamerica.com/news/story/real-versus-fake-christmas-trees-environmentally-friendly-105179766

The KOMO and ABC News stories and GMA segment has been rebroadcast by several other media outlets, such ABC 7 in Chicago. https://abc7chicago.com/real-vs-fake-christmas-tree-environmentally-friendly-better-for-environment/14140715/

Outcomes:
The WSU Ornamental Plant Pathology program benefited cut flower, Christmas tree, forest and nursery stakeholders by providing educational, extension and research outcomes. The program hosted information sessions about the diagnosis of sooty bark disease which has resulted in an increased number of samples being collected by many stakeholders such as arborists and urban foresters. Diagnostic tests have increased our knowledge about the distribution of pathogens, such as *Cryptostroma coritcale*. Sampling in peony grower coolers revealed much lower levels of ozone being generated than anticipated by the ozone generators growers have been trying to use to reduce *Botrytis* decay during storage of cut flowers. The program also developed and delivered educational materials and outcomes to enhance capacity for reporting, identifying, and managing problematic pests and pathogens.

The Ornamental Plant Pathology program benefited the broader public by providing educational, extension, and research outcomes to them. Many public presentations were given to societies such as the South Sound Mushroom Club and Master Gardeners. Several news releases and media stories, particularly relating to Christmas tree research, helped provide information to the public about WSU's research. Additional site visits, diagnostics, and engagement activities were conducted to increase awareness of the effects of sooty bark disease and its interaction with climate change. A review of public engagement approaches was also published to highlight the methods for public engagement in plant disease research with a focus on *Phytophthora* species. The program also hosted many tours for students and stakeholders at the WSU Research and Extension Center.

Collaboration efforts by Plant Diagnostic Lab created resources for monitoring and management of new pests including emerald ash borer and Asian jumping worm. Diagnostic clientele received practical pest management information with a focus on protecting the environment and non-target fauna, such as beneficial insects, pollinators, and salmon.

Publications Outreach and research:
Outreach section

Brooks, R., Hulbert, J.M., Omdall, D., Elliott, M., Chastagner, G.A. 2022. Sooty Bark Disease Diagnostic Guide, WSU Extension Fact Sheet FS375E.

Kline, N., Stark, D., Parke, J., Groth, A., Botello Salgado, B., Elliott, M. 2023. How to prevent Phytophthoras in restoration plantings on your woodlands. OSU Extension Publication EM 9398, EM 9398-S (Spanish version).

Zobrist, K.W., R.A. Bomberger, M.N. Darr, J.R. Glass, J.M. Hulbert, and E.S. Roberts. 2023. Managing Emerald Ash Borer in Washington State. Washington State University Extension Publication FS384 Washington State University. https://pubs.extension.wsu.edu/managing-emerald-ash-borer-in-washington-state

Zobrist, K.W., R.A. Bomberger, M.N. Darr, J.R. Glass, J.M. Hulbert, and E.S. Roberts. 2023. Emerald Ash Borer and its Implications for Washington State. Washington State. Washington State University Extension Publication EM127 Washington State University. https://pubs.extension.wsu.edu/emerald-ash-borer-and-its-implications-for-washington-state

Chastagner, G. and M. Elliott. 2023. Tree mortality in PNW Christmas tree plantations: A potential impact of climate induced stress and root disease. Christmas Tree Lookout 54(1): 18-20.

WSDA. 2023. Washington State Christmas Tree Growers Advisory Committee Newsletter. November 2023. WSDA AGR Pub 800-795 (R/11/23)

Research section

Journals:

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